BLM

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Bureau of Land Management

Draft Miles City Field Office (MCFO) Resource Management Plan Revision (RMP) and Environmental Impact Statement (EIS)

Air Resource Technical Support Document (ARTSD) for Emission Inventories and Near-Field Modeling

March 7, 2013

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Acronyms

AERMIC	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee
API	American Petroleum Institute
ARM	Ambient ratio method
ARTSD	Air Resource Technical Support Document
AQRV	Air quality related value
bbl/day	Barrels per day
BLM	Bureau of Land Management
CBNG	Coal bed natural gas
CFR	*Code of Federal Regulations*
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FR	*Federal Register*
GAQM	Guideline on Air Quality Models
GPO	U.S. Government Printing Office
H1H	Highest-first-high
H2H	Highest-second-high
H4H	Highest-fourth-high
H8H	Highest-eighth-high
HAP	Hazardous air pollutant
Hp	Horsepower
IDLH	Immediately dangerous to life or health
IPCC	Intergovernmental Panel on Climate Change
K	Kelvin
km	Kilometer
m	Meter
MAAQS	Montana Ambient Air Quality Standards
MCFD	Thousand cubic feet per day
MCFO	Miles City Field Office
MDEQ	Montana Department of Environmental Quality
MEI	Maximally exposed individual
MLE	Most likely exposure
$\mu g/m^3$	Micrograms per cubic meter
mg/m^3	Milligrams per cubic meter
MMBtu	Million British thermal units
MRI	Midwest Research Institute
MMscf	Million standard cubic feet
Mscf	Thousand standard cubic feet
NAAQS	National Ambient Air Quality Standards
N_2O	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PM_{10}	Particulate matter with a diameter less than or equal to 10 microns

Acronyms (cont.)

$PM_{2.5}$	Particulate matter with a diameter less than or equal to 2.5 microns
POD	Plan of Development
ppb	Parts per billion
ppm	Parts per million
ppmw	Parts per million by weight
PSD	Prevention of Significant Deterioration
REC	Reduction emission completion
REL	Reference exposure limit
RfC	Reference concentration
RFD	Reasonably Foreseeable Development
RMP	Resource Management Plan
SO_2	Sulfur dioxide
URF	Unit risk factor
WRAP	Western Regional Air Partnership

1.0 INTRODUCTION

The Bureau of Land Management (BLM) prepared the Miles City Field Office (MCFO) Draft Resource Management Plan (RMP) Revision and Environmental Impact Statement (EIS) to assess environmental impacts of future management of public lands (BLM 2013). As part of this analysis, air pollutant emission inventories were developed for multiple resources and near-field modeling was performed to assess impacts related to future oil and gas development. This Air Resource Technical Support Document (ARTSD) provides a description of assumptions and methods used to develop the emission inventories and perform near-field modeling.

Additional future far-field modeling to assess air quality and air quality related values will be summarized in a future ARTSD.

1.1 Scope of the Emission Inventories

Emission inventories were developed for each of the MCFO RMP alternatives and include emissions of criteria air pollutants (including precursor pollutants), hazardous air pollutants (HAPs), and greenhouse gases (GHGs). Specific pollutants included in the emission inventories are listed in Table 1. Two criteria air pollutants, ozone and lead, were not included in the emission inventories. Although ozone is a criteria air pollutant, it is not emitted directly into the atmosphere from sources. Instead, ozone is formed by chemical reactions within the atmosphere from precursor pollutants, including nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Lead emissions were not estimated or modeled because emission sources emit negligible levels of lead.

Table 1. Pollutants Included in Emission Inventories

Criteria Air Pollutants	Hazardous Air Pollutants	Greenhouse Gases

• Carbon monoxide (CO)
• Nitrogen dioxide (NO_2)
• Ozone precursors
  o Nitrogen oxides (NO_x)
  o Volatile organic compounds (VOCs)
• Particulate matter with a diameter less than or equal to 10 microns (PM_{10})
• Particulate matter with a diameter less than or equal to 2.5 microns ($PM_{2.5}$)
• Sulfur dioxide (SO_2)
	• Benzene
	• Ethylbenzene
	• Formaldehyde
	• n-Hexane
	• Toluene
	• Xylenes
		• Carbon dioxide (CO_2)
		• Methane (CH_4)
		• Nitrous oxide (N_2O)

Two types of emission inventories are included in this document. Detailed emission inventories for each alternative are included in Appendices A–E. These emission inventories provide estimates of emissions on an annual basis in terms of short tons per year (tpy) and address emissions from a variety of resource activities. GHG emissions are also reported in terms of carbon dioxide equivalent (CO_2e) in metric tons per year (mtpy).

The second type of inventory was developed specifically for near-field modeling of oil and gas emission sources. This inventory included oil and gas sources that are likely to be present at well pads. Emission

modeling requires appropriate emission rates in order to compare predicted concentrations to the National Ambient Air Quality Standards (NAAQS). In addition to annual emission rates, maximum short-term emission rates were calculated for 1-hour, 8-hour, and 24-hour NAAQS.

1.2 AERMOD Modeling

Near-field modeling assessed potential impacts to air quality within close proximity to the modeled emission sources from oil and gas construction, development, and production activities. The primary goal of this analysis was to model estimated air pollutant emissions and to compare predicted pollutant concentrations to the NAAQS and to Montana Ambient Air Quality Standards (MAAQS) for criteria air pollutants and HAPs.

Two criteria air pollutants were not modeled for the near-field analysis: lead and ozone. Lead was not modeled because it would be emitted in negligible quantities. Ozone was not modeled because AERMOD is not capable of modeling this pollutant, which is formed in complex atmospheric reactions. Impacts to ozone concentrations will be modeled at a later date using a photochemical grid model and extensive regional emission inventories.

In addition to the criteria pollutants listed above, predicted HAP emissions were modeled, with resulting concentrations compared to health-based risk thresholds. Modeled HAPs included benzene, ethylbenzene, formaldehyde, n-hexane, toluene, and xylenes.

1.3 Limits of the Analysis

Because air quality modeling was performed at the land use planning stage, specific information concerning future oil and gas activities was not known. For example, specific locations of emission sources and details concerning the size and type of emission-producing equipment and operational details were not known. Consequently, the assessment was based on reasonable but conservative estimates. Assumptions used in the analysis are described throughout this document and in the emission inventories (Appendices A-F). Due to the lack of specific location data, flat terrain was assumed.

Many of the sources and operations included in the near-field modeling analysis are temporary sources that may operate only a few days or a few hours in one location. In order to conservatively assess air quality impacts using a wide variety of meteorological conditions, source emissions were modeled as if they occur throughout the three modeled years. Maximum pollutant concentrations reported in this document may not occur if emission sources do not operate during times when meteorological conditions would be conducive to high pollutant concentrations.

Large stationary source facilities, such as compressor stations, are not expected to be located on land under BLM jurisdiction. Near-field air quality impacts from these sources would be assessed at the time that these sources undergo the Montana Department of Environmental Quality (MDEQ) air quality permitting process.

As part of the air resource analysis for the four RMPs/EISs, additional modeling will be performed in the future to assess far-field air quality impacts (including ozone and other non-lead criteria air pollutants) and air quality related value (AQRV) impacts. Modeling protocols and results for these future efforts will be provided in future documents.

1.4 Document Organization

This ARTSD is organized as follows.

- Section 2: Emission Inventory Development
- Section 3: Near-field Modeling Methodology
- Section 4: Near-field Modeling Results
- Section 5: Bibliography

2.0 EMISSION INVENTORY DEVELOPMENT

Two types of emission inventories were developed using accepted engineering methodologies and information provided by MCFO personnel. The first type of emission inventory is the alternative-specific inventory. Alternative-specific inventories were developed for each of the five alternatives.

The second type of emission inventory is the near-field modeling emission inventory, which included both annual and short-term emission rates needed for AERMOD modeling of oil and gas activities. The near-field emission inventory was derived from the alternative-specific emission inventories for oil and gas activities.

2.1 Alternative-Specific Emission Inventories

Alternative-specific inventories encompass many resources and the entire planning area. These inventories included emission estimates for the following BLM activities and resource uses on BLM surface land and mineral estate.

- Oil and gas (including oil wells, natural gas wells, and coal bed natural gas [CBNG] wells)
- Coal mining
- Vegetation management
- Fire management
- Forestry and woodland products
- Livestock grazing
- Recreation and trails and travel management
- General purpose BLM fleet travel
- Road maintenance

In addition, emission estimates were developed for oil and gas sources and coal mines accessing non-BLM mineral estate within the planning area, including activities on state, private, and Indian Trust mineral estate. These oil and gas emissions were used for the cumulative emission impact assessment.

Detailed calculations are provided in Appendices A, B, C, D, and E for each of the alternatives. These calculation spreadsheets provide equations, emission factors, and assumptions used to develop the emission inventories. Many of the criteria pollutant calculations were based on appropriate sections of the U.S. Environmental Protection Agency's (EPA's) AP42 Fifth Edition, Volume 1 (EPA 1996, 1998a, 1998b, 1998c, 2006, 2008, 2010b, 2010c). GHG emission estimates were primarily based on calculation methods and emission factors from the Intergovernmental Panel on Climate Change (IPCC 1996, 2006) and the American Institute's *Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry* (API 2009).

2.1.1 Emission Sources

For many resources, emissions would be similar to emissions associated with current levels of activity. For example, forestry management, BLM road travel, and coal mining activities would not increase over current activity levels; emissions from these activities would remain relatively constant. Consequently, emissions from most ongoing resource management activities would not represent increases to regional emissions. However, oil and gas emissions reflect increased activity in future years and would add to regional emissions. Oil and gas emission estimates presented below reflect the year with the greatest total emissions from development and production activities.

2.1.1.1 Oil and Gas

Comprehensive emission estimates were developed for oil and gas operations at three types of wells: oil, CBNG, and conventional natural gas. Table 2 summarizes estimates of new oil, CBNG, and gas wells that could potentially be developed under each of the alternatives. Alternative A oil and gas activity was based on full Reasonably Foreseeable Development (RFD) for federal and non-federal wells. As described in the Draft RMP/EIS (BLM 2013), Alternatives B, C, D, and E reflect less than full RFD for federal wells based on percentages of 5%, 30%, 54%, and 47%, respectively. Non-federal well numbers were based on full RFD.

Table 2. Summary of Alternative Well Numbers and Production Rates

Well Type	Mineral Estate	Alternative [1]				
		A	B	C	D	E
Oil Wells						
Peak Number of Annual Wells Drilled	Federal	41	3	13	23	20
	Non-federal	*136*				
Maximum Producing Wells (Year 20)	Federal	637	32	192	344	300
	Non-federal	*2,109*				
Average Daily Production (bbl/day)	Federal	20				
	Non-federal	*20*				
CBNG Wells						
Peak Number of Annual Wells Drilled	Federal	14	1	5	8	7
	Non-federal	*47*				
Maximum Producing Wells (Year 20)	Federal	267	14	81	145	126
	Non-federal	*885*				
Average Daily Production (MCFD)	Federal	45				
	Non-federal	*45*				
Natural Gas Wells						
Peak Number of Annual Wells Drilled	Federal	34	2	11	19	16
	Non-federal	*111*				
Maximum Producing Wells (Year 20)	Federal	528	27	159	286	249
	Non-federal	*1,747*				
Average Daily Production (MCFD)	Federal	40				
	Non-federal	*40*				

bbl/day = barrels per day

MCFD = thousand cubic feet per day

[1] Federal well numbers for Alternatives B, C, D, and E were rounded to the next largest whole number after applying the percentage of RFD associated with the alternative.

The following equipment and activities were included in one or more of the three types of oil and gas emission inventories.

- Drill rig engines and associated equipment
- Completion engines and associated equipment
- Frac pump engines and associated equipment

- Well workover engines and associated equipment
- Generators
- Well pad and road construction equipment
- Transport vehicles for equipment and materials
- Commuting vehicles for workers
- Dehydrators
- Condensate and oil tanks
- Liquids transfer operations
- Valves, pump seals, flanges, connectors, and other leak sources
- Well venting
- Compressor engines
- Vehicle travel on unpaved roads
- Surface disturbance
- Wind erosion

Assumed equipment sizes, operating times, and other activity variables are provided in Appendices A through E for each of the alternatives.

Total drill rig engine horsepower (hp) varied by the type of well, as shown in Table 3. Tier 4 engine emission factors were assumed for future development due to early near-field modeling results indicating potential difficulties meeting the 1-hour NO_2 NAAQS with engines meeting less-stringent emission standards. If future near-field modeling demonstrates that higher-emitting engines would comply with the 1-hour NO_2 standard, non-Tier 4 engines could be used.[1] Based on information from the MCFO, engines greater than 750 hp are typically genset engines.

The following air quality emission control assumptions were included in the emission calculations to reflect mitigation measures included in the draft Air Resource Management Plan.

1. Roads and well pads would be constructed to reduce the amount of fugitive dust generated by traffic. During construction activities, dust suppression methods would include application of water, dust-suppression chemicals, gravel, or other control methods to achieve 50 percent fugitive dust control efficiency, except when the road or ground surface is wet or frozen.

2. On well pad access roads, dust suppression during drilling, completion, and well workover operations would achieve a 50 percent fugitive dust control efficiency, except when the road or ground is wet or frozen.

3. In high traffic areas during production operations, dust abatement would achieve 50 percent fugitive dust control efficiency, except when roads are wet or frozen.

4. Diesel drill rig engines greater than 200 hp would meet Tier 4 emission standards for non-road diesel engines.

5. Non-road diesel engines would use ultra-low sulfur diesel fuel (15 ppmw) as required by 40 CFR §80.610(e)(3)(iii).

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[1] The BLM and many state air quality agencies believe that the AERMOD near-field model may predict overly conservative ambient 1-hour NO_2 concentrations. Several entities, including the BLM, may initiate studies to ground-truth predicted drill rig 1-hour NO_2 concentrations by comparing modeled concentrations with monitored concentrations.

Table 3. Summary of Drilling and Completion Equipment

Well Type / *Activity* / Equipment Type	Capacity (hp)	Units	Avg. Load Factor (%)	Operating Hours / Day	Operating Days / Well	Total Operating Hours / Well
Oil Wells						
Rig-up, Drilling, and Rig-down						
Main Deck	1,000	3	70	24	16	384
Auxiliary Pump	600	1	80	8	15	120
Generators	150	2	75	24	8	192
Well Completion, Fracing, and Testing						
Main Deck	600	1	50	11	5	55
Auxiliary Pump	225	1	80	8	2	16
Power Swivel	150	1	75	8	2	16
CBNG Wells						
Rig-up, Drilling, and Rig-down						
Main Deck	400	1	60	18	3	54
Auxillary Pump	200	1	90	18	2	36
Well Completion, Fracing, and Testing						
Main Deck	400	1	60	18	1	18
Auxiliary Pump	125	1	90	18	1	18
Water Disposal Well Drilling						
Generator	1476	1	40	24	30	720
Generator	1476	1	40	24	30	720
Natural Gas Wells						
Rig-up, Drilling, and Rig-down						
Main Deck	400	3	70	24	16	384
Auxiliary Pump	200	1	80	8	15	120
Generators	150	2	75	24	8	192
Well Completion, Fracing, and Testing						
Main Deck	400	1	50	11	5	55
Auxiliary Pump	125	1	80	8	2	16
Power Swivel	150	1	75	8	2	16

The following additional measures included in the Draft ARMP were not included in the emission inventories. With regard to mitigation measures associated with Project Plans of Development (PODs), emissions were conservatively estimated without including emission reductions associated with these actions.

1. For oil and gas PODs, oil and gas operators will establish speed limits for project-required unpaved roads in and adjacent to the project area.

2. For oil and gas Project PODs, oil and gas operators will be encouraged to reduce surface disturbance, vehicle traffic, and fugitive dust emissions by consolidating facilities (e.g., using multi-well pads, storage vessels) when feasible.

VOC, methane, and organic HAP emissions are likely to be overestimated in the emission inventories because emission control requirements associated with a recent EPA rule were not accounted for in the emission calculations. In 40 *CFR* Part 60 Subpart OOOO (Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution) (GPO 2013d), hydraulically fractured gas wells (except for "low pressure wells", "wildcat," or "delineation" wells) must comply with reduced emissions completion (REC) requirements that will reduce well venting during completion operations. Neither methane nor VOC emissions were included in the near-field modeling, although impacts from organic HAP emissions are likely overestimated.

2.1.1.2 Coal Mining

Coal mining emissions include emissions from stationary and mobile combustion sources, crushing facilities, and fugitive dust. Emissions were estimated from available MDEQ air quality permitted emissions for individual mines located within the planning area. For criteria air pollutants not included in the permits, emissions were estimated based on fuel usage or engine horsepower data. Because GHG emissions are not included in MDEQ air quality permits, GHG emissions were estimated based on fuel usage and engine horsepower data.

2.1.1.3 Vegetation Management

Vegetation management included chemical and mechanical weed control. Combustion exhaust emission sources include vehicles used for commuting to and from work sites, non-road equipment such as skidders and all-terrain vehicles, and hand-held tools such as chainsaws. Fugitive dust from surface disturbance and from vehicle travel on unpaved roads would also occur during vegetation management activities.

2.1.1.4 Fire Management

Fire management emissions included estimates for smoke from prescribed burns and wildfires, firefighting activities, and mechanical treatment for fire prevention. Smoke and firefighting emissions were based on the annual average number of acres burned. Equipment usage hours and vehicle miles traveled formed the basis for exhaust emissions from heavy equipment, fire engines, and chain saws. Fugitive dust emissions included surface disturbance and vehicle travel on unpaved roads. In Table 4 through Table 13, emission summaries include smoke emissions from prescribed burns only. The detailed emission calculations in the appendices include smoke emissions from all fires.

2.1.1.5 Forestry and Woodland Products

Logging operations and forest maintenance emission sources include exhaust emissions from equipment such as logging trucks, bulldozers, loaders, skidders, and delimbers. Fugitive dust emissions include surface disturbance, wind erosion, and vehicle travel on unpaved roads.

2.1.1.6 Livestock Grazing

Livestock grazing activities include some small construction projects, commuting vehicles, and livestock hauling. With regard to GHG emissions, estimated livestock emissions included methane emissions from enteric fermentation and manure management.

2.1.1.7 Recreation and Trails and Travel Management

Recreational trail uses included in the emission inventory include the use of all-terrain vehicles, motorcycles, and snowmobiles. Vehicle exhaust emissions and fugitive dust emissions were calculated based on estimates of the number of vehicle miles traveled for each type of recreational vehicle.

2.1.1.8 General Purpose BLM Fleet Travel

Exhaust emissions from general purpose BLM fleet travel were based on records of vehicle miles traveled. Fugitive dust emissions were based on the estimated number of miles traveled on unpaved roads.

2.1.1.9 Road Maintenance

Emission sources for road maintenance primarily involve road grading activities and include equipment exhaust from road maintenance equipment and fugitive dust emissions from wind erosion.

2.1.2 Alternative-Specific Emissions

2.1.2.1 Alternative A Emissions

Alternative A criteria pollutant and HAP emissions from BLM resource management on BLM surface land and federal mineral estate are summarized in Table 4. GHG emission estimates for these activities are provided in Table 5. As mentioned earlier, Alternative A would allow new oil and gas development up to 100 percent of RFD. New oil and gas activity represents emission increases over current levels, while emissions from other resources represent activity levels that are similar to current activity levels.

Table 4. Alternative A Criteria Pollutant and HAP Emissions

	Emissions (tons per year)						
Resource or Resource Use	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**HAP**
Oil and Gas Activity							
Oil	734.5	321.3	0.6	74.1	20.7	2,563.1	161.9
Natural Gas	288.8	119.4	0.3	18.6	6.7	82.5	8.3
Coal Bed Natural Gas	126.3	63.9	0.1	13.6	4.2	43.7	8.3
Oil and Gas Subtotal	**1149.6**	**504.6**	**1.0**	**106.3**	**31.6**	**2,689.3**	**178.5**
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	0.9	1.3	0.0	3.6	0.4	0.1	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.4	1.6	0.0	74.7	7.5	1.9	0.2
Road Maintenance	0.5	1.2	0.0	1.4	0.2	0.1	0.0
BLM Emission Total	**5,067.5**	**2,393.8**	**194.6**	**5,285.3**	**681.4**	**2,967.3**	**206.2**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Table 5. Alternative A GHG Emissions

Resource or Resource Use	Emission (tpy)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Activity					
Oil	69,637	414	0	78,464	71,169
Natural Gas	28,786	384	0	36,657	33,249
Coal Bed Natural Gas	10,282	197	0	14,433	13,091
Oil and Gas Subtotal	**108,705**	**995**	**0**	**129,554**	**117,509**
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	178	0	0	179	163
Livestock Grazing	1,382	2,666	0	57,377	52,043
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	285	0	0	297	269
Road Maintenance	147	0	0	147	134
BLM Emission Total	**503,884**	**3,783**	**25**	**590,981**	**536,039**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

2.1.2.2 Alternative B Emissions

Criteria pollutant, HAP, and GHG emissions for Alternative B are provided in Table 6 and Table 7. Emissions for the following resources are the same as those for Alternative A: coal mining; fire management; recreation, trails, and travel management; and vegetation management. Alternative B would allow new oil and gas development of up to 5 percent of RFD.

Table 6. Alternative B Criteria Pollutant and HAP Emissions

Resource or Resource Use	Emissions (tpy)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Activity							
Oil	39.5	16.6	0.0	4.2	1.1	129.3	8.2
Natural Gas	15.1	6.2	0.0	1.0	0.4	4.2	0.4
Coal Bed Natural Gas	6.7	3.4	0.0	0.9	0.2	2.3	0.4
Oil and Gas Subtotal	**26.2**	**26.2**	**0.0**	**6.1**	**1.7**	**135.8.0**	**9**
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	0.2	0.1	0.0	0.5	0.1	0.0	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.3	1.6	0.0	73.7	7.4	1.9	0.2
Road Maintenance	0.5	1.3	0.0	1.5	0.2	0.1	0.0
BLM Emission Total	**3,978.4**	**1,914.4**	**193.6**	**5,181.1**	**651.1**	**413.7**	**36.7**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Table 7. Alternative B GHG Emissions

Resource or Resource Use	Emissions (tpy)				
	CO_2	CH_4	N_2O	CO_2e	CO_2e (mtpy)
Oil and Gas Activity					
Oil	4,016	21	0	4,470	4,055
Natural Gas	1,529	20	0	1,950	1,769
Coal Bed Natural Gas	545	11	0	778	706
Oil and Gas Subtotal	**6,090**	**52**	**0**	**7,198**	**6,530**
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	9	0	0	9	8
Livestock Grazing	1,382	2,458	0	53,010	48,082
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	282	0	0	293	266
Road Maintenance	154	0	0	154	140
BLM Emission Total	**401,104**	**2,632**	**25**	**464,091**	**420,948**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

2.1.2.3 Alternative C Emissions

Criteria pollutant, HAP, and GHG emissions for Alternative C are provided in Table 8 and Table 9. Emissions for the following resources are the same as those for Alternatives A and B: coal mining; fire management; recreation, trails, and travel management; and vegetation management. Alternative C would allow new oil and gas development of up to 30 percent of RFD.

Table 8. Alternative C Criteria Pollutant and HAP Emissions

	Emissions (tpy)						
Resource or Resource Use	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**HAP**
Oil and Gas Activity							
Oil	223.1	97.2	0.2	22.7	6.3	772.9	48.8
Natural Gas	87.9	36.1	0.1	5.8	2.1	24.9	2.5
Coal Bed Natural Gas	38.4	19.4	0.0	4.7	1.3	13.3	2.5
Oil and Gas Subtotal	**349.4**	**152.7**	**0.3**	**33.2**	**9.7**	**811.1**	**53.8**
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	1.6	2.3	0.1	6.4	0.8	0.3	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	71.3	7.2	2.0	0.2
Road Maintenance	0.5	1.4	0.0	1.6	0.2	0.1	0.0
BLM Emission Total	**4,268.2**	**2,043.3**	**194.0**	**5,211.8**	**659.6**	**1,089.4**	**81.5**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Table 9. Alternative C GHG Emissions

Resource or Resource Use	Emissions (tpy)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Activity					
Oil	21,343	125	0	24,012	21,779
Natural Gas	8,818	117	0	11,259	10,212
Coal Bed Natural Gas	3,137	62	0	4,440	4,027
Oil and Gas Subtotal	**33,298**	**304**	**0**	**39,711**	**36,018**
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	314	0	0	316	287
Livestock Grazing	1,382	2,659	0	57,243	51,921
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	300	0	0	312	283
Road Maintenance	161	0	0	161	146
BLM Emission Total	**428,642**	**3,085**	**25**	**501,170**	**454,576**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

2.1.2.4 Alternative D Emissions

Criteria pollutant, HAP, and GHG emissions for Alternative D are provided in Table 10 and Table 11. Emissions for the following resources are the same as those for Alternatives A, B, and C: coal mining; fire management; recreation, trails, and travel management; and vegetation management. Alternative D would allow new oil and gas development of up to 54 percent of RFD.

Table 10. Alternative D Criteria Pollutant and HAP Emissions

Resource or Resource Use	Emissions (tpy)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Activity							
Oil	399.0	174.0	0.3	40.5	11.2	1,384.6	87.5
Natural Gas	157.1	64.8	0.1	10.2	3.7	44.8	4.5
Coal Bed Natural Gas	68.6	34.7	0.0	7.7	2.3	23.7	4.5
Oil and Gas Subtotal	**624.7**	**273.5**	**0.4**	**17.2**	**17.2**	**1,453.1**	**96.5**
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	2.7	3.9	0.1	10.7	1.3	0.4	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	72.7	7.3	2.0	0.2
Road Maintenance	0.5	1.4	0.0	1.6	0.2	0.1	0.0
BLM Emission Total	**4,544.6**	**2,165.7**	**194.1**	**5,242.7**	**667.7**	**1,731.5**	**124.2**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

Table 11. Alternative D GHG Emissions

Resource or Resource Use	Emissions (tpy)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Activity					
Oil	38,079	224	0	42,857	38,872
Natural Gas	15,673	209	0	20,025	18,163
Coal Bed Natural Gas	5,593	108	0	7,871	7,139
Oil and Gas Subtotal	**59,345**	**541**	**0**	**70,753**	**64,174**
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	524	0	0	527	478
Livestock Grazing	1,382	2,663	0	57,320	51,991
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	304	0	0	316	287
Road Maintenance	161	0	0	161	146
BLM Emission Total	**454,903**	**3,326**	**25**	**532,504**	**482,997**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires

2.1.2.5 Alternative E Emissions

Criteria pollutant, HAP, and GHG emissions for Alternative E are provided in Table 12 and Table 13. Emissions for the following resources are the same as those for Alternatives A, B, C, and D: coal mining;

fire management; recreation, trails, and travel management; and vegetation management. Alternative E would allow new oil and gas development of up to 47 percent of RFD.

Table 12. Alternative E Criteria Pollutant and HAP Emissions

Resource or Resource Use	Emissions (tpy)						
	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	HAP
Oil and Gas Activity							
Oil	347.8	151.7	2.3	34.8	9.3	1,207.5	76.3
Natural Gas	136.1	56.3	0.1	8.8	3.2	38.9	3.9
Coal Bed Natural Gas	59.6	30.1	0.0	6.7	2.0	20.6	3.9
Oil and Gas Subtotal	**543.5**	**238.1**	**2.4**	**50.3**	**14.5**	**1,267**	**84.1**
Coal Mining	2,121.0	1,817.4	179.8	4,448.4	444.8	144.2	14.4
Vegetation Management	11.3	0.1	0.0	10.7	1.4	3.1	0.3
Fire Management [1]	1,741.9	58.3	13.6	210.7	151.1	97.3	9.7
Forestry and Woodland Products	2.7	3.9	0.1	10.7	1.3	0.4	0.0
Livestock Grazing	11.3	9.3	0.2	136.9	14.3	4.2	0.4
Recreation – Trails and Travel Management	26.6	0.1	0.0	292.6	30.1	27.1	2.7
General Purpose BLM Fleet Travel	4.6	1.7	0.0	72.7	7.3	2.0	0.2
Road Maintenance	0.5	1.2	0.0	1.4	0.2	0.1	0.0
BLM Emission Total	**4,463.4**	**2,130.1**	**196.1**	**5,234.4**	**665.0**	**1,545.4**	**111.8**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires

Table 13. Alternative E GHG Emissions

Resource or Resource Use	Emissions (tpy)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Activity					
Oil	33,176	195	0	37,342	33,871
Natural Gas	13,516	181	0	17,278	15,672
Coal Bed Natural Gas	4,862	94	0	6,843	6,207
Oil and Gas Subtotal	**51,554**	**470**	**0**	**61,463**	**55,750**
Coal Mining	104,029	1	1	104,365	94,662
Vegetation Management	34	0	0	35	32
Fire Management [1]	289,046	121	24	298,944	271,151
Forestry and Woodland Products	524	0	0	527	478
Livestock Grazing	1,382	2,656	0	57,173	51,857
Recreation – Trails and Travel Management	78	0	0	83	76
General Purpose BLM Fleet Travel	304	0	0	316	287
Road Maintenance	147	0	0	147	134
BLM Emission Total	**447,098**	**3,248**	**25**	**523,053**	**474,427**

[1] Excludes smoke emissions from wildfires, but includes smoke emissions from prescribed fires.

2.2 Emission Inventory for Near-field Modeling

Emission inventories for AERMOD modeling were developed for Alternative A, which is the highest emitting alternative for oil and gas activities and represents dense well pad spacing. The AERMOD emission inventory used similar emission calculation methods to determine annual emissions under Alternative A and refined these emissions to develop short-term emission rates that reflect the timing and seasonality of emissions. Short-term emission rates (1-hour and 24-hour emission rates) and annual emission rates were needed as data inputs to AERMOD. Detailed AERMOD emission inventory calculations for oil and gas sources are provided in Appendix F.

The AERMOD modeling layout consisted of a central well pad surrounded by four well pads within a 6 kilometer (km) × 6 km domain. Emission sources associated with one of the three modeled scenarios were placed at or near the center of the central well pad.

- Construction scenario — Fugitive dust from surface disturbance associated with construction activities and vehicle traffic on unpaved roads, and exhaust emissions from construction equipment.
- Well drilling scenario — Exhaust emissions from drill rig and associated engines and drill rig boilers, as well as fugitive dust from vehicle traffic on unpaved roads.
- Well completion and fracing scenario — Exhaust emissions from completion engines and completion flaring, and fugitive dust from vehicle traffic on unpaved roads.

For each of the above scenarios, four production well pads were assumed to be operating concurrently and each included these emission sources: pumpjack engines, heaters, tanks, flares, and fugitive dust emissions from vehicle traffic on unpaved roads.

Appendix F contains AERMOD emission input summary pages for criteria air pollutants and HAPs.

3.0 NEAR-FIELD MODELING METHODOLOGY

This section describes the information required for AERMOD near-field modeling and the methodology used to perform the modeling.

3.1 Model Versions and Options

AERMOD is a U.S. Environmental Protection Agency (EPA) guideline model for estimating near-field air quality impacts within 50 km of emission sources. The model was developed by the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC). Version 12060 of AERMOD was released on February 29, 2012 and was used in this analysis. Unless otherwise specified in this document, model input options were set to their regulatory default options. Because flat terrain was assumed, the AERMAP terrain processing program was not needed.

3.2 Meteorological Data and Processing

AERMOD requires substantial meteorological data inputs that were developed using the AERSURFACE and AERMET models. The AERSURFACE model (version 08009) provided land surface data, including albedo, Bowen ratio, and surface roughness for each site. These data, along with surface and upper air meteorological data, will be input into the AERMET program (version 11059).

Table 14 provides identifying data for the meteorological monitoring stations used for the modeling. Five years of data from January 2005 through December 2009 were obtained for the Sidney, Montana surface station site and the Glasgow, Montana upper air station site.

Table 14. MCFO Meteorology Data Stations

Surface Station				Upper Air Station			
Name	**WBAN**	**Latitude**	**Longitude**	**Name**	**WBAN**	**Latitude**	**Longitude**
Sidney-Richland Airport, MT	94028	47.716	-104.183	Glasgow, MT	94008	48.20	-106.62

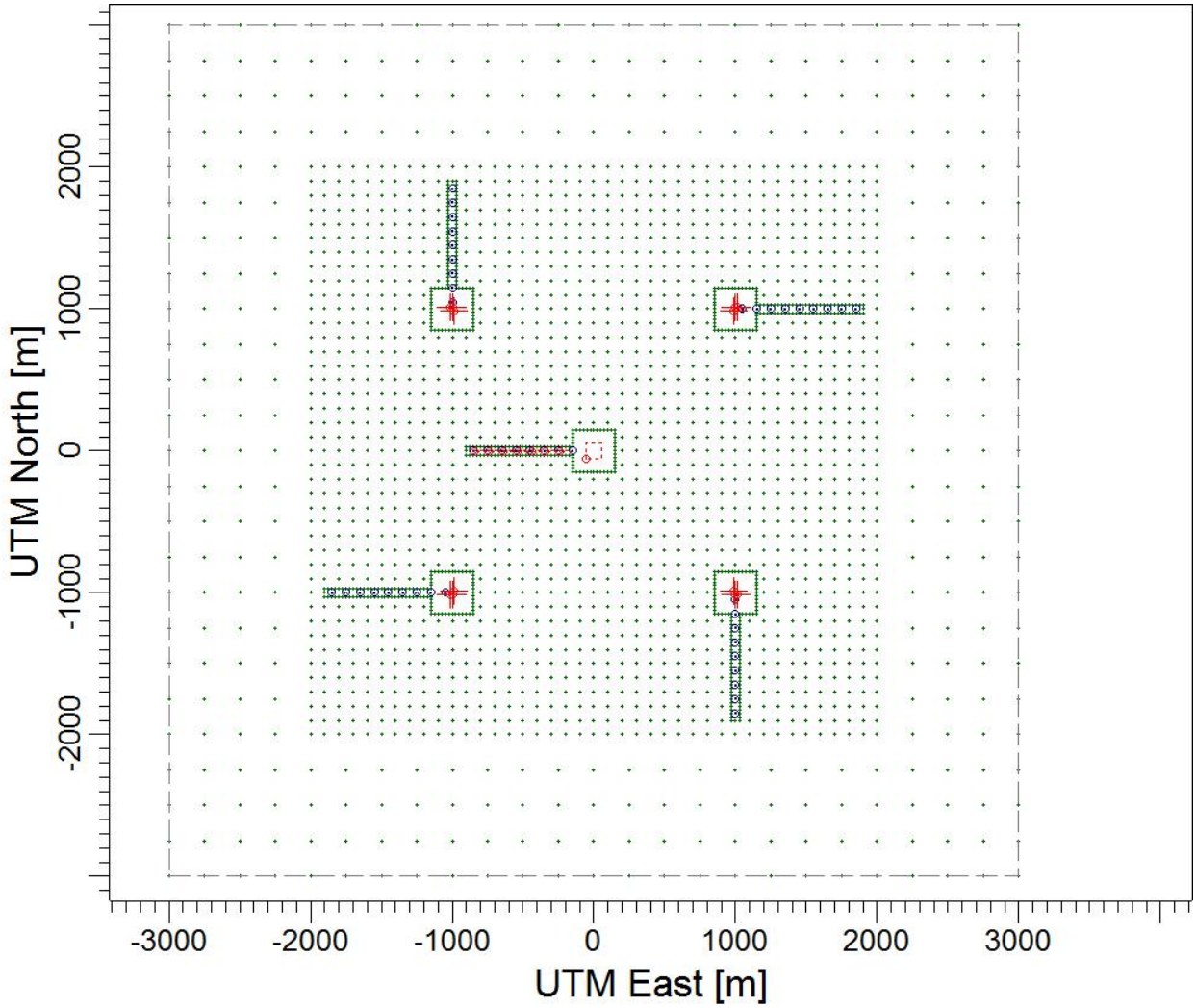
3.3 Modeling Domain and Receptor Locations

The modeling domain included five 3-acre well pads within a 6 × 6 km domain. Receptors were located within a Cartesian grid, with the ambient air boundary beginning 100 meters (m) from the edge of the well pad and 20 m from the edge of access roads. Due to wildlife concerns, fences are typically not installed along the ambient air boundary. Receptor spacing was as follows.

- 25-m intervals along the ambient air boundary
- 100-m intervals from the ambient boundary to 2 km from the center of the domain
- 250-m intervals from 2 km out to 3 km from the center of the domain

All receptors were located on flat terrain. Figure 1 illustrates the well pad and receptor layout for PM_{10} and $PM_{2.5}$ modeling.

Figure 1. Example Well Pad and Receptor Layout for Construction Scenario



3.4 Modeled Scenarios

Modeling scenarios addressed three types of oil and gas activities: construction, drilling, completion and fracing, and production. Short-term and annual modeling runs were completed for each modeled scenario.

Three scenarios were modeled for each of the five years. Each scenario included a center well pad on which construction, drilling, or completion/fracing was assumed to be occurring. Four production well pads surrounded the center pad. This approach represented combined activities within the planning area that can occur simultaneously on well pads in relatively close proximity.

Combined equipment scenarios were modeled to address multiple well types (oil, natural gas, and CBNG). Due to the variety of well types, near-field scenarios combined equipment from more than one type of well. This approach reduced the number of modeling runs and provided reasonable but conservative air quality impact assessments in areas with mixed well types, which reflects the reality of oil and gas development in the planning area. It is not uncommon for an oil well to be located near a natural gas or CBNG well. In order to perform conservative assessments, the highest-emitting equipment type modeled. Examples of this modeling approach are provided below.

- Construction phase — The largest well pad (from all types of wells) was modeled to determine emissions from wind erosion and construction activities.
- Drilling phase — The drill rig with the greatest horsepower, longest drilling time, and greatest emissions was modeled.
- Completion/fracing phase — The completion rig with the greatest horsepower, longest completion period, and greatest emissions was modeled and flaring of the greatest gas flow rate was assumed.
- Production phase — A combination of oil well (e.g., pumpjack engine) and gas well (e.g., glycol dehydrator) equipment was modeled.

3.5 Emission Source Release Parameters

Release parameters for emission sources are provided in Table 15.

Table 15. Release Parameters for Emission Sources

Emission Source	Stack or Release Height (m)	Exhaust Velocity (m/s)	Exhaust Temperature (K)	Stack Diameter (m)
Drill Rig Engines	6.1	25.0	700	0.38
Drill Rig Boilers	3.8	5.0	425	0.20
Completion Flares	16.5	20.0	1,273	0.5
Pumpjack Engines	3.8	10	560	0.20
Heaters	4.6	7.3	425	0.20
Glycol Dehydrator Reboiler	4.6	7.3	425	0.20
Tanks	4.6	2.0	289	0.20
Production Flares	3.8	10.0	1,273	0.38
	Release Height (m)	**Sigma y (m)**	**Sigma z (m)**	
Construction Disturbance at Well Pads	2.0	---	2.37	---
Vehicle Re-entrained Dust	2.55	2.09	2.37	---
Wind Erosion	0.0	---	---	---

K = Kelvin
m = meters
m/s = meters per second

Building downwash was not modeled. Many well sites have no buildings or have small enclosures. Site-specific data were not available for modeling performed for land use planning.

3.6 Background Concentrations and Ambient Air Quality Standards

Background ambient concentrations were used to determine total predicted concentrations by summing model output concentrations with background concentrations and comparing the results to the NAAQS and to the Montana AAQS. The MDEQ provided most background concentrations to be used for modeling (MDEQ 2012a, MDEQ 2012b). CO data were obtained from "Air Quality Statistics Reports" on EPA's AirData website (http://www.epa.gov/airquality/airdata/) and were measured in Billings, which is west of the planning area. Background concentration data are summarized in Table 16 and reflect monitored values that can be compared directly to currently implemented NAAQS and MAAQS.

NAAQS and Montana Ambient Air Quality Standards (MAAQS) are provided in Table 17. Montana standards are shown only if they are more stringent than the NAAQS. Although some NAAQS and MAAQS set forth allowable concentrations in terms of parts per million (ppm) or parts per billion (ppb) within regulatory text, concentrations for these gaseous pollutants have been converted to micrograms per cubic meter (μg/m^3) so that they can be compared directly to AERMOD-calculated concentrations.

Table 16. MCFO Background Concentration Data

Pollutant	Avg. Period	Ranking	Form	Year(s)	Concentration (μg/m^3) [1]	County	AQS Site
CO	1-hour	H2H	Maximum year	2009-2011	7,213	Yellowstone	30-111-0085
	8-hour	H2H	Maximum year	2009-2011	2,175	Yellowstone	30-111-0085
NO_2	1-hour	98th Percentile	3-year average	---	40.0 [2]	---	---
	Annual	H1H	Maximum year	---	6.0 [2]	---	---
$PM_{2.5}$	24-hour	H1H	3-year average	---	22.5 [2]	---	---
	Annual	H1H	3-year average	---	5.5 [2]	---	---
PM_{10}	24-hour	H2H	3-year average	---	30 [2]	---	---
	Annual	H2H [3]	Maximum year	---	8 [2]	---	---
SO_2	1-hour	99th Percentile	3-year average	---	35.0 [2]	---	---
	3-hour	H2H	Maximum year	2010	---	---	---
	24-hour	H2H [3]	Maximum year	---	11.0 [2]	---	---
	Annual	H2H [3]	Maximum year	---	3.0 [2]	---	---

Sources: EPA 2012a, MDEQ 2012a, MDEQ 2012b.
AQS = Air Quality System
CO = carbon monoxide
H1H = highest-first-high
H2H = highest-second-high
μg/m^3 = micrograms per cubic meter
NO_2 = nitrogen dioxide
$PM_{2.5}$ = particulate matter ≤ 2.5 microns
PM_{10} = particulate matter ≤ 10 microns
SO_2 = sulfur dioxide

[1] Gaseous pollutant concentrations were converted to μg/m^3 in order to compare to AERMOD output concentrations.
[2] Background concentration value recommended by MDEQ.
[3] Montana state-only standard.

Table 17. Federal and State Ambient Air Quality Standards for Modeled Pollutants

Pollutant	Averaging Period	Federal NAAQS [1]			PSD Increments		State AAQS [2]
		Concentration $\mu g/m^3$ (ppb)	Standard Type	Form of NAAQS Primary Standard	Increment (Class I / Class II) $\mu g/m^3$	Form of Increment	Concentration $\mu g/m^3$ (ppb)
CO	1-hour	40,000 (35,000)	Primary	H2H (each year)	---	---	26,450 (23,000) [6]
	8-hour	10,000 (9,000)	Primary	H2H (each year)	---	---	---
NO_2	1-hour	188 (100)	Primary	5-year average of the 98th percentile concentrations	---	---	---
	Annual	100 (53)	Primary, Secondary	Max. annual average (each year)	2.5 / 25	H1H	90 (50) [7]
$PM_{2.5}$	24-hour	35	Primary, Secondary [3]	5-year average of the 98th percentile concentrations	2 / 9	H2H	---
	Annual	15.0 [3]	Primary, Secondary	Max. annual average (each year)	1 / 4	H1H	---
PM_{10}	24-hour	150	Primary, Secondary	NTBE more than once per year on average over 5 years	8 / 30	H2H	---
	Annual	Revoked [4]	---	---	4 / 17	H1H	50 [6]
SO_2	1-hour	196 (75)	Primary	5-year average of the 99th percentile concentrations	---	---	---
	3-hour	1,300 (500)	---	H2H (each year)	25 / 512	H2H	---
	24-hour	365 (140) [5]	Primary	H2H (each year)	5 / 91	H2H	262
	Annual	8 (30) [5]	Primary	Max. annual average (each year)	2 / 20	H1H	52 [7]

AAQS = Ambient Air Quality Standards
CO = carbon monoxide
H1H = highest-first-high
H2H = highest-second-high
$\mu g/m^3$ = micrograms per cubic meter
NAAQS = National Ambient Air Quality Standards
NO_2 = nitrogen dioxide
$PM_{2.5}$ = particulate matter ≤ 2.5 microns
PM_{10} = particulate matter ≤10 microns
ppb = parts per billion
PSD = Prevention of Significant Deterioration
SO_2 = sulfur dioxide

1 NAAQS are codified in Title 40 of the Code of Federal Regulations (CF), Part 50.
2 Montana AAQS are codified in Title 17, Chapter 8, Subchapter 2 of the Ambient Air Quality in the Administrative Rules of Montana and are shown in this column.
3 In a January 15, 2013 final rule (GPO 2013a), the EPA lowered the annual primary $PM_{2.5}$ standard from 15.0 $\mu g/m^3$ to 12 $\mu g/m^3$. The revised standard becomes effective on March 18, 2013 and also includes a new secondary 24-hour $PM_{2.5}$ visibility standard of 30 deciviews (equivalent to 19 kilometers standard visual range) based on the 90th percentile averaged over 3 years.
4 The annual PM_{10} NAAQS was revoked on October 17, 2006 but the annual PM_{10} PSD increments remain in effect.
5 The existing annual and 24-hour SO_2 NAAQS will be revoked one year after the effective date in areas with a designated status for the revised SO^2 NAAQS, per 40 CFR §50.4(e).
6 Based on H1H.
7 Not to be exceeded in the averaging period specified.

4.0 NEAR-FIELD MODELING RESULTS

Near-field modeling included criteria air pollutant modeling and HAP modeling. Predicted criteria air pollutant concentrations were compared to the NAAQS, MAAQS, and Prevention of Significant Deterioration (PSD) increments, while predicted HAP concentrations were compared to health-based and risk-based standards.

4.1 Criteria Air Pollutants

Three well pad development scenarios (construction, drilling, and completion) were modeled at a central well pad. Well development activities would be temporary and occur at different times. Well pad construction would occur first over a period of up to 3 days of active site construction involving soil movement (e.g., digging and grading). Drilling would occur next, with up to 15 days of active drilling. Then well completion and fracing would occur for up to 5 days. Once well development is complete, a long-term production phase typically begins. The construction modeling scenario has the greatest short-term (24-hour) emission rates for particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$). Temporary drilling activities accounted for the greatest short-term (1-hour) emission rates for all non-particulate criteria air pollutants. Completion and fracing activities have greater non-particulate emissions than the construction phase. In order to represent production activities at nearby wells, estimated oil and gas production emissions were modeled at four producing wells surrounding the central pad. Production emissions at outlying pads were modeled concurrently with each of the three well development scenarios (construction, drilling, and completion).

Modeled concentrations were compared to NAAQS, MAAQS, and PSD increments. Comparisons to the NAAQS and MAAQS were performed by summing modeled concentrations with background concentrations (representing current air quality) and comparing the total concentrations to the standards. The results of the near-field modeling performed for Alternative A are shown in Table 18. Alternative A near-field modeling represents dense well pad and equipment spacing that could occur in localized areas within high potential oil and gas activity areas. Because this dense spacing could also occur under Alternatives B, C, D, and E, the Alternative A modeling results conservatively predict impacts that could occur in localized areas under each of the alternatives.

Table 18 summarizes modeled results by showing the largest modeled and total concentrations based on the three scenarios and 5 years (2005 through 2009). Additional modeling results are included in the Table G-1 of Appendix G, allowing comparisons by year and by modeled scenario. For example, the maximum total 1-hour CO concentration of 7,534 micrograms per cubic meter ($\mu g/m^3$) was predicted during the drilling scenario using 2009 meteorology. Predicted concentrations were below the NAAQS and MAAQS, as shown by the percentages in the last column of Table 18. Total concentrations of 50 percent of a NAAQS or greater were predicted for the 1-hour nitrogen dioxide (NO_2), 24-hour particulate matter (PM_{10}), and 24-hour fine particulate matter ($PM_{2.5}$) standards. The maximum 1-hour NO_2 impacts were due to heavy-duty construction equipment exhaust during the brief well construction period. Maximum 24-hour PM_{10} and $PM_{2.5}$ impacts occurred during short-term construction-related activities. Predicted ambient concentrations associated with production activities were much less than emissions associated with temporary activities.

Table 18. Near-Field NAAQS Summary for All Alternatives

Pollu-tant.	Avg. Period	Model Output Rank	Concentration (µg/m^3)						Percen-tage of NAAQS (%)
			Modeled Conc.	PSD Increment Class I	PSD Increment Class II	Bckgrnd Conc.[1]	Total Conc.	NAAQS or MAAQS	
CO	1-hour	H2H	321	None	None	7,213	7,534	26,450[6]	28
	8-hour	H2H	231	None	None	2,175	2,406	10,000	24
NO_2	1-hour	H8H [2]	89.7	None	None	40	129.7	188	69
	Annual	H1H [3]	2.8E-02	2.5	25	6	6.28	94[6]	7
PM_{10}	24-hour	H2H	108.0	8	30	30	138.0	150	92
	Annual	H1H	0.6	4	17	8	8.6	50[6]	17
$PM_{2.5}$	24-hour	H8H [4] (H2H)[7]	9.2	2	9	22.5	31.7	35	91
	Annual	H1H	0.86	1	4	5.5	6.36	15	42
SO_2	1-hour	H4H [5]	3.3	None	None	35	38.3	196	20
	24-hour	H2H [3]	0.58	5	91	11	11.58	365[6]	4
	Annual	H1H [2]	1.12E-03	2	20	3	3.00	80[6]	6

H1H = highest-first-high
H2H = highest-second-high
H4H = highest-fourth-high
H8H = highest-eighth-high

1 Background concentrations were provided by the MDEQ (MDEQ 2012a; MDEQ 2012b).
2 5-year average of the 98th percentile (H8H) 1-hour modeled NO_2 concentrations. Post processed using the 1-hour and annual NO_2 Tier 2 method using 80 percent conversion of modeled NO_x to NO_2.
3 Post processed using the annual NO_2 Tier 2 method using 75 percent conversion of modeled NO_x to NO_2.
4 5-year average of the 98th percentile (H8H) 24-hour modeled $PM_{2.5}$ concentrations.
5 5-year average of the 99th percentile (H4H) 1-hour modeled SO_2 concentrations.
6 This is a Montana standard.
7 The H2H rank provided in parentheses was used to compare to the PSD increments, while the H8H rank was compared to the NAAQS.

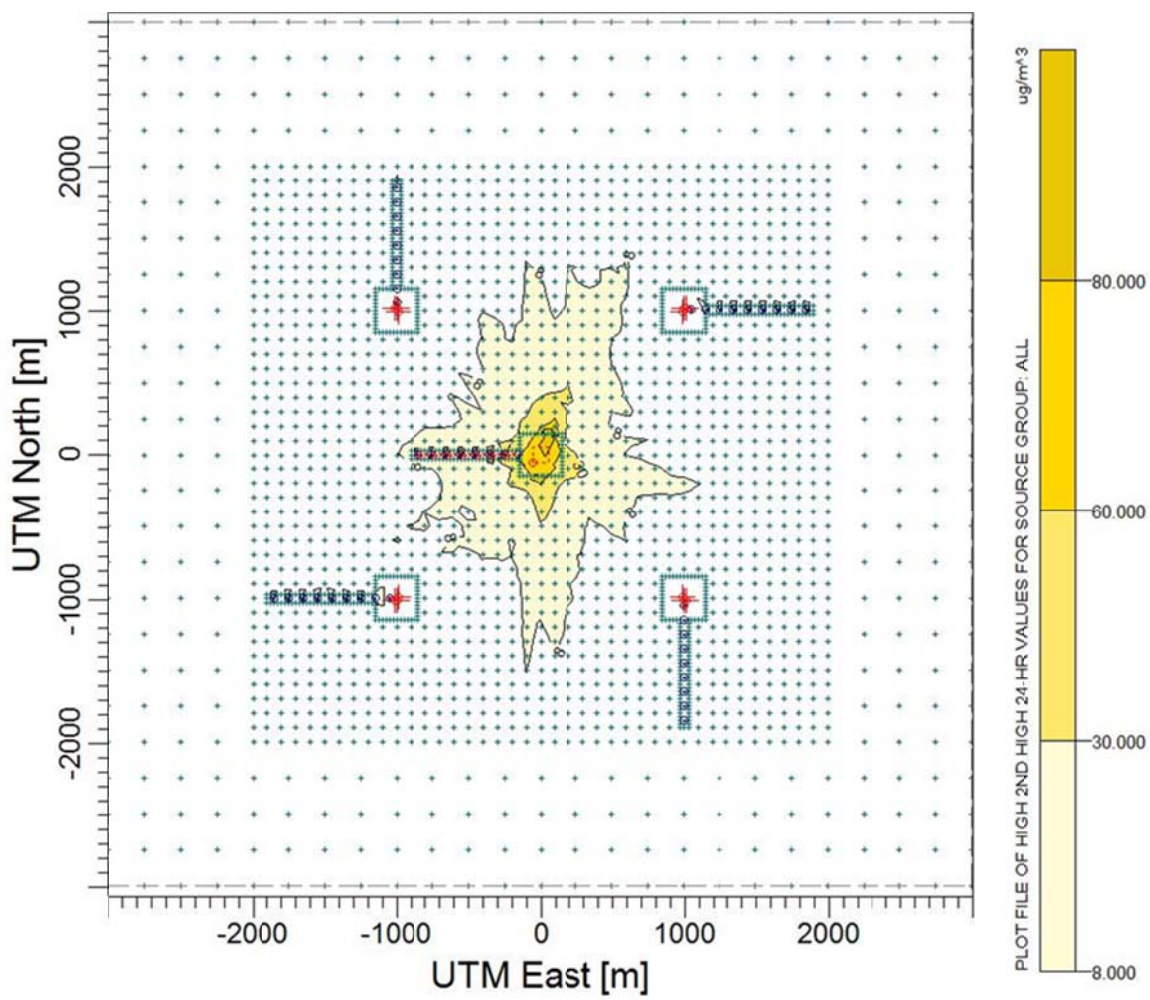
Modeled concentrations can also be compared to PSD increments, which were designed to prevent good air quality from deteriorating to the level set by the NAAQS. In areas attaining the NAAQS, PSD increment analysis is required prior to construction of a major stationary source of air pollutants that have the potential to emit at least 100 tons per year (tpy) or 250 tpy of a criteria air pollutant. The MDEQ Air Resources Management Bureau implements the PSD permitting program for facilities in the planning area. As part of this program, the MDEQ requires large sources to model facility emissions using site-specific parameters and demonstrate compliance with the NAAQS and PSD increments. The MDEQ also assesses PSD increment consumption for aggregated small sources in order to ensure compliance with the Clean Air Act. In contrast, the sources included in this near-field modeling analysis do not meet the definition of a major source of criteria air pollutants and would not be required to undergo PSD analysis. The following PSD analysis is not a regulatory analysis; its purpose is to provide context for evaluating potential air quality impacts and disclose predicted impacts to the public.

The EPA established PSD increments for Class I areas (e.g., national parks and large wilderness areas) and Class II areas (all non-Class I areas). Oil and gas activities are expected to occur within Class II areas and the modeled (not total) concentration can be compared directly to the Class II increment. Temporary 24-hr PM_{10} and $PM_{2.5}$ concentrations greater than the Class II PSD increments were predicted to occur during construction and completion activities. Temporary concentrations above the Class I

increments for PM_{10} and $PM_{2.5}$ are also possible during construction, drilling, and completion if these activities were located very close to a Class I area.

Air pollutant concentrations generally decrease as distance from the source increases. Figure 2 provides an illustration of 24-hr PM_{10} modeled concentrations (not total concentrations) during construction activity. At the center of the figure is a well pad with short-term construction activities. The four surrounding well pads were modeled with emissions representing production activity. Red markers indicate emission sources and green markers indicate receptors (points at which concentrations were calculated). Shaded areas indicate the extent of the area for which PM_{10} concentration increases were predicted to be greater than the PSD Class I increment (8 µg/m^3) or Class II increment (30 µg/m^3) on the day with the second-highest PM_{10} modeled concentration during 2005. Wells would be located in Class II areas and concentrations above the Class II PSD increment were predicted to extend up to approximately 300 meters from the well pad boundary. In order for concentrations to exceed the Class I increment, well pad construction activity would need to be within approximately 1,500 meters of a Class I area. Concentrations of these magnitudes could occur only on days when well pad construction activity is concurrent with meteorological conditions causing high ambient PM_{10} concentrations.

Figure 2. Extent of PM10 Concentrations Above PSD Increments During Well Pad Construction



Modeled concentrations (without background concentrations) were compared to Class I and Class II PSD increments for disclosure purposes only. The PSD increment analysis does not represent a regulatory

PSD increment consumption analysis. Comparisons to PSD Class I and Class II increments are provided for disclosure purposes only.

Modeled NO_2 impacts were estimated using the Tier 2 Ambient Ratio Method (ARM), as recommended by the *Guideline on Air Quality Models* (GAQM, published in 40 Code of Federal Regulations (CFR) Part 51, Appendix W [GPO 2012]). The ARM accounts for atmospheric conversion of nitric oxide to NO_2 by assuming that a fraction of emitted NO_x is converted to NO_2. The GAQM recommends that predicted annual nitrogen oxides (NO_x) impacts be multiplied by a NO_2-to-NO_x ratio of 0.75, which is a nationally set annual default ratio (EPA 2010a). In other words, 75 percent of modeled annual NO_x will be assumed to convert to NO_2 in the atmosphere. For the 1-hour NO_2 analysis, 80 percent conversion will be assumed (EPA 2011b).

4.2 Hazardous Air Pollutants

Near-field modeling was also conducted to determine predicted ambient air quality impacts of HAP emissions. HAPs are defined by the USEPA as toxic air pollutants known or suspected to cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental effects. Similar to the NAAQS modeling, HAP modeling consisted of construction, drilling, and completion of wells.

Health-based impacts from emissions of six HAPs (known as “air toxics”) were assessed. The EPA has not established ambient air quality standards for HAPs; therefore, HAP impacts were compared to EPA Reference Exposure Levels (RELs) and Reference Concentrations (RfCs) for non-carcinogens and to Unit Risk Factors (URFs) for carcinogens. Short-term (1-hour) concentrations were compared to acute RELs shown in Table 19. Acute RELs are defined as concentrations at or below which no adverse health effects are expected. Because no RELs are available for ethylbenzene or n-hexane, Immediately Dangerous to Life or Health (IDLH) values were used. These IDLH values were developed by the National Institute for Occupational Safety and Health and were obtained from EPA's Air Toxics Database (EPA 2011a).

Table 19 summarizes the results of the acute HAP modeling and compares predicted concentrations to RELs and IDLH values. The maximum acute impacts for benzene, formaldehyde, n-hexane, toluene, and xylene were associated with drilling operations, as shown in Table G-2. Maximum impacts for ethyl benzene were associated with well completion and fracing operations. Acute HAP modeling impacts were well below the RELs and IDLH values.

Table 19. Acute Short-term HAP Concentrations for All Alternatives

HAP	Modeled 1-Hour Concentration ($\mu g/m^3$)	Reference Exposure Levels ($\mu g/m^3$)	Percentage of Reference Exposure Level (%)
Benzene	1.37	1,300	0.11
Ethyl Benzene	2.91	350,000 [1]	<0.1 [1]
Formaldehyde	7.49	55	14
n-Hexane	9.98	390,000 [1]	<0.1 [1]
Toluene	1.05	37,000	<0.1
Xylene	0.72	22,000	<0.1

[1] IDLH values were used in lieu of RELs.

Table 20 summarizes the results of HAP modeling of potential chronic effects for each of the six HAPs and compares them to RfCs. Detailed results by year and modeled scenario are provided in Table G-2.

Table 20. Chronic Non-carcinogenic HAP Modeling Results for All Alternatives

HAP	Modeled Annual Concentration ($\mu g/m^3$)	Reference Concentration (RfC) ($\mu g/m^3$)	Percentage of RfC (%)
Benzene	0.02	3	< 0.2%
Ethyl Benzene	0.06	1,000	
Formaldehyde	0.02	9.80	
n-Hexane	0.36	700	
Toluene	0.03	5,000	
Xylene	0.01	100	

Of the HAPs evaluated, only benzene, ethyl benzene, and formaldehyde are identified by the USEPA as known or suspected carcinogens. Cancer risks for benzene, ethylbenzene, and formaldehyde are expressed as unit risk factors (URFs), which provide an upper bound excess probability of contracting cancer expressed per unit concentration ($\mu g/m^3$). Incremental inhalation cancer risk for these air toxics were evaluated using accepted methods. Annual modeled concentrations were multiplied by the EPA's URFs (based on 70-year exposure) for those pollutants, and then the product was multiplied by an adjustment factor that represents the ratio of projected exposure time of 50 years. The adjustment factors represented two scenarios: a most likely exposure (MLE) scenario and one reflective of the maximally exposed individual (MEI).

The MLE duration was assumed to be 9 years, which corresponds to the mean duration that a family remains at a residence (EPA 1993a). This duration corresponds to an adjustment factor of 9/70 = 0.13. A second adjustment was made for time spent at home versus time spent elsewhere. For the MLE scenario, the at-home time fraction is 0.64, while the rest of the day (0.36 of the day) the individual is assumed to remain in an area where annual air toxic concentrations would be one-quarter as large as the maximum annual average concentration. Therefore, the MLE adjustment factor was calculated as (0.13) x [(0.64 x 1.0) + (0.36 x 0.25)] = 0.0949.

The duration of exposure for the MEI was assumed to be 50 years (i.e., an assumed typical life of a project), corresponding to an adjustment factor of 50/70 = 0.71. The MEI scenario assumed that an individual would be at home 100 percent of the time, for a final adjustment factor of (0.71 x 1.0) = 0.71. The potential increase in cancer risk was then estimated by multiplying the annual modeled HAP concentrations by the URF and the appropriate exposure adjustment factor (MLE or MEI). Predicted cancer risk is expressed in terms of the incremental increase in cancer risk per million individuals. Incremental cancer risks were well below a 1 per million risk for benzene, ethyl benzene, and formaldehyde. Summarized results are shown in Table 21, with detailed results provided in Table G-3.

Table 21. Carcinogenic HAP Modeling Results for All Alternatives

HAP	Modeled Annual Concentration ($\mu g/m^3$)	Unit Risk Factor $(\mu g/m^3)^{-1}$	Adjustment Factor	Cancer Risk (Per Million)	Risk Exceeds 1 Per Million?
Most Likely Exposure					
Benzene	0.025	7.80×10^{-6}	0.0949	0.02	No
Ethyl Benzene	0.064	2.50×10^{-6}	0.0949	0.02	No
Formaldehyde	0.018	1.30×10^{-5}	0.0949	0.02	No
Maximally Exposed Individual					
Benzene	0.025	7.80×10^{-6}	0.71	0.14	No
Ethyl Benzene	0.064	2.50×10^{-6}	0.71	0.11	No
Formaldehyde	0.018	1.30×10^{-5}	0.71	0.17	No

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Appendix A

Alternative A Emission Inventory

Summary of Emissions A-1

Oil Development and Production A-2

Natural Gas Development and Production A-29

Coal Bed Methane Natural Gas Development and Production A-54

Coal Mining A-77

Vegetation Management A-79

Fire Management A-84

Forestry and Woodland Products A-89

Livestock Grazing A-94

Recreation, Trails, and Travel Management A-100

General Purpose BLM Fleet Travel A-103

Road Maintenance A-106

Alternative A Summary

MCFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)											Emissions (mtpy)
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq}
Federal / BLM												
Oil and Gas												
Oil	734.5	321.3	2,563.1	0.6	74.1	20.7	161.9	69,636.6	413.8	0.4	78,464.2	71,169
Natural Gas	288.8	119.4	82.5	0.3	18.6	6.7	8.3	28,676.3	384.0	0.2	36,657.4	33,249
CBNG	126.3	63.8	43.7	0.1	13.6	4.2	8.3	10,282.1	197.2	0.0	14,433.3	13,091
Coal Mining [1]	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	14.4	104,029.1	0.6	1.0	104,364.7	94,662
Vegetation Management	11.3	0.1	3.1	0.0	10.7	1.4	0.3	33.9	0.0	0.0	34.8	32
Fire Management [2]	1,741.9	58.3	97.3	13.6	210.7	151.1	9.7	289,046.1	121.5	23.7	298,943.9	271,151
Forestry and Woodland Products	0.9	1.3	0.1	0.0	3.6	0.4	0.0	178.2	0.0	0.0	179.3	163
Livestock Grazing	11.3	9.3	4.2	0.2	136.9	14.3	0.4	1,382.3	2,665.6	0.1	57,377.4	52,043
Recreation - Trails and Travel Management	26.6	0.1	27.1	0.0	292.6	30.1	2.7	78.0	0.2	0.0	83.4	76
General Purpose BLM Fleet Travel	4.4	1.6	1.9	0.0	74.7	7.5	0.2	285.3	0.0	0.0	296.8	269
Road Maintenance	0.5	1.2	0.1	0.0	1.4	0.2	0.0	146.7	0.0	0.0	147.2	134
Federal Emission Total	**5,067.4**	**2,394.0**	**2,967.4**	**194.6**	**5,285.3**	**681.5**	**206.3**	**503,774.4**	**3,782.9**	**25.5**	**590,982.4**	**536,038**
Non-Federal												-
Oil and Gas	3,583.0	2,936.2	8,964.5	46.0	416.3	163.2	597.1	359,269.4	3,292.7	1.4	428,386.3	388,559
Coal Mining [1]	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	15.7	143,391.0	0.9	1.4	143,853.6	130,479
Non-Federal Emission Total	**6,607.8**	**5,320.0**	**9,121.1**	**246.7**	**4,837.9**	**644.4**	**612.8**	**502,660.4**	**3,293.5**	**2.9**	**572,239.9**	**519,038**

tpy = short tons per year

mtpy = metric tons per year

1. In available air quality permits for coal mines located in the MCFO, total suspended particulate (TSP) is usually reported and PM10 and/or PM2.5 may be reported. In permits containing only TSP emissions, all TSP was assumed to be PM10. If PM10 was reported and PM2.5 was not reported, all PM10 was assumed to be PM2.5. These assumptions overestimate PM10 and PM2.5 emissions. With regard to greenhouse gases, coal mine emissions do not include ventilation emissions or emissions associated with electricity provided to the mine.

2. Excludes smoke emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	33,634	38,897	5,713	17,023	24,469	3,772
Alt. A O&G (%) of NEI Emissions	3.4%	1.3%	47.1%	0.01%	0.4%	0.8%
Alt. A (%) of NEI Emissions	15.1%	6.2%	51.9%	1.1%	21.6%	18.1%

County Emissions (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties).

Source: EPA 2008 National Emission Inventory (NEI), http://neibrowser.epa.gov/eis-public-web/geo/county-emissions.html?stateJurisdictionId=28&inventoryYear=2008, accessed December 12, 2011.

Alternative A input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	41	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	136
Federal Producing Wells - RMP Year 20	637	Non-Federal Producing Wells - RMP Year 20	2,109
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 100% full RFD estimates for Federal, full RFD estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.58	0.16	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.30	1.31	21.26	0.25	112.30	5.99	0.60	22422.25	0.23	0.26	22506.44	20423.27
Commuting Vehicles - Construction	18.55	1.89	0.52	0.00	0.62	0.22	0.02	136.81	0.01	0.01	139.86	126.91
Wind Erosion	0.47	0.07	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**21.89**	**3.43**	**21.79**	**0.25**	**112.93**	**6.21**	**0.62**	**22,559.06**	**0.24**	**0.27**	**22,646.30**	**20,550.18**
Well Workover Operations - Fugitive Dust	2.76	0.28	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.19	0.19	3.79	0.06	32.86	1.77	0.18	6693.25	0.09	0.08	6718.92	6097.02
Well Workover Operations - On-road Exhaust	0.01	0.01	0.09	0.00	0.16	0.06	0.006	19.75	0.00	0.00	20.30	18.42
Well Visits for Inspection & Repair - Operations	3.08	0.31	0.09	0.00	2.02	0.09	0.009	40.18	0.01	0.02	44.96	40.80
Recompletion Traffic	4.74	0.48	0.17	0.00	0.27	0.10	0.01	40.07	0.00	0.00	41.10	37.30
Water Tanks & Traffic	12.60	1.33	1.07	0.01	0.68	0.14	0.01	312.20	72.81	0.00	1841.99	1671.50
Oil Tanks & Traffic	10.22	1.07	0.70	0.00	0.44	2,252.40	129.80	319.28	256.72	0.00	5710.89	5182.29
Venting	---	---	---	---	---	28.37	2.31	0.92	35.53	0.00	747.07	677.93
Compression and Well Pumps	12.95	12.95	292.17	0.20	584.34	204.52	20.45	39,424.08	0.74	0.07	39462.75	35810.12
Dehydrators	0.00	0.00	0.04	0.00	0.03	66.98	8.30	43.26	44.84	0.00	985.21	894.02
Compression Station Fugitives	---	---	---	---	---	2.24	0.22	0.07	2.80	0.00	58.96	53.50
Sub-total: Operations	**46.55**	**16.62**	**298.11**	**0.27**	**620.79**	**2,556.66**	**161.30**	**46,893.06**	**413.55**	**0.18**	**55,632.14**	**50,482.89**
Road Maintenance	5.55	0.61	1.41	0.037	0.72	0.22	0.022	179.77	0.00	0.00	181.07	164.31
Sub-total: Maintenance	**5.55**	**0.61**	**1.41**	**0.037**	**0.72**	**0.22**	**0.022**	**179.769**	**0.002**	**0.00**	**181.07**	**164.31**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.16	0.14
Well Reclamation	0.15	0.02	0.02	0.00	0.02	0.00	0.00	4.53	0.00	0.00	4.55	4.13
Sub-total: Reclamation	**0.16**	**0.02**	**0.02**	**0.0008**	**0.02**	**0.005**	**0.0005**	**4.6835**	**0.0001**	**0.0001**	**4.7108**	**4.2748**
Total Emissions	**74.15**	**20.68**	**321.33**	**0.56**	**734.46**	**2,563.10**	**161.95**	**69,636.57**	**413.79**	**0.45**	**78,464.22**	**71,201.65**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	5.24	0.52	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	36.18	35.16	691.10	14.35	177.48	50.50	5.05	74376.25	0.77	0.26	74471.70	67578.68
Commuting Vehicles - Construction	61.54	6.26	1.74	0.01	2.06	0.72	0.07	453.79	0.02	0.01	457.11	414.80
Wind Erosion	1.55	0.23	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**104.50**	**42.18**	**692.84**	**14.36**	**179.54**	**51.22**	**5.12**	**74,830.04**	**0.79**	**0.27**	**74,928.81**	**67,993.47**
Well Workover Operations - Fugitive Dust	9.12	0.91	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	15.92	15.44	280.07	4.77	94.09	20.27	2.03	22160.21	0.31	0.25	22245.21	20186.21
Well Workover Operations - On-road Exhaust	0.02	0.02	0.29	0.00	0.52	0.21	0.021	65.37	0.00	0.01	67.20	60.98
Well Visits for Inspection & Repair - Operations	10.21	1.02	0.31	0.00	6.69	0.30	0.030	133.04	0.02	0.05	148.87	135.09
Recompletion Traffic	15.70	1.60	0.56	0.00	0.88	0.34	0.03	132.65	0.00	0.01	136.08	123.48
Water Tanks & Traffic	41.71	4.41	3.55	0.02	2.25	0.46	0.05	1,033.64	241.07	0.01	6098.52	5534.04
Oil Tanks & Traffic	33.83	3.54	2.30	0.01	1.46	7,457.30	429.76	1,057.07	849.96	0.01	18907.79	17157.71
Venting	---	---	---	---	---	94.03	7.64	3.06	117.76	0.00	2476.06	2246.88
Compression and Well Pumps	42.88	42.88	967.32	0.66	1,934.64	677.13	67.71	130,526.52	2.46	0.25	130654.54	118561.29
Dehydrators	0.01	0.01	0.12	0.00	0.10	221.75	27.48	143.24	148.47	0.00	3261.85	2959.94
Compression Station Fugitives	---	---	---	---	---	7.41	0.74	0.24	9.28	0.00	195.19	177.12
Sub-total: Operations	**169.41**	**69.83**	**1,254.52**	**5.46**	**2,040.62**	**8,479.20**	**535.49**	**155,255.04**	**1,369.33**	**0.58**	**184,191.30**	**167,142.74**
Road Maintenance	18.37	2.02	4.68	0.121	2.39	0.73	0.073	595.18	0.01	0.01	599.48	543.99
Sub-total: Maintenance	**18.37**	**2.02**	**4.68**	**0.121**	**2.39**	**0.73**	**0.073**	**595.185**	**0.006**	**0.01**	**599.48**	**543.99**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.47
Well Reclamation	0.50	0.06	0.06	0.00	0.07	0.01	0.00	14.99	0.00	0.00	15.08	13.68
Sub-total: Reclamation	**0.52**	**0.06**	**0.06**	**0.0027**	**0.07**	**0.015**	**0.0015**	**15.5062**	**0.0002**	**0.0003**	**15.5966**	**14.1530**
Total Emissions	**292.80**	**114.10**	**1,952.10**	**19.94**	**2,222.62**	**8,531.17**	**540.69**	**230,695.77**	**1,370.13**	**0.86**	**259,735.18**	**235,694.36**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

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)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**7.70E+01**	**7.70E+00**	**3.85E-02**	**3.85E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.030	0.0051	2.60	0.14	0.03	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	53	9	4,622	249	0.44	0.03	0.00	2.31	0.12	0.03	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	1	330	18	0.02	0.00	0.00	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	11	1	0	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	0	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	**4.91E-01**	**2.87E-02**	**5.23E-03**	**2.72E+00**	**1.43E-01**	**2.87E-02**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.19E-01**	**3.16E-02**	**5.99E-03**	**2.74E+00**	**1.46E-01**	**3.20E-02**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
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, Fracing, & 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 (%)[b]**	**# 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	**5.05E+00**	**2.63E-01**	**1.05E-01**	**1.29E+00**	**3.69E-01**	**2.55E-01**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.08E+00**	**2.66E-01**	**1.05E-01**	**1.30E+00**	**3.71E-01**	**2.59E-01**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	0.27	129.02	0.06	0.07	0.03	12.90	0.01	0.01
	Pickup Trucks	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.27	13.73	0.01	0.01	0.03	1.37	0.00	0.00
	Pickup Trucks	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.27	5.49	0.00	0.01	0.03	0.55	0.00	0.00
	Haul Trucks	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Pickup Trucks	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.27	120.78	0.06	0.14	0.03	12.08	0.01	0.01
	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Tool Pusher	25	10	8	80	1	0.22	17.39	0.01		0.02	1.74	0.00	
	Mud Logger	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Engineer	25	10	15	150	1	0.22	32.60	0.02		0.02	3.26	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.27	16.47	0.01	0.02	0.03	1.65	0.00	0.00
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
									Subtotal	**2.47E-01**				**2.47E-02**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00	0.20	0.02	0.65	0.00	0.02
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Welders	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Haul Water Truck	25	10	150	1500	1	0.22	326.03	0.16		0.02	32.60	0.02	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**2.05E-01**				**2.05E-02**
									Total	**4.51E-01**				**4.51E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	10	47	470	1	2.8142	0.2851	0.2380	0.0137	1.7832	0.3668	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.001	0.000	0.000	0.000	0.001	0.000	0.4	0.0000	0.0000
	Pickup Trucks	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	4	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Haul Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	1	10	1	0.0510	0.0024	0.0020	0.0001	0.1377	0.0606	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																		Subtotal	**1.88E-03**	**1.79E-04**	**1.50E-04**	**8.64E-06**	**1.61E-03**	**4.61E-04**	**5.25E-01**	**2.30E-05**	**3.20E-05**

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	10	44	440	1	2.6346	0.2669	0.2228	0.0128	1.6694	0.3434	0.0013	0.0001	0.0001	0.0000	0.0008	0.0002	0.00	0.00	0.00	0.00	0.01	0.00	0.4	0.0000	0.0000
	Fuel Haul Truck	HDDV	10	6	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	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Tool Pusher	LDDT	10	8	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							0.0	0.0000	0.0000
	Mud Logger	LDDT	10	6	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							0.0	0.0000	0.0000
	Mud Engineer	LDDT	10	15	150	1	0.7646	0.0359	0.0293	0.0019	2.0658	0.9084	0.0004	0.0000	0.0000	0.0000	0.0010	0.0005							0.1	0.0000	0.0000
	Logger, Engr Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000

Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	10	6	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	0.0000	0.0000
	Haul Water Truck	HDDV	10	150	1500	1	8.9815	0.9101	0.7596	0.0437	5.6911	1.1706	0.0045	0.0005	0.0004	0.0000	0.0028	0.0006							1.3	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**1.09E-02**	**9.31E-04**	**7.74E-04**	**4.52E-05**	**1.36E-02**	**4.82E-03**	**2.81E+00**	**1.08E-04**	**1.99E-04**
																	Total		**1.28E-02**	**1.11E-03**	**9.23E-04**	**5.38E-05**	**1.52E-02**	**5.28E-03**	**3.34E+00**	**1.31E-04**	**2.31E-04**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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_2O[a]
Diesel	0.30	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	k (s/12)[a] (W/3)[a]	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 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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	10	12	120	1	0.08	9.68	**4.84E-03**	0.01	0.96	**4.82E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	10	12	120	1	0.30	0.01	0.00	0.00	6.34	0.28	**1.49E-04**	**3.35E-06**	**1.55E-06**	**1.16E-06**	**3.17E-03**	**1.42E-04**	**6.31E-02**	**8.99E-06**	**2.36E-05**

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for 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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	1.0	60	0.08	4.84	**2.42E-03**	0.01	0.48	**2.41E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

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 (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	1.0	60	**1.53E-04**	**7.19E-06**	**5.85E-06**	**3.70E-07**	**4.13E-04**	**1.82E-04**	**2.71E-02**	**1.32E-07**	**3.51E-06**

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	10	56	562	1	0.07	39.21	**1.96E-02**	0.01	3.90	**1.95E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	10	56	562	1	3.362	0.341	0.284	0.016	2.131	0.438	**1.68E-03**	**1.70E-04**	**1.42E-04**	**8.17E-06**	**1.07E-03**	**2.19E-04**	**4.90E-01**	**2.29E-05**	**3.75E-06**

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other 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/10^3 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[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] 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)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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														
							(lb/well)						(tpy/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_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	10	37	365	1	2.185	0.221	0.185	0.011	1.385	0.285	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.319	0.000	0.000
						TOTAL							**1.09E-03**	**1.11E-04**	**9.24E-05**	**5.31E-06**	**6.92E-04**	**1.42E-04**	**3.19E-01**	**1.49E-05**	**2.44E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a]	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-HA	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**

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

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)[a] (W/3)[b]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01	0.15	0.02	1.30	0.00	0.01
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Water Truck	25	10	50	500	1	0.22	108.68	0.05		0.02	10.87	0.01	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**1.49E-01**				**1.49E-02**
									Total	**1.49E-01**				**1.49E-02**

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_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Well Recompletion	Fuel Haul Truck	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	10	50	500	1	2.9938	0.3034	0.2532	0.0146	1.8970	0.3902	0.0015	0.0002	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**
																	Total		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	20	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.054	MMSCF/well

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		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]	N_2O[c]
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

[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 and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

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	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O 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_2 emissions per well (lb/hr)	CH_4 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
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
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	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	1.63E-03	2.44E-04
								TOTAL	**1.14E-02**	**1.71E-03**

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	0.250
Number of Roads Reclaimed Annually Per Well	0.017
Annual Miles of Roads reclaimed Per Well	0.004
Number of wells reclaimed (per well)	0.017

Reclaimation 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
0.004	6	0.0007	0.0070
		Total	**0.0070**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.004	5	0.021	0.765	**8.01E-06**	0.069	**7.26E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Road Reclamation	Grader	80	0.004	0.4238	0.0720	0.0197	0.4106	0.0629	**8.87E-07**	**1.51E-07**	**4.12E-08**	**8.60E-07**	**1.32E-07**	**1.46E-07**	**2.27E-04**	**2.04E-09**	**2.24E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0007	0.0419	0.081	**1.69E-06**	0.008	**1.68E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0007	0.0419	**1.07E-07**	**5.02E-09**	**4.09E-09**	**2.59E-10**	**2.88E-07**	**1.27E-07**	**1.89E-05**	**9.23E-11**	**2.45E-09**

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	0.017	10	0.017	0.17

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.1005	5	0.503	0.765	**1.92E-04**	0.069	**1.74E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.1005	0.5297	0.0900	0.0246	0.5132	0.0786	**2.66E-05**	**4.52E-06**	**1.24E-06**	**2.58E-05**	**3.95E-06**	**7.02E-06**	**6.65E-03**	**1.11E-07**	**6.71E-08**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.0168	1.0051	0.081	**4.05E-05**	0.008	**4.03E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.0168	1.0051	**2.56E-06**	**1.20E-07**	**9.81E-08**	**6.20E-09**	**6.92E-06**	**3.04E-06**	**4.54E-04**	**2.22E-09**	**5.87E-08**

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

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)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Alternative A input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	34	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	111
Federal Producing Wells - RMP Year 20	528	Non-Federal Producing Wells - RMP Year 20	1,747
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 100% full RFD estimates for Federal, full RFD estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.41	0.04	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.32	0.34	5.64	0.10	41.65	2.19	0.22	8091.07	0.06	0.09	8120.96	7369.29
Commuting Vehicles - Construction	6.15	0.63	0.17	0.00	0.21	0.07	0.01	45.38	0.00	0.00	46.39	42.10
Wind Erosion	0.11	0.02	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.59	0.00	0.26	77.09	0.00	1619.12	1469.26
Sub-total: Construction	**7.00**	**1.02**	**5.81**	**0.10**	**41.85**	**2.86**	**0.23**	**8,136.71**	**77.15**	**0.10**	**9,786.48**	**8,880.65**
Well Workover Operations - Fugitive Dust	0.91	0.09	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.16	0.16	3.14	0.05	27.24	1.47	0.15	5555.35	0.04	0.06	5575.67	5059.60
Well Workover Operations - On-road Exhaust	0.00	0.00	0.03	0.00	0.05	0.02	0.002	6.55	0.00	0.00	6.73	6.11
Well Visits for Inspection & Repair - Operations	1.02	0.10	0.03	0.00	0.67	0.03	0.003	13.32	0.00	0.00	14.91	13.53
Wellhead and Compressor Station Fugitives	---	---	---	---	---	1.43	0.14	0.63	186.77	0.00	3922.84	3559.75
Compression	4.84	4.84	109.14	0.07	218.28	76.40	7.64	14,727.24	0.28	0.03	14741.68	13377.21
Station Visits - Operations	0.33	0.03	0.02	0.00	0.06	0.02	0.00	3.64	0.00	0.00	3.78	3.43
Dehydrators	0.01	0.00	0.07	0.00	0.06	0.17	0.08	79.69	119.73	0.00	2594.43	2354.29
Sub-total: Operations	**7.26**	**5.23**	**112.43**	**0.13**	**246.36**	**79.54**	**8.02**	**20,386.41**	**306.82**	**0.10**	**26,860.04**	**24,373.91**
Road Maintenance	4.00	0.45	1.13	0.030	0.50	0.14	0.014	142.33	0.00	0.00	143.14	129.89
Sub-total: Maintenance	**4.00**	**0.45**	**1.13**	**0.030**	**0.50**	**0.14**	**0.014**	**142.335**	**0.001**	**0.00**		**129.89**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.36	0.33
Well Reclamation	0.35	0.04	0.04	0.00	0.05	0.01	0.00	10.44	0.00	0.00	10.50	9.53
Sub-total: Reclamation	**0.36**	**0.04**	**0.04**	**0.0019**	**0.05**	**0.011**	**0.0011**	**10.7977**	**0.0002**	**0.0002**	**10.8606**	**9.8554**
Total Emissions	**18.63**	**6.74**	**119.43**	**0.26**	**288.75**	**82.55**	**8.26**	**28,676.25**	**383.97**	**0.20**	**36,657.38**	**33,394.31**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.33	1.38	109.19	0.33	135.75	7.16	0.72	26401.82	0.27	0.09	26436.08	23989.19
Commuting Vehicles - Construction	20.09	2.05	0.57	0.00	0.67	0.23	0.02	148.15	0.01	0.00	149.25	135.43
Wind Erosion	0.36	0.05	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	1.93	0.00	0.85	251.67	0.00	5285.97	4796.70
Sub-total: Construction	**23.12**	**3.62**	**109.76**	**0.34**	**136.42**	**9.32**	**0.74**	**26,550.82**	**251.95**	**0.10**	**31,871.30**	**28,921.32**
Well Workover Operations - Fugitive Dust	3.02	0.30	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	13.19	12.79	232.00	3.95	77.94	16.79	1.68	18356.52	0.26	0.21	18426.92	16721.34
Well Workover Operations - On-road Exhaust	0.01	0.01	0.10	0.00	0.17	0.07	0.007	21.66	0.00	0.00	22.27	20.20
Well Visits for Inspection & Repair - Operations	3.38	0.34	0.10	0.00	2.22	0.10	0.010	44.08	0.01	0.02	49.33	44.76
Wellhead and Compressor Station Fugitives	---	---	---	---	---	4.74	0.47	2.08	617.97	0.00	12979.55	11778.18
Compression	16.01	16.01	361.12	0.25	722.24	252.78	25.28	48,728.20	0.92	0.09	48775.99	44261.33
Station Visits - Operations	1.08	0.11	0.07	0.00	0.18	0.08	0.01	12.03	0.00	0.00	12.51	11.36
Dehydrators	0.02	0.01	0.22	0.00	0.18	0.56	0.26	263.67	396.14	0.00	8584.21	7789.66
Sub-total: Operations	**36.70**	**29.57**	**593.61**	**4.20**	**802.93**	**275.12**	**27.72**	**67,428.23**	**1,015.30**	**0.33**	**88,850.78**	**80,626.84**
Road Maintenance	13.24	1.47	3.75	0.100	1.64	0.46	0.046	470.94	0.00	0.01	473.61	429.78
Sub-total: Maintenance	**13.24**	**1.47**	**3.75**	**0.100**	**1.64**	**0.46**	**0.046**	**470.944**	**0.005**	**0.01**		**429.78**
Road Reclamation	0.05	0.01	0.00	0.00	0.01	0.00	0.00	1.19	0.00	0.00	1.20	1.09
Well Reclamation	1.15	0.14	0.14	0.01	0.16	0.03	0.00	34.53	0.00	0.00	34.73	31.52
Sub-total: Reclamation	**1.20**	**0.14**	**0.15**	**0.0062**	**0.16**	**0.035**	**0.0035**	**35.7264**	**0.0006**	**0.0006**	**35.9347**	**32.6086**
Total Emissions	**74.26**	**34.80**	**707.26**	**4.64**	**941.16**	**284.94**	**28.51**	**94,485.72**	**1,267.25**	**0.43**	**120,758.01**	**110,010.55**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**24**	**2.41**	**1.21E-02**	**1.21E-03**

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

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (non-genset)	2.60	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	4	1,849	100	0.11	0.01	0.00	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	5.73E-03	3.60E-05	8.35E-06	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	**1.38E-01**	**6.64E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**6.64E-03**	**2.34E+02**	**1.80E-03**	**2.67E-03**
												Total		**1.66E-01**	**9.51E-03**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**9.96E-03**	**2.38E+02**	**1.85E-03**	**2.71E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	1,849	16	4	1,849	100	0.92	0.01	0.00	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**9.56E-01**	**9.13E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
													Total	**9.84E-01**	**1.20E-02**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**1.25E-02**	**2.38E+02**	**2.44E-03**	**2.71E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	4	47	188	1	0.27	51.61	0.03	0.026	0.03	5.16	0.00	0.003
	Pickup Trucks	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
Well Pad	Semi Trucks	42	4	5	20	1	0.27	5.49	0.00	0.004	0.03	0.55	0.00	0.000
	Pickup Trucks	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
Other Construction Activities	Semi Trucks	42	4	2	8	1	0.27	2.20	0.00	0.002	0.03	0.22	0.00	0.000
	Haul Trucks	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Pickup Trucks	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	4	44	176	1	0.27	48.31	0.02	0.058	0.03	4.83	0.00	0.006
	Fuel Haul Truck	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Haul Truck, Water Hauling	25	4	4	16	1	0.22	3.48	0.00		0.02	0.35	0.00	
	Rig Crew	5	4	51	204	1	0.11	21.49	0.01		0.01	2.15	0.00	
	Rig Mechanics	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Co. Supervisor	5	4	20	80	1	0.11	8.43	0.00		0.01	0.84	0.00	
	Tool Pusher	25	4	8	32	1	0.22	6.96	0.00		0.02	0.70	0.00	
	Mud Logger	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Engineer	25	4	15	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Logger, Engr Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Drill Bit Delivery	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	4	6	24	1	0.27	6.59	0.00	0.009	0.03	0.66	0.00	0.001
	Semi Completion, Unit Rig	42	4	1	4	1	0.27	1.10	0.00		0.03	0.11	0.00	
	Semi Fracing, Blender	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Semi Pumping/Tank Battery	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Tubing Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Cementer, Pump Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
									Subtotal	**9.86E-02**				**9.86E-03**

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle type)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle type)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Well Completion, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	4	3	12	1	0.22	2.61	0.00	0.082	0.02	0.26	0.00	0.008
	Haul Completion,	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Service Tools	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Perforators Logging Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Installation	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Testing	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Tank	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Pump	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Chemical	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Sand	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Other	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Welders	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Haul Water Truck	25	4	150	600	1	0.22	130.41	0.07		0.02	13.04	0.01	
	Pickup Cementer, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Casing Crew	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Completion Crew	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion, Pusher	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Perforators, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Fracing, Engineer	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
	Pickup Co. Supervisor	5	4	10	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
	Pickup Miscellaneous Supplies	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
	Pickup Roustabout Crew	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
									Subtotal	**8.19E-02**				**8.19E-03**
									Total	**1.81E-01**				**1.81E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SOx**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	**Class**					**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_2O**
Improved & Two-Track Road	Semi Trucks	HDDV	4	47	188	1	1.1257	0.1141	0.0952	0.0055	0.7133	0.1467	0.0006	0.0001	0.0000	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.000	0.000	0.1641	0.000008	0.000009
	Pickup Trucks	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0054	0.000000	0.000001
Well Pad	Semi Trucks	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0175	0.000001	0.000001
	Pickup Trucks	LDDT	4	4	16	1	0.0816	0.0038	0.0031	0.0002	0.2204	0.0969	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0072	0.000000	0.000001
Other Construction Activities	Semi Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0070	0.000000	0.000000
	Haul Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0070	0.000000	0.000000
	Pickup Trucks	LDDT	4	1	4	1	0.0204	0.0010	0.0008	0.0000	0.0551	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0018	0.000000	0.000000
																		Subtotal	**7.52E-04**	**7.18E-05**	**5.98E-05**	**3.46E-06**	**6.45E-04**	**1.84E-04**	**2.10E-01**	**9.21E-06**	**1.28E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	4	44	176	1	1.0538	0.1068	0.0891	0.0051	0.6678	0.1374	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.000007	0.000009
	Fuel Haul Truck	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Mud Haul Truck, Water Hauling	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Rig Crew	LDDT	4	51	204	1	1.0398	0.0489	0.0398	0.0025	2.8095	1.2354	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Rig Mechanics	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Co. Supervisor	LDDT	4	20	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							0.0	0.000000	0.000005
	Tool Pusher	LDDT	4	8	32	1	0.1631	0.0077	0.0062	0.0004	0.4407	0.1938	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000002
	Mud Logger	LDDT	4	6	24	1	0.1223	0.0058	0.0047	0.0003	0.3305	0.1453	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000001
	Mud Engineer	LDDT	4	15	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							0.0	0.000000	0.000004
	Logger, Engr Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Drill Bit Delivery	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.000001	0.000001
	Semi Completion, Unit Rig	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Fracing, Blender	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Pumping/Tank Battery	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Tubing Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Pump Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Cement Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Completion, Equip Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Service Tools	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Haul Perforators Logging Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Installation	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Testing	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Tank	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Pump	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Chemical	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Sand	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Other	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Welders	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Haul Water Truck	HDDV	4	150	600	1	3.5926	0.3640	0.3038	0.0175	2.2765	0.4683	0.0018	0.0002	0.0002	0.0000	0.0011	0.0002							0.5	0.000024	0.000029
	Pickup Cementer, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Casing Crew	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Completion Crew	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Pickup Completion, Pusher	LDDT	4	5	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.000000	0.000001
	Pickup Perforators, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Fracing, Engineer	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Co. Supervisor	LDDT	4	10	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.000000	0.000002
	Pickup Miscellaneous Supplies	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000001
	Pickup Roustabout Crew	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
																	Subtotal		**4.36E-03**	**3.72E-04**	**3.09E-04**	**1.81E-05**	**5.42E-03**	**1.93E-03**	**1.12E+00**	**4.30E-05**	**7.97E-05**
																	Total		**5.11E-03**	**4.44E-04**	**3.69E-04**	**2.15E-05**	**6.07E-03**	**2.11E-03**	**1.33E+00**	**5.22E-05**	**9.25E-05**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[a]
Diesel	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						Max. Annual Emissions (tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						Max. Annual Emissions (tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	4	12	48	1	0.08	3.87	**1.94E-03**	0.01	0.39	**1.93E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	4	12	48	1	0.12	0.00	0.00	0.00	2.54	0.11	**5.96E-05**	**1.34E-06**	**6.19E-07**	**4.66E-07**	**1.27E-03**	**5.66E-05**	**2.52E-02**	**3.60E-06**	**9.44E-06**

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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	0.5	32	0.08	2.58	**1.29E-03**	0.01	0.26	**1.28E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	0.5	32	**8.16E-05**	**3.83E-06**	**3.12E-06**	**1.98E-07**	**2.20E-04**	**9.69E-05**	**1.44E-02**	**7.05E-08**	**1.87E-06**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	0.50	2024.16	1.00	0.00	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	0.00	0.00
								TOTAL	**3.25E-03**	**4.88E-04**

[a] 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[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	0.047
Annual Miles of Roads reclaimed Per Well	0.012
Number of wells reclaimed (per well)	0.047

Reclaimation 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
0.0116	6	0.00194	0.0194
		Total	**0.019**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.012	5	0.058	0.765	**2.23E-05**	0.069	**2.02E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.012	0.4238	0.0720	0.0197	0.4106	0.0629	**2.47E-06**	**4.19E-07**	**1.15E-07**	**2.39E-06**	**3.66E-07**	**4.07E-07**	**6.31E-04**	**5.67E-09**	**6.22E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0019	0.116	0.08	**4.70E-06**	0.01	**4.67E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0019	0.1165	**2.97E-07**	**1.40E-08**	**1.14E-08**	**7.19E-10**	**8.02E-07**	**3.53E-07**	**5.26E-05**	**2.57E-10**	**6.80E-09**

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	0.047	10	0.047	0.47

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.28	5	1.40	0.765	**5.35E-04**	0.069	**4.84E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.28	0.5297	0.0900	0.0246	0.5132	0.0786	**7.40E-05**	**1.26E-05**	**3.44E-06**	**7.17E-05**	**1.10E-05**	**1.95E-05**	**1.85E-02**	**3.08E-07**	**1.87E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.05	2.80	0.081	**1.13E-04**	0.008	**1.12E-05**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.05	2.80	**7.12E-06**	**3.35E-07**	**2.73E-07**	**1.73E-08**	**1.93E-05**	**8.47E-06**	**1.26E-03**	**6.16E-09**	**1.63E-07**

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

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)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

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)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

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	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

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

Volume Flow:	40	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.12	MMSCF/well

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

BTU value = 994 BTU/scf

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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
Component	(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 =	0.00349	0.00002	0.00001	0.00310

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 (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.15E-04**			**6.12E-05**

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip)						Emissions (tpy/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_2O
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	0.00	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	0.00	0.00289	0.00000	0.00000
													Total	**3.89E-05**	**1.83E-06**	**1.49E-06**	**9.42E-08**	**1.05E-04**	**4.62E-05**	**6.89E-03**	**3.36E-08**	**8.91E-07**

Alternative A input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	14	Peak Year Non-Federal Producing Wells Drilled	47
Federal Producing Wells - Year 20 (RMP Totals)	267	Non-Federal Producing Wells - Year 2027 (RMP Totals)	885
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

* 100% full RFD estimates for Federal, full RFD estimates (100%) for non-Federal

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	8.27	0.83	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.16	0.02	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.05	0.04	0.66	0.02	1.47	0.11	0.01	309.01	0.00	0.00	310.15	281.44
Commuting Vehicles - Construction	0.94	0.10	0.04	0.00	0.06	0.02	0.00	8.18	0.00	0.00	8.40	7.62
Completion Venting	---	---	---	---	---	0.00	0.00	0.92	38.41	0.00	807.43	732.69
Sub-total: Construction	**9.42**	**0.99**	**0.69**	**0.02**	**1.53**	**0.14**	**0.01**	**318.10**	**38.41**	**0.00**	**1125.98**	**1021.76**
Natural Gas Compression - Operations	2.75	2.75	62.09	0.04	124.18	43.46	8.30	8,378.21	0.16	0.02	8,386.43	7610.19
Dehydrators	0.00	0.00	0.04	0.00	0.03	0.00	0.00	45.33	69.76	0.00	1,510.48	1370.67
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	2.12	88.86	0.00	1,868.20	1695.28
Station Visits - Operations	0.19	0.02	0.01	0.00	0.03	0.01	0.00	2.07	0.00	0.00	2.15	1.95
Well Workover - Operations	0.51	0.37	0.89	0.01	0.42	0.05	0.00	1,509.91	0.01	0.01	1,513.66	1373.55
Well & Pipeline visits for Inspection & Repair - Operations	0.08	0.01	0.01	0.00	0.01	0.01	0.00	0.90	0.00	0.00	0.94	0.85
Sub-total: Operations	**3.53**	**3.15**	**63.03**	**0.06**	**124.68**	**43.53**	**8.31**	**9938.55**	**158.79**	**0.03**	**13281.86**	**12052.50**
Road Maintenance	0.43	0.05	0.06	0.00	0.03	0.01	0.00	17.46	0.00	0.00	17.52	15.90
Sub-total: Maintenance	**0.43**	**0.05**	**0.06**	**0.00**	**0.03**	**0.01**	**0.00**	**17.46**	**0.00**	**0.00**	**17.52**	**15.90**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.26	0.24
Well Reclamation	0.23	0.03	0.03	0.00	0.03	0.00	0.00	7.69	0.00	0.00	7.72	7.01
Sub-total: Reclamation	**0.24**	**0.03**	**0.03**	**0.0015**	**0.03**	**0.005**	**0.0005**	**7.9548**	**0.0001**	**0.0001**	**7.9841**	**7.2451**
Total Emissions	**13.62**	**4.22**	**63.82**	**0.08**	**126.27**	**43.69**	**8.32**	**10,282.06**	**197.20**	**0.03**	**14,433.34**	**13,097.41**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	27.75	2.78	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.54	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.51	0.45	7.57	0.20	2.38	0.60	0.06	1,037.39	0.01	0.01	1,041.23	944.86
Commuting Vehicles - Construction	3.14	0.32	0.12	0.00	0.21	0.08	0.01	27.45	0.00	0.00	28.20	25.59
Completion Venting	---	---	---	---	---	0.00	0.00	3.07	128.93	0.00	2,710.66	2459.76
Sub-total: Construction	**31.94**	**3.63**	**7.69**	**0.20**	**2.59**	**0.69**	**0.07**	**1067.91**	**128.94**	**0.01**	**3780.09**	**3430.20**
Natural Gas Compression - Operations	9.12	9.12	205.80	0.14	411.61	144.06	27.52	27,770.47	0.52	0.05	27,797.71	25224.78
Dehydrators	0.01	0.01	0.13	0.00	0.11	0.01	0.00	150.27	231.22	0.00	5,006.64	4543.23
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.01	0.00	7.02	294.54	0.00	6,192.36	5619.20
Station Visits - Operations	0.61	0.06	0.04	0.00	0.10	0.05	0.00	6.86	0.00	0.00	7.13	6.47
Well Workover - Operations	5.12	1.23	62.81	21.06	4.62	3.47	0.35	4,998.14	0.07	0.07	5,021.55	4556.76
Well & Pipeline visits for Inspection & Repair - Operations	0.27	0.03	0.02	0.00	0.05	0.02	0.00	3.00	0.00	0.00	3.12	2.83
Sub-total: Operations	**15.14**	**10.45**	**268.80**	**21.20**	**416.49**	**147.62**	**27.88**	**32935.75**	**526.35**	**0.13**	**44028.51**	**39953.28**
Road Maintenance	1.41	0.15	0.20	0.01	0.09	0.03	0.00	57.87	0.00	0.00	58.08	52.71
Sub-total: Maintenance	**1.41**	**0.15**	**0.20**	**0.01**	**0.09**	**0.03**	**0.00**	**57.87**	**0.00**	**0.00**	**58.08**	**52.71**
Road Reclamation	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.87	0.79
Well Reclamation	0.76	0.09	0.10	0.00	0.10	0.02	0.00	25.50	0.00	0.00	25.59	23.22
Sub-total: Reclamation	**0.80**	**0.10**	**0.11**	**0.0049**	**0.10**	**0.017**	**0.0017**	**26.3670**	**0.0004**	**0.0003**	**26.4643**	**24.0148**
Total Emissions	**49.29**	**14.33**	**276.79**	**21.42**	**419.27**	**148.35**	**27.95**	**34,087.89**	**655.29**	**0.14**	**47,893.15**	**43,460.21**

Fugitive Dust Emissions From Well Pad and Compressor Station Construction

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Construction Activities: All Project Years

Area Disturbed for CBNG Wells	Emission Estimation Basis	Avg. Disturbed Acres per Well[a]	Construction Days	Total # of Well Pads or Stations	Total Disturbed Acres	Emissions			
						(lb/well)		(tpy/well)	
						PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Well Pad and Road Construction	Per Well	3.48	5	1	3.48	1.16E+03	1.16E+02	5.81E-01	5.81E-02
Field Compressor Station	Per Well	0.04	6	1	0.04	1.66E+01	1.66E+00	8.30E-03	8.30E-04
Sales Compressor Station	Per Well	0.01	6	1	0.01	2.77E+00	2.77E-01	1.38E-03	1.38E-04
				Total	**3.53**	**1.18E+03**	**1.18E+02**	**5.91E-01**	**5.91E-02**

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

Exhaust Emissions from Heavy Construction Equipment (Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/ Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity) NO_x	$PM_{2.5}/PM_{10}$[a]	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																		Subtotal	**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaks
2010)

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.022	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.015	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.015	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.015	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.015	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.015	530.28	0.004	0.006
>750 (genset)	0.50	0.022	0.0051	2.60	0.14	0.022	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	8.6	0.4	0.1	74.3	4.0	0.00	0.00	0.00	0.04	0.00	0.006	0.000	0.000	0.056	0.003	0.00	7.6	0.0001	0.0001
	Auxillary Pump	200	1	90	18	2	36	1.00	4.3	0.2	0.1	37.1	2.0	0.00	0.00	0.00	0.02	0.00						0.00	3.8	0.0000	0.0000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	2.9	0.1	0.0	24.8	1.3	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.021	0.001	0.00	2.5	0.0000	0.0000
	Auxillary Pump	125	1	90	18	1	18	1.00	1.3	0.1	0.0	16.5	0.6	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.012	0.001	0.00	1.2	0.0000	0.0000
	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
																		Subtotal	**1.09E-02**	**5.29E-04**	**1.69E-04**	**8.85E-02**	**4.64E-03**	**5.29E-04**	**1.76E+01**	**1.43E-04**	**1.99E-04**
																		Total	**1.86E-02**	**1.21E-03**	**3.99E-04**	**9.16E-02**	**5.43E-03**	**1.27E-03**	**1.88E+01**	**1.55E-04**	**2.12E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.0000	0.0000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Exhaust Emissions from Heavy Construction Equipment (Non-Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	$M_{2.5}/PM_1$	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																		Subtotal	**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	103.2	6.1	2.9	30.2	7.4	0.05	0.00	0.00	0.02	0.00	0.076	0.005	0.002	0.021	0.006	0.00	7.6	0.000	0.000
	Auxillary Pump	200	1	90	18	2	36	1.00	48.2	3.2	1.5	11.9	4.1	0.02	0.00	0.00	0.01	0.00						0.00	3.8	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	34.4	2.0	1.0	10.1	2.5	0.02	0.00	0.00	0.01	0.00	0.025	0.002	0.001	0.007	0.002	0.00	2.5	0.000	0.000
	Auxillary Pump	125	1	90	18	1	18	1.00	15.9	1.2	0.5	4.4	1.4	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00	0.024	0.001	0.000	0.006	0.002	0.00	1.2	0.000	0.000
	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
																		Subtotal	**1.25E-01**	**7.52E-03**	**3.38E-03**	**3.43E-02**	**9.43E-03**	**7.30E-03**	**1.76E+01**	**1.43E-04**	**2.00E-04**
																		Total	**1.33E-01**	**8.21E-03**	**3.61E-03**	**3.73E-02**	**1.02E-02**	**8.04E-03**	**1.88E+01**	**1.55E-04**	**2.13E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.000	0.000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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		
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/activity)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/activity)	$PM_{2.5}$ Emissions (tpy/well)
Drilling Roads	Semi Trucks	42	6	3	18	1.000	0.27	4.94	0.002	0.03	0.49	0.000
Drilling Well Pad	Haul Trucks	25	6	2	12	1.000	0.22	2.61	0.001	0.02	0.26	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Water Disposal Well Pad	Haul Trucks	25	10	5	50	0.005	0.22	10.87	0.000	0.02	1.09	0.000
	Pickup Trucks	5	10	5	50	0.005	0.11	5.27	0.000	0.01	0.53	0.000
New Pipeline Intermediate	Haul Trucks	25	6	40	240	0.111	0.22	52.17	0.003	0.02	5.22	0.000
	Pickup Trucks	5	6	160	960	0.111	0.11	101.14	0.006	0.01	10.11	0.001
New Sales Pipeline	Haul Trucks	25	35	94	3,290	0.000	0.22	715.10	0.000	0.02	71.51	0.000
	Pickup Trucks	5	50	94	4,700	0.000	0.11	495.14	0.000	0.01	49.51	0.000
Electric Line	Haul Trucks	25	6	1	6	1.000	0.22	1.30	0.001	0.02	0.13	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Field Compression Station	Semi Trucks	42	10	15	150	0.111	0.27	41.18	0.002	0.03	4.12	0.000
	Haul Trucks	25	10	48	480	0.111	0.22	104.33	0.006	0.02	10.43	0.001
	Pickup Trucks	5	10	192	1,920	0.111	0.11	202.27	0.011	0.01	20.23	0.001
Sales Compression Station	Semi Trucks	42	10	19	190	0.011	0.27	52.16	0.000	0.03	5.22	0.000
	Haul Trucks	25	10	48	480	0.011	0.22	104.33	0.001	0.02	10.43	0.000
	Pickup Trucks	5	10	192	1,920	0.011	0.11	202.27	0.001	0.01	20.23	0.000
Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2								**Subtotal**	**3.56E-02**			**3.56E-03**

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/well)	$PM_{2.5}$ Emissions (tpy/well)
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Fuel Haul Truck	25	6	2	12	1.00	0.22	2.61	0.001	0.022	0.261	0.000
	Mud Haul Truck, Water Hauling	25	6	7	42	1.00	0.22	9.13	0.005	0.022	0.913	0.000
	Rig Crew	25	6	3	18	1.00	0.22	3.91	0.002	0.022	0.391	0.000
	Co. Supervisor	5	6	8	48	1.00	0.11	5.06	0.003	0.011	0.506	0.000
	Tool Pusher	25	6	6	36	1.00	0.22	7.82	0.004	0.022	0.782	0.000
	Logger, Engr Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
Well Completion, Fracing & Testing	Semi Casing Haulers	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Semi Completion, Unit Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Semi Fracing Blender	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Tubing Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Completion, Equip Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Perforators Logging Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Tank	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Pump	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Welders	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Water Truck	25	6	9	54	1.00	0.22	11.74	0.006	0.022	1.174	0.001
	Pickup Cementer, Engineer	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Co. Supervisor	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
	Pickup Miscellaneous Supplies	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Roustabout Crew	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
Water Disposal Well Drilling	Drill Rig Transport truck	42	6	10	60	0.01	0.27	16.47	0.000	0.027	1.647	0.000
	Mud Haul Truck, Water Hauling	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Rig Crew	25	6	10	60	0.01	0.22	13.04	0.000	0.022	1.304	0.000
	Co. Supervisor	5	6	5	30	0.01	0.11	3.16	0.000	0.011	0.316	0.000
	Tool Pusher	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Tubing Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
								Subtotal	**3.11E-02**			**3.11E-03**
								Total	**6.67E-02**			**6.67E-03**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaks0, 2010)

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy/well)								
	Type	Class					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_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	0.11	0.01	0.01	0.00	0.07	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.02	0.00	0.00
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.99	0.30	0.25	0.01	1.90	0.39	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	25	5	125	0.01	0.64	0.03	0.02	0.00	1.72	0.76	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	1.44	0.15	0.12	0.01	0.91	0.19	0.000	0.00	0.000	0.000	0.00	0.00	0.02	0.00	0.00
	Pickup Trucks	LDDT	6	160	960	0.11	4.89	0.23	0.19	0.01	13.22	5.81	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.05	0.00	0.00
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	19.70	2.00	1.67	0.10	12.48	2.57	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	50	94	4700	0.00	23.96	1.13	0.92	0.06	64.73	28.46	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	0.90	0.09	0.08	0.00	0.57	0.12	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.01	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.11	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.11	9.79	0.46	0.37	0.02	26.44	11.63	0.001	0.0000	0.0000	0.0000	0.00	0.001	0.10	0.00	0.00
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.14	0.12	0.10	0.01	0.72	0.15	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.00	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.01	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.01	9.79	0.46	0.37	0.02	26.44	11.63	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Fuel Haul Truck	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	0.25	0.03	0.02	0.00	0.16	0.03	0.000	0.00	0.00	0.00	0.0	0.00	0.04	0.00	0.00
	Rig Crew	LDDT	6	3	18	1.00	0.09	0.00	0.00	0.00	0.25	0.11	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Rig Mechanics	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Co. Supervisor	LDDT	6	8	48	1.00	0.24	0.01	0.01	0.00	0.66	0.29	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Tool Pusher	LDDT	6	6	36	1.00	0.18	0.01	0.01	0.00	0.50	0.22	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Mud Logger	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Mud Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Logger, Engr	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Drill Bit Delivery	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**1.88E-03**	**1.23E-04**	**1.02E-04**	**6.12E-06**	**3.75E-03**	**1.55E-03**	**4.07E-01**	**9.83E-06**	**3.89E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tpy) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Fracing Blender	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Tubing Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Service Tools	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Installation	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Testing	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Tank	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Pump	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Chemical	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Sand	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Other	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Welders	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Water Truck	HDDV	6	9	54	1.00	0.32	0.03	0.03	0.00	0.20	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Completion Crew	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Completion Pusher	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	0.60	0.06	0.05	0.00	0.38	0.08	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	0.30	0.03	0.03	0.00	0.19	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Rig Crew	LDDT	10	10	100	0.01	0.51	0.02	0.02	0.00	1.38	0.61	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Co. Supervisor	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tool Pusher	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tubing Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**6.51E-04**	**6.00E-05**	**5.00E-05**	**2.90E-06**	**6.39E-04**	**2.01E-04**	**1.77E-01**	**7.47E-06**	**1.14E-05**
											Total		**2.53E-03**	**1.83E-04**	**1.52E-04**	**9.02E-06**	**4.39E-03**	**1.76E-03**	**5.84E-01**	**1.73E-05**	**5.02E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power	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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	12	1	12	8,760	0.12	0.01	0.00	0.24	0.08	0.01	16.2	0.00	0.01	0.00
Sales Compression Station	12	1	12	8,760	0.11	0.00	0.00	0.22	0.08	0.00	15.1	0.00	0.01	0.00
				Total	**2.33E-01**	**1.03E-02**	**1.58E-04**	**4.65E-01**	**1.63E-01**	**1.03E-02**	**3.14E+01**	**5.92E-04**	**1.48E-02**	**5.92E-05**

Sub-total: Construction

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867
CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (lb/yr)**	**VOC (tpy)**	**CO2 (lb/yr)**	**CO2 (tpy)**	**CH4 (lb/yr)**	**CH4 (tpy)**
-total: Construct	1	8760	0.00	**3.25E-07**	0.78	**3.92E-04**	32.90	**1.64E-02**

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.41E-04**	**1.08E-05**	**8.49E-07**	**1.19E-04**	**7.78E-06**	**8.07E-06**	**1.70E-01**	**3.25E-06**	**1.06E-07**	**3.11E-06**

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)
16.43	0.016	**2.61E-01**	0.000	**0.00E+00**	0.000	**0.00E+00**

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

Sub-total: Construction

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

The following South Baker Compressor Station assumptions were used with CBNG specific gas composition analysis to derive dehydrator emissions:

per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station ---
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.5	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	6.92E-04			6.89E-05

Assume no dust control (watering)

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.5	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.004	0.000	0.000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	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	0.00	0.003	0.000	0.000
													Total	4.37E-05	2.06E-06	1.67E-06	1.06E-07	1.18E-04	5.20E-05	7.75E-03	3.78E-08	1.00E-06

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Emission Factors for Publicly Accessible Unpaved Roads[e]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	0.0051	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	6.35	0.32	0.11	2.96	0.32	**3.17E-03**	**1.59E-04**	**5.40E-05**	**1.48E-03**	**1.59E-04**	**1.21E-03**	**5.61E+00**	**4.03E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS

Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	141.65	8.05	47.59	10.25	7.81	**7.08E-02**	**4.03E-03**	**2.38E-02**	**5.13E-03**	**3.91E-03**	**1.21E-03**	**5.60E+00**	**7.79E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Emissions for Well and Pipe Inspections

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Fugitive Dust Emissions Estimation for Road Traffic: Well & Pipeline

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/ Year	PM_{10}			$PM_{2.5}$		
							Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)	Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)
Visits for Inspection and Repair	200-hp Pickup	40	0.625	12	1	8	0.08	0.05	**3.02E-04**	0.01	0.01	**3.01E-05**

Activity rates based on values shown in SEIS
Assume no dust control (watering)

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/Well	Emissions (lbs/trip/well)						Emissions (tpy/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_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	0.003	0.000	0.000	0.000	0.009	0.004	**1.91E-05**	**8.99E-07**	**7.32E-07**	**4.63E-08**	**5.16E-05**	**2.27E-05**	**3.39E-03**	**1.65E-08**	**4.38E-07**

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.08	0.83
Winter	1	0.25	5	10	0.05	0.50
				Total	0.13	1.33

Based on values shown in SEIS

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^{2}$	5	0.765
Sub-total: Constructi	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph

Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)[b]	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Maintenance	Grader	1	5	4	0.765	**1.53E-03**	0.069	**1.39E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Year 2008	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.006
Year 2018	1.86	0.25	0.10	0.82	0.25	0.25	546.2	0.004	0.006
Year 2028	0.56	0.16	0.09	0.27	0.16	0.15	546.5	0.002	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions													
				(lb/hour)					(tpy/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_2O
Road Maintenance	Grader	135	1	0.55	0.08	0.03	0.24	0.07	**2.22E-04**	**3.01E-05**	**1.16E-05**	**9.78E-05**	**2.92E-05**	**2.92E-05**	**6.50E-02**	**4.44E-07**	**7.14E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Sub-total: Construction

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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Maintenance	Pickup Truck	40	6	0.13	0.80	0.08	**3.34E-05**	0.01	**3.33E-06**

[a] Assume No dust control measures (watering) would be applied

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	**2.04E-06**	**9.59E-08**	**7.80E-08**	**4.94E-09**	**5.51E-06**	**2.42E-06**	**3.61E-04**	**1.76E-09**	**4.67E-08**

Exhaust 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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0720
Annual Miles of Roads reclaimed Per Well	0.0180
Number of wells reclaimed (per well)	0.0720

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

Sub-total: Construction

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.0180	6	0.0030	0.0300
		Total	0.0300

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.0180	5	0.0901	0.765	**3.44E-05**	0.069	**3.12E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.018	0.4238	0.0720	0.0197	0.4106	0.0629	**3.82E-06**	**6.48E-07**	**1.77E-07**	**3.70E-06**	**5.66E-07**	**6.29E-07**	**9.75E-04**	**8.76E-09**	**9.53E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.00300	0.01801	0.08	**7.26E-07**	0.01	**7.23E-08**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0030	0.0180	**4.59E-08**	**2.16E-09**	**1.76E-09**	**1.11E-10**	**1.24E-07**	**5.45E-08**	**8.13E-06**	**3.97E-11**	**1.05E-09**

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	0.0720	10	0.0720	0.7205

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.4323	5	2.1615	0.765	**8.27E-04**	0.069	**7.49E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.4323	0.5297	0.0900	0.0246	0.5132	0.0786	**1.15E-04**	**1.95E-05**	**5.31E-06**	**1.11E-04**	**1.70E-05**	**3.02E-05**	**2.86E-02**	**4.77E-07**	**2.86E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	6	0.0720	0.4323	0.081	**1.74E-05**	0.008	**1.73E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0720	0.4323	**1.10E-06**	**5.18E-08**	**4.22E-08**	**2.67E-09**	**2.98E-06**	**1.31E-06**	**1.95E-04**	**9.53E-10**	**2.53E-08**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy)	PM2.5 Emissions (tpy)
Well Pad, Road and Pipeline construction	26.08	1.38	1.46		1.00	3.48	14108.09	1.00	0.01	0.00
Sub-total: Construction	26.08	1.38		1.46	1.00	0.05	196.11	1.00	0.0002	0.00002
								TOTAL	**1.15E-02**	**1.72E-03**

[a] Average disturbed area for new CBNG wells shown in SEIS

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
Sub-total: Constr	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.065	0.000	0.001	0.062
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	10	0.0004	0	0.0005	0	0.0002	0.004	0.000	0.000	0.004
flanges	7	0.0009	0	0.0002	0	0.0000	0.006	0.000	0.000	0.006
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.075	0.000	0.002	0.072

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	0.01	**6.26E-06**	15.08	**7.54E-03**	632.73	**3.16E-01**

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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
Reactive VOC	0.000	---	0.000	0.002		0.000
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
n-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	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

Alternatives A-E
MCFO Existing Coal Mine Emission Estimates

Ownership	Permit Number (Permit Date) [1]	Permitted Production (tons/yr)	Emissions (tpy)									
			CO	NOx	VOC	SO2	PM10	PM2.5	CO2	CH4 [2]	N2O [3]	CO2eq
Federal [1]												
Decker Coal Mine	1435-06 (12/9/2010)	16,000,000	1,151.0	701.0	56.0	77.0	1,732.6	173.3	46,290.6	2.78E-01	4.63E-01	46,439.9
Spring Creek Coal Mine	1120-10 (3/18/2009)	24,000,000	247.3	651.6	54.6	29.1	1,038.8	103.9	59,891.9	3.59E-01	5.99E-01	60,085.1
Western Energy Rosebud Coal Mine												
Portable Crushing Facility	4436-00 (8-13-09)	5,694,000	22.8	99.6	2.9	33.6	8.7	0.9	1,204.9	7.23E-03	1.20E-02	1,208.8
Entire Mine (replaces 1483-07)	1483-08 (10-23-01)	13,000,000	793.0	445.0	37.0	48.0	1,863.4	186.3	1,204.9	7.23E-03	1.20E-02	1,208.8
Federal Emission Total		**58,694,000**	**2,214**	**1,897**	**151**	**188**	**4,643**	**464**	**108,592**	**6.52E-01**	**1.09E+00**	**108,943**
Federal Emissions on Unit-Production Basis (ton/ton of coal production)			**3.77E-05**	**3.23E-05**	**2.57E-06**	**3.20E-06**	**7.91E-05**	**7.91E-06**	**1.85E-03**	**1.11E-08**	**1.85E-08**	**1.86E-03**
Non-Federal [1]												
Savage Coal Mine	1851-04 (2/21/2004)	450,000	37.0	18.5	2.3	1.9	80.4	8.0	1,521.0	9.13E-03	1.52E-02	1,525.9
Absaloka Coal Mine												
Emission Increase	1418-06 (3/25/2010)		465.3	519.1	26.2	31.0	619.4	78.6	27,979.5	1.68E-01	2.80E-01	28,069.8
Original Permit	Permit Unavailable [4]	11,000,000	791.3	481.9	38.5	52.9	1,191.1	119.1	31,824.8	1.91E-01	3.18E-01	31,927.4
Non-Federal Emission Total		**11,450,000**	**1,294**	**1,019**	**67**	**86**	**1,891**	**206**	**61,325**	**3.68E-01**	**6.13E-01**	**61,523**
Non-Federal Emissions on Unit-Production Basis (ton/ton of coal production)			**1.13E-04**	**8.90E-05**	**5.85E-06**	**7.50E-06**	**1.65E-04**	**1.80E-05**	**5.36E-03**	**3.21E-08**	**5.36E-08**	**5.37E-03**

tpy = short tons per year

Blue-shaded cells indicate that pollutant emission limits are not included in mine air quality permits and were instead estimated based on fuel usage or engine horsepower, as available. When PM10 and/or PM2.5 emission limits were not included in permits, PM10 emissions were assumed to be equal to total suspended particulate (TSP) emissions and PM2.5 emissions were assumed to be equal to 10 percent of PM10 emissions.

2. CH4 emissions are assumed to be 0.0006 percent of CO2 emissions.

3. N2O emissions are assumed to be 0.001 percent of CO2 emissions.

4. This permit was not available online. Emissions are estimated based on scaling Decker Mine.

MCFO Future Coal Mining Emission Estimates

Ownership	Maximum 2020 Production (tons)	Emissions (tpy)									
		CO	NOx	VOC	SO2	PM10	PM2.5	CO2	CH4	N2O	CO2eq
Federal[1]	56,227,555	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	104,029.1	0.6	1.0	104,364.7
Non-Federal [1]	26,772,445	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	143,391.0	0.9	1.4	143,853.6

1. Emissions are scaled based on year 2020 high scenario Powder River Basin projections and RFD guidance relative to existing permitted production limits. Note that future production slightly is slightly less than the existing mine maximum production capacity included in current mine air quality permits. Existing mines with federal leases are not all producing at maximum permitted capacity, while existing mines with non-federal leases are producing at less than permitted capacity.

Alternatives A-E
MCFO Existing Coal Mine Emission Estimates (cont.)

Fuel Combustion Emission Factors

Fuel Type	Emissions (lb/gal)		
	CO2	CH4	N2O
Gaoline	19.4	Negl.	Negl.
Diesel	22.2	Negl.	Negl.

CO2 emission factors are based on IPCC recommended calculation procedures summarized in "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel", http://www.epa.gov/oms/climate/420f05001.htm, accessed 8/31.2011.

Emission Factors for Non-Road Diesel Engines

Engine Horsepower	Emissions (g/hp-hr)								
	CO	NOx	VOC	SO2	PM10	PM2.5	CO2	CH4	N2O
300 to 600	0.83	2.18	0.18	0.10	0.19	0.19	535.1	0.003	0.006
Non-road diesel engine >750 hp	---	---	---	---	---	---	534.4	0.004	0.006

Source: EPA NONROADS 2008a

N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

MCFO Existing Coal Mining Emission Estimates for Emissions Not Included in Permits

Ownership	Gasoline Usage (gal)	Diesel Usage (gal)	Estimate Criteria Pollutants?	Emissions (tpy)						
				CO	NOx	VOC	SO2	PM10	PM2.5	CO2
Federal										
Decker Coal Mine	213,900	3,983,400	No	---	---	---	---	---	---	46,290.6
Spring Creek Coal Mine	120,000	5,290,802	Yes	247.3	651.6	54.6	29.1	---	---	59,891.9
Western Energy Rosebud Coal Mine										
Portable Crushing Facility [1]	---	---	No	---	---	---	---	---	---	1,204.9
Entire Mine (replaces 1483-07)			No	---	---	---	---	---	---	-
Non-Federal										
Savage Coal Mine	14,789	124,099	No	---	---	---	---	---	---	1,521.0
Absaloka Coal Mine										
Emission Increase	132,013	2,405,316	No	---	---	---	---	---	---	27,979.5

[1] This portable crushing facility includes a 947 hp diesel engine. Assumptions include operation 10 hr/day, 360 days/yr at a load factor of 60%.

Weed Treatment **Alternatives A-E**

Total Annual Emissions for Weed Treatment - RMP Year - Alternatives A - E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	8.66	0.87	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.34	0.32	0.05	0.00	10.35	2.18	0.22	24.20	0.02	0.00	24.64	22.36
Sub-total: Heavy Equipment	**9.00**	**1.18**	**0.05**	**0.00**	**10.35**	**2.18**	**0.22**	**24.20**	**0.02**	**0.0002**	**24.64**	**22.36**
Commuting Vehicles - Fugitive Dust	1.63	0.16	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.03	0.03	0.05	0.00	0.95	0.91	0.09	9.69	0.01	0.00	10.16	9.22
Sub-total: Commuting Vehicles	**1.66**	**0.19**	**0.05**	**0.00**	**0.95**	**0.91**	**0.09**	**9.69**	**0.01**	**0.0010**	**10.16**	**9.22**
Total	**10.67**	**1.38**	**0.09**	**0.01**	**11.31**	**3.09**	**0.31**	**33.89**	**0.03**	**0.001**	**34.80**	**31.58**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternatives A-E

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, November 1, 2006.

Fugitive Dust Emission Estimations for Silviculture Treatments, Forest Products, Weed Treatment and Insect Control - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Weed Treatment	1200	24,000	1	24.00	8.40	0.84
			Total	**24.00**	**8.40**	**0.84**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	1200.0	15	29.6	52.104	0.033	2,084.18	0	**0.26**	**0.03**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternatives A-E

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/ Year	Emissions													
								(lbs/year/activity)					(tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Weed Treatment	Spray Vehicle	40	1	100	8	100	800	93.33	687.70	9.89	20,707.95	4,366.03	0.05	0.34	0.00	10.35	2.18	0.32	24.20	0.02	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**4.67E-02**	**3.44E-01**	**4.95E-03**	**1.04E+01**	**2.18E+00**	**3.16E-01**	**2.42E+01**	**1.90E-02**	**1.51E-04**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternatives A-E

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)
Forest/Woodland Weed Treatment	ATV and Other Equipment	5	60	200	12,000	1	12,000	0.27	1.63	1.63	0.03	0.16	0.16
							Total		**1.63**			**0.16**	

Source of activity data: MCFO

Assume no watering

[a] Accounts for MCFO "other" equipment associated with this project.

ALTERNATIVE: Alternatives A-E

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								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_2O
Forest/Woodland Weed Treatment	ATV	R12S	160	100	16,000	1	16,000	0.00	0.03	0.03	0.00	0.84	0.86	0.00	0.03	0.03	0.00	0.84	0.86	2.47	0.01	0.00
Forest/Woodland Weed Treatment	Other Equipment	LDDT	160	100	16,000	1	16,000	0.04	0.00	0.00	0.00	0.11	0.05	0.04	0.00	0.00	0.00	0.11	0.05	7.22	0.00	0.00
							Total	**0.05**	**0.03**	**0.03**	**0.00**	**0.95**	**0.91**	**0.05**	**0.03**	**0.03**	**0.00**	**0.95**	**0.91**	**9.69**	**0.01**	**0.001**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except the ATVs, which are gasoline-powered. Accounts for MCFO "other" equipment associated with this project.

Fire Management and Ecology **Alternative A-E**

Total Annual Emissions from Fire Management Projects - Alternative A-E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	404.53	340.00	109.93	30.14	3,936.51	200.76	20.08	0.00	208.50	30.21	13,743.05	12,471.01
Heavy Equipment Exhaust	2.02	1.88	10.75	0.73	55.44	11.05	1.10	288,900.65	32.17	10.75	289,576.24	262,773.36
Commuting Vehicles - Fugitive Dust	25.34	2.53	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.06	0.05	0.50	0.00	0.50	0.25	0.03	145.49	0.01	0.01	145.67	132.19
Total	**432.0**	**344.5**	**121.2**	**30.9**	**3,992.4**	**212.1**	**21.2**	**289,046.1**	**240.7**	**41.0**	**303,465.0**	**275,376.6**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative A-E

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage [b]	# of Days to Complete/ Year[c]	Emissions (tons/year)	
			PM_{10}	$PM_{2.5}$
Mechanical Treatments (Hand Work)	125	1	0.46	0.05
Prescribed Fire	1,875	1	6.88	0.69
Wild Fire	2,500	1	9.17	0.92
Coal Seam Fire	3	1	0.01	0.00
		Total	**16.51**	**1.65**

[a] Source: MCFO

[b] assume only 25% of treated acreage is disturbed by heavy equipment

[c] assume land area disturbed once, therefore input one day to complete for calculation purposes.

	Emission Factor [a] (tons/acre burned)								
Activity	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**SO_2**	**CO**	**VOC**	**CO_2 [b]**	**CH_4**	**N_2O**
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005

[b] no emission factor for CO2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Prescribed Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	1,875	165.76	144.87	47.08	12.91	1685.92	85.98	0.00	89.30	12.9375
Wild Fire and Coal Seam Fire	2,503	221.28	193.39	62.85	17.23	2250.59	114.78	0.00	119.20	17.2707
	Total	**387.04**	**338.26**	**109.93**	**30.14**	**3936.51**	**200.76**	**0.00**	**208.50**	**30.21**

[a] based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	4503.0	15	29.6	52.104	0.033	7,820.87	0	**0.98**	**0.10**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* assume roadway 12 feet wide for disturbance estimation.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation (not used)
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

ALTERNATIVE: Alternative A-E

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200	0	800	8100	2600	0	2680000	300	100
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.0	0.0	4.0	28.0	2.8	0.0	12600.0	0.0	0.4

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	82	1	80	8	20	5	640	544.13	62.19	14.80	448.87	53.30	0.27	0.03	0.01	0.22	0.03	0.03	34.41	0.00	0.00
	Chain Saw	6	10	50	8	20	5	4000	70.00	515.78	7.42	15,530.97	3,274.52	0.03	0.26	0.00	7.77	1.64	0.24	18.15	0.01	0.00
Prescribed Fire	Skid Steer Loader	82	1	80	4	2.0	5	32	27.21	3.11	0.74	22.44	2.66	0.01	0.00	0.00	0.01	0.00	0.00	1.72	0.00	0.00
	Chain Saw	6	4	50	4	2.0	5	80	1.40	10.32	0.15	310.62	65.49	0.00	0.01	0.00	0.16	0.03	0.00	0.36	0.00	0.00
	Pumps	25	6	95	5	2.0	5	285	73.87	8.44	2.01	60.94	7.24	0.04	0.00	0.00	0.03	0.00	0.00	4.67	0.00	0.00
Wild Fire	Dozer	100	2	80	8	0.5	115	736	802.69	61.14	18.86	300.09	71.51	0.40	0.03	0.01	0.15	0.04	0.03	43.84	0.00	0.00
	Chain Saw	6	20	50	6	3.0	115	20700	362.25	2,669.15	38.39	80,372.75	16,945.64	0.18	1.33	0.02	40.19	8.47	1.23	93.92	0.07	0.00
	Pumps	25	12	95	6	3.0	115	23598	6,116.76	699.08	166.39	5,045.98	599.14	3.06	0.35	0.08	2.52	0.30	0.34	386.77	0.00	0.00
Underground Coal Seam Fire	Excavator	100	1	80	8	5	3	96	99.54	11.38	2.71	82.11	9.75	0.05	0.01	0.00	0.04	0.00	0.01	6.29	0.00	0.00
	Water Tender	75	1	50	8	5	3	60	46.66	5.33	1.27	38.49	4.57	0.02	0.00	0.00	0.02	0.00	0.00	2.95	0.00	0.00
													Total	**4.07**	**2.02**	**0.13**	**51.11**	**10.52**	**1.88**	**593.08**	**0.09**	**0.01**

Activity data source: MCFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	46.5	2715	47	126248	13,291.87	0.00	1,195.30	8,623.41	1,045.84	6.65	0.00	0.60	4.31	0.52	0.00	276,488.89	30.75	10.31
					Total	13,351.58	0.00	1,200.17	8,668.51	1,058.24	**6.68**	**0.00**	**0.60**	**4.33**	**0.53**	**0.00**	**288,307.58**	**32.08**	**10.75**

Activity data source: MCFO, weighted average of Field personnel data survey response.

ALTERNATIVE: Alternative A-E

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source: MCFO
S = mean vehicle speed (mph)		Listed in the table	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA #AQ006
	PM_{10}	0.00047	EPA #AQ006
M = surface material moisture content (%)		2.0	EPA #AQ006
P = Number of days precip per year		80	EPA #AQ006
CE = emission control percent for watering unpaved roads [b]		50%	Source: MCFO

[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 Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	30	70	20	1,400	5.0	7000	0.67	2.33	3.49	0.07	0.23	0.35
	ATV	30	70	10	700	5.0	3500	0.67	1.16		0.07	0.12	
Prescribed Fires	Fire Truck	30	70	10	700	5.0	3500	0.67	1.16	2.68	0.07	0.12	0.27
	Fuel Truck	30	70	1	70	5.0	350	0.67	0.12		0.07	0.01	
	Water Truck	30	70	2	140	5.0	700	0.67	0.23		0.07	0.02	
	Support Truck	30	70	10	700	5.0	3500	0.67	1.16		0.07	0.12	
Wild Fires	Fire Truck	30	70	2	140	115.0	16100	0.67	5.36	18.75	0.07	0.53	1.87
	Fuel Truck	30	70	1	70	115.0	8050	0.67	2.68		0.07	0.27	
	Water Truck	30	70	2	140	115.0	16100	0.67	5.36		0.07	0.53	
	Support Truck	30	70	2	140	115.0	16100	0.67	5.36		0.07	0.53	
Coal Seam Fires	Support Truck	30	70	6	420	3.0	1260	0.67	0.42	0.42	0.07	0.04	0.04
								Total	**25.34**			**2.53**	

Source of activity data: MCFO

ALTERNATIVE: Alternative A-E

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04
Source: MOBILE6.2.03									

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	160	20	3,200	5.0	16,000	0.05	0.00	0.00	0.00	0.03	0.01	13.96	0.00	0.00
	ATV	R12S	70	10	700	5.0	3,500	0.00	0.01	0.01	0.00	0.18	0.19	0.54	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	160	10	1,600	5.0	8,000	0.02	0.00	0.00	0.00	0.02	0.00	6.98	0.00	0.00
	Fuel Truck	HDDV	160	1	160	5.0	800	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00
	Water Truck	HDDV	160	2	320	5.0	1,600	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00
	Support Truck	HDDV	160	10	1,600	5.0	8,000	0.02	0.00	0.00	0.00	0.02	0.00	6.98	0.00	0.00
Wild Fires	Fire Truck	HDDV	160	2	320	115.0	36,800	0.11	0.01	0.01	0.00	0.07	0.01	32.12	0.00	0.00
	Fuel Truck	HDDV	160	1	160	115.0	18,400	0.06	0.01	0.00	0.00	0.03	0.01	16.06	0.00	0.00
	Water Truck	HDDV	160	2	320	115.0	36,800	0.11	0.01	0.01	0.00	0.07	0.01	32.12	0.00	0.00
	Support Truck	HDDV	160	2	320	115.0	36,800	0.11	0.01	0.01	0.00	0.07	0.01	32.12	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	160	6	960	3.0	2,880	0.01	0.00	0.00	0.00	0.01	0.00	2.51	0.00	0.00
							Total	**0.50**	**0.06**	**0.05**	**0.00**	**0.50**	**0.25**	**145.49**	**0.01**	**0.01**

Activity data source: MCFO. Year 2008 emissions factors used (conservative).

Forest Products **Alternative A**

Total Annual Emissions from Forest and Woodlands Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	1.21	0.03	0.83	0.12	0.01	149.95	0.00	0.00	150.49	136.56
Sub-total: Heavy Equipment	**1.43**	**0.22**	**1.21**	**0.03**	**0.83**	**0.12**	**0.01**	**149.95**	**0.00**	**0.00**	**150.49**	**136.56**
Commuting Vehicles - Fugitive Dust	2.17	0.22	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.08	0.02	0.00	28.24	0.00	0.00	28.79	26.13
Sub-total: Commuting Vehicles	**2.18**	**0.22**	**0.10**	**0.00**	**0.08**	**0.02**	**0.00**	**28.24**	**0.00**	**0.00**	**28.79**	**26.13**
Total	**3.61**	**0.45**	**1.31**	**0.03**	**0.91**	**0.14**	**0.01**	**178.19**	**0.003**	**0.003**	**179.29**	**162.69**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative A

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, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	185	3,700	1	3.70	1.30	0.13
			Total	**3.70**	**1.30**	**0.13**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	185.0	15	29.6	52.104	0.033	321.31	0	**0.04**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* assume roadway 12 feet wide for disturbance estimation.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative A

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Forest Products	Skidder	205	1	70	8	17	136	202.35	23.13	5.50	166.92	19.82	1.0E-01	1.2E-02	2.8E-03	8.3E-02	9.9E-03	1.1E-02	1.3E+01	1.5E-04	1.3E-04
	Log Truck	450	2	60	10	17	340	888.48	49.82	23.34	356.46	45.20	4.4E-01	2.5E-02	1.2E-02	1.8E-01	2.3E-02	2.4E-02	5.4E+01	3.4E-04	6.1E-04
	Chainsaw	6	1	80	8	17	136	1.90	14.03	0.20	422.44	89.07	9.5E-04	7.0E-03	1.0E-04	2.1E-01	4.5E-02	6.5E-03	4.9E-01	3.9E-04	3.1E-06
	Feller Buncher	300	1	100	8	17	136	423.03	48.35	11.51	348.97	41.44	2.1E-01	2.4E-02	5.8E-03	1.7E-01	2.1E-02	2.3E-02	2.7E+01	3.1E-04	2.7E-04
	Loader	200	1	80	10	17	170	263.25	14.76	6.92	105.62	13.39	1.3E-01	7.4E-03	3.5E-03	5.3E-02	6.7E-03	7.2E-03	1.6E+01	1.0E-04	1.8E-04
	Dozer	200	1	90	8	17	136	236.93	13.29	6.22	95.05	12.05	1.2E-01	6.6E-03	3.1E-03	4.8E-02	6.0E-03	6.4E-03	1.4E+01	9.2E-05	1.6E-04
	Delimber	250	1	100	10	17	170	411.33	23.07	10.81	165.03	20.92	2.1E-01	1.2E-02	5.4E-03	8.3E-02	1.0E-02	1.1E-02	2.5E+01	1.6E-04	2.8E-04
												Total	**1.2E+00**	**9.3E-02**	**3.2E-02**	**8.3E-01**	**1.2E-01**	**9.0E-02**	**1.5E+02**	**1.5E-03**	**1.6E-03**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved ro		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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	70	17	1,190	1	1,190	0.61	0.36	2.17	0.06	0.04	0.22
	Log Truck	25	70	68	4,760	1	4,760	0.61	1.45		0.06	0.14	
	Pick-up Truck	25	70	17	1,190	1	1,190	0.61	0.36		0.06	0.04	
							Total		**2.17**			**0.22**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control (MCFO, 2010)

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	17	3,400	1	3,400	0.01	0.00	0.00	0.00	0.01	0.00	0.10	0.01	0.01	0.00	0.08	0.02	2.97	0.00	0.00
	Log Truck	HDDV	400	68	27,200	1	27,200	0.08	0.01	0.01	0.00	0.05	0.01							23.74	0.00	0.00
	Pick-up Truck	LDDT	200	17	3,400	1	3,400	0.01	0.00	0.00	0.00	0.02	0.01							1.53	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.08**	**0.02**	**0.10**	**0.01**	**0.01**	**0.00**	**0.08**	**0.02**	**28.24**	**0.0013**	**0.0017**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing — Alternative A

Total Annual Emissions from Livestock Grazing Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	1.37	0.14	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.50	0.48	7.27	0.17	3.15	0.55	0.05	775.33	0.01	0.01	778.2	**706.2**
Sub-total: Construction	**1.87**	**0.62**	**7.27**	**0.17**	**3.15**	**0.55**	**0.05**	**775.33**	**0.01**	**0.01**	**778.2**	**706.2**
Commuting Vehicles - Fugitive Dust	134.71	13.45	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.31	0.27	1.98	0.01	8.17	3.63	0.36	606.92	0.06	0.05	**623.6**	**565.9**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	2665.50	---	**55,975.6**	**50,794.5**
Sub-total: Operations and Maintenance	**135.02**	**13.71**	**1.98**	**0.01**	**8.17**	**3.63**	**0.36**	**606.92**	**2665.57**	**0.05**	**56,599.2**	**51,360.4**
Total	**136.89**	**14.34**	**9.25**	**0.18**	**11.32**	**4.17**	**0.42**	**1382.25**	**2665.57**	**0.06**	**57,377.4**	**52,066.6**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative A

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, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)		
			TSP	PM_{10}	$PM_{2.5}$
Springs	1.00	1	0.04	0.01	0.00
Reservoirs/Pits	37.00	1	0.52	0.18	0.02
Wells	3.00	1	0.12	0.04	0.00
Pipelines	48.00	1	1.92	0.67	0.07
Fences	30.00	1	1.20	0.42	0.04
Reservoirs Maintenance	1.00	1	0.04	0.01	0.00
		Total	**3.84**	**1.34**	**0.13**

[a] information from MCFO. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	120.0	15	29.6	52.104	0.033	208.42	0	**0.03**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:

p = number of days with > 0.001 in precipitation (not used)

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

ALTERNATIVE: Alternative A

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	2	2.00	32.0	15	2	0	12	2	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	40.00	960.0	3,888	236	85	1,645	247	1.94	0.12	0.04	0.82	0.12	0.11	198.02	0.00	0.00
	Scraper	650	1	70	8	3	40.00	960.0	5,054	306	111	2,138	321	2.53	0.15	0.06	1.07	0.16	0.15	257.43	0.00	0.00
Wells	Drill Rig	200	1	100	8	3	10.00	240.0	463	31	12	155	38	0.23	0.02	0.01	0.08	0.02	0.01	26.81	0.00	0.00
	Water Truck	200	1	70	8	3	10.00	240.0	324	22	8	108	27	0.16	0.01	0.00	0.05	0.01	0.01	18.77	0.00	0.00
Pipelines	Dozer	200	1	75	2	25	5.00	250.0	409	31	10	153	36	0.20	0.02	0.00	0.08	0.02	0.02	22.33	0.00	0.00
	Trencher	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
	Backhoe	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	25	8.00	1600.0	2,891	192	72	966	240	1.45	0.10	0.04	0.48	0.12	0.09	167.56	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	2	5.00	20.0	81	5	2	34	5	0.04	0.00	0.00	0.02	0.00	0.00	4.13	0.00	0.00
													Total	**7.27E+00**	**4.99E-01**	**1.67E-01**	**3.15E+00**	**5.45E-01**	**4.84E-01**	**7.75E+02**	**8.44E-03**	**8.81E-03**

Source for activity data: MCFO

all emissions calculated with year 2008 factors (conservative)

ALTERNATIVE: Alternative A

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a (S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = emission control percent for watering unpaved roads [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 Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	140	2	280	2.00	560	0.72	0.20	0.40	0.07	0.02	0.04
	Pick-up Truck	35	140	2	280	2.00	560	0.72	0.20		0.07	0.02	
Reservoirs/Pits	Tractor-Trailer	35	140	3	420	40.00	16800	0.72	6.04	12.08	0.07	0.60	1.21
	Pick-up Truck	35	140	3	420	40.00	16800	0.72	6.04		0.07	0.60	
Wells	Drill Truck	35	140	3	420	10.00	4200	0.72	1.51	6.04	0.07	0.15	0.60
	Support Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Water Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Pick-up Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
Pipelines	Tractor-Trailer	35	140	25	3500	5.00	17500	0.72	6.29	12.58	0.07	0.63	1.26
	Pick-up Truck	35	140	25	3500	5.00	17500	0.72	6.29		0.07	0.63	
Fences	Support Truck	35	140	25	3500	8.00	28000	0.72	10.06	30.19	0.07	1.00	3.01
	Pick-up Truck	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
	ATV	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
Reservoirs Maintenance	Tractor-Trailer	35	140	2	280	5.00	1400	0.72	0.50	1.01	0.07	0.05	0.10
	Pick-up Truck	35	140	2	280	5.00	1400	0.72	0.50		0.07	0.05	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	140	1087	152180	1.00	152180	0.72	54.70	54.70	0.07	5.46	5.46
	Pick-up-Trailer (spring calves)	35	140	352	49280	1.00	49280	0.72	17.71	17.71	0.07	1.77	1.77
								Total	**134.71**			**13.45**	

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked
for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load

ALTERNATIVE: Alternative A

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions														
								(tons/vehicle type)						(tons/year)								
								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_2O**
Springs	Tractor-Trailer	HDDV	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	1.05	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	300	3	900	40.00	36,000.0	0.11	0.01	0.01	0.00	0.07	0.01	0.15	0.01	0.01	0.00	1.02	0.06	31.42	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	40.00	36,000.0	0.04	0.00	0.00	0.00	0.95	0.04							18.92	0.00	0.00
Wells	Drill Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00	0.0920	0.0084	0.0070	0.0005	0.2890	0.0212	7.86	0.00	0.00
	Support Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Water Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	10.00	9,000.0	0.01	0.00	0.00	0.00	0.24	0.01							4.73	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	300	25	7500	5.00	37,500.0	0.11	0.01	0.01	0.00	0.07	0.01	0.16	0.01	0.01	0.00	1.06	0.06	32.73	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	5.00	37,500.0	0.05	0.00	0.00	0.00	0.99	0.04							19.71	0.00	0.00
Fences	Support Truck	HDDV	300	25	7500	8.00	60,000.0	0.18	0.02	0.02	0.00	0.11	0.02	0.27	0.14	0.13	0.00	4.86	3.32	52.37	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	8.00	60,000.0	0.07	0.00	0.00	0.00	1.59	0.07							31.54	0.00	0.00
	ATV	R12S	300	25	7500	8.00	60,000.0	0.02	0.12	0.11	0.00	3.16	3.22							9.27	0.03	0.01
Reservoirs Maintenance	Tractor-Trailer	HDDV	300	2	600	5.00	3,000.0	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.08	0.00	2.62	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	5.00	3,000.0	0.00	0.00	0.00	0.00	0.08	0.00							1.58	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	300	1087	326100	1.00	326,100.0	0.98	0.10	0.08	0.00	0.62	0.13	1.29	0.13	0.11	0.01	0.82	0.17	284.62	0.01	0.02
	Pcik-up-Trailer (spring calves)	HDDV	300	352	105600	1.00	105,600.0	0.32	0.03	0.03	0.00	0.20	0.04							92.17	0.00	0.01
													TOTAL	**1.98**	**0.31**	**0.27**	**0.01**	**8.17**	**3.63**	**606.92**	**0.06**	**0.05**

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load.

ALTERNATIVE: Alternative A

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	519,729	9.74	2530.28	0.37	95.48	2625.76
Horse	17,488	3.31	28.92	0.43	3.76	32.67
Sheep	9,291	1.47	6.83	0.05	0.24	7.07
					Total Methane emissions	**2665.50**

AUM numbers provided by Dawn Doran (per direction from Todd Yeager) on 7/5/2011.

Trails and Travel Management — Alternatives A-E

Total Annual Emissions from Trails and Travel Managment - Alternatives A-E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Recreation Vehicles - Fugitive Dust	291.60	29.10	---	---	---	---	---	---	---	---	---	---
Recreation Vehicles - Vehicle Exhaust	1.04	0.95	0.14	0.02	26.60	27.11	2.71	77.99	0.24	0.002	83.44	75.71
Sub-total: Vehicles	**292.64**	**30.06**	**0.14**	**0.02**	**26.60**	**27.11**	**2.71**	**77.99**	**0.24**	**0.00**	**83.44**	**75.71**
Total	**292.64**	**30.06**	**0.14**	**0.02**	**26.60**	**27.11**	**2.71**	**77.99**	**0.236**	**0.002**	**83.44**	**75.71**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternatives A-E

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	

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

Fugitive Dust Emission Estimations for Recreation Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activity/ Year	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
								Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ year)	Controlled Em. Factor (lb/VMT)	Emissions (tons/vehicle type)	Emissions (tons/ year)
Recreation	ATV	15	70	2	140	2017	282,380	1.22	171.56	291.60	0.12	17.12	29.10
	Off-Road Motorcyles	25	100	2	200	988	197,600	1.22	120.05		0.12	11.98	
							Total		**291.60**			**29.10**	

Source of activity data: MCFO
No emissions control applied.

ALTERNATIVE: Alternatives A-E

Emission Factors for Off-Road Recreation Vehicles

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Recreation Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Activity	Vehicle Miles Traveled per Activity	# of Activity per Year	Total Annual Vehicle Miles Traveled per Activity	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Recreation	ATV	R12S	70	2	140	2017	282,380	0.08	0.58	0.53	0.01	14.88	15.16	43.63	0.13	0.00
	Off-Road Motorcyles	R12S	100	2	200	988	197,600	0.05	0.41	0.37	0.01	10.41	10.61	30.53	0.09	0.00
	Snowmobiles	R12S	120	1	120	207	24,840	0.01	0.05	0.05	0.00	1.31	1.33	3.84	0.01	0.00
							Total	**1.39E-01**	**1.04E+00**	**9.53E-01**	**1.55E-02**	**2.66E+01**	**2.71E+01**	**7.80E+01**	**2.36E-01**	**1.58E-03**

Source of activity data: MCFO

[a] All recreation vehicles are assumed gasoline-powered.

General Purpose Travel - BLM Fleet Alternative A

Total Annual Emissions from General Purpose BLM Travel - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Commuting Vehicles - Fugitive Dust	74.58	7.44	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.08	0.06	1.61	0.00	4.35	1.91	0.19	285.28	0.00	0.04	296.75	269.29
Sub-total: Commuting Vehicles	**74.66**	**7.50**	**1.61**	**0.00**	**4.35**	**1.91**	**0.19**	**285.28**	**0.00**	**0.04**	**296.75**	**269.29**
Total	**74.66**	**7.50**	**1.61**	**0.00**	**4.35**	**1.91**	**0.19**	**285.28**	**0.00**	**0.04**	**296.75**	**269.29**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads [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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/fleet group)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/fleet group)	$PM_{2.5}$ Emissions (tpy)
General Purpose BLM Travel	DM/FM Staff	25	3,170	0.61	0.96	74.58	0.06	0.10	7.44
	Support Services	25	26,283	0.61	7.98		0.06	0.80	
	Fire Management	45	110,972	0.61	33.71		0.06	3.36	
	Minerals and NRR	15	54,231	0.47	12.76		0.05	1.27	
	Renewable Resources	25	63,088	0.61	19.16		0.06	1.91	
		Total	**257,744**	**Total**	**74.58**			**7.442**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control.

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions (tons/fleet group)						Emissions (tpy)								
				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_2O
General Purpose BLM Travel	DM/FM Staff	LDDT	21,132	0.05	0.00	0.00	0.00	0.15	0.06	1.61	0.08	0.06	0.00	4.35	1.91	9.54	0.00	0.00
	Support Services	LDDT	75,094	0.19	0.01	0.01	0.00	0.52	0.23							33.90	0.00	0.00
	Fire Management	LDDT	197,284	0.50	0.02	0.02	0.00	1.36	0.60							89.05	0.00	0.01
	Minerals and NRR	LDDT	180,771	0.46	0.02	0.02	0.00	1.24	0.55							81.60	0.00	0.01
	Renewable Resources	LDDT	157,720	0.40	0.02	0.02	0.00	1.09	0.48							71.19	0.00	0.01
			Total	**1.6107**	**0.0757**	**0.0617**	**0.00390**	**4.35**	**1.91370**	**1.61E+00**	**7.57E-02**	**6.17E-02**	**3.90E-03**	**4.35E+00**	**1.91E+00**	**2.85E+02**	**1.39E-03**	**3.69E-02**

Source of activity data: MCFO

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance **Alternative A**

Total Annual Emissions from Road Maintenance Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.45	0.21	1.24	0.03	0.49	0.08	0.01	146.71	0.00	0.00	147.25	133.62
Total	**1.45**	**0.21**	**1.24**	**0.03**	**0.49**	**0.08**	**0.01**	**146.71**	**0.0012**	**0.0017**	**147.25**	**133.62**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative A

Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	115

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^{2}$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)

Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[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.

* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	192	5	960	0.765	0.37	0.069	0.03
Road Maintenance	Semi-truck	28	20	56	1.09	0.03	0.11	0.00
Road Maintenance	Lowboy Trailer	---	20	756	1.09	0.41	0.11	0.04
				Total	**0.81**		**0.08**	

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	1	0.10	72	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00
Backhoe	87	1	0.80	133	0.05	0.00	0.00	0.02	0.00	0.00	5.51	0.00	0.00
Semi-truck	450	1	0.50	280	0.30	0.02	0.01	0.12	0.02	0.02	37.20	0.00	0.00
Lowboy Trailer	450	1	0.50	378	0.41	0.02	0.01	0.16	0.02	0.02	50.21	0.00	0.00
Bobcat	82	1	0.80	188	0.07	0.01	0.00	0.03	0.01	0.00	7.34	0.00	0.00
Grader	165	1	0.90	192	0.16	0.01	0.00	0.06	0.01	0.01	16.97	0.00	0.00
Loader	200	1	0.75	148	0.12	0.01	0.00	0.05	0.01	0.01	13.21	0.00	0.00
Dump Truck	350	1	0.50	142	0.12	0.01	0.00	0.05	0.01	0.01	14.71	0.00	0.00
Airport Forklift	100	1	0.10	16	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Snowplow	350	1	0.25	20	0.01	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Total					**1.2E+00**	**7.8E-02**	**3.2E-02**	**4.9E-01**	**7.8E-02**	**7.5E-02**	**1.5E+02**	**1.2E-03**	**1.7E-03**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2577.3	15	29.6	52.104	0.033	4,476.30	0	**0.56**	**0.06**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Appendix B

Alternative B Emission Inventory

Summary of Emissions.....B-1

Oil Development and Production.....B-2

Natural Gas Development and Production.....B-29

Coal Bed Methane Natural Gas Development and Production B-54

Coal Mining ..... (*see pages A-77 through A-78*)

Vegetation Management ..... (*see pages A-79 through A-83*)

Fire Management ..... (*see pages A-84 through A-88*)

Forestry and Woodland Products.....B-77

Livestock Grazing.....B-82

Recreation, Trails, and Travel Management ..... (*see pages A-100 through A-102*)

General Purpose BLM Fleet Travel.....B-88

Road Maintenance B-91

Alternative B Summary

MCFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)											Emissions (mtpy)
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq}
Federal / BLM												
Oil and Gas												
Oil	39.5	16.6	129.3	0.0	4.2	1.1	8.2	4,015.7	21.3	0.0	4,470.8	4,055
Natural Gas	15.1	6.2	4.2	0.0	1.0	0.4	0.4	1,529.1	20.2	0.0	1,949.9	1,769
CBNG	6.7	3.4	2.3	0.0	0.9	0.2	0.4	545.3	11.1	0.0	778.3	706
Coal Mining [1]	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	14.4	104,029.1	0.6	1.0	104,364.7	94,662
Vegetation Management	11.3	0.1	3.1	0.0	10.7	1.4	0.3	33.9	0.0	0.0	34.8	32
Fire Management [2]	1,741.9	58.3	97.3	13.6	210.7	151.1	9.7	289,046.1	121.5	23.7	298,943.9	271,151
Forestry and Woodland Products	0.2	0.1	0.0	0.0	0.5	0.1	0.0	8.7	0.0	0.0	8.8	8
Livestock Grazing	11.3	9.3	4.2	0.2	136.9	14.3	0.4	1,382.3	2,457.6	0.1	53,010.4	48,082
Recreation - Trails and Travel Management	26.6	0.1	27.1	0.0	292.6	30.1	2.7	78.0	0.2	0.0	83.4	76
General Purpose BLM Fleet Travel	4.3	1.6	1.9	0.0	73.7	7.4	0.2	281.7	0.0	0.0	293.0	266
Road Maintenance	0.5	1.3	0.1	0.0	1.5	0.2	0.0	153.8	0.0	0.0	154.3	140
Federal Emission Total	**3,978.4**	**1,914.4**	**413.7**	**193.7**	**5,181.1**	**651.1**	**36.8**	**401,103.7**	**2,632.5**	**24.9**	**464,092.3**	**420,945**
Non-Federal												-
Oil and Gas	3,583.1	2,924.4	8,964.5	46.0	417.1	163.3	597.2	359,291.3	3,292.7	1.1	428,304.3	388,485
Coal Mining [1]	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	15.7	143,391.0	0.9	1.4	143,853.6	130,479
Non-Federal Emission Total	**6,607.9**	**5,308.2**	**9,121.2**	**246.7**	**4,838.6**	**644.5**	**612.8**	**502,682.3**	**3,293.5**	**2.5**	**572,157.9**	**518,964**

tpy = short tons per year

mtpy = metric tons per year

1. In available air quality permits for coal mines located in the MCFO, total suspended particulate (TSP) is usually reported and PM10 and/or PM2.5 may be reported. In permits containing only TSP emissions, all TSP was assumed to be PM10. This assumption overestimates PM10 emissions. If PM10 was reported and PM2.5 was not reported, PM2.5 was assumed to equal 10 percent of PM2.5. With regard to greenhouse gases, coal mine emissions do not include ventilation emissions or emissions associated with electricity provided to the mine.

2. Excludes smoke emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	33,634	38,897	5,713	17,023	24,469	3,772
Alt. A O&G (%) of NEI Emissions	0.2%	0.1%	2.4%	0.0%	0.0%	0.0%
Alt. A (%) of NEI Emissions	11.8%	4.9%	7.2%	1.1%	21.2%	17.3%

County Emissions (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties).

Source: EPA 2008 National Emission Inventory (NEI), http://neibrowser.epa.gov/eis-public-web/geo/county-emissions.html?stateJurisdictionId=28&inventoryYear=2008, accessed December 12, 2011.

Alternative B input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	3	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	136
Federal Producing Wells - RMP Year 20	32	Non-Federal Producing Wells - RMP Year 20	2,109
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 5% full RFD estimates (rounded to next highest number) for Federal, full RFD estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.12	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.09	0.10	1.56	0.02	8.22	0.44	0.04	1640.65	0.02	0.02	1646.81	1494.39
Commuting Vehicles - Construction	1.36	0.14	0.04	0.00	0.05	0.02	0.00	10.01	0.00	0.00	10.23	9.29
Wind Erosion	0.03	0.01	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**1.60**	**0.25**	**1.59**	**0.02**	**8.26**	**0.45**	**0.05**	**1,650.66**	**0.02**	**0.02**	**1,657.05**	**1,503.67**
Well Workover Operations - Fugitive Dust	0.14	0.01	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.01	0.01	0.19	0.00	1.65	0.09	0.01	336.24	0.00	0.00	337.53	306.29
Well Workover Operations - On-road Exhaust	0.00	0.00	0.00	0.00	0.01	0.00	0.000	0.99	0.00	0.00	1.02	0.93
Well Visits for Inspection & Repair - Operations	0.15	0.02	0.00	0.00	0.10	0.00	0.000	2.02	0.00	0.00	2.26	2.05
Recompletion Traffic	0.24	0.02	0.01	0.00	0.01	0.01	0.00	2.01	0.00	0.00	2.06	1.87
Water Tanks & Traffic	0.63	0.07	0.05	0.00	0.03	0.01	0.00	15.68	3.66	0.00	92.53	83.97
Oil Tanks & Traffic	0.51	0.05	0.03	0.00	0.02	113.15	6.52	16.04	12.90	0.00	286.89	260.34
Venting	---	---	---	---	---	1.79	0.15	0.06	2.24	0.00	47.17	42.81
Compression and Well Pumps	0.65	0.65	14.68	0.01	29.35	10.27	1.03	1,980.49	0.04	0.00	1982.43	1798.94
Dehydrators	0.00	0.00	0.00	0.00	0.00	3.36	0.42	2.17	2.25	0.00	49.49	44.91
Compression Station Fugitives	---	---	---	---	---	0.11	0.01	0.00	0.14	0.00	2.96	2.69
Sub-total: Operations	**2.34**	**0.83**	**14.98**	**0.01**	**31.19**	**128.80**	**8.13**	**2,355.71**	**21.23**	**0.01**	**2,804.35**	**2,544.78**
Road Maintenance	0.28	0.03	0.07	0.002	0.04	0.01	0.001	9.03	0.00	0.00	9.10	8.25
Sub-total: Maintenance	**0.28**	**0.03**	**0.07**	**0.002**	**0.04**	**0.01**	**0.001**	**9.031**	**0.000**	**0.00**	**9.10**	**8.25**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
Well Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.29	0.27
Sub-total: Reclamation	**0.01**	**0.00**	**0.00**	**0.0001**	**0.00**	**0.000**	**0.0000**	**0.3018**	**0.0000**	**0.0000**	**0.3035**	**0.2754**
Total Emissions	**4.23**	**1.12**	**16.64**	**0.03**	**39.49**	**129.27**	**8.18**	**4,015.70**	**21.25**	**0.03**	**4,470.80**	**4,056.98**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	5.24	0.52	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	36.18	35.16	691.10	14.35	177.48	50.50	5.05	74376.25	0.77	0.02	74398.18	67511.96
Commuting Vehicles - Construction	61.54	6.26	1.74	0.01	2.06	0.72	0.07	453.79	0.02	0.00	454.38	412.32
Wind Erosion	1.55	0.23	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**104.50**	**42.18**	**692.84**	**14.36**	**179.54**	**51.22**	**5.12**	**74,830.04**	**0.79**	**0.02**	**74,852.56**	**67,924.28**
Well Workover Operations - Fugitive Dust	9.12	0.91	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	15.92	15.44	280.07	4.77	94.09	20.27	2.03	22160.21	0.31	0.25	22245.21	20186.21
Well Workover Operations - On-road Exhaust	0.02	0.02	0.29	0.00	0.52	0.21	0.021	65.37	0.00	0.01	67.20	60.98
Well Visits for Inspection & Repair - Operations	10.21	1.02	0.31	0.00	6.69	0.30	0.030	133.04	0.02	0.05	148.87	135.09
Recompletion Traffic	15.70	1.60	0.56	0.00	0.88	0.34	0.03	132.65	0.00	0.01	136.08	123.48
Water Tanks & Traffic	41.71	4.41	3.55	0.02	2.25	0.46	0.05	1,033.64	241.07	0.01	6098.52	5534.04
Oil Tanks & Traffic	33.83	3.54	2.30	0.01	1.46	7,457.30	429.76	1,057.07	849.96	0.01	18907.79	17157.71
Venting	---	---	---	---	---	94.03	7.64	3.06	117.76	0.00	2476.06	2246.88
Compression and Well Pumps	42.88	42.88	967.32	0.66	1,934.64	677.13	67.71	130,526.52	2.46	0.25	130654.54	118561.29
Dehydrators	0.01	0.01	0.12	0.00	0.10	221.75	27.48	143.24	148.47	0.00	3261.85	2959.94
Compression Station Fugitives	---	---	---	---	---	7.41	0.74	0.24	9.28	0.00	195.19	177.12
Sub-total: Operations	**169.41**	**69.83**	**1,254.52**	**5.46**	**2,040.62**	**8,479.20**	**535.49**	**155,255.04**	**1,369.33**	**0.58**	**184,191.30**	**167,142.74**
Road Maintenance	18.37	2.02	4.68	0.121	2.39	0.73	0.073	595.18	0.01	0.01	599.48	543.99
Sub-total: Maintenance	**18.37**	**2.02**	**4.68**	**0.121**	**2.39**	**0.73**	**0.073**	**595.185**	**0.006**	**0.01**	**599.48**	**543.99**
Road Reclamation	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.67	0.61
Well Reclamation	0.64	0.08	0.08	0.00	0.09	0.02	0.00	19.22	0.00	0.00	19.34	17.55
Sub-total: Reclamation	**0.67**	**0.08**	**0.08**	**0.0035**	**0.09**	**0.020**	**0.0020**	**19.8879**	**0.0003**	**0.0004**	**20.0039**	**18.1523**
Total Emissions	**292.95**	**114.11**	**1,952.12**	**19.94**	**2,222.64**	**8,531.17**	**540.69**	**230,700.15**	**1,370.13**	**0.61**	**259,663.34**	**235,629.17**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

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)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**7.70E+01**	**7.70E+00**	**3.85E-02**	**3.85E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.030	0.0051	2.60	0.14	0.03	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	53	9	4,622	249	0.44	0.03	0.00	2.31	0.12	0.03	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	1	330	18	0.02	0.00	0.00	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	600	1	50	11	5	55	1	11	1	0	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	0	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	**4.91E-01**	**2.87E-02**	**5.23E-03**	**2.72E+00**	**1.43E-01**	**2.87E-02**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.19E-01**	**3.16E-02**	**5.99E-03**	**2.74E+00**	**1.46E-01**	**3.20E-02**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
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, Fracing & 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 (%)[b]**	**# 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	**5.05E+00**	**2.63E-01**	**1.05E-01**	**1.29E+00**	**3.69E-01**	**2.55E-01**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.08E+00**	**2.66E-01**	**1.05E-01**	**1.30E+00**	**3.71E-01**	**2.59E-01**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	0.27	129.02	0.06	0.07	0.03	12.90	0.01	0.01
	Pickup Trucks	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.27	13.73	0.01	0.01	0.03	1.37	0.00	0.00
	Pickup Trucks	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.27	5.49	0.00	0.01	0.03	0.55	0.00	0.00
	Haul Trucks	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Pickup Trucks	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.27	120.78	0.06	0.14	0.03	12.08	0.01	0.01
	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Tool Pusher	25	10	8	80	1	0.22	17.39	0.01		0.02	1.74	0.00	
	Mud Logger	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Engineer	25	10	15	150	1	0.22	32.60	0.02		0.02	3.26	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.27	16.47	0.01	0.02	0.03	1.65	0.00	0.00
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
									Subtotal	**2.47E-01**				**2.47E-02**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00	0.20	0.02	0.65	0.00	0.02
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Welders	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Haul Water Truck	25	10	150	1500	1	0.22	326.03	0.16		0.02	32.60	0.02	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**2.05E-01**				**2.05E-02**
									Total	**4.51E-01**				**4.51E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	10	47	470	1	2.8142	0.2851	0.2380	0.0137	1.7832	0.3668	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.001	0.000	0.000	0.000	0.001	0.000	0.4	0.0000	0.0000
	Pickup Trucks	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	4	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Haul Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	1	10	1	0.0510	0.0024	0.0020	0.0001	0.1377	0.0606	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																		Subtotal	**1.88E-03**	**1.79E-04**	**1.50E-04**	**8.64E-06**	**1.61E-03**	**4.61E-04**	**5.25E-01**	**2.30E-05**	**3.20E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	10	44	440	1	2.6346	0.2669	0.2228	0.0128	1.6694	0.3434	0.0013	0.0001	0.0001	0.0000	0.0008	0.0002	0.00	0.00	0.00	0.00	0.01	0.00	0.4	0.0000	0.0000
	Fuel Haul Truck	HDDV	10	6	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	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Tool Pusher	LDDT	10	8	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							0.0	0.0000	0.0000
	Mud Logger	LDDT	10	6	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							0.0	0.0000	0.0000
	Mud Engineer	LDDT	10	15	150	1	0.7646	0.0359	0.0293	0.0019	2.0658	0.9084	0.0004	0.0000	0.0000	0.0000	0.0010	0.0005							0.1	0.0000	0.0000
	Logger, Engr Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	10	6	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	0.0000	0.0000
	Haul Water Truck	HDDV	10	150	1500	1	8.9815	0.9101	0.7596	0.0437	5.6911	1.1706	0.0045	0.0005	0.0004	0.0000	0.0028	0.0006							1.3	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**1.09E-02**	**9.31E-04**	**7.74E-04**	**4.52E-05**	**1.36E-02**	**4.82E-03**	**2.81E+00**	**1.08E-04**	**1.99E-04**
																	Total		**1.28E-02**	**1.11E-03**	**9.23E-04**	**5.38E-05**	**1.52E-02**	**5.28E-03**	**3.34E+00**	**1.31E-04**	**2.31E-04**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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_2O[a]
Diesel	0.30	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	k (s/12)[a] (W/3)[a]	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 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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	10	12	120	1	0.08	9.68	**4.84E-03**	0.01	0.96	**4.82E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	10	12	120	1	0.30	0.01	0.00	0.00	6.34	0.28	**1.49E-04**	**3.35E-06**	**1.55E-06**	**1.16E-06**	**3.17E-03**	**1.42E-04**	**6.31E-02**	**8.99E-06**	**2.36E-05**

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for 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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	1.0	60	0.08	4.84	**2.42E-03**	0.01	0.48	**2.41E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

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 (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	1.0	60	**1.53E-04**	**7.19E-06**	**5.85E-06**	**3.70E-07**	**4.13E-04**	**1.82E-04**	**2.71E-02**	**1.32E-07**	**3.51E-06**

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	10	56	562	1	0.07	39.21	**1.96E-02**	0.01	3.90	**1.95E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	10	56	562	1	3.362	0.341	0.284	0.016	2.131	0.438	**1.68E-03**	**1.70E-04**	**1.42E-04**	**8.17E-06**	**1.07E-03**	**2.19E-04**	**4.90E-01**	**2.29E-05**	**3.75E-06**

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other 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/10^3 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[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] 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)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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														
							(lb/well)						(tpy/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_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	10	37	365	1	2.185	0.221	0.185	0.011	1.385	0.285	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.319	0.000	0.000
						TOTAL							**1.09E-03**	**1.11E-04**	**9.24E-05**	**5.31E-06**	**6.92E-04**	**1.42E-04**	**3.19E-01**	**1.49E-05**	**2.44E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a]	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-HA	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**

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

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)[a] (W/3)[b]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01	0.15	0.02	1.30	0.00	0.01
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Water Truck	25	10	50	500	1	0.22	108.68	0.05		0.02	10.87	0.01	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**1.49E-01**				**1.49E-02**
									Total	**1.49E-01**				**1.49E-02**

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_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Well Recompletion	Fuel Haul Truck	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	10	50	500	1	2.9938	0.3034	0.2532	0.0146	1.8970	0.3902	0.0015	0.0002	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**
																	Total		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	20	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.054	MMSCF/well

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		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]	N_2O[c]
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

[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 and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

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	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O 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_2 emissions per well (lb/hr)	CH_4 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
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
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	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	1.63E-03	2.44E-04
								TOTAL	**1.14E-02**	**1.71E-03**

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	0.250
Number of Roads Reclaimed Annually Per Well	0.021
Annual Miles of Roads reclaimed Per Well	0.005
Number of wells reclaimed (per well)	0.021

Reclaimation 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
0.005	6	0.0009	0.0090
		Total	**0.0090**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.005	5	0.027	0.765	**1.03E-05**	0.069	**9.31E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Road Reclamation	Grader	80	0.005	0.4238	0.0720	0.0197	0.4106	0.0629	**1.14E-06**	**1.93E-07**	**5.28E-08**	**1.10E-06**	**1.69E-07**	**1.88E-07**	**2.91E-04**	**2.61E-09**	**2.87E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0009	0.0537	0.081	**2.17E-06**	0.008	**2.16E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0009	0.0537	**1.37E-07**	**6.44E-09**	**5.24E-09**	**3.32E-10**	**3.70E-07**	**1.63E-07**	**2.42E-05**	**1.18E-10**	**3.14E-09**

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	0.021	10	0.021	0.21

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.1289	5	0.645	0.765	**2.47E-04**	0.069	**2.23E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.1289	0.5297	0.0900	0.0246	0.5132	0.0786	**3.41E-05**	**5.80E-06**	**1.58E-06**	**3.31E-05**	**5.06E-06**	**9.00E-06**	**8.53E-03**	**1.42E-07**	**8.60E-08**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.0215	1.2891	0.081	**5.20E-05**	0.008	**5.17E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.0215	1.2891	**3.29E-06**	**1.54E-07**	**1.26E-07**	**7.96E-09**	**8.88E-06**	**3.90E-06**	**5.82E-04**	**2.84E-09**	**7.53E-08**

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

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)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Alternative B input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	2	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	111
Federal Producing Wells - RMP Year 20	27	Non-Federal Producing Wells - RMP Year 20	1,747
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 5% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.02	0.00	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.02	0.02	0.33	0.01	2.45	0.13	0.01	475.95	0.00	0.01	477.70	433.49
Commuting Vehicles - Construction	0.36	0.04	0.01	0.00	0.01	0.00	0.00	2.67	0.00	0.00	2.73	2.48
Wind Erosion	0.01	0.00	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.03	0.00	0.02	4.53	0.00	95.24	86.43
Sub-total: Construction	**0.41**	**0.06**	**0.34**	**0.01**	**2.46**	**0.17**	**0.01**	**478.63**	**4.54**	**0.01**	**575.68**	**522.39**
Well Workover Operations - Fugitive Dust	0.05	0.00	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.01	0.01	0.16	0.00	1.39	0.08	0.01	284.08	0.00	0.00	285.12	258.73
Well Workover Operations - On-road Exhaust	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.33	0.00	0.00	0.34	0.31
Well Visits for Inspection & Repair - Operations	0.05	0.01	0.00	0.00	0.03	0.00	0.000	0.68	0.00	0.00	0.76	0.69
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.07	0.01	0.03	9.55	0.00	200.60	182.03
Compression	0.25	0.25	5.58	0.00	11.16	3.91	0.39	753.10	0.01	0.00	753.84	684.06
Station Visits - Operations	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.19	0.18
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.01	0.00	4.08	6.12	0.00	132.67	120.39
Sub-total: Operations	**0.37**	**0.27**	**5.75**	**0.01**	**12.60**	**4.07**	**0.41**	**1,042.49**	**15.69**	**0.01**	**1,373.53**	**1,246.39**
Road Maintenance	0.20	0.02	0.06	0.002	0.03	0.01	0.001	7.28	0.00	0.00	7.32	6.64
Sub-total: Maintenance	**0.20**	**0.02**	**0.06**	**0.002**	**0.03**	**0.01**	**0.001**	**7.278**	**0.000**	**0.00**		**6.64**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.02
Well Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.69	0.62
Sub-total: Reclamation	**0.02**	**0.00**	**0.00**	**0.0001**	**0.00**	**0.001**	**0.0001**	**0.7081**	**0.0000**	**0.0000**	**0.7122**	**0.6463**
Total Emissions	**1.01**	**0.35**	**6.15**	**0.01**	**15.09**	**4.24**	**0.42**	**1,529.10**	**20.23**	**0.01**	**1,949.91**	**1,776.07**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.33	1.38	97.35	0.33	135.75	7.16	0.72	26401.82	0.27	0.01	26409.19	23964.78
Commuting Vehicles - Construction	20.09	2.05	0.57	0.00	0.67	0.23	0.02	148.15	0.01	0.00	148.33	134.60
Wind Erosion	0.36	0.05	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	1.93	0.00	0.85	251.67	0.00	5285.97	4796.70
Sub-total: Construction	**23.12**	**3.62**	**97.92**	**0.34**	**136.42**	**9.32**	**0.74**	**26,550.82**	**251.95**	**0.01**	**31,843.48**	**28,896.08**
Well Workover Operations - Fugitive Dust	3.02	0.30	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	13.19	12.79	232.00	3.95	77.94	16.79	1.68	18356.52	0.26	0.21	18426.92	16721.34
Well Workover Operations - On-road Exhaust	0.01	0.01	0.10	0.00	0.17	0.07	0.007	21.66	0.00	0.00	22.27	20.20
Well Visits for Inspection & Repair - Operations	3.38	0.34	0.10	0.00	2.22	0.10	0.010	44.08	0.01	0.02	49.33	44.76
Wellhead and Compressor Station Fugitives	---	---	---	---	---	4.74	0.47	2.08	617.97	0.00	12979.55	11778.18
Compression	16.01	16.01	361.12	0.25	722.24	252.78	25.28	48,728.20	0.92	0.09	48775.99	44261.33
Station Visits - Operations	1.08	0.11	0.07	0.00	0.18	0.08	0.01	12.03	0.00	0.00	12.51	11.36
Dehydrators	0.02	0.01	0.22	0.00	0.18	0.56	0.26	263.67	396.14	0.00	8584.21	7789.66
Sub-total: Operations	**36.70**	**29.57**	**593.61**	**4.20**	**802.93**	**275.12**	**27.72**	**67,428.23**	**1,015.30**	**0.33**	**88,850.78**	**80,626.84**
Road Maintenance	13.24	1.47	3.75	0.100	1.64	0.46	0.046	470.94	0.00	0.01	473.61	429.78
Sub-total: Maintenance	**13.24**	**1.47**	**3.75**	**0.100**	**1.64**	**0.46**	**0.046**	**470.944**	**0.005**	**0.01**		**429.78**
Road Reclamation	0.06	0.01	0.01	0.00	0.01	0.00	0.00	1.53	0.00	0.00	1.54	1.40
Well Reclamation	1.48	0.18	0.18	0.01	0.20	0.04	0.00	44.29	0.00	0.00	44.54	40.42
Sub-total: Reclamation	**1.54**	**0.18**	**0.19**	**0.0080**	**0.21**	**0.045**	**0.0045**	**45.8160**	**0.0007**	**0.0008**	**46.0831**	**41.8177**
Total Emissions	**74.60**	**34.84**	**695.47**	**4.64**	**941.21**	**284.95**	**28.51**	**94,495.81**	**1,267.25**	**0.34**	**120,740.34**	**109,994.52**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**24**	**2.41**	**1.21E-02**	**1.21E-03**

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

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (non-genset)	2.30	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	4	1,849	100	0.11	0.01	0.00	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	5.73E-03	3.60E-05	8.35E-06	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	**1.38E-01**	**6.64E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**6.64E-03**	**2.34E+02**	**1.80E-03**	**2.67E-03**
												Total		**1.66E-01**	**9.51E-03**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**9.96E-03**	**2.38E+02**	**1.85E-03**	**2.71E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	1,636	16	4	1,849	100	0.82	0.01	0.00	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**8.49E-01**	**9.13E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
												Total		**8.77E-01**	**1.20E-02**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**1.25E-02**	**2.38E+02**	**2.44E-03**	**2.71E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	4	47	188	1	0.27	51.61	0.03	0.026	0.03	5.16	0.00	0.003
	Pickup Trucks	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
Well Pad	Semi Trucks	42	4	5	20	1	0.27	5.49	0.00	0.004	0.03	0.55	0.00	0.000
	Pickup Trucks	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
Other Construction Activities	Semi Trucks	42	4	2	8	1	0.27	2.20	0.00	0.002	0.03	0.22	0.00	0.000
	Haul Trucks	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Pickup Trucks	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	4	44	176	1	0.27	48.31	0.02	0.058	0.03	4.83	0.00	0.006
	Fuel Haul Truck	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Haul Truck, Water Hauling	25	4	4	16	1	0.22	3.48	0.00		0.02	0.35	0.00	
	Rig Crew	5	4	51	204	1	0.11	21.49	0.01		0.01	2.15	0.00	
	Rig Mechanics	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Co. Supervisor	5	4	20	80	1	0.11	8.43	0.00		0.01	0.84	0.00	
	Tool Pusher	25	4	8	32	1	0.22	6.96	0.00		0.02	0.70	0.00	
	Mud Logger	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Engineer	25	4	15	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Logger, Engr Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Drill Bit Delivery	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	4	6	24	1	0.27	6.59	0.00	0.009	0.03	0.66	0.00	0.001
	Semi Completion, Unit Rig	42	4	1	4	1	0.27	1.10	0.00		0.03	0.11	0.00	
	Semi Fracing, Blender	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Semi Pumping/Tank Battery	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Tubing Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Cementer, Pump Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
									Subtotal	**9.86E-02**				**9.86E-03**

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 (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)
Well Completion, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	4	3	12	1	0.22	2.61	0.00	0.082	0.02	0.26	0.00	0.008
	Haul Completion,	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Service Tools	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Perforators Logging Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Installation	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Testing	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Tank	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Pump	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Chemical	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Sand	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Other	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Welders	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Haul Water Truck	25	4	150	600	1	0.22	130.41	0.07		0.02	13.04	0.01	
	Pickup Cementer, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Casing Crew	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Completion Crew	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion, Pusher	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Perforators, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Fracing, Engineer	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
	Pickup Co. Supervisor	5	4	10	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
	Pickup Miscellaneous Supplies	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
	Pickup Roustabout Crew	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
									Subtotal	**8.19E-02**				**8.19E-03**
									Total	**1.81E-01**				**1.81E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	4	47	188	1	1.1257	0.1141	0.0952	0.0055	0.7133	0.1467	0.0006	0.0001	0.0000	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.000	0.000	0.1641	0.000008	0.000009
	Pickup Trucks	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0054	0.000000	0.000001
Well Pad	Semi Trucks	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0175	0.000001	0.000001
	Pickup Trucks	LDDT	4	4	16	1	0.0816	0.0038	0.0031	0.0002	0.2204	0.0969	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0072	0.000000	0.000001
Other Construction Activities	Semi Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0070	0.000000	0.000000
	Haul Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0070	0.000000	0.000000
	Pickup Trucks	LDDT	4	1	4	1	0.0204	0.0010	0.0008	0.0000	0.0551	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0018	0.000000	0.000000
																		Subtotal	**7.52E-04**	**7.18E-05**	**5.98E-05**	**3.46E-06**	**6.45E-04**	**1.84E-04**	**2.10E-01**	**9.21E-06**	**1.28E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	4	44	176	1	1.0538	0.1068	0.0891	0.0051	0.6678	0.1374	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.000007	0.000009
	Fuel Haul Truck	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Mud Haul Truck, Water Hauling	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Rig Crew	LDDT	4	51	204	1	1.0398	0.0489	0.0398	0.0025	2.8095	1.2354	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Rig Mechanics	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Co. Supervisor	LDDT	4	20	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							0.0	0.000000	0.000005
	Tool Pusher	LDDT	4	8	32	1	0.1631	0.0077	0.0062	0.0004	0.4407	0.1938	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000002
	Mud Logger	LDDT	4	6	24	1	0.1223	0.0058	0.0047	0.0003	0.3305	0.1453	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000001
	Mud Engineer	LDDT	4	15	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							0.0	0.000000	0.000004
	Logger, Engr Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Drill Bit Delivery	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.000001	0.000001
	Semi Completion, Unit Rig	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Fracing, Blender	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Pumping/Tank Battery	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Tubing Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Pump Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Cement Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Completion, Equip Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Service Tools	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Haul Perforators Logging Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Installation	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Testing	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Tank	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Pump	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Chemical	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Sand	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Other	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Welders	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Haul Water Truck	HDDV	4	150	600	1	3.5926	0.3640	0.3038	0.0175	2.2765	0.4683	0.0018	0.0002	0.0002	0.0000	0.0011	0.0002							0.5	0.000024	0.000029
	Pickup Cementer, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Casing Crew	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Completion Crew	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Pickup Completion, Pusher	LDDT	4	5	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.000000	0.000001
	Pickup Perforators, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Fracing, Engineer	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Co. Supervisor	LDDT	4	10	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.000000	0.000002
	Pickup Miscellaneous Supplies	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000001
	Pickup Roustabout Crew	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
																	Subtotal		**4.36E-03**	**3.72E-04**	**3.09E-04**	**1.81E-05**	**5.42E-03**	**1.93E-03**	**1.12E+00**	**4.30E-05**	**7.97E-05**
																	Total		**5.11E-03**	**4.44E-04**	**3.69E-04**	**2.15E-05**	**6.07E-03**	**2.11E-03**	**1.33E+00**	**5.22E-05**	**9.25E-05**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[a]
Diesel	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	(lbs/well) PM_{10}	(lbs/well) SO_x	(lbs/well) CO	(lbs/well) VOC	(tpy/well) NO_x	(tpy/well) PM_{10}	(tpy/well) SO_x	(tpy/well) CO	(tpy/well) VOC	(tpy/well) PM2.5	(tpy/well) CO_2	(tpy/well) CH_4	(tpy/well) N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	4	12	48	1	0.08	3.87	**1.94E-03**	0.01	0.39	**1.93E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	4	12	48	1	0.12	0.00	0.00	0.00	2.54	0.11	**5.96E-05**	**1.34E-06**	**6.19E-07**	**4.66E-07**	**1.27E-03**	**5.66E-05**	**2.52E-02**	**3.60E-06**	**9.44E-06**

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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	0.5	32	0.08	2.58	**1.29E-03**	0.01	0.26	**1.28E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	0.5	32	**8.16E-05**	**3.83E-06**	**3.12E-06**	**1.98E-07**	**2.20E-04**	**9.69E-05**	**1.44E-02**	**7.05E-08**	**1.87E-06**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	0.50	2024.16	1.00	0.00	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	0.00	0.00
								TOTAL	**3.25E-03**	**4.88E-04**

[a] 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[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	0.060
Annual Miles of Roads reclaimed Per Well	0.015
Number of wells reclaimed (per well)	0.060

Reclaimation 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
0.0149	6	0.00249	0.0249
		Total	**0.025**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.015	5	0.075	0.765	**2.86E-05**	0.069	**2.59E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.015	0.4238	0.0720	0.0197	0.4106	0.0629	**3.17E-06**	**5.38E-07**	**1.47E-07**	**3.07E-06**	**4.69E-07**	**5.22E-07**	**8.09E-04**	**7.27E-09**	**7.97E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0025	0.149	0.08	**6.02E-06**	0.01	**6.00E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0025	0.1494	**3.81E-07**	**1.79E-08**	**1.46E-08**	**9.22E-10**	**1.03E-06**	**4.52E-07**	**6.74E-05**	**3.29E-10**	**8.73E-09**

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	0.060	10	0.060	0.60

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.36	5	1.79	0.765	**6.86E-04**	0.069	**6.21E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.36	0.5297	0.0900	0.0246	0.5132	0.0786	**9.50E-05**	**1.61E-05**	**4.41E-06**	**9.20E-05**	**1.41E-05**	**2.50E-05**	**2.37E-02**	**3.95E-07**	**2.39E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.06	3.59	0.081	**1.45E-04**	0.008	**1.44E-05**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.06	3.59	**9.14E-06**	**4.30E-07**	**3.50E-07**	**2.21E-08**	**2.47E-05**	**1.09E-05**	**1.62E-03**	**7.90E-09**	**2.09E-07**

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

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)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

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)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

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	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

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

Volume Flow:	40	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.12	MMSCF/well

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

BTU value = 994 BTU/scf

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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

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

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
Component	(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 =	0.00349	0.00002	0.00001	0.00310

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 (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.15E-04**			**6.12E-05**

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip)						Emissions (tpy/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_2O
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	0.00	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	0.00	0.00289	0.00000	0.00000
													Total	**3.89E-05**	**1.83E-06**	**1.49E-06**	**9.42E-08**	**1.05E-04**	**4.62E-05**	**6.89E-03**	**3.36E-08**	**8.91E-07**

Alternative B input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	1	Peak Year Non-Federal Producing Wells Drilled	47
Federal Producing Wells - Year 20 (RMP Totals)	14	Non-Federal Producing Wells - Year 2027 (RMP Totals)	885
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

* 5% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	0.59	0.06	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.01	0.00	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.00	0.00	0.05	0.00	0.10	0.01	0.00	22.07	0.00	0.00	22.15	20.10
Commuting Vehicles - Construction	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.60	0.54
Completion Venting	---	---	---	---	---	0.00	0.00	0.07	2.74	0.00	57.67	52.34
Sub-total: Construction	**0.67**	**0.07**	**0.05**	**0.00**	**0.11**	**0.01**	**0.00**	**22.72**	**2.74**	**0.00**	**80.43**	**72.98**
Natural Gas Compression - Operations	0.14	0.14	3.26	0.00	6.51	2.28	0.44	439.31	0.01	0.00	439.74	399.04
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	3.66	0.00	79.20	71.87
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	0.11	4.66	0.00	97.96	88.89
Station Visits - Operations	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.11	0.10
Well Workover - Operations	0.03	0.02	0.05	0.00	0.02	0.00	0.00	79.17	0.00	0.00	79.37	72.02
Well & Pipeline visits for Inspection & Repair - Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.04
Sub-total: Operations	**0.19**	**0.17**	**3.31**	**0.00**	**6.54**	**2.28**	**0.44**	**521.12**	**8.33**	**0.00**	**696.43**	**631.97**
Road Maintenance	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.92	0.83
Sub-total: Maintenance	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.92**	**0.00**	**0.00**	**0.92**	**0.83**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.02
Well Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.47
Sub-total: Reclamation	**0.02**	**0.00**	**0.00**	**0.0001**	**0.00**	**0.000**	**0.0000**	**0.5345**	**0.0000**	**0.0000**	**0.5365**	**0.4868**
Total Emissions	**0.90**	**0.24**	**3.36**	**0.00**	**6.65**	**2.29**	**0.44**	**545.29**	**11.07**	**0.00**	**778.31**	**706.27**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	27.75	2.78	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.54	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.51	0.45	7.57	0.20	2.38	0.60	0.06	1,037.39	0.01	0.01	1,041.23	944.86
Commuting Vehicles - Construction	3.14	0.32	0.12	0.00	0.21	0.08	0.01	27.45	0.00	0.00	28.20	25.59
Completion Venting	---	---	---	---	---	0.00	0.00	3.07	128.93	0.00	2,710.66	2459.76
Sub-total: Construction	**31.94**	**3.63**	**7.69**	**0.20**	**2.59**	**0.69**	**0.07**	**1067.91**	**128.94**	**0.01**	**3780.09**	**3430.20**
Natural Gas Compression - Operations	9.12	9.12	205.80	0.14	411.61	144.06	27.52	27,770.47	0.52	0.05	27,797.71	25224.78
Dehydrators	0.01	0.01	0.13	0.00	0.11	0.01	0.00	150.27	231.22	0.00	5,006.64	4543.23
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.01	0.00	7.02	294.54	0.00	6,192.36	5619.20
Station Visits - Operations	0.61	0.06	0.04	0.00	0.10	0.05	0.00	6.86	0.00	0.00	7.13	6.47
Well Workover - Operations	5.12	1.23	62.81	21.06	4.62	3.47	0.35	4,998.14	0.07	0.07	5,021.55	4556.76
Well & Pipeline visits for Inspection & Repair - Operations	0.27	0.03	0.02	0.00	0.05	0.02	0.00	3.00	0.00	0.00	3.12	2.83
Sub-total: Operations	**15.14**	**10.45**	**268.80**	**21.20**	**416.49**	**147.62**	**27.88**	**32935.75**	**526.35**	**0.13**	**44028.51**	**39953.28**
Road Maintenance	1.41	0.15	0.20	0.01	0.09	0.03	0.00	57.87	0.00	0.00	58.08	52.71
Sub-total: Maintenance	**1.41**	**0.15**	**0.20**	**0.01**	**0.09**	**0.03**	**0.00**	**57.87**	**0.00**	**0.00**	**58.08**	**52.71**
Road Reclamation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	1.12	1.02
Well Reclamation	0.98	0.12	0.13	0.01	0.13	0.02	0.00	32.67	0.00	0.00	32.79	29.76
Sub-total: Reclamation	**1.02**	**0.13**	**0.14**	**0.0062**	**0.13**	**0.021**	**0.0021**	**33.7873**	**0.0006**	**0.0004**	**33.9120**	**30.7731**
Total Emissions	**49.51**	**14.36**	**276.82**	**21.42**	**419.30**	**148.35**	**27.95**	**34,095.31**	**655.29**	**0.14**	**47,900.60**	**43,466.97**

Fugitive Dust Emissions From Well Pad and Compressor Station Construction

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Construction Activities: All Project Years

Area Disturbed for CBNG Wells	Emission Estimation Basis	Avg. Disturbed Acres per Well[a]	Construction Days	Total # of Well Pads or Stations	Total Disturbed Acres	Emissions			
						(lb/well)		(tpy/well)	
						PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Well Pad and Road Construction	Per Well	3.48	5	1	3.48	1.16E+03	1.16E+02	5.81E-01	5.81E-02
Field Compressor Station	Per Well	0.04	6	1	0.04	1.66E+01	1.66E+00	8.30E-03	8.30E-04
Sales Compressor Station	Per Well	0.01	6	1	0.01	2.77E+00	2.77E-01	1.38E-03	1.38E-04
				Total	**3.53**	**1.18E+03**	**1.18E+02**	**5.91E-01**	**5.91E-02**

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

Exhaust Emissions from Heavy Construction Equipment (Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/ Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity) NO_x	$PM_{2.5}/PM_{10}$[a]	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																	Subtotal		**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso,

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	8.6	0.4	0.1	74.3	4.0	0.00	0.00	0.00	0.04	0.00	0.006	0.000	0.000	0.056	0.003	0.00	7.6	0.0001	0.0001
	Auxillary Pump	200	1	90	18	2	36	1.00	4.3	0.2	0.1	37.1	2.0	0.00	0.00	0.00	0.02	0.00						0.00	3.8	0.0000	0.0000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	2.9	0.1	0.0	24.8	1.3	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.021	0.001	0.00	2.5	0.0000	0.0000
	Auxillary Pump	125	1	90	18	1	18	1.00	1.3	0.1	0.0	16.5	0.6	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.012	0.001	0.00	1.2	0.0000	0.0000
	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
																	Subtotal		**1.09E-02**	**5.29E-04**	**1.69E-04**	**8.85E-02**	**4.64E-03**	**5.29E-04**	**1.76E+01**	**1.43E-04**	**1.99E-04**
																	Total		**1.86E-02**	**1.21E-03**	**3.99E-04**	**9.16E-02**	**5.43E-03**	**1.27E-03**	**1.88E+01**	**1.55E-04**	**2.12E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.0000	0.0000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Exhaust Emissions from Heavy Construction Equipment (Non-Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	$PM_{2.5}/PM_{10}$	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																	Subtotal		**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	103.2	6.1	2.9	30.2	7.4	0.05	0.00	0.00	0.02	0.00	0.076	0.005	0.002	0.021	0.006	0.00	7.6	0.000	0.000
	Auxillary Pump	200	1	90	18	2	36	1.00	48.2	3.2	1.5	11.9	4.1	0.02	0.00	0.00	0.01	0.00						0.00	3.8	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	34.4	2.0	1.0	10.1	2.5	0.02	0.00	0.00	0.01	0.00	0.025	0.002	0.001	0.007	0.002	0.00	2.5	0.000	0.000
	Auxillary Pump	125	1	90	18	1	18	1.00	15.9	1.2	0.5	4.4	1.4	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00	0.024	0.001	0.000	0.006	0.002	0.00	1.2	0.000	0.000
	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
																	Subtotal		**1.25E-01**	**7.52E-03**	**3.38E-03**	**3.43E-02**	**9.43E-03**	**7.30E-03**	**1.76E+01**	**1.43E-04**	**2.00E-04**
																	Total		**1.33E-01**	**8.21E-03**	**3.61E-03**	**3.73E-02**	**1.02E-02**	**8.04E-03**	**1.88E+01**	**1.55E-04**	**2.13E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.000	0.000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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		
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	PM_{10}			$PM_{2.5}$		
							Controlled Em. Factor (lb/VMT)	Emissions (lbs/activity)	Emissions (tpy/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/activity)	Emissions (tpy/well)
Drilling Roads	Semi Trucks	42	6	3	18	1.000	0.27	4.94	0.002	0.03	0.49	0.000
Drilling Well Pad	Haul Trucks	25	6	2	12	1.000	0.22	2.61	0.001	0.02	0.26	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Water Disposal Well Pad	Haul Trucks	25	10	5	50	0.005	0.22	10.87	0.000	0.02	1.09	0.000
	Pickup Trucks	5	10	5	50	0.005	0.11	5.27	0.000	0.01	0.53	0.000
New Pipeline Intermediate	Haul Trucks	25	6	40	240	0.111	0.22	52.17	0.003	0.02	5.22	0.000
	Pickup Trucks	5	6	160	960	0.111	0.11	101.14	0.006	0.01	10.11	0.001
New Sales Pipeline	Haul Trucks	25	35	94	3,290	0.000	0.22	715.10	0.000	0.02	71.51	0.000
	Pickup Trucks	5	50	94	4,700	0.000	0.11	495.14	0.000	0.01	49.51	0.000
Electric Line	Haul Trucks	25	6	1	6	1.000	0.22	1.30	0.001	0.02	0.13	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Field Compression Station	Semi Trucks	42	10	15	150	0.111	0.27	41.18	0.002	0.03	4.12	0.000
	Haul Trucks	25	10	48	480	0.111	0.22	104.33	0.006	0.02	10.43	0.001
	Pickup Trucks	5	10	192	1,920	0.111	0.11	202.27	0.011	0.01	20.23	0.001
Sales Compression Station	Semi Trucks	42	10	19	190	0.011	0.27	52.16	0.000	0.03	5.22	0.000
	Haul Trucks	25	10	48	480	0.011	0.22	104.33	0.001	0.02	10.43	0.000
	Pickup Trucks	5	10	192	1,920	0.011	0.11	202.27	0.001	0.01	20.23	0.000
Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 20								**Subtotal**	**3.56E-02**			**3.56E-03**

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/well)	$PM_{2.5}$ Emissions (tpy/well)
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Fuel Haul Truck	25	6	2	12	1.00	0.22	2.61	0.001	0.022	0.261	0.000
	Mud Haul Truck, Water Hauling	25	6	7	42	1.00	0.22	9.13	0.005	0.022	0.913	0.000
	Rig Crew	25	6	3	18	1.00	0.22	3.91	0.002	0.022	0.391	0.000
	Co. Supervisor	5	6	8	48	1.00	0.11	5.06	0.003	0.011	0.506	0.000
	Tool Pusher	25	6	6	36	1.00	0.22	7.82	0.004	0.022	0.782	0.000
	Logger, Engr Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
Well Completion, Fracing & Testing	Semi Casing Haulers	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Semi Completion, Unit Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Semi Fracing Blender	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Tubing Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Completion, Equip Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Perforators Logging Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Tank	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Pump	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Welders	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Water Truck	25	6	9	54	1.00	0.22	11.74	0.006	0.022	1.174	0.001
	Pickup Cementer, Engineer	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Co. Supervisor	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
	Pickup Miscellaneous Supplies	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Roustabout Crew	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
Water Disposal Well Drilling	Drill Rig Transport truck	42	6	10	60	0.01	0.27	16.47	0.000	0.027	1.647	0.000
	Mud Haul Truck, Water Hauling	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Rig Crew	25	6	10	60	0.01	0.22	13.04	0.000	0.022	1.304	0.000
	Co. Supervisor	5	6	5	30	0.01	0.11	3.16	0.000	0.011	0.316	0.000
	Tool Pusher	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Tubing Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
								Subtotal	**3.11E-02**			**3.11E-03**
								Total	**6.67E-02**			**6.67E-03**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaksо, 2010)

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy/well)								
	Type	Class					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_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	0.11	0.01	0.01	0.00	0.07	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.02	0.00	0.00
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.99	0.30	0.25	0.01	1.90	0.39	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	25	5	125	0.01	0.64	0.03	0.02	0.00	1.72	0.76	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	1.44	0.15	0.12	0.01	0.91	0.19	0.000	0.00	0.000	0.000	0.00	0.00	0.02	0.00	0.00
	Pickup Trucks	LDDT	6	160	960	0.11	4.89	0.23	0.19	0.01	13.22	5.81	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.05	0.00	0.00
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	19.70	2.00	1.67	0.10	12.48	2.57	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	50	94	4700	0.00	23.96	1.13	0.92	0.06	64.73	28.46	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	0.90	0.09	0.08	0.00	0.57	0.12	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.01	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.11	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.11	9.79	0.46	0.37	0.02	26.44	11.63	0.001	0.0000	0.0000	0.0000	0.00	0.001	0.10	0.00	0.00
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.14	0.12	0.10	0.01	0.72	0.15	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.00	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.01	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.01	9.79	0.46	0.37	0.02	26.44	11.63	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Fuel Haul Truck	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	0.25	0.03	0.02	0.00	0.16	0.03	0.000	0.00	0.00	0.00	0.0	0.00	0.04	0.00	0.00
	Rig Crew	LDDT	6	3	18	1.00	0.09	0.00	0.00	0.00	0.25	0.11	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Rig Mechanics	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Co. Supervisor	LDDT	6	8	48	1.00	0.24	0.01	0.01	0.00	0.66	0.29	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Tool Pusher	LDDT	6	6	36	1.00	0.18	0.01	0.01	0.00	0.50	0.22	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Mud Logger	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Mud Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Logger, Engr	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Drill Bit Delivery	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**1.88E-03**	**1.23E-04**	**1.02E-04**	**6.12E-06**	**3.75E-03**	**1.55E-03**	**4.07E-01**	**9.83E-06**	**3.89E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tpy) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Fracing Blender	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Tubing Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Service Tools	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Installation	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Testing	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Tank	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Pump	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Chemical	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Sand	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Other	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Welders	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Water Truck	HDDV	6	9	54	1.00	0.32	0.03	0.03	0.00	0.20	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Completion Crew	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Completion Pusher	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	0.60	0.06	0.05	0.00	0.38	0.08	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	0.30	0.03	0.03	0.00	0.19	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Rig Crew	LDDT	10	10	100	0.01	0.51	0.02	0.02	0.00	1.38	0.61	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Co. Supervisor	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tool Pusher	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tubing Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**6.51E-04**	**6.00E-05**	**5.00E-05**	**2.90E-06**	**6.39E-04**	**2.01E-04**	**1.77E-01**	**7.47E-06**	**1.14E-05**
											Total		**2.53E-03**	**1.83E-04**	**1.52E-04**	**9.02E-06**	**4.39E-03**	**1.76E-03**	**5.84E-01**	**1.73E-05**	**5.02E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power	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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	12	1	12	8,760	0.12	0.01	0.00	0.24	0.08	0.01	16.2	0.00	0.01	0.00
Sales Compression Station	12	1	12	8,760	0.11	0.00	0.00	0.22	0.08	0.00	15.1	0.00	0.01	0.00
				Total	**2.33E-01**	**1.03E-02**	**1.58E-04**	**4.65E-01**	**1.63E-01**	**1.03E-02**	**3.14E+01**	**5.92E-04**	**1.48E-02**	**5.92E-05**

Sub-total: Construction

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867
CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
Component	(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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (lb/yr)**	**VOC (tpy)**	**CO2 (lb/yr)**	**CO2 (tpy)**	**CH4 (lb/yr)**	**CH4 (tpy)**
b-total: Construct	1	8760	0.00	**3.25E-07**	0.78	**3.92E-04**	32.90	**1.64E-02**

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.41E-04**	**1.08E-05**	**8.49E-07**	**1.19E-04**	**7.78E-06**	**8.07E-06**	**1.70E-01**	**3.25E-06**	**1.06E-07**	**3.11E-06**

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)
16.43	0.016	**2.61E-01**	0.000	**0.00E+00**	0.000	**0.00E+00**

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

Sub-total: Construction

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

The following South Baker Compressor Station assumptions were used with CBNG specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station ---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.5	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.92E-04**			**6.89E-05**

Assume no dust control (watering)

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.5	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.004	0.000	0.000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	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	0.00	0.003	0.000	0.000
													Total	**4.37E-05**	**2.06E-06**	**1.67E-06**	**1.06E-07**	**1.18E-04**	**5.20E-05**	**7.75E-03**	**3.78E-08**	**1.00E-06**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	0.0051	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	6.35	0.32	0.11	2.96	0.32	**3.17E-03**	**1.59E-04**	**5.40E-05**	**1.48E-03**	**1.59E-04**	**1.21E-03**	**5.61E+00**	**4.03E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	141.65	8.05	47.59	10.25	7.81	**7.08E-02**	**4.03E-03**	**2.38E-02**	**5.13E-03**	**3.91E-03**	**1.21E-03**	**5.60E+00**	**7.79E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Emissions for Well and Pipe Inspections

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Fugitive Dust Emissions Estimation for Road Traffic: Well & Pipeline

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/ Year	PM_{10}			$PM_{2.5}$		
							Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)	Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)
Visits for Inspection and Repair	200-hp Pickup	40	0.625	12	1	8	0.08	0.05	**3.02E-04**	0.01	0.01	**3.01E-05**

Activity rates based on values shown in SEIS
Assume no dust control (watering)

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/Well	Emissions (lbs/trip/well)						Emissions (tpy/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_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	0.003	0.000	0.000	0.000	0.009	0.004	**1.91E-05**	**8.99E-07**	**7.32E-07**	**4.63E-08**	**5.16E-05**	**2.27E-05**	**3.39E-03**	**1.65E-08**	**4.38E-07**

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.08	0.83
Winter	1	0.25	5	10	0.05	0.50
				Total	0.13	1.33

Based on values shown in SEIS

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^{2}$	5	0.765
Sub-total: Constructi	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph

Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)[b]	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Maintenance	Grader	1	5	4	0.765	**1.53E-03**	0.069	**1.39E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Year 2008	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.006
Year 2018	1.86	0.25	0.10	0.82	0.25	0.25	546.2	0.004	0.006
Year 2028	0.56	0.16	0.09	0.27	0.16	0.15	546.5	0.002	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions													
				(lb/hour)					(tpy/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_2O
Road Maintenance	Grader	135	1	0.55	0.08	0.03	0.24	0.07	**2.22E-04**	**3.01E-05**	**1.16E-05**	**9.78E-05**	**2.92E-05**	**2.92E-05**	**6.50E-02**	**4.44E-07**	**7.14E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Sub-total: Construction

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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Maintenance	Pickup Truck	40	6	0.13	0.80	0.08	**3.34E-05**	0.01	**3.33E-06**

[a] Assume No dust control measures (watering) would be applied

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	**2.04E-06**	**9.59E-08**	**7.80E-08**	**4.94E-09**	**5.51E-06**	**2.42E-06**	**3.61E-04**	**1.76E-09**	**4.67E-08**

Exhaust 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 abandonme
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.2500
Number of Roads Reclaimed Annually Per Well	0.0923
Annual Miles of Roads reclaimed Per Well	0.0231
Number of wells reclaimed (per well)	0.0923

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

Sub-total: Construction

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.0231	6	0.0038	0.0385
		Total	0.0385

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.0231	5	0.1154	0.765	**4.41E-05**	0.069	**4.00E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.023	0.4238	0.0720	0.0197	0.4106	0.0629	**4.89E-06**	**8.31E-07**	**2.27E-07**	**4.74E-06**	**7.25E-07**	**8.06E-07**	**1.25E-03**	**1.12E-08**	**1.22E-08**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.00385	0.02308	0.08	**9.31E-07**	0.01	**9.26E-08**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0038	0.0231	**5.88E-08**	**2.77E-09**	**2.25E-09**	**1.42E-10**	**1.59E-07**	**6.99E-08**	**1.04E-05**	**5.09E-11**	**1.35E-09**

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	0.0923	10	0.0923	0.9232

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.5539	5	2.7697	0.765	**1.06E-03**	0.069	**9.60E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.5539	0.5297	0.0900	0.0246	0.5132	0.0786	**1.47E-04**	**2.49E-05**	**6.81E-06**	**1.42E-04**	**2.18E-05**	**3.87E-05**	**3.67E-02**	**6.11E-07**	**3.66E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	6	0.0923	0.5539	0.081	**2.23E-05**	0.008	**2.22E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0923	0.5539	**1.41E-06**	**6.64E-08**	**5.40E-08**	**3.42E-09**	**3.81E-06**	**1.68E-06**	**2.50E-04**	**1.22E-09**	**3.24E-08**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy)	PM2.5 Emissions (tpy)
Well Pad, Road and Pipeline construction	26.08	1.38	1.46		1.00	3.48	14108.09	1.00	0.01	0.00
Sub-total: Construction	26.08	1.38		1.46	1.00	0.05	196.11	1.00	0.0002	0.00002
								TOTAL	**1.15E-02**	**1.72E-03**

[a] Average disturbed area for new CBNG wells shown in SEIS

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
Sub-total: Constr	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.065	0.000	0.001	0.062
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	10	0.0004	0	0.0005	0	0.0002	0.004	0.000	0.000	0.004
flanges	7	0.0009	0	0.0002	0	0.0000	0.006	0.000	0.000	0.006
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.075	0.000	0.002	0.072

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	0.01	**6.26E-06**	15.08	**7.54E-03**	632.73	**3.16E-01**

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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
Reactive VOC	0.000	---	0.000	0.002		0.000
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
n-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	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

Forest Products **Alternative B**

Total Annual Emissions from Forest and Woodlands Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	0.29	0.03	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.01	0.01	0.06	0.00	0.17	0.03	0.00	7.82	0.00	0.00	7.85	7.12
Sub-total: Heavy Equipment	**0.30**	**0.04**	**0.06**	**0.00**	**0.17**	**0.03**	**0.00**	**7.82**	**0.00**	**0.00**	**7.85**	**7.12**
Commuting Vehicles - Fugitive Dust	0.21	0.02	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.90	0.00	0.00	0.94	0.85
Sub-total: Commuting Vehicles	**0.21**	**0.02**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**	**0.90**	**0.00**	**0.00**	**0.94**	**0.85**
Total	**0.51**	**0.06**	**0.07**	**0.00**	**0.19**	**0.04**	**0.00**	**8.72**	**0.000**	**0.000**	**8.79**	**7.97**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative B

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, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	40	800	1	0.80	0.28	0.03
			Total	**0.80**	**0.28**	**0.03**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	40.0	15	29.6	52.104	0.033	69.47	0	**0.01**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative B

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Forest Products	Skidder	205	1	70	8	10	80	119.03	13.60	3.24	98.19	11.66	6.0E-02	6.8E-03	1.6E-03	4.9E-02	5.8E-03	6.6E-03	7.5E+00	8.9E-05	7.7E-05
	Log Truck	450	2	50	10	0	0	0.00	0.00	0.00	0.00	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Chainsaw	6	1	80	8	10	80	1.12	8.25	0.12	248.50	52.39	5.6E-04	4.1E-03	5.9E-05	1.2E-01	2.6E-02	3.8E-03	2.9E-01	2.3E-04	1.8E-06
	Feller Buncher	300	1	100	8	0	0	0.00	0.00	0.00	0.00	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Loader	200	1	100	10	0	0	0.00	0.00	0.00	0.00	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Dozer	200	1	80	8	0	0	0.00	0.00	0.00	0.00	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Delimber	250	1	100	10	0	0	0.00	0.00	0.00	0.00	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
												Total	**6.0E-02**	**1.1E-02**	**1.7E-03**	**1.7E-01**	**3.2E-02**	**1.0E-02**	**7.8E+00**	**3.2E-04**	**7.8E-05**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved ro		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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	70	10	700	0	0	0.61	0.00	0.21	0.06	0.00	0.02
	Log Truck	25	70	40	2,800	0	0	0.61	0.00		0.06	0.00	
	Pick-up Truck	25	70	10	700	1	700	0.61	0.21		0.06	0.02	
							Total		**0.21**			**0.02**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control (MCFO, 2010)

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	10	2,000	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
	Log Truck	HDDV	400	40	16,000	0	0	0.00	0.00	0.00	0.00	0.00	0.00							0.00	0.00	0.00
	Pick-up Truck	LDDT	200	10	2,000	1	2,000	0.01	0.00	0.00	0.00	0.01	0.01							0.90	0.00	0.00
							Total	**0.01**	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.90**	**0.0000**	**0.0001**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing **Alternative B**

Total Annual Emissions from Livestock Grazing Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	1.37	0.14	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.50	0.48	7.27	0.17	3.15	0.55	0.05	775.33	0.01	0.01	778.2	**706.2**
Sub-total: Construction	**1.87**	**0.62**	**7.27**	**0.17**	**3.15**	**0.55**	**0.05**	**775.33**	**0.01**	**0.01**	**778.2**	**706.2**
Commuting Vehicles - Fugitive Dust	134.71	13.45	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.31	0.27	1.98	0.01	8.17	3.63	0.36	606.92	0.06	0.05	**623.6**	**565.9**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	2457.55	---	**51,608.5**	**46,831.7**
Sub-total: Operations and Maintenance	**135.02**	**13.71**	**1.98**	**0.01**	**8.17**	**3.63**	**0.36**	**606.92**	**2457.61**	**0.05**	**52,232.1**	**47,397.6**
Total	**136.89**	**14.34**	**9.25**	**0.18**	**11.32**	**4.17**	**0.42**	**1382.25**	**2457.62**	**0.06**	**53,010.4**	**48,103.8**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative B

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, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)		
			TSP	PM_{10}	$PM_{2.5}$
Springs	1.00	1	0.04	0.01	0.00
Reservoirs/Pits	37.00	1	0.52	0.18	0.02
Wells	3.00	1	0.12	0.04	0.00
Pipelines	48.00	1	1.92	0.67	0.07
Fences	30.00	1	1.20	0.42	0.04
Reservoirs Maintenance	1.00	1	0.04	0.01	0.00
		Total	**3.84**	**1.34**	**0.13**

[a] information from MCFO. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	120.0	15	29.6	52.104	0.033	208.42	0	**0.03**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative B

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	2	2.00	32.0	15	2	0	12	2	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	40.00	960.0	3,888	236	85	1,645	247	1.94	0.12	0.04	0.82	0.12	0.11	198.02	0.00	0.00
	Scraper	650	1	70	8	3	40.00	960.0	5,054	306	111	2,138	321	2.53	0.15	0.06	1.07	0.16	0.15	257.43	0.00	0.00
Wells	Drill Rig	200	1	100	8	3	10.00	240.0	463	31	12	155	38	0.23	0.02	0.01	0.08	0.02	0.01	26.81	0.00	0.00
	Water Truck	200	1	70	8	3	10.00	240.0	324	22	8	108	27	0.16	0.01	0.00	0.05	0.01	0.01	18.77	0.00	0.00
Pipelines	Dozer	200	1	75	2	25	5.00	250.0	409	31	10	153	36	0.20	0.02	0.00	0.08	0.02	0.02	22.33	0.00	0.00
	Trencher	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
	Backhoe	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	25	8.00	1600.0	2,891	192	72	966	240	1.45	0.10	0.04	0.48	0.12	0.09	167.56	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	2	5.00	20.0	81	5	2	34	5	0.04	0.00	0.00	0.02	0.00	0.00	4.13	0.00	0.00
													Total	**7.27E+00**	**4.99E-01**	**1.67E-01**	**3.15E+00**	**5.45E-01**	**4.84E-01**	**7.75E+02**	**8.44E-03**	**8.81E-03**

Source for activity data: MCFO

all emissions calculated with year 2008 factors (conservative)

ALTERNATIVE: Alternative B

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = emission control percent for watering unpaved roads [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 Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	140	2	280	2.00	560	0.72	0.20	0.40	0.07	0.02	0.04
	Pick-up Truck	35	140	2	280	2.00	560	0.72	0.20		0.07	0.02	
Reservoirs/Pits	Tractor-Trailer	35	140	3	420	40.00	16800	0.72	6.04	12.08	0.07	0.60	1.21
	Pick-up Truck	35	140	3	420	40.00	16800	0.72	6.04		0.07	0.60	
Wells	Drill Truck	35	140	3	420	10.00	4200	0.72	1.51	6.04	0.07	0.15	0.60
	Support Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Water Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Pick-up Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
Pipelines	Tractor-Trailer	35	140	25	3500	5.00	17500	0.72	6.29	12.58	0.07	0.63	1.26
	Pick-up Truck	35	140	25	3500	5.00	17500	0.72	6.29		0.07	0.63	
Fences	Support Truck	35	140	25	3500	8.00	28000	0.72	10.06	30.19	0.07	1.00	3.01
	Pick-up Truck	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
	ATV	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
Reservoirs Maintenance	Tractor-Trailer	35	140	2	280	5.00	1400	0.72	0.50	1.01	0.07	0.05	0.10
	Pick-up Truck	35	140	2	280	5.00	1400	0.72	0.50		0.07	0.05	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	140	1087	152180	1.00	152180	0.72	54.70	54.70	0.07	5.46	5.46
	Pick-up-Trailer (spring calves)	35	140	352	49280	1.00	49280	0.72	17.71	17.71	0.07	1.77	1.77
							Total		**134.71**			**13.45**	

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked
for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load

ALTERNATIVE: Alternative B

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions														
								(tons/vehicle type)						(tons/year)								
								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_2O**
Springs	Tractor-Trailer	HDDV	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	1.05	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	300	3	900	40.00	36,000.0	0.11	0.01	0.01	0.00	0.07	0.01	0.15	0.01	0.01	0.00	1.02	0.06	31.42	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	40.00	36,000.0	0.04	0.00	0.00	0.00	0.95	0.04							18.92	0.00	0.00
Wells	Drill Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00	0.0920	0.0084	0.0070	0.0005	0.2890	0.0212	7.86	0.00	0.00
	Support Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Water Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	10.00	9,000.0	0.01	0.00	0.00	0.00	0.24	0.01							4.73	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	300	25	7500	5.00	37,500.0	0.11	0.01	0.01	0.00	0.07	0.01	0.16	0.01	0.01	0.00	1.06	0.06	32.73	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	5.00	37,500.0	0.05	0.00	0.00	0.00	0.99	0.04							19.71	0.00	0.00
Fences	Support Truck	HDDV	300	25	7500	8.00	60,000.0	0.18	0.02	0.02	0.00	0.11	0.02	0.27	0.14	0.13	0.00	4.86	3.32	52.37	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	8.00	60,000.0	0.07	0.00	0.00	0.00	1.59	0.07							31.54	0.00	0.00
	ATV	R12S	300	25	7500	8.00	60,000.0	0.02	0.12	0.11	0.00	3.16	3.22							9.27	0.03	0.01
Reservoirs Maintenance	Tractor-Trailer	HDDV	300	2	600	5.00	3,000.0	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.08	0.00	2.62	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	5.00	3,000.0	0.00	0.00	0.00	0.00	0.08	0.00							1.58	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	300	1087	326100	1.00	326,100.0	0.98	0.10	0.08	0.00	0.62	0.13	1.29	0.13	0.11	0.01	0.82	0.17	284.62	0.01	0.02
	Pcik-up-Trailer (spring calves)	HDDV	300	352	105600	1.00	105,600.0	0.32	0.03	0.03	0.00	0.20	0.04							92.17	0.00	0.01
													TOTAL	**1.98**	**0.31**	**0.27**	**0.01**	**8.17**	**3.63**	**606.92**	**0.06**	**0.05**

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load.

ALTERNATIVE: Alternative B

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	479,386	9.74	2333.87	0.37	88.07	2421.94
Horse	16,131	3.31	26.67	0.43	3.47	30.14
Sheep	7,189	1.47	5.28	0.05	0.18	5.47
					Total Methane emissions	**2457.55**

AUM numbers provided by Dawn Doran (per direction from Todd Yeager) on 7/5/2011.

General Purpose Travel - BLM Fleet Alternative B

Total Annual Emissions from General Purpose BLM Travel - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Commuting Vehicles - Fugitive Dust	73.62	7.35	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.07	0.06	1.59	0.00	4.30	1.89	0.19	281.72	0.00	0.04	293.05	265.93
Sub-total: Commuting Vehicles	**73.70**	**7.41**	**1.59**	**0.00**	**4.30**	**1.89**	**0.19**	**281.72**	**0.00**	**0.04**	**293.05**	**265.93**
Total	**73.70**	**7.41**	**1.59**	**0.00**	**4.30**	**1.89**	**0.19**	**281.72**	**0.00**	**0.04**	**293.05**	**265.93**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads[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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/fleet group)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/fleet group)	$PM_{2.5}$ Emissions (tpy)
General Purpose BLM Travel	DM/FM Staff	25	3,170	0.61	0.96	73.62	0.06	0.10	7.35
	Support Services	25	26,283	0.61	7.98		0.06	0.80	
	Fire Management	45	110,972	0.61	33.71		0.06	3.36	
	Minerals and NRR	15	54,231	0.47	12.76		0.05	1.27	
	Renewable Resources	25	59,934	0.61	18.21		0.06	1.82	
		Total	**254,590**	**Total**	**73.62**			**7.347**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control.

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions														
				(tons/fleet group)						(tpy)								
				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_2O
General Purpose BLM Travel	DM/FM Staff	LDDT	21,132	0.05	0.00	0.00	0.00	0.15	0.06	1.59	0.07	0.06	0.00	4.30	1.89	9.54	0.00	0.00
	Support Services	LDDT	75,094	0.19	0.01	0.01	0.00	0.52	0.23							33.90	0.00	0.00
	Fire Management	LDDT	197,284	0.50	0.02	0.02	0.00	1.36	0.60							89.05	0.00	0.01
	Minerals and NRR	LDDT	180,771	0.46	0.02	0.02	0.00	1.24	0.55							81.60	0.00	0.01
	Renewable Resources	LDDT	149,834	0.38	0.02	0.01	0.00	1.03	0.45							67.63	0.00	0.01
			Total	**1.5906**	**0.0748**	**0.0609**	**0.00385**	**4.30**	**1.88982**	**1.59E+00**	**7.48E-02**	**6.09E-02**	**3.85E-03**	**4.30E+00**	**1.89E+00**	**2.82E+02**	**1.38E-03**	**3.65E-02**

Source of activity data: MCFO

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance Alternative B

Total Annual Emissions from Road Maintenance Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.48	0.22	1.30	0.03	0.51	0.08	0.01	153.75	0.00	0.00	154.32	140.03
Total	**1.48**	**0.22**	**1.30**	**0.03**	**0.51**	**0.08**	**0.01**	**153.75**	**0.0012**	**0.0017**	**154.32**	**140.03**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative B

Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	121

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^{2}$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)

Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[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.

* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	201	5	1,005	0.765	0.38	0.069	0.03
Road Maintenance	Semi-truck	29	20	59	1.09	0.03	0.11	0.00
Road Maintenance	Lowboy Trailer	---	20	756	1.09	0.41	0.11	0.04
				Total	**0.83**		**0.08**	

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	1	0.10	76	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00
Backhoe	87	1	0.80	140	0.05	0.00	0.00	0.02	0.00	0.00	5.80	0.00	0.00
Semi-truck	450	1	0.50	294	0.32	0.02	0.01	0.13	0.02	0.02	39.06	0.00	0.00
Lowboy Trailer	450	1	0.50	396	0.43	0.02	0.01	0.17	0.02	0.02	52.60	0.00	0.00
Bobcat	82	1	0.80	197	0.07	0.01	0.00	0.03	0.01	0.01	7.69	0.00	0.00
Grader	165	1	0.90	201	0.16	0.01	0.00	0.06	0.01	0.01	17.76	0.00	0.00
Loader	200	1	0.75	155	0.13	0.01	0.00	0.05	0.01	0.01	13.84	0.00	0.00
Dump Truck	350	1	0.50	149	0.13	0.01	0.00	0.05	0.01	0.01	15.42	0.00	0.00
Airport Forklift	100	1	0.10	17	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Snowplow	350	1	0.25	20	0.01	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Total					**1.3E+00**	**8.1E-02**	**3.3E-02**	**5.1E-01**	**8.2E-02**	**7.9E-02**	**1.5E+02**	**1.2E-03**	**1.7E-03**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2646.8	15	29.6	52.104	0.033	4,597.06	0	**0.57**	**0.06**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* assume roadway 12 feet wide for disturbance estimation.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

Appendix C

Alternative C Emission Inventory

Summary of Emissions C-1

Oil Development and Production C-2

Natural Gas Development and Production C-29

Coal Bed Methane Natural Gas Development and Production C-54

Coal Mining ..... (*see pages A-77 through A-78*)

Vegetation Management ..... (*see pages A-79 through A-83*)

Fire Management ..... (*see pages A-84 through A-88*)

Forestry and Woodland Products C-77

Livestock Grazing C-82

Recreation, Trails, and Travel Management ..... (*see pages A-100 through A-102*)

General Purpose BLM Fleet Travel C-88

Road Maintenance C-91

Alternative C Summary

MCFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)											Emissions (mtpy)
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq}
Federal / BLM												
Oil and Gas												
Oil	223.1	97.2	772.9	0.2	22.7	6.3	48.8	21,342.9	125.0	0.1	24,011.6	21,779
Natural Gas	87.9	36.1	24.9	0.1	5.8	2.1	2.5	8,818.3	117.4	0.1	11,258.7	10,212
CBNG	38.4	19.4	13.3	0.0	4.7	1.3	2.5	3,136.8	61.9	0.0	4,439.7	4,027
Coal Mining [1]	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	14.4	104,029.1	0.6	1.0	104,364.7	94,662
Vegetation Management	11.3	0.1	3.1	0.0	10.7	1.4	0.3	33.9	0.0	0.0	34.8	32
Fire Management [2]	1,741.9	58.3	97.3	13.6	210.7	151.1	9.7	289,046.1	121.5	23.7	298,943.9	271,151
Forestry and Woodland Products	1.6	2.3	0.3	0.1	6.4	0.8	0.0	314.5	0.0	0.0	316.4	287
Livestock Grazing	11.3	9.3	4.2	0.2	136.9	14.3	0.4	1,382.3	2,659.2	0.1	57,243.2	51,921
Recreation - Trails and Travel Management	26.6	0.1	27.1	0.0	292.6	30.1	2.7	78.0	0.2	0.0	83.4	76
General Purpose BLM Fleet Travel	4.6	1.7	2.0	0.0	71.3	7.2	0.2	299.5	0.0	0.0	311.6	283
Road Maintenance	0.5	1.4	0.1	0.0	1.6	0.2	0.0	160.6	0.0	0.0	161.2	146
Federal Emission Total	**4,268.3**	**2,043.3**	**1,089.3**	**194.0**	**5,211.6**	**659.5**	**81.7**	**428,642.0**	**3,085.8**	**25.1**	**501,169.2**	**454,575**
Non-Federal												-
Oil and Gas	3,583.1	2,924.4	8,964.5	46.0	416.8	163.3	597.2	359,284.4	3,292.7	1.2	428,325.2	388,504
Coal Mining [1]	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	15.7	143,391.0	0.9	1.4	143,853.6	130,479
Non-Federal Emission Total	**6,607.8**	**5,308.2**	**9,121.2**	**246.7**	**4,838.4**	**644.4**	**612.8**	**502,675.4**	**3,293.5**	**2.6**	**572,178.8**	**518,983**

tpy = short tons per year

mtpy = metric tons per year

1. In available air quality permits for coal mines located in the MCFO, total suspended particulate (TSP) is usually reported and PM10 and/or PM2.5 may be reported. In permits containing only TSP emissions, all TSP was assumed to be PM10. This assumption overestimates PM10 emissions. If PM10 was reported and PM2.5 was not reported, PM2.5 was assumed to equal 10 percent of PM2.5. With regard to greenhouse gases, coal mine emissions do not include ventilation emissions or emissions associated with electricity provided to the mine.

2. Excludes smoke emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	33,634	38,897	5,713	17,023	24,469	3,772
Alt. A O&G (%) of NEI Emissions	1.0%	0.4%	14.2%	0.0%	0.1%	0.3%
Alt. A (%) of NEI Emissions	12.7%	5.3%	19.1%	1.1%	21.3%	17.5%

County Emissions (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties).

Source: EPA 2008 National Emission Inventory (NEI), http://neibrowser.epa.gov/eis-public-web/geo/county-emissions.html?stateJurisdictionId=28&inventoryYear=2008, accessed December 12, 2011.

Alternative C input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	13	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	136
Federal Producing Wells - RMP Year 20	192	Non-Federal Producing Wells - RMP Year 20	2,109
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 30% full RFD estimates (rounded to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.50	0.05	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.41	0.42	6.74	0.08	35.61	1.90	0.19	7109.49	0.07	0.08	7136.19	6475.67
Commuting Vehicles - Construction	5.88	0.60	0.17	0.00	0.20	0.07	0.01	43.38	0.00	0.00	44.34	40.24
Wind Erosion	0.15	0.02	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**6.94**	**1.09**	**6.91**	**0.08**	**35.81**	**1.97**	**0.20**	**7,152.87**	**0.08**	**0.08**	**7,180.53**	**6,515.91**
Well Workover Operations - Fugitive Dust	0.83	0.08	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.06	0.06	1.14	0.02	9.90	0.53	0.05	2017.43	0.03	0.02	2025.17	1837.72
Well Workover Operations - On-road Exhaust	0.00	0.00	0.03	0.00	0.05	0.02	0.002	5.95	0.00	0.00	6.12	5.55
Well Visits for Inspection & Repair - Operations	0.93	0.09	0.03	0.00	0.61	0.03	0.003	12.11	0.00	0.00	13.55	12.30
Recompletion Traffic	1.43	0.15	0.05	0.00	0.08	0.03	0.00	12.08	0.00	0.00	12.39	11.24
Water Tanks & Traffic	3.80	0.40	0.32	0.00	0.20	0.04	0.00	94.10	21.95	0.00	555.20	503.81
Oil Tanks & Traffic	3.08	0.32	0.21	0.00	0.13	678.90	39.12	96.23	77.38	0.00	1721.34	1562.01
Venting	---	---	---	---	---	8.80	0.72	0.29	11.02	0.00	231.76	210.31
Compression and Well Pumps	3.90	3.90	88.06	0.06	176.13	61.64	6.16	11,882.93	0.22	0.02	11894.58	10793.63
Dehydrators	0.00	0.00	0.01	0.00	0.01	20.19	2.50	13.04	13.52	0.00	296.95	269.47
Compression Station Fugitives	---	---	---	---	---	0.67	0.07	0.02	0.85	0.00	17.77	16.13
Sub-total: Operations	**14.03**	**5.01**	**89.86**	**0.08**	**187.11**	**770.86**	**48.64**	**14,134.18**	**124.96**	**0.05**	**16,774.83**	**15,222.17**
Road Maintenance	1.67	0.18	0.43	0.011	0.22	0.07	0.007	54.18	0.00	0.00	54.58	49.52
Sub-total: Maintenance	**1.67**	**0.18**	**0.43**	**0.011**	**0.22**	**0.07**	**0.007**	**54.185**	**0.001**	**0.00**	**54.58**	**49.52**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.06	0.05
Well Reclamation	0.05	0.01	0.01	0.00	0.01	0.00	0.00	1.63	0.00	0.00	1.64	1.49
Sub-total: Reclamation	**0.06**	**0.01**	**0.01**	**0.0003**	**0.01**	**0.002**	**0.0002**	**1.6847**	**0.0000**	**0.0000**	**1.6945**	**1.5376**
Total Emissions	**22.70**	**6.29**	**97.20**	**0.17**	**223.14**	**772.90**	**48.84**	**21,342.92**	**125.04**	**0.14**	**24,011.63**	**21,789.14**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	5.24	0.52	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	36.18	35.16	691.10	14.35	177.48	50.50	5.05	74376.25	0.77	0.08	74417.53	67529.52
Commuting Vehicles - Construction	61.54	6.26	1.74	0.01	2.06	0.72	0.07	453.79	0.02	0.00	455.10	412.97
Wind Erosion	1.55	0.23	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**104.50**	**42.18**	**692.84**	**14.36**	**179.54**	**51.22**	**5.12**	**74,830.04**	**0.79**	**0.08**	**74,872.62**	**67,942.49**
Well Workover Operations - Fugitive Dust	9.12	0.91	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	15.92	15.44	280.07	4.77	94.09	20.27	2.03	22160.21	0.31	0.25	22245.21	20186.21
Well Workover Operations - On-road Exhaust	0.02	0.02	0.29	0.00	0.52	0.21	0.021	65.37	0.00	0.01	67.20	60.98
Well Visits for Inspection & Repair - Operations	10.21	1.02	0.31	0.00	6.69	0.30	0.030	133.04	0.02	0.05	148.87	135.09
Recompletion Traffic	15.70	1.60	0.56	0.00	0.88	0.34	0.03	132.65	0.00	0.01	136.08	123.48
Water Tanks & Traffic	41.71	4.41	3.55	0.02	2.25	0.46	0.05	1,033.64	241.07	0.01	6098.52	5534.04
Oil Tanks & Traffic	33.83	3.54	2.30	0.01	1.46	7,457.30	429.76	1,057.07	849.96	0.01	18907.79	17157.71
Venting	---	---	---	---	---	94.03	7.64	3.06	117.76	0.00	2476.06	2246.88
Compression and Well Pumps	42.88	42.88	967.32	0.66	1,934.64	677.13	67.71	130,526.52	2.46	0.25	130654.54	118561.29
Dehydrators	0.01	0.01	0.12	0.00	0.10	221.75	27.48	143.24	148.47	0.00	3261.85	2959.94
Compression Station Fugitives	---	---	---	---	---	7.41	0.74	0.24	9.28	0.00	195.19	177.12
Sub-total: Operations	**169.41**	**69.83**	**1,254.52**	**5.46**	**2,040.62**	**8,479.20**	**535.49**	**155,255.04**	**1,369.33**	**0.58**	**184,191.30**	**167,142.74**
Road Maintenance	18.37	2.02	4.68	0.121	2.39	0.73	0.073	595.18	0.01	0.01	599.48	543.99
Sub-total: Maintenance	**18.37**	**2.02**	**4.68**	**0.121**	**2.39**	**0.73**	**0.073**	**595.185**	**0.006**	**0.01**	**599.48**	**543.99**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.62	0.56
Well Reclamation	0.60	0.07	0.07	0.00	0.08	0.02	0.00	17.89	0.00	0.00	17.99	16.33
Sub-total: Reclamation	**0.62**	**0.07**	**0.08**	**0.0032**	**0.09**	**0.018**	**0.0018**	**18.5050**	**0.0003**	**0.0003**	**18.6129**	**16.8901**
Total Emissions	**292.90**	**114.11**	**1,952.12**	**19.94**	**2,222.63**	**8,531.17**	**540.69**	**230,698.77**	**1,370.13**	**0.68**	**259,682.02**	**235,646.11**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

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)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**7.70E+01**	**7.70E+00**	**3.85E-02**	**3.85E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 genset)	0.50	0.030	0.0051	2.60	0.14	0.03	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	53	9	4,622	249	0.44	0.03	0.00	2.31	0.12	0.03	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	1	330	18	0.02	0.00	0.00	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	600	1	50	11	5	55	1	11	1	0	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	0	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	**4.91E-01**	**2.87E-02**	**5.23E-03**	**2.72E+00**	**1.43E-01**	**2.87E-02**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.19E-01**	**3.16E-02**	**5.99E-03**	**2.74E+00**	**1.46E-01**	**3.20E-02**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
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, Fracing & 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 (%)[b]**	**# 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	**5.05E+00**	**2.63E-01**	**1.05E-01**	**1.29E+00**	**3.69E-01**	**2.55E-01**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.08E+00**	**2.66E-01**	**1.05E-01**	**1.30E+00**	**3.71E-01**	**2.59E-01**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	0.27	129.02	0.06	0.07	0.03	12.90	0.01	0.01
	Pickup Trucks	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.27	13.73	0.01	0.01	0.03	1.37	0.00	0.00
	Pickup Trucks	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.27	5.49	0.00	0.01	0.03	0.55	0.00	0.00
	Haul Trucks	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Pickup Trucks	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.27	120.78	0.06	0.14	0.03	12.08	0.01	0.01
	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Tool Pusher	25	10	8	80	1	0.22	17.39	0.01		0.02	1.74	0.00	
	Mud Logger	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Engineer	25	10	15	150	1	0.22	32.60	0.02		0.02	3.26	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.27	16.47	0.01	0.02	0.03	1.65	0.00	0.00
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
									Subtotal	**2.47E-01**				**2.47E-02**

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 (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/vehicle type)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)
Well Completion, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00	0.20	0.02	0.65	0.00	0.02
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Welders	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Haul Water Truck	25	10	150	1500	1	0.22	326.03	0.16		0.02	32.60	0.02	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**2.05E-01**				**2.05E-02**
									Total	**4.51E-01**				**4.51E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	10	47	470	1	2.8142	0.2851	0.2380	0.0137	1.7832	0.3668	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.001	0.000	0.000	0.000	0.001	0.000	0.4	0.0000	0.0000
	Pickup Trucks	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	4	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Haul Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	1	10	1	0.0510	0.0024	0.0020	0.0001	0.1377	0.0606	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																		Subtotal	**1.88E-03**	**1.79E-04**	**1.50E-04**	**8.64E-06**	**1.61E-03**	**4.61E-04**	**5.25E-01**	**2.30E-05**	**3.20E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	10	44	440	1	2.6346	0.2669	0.2228	0.0128	1.6694	0.3434	0.0013	0.0001	0.0001	0.0000	0.0008	0.0002	0.00	0.00	0.00	0.00	0.01	0.00	0.4	0.0000	0.0000
	Fuel Haul Truck	HDDV	10	6	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	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Tool Pusher	LDDT	10	8	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							0.0	0.0000	0.0000
	Mud Logger	LDDT	10	6	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							0.0	0.0000	0.0000
	Mud Engineer	LDDT	10	15	150	1	0.7646	0.0359	0.0293	0.0019	2.0658	0.9084	0.0004	0.0000	0.0000	0.0000	0.0010	0.0005							0.1	0.0000	0.0000
	Logger, Engr Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	10	6	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	0.0000	0.0000
	Haul Water Truck	HDDV	10	150	1500	1	8.9815	0.9101	0.7596	0.0437	5.6911	1.1706	0.0045	0.0005	0.0004	0.0000	0.0028	0.0006							1.3	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**1.09E-02**	**9.31E-04**	**7.74E-04**	**4.52E-05**	**1.36E-02**	**4.82E-03**	**2.81E+00**	**1.08E-04**	**1.99E-04**
																	Total		**1.28E-02**	**1.11E-03**	**9.23E-04**	**5.38E-05**	**1.52E-02**	**5.28E-03**	**3.34E+00**	**1.31E-04**	**2.31E-04**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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_2O[a]
Diesel	0.30	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	10	12	120	1	0.08	9.68	**4.84E-03**	0.01	0.96	**4.82E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	10	12	120	1	0.30	0.01	0.00	0.00	6.34	0.28	**1.49E-04**	**3.35E-06**	**1.55E-06**	**1.16E-06**	**3.17E-03**	**1.42E-04**	**6.31E-02**	**8.99E-06**	**2.36E-05**

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for 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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	1.0	60	0.08	4.84	**2.42E-03**	0.01	0.48	**2.41E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

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 (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	1.0	60	**1.53E-04**	**7.19E-06**	**5.85E-06**	**3.70E-07**	**4.13E-04**	**1.82E-04**	**2.71E-02**	**1.32E-07**	**3.51E-06**

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E \text{ (lb/VMT)} = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	10	56	562	1	0.07	39.21	**1.96E-02**	0.01	3.90	**1.95E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	10	56	562	1	3.362	0.341	0.284	0.016	2.131	0.438	**1.68E-03**	**1.70E-04**	**1.42E-04**	**8.17E-06**	**1.07E-03**	**2.19E-04**	**4.90E-01**	**2.29E-05**	**3.75E-06**

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other 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/10^3 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[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] 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)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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														
							(lb/well)						(tpy/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_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	10	37	365	1	2.185	0.221	0.185	0.011	1.385	0.285	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.319	0.000	0.000
						TOTAL							**1.09E-03**	**1.11E-04**	**9.24E-05**	**5.31E-06**	**6.92E-04**	**1.42E-04**	**3.19E-01**	**1.49E-05**	**2.44E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (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-HA	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**

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

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01	0.15	0.02	1.30	0.00	0.01
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Water Truck	25	10	50	500	1	0.22	108.68	0.05		0.02	10.87	0.01	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**1.49E-01**				**1.49E-02**
									Total	**1.49E-01**				**1.49E-02**

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_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Well Recompletion	Fuel Haul Truck	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	10	50	500	1	2.9938	0.3034	0.2532	0.0146	1.8970	0.3902	0.0015	0.0002	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**
																	Total		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	20	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.054	MMSCF/well

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		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]	N_2O[c]
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

[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 and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

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	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O 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_2 emissions per well (lb/hr)	CH_4 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
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
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	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	1.63E-03	2.44E-04
								TOTAL	**1.14E-02**	**1.71E-03**

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	0.250
Number of Roads Reclaimed Annually Per Well	0.020
Annual Miles of Roads reclaimed Per Well	0.005
Number of wells reclaimed (per well)	0.020

Reclaimation 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
0.005	6	0.0008	0.0083
		Total	**0.0083**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.005	5	0.025	0.765	**9.56E-06**	0.069	**8.66E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Road Reclamation	Grader	80	0.005	0.4238	0.0720	0.0197	0.4106	0.0629	**1.06E-06**	**1.80E-07**	**4.91E-08**	**1.03E-06**	**1.57E-07**	**1.75E-07**	**2.71E-04**	**2.43E-09**	**2.67E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0008	0.0500	0.081	**2.02E-06**	0.008	**2.01E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0008	0.0500	**1.27E-07**	**5.99E-09**	**4.88E-09**	**3.09E-10**	**3.44E-07**	**1.51E-07**	**2.26E-05**	**1.10E-10**	**2.92E-09**

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	0.020	10	0.020	0.20

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.1199	5	0.600	0.765	**2.29E-04**	0.069	**2.08E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.1199	0.5297	0.0900	0.0246	0.5132	0.0786	**3.18E-05**	**5.40E-06**	**1.47E-06**	**3.08E-05**	**4.71E-06**	**8.38E-06**	**7.94E-03**	**1.32E-07**	**8.00E-08**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.0200	1.1995	0.081	**4.84E-05**	0.008	**4.81E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.0200	1.1995	**3.06E-06**	**1.44E-07**	**1.17E-07**	**7.40E-09**	**8.26E-06**	**3.63E-06**	**5.41E-04**	**2.64E-09**	**7.01E-08**

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

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)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Alternative C input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	11	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	111
Federal Producing Wells - RMP Year 20	159	Non-Federal Producing Wells - RMP Year 20	1,747
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 30% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.13	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.10	0.11	1.82	0.03	13.47	0.71	0.07	2617.70	0.02	0.03	2627.37	2384.18
Commuting Vehicles - Construction	1.99	0.20	0.06	0.00	0.07	0.02	0.00	14.68	0.00	0.00	15.01	13.62
Wind Erosion	0.04	0.01	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.19	0.00	0.08	24.94	0.00	523.83	475.35
Sub-total: Construction	**2.26**	**0.33**	**1.88**	**0.03**	**13.54**	**0.92**	**0.07**	**2,632.46**	**24.96**	**0.03**	**3,166.21**	**2,873.15**
Well Workover Operations - Fugitive Dust	0.28	0.03	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.05	0.05	0.95	0.02	8.20	0.44	0.04	1672.92	0.01	0.02	1679.04	1523.63
Well Workover Operations - On-road Exhaust	0.00	0.00	0.01	0.00	0.02	0.01	0.001	1.97	0.00	0.00	2.03	1.84
Well Visits for Inspection & Repair - Operations	0.31	0.03	0.01	0.00	0.20	0.01	0.001	4.01	0.00	0.00	4.49	4.07
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.43	0.04	0.19	56.24	0.00	1181.31	1071.97
Compression	1.46	1.46	32.87	0.02	65.73	23.01	2.30	4,434.91	0.08	0.01	4439.26	4028.36
Station Visits - Operations	0.10	0.01	0.01	0.00	0.02	0.01	0.00	1.09	0.00	0.00	1.14	1.03
Dehydrators	0.00	0.00	0.02	0.00	0.02	0.05	0.02	24.00	36.05	0.00	781.28	708.96
Sub-total: Operations	**2.19**	**1.57**	**33.86**	**0.04**	**74.19**	**23.95**	**2.41**	**6,139.09**	**92.39**	**0.03**	**8,088.54**	**7,339.87**
Road Maintenance	1.20	0.13	0.34	0.009	0.15	0.04	0.004	42.86	0.00	0.00	43.10	39.12
Sub-total: Maintenance	**1.20**	**0.13**	**0.34**	**0.009**	**0.15**	**0.04**	**0.004**	**42.862**	**0.000**	**0.00**		**39.12**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.13	0.12
Well Reclamation	0.13	0.02	0.02	0.00	0.02	0.00	0.00	3.75	0.00	0.00	3.77	3.42
Sub-total: Reclamation	**0.13**	**0.02**	**0.02**	**0.0007**	**0.02**	**0.004**	**0.0004**	**3.8811**	**0.0001**	**0.0001**	**3.9037**	**3.5424**
Total Emissions	**5.79**	**2.05**	**36.10**	**0.08**	**87.89**	**24.92**	**2.49**	**8,818.30**	**117.36**	**0.06**	**11,258.65**	**10,255.68**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.33	1.38	97.35	0.33	135.75	7.16	0.72	26401.82	0.27	0.03	26416.75	23971.65
Commuting Vehicles - Construction	20.09	2.05	0.57	0.00	0.67	0.23	0.02	148.15	0.01	0.00	148.59	134.83
Wind Erosion	0.36	0.05	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	1.93	0.00	0.85	251.67	0.00	5285.97	4796.70
Sub-total: Construction	**23.12**	**3.62**	**97.92**	**0.34**	**136.42**	**9.32**	**0.74**	**26,550.82**	**251.95**	**0.03**	**31,851.31**	**28,903.18**
Well Workover Operations - Fugitive Dust	3.02	0.30	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	13.19	12.79	232.00	3.95	77.94	16.79	1.68	18356.52	0.26	0.21	18426.92	16721.34
Well Workover Operations - On-road Exhaust	0.01	0.01	0.10	0.00	0.17	0.07	0.007	21.66	0.00	0.00	22.27	20.20
Well Visits for Inspection & Repair - Operations	3.38	0.34	0.10	0.00	2.22	0.10	0.010	44.08	0.01	0.02	49.33	44.76
Wellhead and Compressor Station Fugitives	---	---	---	---	---	4.74	0.47	2.08	617.97	0.00	12979.55	11778.18
Compression	16.01	16.01	361.12	0.25	722.24	252.78	25.28	48,728.20	0.92	0.09	48775.99	44261.33
Station Visits - Operations	1.08	0.11	0.07	0.00	0.18	0.08	0.01	12.03	0.00	0.00	12.51	11.36
Dehydrators	0.02	0.01	0.22	0.00	0.18	0.56	0.26	263.67	396.14	0.00	8584.21	7789.66
Sub-total: Operations	**36.70**	**29.57**	**593.61**	**4.20**	**802.93**	**275.12**	**27.72**	**67,428.23**	**1,015.30**	**0.33**	**88,850.78**	**80,626.84**
Road Maintenance	13.24	1.47	3.75	0.100	1.64	0.46	0.046	470.94	0.00	0.01	473.61	429.78
Sub-total: Maintenance	**13.24**	**1.47**	**3.75**	**0.100**	**1.64**	**0.46**	**0.046**	**470.944**	**0.005**	**0.01**		**429.78**
Road Reclamation	0.06	0.01	0.01	0.00	0.01	0.00	0.00	1.42	0.00	0.00	1.43	1.30
Well Reclamation	1.38	0.17	0.17	0.01	0.19	0.04	0.00	41.22	0.00	0.00	41.46	37.62
Sub-total: Reclamation	**1.43**	**0.17**	**0.18**	**0.0074**	**0.20**	**0.042**	**0.0042**	**42.6430**	**0.0007**	**0.0008**	**42.8916**	**38.9216**
Total Emissions	**74.50**	**34.83**	**695.45**	**4.64**	**941.19**	**284.95**	**28.51**	**94,492.64**	**1,267.25**	**0.37**	**120,744.97**	**109,998.72**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**24**	**2.41**	**1.21E-02**	**1.21E-03**

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

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (non-genset)	2.30	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	4	1,849	100	0.11	0.01	0.00	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	5.73E-03	3.60E-05	8.35E-06	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	**1.38E-01**	**6.64E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**6.64E-03**	**2.34E+02**	**1.80E-03**	**2.67E-03**
												Total		**1.66E-01**	**9.51E-03**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**9.96E-03**	**2.38E+02**	**1.85E-03**	**2.71E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	1,636	16	4	1,849	100	0.82	0.01	0.00	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**8.49E-01**	**9.13E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
												Total		**8.77E-01**	**1.20E-02**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**1.25E-02**	**2.38E+02**	**2.44E-03**	**2.71E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lbs/vehicle/ well)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/vehicle/ well)	Emissions (tons/ vehicle type/well)	Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	4	47	188	1	0.27	51.61	0.03	0.026	0.03	5.16	0.00	0.003
	Pickup Trucks	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
Well Pad	Semi Trucks	42	4	5	20	1	0.27	5.49	0.00	0.004	0.03	0.55	0.00	0.000
	Pickup Trucks	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
Other Construction Activities	Semi Trucks	42	4	2	8	1	0.27	2.20	0.00	0.002	0.03	0.22	0.00	0.000
	Haul Trucks	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Pickup Trucks	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	4	44	176	1	0.27	48.31	0.02	0.058	0.03	4.83	0.00	0.006
	Fuel Haul Truck	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Haul Truck, Water Hauling	25	4	4	16	1	0.22	3.48	0.00		0.02	0.35	0.00	
	Rig Crew	5	4	51	204	1	0.11	21.49	0.01		0.01	2.15	0.00	
	Rig Mechanics	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Co. Supervisor	5	4	20	80	1	0.11	8.43	0.00		0.01	0.84	0.00	
	Tool Pusher	25	4	8	32	1	0.22	6.96	0.00		0.02	0.70	0.00	
	Mud Logger	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Engineer	25	4	15	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Logger, Engr Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Drill Bit Delivery	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	4	6	24	1	0.27	6.59	0.00	0.009	0.03	0.66	0.00	0.001
	Semi Completion, Unit Rig	42	4	1	4	1	0.27	1.10	0.00		0.03	0.11	0.00	
	Semi Fracing, Blender	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Semi Pumping/Tank Battery	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Tubing Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Cementer, Pump Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
									Subtotal	**9.86E-02**				**9.86E-03**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	4	3	12	1	0.22	2.61	0.00	0.082	0.02	0.26	0.00	0.008
	Haul Completion,	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Service Tools	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Perforators Logging Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Installation	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Testing	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Tank	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Pump	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Chemical	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Sand	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Other	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Welders	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Haul Water Truck	25	4	150	600	1	0.22	130.41	0.07		0.02	13.04	0.01	
	Pickup Cementer, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Casing Crew	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Completion Crew	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion, Pusher	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Perforators, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Fracing, Engineer	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
	Pickup Co. Supervisor	5	4	10	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
	Pickup Miscellaneous Supplies	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
	Pickup Roustabout Crew	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
									Subtotal	**8.19E-02**				**8.19E-03**
									Total	**1.81E-01**				**1.81E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	4	47	188	1	1.1257	0.1141	0.0952	0.0055	0.7133	0.1467	0.0006	0.0001	0.0000	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.000	0.000	0.1641	0.000008	0.000009
	Pickup Trucks	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0054	0.000000	0.000001
Well Pad	Semi Trucks	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0175	0.000001	0.000001
	Pickup Trucks	LDDT	4	4	16	1	0.0816	0.0038	0.0031	0.0002	0.2204	0.0969	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0072	0.000000	0.000001
Other Construction Activities	Semi Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0070	0.000000	0.000000
	Haul Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0070	0.000000	0.000000
	Pickup Trucks	LDDT	4	1	4	1	0.0204	0.0010	0.0008	0.0000	0.0551	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0018	0.000000	0.000000
																		Subtotal	**7.52E-04**	**7.18E-05**	**5.98E-05**	**3.46E-06**	**6.45E-04**	**1.84E-04**	**2.10E-01**	**9.21E-06**	**1.28E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	4	44	176	1	1.0538	0.1068	0.0891	0.0051	0.6678	0.1374	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.000007	0.000009
	Fuel Haul Truck	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Mud Haul Truck, Water Hauling	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Rig Crew	LDDT	4	51	204	1	1.0398	0.0489	0.0398	0.0025	2.8095	1.2354	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Rig Mechanics	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Co. Supervisor	LDDT	4	20	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							0.0	0.000000	0.000005
	Tool Pusher	LDDT	4	8	32	1	0.1631	0.0077	0.0062	0.0004	0.4407	0.1938	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000002
	Mud Logger	LDDT	4	6	24	1	0.1223	0.0058	0.0047	0.0003	0.3305	0.1453	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000001
	Mud Engineer	LDDT	4	15	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							0.0	0.000000	0.000004
	Logger, Engr Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Drill Bit Delivery	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.000001	0.000001
	Semi Completion, Unit Rig	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Fracing, Blender	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Pumping/Tank Battery	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Tubing Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Pump Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Cement Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Completion, Equip Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Service Tools	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Haul Perforators Logging Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Installation	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Testing	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Tank	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Pump	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Chemical	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Sand	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Other	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Welders	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Haul Water Truck	HDDV	4	150	600	1	3.5926	0.3640	0.3038	0.0175	2.2765	0.4683	0.0018	0.0002	0.0002	0.0000	0.0011	0.0002							0.5	0.000024	0.000029
	Pickup Cementer, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Casing Crew	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Completion Crew	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Pickup Completion, Pusher	LDDT	4	5	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.000000	0.000001
	Pickup Perforators, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Fracing, Engineer	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Co. Supervisor	LDDT	4	10	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.000000	0.000002
	Pickup Miscellaneous Supplies	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000001
	Pickup Roustabout Crew	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
																	Subtotal		**4.36E-03**	**3.72E-04**	**3.09E-04**	**1.81E-05**	**5.42E-03**	**1.93E-03**	**1.12E+00**	**4.30E-05**	**7.97E-05**
																	Total		**5.11E-03**	**4.44E-04**	**3.69E-04**	**2.15E-05**	**6.07E-03**	**2.11E-03**	**1.33E+00**	**5.22E-05**	**9.25E-05**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[a]
Diesel	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

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_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O**
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O**
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	4	12	48	1	0.08	3.87	**1.94E-03**	0.01	0.39	**1.93E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	4	12	48	1	0.12	0.00	0.00	0.00	2.54	0.11	**5.96E-05**	**1.34E-06**	**6.19E-07**	**4.66E-07**	**1.27E-03**	**5.66E-05**	**2.52E-02**	**3.60E-06**	**9.44E-06**

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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	0.5	32	0.08	2.58	**1.29E-03**	0.01	0.26	**1.28E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	0.5	32	**8.16E-05**	**3.83E-06**	**3.12E-06**	**1.98E-07**	**2.20E-04**	**9.69E-05**	**1.44E-02**	**7.05E-08**	**1.87E-06**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	0.50	2024.16	1.00	0.00	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	0.00	0.00
								TOTAL	**3.25E-03**	**4.88E-04**

[a] 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[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	0.056
Annual Miles of Roads reclaimed Per Well	0.014
Number of wells reclaimed (per well)	0.056

Reclaimation 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
0.0139	6	0.00232	0.0232
		Total	**0.023**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.014	5	0.070	0.765	**2.66E-05**	0.069	**2.41E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.014	0.4238	0.0720	0.0197	0.4106	0.0629	**2.95E-06**	**5.00E-07**	**1.37E-07**	**2.85E-06**	**4.37E-07**	**4.85E-07**	**7.53E-04**	**6.76E-09**	**7.42E-09**

Emission Factors for Road Traffic

$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0023	0.139	0.08	**5.61E-06**	0.01	**5.58E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0023	0.1390	**3.54E-07**	**1.67E-08**	**1.36E-08**	**8.58E-10**	**9.57E-07**	**4.21E-07**	**6.28E-05**	**3.07E-10**	**8.12E-09**

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	0.056	10	0.056	0.56

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.33	5	1.67	0.765	**6.38E-04**	0.069	**5.78E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.33	0.5297	0.0900	0.0246	0.5132	0.0786	**8.84E-05**	**1.50E-05**	**4.10E-06**	**8.56E-05**	**1.31E-05**	**2.33E-05**	**2.21E-02**	**3.68E-07**	**2.23E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.06	3.34	0.081	**1.35E-04**	0.008	**1.34E-05**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.06	3.34	**8.50E-06**	**4.00E-07**	**3.26E-07**	**2.06E-08**	**2.30E-05**	**1.01E-05**	**1.51E-03**	**7.36E-09**	**1.95E-07**

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

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)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

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)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

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	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

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

Volume Flow:	40	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.12	MMSCF/well

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

BTU value = 994 BTU/scf

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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

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 >20º API		Heavy Oil <20º 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 =	0.00349	0.00002	0.00001	0.00310

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 (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.15E-04**			**6.12E-05**

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions														
								(lbs/trip)						(tpy/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_2O
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	0.00	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	0.00	0.00289	0.00000	0.00000
													Total	**3.89E-05**	**1.83E-06**	**1.49E-06**	**9.42E-08**	**1.05E-04**	**4.62E-05**	**6.89E-03**	**3.36E-08**	**8.91E-07**

Alternative C input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	5	Peak Year Non-Federal Producing Wells Drilled	47
Federal Producing Wells - Year 20 (RMP Totals)	81	Non-Federal Producing Wells - Year 2027 (RMP Totals)	885
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

* 30% full RMP estimates (rounded up to next higher number) for Federal, full RMP estimates (100%) for non-Federal

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	2.95	0.30	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.06	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.02	0.01	0.23	0.01	0.52	0.04	0.00	110.36	0.00	0.00	110.77	100.51
Commuting Vehicles - Construction	0.33	0.03	0.01	0.00	0.02	0.01	0.00	2.92	0.00	0.00	3.00	2.72
Completion Venting	---	---	---	---	---	0.00	0.00	0.33	13.72	0.00	288.37	261.68
Sub-total: Construction	**3.36**	**0.35**	**0.25**	**0.01**	**0.55**	**0.05**	**0.00**	**113.61**	**13.72**	**0.00**	**402.13**	**364.91**
Natural Gas Compression - Operations	0.84	0.84	18.84	0.01	37.67	13.19	2.52	2,541.70	0.05	0.00	2,544.20	2308.71
Dehydrators	0.00	0.00	0.01	0.00	0.01	0.00	0.00	13.75	21.16	0.00	458.24	415.82
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	0.64	26.96	0.00	566.76	514.30
Station Visits - Operations	0.06	0.01	0.00	0.00	0.01	0.00	0.00	0.63	0.00	0.00	0.65	0.59
Well Workover - Operations	0.16	0.11	0.27	0.00	0.13	0.01	0.00	458.06	0.00	0.00	459.20	416.70
Well & Pipeline visits for Inspection & Repair - Operations	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.29	0.26
Sub-total: Operations	**1.07**	**0.96**	**19.12**	**0.02**	**37.82**	**13.21**	**2.52**	**3015.07**	**48.17**	**0.01**	**4029.33**	**3656.38**
Road Maintenance	0.13	0.01	0.02	0.00	0.01	0.00	0.00	5.30	0.00	0.00	5.32	4.82
Sub-total: Maintenance	**0.13**	**0.01**	**0.02**	**0.00**	**0.01**	**0.00**	**0.00**	**5.30**	**0.00**	**0.00**	**5.32**	**4.82**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.10	0.09
Well Reclamation	0.08	0.01	0.01	0.00	0.01	0.00	0.00	2.78	0.00	0.00	2.79	2.53
Sub-total: Reclamation	**0.09**	**0.01**	**0.01**	**0.0005**	**0.01**	**0.002**	**0.0002**	**2.8779**	**0.0000**	**0.0000**	**2.8885**	**2.6212**
Total Emissions	**4.65**	**1.33**	**19.40**	**0.02**	**38.39**	**13.26**	**2.53**	**3,136.85**	**61.89**	**0.01**	**4,439.67**	**4,028.74**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	27.75	2.78	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.54	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.51	0.45	7.57	0.20	2.38	0.60	0.06	1,037.39	0.01	0.01	1,041.23	944.86
Commuting Vehicles - Construction	3.14	0.32	0.12	0.00	0.21	0.08	0.01	27.45	0.00	0.00	28.20	25.59
Completion Venting	---	---	---	---	---	0.00	0.00	3.07	128.93	0.00	2,710.66	2459.76
Sub-total: Construction	**31.94**	**3.63**	**7.69**	**0.20**	**2.59**	**0.69**	**0.07**	**1067.91**	**128.94**	**0.01**	**3780.09**	**3430.20**
Natural Gas Compression - Operations	9.12	9.12	205.80	0.14	411.61	144.06	27.52	27,770.47	0.52	0.05	27,797.71	25224.78
Dehydrators	0.01	0.01	0.13	0.00	0.11	0.01	0.00	150.27	231.22	0.00	5,006.64	4543.23
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.01	0.00	7.02	294.54	0.00	6,192.36	5619.20
Station Visits - Operations	0.61	0.06	0.04	0.00	0.10	0.05	0.00	6.86	0.00	0.00	7.13	6.47
Well Workover - Operations	5.12	1.23	62.81	21.06	4.62	3.47	0.35	4,998.14	0.07	0.07	5,021.55	4556.76
Well & Pipeline visits for Inspection & Repair - Operations	0.27	0.03	0.02	0.00	0.05	0.02	0.00	3.00	0.00	0.00	3.12	2.83
Sub-total: Operations	**15.14**	**10.45**	**268.80**	**21.20**	**416.49**	**147.62**	**27.88**	**32935.75**	**526.35**	**0.13**	**44028.51**	**39953.28**
Road Maintenance	1.41	0.15	0.20	0.01	0.09	0.03	0.00	57.87	0.00	0.00	58.08	52.71
Sub-total: Maintenance	**1.41**	**0.15**	**0.20**	**0.01**	**0.09**	**0.03**	**0.00**	**57.87**	**0.00**	**0.00**	**58.08**	**52.71**
Road Reclamation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	1.04	0.94
Well Reclamation	0.91	0.11	0.12	0.01	0.12	0.02	0.00	30.41	0.00	0.00	30.52	27.69
Sub-total: Reclamation	**0.95**	**0.12**	**0.13**	**0.0058**	**0.12**	**0.020**	**0.0020**	**31.4439**	**0.0005**	**0.0003**	**31.5599**	**28.6388**
Total Emissions	**49.44**	**14.35**	**276.81**	**21.42**	**419.29**	**148.35**	**27.95**	**34,092.97**	**655.29**	**0.14**	**47,898.24**	**43,464.83**

Fugitive Dust Emissions From Well Pad and Compressor Station Construction

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Construction Activities: All Project Years

Area Disturbed for CBNG Wells	Emission Estimation Basis	Avg. Disturbed Acres per Well[a]	Construction Days	Total # of Well Pads or Stations	Total Disturbed Acres	Emissions			
						(lb/well)		(tpy/well)	
						PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Well Pad and Road Construction	Per Well	3.48	5	1	3.48	1.16E+03	1.16E+02	5.81E-01	5.81E-02
Field Compressor Station	Per Well	0.04	6	1	0.04	1.66E+01	1.66E+00	8.30E-03	8.30E-04
Sales Compressor Station	Per Well	0.01	6	1	0.01	2.77E+00	2.77E-01	1.38E-03	1.38E-04
				Total	**3.53**	**1.18E+03**	**1.18E+02**	**5.91E-01**	**5.91E-02**

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

Exhaust Emissions from Heavy Construction Equipment (Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/ Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity) NO_x	$PM_{2.5}/PM_{10}$[a]	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																	Subtotal		**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso,

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	8.6	0.4	0.1	74.3	4.0	0.00	0.00	0.00	0.04	0.00	0.006	0.000	0.000	0.056	0.003	0.00	7.6	0.0001	0.0001
	Auxillary Pump	200	1	90	18	2	36	1.00	4.3	0.2	0.1	37.1	2.0	0.00	0.00	0.00	0.02	0.00						0.00	3.8	0.0000	0.0000
Well Completion, Fraading & Testing	Main Deck	400	1	60	18	1	18	1.00	2.9	0.1	0.0	24.8	1.3	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.021	0.001	0.00	2.5	0.0000	0.0000
	Auxillary Pump	125	1	90	18	1	18	1.00	1.3	0.1	0.0	16.5	0.6	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.012	0.001	0.00	1.2	0.0000	0.0000
	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
																	Subtotal		**1.09E-02**	**5.29E-04**	**1.69E-04**	**8.85E-02**	**4.64E-03**	**5.29E-04**	**1.76E+01**	**1.43E-04**	**1.99E-04**
																	Total		**1.86E-02**	**1.21E-03**	**3.99E-04**	**9.16E-02**	**5.43E-03**	**1.27E-03**	**1.88E+01**	**1.55E-04**	**2.12E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.0000	0.0000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Exhaust Emissions from Heavy Construction Equipment (Non-Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	$PM_{2.5}/PM_{10}$	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																		Subtotal	**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	103.2	6.1	2.9	30.2	7.4	0.05	0.00	0.00	0.02	0.00	0.076	0.005	0.002	0.021	0.006	0.00	7.6	0.000	0.000
	Auxillary Pump	200	1	90	18	2	36	1.00	48.2	3.2	1.5	11.9	4.1	0.02	0.00	0.00	0.01	0.00						0.00	3.8	0.000	0.000
Well Completion, Fraading & Testing	Main Deck	400	1	60	18	1	18	1.00	34.4	2.0	1.0	10.1	2.5	0.02	0.00	0.00	0.01	0.00	0.025	0.002	0.001	0.007	0.002	0.00	2.5	0.000	0.000
	Auxillary Pump	125	1	90	18	1	18	1.00	15.9	1.2	0.5	4.4	1.4	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00	0.024	0.001	0.000	0.006	0.002	0.00	1.2	0.000	0.000
	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
																		Subtotal	**1.25E-01**	**7.52E-03**	**3.38E-03**	**3.43E-02**	**9.43E-03**	**7.30E-03**	**1.76E+01**	**1.43E-04**	**2.00E-04**
																		Total	**1.33E-01**	**8.21E-03**	**3.61E-03**	**3.73E-02**	**1.02E-02**	**8.04E-03**	**1.88E+01**	**1.55E-04**	**2.13E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.000	0.000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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		
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/activity)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/activity)	$PM_{2.5}$ Emissions (tpy/well)
Drilling Roads	Semi Trucks	42	6	3	18	1.000	0.27	4.94	0.002	0.03	0.49	0.000
Drilling Well Pad	Haul Trucks	25	6	2	12	1.000	0.22	2.61	0.001	0.02	0.26	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Water Disposal Well Pad	Haul Trucks	25	10	5	50	0.005	0.22	10.87	0.000	0.02	1.09	0.000
	Pickup Trucks	5	10	5	50	0.005	0.11	5.27	0.000	0.01	0.53	0.000
New Pipeline Intermediate	Haul Trucks	25	6	40	240	0.111	0.22	52.17	0.003	0.02	5.22	0.000
	Pickup Trucks	5	6	160	960	0.111	0.11	101.14	0.006	0.01	10.11	0.001
New Sales Pipeline	Haul Trucks	25	35	94	3,290	0.000	0.22	715.10	0.000	0.02	71.51	0.000
	Pickup Trucks	5	50	94	4,700	0.000	0.11	495.14	0.000	0.01	49.51	0.000
Electric Line	Haul Trucks	25	6	1	6	1.000	0.22	1.30	0.001	0.02	0.13	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Field Compression Station	Semi Trucks	42	10	15	150	0.111	0.27	41.18	0.002	0.03	4.12	0.000
	Haul Trucks	25	10	48	480	0.111	0.22	104.33	0.006	0.02	10.43	0.001
	Pickup Trucks	5	10	192	1,920	0.111	0.11	202.27	0.011	0.01	20.23	0.001
Sales Compression Station	Semi Trucks	42	10	19	190	0.011	0.27	52.16	0.000	0.03	5.22	0.000
	Haul Trucks	25	10	48	480	0.011	0.22	104.33	0.001	0.02	10.43	0.000
	Pickup Trucks	5	10	192	1,920	0.011	0.11	202.27	0.001	0.01	20.23	0.000
Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso,								**Subtotal**	**3.56E-02**			**3.56E-03**

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/well)	$PM_{2.5}$ Emissions (tpy/well)
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Fuel Haul Truck	25	6	2	12	1.00	0.22	2.61	0.001	0.022	0.261	0.000
	Mud Haul Truck, Water Hauling	25	6	7	42	1.00	0.22	9.13	0.005	0.022	0.913	0.000
	Rig Crew	25	6	3	18	1.00	0.22	3.91	0.002	0.022	0.391	0.000
	Co. Supervisor	5	6	8	48	1.00	0.11	5.06	0.003	0.011	0.506	0.000
	Tool Pusher	25	6	6	36	1.00	0.22	7.82	0.004	0.022	0.782	0.000
	Logger, Engr Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000

Coal Bed Natural Gas - Alternative C

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10}			$PM_{2.5}$		
							Controlled Em. Factor (lb/VMT)	Emissions (lbs/well)	Emissions (tpy/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/well)	Emissions (tpy/well)
Well Completion, Fraading & Testing	Semi Casing Haulers	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Semi Completion, Unit Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Semi Fracing Blender	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Tubing Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Completion, Equip Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Perforators Logging Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Tank	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Pump	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Welders	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Water Truck	25	6	9	54	1.00	0.22	11.74	0.006	0.022	1.174	0.001
	Pickup Cementer, Engineer	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Co. Supervisor	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
	Pickup Miscellaneous Supplies	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Roustabout Crew	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
Water Disposal Well Drilling	Drill Rig Transport truck	42	6	10	60	0.01	0.27	16.47	0.000	0.027	1.647	0.000
	Mud Haul Truck, Water Hauling	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Rig Crew	25	6	10	60	0.01	0.22	13.04	0.000	0.022	1.304	0.000
	Co. Supervisor	5	6	5	30	0.01	0.11	3.16	0.000	0.011	0.316	0.000
	Tool Pusher	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Tubing Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
								Subtotal	**3.11E-02**			**3.11E-03**
								Total	**6.67E-02**			**6.67E-03**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy/well)								
	Type	Class					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_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	0.11	0.01	0.01	0.00	0.07	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.02	0.00	0.00
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.99	0.30	0.25	0.01	1.90	0.39	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	25	5	125	0.01	0.64	0.03	0.02	0.00	1.72	0.76	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	1.44	0.15	0.12	0.01	0.91	0.19	0.000	0.00	0.000	0.000	0.00	0.00	0.02	0.00	0.00
	Pickup Trucks	LDDT	6	160	960	0.11	4.89	0.23	0.19	0.01	13.22	5.81	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.05	0.00	0.00
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	19.70	2.00	1.67	0.10	12.48	2.57	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	50	94	4700	0.00	23.96	1.13	0.92	0.06	64.73	28.46	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	0.90	0.09	0.08	0.00	0.57	0.12	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.01	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.11	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.11	9.79	0.46	0.37	0.02	26.44	11.63	0.001	0.0000	0.0000	0.0000	0.00	0.001	0.10	0.00	0.00
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.14	0.12	0.10	0.01	0.72	0.15	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.00	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.01	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.01	9.79	0.46	0.37	0.02	26.44	11.63	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Fuel Haul Truck	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	0.25	0.03	0.02	0.00	0.16	0.03	0.000	0.00	0.00	0.00	0.0	0.00	0.04	0.00	0.00
	Rig Crew	LDDT	6	3	18	1.00	0.09	0.00	0.00	0.00	0.25	0.11	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Rig Mechanics	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Co. Supervisor	LDDT	6	8	48	1.00	0.24	0.01	0.01	0.00	0.66	0.29	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Tool Pusher	LDDT	6	6	36	1.00	0.18	0.01	0.01	0.00	0.50	0.22	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Mud Logger	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Mud Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Logger, Engr	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Drill Bit Delivery	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**1.88E-03**	**1.23E-04**	**1.02E-04**	**6.12E-06**	**3.75E-03**	**1.55E-03**	**4.07E-01**	**9.83E-06**	**3.89E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaksi, 2010)

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tpy) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Well Completion, Fraading & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Fracing Blender	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Tubing Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Service Tools	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Installation	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Testing	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Tank	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Pump	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Chemical	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Sand	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Other	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Welders	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Water Truck	HDDV	6	9	54	1.00	0.32	0.03	0.03	0.00	0.20	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Completion Crew	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Completion Pusher	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	0.60	0.06	0.05	0.00	0.38	0.08	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	0.30	0.03	0.03	0.00	0.19	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Rig Crew	LDDT	10	10	100	0.01	0.51	0.02	0.02	0.00	1.38	0.61	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Co. Supervisor	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tool Pusher	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tubing Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**6.51E-04**	**6.00E-05**	**5.00E-05**	**2.90E-06**	**6.39E-04**	**2.01E-04**	**1.77E-01**	**7.47E-06**	**1.14E-05**
											Total		**2.53E-03**	**1.83E-04**	**1.52E-04**	**9.02E-06**	**4.39E-03**	**1.76E-03**	**5.84E-01**	**1.73E-05**	**5.02E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power	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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	12	1	12	8,760	0.12	0.01	0.00	0.24	0.08	0.01	16.2	0.00	0.01	0.00
Sales Compression Station	12	1	12	8,760	0.11	0.00	0.00	0.22	0.08	0.00	15.1	0.00	0.01	0.00
				Total	**2.33E-01**	**1.03E-02**	**1.58E-04**	**4.65E-01**	**1.63E-01**	**1.03E-02**	**3.14E+01**	**5.92E-04**	**1.48E-02**	**5.92E-05**

Sub-total: Construction

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867
CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
Component	(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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (lb/yr)	VOC (tpy)	CO2 (lb/yr)	CO2 (tpy)	CH4 (lb/yr)	CH4 (tpy)
b-total: Construct	1	8760	0.00	**3.25E-07**	0.78	**3.92E-04**	32.90	**1.64E-02**

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.41E-04**	**1.08E-05**	**8.49E-07**	**1.19E-04**	**7.78E-06**	**8.07E-06**	**1.70E-01**	**3.25E-06**	**1.06E-07**	**3.11E-06**

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)
16.43	0.016	**2.61E-01**	0.000	**0.00E+00**	0.000	**0.00E+00**

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

Sub-total: Construction

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

The following South Baker Compressor Station assumptions were used with CBNG specific gas composition analysis to derive dehydrator emissions:

per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station ---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.5	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	6.92E-04			6.89E-05

Assume no dust control (watering)

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.5	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.004	0.000	0.000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	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	0.00	0.003	0.000	0.000
													Total	4.37E-05	2.06E-06	1.67E-06	1.06E-07	1.18E-04	5.20E-05	7.75E-03	3.78E-08	1.00E-06

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	0.0051	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	6.35	0.32	0.11	2.96	0.32	**3.17E-03**	**1.59E-04**	**5.40E-05**	**1.48E-03**	**1.59E-04**	**1.21E-03**	**5.61E+00**	**4.03E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	141.65	8.05	47.59	10.25	7.81	**7.08E-02**	**4.03E-03**	**2.38E-02**	**5.13E-03**	**3.91E-03**	**1.21E-03**	**5.60E+00**	**7.79E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Emissions for Well and Pipe Inspections

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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)		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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Fugitive Dust Emissions Estimation for Road Traffic: Well & Pipeline

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/ Year	PM_{10}			$PM_{2.5}$		
							Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)	Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)
Visits for Inspection and Repair	200-hp Pickup	40	0.625	12	1	8	0.08	0.05	**3.02E-04**	0.01	0.01	**3.01E-05**

Activity rates based on values shown in SEIS
Assume no dust control (watering)

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/Well	Emissions (lbs/trip/well)						Emissions (tpy/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_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	0.003	0.000	0.000	0.000	0.009	0.004	**1.91E-05**	**8.99E-07**	**7.32E-07**	**4.63E-08**	**5.16E-05**	**2.27E-05**	**3.39E-03**	**1.65E-08**	**4.38E-07**

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.08	0.83
Winter	1	0.25	5	10	0.05	0.50
				Total	0.13	1.33

Based on values shown in SEIS

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^{2}$	5	0.765
Sub-total: Constructi	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph

Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)[b]	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Maintenance	Grader	1	5	4	0.765	**1.53E-03**	0.069	**1.39E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Year 2008	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.006
Year 2018	1.86	0.25	0.10	0.82	0.25	0.25	546.2	0.004	0.006
Year 2028	0.56	0.16	0.09	0.27	0.16	0.15	546.5	0.002	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions													
				(lb/hour)					(tpy/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_2O
Road Maintenance	Grader	135	1	0.55	0.08	0.03	0.24	0.07	**2.22E-04**	**3.01E-05**	**1.16E-05**	**9.78E-05**	**2.92E-05**	**2.92E-05**	**6.50E-02**	**4.44E-07**	**7.14E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Sub-total: Construction

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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Maintenance	Pickup Truck	40	6	0.13	0.80	0.08	**3.34E-05**	0.01	**3.33E-06**

[a] Assume No dust control measures (watering) would be applied

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	**2.04E-06**	**9.59E-08**	**7.80E-08**	**4.94E-09**	**5.51E-06**	**2.42E-06**	**3.61E-04**	**1.76E-09**	**4.67E-08**

Exhaust 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 abandonme
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.2500
Number of Roads Reclaimed Annually Per Well	0.0859
Annual Miles of Roads reclaimed Per Well	0.0215
Number of wells reclaimed (per well)	0.0859

Reclaimation rates derived from RMP (total Federal and non-Federal)
Sub-total: Construction

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.0215	6	0.0036	0.0358
		Total	0.0358

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.0215	5	0.1074	0.765	**4.11E-05**	0.069	**3.72E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.021	0.4238	0.0720	0.0197	0.4106	0.0629	**4.55E-06**	**7.73E-07**	**2.11E-07**	**4.41E-06**	**6.75E-07**	**7.50E-07**	**1.16E-03**	**1.05E-08**	**1.14E-08**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.00358	0.02148	0.08	**8.66E-07**	0.01	**8.62E-08**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0036	0.0215	**5.47E-08**	**2.57E-09**	**2.10E-09**	**1.33E-10**	**1.48E-07**	**6.50E-08**	**9.70E-06**	**4.74E-11**	**1.25E-09**

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	0.0859	10	0.0859	0.8592

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.5155	5	2.5776	0.765	**9.86E-04**	0.069	**8.93E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.5155	0.5297	0.0900	0.0246	0.5132	0.0786	**1.37E-04**	**2.32E-05**	**6.34E-06**	**1.32E-04**	**2.03E-05**	**3.60E-05**	**3.41E-02**	**5.69E-07**	**3.41E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	6	0.0859	0.5155	0.081	**2.08E-05**	0.008	**2.07E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0859	0.5155	**1.31E-06**	**6.18E-08**	**5.03E-08**	**3.18E-09**	**3.55E-06**	**1.56E-06**	**2.33E-04**	**1.14E-09**	**3.01E-08**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy)	PM2.5 Emissions (tpy)
Well Pad, Road and Pipeline construction	26.08	1.38	1.46		1.00	3.48	14108.09	1.00	0.01	0.00
Sub-total: Construction	26.08	1.38		1.46	1.00	0.05	196.11	1.00	0.0002	0.00002
								TOTAL	**1.15E-02**	**1.72E-03**

[a] Average disturbed area for new CBNG wells shown in SEIS

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
Sub-total: Constr	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.065	0.000	0.001	0.062
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	10	0.0004	0	0.0005	0	0.0002	0.004	0.000	0.000	0.004
flanges	7	0.0009	0	0.0002	0	0.0000	0.006	0.000	0.000	0.006
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.075	0.000	0.002	0.072

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	0.01	**6.26E-06**	15.08	**7.54E-03**	632.73	**3.16E-01**

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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
Reactive VOC	0.000	---	0.000	0.002		0.000
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
n-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	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

Forest Products **Alternative C**

Total Annual Emissions from Forest and Woodlands Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	2.35	0.23	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.16	0.16	2.14	0.06	1.47	0.21	0.02	264.62	0.00	0.00	265.58	241.00
Sub-total: Heavy Equipment	**2.51**	**0.39**	**2.14**	**0.06**	**1.47**	**0.21**	**0.02**	**264.62**	**0.00**	**0.00**	**265.58**	**241.00**
Commuting Vehicles - Fugitive Dust	3.83	0.38	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.01	0.18	0.00	0.14	0.04	0.00	49.84	0.00	0.00	50.81	46.11
Sub-total: Commuting Vehicles	**3.84**	**0.40**	**0.18**	**0.00**	**0.14**	**0.04**	**0.00**	**49.84**	**0.00**	**0.00**	**50.81**	**46.11**
Total	**6.35**	**0.79**	**2.32**	**0.06**	**1.61**	**0.25**	**0.03**	**314.46**	**0.005**	**0.006**	**316.39**	**287.11**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative C

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, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	325	6,500	1	6.50	2.28	0.23
			Total	**6.50**	**2.28**	**0.23**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	325.0	15	29.6	52.104	0.033	564.46	0	**0.07**	**0.01**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative C

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Forest Products	Skidder	205	1	70	8	30	240	357.08	40.81	9.71	294.57	34.98	1.8E-01	2.0E-02	4.9E-03	1.5E-01	1.7E-02	2.0E-02	2.3E+01	2.7E-04	2.3E-04
	Log Truck	450	2	60	10	30	600	1,567.91	87.93	41.19	629.04	79.76	7.8E-01	4.4E-02	2.1E-02	3.1E-01	4.0E-02	4.3E-02	9.6E+01	6.1E-04	1.1E-03
	Chainsaw	6	1	80	8	30	240	3.36	24.76	0.36	745.49	157.18	1.7E-03	1.2E-02	1.8E-04	3.7E-01	7.9E-02	1.1E-02	8.7E-01	6.8E-04	5.4E-06
	Feller Buncher	300	1	100	8	30	240	746.52	85.32	20.31	615.83	73.12	3.7E-01	4.3E-02	1.0E-02	3.1E-01	3.7E-02	4.1E-02	4.7E+01	5.6E-04	4.8E-04
	Loader	200	1	80	10	30	300	464.57	26.05	12.20	186.38	23.63	2.3E-01	1.3E-02	6.1E-03	9.3E-02	1.2E-02	1.3E-02	2.8E+01	1.8E-04	3.2E-04
	Dozer	200	1	90	8	30	240	418.11	23.45	10.98	167.74	21.27	2.1E-01	1.2E-02	5.5E-03	8.4E-02	1.1E-02	1.1E-02	2.6E+01	1.6E-04	2.9E-04
	Delimber	250	1	100	10	30	300	725.88	40.71	19.07	291.22	36.92	3.6E-01	2.0E-02	9.5E-03	1.5E-01	1.8E-02	2.0E-02	4.4E+01	2.8E-04	5.0E-04
												Total	**2.1E+00**	**1.6E-01**	**5.7E-02**	**1.5E+00**	**2.1E-01**	**1.6E-01**	**2.6E+02**	**2.7E-03**	**2.9E-03**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved ro		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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	70	30	2,100	1	2,100	0.61	0.64	3.83	0.06	0.06	0.38
	Log Truck	25	70	120	8,400	1	8,400	0.61	2.55		0.06	0.25	
	Pick-up Truck	25	70	30	2,100	1	2,100	0.61	0.64		0.06	0.06	
							Total		**3.83**			**0.38**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control (MCFO, 2010)

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	30	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	0.18	0.02	0.01	0.00	0.14	0.04	5.24	0.00	0.00
	Log Truck	HDDV	400	120	48,000	1	48,000	0.14	0.01	0.01	0.00	0.09	0.02							41.89	0.00	0.00
	Pick-up Truck	LDDT	200	30	6,000	1	6,000	0.02	0.00	0.00	0.00	0.04	0.02							2.71	0.00	0.00
							Total	**0.18**	**0.02**	**0.01**	**0.00**	**0.14**	**0.04**	**0.18**	**0.02**	**0.01**	**0.00**	**0.14**	**0.04**	**49.84**	**0.0022**	**0.0030**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing **Alternative C**

Total Annual Emissions from Livestock Grazing Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	1.37	0.14	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.50	0.48	7.27	0.17	3.15	0.55	0.05	775.33	0.01	0.01	778.2	**706.2**
Sub-total: Construction	**1.87**	**0.62**	**7.27**	**0.17**	**3.15**	**0.55**	**0.05**	**775.33**	**0.01**	**0.01**	**778.2**	**706.2**
Commuting Vehicles - Fugitive Dust	134.71	13.45	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.31	0.27	1.98	0.01	8.17	3.63	0.36	606.92	0.06	0.05	**623.6**	**565.9**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	2659.11	---	**55,841.4**	**50,672.8**
Sub-total: Operations and Maintenance	**135.02**	**13.71**	**1.98**	**0.01**	**8.17**	**3.63**	**0.36**	**606.92**	**2659.18**	**0.05**	**56,465.0**	**51,238.7**
Total	**136.89**	**14.34**	**9.25**	**0.18**	**11.32**	**4.17**	**0.42**	**1382.25**	**2659.19**	**0.06**	**57,243.2**	**51,944.9**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative C

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, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)		
			TSP	PM_{10}	$PM_{2.5}$
Springs	1.00	1	0.04	0.01	0.00
Reservoirs/Pits	37.00	1	0.52	0.18	0.02
Wells	3.00	1	0.12	0.04	0.00
Pipelines	48.00	1	1.92	0.67	0.07
Fences	30.00	1	1.20	0.42	0.04
Reservoirs Maintenance	1.00	1	0.04	0.01	0.00
		Total	**3.84**	**1.34**	**0.13**

[a] information from MCFO. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	120.0	15	29.6	52.104	0.033	208.42	0	**0.03**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

ALTERNATIVE: Alternative C

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	2	2.00	32.0	15	2	0	12	2	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	40.00	960.0	3,888	236	85	1,645	247	1.94	0.12	0.04	0.82	0.12	0.11	198.02	0.00	0.00
	Scraper	650	1	70	8	3	40.00	960.0	5,054	306	111	2,138	321	2.53	0.15	0.06	1.07	0.16	0.15	257.43	0.00	0.00
Wells	Drill Rig	200	1	100	8	3	10.00	240.0	463	31	12	155	38	0.23	0.02	0.01	0.08	0.02	0.01	26.81	0.00	0.00
	Water Truck	200	1	70	8	3	10.00	240.0	324	22	8	108	27	0.16	0.01	0.00	0.05	0.01	0.01	18.77	0.00	0.00
Pipelines	Dozer	200	1	75	2	25	5.00	250.0	409	31	10	153	36	0.20	0.02	0.00	0.08	0.02	0.02	22.33	0.00	0.00
	Trencher	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
	Backhoe	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	25	8.00	1600.0	2,891	192	72	966	240	1.45	0.10	0.04	0.48	0.12	0.09	167.56	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	2	5.00	20.0	81	5	2	34	5	0.04	0.00	0.00	0.02	0.00	0.00	4.13	0.00	0.00
													Total	**7.27E+00**	**4.99E-01**	**1.67E-01**	**3.15E+00**	**5.45E-01**	**4.84E-01**	**7.75E+02**	**8.44E-03**	**8.81E-03**

Source for activity data: MCFO

all emissions calculated with year 2008 factors (conservative)

ALTERNATIVE: Alternative C

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = emission control percent for watering unpaved roads [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 Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	140	2	280	2.00	560	0.72	0.20	0.40	0.07	0.02	0.04
	Pick-up Truck	35	140	2	280	2.00	560	0.72	0.20		0.07	0.02	
Reservoirs/Pits	Tractor-Trailer	35	140	3	420	40.00	16800	0.72	6.04	12.08	0.07	0.60	1.21
	Pick-up Truck	35	140	3	420	40.00	16800	0.72	6.04		0.07	0.60	
Wells	Drill Truck	35	140	3	420	10.00	4200	0.72	1.51	6.04	0.07	0.15	0.60
	Support Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Water Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Pick-up Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
Pipelines	Tractor-Trailer	35	140	25	3500	5.00	17500	0.72	6.29	12.58	0.07	0.63	1.26
	Pick-up Truck	35	140	25	3500	5.00	17500	0.72	6.29		0.07	0.63	
Fences	Support Truck	35	140	25	3500	8.00	28000	0.72	10.06	30.19	0.07	1.00	3.01
	Pick-up Truck	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
	ATV	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
Reservoirs Maintenance	Tractor-Trailer	35	140	2	280	5.00	1400	0.72	0.50	1.01	0.07	0.05	0.10
	Pick-up Truck	35	140	2	280	5.00	1400	0.72	0.50		0.07	0.05	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	140	1087	152180	1.00	152180	0.72	54.70	54.70	0.07	5.46	5.46
	Pick-up-Trailer (spring calves)	35	140	352	49280	1.00	49280	0.72	17.71	17.71	0.07	1.77	1.77
							Total		**134.71**			**13.45**	

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked
for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load

ALTERNATIVE: Alternative C

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O**
Springs	Tractor-Trailer	HDDV	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	1.05	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	300	3	900	40.00	36,000.0	0.11	0.01	0.01	0.00	0.07	0.01	0.15	0.01	0.01	0.00	1.02	0.06	31.42	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	40.00	36,000.0	0.04	0.00	0.00	0.00	0.95	0.04							18.92	0.00	0.00
Wells	Drill Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00	0.0920	0.0084	0.0070	0.0005	0.2890	0.0212	7.86	0.00	0.00
	Support Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Water Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	10.00	9,000.0	0.01	0.00	0.00	0.00	0.24	0.01							4.73	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	300	25	7500	5.00	37,500.0	0.11	0.01	0.01	0.00	0.07	0.01	0.16	0.01	0.01	0.00	1.06	0.06	32.73	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	5.00	37,500.0	0.05	0.00	0.00	0.00	0.99	0.04							19.71	0.00	0.00
Fences	Support Truck	HDDV	300	25	7500	8.00	60,000.0	0.18	0.02	0.02	0.00	0.11	0.02	0.27	0.14	0.13	0.00	4.86	3.32	52.37	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	8.00	60,000.0	0.07	0.00	0.00	0.00	1.59	0.07							31.54	0.00	0.00
	ATV	R12S	300	25	7500	8.00	60,000.0	0.02	0.12	0.11	0.00	3.16	3.22							9.27	0.03	0.01
Reservoirs Maintenance	Tractor-Trailer	HDDV	300	2	600	5.00	3,000.0	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.08	0.00	2.62	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	5.00	3,000.0	0.00	0.00	0.00	0.00	0.08	0.00							1.58	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	300	1087	326100	1.00	326,100.0	0.98	0.10	0.08	0.00	0.62	0.13	1.29	0.13	0.11	0.01	0.82	0.17	284.62	0.01	0.02
	Pcik-up-Trailer (spring calves)	HDDV	300	352	105600	1.00	105,600.0	0.32	0.03	0.03	0.00	0.20	0.04							92.17	0.00	0.01
													TOTAL	**1.98**	**0.31**	**0.27**	**0.01**	**8.17**	**3.63**	**606.92**	**0.06**	**0.05**

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load.

ALTERNATIVE: Alternative C

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	518,485	9.74	2524.22	0.37	95.25	2619.48
Horse	17,446	3.31	28.85	0.43	3.75	32.60
Sheep	9,258	1.47	6.80	0.05	0.24	7.04
					Total Methane emissions	**2659.11**

AUM numbers provided by Dawn Doran (per direction from Todd Yeager) on 7/5/2011.

General Purpose Travel - BLM Fleet Alternative C

Total Annual Emissions from General Purpose BLM Travel - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Commuting Vehicles - Fugitive Dust	71.23	7.11	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.08	0.06	1.69	0.00	4.57	2.01	0.20	299.54	0.00	0.04	311.59	282.75
Sub-total: Commuting Vehicles	**71.31**	**7.17**	**1.69**	**0.00**	**4.57**	**2.01**	**0.20**	**299.54**	**0.00**	**0.04**	**311.59**	**282.75**
Total	**71.31**	**7.17**	**1.69**	**0.00**	**4.57**	**2.01**	**0.20**	**299.54**	**0.00**	**0.04**	**311.59**	**282.75**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads[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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/fleet group)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/fleet group)	$PM_{2.5}$ Emissions (tpy)
General Purpose BLM Travel	DM/FM Staff	25	3,329	0.61	1.01	71.23	0.06	0.10	7.11
	Support Services	25	27,597	0.61	8.38		0.06	0.84	
	Fire Management	45	93,217	0.61	28.32		0.06	2.83	
	Minerals and NRR	15	56,943	0.47	13.40		0.05	1.34	
	Renewable Resources	25	66,242	0.61	20.12		0.06	2.01	
		Total	**247,328**	**Total**	**71.23**			**7.108**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control.

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions														
				(tons/fleet group)						(tpy)								
				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_2O
General Purpose BLM Travel	DM/FM Staff	LDDT	22,189	0.057	0.003	0.002	0.000	0.153	0.067	1.69	0.08	0.06	0.00	4.57	2.01	10.02	0.00	0.00
	Support Services	LDDT	78,848	0.201	0.009	0.008	0.000	0.543	0.239							35.59	0.00	0.00
	Fire Management	LDDT	207,148	0.528	0.025	0.020	0.001	1.426	0.627							93.50	0.00	0.01
	Minerals and NRR	LDDT	189,810	0.484	0.023	0.019	0.001	1.307	0.575							85.68	0.00	0.01
	Renewable Resources	LDDT	165,606	0.422	0.020	0.016	0.001	1.140	0.501							74.75	0.00	0.01
			Total	**1.691**	**0.080**	**0.065**	**0.004**	**4.570**	**2.009**	**1.69E+00**	**7.95E-02**	**6.47E-02**	**4.10E-03**	**4.57E+00**	**2.01E+00**	**3.00E+02**	**1.46E-03**	**3.88E-02**

Source of activity data: MCFO

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance Alternative C

Total Annual Emissions from Road Maintenance Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.55	0.23	1.36	0.03	0.53	0.09	0.01	160.62	0.00	0.00	161.21	146.29
Total	**1.55**	**0.23**	**1.36**	**0.03**	**0.53**	**0.09**	**0.01**	**160.62**	**0.0013**	**0.0018**	**161.21**	**146.29**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative C

Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	127

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^{2}$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)

Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[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.

* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	210	5	1,050	0.765	0.40	0.069	0.04
Road Maintenance	Semi-truck	31	20	61	1.09	0.03	0.11	0.00
Road Maintenance	Lowboy Trailer	---	20	792	1.09	0.43	0.11	0.04
Total					**0.87**		**0.08**	

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	1	0.10	79	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00
Backhoe	87	1	0.80	146	0.06	0.00	0.00	0.02	0.00	0.00	6.05	0.00	0.00
Semi-truck	450	1	0.50	307	0.33	0.02	0.01	0.13	0.02	0.02	40.79	0.00	0.00
Lowboy Trailer	450	1	0.50	414	0.45	0.03	0.01	0.18	0.02	0.02	55.00	0.00	0.00
Bobcat	82	1	0.80	206	0.07	0.01	0.00	0.03	0.01	0.01	8.04	0.00	0.00
Grader	165	1	0.90	210	0.17	0.01	0.00	0.06	0.02	0.01	18.56	0.00	0.00
Loader	200	1	0.75	162	0.13	0.01	0.00	0.05	0.01	0.01	14.46	0.00	0.00
Dump Truck	350	1	0.50	156	0.13	0.01	0.00	0.05	0.01	0.01	16.12	0.00	0.00
Airport Forklift	100	1	0.10	18	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00
Snowplow	350	1	0.25	20	0.01	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Total					**1.4E+00**	**8.5E-02**	**3.5E-02**	**5.3E-01**	**8.6E-02**	**8.3E-02**	**1.6E+02**	**1.3E-03**	**1.8E-03**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2768.4	15	29.6	52.104	0.033	4,808.26	0	**0.60**	**0.06**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Appendix D

Alternative D Emission Inventory

Summary of Emissions D-1

Oil Development and Production D-2

Natural Gas Development and Production D-29

Coal Bed Methane Natural Gas Development and Production D-54

Coal Mining ..... (*see pages A-77 through A-78*)

Vegetation Management ..... (*see pages A-79 through A-83*)

Fire Management ..... (*see pages A-84 through A-88*)

Forestry and Woodland Products D-77

Livestock Grazing D-82

Recreation, Trails, and Travel Management ..... (*see pages A-100 through A-102*)

General Purpose BLM Fleet Travel D-88

Road Maintenance D-91

Alternative D Summary

MCFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)											Emissions (mtpy)
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq}
Federal / BLM												
Oil and Gas												
Oil	399.0	174.0	1,384.6	0.3	40.5	11.2	87.5	38,078.7	223.9	0.2	42,856.6	38,872
Natural Gas	157.1	64.8	44.8	0.1	10.2	3.7	4.5	15,673.3	209.3	0.1	20,024.7	18,163
CBNG	68.6	34.7	23.7	0.0	7.7	2.3	4.5	5,593.4	108.2	0.0	7,870.8	7,139
Coal Mining [1]	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	14.4	104,029.1	0.6	1.0	104,364.7	94,662
Vegetation Management	11.3	0.1	3.1	0.0	10.7	1.4	0.3	33.9	0.0	0.0	34.8	32
Fire Management [2]	1,741.9	58.3	97.3	13.6	210.7	151.1	9.7	289,046.1	121.5	23.7	298,943.9	271,151
Forestry and Woodland Products	2.7	3.9	0.4	0.1	10.7	1.3	0.0	524.1	0.0	0.0	527.3	478
Livestock Grazing	11.3	9.3	4.2	0.2	136.9	14.3	0.4	1,382.3	2,662.8	0.1	57,319.6	51,991
Recreation - Trails and Travel Management	26.6	0.1	27.1	0.0	292.6	30.1	2.7	78.0	0.2	0.0	83.4	76
General Purpose BLM Fleet Travel	4.6	1.7	2.0	0.0	72.7	7.3	0.2	304.0	0.0	0.0	316.2	287
Road Maintenance	0.5	1.4	0.1	0.0	1.6	0.2	0.0	160.6	0.0	0.0	161.2	146
Federal Emission Total	**4,544.7**	**2,165.7**	**1,731.6**	**194.2**	**5,242.5**	**667.8**	**124.3**	**454,903.5**	**3,326.6**	**25.2**	**532,503.1**	**482,996**
Non-Federal												-
Oil and Gas	3,583.1	2,936.2	8,964.5	46.0	416.6	163.3	597.2	359,278.6	3,292.7	1.3	428,346.5	388,523
Coal Mining [1]	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	15.7	143,391.0	0.9	1.4	143,853.6	130,479
Non-Federal Emission Total	**6,607.8**	**5,320.0**	**9,121.1**	**246.7**	**4,838.2**	**644.4**	**612.8**	**502,669.6**	**3,293.5**	**2.7**	**572,200.0**	**519,002**

tpy = short tons per year

mtpy = metric tons per year

1. In available air quality permits for coal mines located in the MCFO, total suspended particulate (TSP) is usually reported and PM10 and/or PM2.5 may be reported. In permits containing only TSP emissions, all TSP was assumed to be PM10. This assumption overestimates PM10 emissions. If PM10 was reported and PM2.5 was not reported, PM2.5 was assumed to equal 10 percent of PM2.5. With regard to greenhouse gases, coal mine emissions do not include ventilation emissions or emissions associated with electricity provided to the mine.

2. Excludes smoke emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	33,634	38,897	5,713	17,023	24,469	3,772
Alt. A O&G (%) of NEI Emissions	1.9%	0.7%	25.4%	0.0%	0.2%	0.5%
Alt. A (%) of NEI Emissions	13.5%	5.6%	30.3%	1.1%	21.4%	17.7%

County Emissions (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties).

Source: EPA 2008 National Emission Inventory (NEI), http://neibrowser.epa.gov/eis-public-web/geo/county-emissions.html?stateJurisdictionId=28&inventoryYear=2008, accessed December 12, 2011.

Alternative D input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	23	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	136
Federal Producing Wells - RMP Year 20	344	Non-Federal Producing Wells - RMP Year 20	2,109
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 54% full RFD estimates (rounded to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.89	0.09	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.73	0.74	11.93	0.14	63.00	3.36	0.34	12578.34	0.13	0.14	12625.56	11456.95
Commuting Vehicles - Construction	10.41	1.06	0.29	0.00	0.35	0.12	0.01	76.74	0.00	0.01	78.46	71.19
Wind Erosion	0.26	0.04	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**12.28**	**1.92**	**12.22**	**0.14**	**63.35**	**3.48**	**0.35**	**12,655.08**	**0.13**	**0.15**	**12,704.02**	**11,528.15**
Well Workover Operations - Fugitive Dust	1.49	0.15	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.10	0.10	2.05	0.03	17.75	0.96	0.10	3614.56	0.05	0.04	3628.43	3292.58
Well Workover Operations - On-road Exhaust	0.00	0.00	0.05	0.00	0.08	0.03	0.003	10.66	0.00	0.00	10.96	9.95
Well Visits for Inspection & Repair - Operations	1.67	0.17	0.05	0.00	1.09	0.05	0.005	21.70	0.00	0.01	24.28	22.03
Recompletion Traffic	2.56	0.26	0.09	0.00	0.14	0.06	0.01	21.64	0.00	0.00	22.20	20.14
Water Tanks & Traffic	6.80	0.72	0.58	0.00	0.37	0.08	0.01	168.60	39.32	0.00	994.73	902.66
Oil Tanks & Traffic	5.52	0.58	0.38	0.00	0.24	1,216.36	70.10	172.42	138.64	0.00	3084.06	2798.60
Venting	---	---	---	---	---	15.65	1.27	0.51	19.61	0.00	412.25	374.09
Compression and Well Pumps	6.99	6.99	157.78	0.11	315.56	110.45	11.04	21,290.24	0.40	0.04	21311.12	19338.59
Dehydrators	0.00	0.00	0.02	0.00	0.02	36.17	4.48	23.36	24.22	0.00	532.04	482.80
Compression Station Fugitives	---	---	---	---	---	1.21	0.12	0.04	1.51	0.00	31.84	28.89
Sub-total: Operations	**25.14**	**8.97**	**160.99**	**0.15**	**335.25**	**1,381.01**	**87.14**	**25,323.73**	**223.75**	**0.09**	**30,051.91**	**27,270.34**
Road Maintenance	3.00	0.33	0.76	0.020	0.39	0.12	0.012	97.08	0.00	0.00	97.78	88.73
Sub-total: Maintenance	**3.00**	**0.33**	**0.76**	**0.020**	**0.39**	**0.12**	**0.012**	**97.081**	**0.001**	**0.00**	**97.78**	**88.73**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.10	0.09
Well Reclamation	0.09	0.01	0.01	0.00	0.01	0.00	0.00	2.74	0.00	0.00	2.75	2.50
Sub-total: Reclamation	**0.10**	**0.01**	**0.01**	**0.0005**	**0.01**	**0.003**	**0.0003**	**2.8313**	**0.0000**	**0.0001**	**2.8478**	**2.5842**
Total Emissions	**40.51**	**11.24**	**173.99**	**0.31**	**399.00**	**1,384.62**	**87.50**	**38,078.73**	**223.89**	**0.25**	**42,856.56**	**38,889.80**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	5.24	0.52	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	36.18	35.16	691.10	14.35	177.48	50.50	5.05	74376.25	0.77	0.14	74436.87	67547.07
Commuting Vehicles - Construction	61.54	6.26	1.74	0.01	2.06	0.72	0.07	453.79	0.02	0.01	455.81	413.62
Wind Erosion	1.55	0.23	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**104.50**	**42.18**	**692.84**	**14.36**	**179.54**	**51.22**	**5.12**	**74,830.04**	**0.79**	**0.15**	**74,892.69**	**67,960.70**
Well Workover Operations - Fugitive Dust	9.12	0.91	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	15.92	15.44	280.07	4.77	94.09	20.27	2.03	22160.21	0.31	0.25	22245.21	20186.21
Well Workover Operations - On-road Exhaust	0.02	0.02	0.29	0.00	0.52	0.21	0.021	65.37	0.00	0.01	67.20	60.98
Well Visits for Inspection & Repair - Operations	10.21	1.02	0.31	0.00	6.69	0.30	0.030	133.04	0.02	0.05	148.87	135.09
Recompletion Traffic	15.70	1.60	0.56	0.00	0.88	0.34	0.03	132.65	0.00	0.01	136.08	123.48
Water Tanks & Traffic	41.71	4.41	3.55	0.02	2.25	0.46	0.05	1,033.64	241.07	0.01	6098.52	5534.04
Oil Tanks & Traffic	33.83	3.54	2.30	0.01	1.46	7,457.30	429.76	1,057.07	849.96	0.01	18907.79	17157.71
Venting	---	---	---	---	---	94.03	7.64	3.06	117.76	0.00	2476.06	2246.88
Compression and Well Pumps	42.88	42.88	967.32	0.66	1,934.64	677.13	67.71	130,526.52	2.46	0.25	130654.54	118561.29
Dehydrators	0.01	0.01	0.12	0.00	0.10	221.75	27.48	143.24	148.47	0.00	3261.85	2959.94
Compression Station Fugitives	---	---	---	---	---	7.41	0.74	0.24	9.28	0.00	195.19	177.12
Sub-total: Operations	**169.41**	**69.83**	**1,254.52**	**5.46**	**2,040.62**	**8,479.20**	**535.49**	**155,255.04**	**1,369.33**	**0.58**	**184,191.30**	**167,142.74**
Road Maintenance	18.37	2.02	4.68	0.121	2.39	0.73	0.073	595.18	0.01	0.01	599.48	543.99
Sub-total: Maintenance	**18.37**	**2.02**	**4.68**	**0.121**	**2.39**	**0.73**	**0.073**	**595.185**	**0.006**	**0.01**	**599.48**	**543.99**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.58	0.53
Well Reclamation	0.56	0.07	0.07	0.00	0.08	0.02	0.00	16.78	0.00	0.00	16.88	15.31
Sub-total: Reclamation	**0.58**	**0.07**	**0.07**	**0.0030**	**0.08**	**0.017**	**0.0017**	**17.3584**	**0.0003**	**0.0003**	**17.4595**	**15.8435**
Total Emissions	**292.86**	**114.10**	**1,952.11**	**19.94**	**2,222.63**	**8,531.17**	**540.69**	**230,697.62**	**1,370.13**	**0.74**	**259,700.93**	**235,663.27**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

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)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**7.70E+01**	**7.70E+00**	**3.85E-02**	**3.85E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.030	0.0051	2.60	0.14	0.03	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	53	9	4,622	249	0.44	0.03	0.00	2.31	0.12	0.03	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	1	330	18	0.02	0.00	0.00	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	600	1	50	11	5	55	1	11	1	0	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	0	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	**4.91E-01**	**2.87E-02**	**5.23E-03**	**2.72E+00**	**1.43E-01**	**2.87E-02**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.19E-01**	**3.16E-02**	**5.99E-03**	**2.74E+00**	**1.46E-01**	**3.20E-02**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
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, Fracing & 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 (%)[b]**	**# 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	**5.05E+00**	**2.63E-01**	**1.05E-01**	**1.29E+00**	**3.69E-01**	**2.55E-01**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.08E+00**	**2.66E-01**	**1.05E-01**	**1.30E+00**	**3.71E-01**	**2.59E-01**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	0.27	129.02	0.06	0.07	0.03	12.90	0.01	0.01
	Pickup Trucks	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.27	13.73	0.01	0.01	0.03	1.37	0.00	0.00
	Pickup Trucks	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.27	5.49	0.00	0.01	0.03	0.55	0.00	0.00
	Haul Trucks	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Pickup Trucks	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.27	120.78	0.06	0.14	0.03	12.08	0.01	0.01
	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Tool Pusher	25	10	8	80	1	0.22	17.39	0.01		0.02	1.74	0.00	
	Mud Logger	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Engineer	25	10	15	150	1	0.22	32.60	0.02		0.02	3.26	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.27	16.47	0.01	0.02	0.03	1.65	0.00	0.00
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
									Subtotal	**2.47E-01**				**2.47E-02**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00	0.20	0.02	0.65	0.00	0.02
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Welders	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Haul Water Truck	25	10	150	1500	1	0.22	326.03	0.16		0.02	32.60	0.02	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**2.05E-01**				**2.05E-02**
									Total	**4.51E-01**				**4.51E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SOx**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	**Class**					**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_2O**
Improved & Two-Track Road	Semi Trucks	HDDV	10	47	470	1	2.8142	0.2851	0.2380	0.0137	1.7832	0.3668	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.001	0.000	0.000	0.000	0.001	0.000	0.4	0.0000	0.0000
	Pickup Trucks	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	4	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Haul Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	1	10	1	0.0510	0.0024	0.0020	0.0001	0.1377	0.0606	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																		Subtotal	**1.88E-03**	**1.79E-04**	**1.50E-04**	**8.64E-06**	**1.61E-03**	**4.61E-04**	**5.25E-01**	**2.30E-05**	**3.20E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	10	44	440	1	2.6346	0.2669	0.2228	0.0128	1.6694	0.3434	0.0013	0.0001	0.0001	0.0000	0.0008	0.0002	0.00	0.00	0.00	0.00	0.01	0.00	0.4	0.0000	0.0000
	Fuel Haul Truck	HDDV	10	6	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	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Tool Pusher	LDDT	10	8	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							0.0	0.0000	0.0000
	Mud Logger	LDDT	10	6	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							0.0	0.0000	0.0000
	Mud Engineer	LDDT	10	15	150	1	0.7646	0.0359	0.0293	0.0019	2.0658	0.9084	0.0004	0.0000	0.0000	0.0000	0.0010	0.0005							0.1	0.0000	0.0000
	Logger, Engr Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	10	6	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	0.0000	0.0000
	Haul Water Truck	HDDV	10	150	1500	1	8.9815	0.9101	0.7596	0.0437	5.6911	1.1706	0.0045	0.0005	0.0004	0.0000	0.0028	0.0006							1.3	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**1.09E-02**	**9.31E-04**	**7.74E-04**	**4.52E-05**	**1.36E-02**	**4.82E-03**	**2.81E+00**	**1.08E-04**	**1.99E-04**
																	Total		**1.28E-02**	**1.11E-03**	**9.23E-04**	**5.38E-05**	**1.52E-02**	**5.28E-03**	**3.34E+00**	**1.31E-04**	**2.31E-04**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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_2O[a]
Diesel	0.30	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	k (s/12)[a] (W/3)[a]	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 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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	10	12	120	1	0.08	9.68	**4.84E-03**	0.01	0.96	**4.82E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	10	12	120	1	0.30	0.01	0.00	0.00	6.34	0.28	**1.49E-04**	**3.35E-06**	**1.55E-06**	**1.16E-06**	**3.17E-03**	**1.42E-04**	**6.31E-02**	**8.99E-06**	**2.36E-05**

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for 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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	1.0	60	0.08	4.84	**2.42E-03**	0.01	0.48	**2.41E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

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 (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	1.0	60	**1.53E-04**	**7.19E-06**	**5.85E-06**	**3.70E-07**	**4.13E-04**	**1.82E-04**	**2.71E-02**	**1.32E-07**	**3.51E-06**

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	10	56	562	1	0.07	39.21	**1.96E-02**	0.01	3.90	**1.95E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	10	56	562	1	3.362	0.341	0.284	0.016	2.131	0.438	**1.68E-03**	**1.70E-04**	**1.42E-04**	**8.17E-06**	**1.07E-03**	**2.19E-04**	**4.90E-01**	**2.29E-05**	**3.75E-06**

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other 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/10^3 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[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] 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)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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														
							(lb/well)						(tpy/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_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	10	37	365	1	2.185	0.221	0.185	0.011	1.385	0.285	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.319	0.000	0.000
						TOTAL							**1.09E-03**	**1.11E-04**	**9.24E-05**	**5.31E-06**	**6.92E-04**	**1.42E-04**	**3.19E-01**	**1.49E-05**	**2.44E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a]	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-HA	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**

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

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)[a] (W/3)[b]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01	0.15	0.02	1.30	0.00	0.01
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Water Truck	25	10	50	500	1	0.22	108.68	0.05		0.02	10.87	0.01	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**1.49E-01**				**1.49E-02**
									Total	**1.49E-01**				**1.49E-02**

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_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Well Recompletion	Fuel Haul Truck	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	10	50	500	1	2.9938	0.3034	0.2532	0.0146	1.8970	0.3902	0.0015	0.0002	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**
																	Total		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	20	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.054	MMSCF/well

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		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]	N_2O[c]
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

[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 and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

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	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O 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_2 emissions per well (lb/hr)	CH_4 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
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
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	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	1.63E-03	2.44E-04
								TOTAL	**1.14E-02**	**1.71E-03**

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	0.250
Number of Roads Reclaimed Annually Per Well	0.019
Annual Miles of Roads reclaimed Per Well	0.005
Number of wells reclaimed (per well)	0.019

Reclaimation 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
0.005	6	0.0008	0.0078
		Total	**0.0078**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.005	5	0.023	0.765	**8.97E-06**	0.069	**8.12E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Road Reclamation	Grader	80	0.005	0.4238	0.0720	0.0197	0.4106	0.0629	**9.93E-07**	**1.69E-07**	**4.61E-08**	**9.62E-07**	**1.47E-07**	**1.64E-07**	**2.54E-04**	**2.28E-09**	**2.50E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0008	0.0469	0.081	**1.89E-06**	0.008	**1.88E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0008	0.0469	**1.19E-07**	**5.62E-09**	**4.57E-09**	**2.89E-10**	**3.23E-07**	**1.42E-07**	**2.12E-05**	**1.03E-10**	**2.74E-09**

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	0.019	10	0.019	0.19

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.1125	5	0.563	0.765	**2.15E-04**	0.069	**1.95E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.1125	0.5297	0.0900	0.0246	0.5132	0.0786	**2.98E-05**	**5.06E-06**	**1.38E-06**	**2.89E-05**	**4.42E-06**	**7.86E-06**	**7.45E-03**	**1.24E-07**	**7.51E-08**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.0188	1.1252	0.081	**4.54E-05**	0.008	**4.52E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.0188	1.1252	**2.87E-06**	**1.35E-07**	**1.10E-07**	**6.95E-09**	**7.75E-06**	**3.41E-06**	**5.08E-04**	**2.48E-09**	**6.57E-08**

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

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)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Alternative D input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	19	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	111
Federal Producing Wells - RMP Year 20	286	Non-Federal Producing Wells - RMP Year 20	1,747
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 54% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.23	0.02	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.18	0.19	3.15	0.06	23.27	1.23	0.12	4521.48	0.04	0.05	4538.18	4118.13
Commuting Vehicles - Construction	3.44	0.35	0.10	0.00	0.12	0.04	0.00	25.36	0.00	0.00	25.92	23.53
Wind Erosion	0.06	0.01	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.33	0.00	0.14	43.08	0.00	904.81	821.06
Sub-total: Construction	**3.91**	**0.57**	**3.25**	**0.06**	**23.39**	**1.60**	**0.13**	**4,546.98**	**43.12**	**0.05**	**5,468.91**	**4,962.72**
Well Workover Operations - Fugitive Dust	0.49	0.05	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.09	0.09	1.70	0.03	14.75	0.79	0.08	3009.15	0.02	0.03	3020.16	2740.61
Well Workover Operations - On-road Exhaust	0.00	0.00	0.02	0.00	0.03	0.01	0.001	3.55	0.00	0.00	3.65	3.31
Well Visits for Inspection & Repair - Operations	0.55	0.06	0.02	0.00	0.36	0.02	0.002	7.22	0.00	0.00	8.08	7.33
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.78	0.08	0.34	101.17	0.00	2124.87	1928.20
Compression	2.62	2.62	59.12	0.04	118.24	41.38	4.14	7,977.26	0.15	0.02	7985.08	7245.99
Station Visits - Operations	0.18	0.02	0.01	0.00	0.03	0.01	0.00	1.97	0.00	0.00	2.05	1.86
Dehydrators	0.00	0.00	0.04	0.00	0.03	0.09	0.04	43.16	64.85	0.00	1405.31	1275.24
Sub-total: Operations	**3.93**	**2.83**	**60.90**	**0.07**	**133.44**	**43.09**	**4.34**	**11,042.64**	**166.19**	**0.05**	**14,549.19**	**13,202.53**
Road Maintenance	2.17	0.24	0.61	0.016	0.27	0.08	0.008	77.10	0.00	0.00	77.53	70.36
Sub-total: Maintenance	**2.17**	**0.24**	**0.61**	**0.016**	**0.27**	**0.08**	**0.008**	**77.098**	**0.001**	**0.00**		**70.36**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.22	0.20
Well Reclamation	0.21	0.03	0.03	0.00	0.03	0.01	0.00	6.33	0.00	0.00	6.36	5.77
Sub-total: Reclamation	**0.22**	**0.03**	**0.03**	**0.0011**	**0.03**	**0.006**	**0.0006**	**6.5449**	**0.0001**	**0.0001**	**6.5831**	**5.9738**
Total Emissions	**10.23**	**3.67**	**64.79**	**0.14**	**157.13**	**44.76**	**4.48**	**15,673.27**	**209.31**	**0.11**	**20,024.69**	**18,241.58**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.33	1.38	109.19	0.33	135.75	7.16	0.72	26401.82	0.27	0.05	26423.48	23977.75
Commuting Vehicles - Construction	20.09	2.05	0.57	0.00	0.67	0.23	0.02	148.15	0.01	0.00	148.82	135.04
Wind Erosion	0.36	0.05	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	1.93	0.00	0.85	251.67	0.00	5285.97	4796.70
Sub-total: Construction	**23.12**	**3.62**	**109.76**	**0.34**	**136.42**	**9.32**	**0.74**	**26,550.82**	**251.95**	**0.05**	**31,858.26**	**28,909.49**
Well Workover Operations - Fugitive Dust	3.02	0.30	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	13.19	12.79	232.00	3.95	77.94	16.79	1.68	18356.52	0.26	0.21	18426.92	16721.34
Well Workover Operations - On-road Exhaust	0.01	0.01	0.10	0.00	0.17	0.07	0.007	21.66	0.00	0.00	22.27	20.20
Well Visits for Inspection & Repair - Operations	3.38	0.34	0.10	0.00	2.22	0.10	0.010	44.08	0.01	0.02	49.33	44.76
Wellhead and Compressor Station Fugitives	---	---	---	---	---	4.74	0.47	2.08	617.97	0.00	12979.55	11778.18
Compression	16.01	16.01	361.12	0.25	722.24	252.78	25.28	48,728.20	0.92	0.09	48775.99	44261.33
Station Visits - Operations	1.08	0.11	0.07	0.00	0.18	0.08	0.01	12.03	0.00	0.00	12.51	11.36
Dehydrators	0.02	0.01	0.22	0.00	0.18	0.56	0.26	263.67	396.14	0.00	8584.21	7789.66
Sub-total: Operations	**36.70**	**29.57**	**593.61**	**4.20**	**802.93**	**275.12**	**27.72**	**67,428.23**	**1,015.30**	**0.33**	**88,850.78**	**80,626.84**
Road Maintenance	13.24	1.47	3.75	0.100	1.64	0.46	0.046	470.94	0.00	0.01	473.61	429.78
Sub-total: Maintenance	**13.24**	**1.47**	**3.75**	**0.100**	**1.64**	**0.46**	**0.046**	**470.944**	**0.005**	**0.01**		**429.78**
Road Reclamation	0.05	0.01	0.01	0.00	0.01	0.00	0.00	1.34	0.00	0.00	1.34	1.22
Well Reclamation	1.29	0.16	0.16	0.01	0.18	0.04	0.00	38.64	0.00	0.00	38.87	35.27
Sub-total: Reclamation	**1.34**	**0.16**	**0.16**	**0.0070**	**0.18**	**0.039**	**0.0039**	**39.9791**	**0.0006**	**0.0007**	**40.2122**	**36.4902**
Total Emissions	**74.41**	**34.82**	**707.28**	**4.64**	**941.18**	**284.95**	**28.51**	**94,489.98**	**1,267.25**	**0.39**	**120,749.25**	**110,002.60**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**24**	**2.41**	**1.21E-02**	**1.21E-03**

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

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (non-genset)	2.60	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	4	1,849	100	0.11	0.01	0.00	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	5.73E-03	3.60E-05	8.35E-06	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	**1.38E-01**	**6.64E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**6.64E-03**	**2.34E+02**	**1.80E-03**	**2.67E-03**
												Total		**1.66E-01**	**9.51E-03**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**9.96E-03**	**2.38E+02**	**1.85E-03**	**2.71E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	1,849	16	4	1,849	100	0.92	0.01	0.00	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**9.56E-01**	**9.13E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
												Total		**9.84E-01**	**1.20E-02**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**1.25E-02**	**2.38E+02**	**2.44E-03**	**2.71E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	4	47	188	1	0.27	51.61	0.03	0.026	0.03	5.16	0.00	0.003
	Pickup Trucks	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
Well Pad	Semi Trucks	42	4	5	20	1	0.27	5.49	0.00	0.004	0.03	0.55	0.00	0.000
	Pickup Trucks	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
Other Construction Activities	Semi Trucks	42	4	2	8	1	0.27	2.20	0.00	0.002	0.03	0.22	0.00	0.000
	Haul Trucks	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Pickup Trucks	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	4	44	176	1	0.27	48.31	0.02	0.058	0.03	4.83	0.00	0.006
	Fuel Haul Truck	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Haul Truck, Water Hauling	25	4	4	16	1	0.22	3.48	0.00		0.02	0.35	0.00	
	Rig Crew	5	4	51	204	1	0.11	21.49	0.01		0.01	2.15	0.00	
	Rig Mechanics	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Co. Supervisor	5	4	20	80	1	0.11	8.43	0.00		0.01	0.84	0.00	
	Tool Pusher	25	4	8	32	1	0.22	6.96	0.00		0.02	0.70	0.00	
	Mud Logger	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Engineer	25	4	15	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Logger, Engr Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Drill Bit Delivery	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	4	6	24	1	0.27	6.59	0.00	0.009	0.03	0.66	0.00	0.001
	Semi Completion, Unit Rig	42	4	1	4	1	0.27	1.10	0.00		0.03	0.11	0.00	
	Semi Fracing, Blender	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Semi Pumping/Tank Battery	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Tubing Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Cementer, Pump Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
									Subtotal	**9.86E-02**				**9.86E-03**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Completion,	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Service Tools	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Perforators Logging Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Installation	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Testing	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Tank	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Pump	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Chemical	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Sand	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Other	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Welders	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Haul Water Truck	25	4	150	600	1	0.22	130.41	0.07	0.082	0.02	13.04	0.01	0.008
	Pickup Cementer, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Casing Crew	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Completion Crew	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion, Pusher	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Perforators, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Fracing, Engineer	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
	Pickup Co. Supervisor	5	4	10	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
	Pickup Miscellaneous Supplies	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
	Pickup Roustabout Crew	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
									Subtotal	**8.19E-02**				**8.19E-03**
								Total		**1.81E-01**				**1.81E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	4	47	188	1	1.1257	0.1141	0.0952	0.0055	0.7133	0.1467	0.0006	0.0001	0.0000	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.000	0.000	0.1641	0.000008	0.000009
	Pickup Trucks	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0054	0.000000	0.000001
Well Pad	Semi Trucks	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0175	0.000001	0.000001
	Pickup Trucks	LDDT	4	4	16	1	0.0816	0.0038	0.0031	0.0002	0.2204	0.0969	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0072	0.000000	0.000001
Other Construction Activities	Semi Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0070	0.000000	0.000000
	Haul Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0070	0.000000	0.000000
	Pickup Trucks	LDDT	4	1	4	1	0.0204	0.0010	0.0008	0.0000	0.0551	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0018	0.000000	0.000000
																		Subtotal	**7.52E-04**	**7.18E-05**	**5.98E-05**	**3.46E-06**	**6.45E-04**	**1.84E-04**	**2.10E-01**	**9.21E-06**	**1.28E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	4	44	176	1	1.0538	0.1068	0.0891	0.0051	0.6678	0.1374	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.000007	0.000009
	Fuel Haul Truck	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Mud Haul Truck, Water Hauling	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Rig Crew	LDDT	4	51	204	1	1.0398	0.0489	0.0398	0.0025	2.8095	1.2354	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Rig Mechanics	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Co. Supervisor	LDDT	4	20	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							0.0	0.000000	0.000005
	Tool Pusher	LDDT	4	8	32	1	0.1631	0.0077	0.0062	0.0004	0.4407	0.1938	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000002
	Mud Logger	LDDT	4	6	24	1	0.1223	0.0058	0.0047	0.0003	0.3305	0.1453	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000001
	Mud Engineer	LDDT	4	15	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							0.0	0.000000	0.000004
	Logger, Engr Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Drill Bit Delivery	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.000001	0.000001
	Semi Completion, Unit Rig	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Fracing, Blender	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Pumping/Tank Battery	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Tubing Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Pump Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Cement Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Completion, Equip Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Service Tools	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Haul Perforators Logging Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Installation	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Testing	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Tank	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Pump	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Chemical	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Sand	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Other	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Welders	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Haul Water Truck	HDDV	4	150	600	1	3.5926	0.3640	0.3038	0.0175	2.2765	0.4683	0.0018	0.0002	0.0002	0.0000	0.0011	0.0002							0.5	0.000024	0.000029
	Pickup Cementer, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Casing Crew	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Completion Crew	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Pickup Completion, Pusher	LDDT	4	5	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.000000	0.000001
	Pickup Perforators, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Fracing, Engineer	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Co. Supervisor	LDDT	4	10	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.000000	0.000002
	Pickup Miscellaneous Supplies	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000001
	Pickup Roustabout Crew	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
																	Subtotal		**4.36E-03**	**3.72E-04**	**3.09E-04**	**1.81E-05**	**5.42E-03**	**1.93E-03**	**1.12E+00**	**4.30E-05**	**7.97E-05**
																	Total		**5.11E-03**	**4.44E-04**	**3.69E-04**	**2.15E-05**	**6.07E-03**	**2.11E-03**	**1.33E+00**	**5.22E-05**	**9.25E-05**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads[a]

E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[a]
Diesel	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

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_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O**
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						Max. Annual Emissions (tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	4	12	48	1	0.08	3.87	**1.94E-03**	0.01	0.39	**1.93E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	4	12	48	1	0.12	0.00	0.00	0.00	2.54	0.11	**5.96E-05**	**1.34E-06**	**6.19E-07**	**4.66E-07**	**1.27E-03**	**5.66E-05**	**2.52E-02**	**3.60E-06**	**9.44E-06**

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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	0.5	32	0.08	2.58	**1.29E-03**	0.01	0.26	**1.28E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	0.5	32	**8.16E-05**	**3.83E-06**	**3.12E-06**	**1.98E-07**	**2.20E-04**	**9.69E-05**	**1.44E-02**	**7.05E-08**	**1.87E-06**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	0.50	2024.16	1.00	0.00	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	0.00	0.00
								TOTAL	**3.25E-03**	**4.88E-04**

[a] 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[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	0.052
Annual Miles of Roads reclaimed Per Well	0.013
Number of wells reclaimed (per well)	0.052

Reclaimation 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
0.0130	6	0.00217	0.0217
		Total	**0.022**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.013	5	0.065	0.765	**2.49E-05**	0.069	**2.26E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.013	0.4238	0.0720	0.0197	0.4106	0.0629	**2.76E-06**	**4.69E-07**	**1.28E-07**	**2.68E-06**	**4.10E-07**	**4.55E-07**	**7.06E-04**	**6.34E-09**	**6.96E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0022	0.130	0.08	**5.26E-06**	0.01	**5.23E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0022	0.1303	**3.32E-07**	**1.56E-08**	**1.27E-08**	**8.05E-10**	**8.98E-07**	**3.95E-07**	**5.88E-05**	**2.87E-10**	**7.61E-09**

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	0.052	10	0.052	0.52

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.31	5	1.56	0.765	**5.98E-04**	0.069	**5.42E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.31	0.5297	0.0900	0.0246	0.5132	0.0786	**8.29E-05**	**1.41E-05**	**3.85E-06**	**8.03E-05**	**1.23E-05**	**2.19E-05**	**2.07E-02**	**3.45E-07**	**2.09E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.05	3.13	0.081	**1.26E-04**	0.008	**1.26E-05**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.05	3.13	**7.97E-06**	**3.75E-07**	**3.05E-07**	**1.93E-08**	**2.15E-05**	**9.47E-06**	**1.41E-03**	**6.90E-09**	**1.83E-07**

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

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)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

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)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

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	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

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

Volume Flow:	40	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.12	MMSCF/well

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

BTU value = 994 BTU/scf

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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

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 >20º API		Heavy Oil <20º 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 =	0.00349	0.00002	0.00001	0.00310

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 (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.15E-04**			**6.12E-05**

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip)						Emissions (tpy/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_2O
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	0.00	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	0.00	0.00289	0.00000	0.00000
													Total	**3.89E-05**	**1.83E-06**	**1.49E-06**	**9.42E-08**	**1.05E-04**	**4.62E-05**	**6.89E-03**	**3.36E-08**	**8.91E-07**

Alternative D input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	8	Peak Year Non-Federal Producing Wells Drilled	47
Federal Producing Wells - Year 20 (RMP Totals)	145	Non-Federal Producing Wells - Year 2027 (RMP Totals)	885
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

* 54% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	4.72	0.47	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.09	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.03	0.02	0.38	0.01	0.84	0.06	0.01	176.58	0.00	0.00	177.23	160.82
Commuting Vehicles - Construction	0.54	0.05	0.02	0.00	0.04	0.01	0.00	4.67	0.00	0.00	4.80	4.36
Completion Venting	---	---	---	---	---	0.00	0.00	0.52	21.95	0.00	461.39	418.68
Sub-total: Construction	**5.38**	**0.56**	**0.40**	**0.01**	**0.87**	**0.08**	**0.01**	**181.77**	**21.95**	**0.00**	**643.41**	**583.86**
Natural Gas Compression - Operations	1.49	1.49	33.72	0.02	67.44	23.60	4.51	4,549.96	0.09	0.01	4,554.43	4132.87
Dehydrators	0.00	0.00	0.02	0.00	0.02	0.00	0.00	24.62	37.88	0.00	820.30	744.37
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	1.15	48.26	0.00	1,014.57	920.66
Station Visits - Operations	0.10	0.01	0.01	0.00	0.02	0.01	0.00	1.12	0.00	0.00	1.17	1.06
Well Workover - Operations	0.28	0.20	0.48	0.01	0.23	0.03	0.00	819.99	0.01	0.01	822.02	745.94
Well & Pipeline visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.49	0.00	0.00	0.51	0.46
Sub-total: Operations	**1.92**	**1.71**	**34.23**	**0.03**	**67.71**	**23.64**	**4.51**	**5397.34**	**86.23**	**0.02**	**7212.99**	**6545.37**
Road Maintenance	0.23	0.02	0.03	0.00	0.01	0.00	0.00	9.48	0.00	0.00	9.52	8.64
Sub-total: Maintenance	**0.23**	**0.02**	**0.03**	**0.00**	**0.01**	**0.00**	**0.00**	**9.48**	**0.00**	**0.00**	**9.52**	**8.64**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.16	0.15
Well Reclamation	0.14	0.02	0.02	0.00	0.02	0.00	0.00	4.67	0.00	0.00	4.69	4.26
Sub-total: Reclamation	**0.15**	**0.02**	**0.02**	**0.0009**	**0.02**	**0.003**	**0.0003**	**4.8317**	**0.0001**	**0.0001**	**4.8495**	**4.4007**
Total Emissions	**7.68**	**2.32**	**34.68**	**0.04**	**68.62**	**23.73**	**4.52**	**5,593.42**	**108.18**	**0.02**	**7,870.77**	**7,142.26**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	27.75	2.78	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.54	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.51	0.45	7.57	0.20	2.38	0.60	0.06	1,037.39	0.01	0.01	1,041.23	944.86
Commuting Vehicles - Construction	3.14	0.32	0.12	0.00	0.21	0.08	0.01	27.45	0.00	0.00	28.20	25.59
Completion Venting	---	---	---	---	---	0.00	0.00	3.07	128.93	0.00	2,710.66	2459.76
Sub-total: Construction	**31.94**	**3.63**	**7.69**	**0.20**	**2.59**	**0.69**	**0.07**	**1067.91**	**128.94**	**0.01**	**3780.09**	**3430.20**
Natural Gas Compression - Operations	9.12	9.12	205.80	0.14	411.61	144.06	27.52	27,770.47	0.52	0.05	27,797.71	25224.78
Dehydrators	0.01	0.01	0.13	0.00	0.11	0.01	0.00	150.27	231.22	0.00	5,006.64	4543.23
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.01	0.00	7.02	294.54	0.00	6,192.36	5619.20
Station Visits - Operations	0.61	0.06	0.04	0.00	0.10	0.05	0.00	6.86	0.00	0.00	7.13	6.47
Well Workover - Operations	5.12	1.23	62.81	21.06	4.62	3.47	0.35	4,998.14	0.07	0.07	5,021.55	4556.76
Well & Pipeline visits for Inspection & Repair - Operations	0.27	0.03	0.02	0.00	0.05	0.02	0.00	3.00	0.00	0.00	3.12	2.83
Sub-total: Operations	**15.14**	**10.45**	**268.80**	**21.20**	**416.49**	**147.62**	**27.88**	**32935.75**	**526.35**	**0.13**	**44028.51**	**39953.28**
Road Maintenance	1.41	0.15	0.20	0.01	0.09	0.03	0.00	57.87	0.00	0.00	58.08	52.71
Sub-total: Maintenance	**1.41**	**0.15**	**0.20**	**0.01**	**0.09**	**0.03**	**0.00**	**57.87**	**0.00**	**0.00**	**58.08**	**52.71**
Road Reclamation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.98	0.89
Well Reclamation	0.85	0.11	0.11	0.01	0.11	0.02	0.00	28.52	0.00	0.00	28.62	25.97
Sub-total: Reclamation	**0.89**	**0.11**	**0.12**	**0.0054**	**0.12**	**0.019**	**0.0019**	**29.4901**	**0.0005**	**0.0003**	**29.5989**	**26.8593**
Total Emissions	**49.38**	**14.34**	**276.80**	**21.42**	**419.28**	**148.35**	**27.95**	**34,091.02**	**655.29**	**0.14**	**47,896.28**	**43,463.05**

Fugitive Dust Emissions From Well Pad and Compressor Station Construction

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Construction Activities: All Project Years

Area Disturbed for CBNG Wells	Emission Estimation Basis	Avg. Disturbed Acres per Well[a]	Construction Days	Total # of Well Pads or Stations	Total Disturbed Acres	Emissions			
						(lb/well)		(tpy/well)	
						PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Well Pad and Road Construction	Per Well	3.48	5	1	3.48	1.16E+03	1.16E+02	5.81E-01	5.81E-02
Field Compressor Station	Per Well	0.04	6	1	0.04	1.66E+01	1.66E+00	8.30E-03	8.30E-04
Sales Compressor Station	Per Well	0.01	6	1	0.01	2.77E+00	2.77E-01	1.38E-03	1.38E-04
				Total	**3.53**	**1.18E+03**	**1.18E+02**	**5.91E-01**	**5.91E-02**

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

Exhaust Emissions from Heavy Construction Equipment (Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/ Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity) NO_x	$PM_{2.5}/PM_{10}$[a]	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																		Subtotal	**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso,

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	8.6	0.4	0.1	74.3	4.0	0.00	0.00	0.00	0.04	0.00	0.006	0.000	0.000	0.056	0.003	0.00	7.6	0.0001	0.0001
	Auxillary Pump	200	1	90	18	2	36	1.00	4.3	0.2	0.1	37.1	2.0	0.00	0.00	0.00	0.02	0.00						0.00	3.8	0.0000	0.0000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	2.9	0.1	0.0	24.8	1.3	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.021	0.001	0.00	2.5	0.0000	0.0000
	Auxillary Pump	125	1	90	18	1	18	1.00	1.3	0.1	0.0	16.5	0.6	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.012	0.001	0.00	1.2	0.0000	0.0000
	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
																		Subtotal	**1.09E-02**	**5.29E-04**	**1.69E-04**	**8.85E-02**	**4.64E-03**	**5.29E-04**	**1.76E+01**	**1.43E-04**	**1.99E-04**
																		Total	**1.86E-02**	**1.21E-03**	**3.99E-04**	**9.16E-02**	**5.43E-03**	**1.27E-03**	**1.88E+01**	**1.55E-04**	**2.12E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.0000	0.0000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Exhaust Emissions from Heavy Construction Equipment (Non-Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	$PM_{2.5}/PM_{10}$	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																	Subtotal		**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	103.2	6.1	2.9	30.2	7.4	0.05	0.00	0.00	0.02	0.00	0.076	0.005	0.002	0.021	0.006	0.00	7.6	0.000	0.000
	Auxillary Pump	200	1	90	18	2	36	1.00	48.2	3.2	1.5	11.9	4.1	0.02	0.00	0.00	0.01	0.00						0.00	3.8	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	34.4	2.0	1.0	10.1	2.5	0.02	0.00	0.00	0.01	0.00	0.025	0.002	0.001	0.007	0.002	0.00	2.5	0.000	0.000
	Auxillary Pump	125	1	90	18	1	18	1.00	15.9	1.2	0.5	4.4	1.4	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00	0.024	0.001	0.000	0.006	0.002	0.00	1.2	0.000	0.000
	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
																	Subtotal		**1.25E-01**	**7.52E-03**	**3.38E-03**	**3.43E-02**	**9.43E-03**	**7.30E-03**	**1.76E+01**	**1.43E-04**	**2.00E-04**
																	Total		**1.33E-01**	**8.21E-03**	**3.61E-03**	**3.73E-02**	**1.02E-02**	**8.04E-03**	**1.88E+01**	**1.55E-04**	**2.13E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.000	0.000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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		
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/activity)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/activity)	$PM_{2.5}$ Emissions (tpy/well)
Drilling Roads	Semi Trucks	42	6	3	18	1.000	0.27	4.94	0.002	0.03	0.49	0.000
Drilling Well Pad	Haul Trucks	25	6	2	12	1.000	0.22	2.61	0.001	0.02	0.26	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Water Disposal Well Pad	Haul Trucks	25	10	5	50	0.005	0.22	10.87	0.000	0.02	1.09	0.000
	Pickup Trucks	5	10	5	50	0.005	0.11	5.27	0.000	0.01	0.53	0.000
New Pipeline Intermediate	Haul Trucks	25	6	40	240	0.111	0.22	52.17	0.003	0.02	5.22	0.000
	Pickup Trucks	5	6	160	960	0.111	0.11	101.14	0.006	0.01	10.11	0.001
New Sales Pipeline	Haul Trucks	25	35	94	3,290	0.000	0.22	715.10	0.000	0.02	71.51	0.000
	Pickup Trucks	5	50	94	4,700	0.000	0.11	495.14	0.000	0.01	49.51	0.000
Electric Line	Haul Trucks	25	6	1	6	1.000	0.22	1.30	0.001	0.02	0.13	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Field Compression Station	Semi Trucks	42	10	15	150	0.111	0.27	41.18	0.002	0.03	4.12	0.000
	Haul Trucks	25	10	48	480	0.111	0.22	104.33	0.006	0.02	10.43	0.001
	Pickup Trucks	5	10	192	1,920	0.111	0.11	202.27	0.011	0.01	20.23	0.001
Sales Compression Station	Semi Trucks	42	10	19	190	0.011	0.27	52.16	0.000	0.03	5.22	0.000
	Haul Trucks	25	10	48	480	0.011	0.22	104.33	0.001	0.02	10.43	0.000
	Pickup Trucks	5	10	192	1,920	0.011	0.11	202.27	0.001	0.01	20.23	0.000
Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2								**Subtotal**	**3.56E-02**			**3.56E-03**

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/well)	$PM_{2.5}$ Emissions (tpy/well)
	Semi Rig Transport & Drill Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Fuel Haul Truck	25	6	2	12	1.00	0.22	2.61	0.001	0.022	0.261	0.000

Coal Bed Natural Gas - Alternative D

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10}			$PM_{2.5}$		
							Controlled Em. Factor (lb/VMT)	Emissions (lbs/well)	Emissions (tpy/well)	Controlled Em. Factor (lb/VMT)	Emissions (lbs/well)	Emissions (tpy/well)
Rig-up, Drilling, and Rig-down	Mud Haul Truck, Water Hauling	25	6	7	42	1.00	0.22	9.13	0.005	0.022	0.913	0.000
	Rig Crew	25	6	3	18	1.00	0.22	3.91	0.002	0.022	0.391	0.000
	Co. Supervisor	5	6	8	48	1.00	0.11	5.06	0.003	0.011	0.506	0.000
	Tool Pusher	25	6	6	36	1.00	0.22	7.82	0.004	0.022	0.782	0.000
	Logger, Engr Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
Well Completion, Fracing & Testing	Semi Casing Haulers	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Semi Completion, Unit Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Semi Fracing Blender	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Tubing Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Completion, Equip Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Perforators Logging Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Tank	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Pump	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Welders	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Water Truck	25	6	9	54	1.00	0.22	11.74	0.006	0.022	1.174	0.001
	Pickup Cementer, Engineer	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Co. Supervisor	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
	Pickup Miscellaneous Supplies	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Roustabout Crew	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
Water Disposal Well Drilling	Drill Rig Transport truck	42	6	10	60	0.01	0.27	16.47	0.000	0.027	1.647	0.000
	Mud Haul Truck, Water Hauling	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Rig Crew	25	6	10	60	0.01	0.22	13.04	0.000	0.022	1.304	0.000
	Co. Supervisor	5	6	5	30	0.01	0.11	3.16	0.000	0.011	0.316	0.000
	Tool Pusher	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Tubing Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
								Subtotal	**3.11E-02**			**3.11E-03**
								Total	**6.67E-02**			**6.67E-03**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaksi, 2010)

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy/well)								
	Type	Class					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_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	0.11	0.01	0.01	0.00	0.07	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.02	0.00	0.00
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.99	0.30	0.25	0.01	1.90	0.39	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	25	5	125	0.01	0.64	0.03	0.02	0.00	1.72	0.76	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	1.44	0.15	0.12	0.01	0.91	0.19	0.000	0.00	0.000	0.000	0.00	0.00	0.02	0.00	0.00
	Pickup Trucks	LDDT	6	160	960	0.11	4.89	0.23	0.19	0.01	13.22	5.81	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.05	0.00	0.00
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	19.70	2.00	1.67	0.10	12.48	2.57	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	50	94	4700	0.00	23.96	1.13	0.92	0.06	64.73	28.46	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	0.90	0.09	0.08	0.00	0.57	0.12	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.01	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.11	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.11	9.79	0.46	0.37	0.02	26.44	11.63	0.001	0.0000	0.0000	0.0000	0.00	0.001	0.10	0.00	0.00
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.14	0.12	0.10	0.01	0.72	0.15	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.00	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.01	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.01	9.79	0.46	0.37	0.02	26.44	11.63	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Fuel Haul Truck	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	0.25	0.03	0.02	0.00	0.16	0.03	0.000	0.00	0.00	0.00	0.0	0.00	0.04	0.00	0.00
	Rig Crew	LDDT	6	3	18	1.00	0.09	0.00	0.00	0.00	0.25	0.11	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Rig Mechanics	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Co. Supervisor	LDDT	6	8	48	1.00	0.24	0.01	0.01	0.00	0.66	0.29	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Tool Pusher	LDDT	6	6	36	1.00	0.18	0.01	0.01	0.00	0.50	0.22	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Mud Logger	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Mud Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Logger, Engr	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Drill Bit Delivery	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**1.88E-03**	**1.23E-04**	**1.02E-04**	**6.12E-06**	**3.75E-03**	**1.55E-03**	**4.07E-01**	**9.83E-06**	**3.89E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	Emissions (tpy) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Fracing Blender	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Tubing Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Service Tools	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Installation	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Testing	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Tank	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Pump	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Chemical	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Sand	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Other	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Welders	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Water Truck	HDDV	6	9	54	1.00	0.32	0.03	0.03	0.00	0.20	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Completion Crew	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Completion Pusher	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	0.60	0.06	0.05	0.00	0.38	0.08	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	0.30	0.03	0.03	0.00	0.19	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Rig Crew	LDDT	10	10	100	0.01	0.51	0.02	0.02	0.00	1.38	0.61	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Co. Supervisor	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tool Pusher	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tubing Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**6.51E-04**	**6.00E-05**	**5.00E-05**	**2.90E-06**	**6.39E-04**	**2.01E-04**	**1.77E-01**	**7.47E-06**	**1.14E-05**
											Total		**2.53E-03**	**1.83E-04**	**1.52E-04**	**9.02E-06**	**4.39E-03**	**1.76E-03**	**5.84E-01**	**1.73E-05**	**5.02E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power	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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	12	1	12	8,760	0.12	0.01	0.00	0.24	0.08	0.01	16.2	0.00	0.01	0.00
Sales Compression Station	12	1	12	8,760	0.11	0.00	0.00	0.22	0.08	0.00	15.1	0.00	0.01	0.00
				Total	**2.33E-01**	**1.03E-02**	**1.58E-04**	**4.65E-01**	**1.63E-01**	**1.03E-02**	**3.14E+01**	**5.92E-04**	**1.48E-02**	**5.92E-05**

Sub-total: Construction

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
Component	(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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (lb/yr)	VOC (tpy)	CO2 (lb/yr)	CO2 (tpy)	CH4 (lb/yr)	CH4 (tpy)
b-total: Construct	1	8760	0.00	**3.25E-07**	0.78	**3.92E-04**	32.90	**1.64E-02**

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.41E-04**	**1.08E-05**	**8.49E-07**	**1.19E-04**	**7.78E-06**	**8.07E-06**	**1.70E-01**	**3.25E-06**	**1.06E-07**	**3.11E-06**

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)
16.43	0.016	**2.61E-01**	0.000	**0.00E+00**	0.000	**0.00E+00**

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

Sub-total: Construction

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

The following South Baker Compressor Station assumptions were used with CBNG specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station ---
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.5	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	6.92E-04			6.89E-05

Assume no dust control (watering)

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip)						Emissions (tpy/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_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.5	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.004	0.000	0.000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	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	0.00	0.003	0.000	0.000
													Total	4.37E-05	2.06E-06	1.67E-06	1.06E-07	1.18E-04	5.20E-05	7.75E-03	3.78E-08	1.00E-06

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	0.0051	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	6.35	0.32	0.11	2.96	0.32	**3.17E-03**	**1.59E-04**	**5.40E-05**	**1.48E-03**	**1.59E-04**	**1.21E-03**	**5.61E+00**	**4.03E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10} Emission Factor (lb/VMT)[b, c]	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)[b]	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	Emissions (tpy) NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	141.65	8.05	47.59	10.25	7.81	**7.08E-02**	**4.03E-03**	**2.38E-02**	**5.13E-03**	**3.91E-03**	**1.21E-03**	**5.60E+00**	**7.79E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Emissions for Well and Pipe Inspections

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Fugitive Dust Emissions Estimation for Road Traffic: Well & Pipeline

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/ Year	PM_{10}			$PM_{2.5}$		
							Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)	Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)
Visits for Inspection and Repair	200-hp Pickup	40	0.625	12	1	8	0.08	0.05	**3.02E-04**	0.01	0.01	**3.01E-05**

Activity rates based on values shown in SEIS
Assume no dust control (watering)

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/Well	Emissions														
							(lbs/trip/well)						(tpy/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_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	0.003	0.000	0.000	0.000	0.009	0.004	**1.91E-05**	**8.99E-07**	**7.32E-07**	**4.63E-08**	**5.16E-05**	**2.27E-05**	**3.39E-03**	**1.65E-08**	**4.38E-07**

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.08	0.83
Winter	1	0.25	5	10	0.05	0.50
				Total	0.13	1.33

Based on values shown in SEIS

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^{2}$	5	0.765
Sub-total: Constructi	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph

Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)[b]	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Maintenance	Grader	1	5	4	0.765	**1.53E-03**	0.069	**1.39E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Year 2008	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.006
Year 2018	1.86	0.25	0.10	0.82	0.25	0.25	546.2	0.004	0.006
Year 2028	0.56	0.16	0.09	0.27	0.16	0.15	546.5	0.002	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions													
				(lb/hour)					(tpy/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_2O
Road Maintenance	Grader	135	1	0.55	0.08	0.03	0.24	0.07	**2.22E-04**	**3.01E-05**	**1.16E-05**	**9.78E-05**	**2.92E-05**	**2.92E-05**	**6.50E-02**	**4.44E-07**	**7.14E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Sub-total: Construction

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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Maintenance	Pickup Truck	40	6	0.13	0.80	0.08	**3.34E-05**	0.01	**3.33E-06**

[a] Assume No dust control measures (watering) would be applied

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	**2.04E-06**	**9.59E-08**	**7.80E-08**	**4.94E-09**	**5.51E-06**	**2.42E-06**	**3.61E-04**	**1.76E-09**	**4.67E-08**

Exhaust 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 abandonme
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.2500
Number of Roads Reclaimed Annually Per Well	0.0806
Annual Miles of Roads reclaimed Per Well	0.0201
Number of wells reclaimed (per well)	0.0806

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

Sub-total: Construction

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.0201	6	0.0034	0.0336
		Total	0.0336

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.0201	5	0.1007	0.765	**3.85E-05**	0.069	**3.49E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.020	0.4238	0.0720	0.0197	0.4106	0.0629	**4.27E-06**	**7.25E-07**	**1.98E-07**	**4.14E-06**	**6.33E-07**	**7.03E-07**	**1.09E-03**	**9.80E-09**	**1.07E-08**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.00336	0.02015	0.08	**8.12E-07**	0.01	**8.09E-08**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0034	0.0201	**5.13E-08**	**2.41E-09**	**1.97E-09**	**1.24E-10**	**1.39E-07**	**6.10E-08**	**9.09E-06**	**4.44E-11**	**1.18E-09**

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	0.0806	10	0.0806	0.8058

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.4835	5	2.4175	0.765	**9.25E-04**	0.069	**8.38E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.4835	0.5297	0.0900	0.0246	0.5132	0.0786	**1.28E-04**	**2.18E-05**	**5.94E-06**	**1.24E-04**	**1.90E-05**	**3.38E-05**	**3.20E-02**	**5.33E-07**	**3.20E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	6	0.0806	0.4835	0.081	**1.95E-05**	0.008	**1.94E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0806	0.4835	**1.23E-06**	**5.79E-08**	**4.72E-08**	**2.98E-09**	**3.33E-06**	**1.46E-06**	**2.18E-04**	**1.07E-09**	**2.82E-08**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy)	PM2.5 Emissions (tpy)
Well Pad, Road and Pipeline construction	26.08	1.38	1.46		1.00	3.48	14108.09	1.00	0.01	0.00
Sub-total: Construction	26.08	1.38		1.46	1.00	0.05	196.11	1.00	0.0002	0.00002
								TOTAL	**1.15E-02**	**1.72E-03**

[a] Average disturbed area for new CBNG wells shown in SEIS

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
Sub-total: Constr	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.065	0.000	0.001	0.062
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	10	0.0004	0	0.0005	0	0.0002	0.004	0.000	0.000	0.004
flanges	7	0.0009	0	0.0002	0	0.0000	0.006	0.000	0.000	0.006
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.075	0.000	0.002	0.072

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	0.01	**6.26E-06**	15.08	**7.54E-03**	632.73	**3.16E-01**

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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
Reactive VOC	0.000	---	0.000	0.002		0.000
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
n-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	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

Forest Products **Alternative D**

Total Annual Emissions from Forest and Woodlands Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	3.97	0.40	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.27	0.26	3.57	0.09	2.44	0.36	0.04	441.03	0.00	0.00	442.63	401.66
Sub-total: Heavy Equipment	**4.24**	**0.66**	**3.57**	**0.09**	**2.44**	**0.36**	**0.04**	**441.03**	**0.00**	**0.00**	**442.63**	**401.66**
Commuting Vehicles - Fugitive Dust	6.38	0.64	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.03	0.02	0.29	0.00	0.24	0.07	0.01	83.07	0.00	0.00	84.69	76.85
Sub-total: Commuting Vehicles	**6.41**	**0.66**	**0.29**	**0.00**	**0.24**	**0.07**	**0.01**	**83.07**	**0.00**	**0.00**	**84.69**	**76.85**
Total	**10.65**	**1.32**	**3.86**	**0.10**	**2.68**	**0.42**	**0.04**	**524.10**	**0.008**	**0.010**	**527.32**	**478.51**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative D

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, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	550	11,000	1	11.00	3.85	0.39
			Total	**11.00**	**3.85**	**0.39**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	550.0	15	29.6	52.104	0.033	955.25	0	**0.12**	**0.01**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative D

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Forest Products	Skidder	205	1	70	8	50	400	595.14	68.02	16.19	490.96	58.29	3.0E-01	3.4E-02	8.1E-03	2.5E-01	2.9E-02	3.3E-02	3.8E+01	4.4E-04	3.8E-04
	Log Truck	450	2	60	10	50	1000	2,613.18	146.54	68.65	1,048.40	132.93	1.3E+00	7.3E-02	3.4E-02	5.2E-01	6.6E-02	7.1E-02	1.6E+02	1.0E-03	1.8E-03
	Chainsaw	6	1	80	8	50	400	5.60	41.26	0.59	1,242.48	261.96	2.8E-03	2.1E-02	3.0E-04	6.2E-01	1.3E-01	1.9E-02	1.5E+00	1.1E-03	9.1E-06
	Feller Buncher	300	1	100	8	50	400	1,244.19	142.20	33.85	1,026.39	121.87	6.2E-01	7.1E-02	1.7E-02	5.1E-01	6.1E-02	6.9E-02	7.9E+01	9.3E-04	8.0E-04
	Loader	200	1	80	10	50	500	774.28	43.42	20.34	310.64	39.39	3.9E-01	2.2E-02	1.0E-02	1.6E-01	2.0E-02	2.1E-02	4.7E+01	3.0E-04	5.3E-04
	Dozer	200	1	90	8	50	400	696.85	39.08	18.31	279.57	35.45	3.5E-01	2.0E-02	9.2E-03	1.4E-01	1.8E-02	1.9E-02	4.3E+01	2.7E-04	4.8E-04
	Delimber	250	1	100	10	50	500	1,209.81	67.84	31.78	485.37	61.54	6.0E-01	3.4E-02	1.6E-02	2.4E-01	3.1E-02	3.3E-02	7.4E+01	4.7E-04	8.3E-04
												Total	**3.6E+00**	**2.7E-01**	**9.5E-02**	**2.4E+00**	**3.6E-01**	**2.6E-01**	**4.4E+02**	**4.6E-03**	**4.8E-03**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved rc		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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	70	50	3,500	1	3,500	0.61	1.06	6.38	0.06	0.11	0.64
	Log Truck	25	70	200	14,000	1	14,000	0.61	4.25		0.06	0.42	
	Pick-up Truck	25	70	50	3,500	1	3,500	0.61	1.06		0.06	0.11	
							Total		**6.38**			**0.64**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control (MCFO, 2010)

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.02	0.00	0.29	0.03	0.02	0.00	0.24	0.07	8.73	0.000	0.000
	Log Truck	HDDV	400	200	80,000	1	80,000	0.24	0.02	0.02	0.00	0.15	0.03							69.82	0.003	0.004
	Pick-up Truck	LDDT	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.07	0.03							4.51	0.000	0.001
							Total	**0.29**	**0.03**	**0.02**	**0.00**	**0.24**	**0.07**	**0.29**	**0.03**	**0.02**	**0.00**	**0.24**	**0.07**	**83.07**	**0.0037**	**0.0050**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing **Alternative**

Total Annual Emissions from Livestock Grazing Projects - Alternative

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	1.37	0.14	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.50	0.48	7.27	0.17	3.15	0.55	0.05	775.33	0.01	0.01	778.2	**706.2**
Sub-total: Construction	**1.87**	**0.62**	**7.27**	**0.17**	**3.15**	**0.55**	**0.05**	**775.33**	**0.01**	**0.01**	**778.2**	**706.2**
Commuting Vehicles - Fugitive Dust	134.71	13.45	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.31	0.27	1.98	0.01	8.17	3.63	0.36	606.92	0.06	0.05	**623.6**	**565.9**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	2662.75	---	**55,917.7**	**50,742.0**
Sub-total: Operations and Maintenance	**135.02**	**13.71**	**1.98**	**0.01**	**8.17**	**3.63**	**0.36**	**606.92**	**2662.81**	**0.05**	**56,541.3**	**51,307.9**
Total	**136.89**	**14.34**	**9.25**	**0.18**	**11.32**	**4.17**	**0.42**	**1382.25**	**2662.82**	**0.06**	**57,319.6**	**52,014.1**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative

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, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)		
			TSP	PM_{10}	$PM_{2.5}$
Springs	1.00	1	0.04	0.01	0.00
Reservoirs/Pits	37.00	1	0.52	0.18	0.02
Wells	3.00	1	0.12	0.04	0.00
Pipelines	48.00	1	1.92	0.67	0.07
Fences	30.00	1	1.20	0.42	0.04
Reservoirs Maintenance	1.00	1	0.04	0.01	0.00
		Total	**3.84**	**1.34**	**0.13**

[a] information from MCFO. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	120.0	15	29.6	52.104	0.033	208.42	0	**0.03**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

ALTERNATIVE: Alternative

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	2	2.00	32.0	15	2	0	12	2	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	40.00	960.0	3,888	236	85	1,645	247	1.94	0.12	0.04	0.82	0.12	0.11	198.02	0.00	0.00
	Scraper	650	1	70	8	3	40.00	960.0	5,054	306	111	2,138	321	2.53	0.15	0.06	1.07	0.16	0.15	257.43	0.00	0.00
Wells	Drill Rig	200	1	100	8	3	10.00	240.0	463	31	12	155	38	0.23	0.02	0.01	0.08	0.02	0.01	26.81	0.00	0.00
	Water Truck	200	1	70	8	3	10.00	240.0	324	22	8	108	27	0.16	0.01	0.00	0.05	0.01	0.01	18.77	0.00	0.00
Pipelines	Dozer	200	1	75	2	25	5.00	250.0	409	31	10	153	36	0.20	0.02	0.00	0.08	0.02	0.02	22.33	0.00	0.00
	Trencher	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
	Backhoe	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	25	8.00	1600.0	2,891	192	72	966	240	1.45	0.10	0.04	0.48	0.12	0.09	167.56	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	2	5.00	20.0	81	5	2	34	5	0.04	0.00	0.00	0.02	0.00	0.00	4.13	0.00	0.00
													Total	**7.27E+00**	**4.99E-01**	**1.67E-01**	**3.15E+00**	**5.45E-01**	**4.84E-01**	**7.75E+02**	**8.44E-03**	**8.81E-03**

Source for activity data: MCFO

all emissions calculated with year 2008 factors (conservative)

ALTERNATIVE: Alternative

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = emission control percent for watering unpaved roads [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 Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	140	2	280	2.00	560	0.72	0.20	0.40	0.07	0.02	0.04
	Pick-up Truck	35	140	2	280	2.00	560	0.72	0.20		0.07	0.02	
Reservoirs/Pits	Tractor-Trailer	35	140	3	420	40.00	16800	0.72	6.04	12.08	0.07	0.60	1.21
	Pick-up Truck	35	140	3	420	40.00	16800	0.72	6.04		0.07	0.60	
Wells	Drill Truck	35	140	3	420	10.00	4200	0.72	1.51	6.04	0.07	0.15	0.60
	Support Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Water Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Pick-up Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
Pipelines	Tractor-Trailer	35	140	25	3500	5.00	17500	0.72	6.29	12.58	0.07	0.63	1.26
	Pick-up Truck	35	140	25	3500	5.00	17500	0.72	6.29		0.07	0.63	
Fences	Support Truck	35	140	25	3500	8.00	28000	0.72	10.06	30.19	0.07	1.00	3.01
	Pick-up Truck	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
	ATV	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
Reservoirs Maintenance	Tractor-Trailer	35	140	2	280	5.00	1400	0.72	0.50	1.01	0.07	0.05	0.10
	Pick-up Truck	35	140	2	280	5.00	1400	0.72	0.50		0.07	0.05	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	140	1087	152180	1.00	152180	0.72	54.70	54.70	0.07	5.46	5.46
	Pick-up-Trailer (spring calves)	35	140	352	49280	1.00	49280	0.72	17.71	17.71	0.07	1.77	1.77
							Total		**134.71**			**13.45**	

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked
for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load

ALTERNATIVE: Alternative

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O**
Springs	Tractor-Trailer	HDDV	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	1.05	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	300	3	900	40.00	36,000.0	0.11	0.01	0.01	0.00	0.07	0.01	0.15	0.01	0.01	0.00	1.02	0.06	31.42	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	40.00	36,000.0	0.04	0.00	0.00	0.00	0.95	0.04							18.92	0.00	0.00
Wells	Drill Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00	0.0920	0.0084	0.0070	0.0005	0.2890	0.0212	7.86	0.00	0.00
	Support Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Water Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	10.00	9,000.0	0.01	0.00	0.00	0.00	0.24	0.01							4.73	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	300	25	7500	5.00	37,500.0	0.11	0.01	0.01	0.00	0.07	0.01	0.16	0.01	0.01	0.00	1.06	0.06	32.73	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	5.00	37,500.0	0.05	0.00	0.00	0.00	0.99	0.04							19.71	0.00	0.00
Fences	Support Truck	HDDV	300	25	7500	8.00	60,000.0	0.18	0.02	0.02	0.00	0.11	0.02	0.27	0.14	0.13	0.00	4.86	3.32	52.37	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	8.00	60,000.0	0.07	0.00	0.00	0.00	1.59	0.07							31.54	0.00	0.00
	ATV	R12S	300	25	7500	8.00	60,000.0	0.02	0.12	0.11	0.00	3.16	3.22							9.27	0.03	0.01
Reservoirs Maintenance	Tractor-Trailer	HDDV	300	2	600	5.00	3,000.0	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.08	0.00	2.62	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	5.00	3,000.0	0.00	0.00	0.00	0.00	0.08	0.00							1.58	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	300	1087	326100	1.00	326,100.0	0.98	0.10	0.08	0.00	0.62	0.13	1.29	0.13	0.11	0.01	0.82	0.17	284.62	0.01	0.02
	Pcik-up-Trailer (spring calves)	HDDV	300	352	105600	1.00	105,600.0	0.32	0.03	0.03	0.00	0.20	0.04							92.17	0.00	0.01
													TOTAL	**1.98**	**0.31**	**0.27**	**0.01**	**8.17**	**3.63**	**606.92**	**0.06**	**0.05**

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load.

ALTERNATIVE: Alternative

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	519,192	9.74	2527.67	0.37	95.38	2623.05
Horse	17,470	3.31	28.89	0.43	3.76	32.64
Sheep	9,281	1.47	6.82	0.05	0.24	7.06
					Total Methane emissions	**2662.75**

AUM numbers provided by Dawn Doran (per direction from Todd Yeager) on 7/5/2011.

General Purpose Travel - BLM Fleet Alternative D

Total Annual Emissions from General Purpose BLM Travel - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Commuting Vehicles - Fugitive Dust	72.58	7.24	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.08	0.07	1.72	0.00	4.64	2.04	0.20	304.00	0.00	0.04	316.22	286.95
Sub-total: Commuting Vehicles	**72.66**	**7.31**	**1.72**	**0.00**	**4.64**	**2.04**	**0.20**	**304.00**	**0.00**	**0.04**	**316.22**	**286.95**
Total	**72.66**	**7.31**	**1.72**	**0.00**	**4.64**	**2.04**	**0.20**	**304.00**	**0.00**	**0.04**	**316.22**	**286.95**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads [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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10}			$PM_{2.5}$		
				Controlled Em. Factor (lb/VMT)	Emissions (tons/fleet group)	Emissions (tpy)	Controlled Em. Factor (lb/VMT)	Emissions (tons/fleet group)	Emissions (tpy)
General Purpose BLM Travel	DM/FM Staff	25	3,329	0.61	1.01	72.58	0.06	0.10	7.24
	Support Services	25	27,597	0.61	8.38		0.06	0.84	
	Fire Management	45	97,656	0.61	29.66		0.06	2.96	
	Minerals and NRR	15	56,943	0.47	13.40		0.05	1.34	
	Renewable Resources	25	66,242	0.61	20.12		0.06	2.01	
		Total	**251,767**	**Total**	**72.58**			**7.242**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control.

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions (tons/fleet group)						Emissions (tpy)								
				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_2O
General Purpose BLM Travel	DM/FM Staff	LDDT	22,189	0.057	0.003	0.002	0.000	0.153	0.067	1.72	0.08	0.07	0.00	4.64	2.04	10.02	0.00	0.00
	Support Services	LDDT	78,848	0.201	0.009	0.008	0.000	0.543	0.239							35.59	0.00	0.00
	Fire Management	LDDT	217,013	0.553	0.026	0.021	0.001	1.494	0.657							97.96	0.00	0.01
	Minerals and NRR	LDDT	189,810	0.484	0.023	0.019	0.001	1.307	0.575							85.68	0.00	0.01
	Renewable Resources	LDDT	165,606	0.422	0.020	0.016	0.001	1.140	0.501							74.75	0.00	0.01
			Total	**1.716**	**0.081**	**0.066**	**0.004**	**4.638**	**2.039**	**1.72E+00**	**8.07E-02**	**6.57E-02**	**4.16E-03**	**4.64E+00**	**2.04E+00**	**3.04E+02**	**1.48E-03**	**3.93E-02**

Source of activity data: MCFO

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance Alternative D

Total Annual Emissions from Road Maintenance Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.55	0.23	1.36	0.03	0.53	0.09	0.01	160.62	0.00	0.00	161.21	146.29
Total	**1.55**	**0.23**	**1.36**	**0.03**	**0.53**	**0.09**	**0.01**	**160.62**	**0.0013**	**0.0018**	**161.21**	**146.29**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative D

Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	127

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^{2}$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)

Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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)			
mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[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.

* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	210	5	1,050	0.765	0.40	0.069	0.04
Road Maintenance	Semi-truck	31	20	61	1.09	0.03	0.11	0.00
Road Maintenance	Lowboy Trailer	---	20	792	1.09	0.43	0.11	0.04
				Total	**0.87**		**0.08**	

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	1	0.10	79	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00
Backhoe	87	1	0.80	146	0.06	0.00	0.00	0.02	0.00	0.00	6.05	0.00	0.00
Semi-truck	450	1	0.50	307	0.33	0.02	0.01	0.13	0.02	0.02	40.79	0.00	0.00
Lowboy Trailer	450	1	0.50	414	0.45	0.03	0.01	0.18	0.02	0.02	55.00	0.00	0.00
Bobcat	82	1	0.80	206	0.07	0.01	0.00	0.03	0.01	0.01	8.04	0.00	0.00
Grader	165	1	0.90	210	0.17	0.01	0.00	0.06	0.02	0.01	18.56	0.00	0.00
Loader	200	1	0.75	162	0.13	0.01	0.00	0.05	0.01	0.01	14.46	0.00	0.00
Dump Truck	350	1	0.50	156	0.13	0.01	0.00	0.05	0.01	0.01	16.12	0.00	0.00
Airport Forklift	100	1	0.10	18	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00
Snowplow	350	1	0.25	20	0.01	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Total					**1.4E+00**	**8.5E-02**	**3.5E-02**	**5.3E-01**	**8.6E-02**	**8.3E-02**	**1.6E+02**	**1.3E-03**	**1.8E-03**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2768.4	15	29.6	52.104	0.033	4,808.26	0	**0.60**	**0.06**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005)

Appendix E

Alternative E Emission Inventory

Summary of Emissions.....E-1

Oil Development and Production.....E-2

Natural Gas Development and Production.....E-29

Coal Bed Methane Natural Gas Development and Production E-54

Coal Mining ..... (*see pages A-77 through A-78*)

Vegetation Management ..... (*see pages A-79 through A-83*)

Fire Management ..... (*see pages A-84 through A-88*)

Forestry and Woodland Products.....E-77

Livestock Grazing.....E-82

Recreation, Trails, and Travel Management ..... (*see pages A-100 through A-102*)

General Purpose BLM Fleet Travel.....E-88

Road Maintenance E-91

Alternative E Summary

MCFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)											Emissions (mtpy)
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq}
Federal / BLM												
Oil and Gas												
Oil	347.8	151.7	1,207.5	2.3	34.8	9.3	76.3	33,176.2	195.2	0.2	37,342.2	33,871
Natural Gas	136.1	56.3	38.9	0.1	8.8	3.2	3.9	13,516.0	181.0	0.1	17,278.2	15,672
CBNG	59.6	30.1	20.6	0.0	6.7	2.0	3.9	4,861.7	94.1	0.0	6,843.4	6,207
Coal Mining [1]	2,121.0	1,817.4	144.2	179.8	4,448.4	444.8	14.4	104,029.1	0.6	1.0	104,364.7	94,662
Vegetation Management	11.3	0.1	3.1	0.0	10.7	1.4	0.3	33.9	0.0	0.0	34.8	32
Fire Management [2]	1,741.9	58.3	97.3	13.6	210.7	151.1	9.7	289,046.1	121.5	23.7	298,943.9	271,151
Forestry and Woodland Products	2.7	3.9	0.4	0.1	10.7	1.3	0.0	524.1	0.0	0.0	527.3	478
Livestock Grazing	11.3	9.3	4.2	0.2	136.9	14.3	0.4	1,382.3	2,655.8	0.1	57,172.5	51,857
Recreation - Trails and Travel Management	26.6	0.1	27.1	0.0	292.6	30.1	2.7	78.0	0.2	0.0	83.4	76
General Purpose BLM Fleet Travel [2]	4.6	1.7	2.0	0.0	72.7	7.3	0.2	304.0	0.0	0.0	316.2	287
Road Maintenance [2]	0.5	1.2	0.1	0.0	1.4	0.2	0.0	146.7	0.0	0.0	147.2	134
Federal Emission Total	**4,463.5**	**2,130.2**	**1,545.5**	**196.2**	**5,234.3**	**665.0**	**112.0**	**447,098.1**	**3,248.5**	**25.2**	**523,053.9**	**474,425**
Non-Federal												-
Oil and Gas	3,583.1	2,936.2	8,964.5	46.0	416.7	163.3	597.2	359,280.2	3,292.7	1.2	428,339.5	388,517
Coal Mining [1]	3,024.7	2,383.8	156.7	200.7	4,421.5	481.1	15.7	143,391.0	0.9	1.4	143,853.6	130,479
Non-Federal Emission Total	**6,607.8**	**5,320.0**	**9,121.1**	**246.7**	**4,838.2**	**644.4**	**612.8**	**502,671.2**	**3,293.5**	**2.7**	**572,193.0**	**518,996**

tpy = short tons per year

mtpy = metric tons per year

1. In available air quality permits for coal mines located in the MCFO, total suspended particulate (TSP) is usually reported and PM10 and/or PM2.5 may be reported. In permits containing only TSP emissions, all TSP was assumed to be PM10. This assumption overestimates PM10 emissions. If PM10 was reported and PM2.5 was not reported, PM2.5 was assumed to equal 10 percent of PM2.5. With regard to greenhouse gases, coal mine emissions do not include ventilation emissions or emissions associated with electricity provided to the mine.

2. Excludes smoke emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	33,634	38,897	5,713	17,023	24,469	3,772
Alt. A O&G (%) of NEI Emissions	1.6%	0.6%	22.2%	0.01%	0.2%	0.4%
Alt. A (%) of NEI Emissions	13.3%	5.5%	27.1%	1.2%	21.4%	17.6%

County Emissions (Carter, Custer, Daniels, Dawson, Fallon, Garfield, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure, and Wibaux counties).

Source: EPA 2008 National Emission Inventory (NEI), http://neibrowser.epa.gov/eis-public-web/geo/county-emissions.html?stateJurisdictionId=28&inventoryYear=2008, accessed December 12, 2011.

Alternative E input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	20	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	136
Federal Producing Wells - RMP Year 20	300	Non-Federal Producing Wells - RMP Year 20	2,109
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 47% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.77	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.16	0.17	10.37	2.14	54.78	2.92	0.29	10937.68	0.11	0.12	10978.75	9962.57
Commuting Vehicles - Construction	9.05	0.92	0.26	0.00	0.30	0.11	0.01	66.73	0.00	0.00	68.22	61.91
Wind Erosion	0.23	0.03	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**10.21**	**1.20**	**10.63**	**2.14**	**55.09**	**3.03**	**0.30**	**11,004.42**	**0.12**	**0.13**	**11,046.97**	**10,024.48**
Well Workover Operations - Fugitive Dust	1.30	0.13	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.09	0.09	1.79	0.03	15.48	0.83	0.08	3152.24	0.04	0.04	3164.33	2871.44
Well Workover Operations - On-road Exhaust	0.00	0.00	0.04	0.00	0.07	0.03	0.003	9.30	0.00	0.00	9.56	8.67
Well Visits for Inspection & Repair - Operations	1.45	0.14	0.04	0.00	0.95	0.04	0.004	18.92	0.00	0.01	21.18	19.22
Recompletion Traffic	2.23	0.23	0.08	0.00	0.13	0.05	0.00	18.87	0.00	0.00	19.36	17.56
Water Tanks & Traffic	5.93	0.63	0.50	0.00	0.32	0.07	0.01	147.03	34.29	0.00	867.50	787.20
Oil Tanks & Traffic	4.81	0.50	0.33	0.00	0.21	1,060.78	61.13	150.37	120.90	0.00	2689.59	2440.64
Venting	---	---	---	---	---	13.63	1.11	0.44	17.07	0.00	358.92	325.70
Compression and Well Pumps	6.10	6.10	137.60	0.09	275.20	96.32	9.63	18,567.07	0.35	0.04	18585.28	16865.05
Dehydrators	0.00	0.00	0.02	0.00	0.01	31.54	3.91	20.38	21.12	0.00	463.99	421.04
Compression Station Fugitives	---	---	---	---	---	1.05	0.11	0.03	1.32	0.00	27.77	25.20
Sub-total: Operations	**21.92**	**7.83**	**140.40**	**0.13**	**292.37**	**1,204.35**	**75.99**	**22,084.65**	**195.10**	**0.08**	**26,207.46**	**23,781.73**
Road Maintenance	2.61	0.29	0.67	0.017	0.34	0.10	0.010	84.66	0.00	0.00	85.27	77.38
Sub-total: Maintenance	**2.61**	**0.29**	**0.67**	**0.017**	**0.34**	**0.10**	**0.010**	**84.664**	**0.001**	**0.00**	**85.27**	**77.38**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.08	0.08
Well Reclamation	0.08	0.01	0.01	0.00	0.01	0.00	0.00	2.43	0.00	0.00	2.44	2.22
Sub-total: Reclamation	**0.08**	**0.01**	**0.01**	**0.0004**	**0.01**	**0.002**	**0.0002**	**2.5143**	**0.0000**	**0.0000**	**2.5289**	**2.2949**
Total Emissions	**34.83**	**9.33**	**151.70**	**2.29**	**347.80**	**1,207.48**	**76.30**	**33,176.25**	**195.22**	**0.21**	**37,342.24**	**33,885.88**

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	5.24	0.52	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	36.18	35.16	691.10	14.35	177.48	50.50	5.05	74376.25	0.77	0.12	74431.07	67541.81
Commuting Vehicles - Construction	61.54	6.26	1.74	0.01	2.06	0.72	0.07	453.79	0.02	0.00	455.60	413.43
Wind Erosion	1.55	0.23	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**104.50**	**42.18**	**692.84**	**14.36**	**179.54**	**51.22**	**5.12**	**74,830.04**	**0.79**	**0.13**	**74,886.67**	**67,955.24**
Well Workover Operations - Fugitive Dust	9.12	0.91	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	15.92	15.44	280.07	4.77	94.09	20.27	2.03	22160.21	0.31	0.25	22245.21	20186.21
Well Workover Operations - On-road Exhaust	0.02	0.02	0.29	0.00	0.52	0.21	0.021	65.37	0.00	0.01	67.20	60.98
Well Visits for Inspection & Repair - Operations	10.21	1.02	0.31	0.00	6.69	0.30	0.030	133.04	0.02	0.05	148.87	135.09
Recompletion Traffic	15.70	1.60	0.56	0.00	0.88	0.34	0.03	132.65	0.00	0.01	136.08	123.48
Water Tanks & Traffic	41.71	4.41	3.55	0.02	2.25	0.46	0.05	1,033.64	241.07	0.01	6098.52	5534.04
Oil Tanks & Traffic	33.83	3.54	2.30	0.01	1.46	7,457.30	429.76	1,057.07	849.96	0.01	18907.79	17157.71
Venting	---	---	---	---	---	94.03	7.64	3.06	117.76	0.00	2476.06	2246.88
Compression and Well Pumps	42.88	42.88	967.32	0.66	1,934.64	677.13	67.71	130,526.52	2.46	0.25	130654.54	118561.29
Dehydrators	0.01	0.01	0.12	0.00	0.10	221.75	27.48	143.24	148.47	0.00	3261.85	2959.94
Compression Station Fugitives	---	---	---	---	---	7.41	0.74	0.24	9.28	0.00	195.19	177.12
Sub-total: Operations	**169.41**	**69.83**	**1,254.52**	**5.46**	**2,040.62**	**8,479.20**	**535.49**	**155,255.04**	**1,369.33**	**0.58**	**184,191.30**	**167,142.74**
Road Maintenance	18.37	2.02	4.68	0.121	2.39	0.73	0.073	595.18	0.01	0.01	599.48	543.99
Sub-total: Maintenance	**18.37**	**2.02**	**4.68**	**0.121**	**2.39**	**0.73**	**0.073**	**595.185**	**0.006**	**0.01**	**599.48**	**543.99**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.59	0.54
Well Reclamation	0.57	0.07	0.07	0.00	0.08	0.02	0.00	17.08	0.00	0.00	17.18	15.59
Sub-total: Reclamation	**0.59**	**0.07**	**0.07**	**0.0031**	**0.08**	**0.017**	**0.0017**	**17.6754**	**0.0003**	**0.0003**	**17.7784**	**16.1329**
Total Emissions	**292.87**	**114.11**	**1,952.11**	**19.94**	**2,222.63**	**8,531.17**	**540.69**	**230,697.94**	**1,370.13**	**0.72**	**259,695.23**	**235,658.10**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

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)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**7.70E+01**	**7.70E+00**	**3.85E-02**	**3.85E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.0051	0.12	3.70	0.14	0.01	589.10	0.006	0.006
75 to 100	0.30	0.0051	0.11	3.70	0.14	0.01	589.10	0.006	0.006
100 to 175	0.30	0.0051	0.11	3.70	0.14	0.01	530.10	0.005	0.006
175 to 300	0.30	0.0051	0.11	2.60	0.14	0.01	530.18	0.004	0.006
300 to 600	0.30	0.0051	0.11	2.60	0.14	0.01	530.25	0.004	0.006
600 to 750	0.30	0.0051	0.11	2.60	0.14	0.01	530.28	0.004	0.006
>750 (genset)	0.50	0.0051	0.10	2.60	0.14	0.01	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	9	182	4,622	249	0.44	0.00	0.09	2.31	0.12	0.00	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	1	15	330	18	0.02	0.00	0.01	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	0	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	600	1	50	11	5	55	1	11	0	4	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	1	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.02	0.38	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	**4.91E-01**	**5.23E-03**	**1.06E-01**	**2.72E+00**	**1.43E-01**	**5.23E-03**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.19E-01**	**8.10E-03**	**1.07E-01**	**2.74E+00**	**1.46E-01**	**8.55E-03**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.000	0.000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.27	0.000	0.000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.48	0.000	0.000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
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, Fracing & 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 (%)[b]**	**# 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	**5.05E+00**	**2.63E-01**	**1.05E-01**	**1.29E+00**	**3.69E-01**	**2.55E-01**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.08E+00**	**2.66E-01**	**1.05E-01**	**1.30E+00**	**3.71E-01**	**2.59E-01**	**5.47E+02**	**5.65E-03**	**6.24E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	0.27	129.02	0.06	0.07	0.03	12.90	0.01	0.01
	Pickup Trucks	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.27	13.73	0.01	0.01	0.03	1.37	0.00	0.00
	Pickup Trucks	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.27	5.49	0.00	0.01	0.03	0.55	0.00	0.00
	Haul Trucks	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Pickup Trucks	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.27	120.78	0.06	0.14	0.03	12.08	0.01	0.01
	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Tool Pusher	25	10	8	80	1	0.22	17.39	0.01		0.02	1.74	0.00	
	Mud Logger	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Mud Engineer	25	10	15	150	1	0.22	32.60	0.02		0.02	3.26	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.27	16.47	0.01	0.02	0.03	1.65	0.00	0.00
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
									Subtotal	**2.47E-01**				**2.47E-02**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00	0.20	0.02	0.65	0.00	0.02
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Welders	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Haul Water Truck	25	10	150	1500	1	0.22	326.03	0.16		0.02	32.60	0.02	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**2.05E-01**				**2.05E-02**
									Total	**4.51E-01**				**4.51E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SOx**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	**Class**					**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_2O**
Improved & Two-Track Road	Semi Trucks	HDDV	10	47	470	1	2.8142	0.2851	0.2380	0.0137	1.7832	0.3668	0.0014	0.0001	0.0001	0.0000	0.0009	0.0002	0.001	0.000	0.000	0.000	0.001	0.000	0.4	0.0000	0.0000
	Pickup Trucks	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	4	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0000	0.0000
	Haul Trucks	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Trucks	LDDT	10	1	10	1	0.0510	0.0024	0.0020	0.0001	0.1377	0.0606	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																		Subtotal	**1.88E-03**	**1.79E-04**	**1.50E-04**	**8.64E-06**	**1.61E-03**	**4.61E-04**	**5.25E-01**	**2.30E-05**	**3.20E-05**

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	10	44	440	1	2.6346	0.2669	0.2228	0.0128	1.6694	0.3434	0.0013	0.0001	0.0001	0.0000	0.0008	0.0002	0.00	0.00	0.00	0.00	0.01	0.00	0.4	0.0000	0.0000
	Fuel Haul Truck	HDDV	10	6	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	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Tool Pusher	LDDT	10	8	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							0.0	0.0000	0.0000
	Mud Logger	LDDT	10	6	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							0.0	0.0000	0.0000
	Mud Engineer	LDDT	10	15	150	1	0.7646	0.0359	0.0293	0.0019	2.0658	0.9084	0.0004	0.0000	0.0000	0.0000	0.0010	0.0005							0.1	0.0000	0.0000
	Logger, Engr Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	10	6	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	0.0000	0.0000
	Haul Water Truck	HDDV	10	150	1500	1	8.9815	0.9101	0.7596	0.0437	5.6911	1.1706	0.0045	0.0005	0.0004	0.0000	0.0028	0.0006							1.3	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**1.09E-02**	**9.31E-04**	**7.74E-04**	**4.52E-05**	**1.36E-02**	**4.82E-03**	**2.81E+00**	**1.08E-04**	**1.99E-04**
																	Total		**1.28E-02**	**1.11E-03**	**9.23E-04**	**5.38E-05**	**1.52E-02**	**5.28E-03**	**3.34E+00**	**1.31E-04**	**2.31E-04**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

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]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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_2O[a]
Diesel	0.30	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	k (s/12)[a] (W/3)[a]	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 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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Haul Truck	42	10	1	10	1	0.27	2.75	0.00	0.03	0.27	0.00
	Pickup Truck	5	10	3	30	1	0.11	3.16	0.00	0.01	0.32	0.00
								Total	**4.33E-03**			**4.33E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Haul Truck	HDDV	10	1	10	1	0.060	0.006	0.005	0.000	0.038	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.0087	0.0000	0.0000
	Pickup Truck	LDDT	10	3	30	1	0.153	0.007	0.006	0.000	0.413	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.0135	0.0000	0.0000
												Total	**1.36E-04**	**9.66E-06**	**7.99E-06**	**4.76E-07**	**2.45E-04**	**9.86E-05**	**3.10E-02**	**8.82E-07**	**2.73E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/ well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	10	12	120	1	0.08	9.68	**4.84E-03**	0.01	0.96	**4.82E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	10	12	120	1	0.30	0.01	0.00	0.00	6.34	0.28	**1.49E-04**	**3.35E-06**	**1.55E-06**	**1.16E-06**	**3.17E-03**	**1.42E-04**	**6.31E-02**	**8.99E-06**	**2.36E-05**

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for 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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	1.0	60	0.08	4.84	**2.42E-03**	0.01	0.48	**2.41E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

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 (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	1.0	60	**1.53E-04**	**7.19E-06**	**5.85E-06**	**3.70E-07**	**4.13E-04**	**1.82E-04**	**2.71E-02**	**1.32E-07**	**3.51E-06**

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lb/year/well)	Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	10	56	562	1	0.07	39.21	**1.96E-02**	0.01	3.90	**1.95E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	10	56	562	1	3.362	0.341	0.284	0.016	2.131	0.438	**1.68E-03**	**1.70E-04**	**1.42E-04**	**8.17E-06**	**1.07E-03**	**2.19E-04**	**4.90E-01**	**2.29E-05**	**3.75E-06**

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions[a]

Project Year	Emissions[b]			
	HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other 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/10^3 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[a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] 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)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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														
							(lb/well)						(tpy/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_2O
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	10	37	365	1	2.185	0.221	0.185	0.011	1.385	0.285	0.0011	0.0001	0.0001	0.0000	0.0007	0.0001	0.319	0.000	0.000
						TOTAL							**1.09E-03**	**1.11E-04**	**9.24E-05**	**5.31E-06**	**6.92E-04**	**1.42E-04**	**3.19E-01**	**1.49E-05**	**2.44E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a]	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-HA	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**

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

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	k (s/12)[a] (W/3)[b]
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	10	6	60	1	0.22	13.04	0.01	0.15	0.02	1.30	0.00	0.01
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.22	8.69	0.00		0.02	0.87	0.00	
	Rig Crew	5	10	51	510	1	0.11	53.73	0.03		0.01	5.37	0.00	
	Rig Mechanics	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Co. Supervisor	5	10	20	200	1	0.11	21.07	0.01		0.01	2.11	0.00	
	Semi Completion, Unit Rig	42	10	1	10	1	0.27	2.75	0.00		0.03	0.27	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Tubing Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Cementer, Cement Truck	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Completion,	25	10	3	30	1	0.22	6.52	0.00		0.02	0.65	0.00	
	Haul Service Tools	25	10	2	20	1	0.22	4.35	0.00		0.02	0.43	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.22	2.17	0.00		0.02	0.22	0.00	
	Haul Water Truck	25	10	50	500	1	0.22	108.68	0.05		0.02	10.87	0.01	
	Pickup Cementer, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Casing Crew	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.11	5.27	0.00		0.01	0.53	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.11	1.05	0.00		0.01	0.11	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.11	10.53	0.01		0.01	1.05	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.11	3.16	0.00		0.01	0.32	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
									Subtotal	**1.49E-01**				**1.49E-02**
									Total	**1.49E-01**				**1.49E-02**

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_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Well Recompletion	Fuel Haul Truck	HDDV	10	6	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	0.01	0.00	0.00	0.00	0.01	0.00	0.1	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Rig Crew	LDDT	10	51	510	1	2.5995	0.1222	0.0995	0.0063	7.0237	3.0886	0.0013	0.0001	0.0000	0.0000	0.0035	0.0015							0.2	0.0000	0.0000
	Rig Mechanics	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	10	20	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	10	6	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	0.0000	0.0000
	Tubing Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	10	2	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	10	3	30	1	0.1796	0.0182	0.0152	0.0009	0.1138	0.0234	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Service Tools	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	10	50	500	1	2.9938	0.3034	0.2532	0.0146	1.8970	0.3902	0.0015	0.0002	0.0001	0.0000	0.0009	0.0002							0.4	0.0000	0.0000
	Pickup Cementer, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	10	5	50	1	0.2994	0.0303	0.0253	0.0015	0.1897	0.0390	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	10	5	50	1	0.2549	0.0120	0.0098	0.0006	0.6886	0.3028	0.0001	0.0000	0.0000	0.0000	0.0003	0.0002							0.0	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	10	2	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	10	1	10	1	0.0599	0.0061	0.0051	0.0003	0.0379	0.0078	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	10	10	100	1	0.5097	0.0240	0.0195	0.0012	1.3772	0.6056	0.0003	0.0000	0.0000	0.0000	0.0007	0.0003							0.0	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	10	3	30	1	0.1529	0.0072	0.0059	0.0004	0.4132	0.1817	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	10	4	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
																	Subtotal		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**
																	Total		**5.27E-03**	**4.02E-04**	**3.33E-04**	**1.97E-05**	**8.34E-03**	**3.25E-03**	**1.26E+00**	**4.08E-05**	**1.02E-04**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
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	0.013
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	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
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
Reactive VOC	15.340	---	8.382	33.969		0.389
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
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
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	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

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

Volume Flow:	900	SCF / bbl oil
BBL oil / day:	20	bbl oil / day
Completion activity duration:	3	days
Total Completion/Recompletion Volume Flow per Well	0.054	MMSCF/well

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

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		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]	N_2O[c]
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

[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 and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

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	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º 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
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O 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_2 emissions per well (lb/hr)	CH_4 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
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
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	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	1.63E-03	2.44E-04
								TOTAL	**1.14E-02**	**1.71E-03**

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	0.250
Number of Roads Reclaimed Annually Per Well	0.019
Annual Miles of Roads reclaimed Per Well	0.005
Number of wells reclaimed (per well)	0.019

Reclaimation 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
0.005	6	0.0008	0.0080
		Total	**0.0080**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.005	5	0.024	0.765	**9.13E-06**	0.069	**8.27E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Road Reclamation	Grader	80	0.005	0.4238	0.0720	0.0197	0.4106	0.0629	**1.01E-06**	**1.72E-07**	**4.69E-08**	**9.80E-07**	**1.50E-07**	**1.67E-07**	**2.58E-04**	**2.32E-09**	**2.55E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0008	0.0477	0.081	**1.92E-06**	0.008	**1.92E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0008	0.0477	**1.22E-07**	**5.72E-09**	**4.66E-09**	**2.95E-10**	**3.29E-07**	**1.45E-07**	**2.15E-05**	**1.05E-10**	**2.79E-09**

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	0.019	10	0.019	0.19

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.1146	5	0.573	0.765	**2.19E-04**	0.069	**1.99E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.1146	0.5297	0.0900	0.0246	0.5132	0.0786	**3.03E-05**	**5.16E-06**	**1.41E-06**	**2.94E-05**	**4.50E-06**	**8.00E-06**	**7.58E-03**	**1.26E-07**	**7.64E-08**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.0191	1.1457	0.081	**4.62E-05**	0.008	**4.60E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.0191	1.1457	**2.92E-06**	**1.37E-07**	**1.12E-07**	**7.07E-09**	**7.89E-06**	**3.47E-06**	**5.17E-04**	**2.53E-09**	**6.69E-08**

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

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)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Alternative E input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	16	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	111
Federal Producing Wells - RMP Year 20	249	Non-Federal Producing Wells - RMP Year 20	1,747
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 47% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.19	0.02	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.15	0.16	2.65	0.05	19.60	1.03	0.10	3807.56	0.03	0.04	3821.63	3467.90
Commuting Vehicles - Construction	2.90	0.29	0.08	0.00	0.10	0.03	0.00	21.35	0.00	0.00	21.83	19.81
Wind Erosion	0.05	0.01	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.28	0.00	0.12	36.28	0.00	761.94	691.42
Sub-total: Construction	**3.29**	**0.48**	**2.74**	**0.05**	**19.70**	**1.34**	**0.11**	**3,829.04**	**36.31**	**0.04**	**4,605.40**	**4,179.13**
Well Workover Operations - Fugitive Dust	0.43	0.04	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.07	0.07	1.48	0.03	12.85	0.69	0.07	2619.85	0.02	0.03	2629.44	2386.06
Well Workover Operations - On-road Exhaust	0.00	0.00	0.01	0.00	0.02	0.01	0.001	3.09	0.00	0.00	3.17	2.88
Well Visits for Inspection & Repair - Operations	0.48	0.05	0.01	0.00	0.32	0.01	0.001	6.28	0.00	0.00	7.03	6.38
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.68	0.07	0.30	88.08	0.00	1849.98	1678.74
Compression	2.28	2.28	51.47	0.03	102.94	36.03	3.60	6,945.23	0.13	0.01	6952.04	6308.57
Station Visits - Operations	0.15	0.02	0.01	0.00	0.03	0.01	0.00	1.71	0.00	0.00	1.78	1.62
Dehydrators	0.00	0.00	0.03	0.00	0.03	0.08	0.04	37.58	56.46	0.00	1223.51	1110.26
Sub-total: Operations	**3.43**	**2.47**	**53.02**	**0.06**	**116.18**	**37.51**	**3.78**	**9,614.05**	**144.69**	**0.05**	**12,666.95**	**11,494.51**
Road Maintenance	1.89	0.21	0.53	0.014	0.23	0.07	0.007	67.12	0.00	0.00	67.50	61.26
Sub-total: Maintenance	**1.89**	**0.21**	**0.53**	**0.014**	**0.23**	**0.07**	**0.007**	**67.124**	**0.001**	**0.00**		**61.26**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.20	0.18
Well Reclamation	0.19	0.02	0.02	0.00	0.03	0.01	0.00	5.61	0.00	0.00	5.64	5.12
Sub-total: Reclamation	**0.20**	**0.02**	**0.02**	**0.0010**	**0.03**	**0.006**	**0.0006**	**5.8039**	**0.0001**	**0.0001**	**5.8377**	**5.2974**
Total Emissions	**8.80**	**3.18**	**56.32**	**0.12**	**136.14**	**38.93**	**3.89**	**13,516.01**	**181.00**	**0.09**	**17,278.19**	**15,740.20**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	1.34	0.13	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	1.33	1.38	109.19	0.33	135.75	7.16	0.72	26401.82	0.27	0.04	26420.96	23975.46
Commuting Vehicles - Construction	20.09	2.05	0.57	0.00	0.67	0.23	0.02	148.15	0.01	0.00	148.73	134.96
Wind Erosion	0.36	0.05	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	1.93	0.00	0.85	251.67	0.00	5285.97	4796.70
Sub-total: Construction	**23.12**	**3.62**	**109.76**	**0.34**	**136.42**	**9.32**	**0.74**	**26,550.82**	**251.95**	**0.04**	**31,855.65**	**28,907.13**
Well Workover Operations - Fugitive Dust	3.02	0.30	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	13.19	12.79	232.00	3.95	77.94	16.79	1.68	18356.52	0.26	0.21	18426.92	16721.34
Well Workover Operations - On-road Exhaust	0.01	0.01	0.10	0.00	0.17	0.07	0.007	21.66	0.00	0.00	22.27	20.20
Well Visits for Inspection & Repair - Operations	3.38	0.34	0.10	0.00	2.22	0.10	0.010	44.08	0.01	0.02	49.33	44.76
Wellhead and Compressor Station Fugitives	---	---	---	---	---	4.74	0.47	2.08	617.97	0.00	12979.55	11778.18
Compression	16.01	16.01	361.12	0.25	722.24	252.78	25.28	48,728.20	0.92	0.09	48775.99	44261.33
Station Visits - Operations	1.08	0.11	0.07	0.00	0.18	0.08	0.01	12.03	0.00	0.00	12.51	11.36
Dehydrators	0.02	0.01	0.22	0.00	0.18	0.56	0.26	263.67	396.14	0.00	8584.21	7789.66
Sub-total: Operations	**36.70**	**29.57**	**593.61**	**4.20**	**802.93**	**275.12**	**27.72**	**67,428.23**	**1,015.30**	**0.33**	**88,850.78**	**80,626.84**
Road Maintenance	13.24	1.47	3.75	0.100	1.64	0.46	0.046	470.94	0.00	0.01	473.61	429.78
Sub-total: Maintenance	**13.24**	**1.47**	**3.75**	**0.100**	**1.64**	**0.46**	**0.046**	**470.944**	**0.005**	**0.01**		**429.78**
Road Reclamation	0.05	0.01	0.01	0.00	0.01	0.00	0.00	1.36	0.00	0.00	1.37	1.24
Well Reclamation	1.31	0.16	0.16	0.01	0.18	0.04	0.00	39.36	0.00	0.00	39.59	35.92
Sub-total: Reclamation	**1.37**	**0.16**	**0.17**	**0.0071**	**0.19**	**0.040**	**0.0040**	**40.7202**	**0.0006**	**0.0007**	**40.9576**	**37.1666**
Total Emissions	**74.43**	**34.82**	**707.28**	**4.64**	**941.18**	**284.95**	**28.51**	**94,490.72**	**1,267.25**	**0.38**	**120,747.39**	**110,000.91**

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Well Pad and other structures	0.5	3	1	0.5	1.10E+01	1.10E+00	5.50E-03	5.50E-04
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**24**	**2.41**	**1.21E-02**	**1.21E-03**

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

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (non-genset)	2.60	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	4	1,849	100	0.11	0.01	0.00	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	5.73E-03	3.60E-05	8.35E-06	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	**1.38E-01**	**6.64E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**6.64E-03**	**2.34E+02**	**1.80E-03**	**2.67E-03**
												Total		**1.66E-01**	**9.51E-03**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**9.96E-03**	**2.38E+02**	**1.85E-03**	**2.71E-03**

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	43	10	2	20	1	13.79	1.62	0.37	11.21	1.42	0.01	0.00	0.00	0.01	0.00	0.00	0.8456	0.0000	0.0000
Well Pad	Blade	150	1	43	10	3	30	1	20.69	2.43	0.55	16.81	2.13	0.01	0.00	0.00	0.01	0.00	0.00	1.2684	0.0000	0.0000
	Dozer	175	1	43	10	3	30	1	21.75	1.69	0.60	7.56	1.74	0.01	0.00	0.00	0.00	0.00	0.00	1.4797	0.0000	0.0000
													Subtotal	**2.81E-02**	**2.87E-03**	**7.61E-04**	**1.78E-02**	**2.65E-03**	**3.32E-03**	**3.59E+00**	**4.56E-05**	**3.66E-05**

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (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	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	1,849	16	4	1,849	100	0.92	0.01	0.00	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	0	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	0	352	13	0.01	0.00	0.00	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion, Fracing & Testing	Main Deck	400	1	50	11	5	55	1	7	0	0	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# 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	11.46	0.07	0.02	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	**9.56E-01**	**9.13E-03**	**2.25E-03**	**1.21E+00**	**6.19E-02**	**9.13E-03**	**2.34E+02**	**2.39E-03**	**2.67E-03**
												Total		**9.84E-01**	**1.20E-02**	**3.01E-03**	**1.22E+00**	**6.45E-02**	**1.25E-02**	**2.38E+02**	**2.44E-03**	**2.71E-03**

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	4	47	188	1	0.27	51.61	0.03	0.026	0.03	5.16	0.00	0.003
	Pickup Trucks	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
Well Pad	Semi Trucks	42	4	5	20	1	0.27	5.49	0.00	0.004	0.03	0.55	0.00	0.000
	Pickup Trucks	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
Other Construction Activities	Semi Trucks	42	4	2	8	1	0.27	2.20	0.00	0.002	0.03	0.22	0.00	0.000
	Haul Trucks	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Pickup Trucks	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	4	44	176	1	0.27	48.31	0.02	0.058	0.03	4.83	0.00	0.006
	Fuel Haul Truck	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Haul Truck, Water Hauling	25	4	4	16	1	0.22	3.48	0.00		0.02	0.35	0.00	
	Rig Crew	5	4	51	204	1	0.11	21.49	0.01		0.01	2.15	0.00	
	Rig Mechanics	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Co. Supervisor	5	4	20	80	1	0.11	8.43	0.00		0.01	0.84	0.00	
	Tool Pusher	25	4	8	32	1	0.22	6.96	0.00		0.02	0.70	0.00	
	Mud Logger	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Mud Engineer	25	4	15	60	1	0.22	13.04	0.01		0.02	1.30	0.00	
	Logger, Engr Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Drill Bit Delivery	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	4	6	24	1	0.27	6.59	0.00	0.009	0.03	0.66	0.00	0.001
	Semi Completion, Unit Rig	42	4	1	4	1	0.27	1.10	0.00		0.03	0.11	0.00	
	Semi Fracing, Blender	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Semi Pumping/Tank Battery	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Tubing Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Cementer, Pump Truck	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
									Subtotal	**9.86E-02**				**9.86E-03**

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, Fracing & Testing (continued from above)	Haul Cementer, Cement Truck	25	4	3	12	1	0.22	2.61	0.00	0.082	0.02	0.26	0.00	0.008
	Haul Completion,	25	4	3	12	1	0.22	2.61	0.00		0.02	0.26	0.00	
	Haul Service Tools	25	4	2	8	1	0.22	1.74	0.00		0.02	0.17	0.00	
	Haul Perforators Logging Truck	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Installation	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Anchor, Testing	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Tank	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Pump	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Chemical	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Sand	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Fracing, Other	25	4	1	4	1	0.22	0.87	0.00		0.02	0.09	0.00	
	Haul Welders	25	4	6	24	1	0.22	5.22	0.00		0.02	0.52	0.00	
	Haul Water Truck	25	4	150	600	1	0.22	130.41	0.07		0.02	13.04	0.01	
	Pickup Cementer, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Casing Crew	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Completion Crew	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Completion, Pusher	5	4	5	20	1	0.11	2.11	0.00		0.01	0.21	0.00	
	Pickup Perforators, Engineer	5	4	2	8	1	0.11	0.84	0.00		0.01	0.08	0.00	
	Pickup Fracing, Engineer	5	4	1	4	1	0.11	0.42	0.00		0.01	0.04	0.00	
	Pickup Co. Supervisor	5	4	10	40	1	0.11	4.21	0.00		0.01	0.42	0.00	
	Pickup Miscellaneous Supplies	5	4	3	12	1	0.11	1.26	0.00		0.01	0.13	0.00	
	Pickup Roustabout Crew	5	4	4	16	1	0.11	1.69	0.00		0.01	0.17	0.00	
									Subtotal	**8.19E-02**				**8.19E-03**
									Total	**1.81E-01**				**1.81E-02**

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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																				
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					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_2O
Improved & Two-Track Road	Semi Trucks	HDDV	4	47	188	1	1.1257	0.1141	0.0952	0.0055	0.7133	0.1467	0.0006	0.0001	0.0000	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.000	0.000	0.1641	0.000008	0.000009
	Pickup Trucks	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0054	0.000000	0.000001
Well Pad	Semi Trucks	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0175	0.000001	0.000001
	Pickup Trucks	LDDT	4	4	16	1	0.0816	0.0038	0.0031	0.0002	0.2204	0.0969	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0072	0.000000	0.000001
Other Construction Activities	Semi Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0070	0.000000	0.000000
	Haul Trucks	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0070	0.000000	0.000000
	Pickup Trucks	LDDT	4	1	4	1	0.0204	0.0010	0.0008	0.0000	0.0551	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0018	0.000000	0.000000
																		Subtotal	**7.52E-04**	**7.18E-05**	**5.98E-05**	**3.46E-06**	**6.45E-04**	**1.84E-04**	**2.10E-01**	**9.21E-06**	**1.28E-05**

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/vehicle type/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(tons/well) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	4	44	176	1	1.0538	0.1068	0.0891	0.0051	0.6678	0.1374	0.0005	0.0001	0.0000	0.0000	0.0003	0.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.000007	0.000009
	Fuel Haul Truck	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Mud Haul Truck, Water Hauling	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Rig Crew	LDDT	4	51	204	1	1.0398	0.0489	0.0398	0.0025	2.8095	1.2354	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Rig Mechanics	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Co. Supervisor	LDDT	4	20	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							0.0	0.000000	0.000005
	Tool Pusher	LDDT	4	8	32	1	0.1631	0.0077	0.0062	0.0004	0.4407	0.1938	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000002
	Mud Logger	LDDT	4	6	24	1	0.1223	0.0058	0.0047	0.0003	0.3305	0.1453	0.0001	0.0000	0.0000	0.0000	0.0002	0.0001							0.0	0.000000	0.000001
	Mud Engineer	LDDT	4	15	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							0.0	0.000000	0.000004
	Logger, Engr Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Drill Bit Delivery	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.000001	0.000001
	Semi Completion, Unit Rig	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Fracing, Blender	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Semi Pumping/Tank Battery	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Tubing Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Pump Truck	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Cementer, Cement Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Completion, Equip Truck	HDDV	4	3	12	1	0.0719	0.0073	0.0061	0.0003	0.0455	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000001
	Haul Service Tools	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Haul Perforators Logging Truck	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Installation	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Anchor, Testing	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Tank	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Pump	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Chemical	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Sand	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Fracing, Other	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Haul Welders	HDDV	4	6	24	1	0.1437	0.0146	0.0122	0.0007	0.0911	0.0187	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Haul Water Truck	HDDV	4	150	600	1	3.5926	0.3640	0.3038	0.0175	2.2765	0.4683	0.0018	0.0002	0.0002	0.0000	0.0011	0.0002							0.5	0.000024	0.000029
	Pickup Cementer, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Casing Crew	HDDV	4	2	8	1	0.0479	0.0049	0.0041	0.0002	0.0304	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Completion Crew	HDDV	4	5	20	1	0.1198	0.0121	0.0101	0.0006	0.0759	0.0156	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
	Pickup Completion, Pusher	LDDT	4	5	20	1	0.1019	0.0048	0.0039	0.0002	0.2754	0.1211	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001							0.0	0.000000	0.000001
	Pickup Perforators, Engineer	LDDT	4	2	8	1	0.0408	0.0019	0.0016	0.0001	0.1102	0.0484	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000000
	Pickup Fracing, Engineer	HDDV	4	1	4	1	0.0240	0.0024	0.0020	0.0001	0.0152	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000000	0.000000
	Pickup Co. Supervisor	LDDT	4	10	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.000000	0.000002
	Pickup Miscellaneous Supplies	LDDT	4	3	12	1	0.0612	0.0029	0.0023	0.0001	0.1653	0.0727	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000000	0.000001
	Pickup Roustabout Crew	HDDV	4	4	16	1	0.0958	0.0097	0.0081	0.0005	0.0607	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							0.0	0.000001	0.000001
																	Subtotal		**4.36E-03**	**3.72E-04**	**3.09E-04**	**1.81E-05**	**5.42E-03**	**1.93E-03**	**1.12E+00**	**4.30E-05**	**7.97E-05**
																	Total		**5.11E-03**	**4.44E-04**	**3.69E-04**	**2.15E-05**	**6.07E-03**	**2.11E-03**	**1.33E+00**	**5.22E-05**	**9.25E-05**

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads[a]

E (lb/VMT) =	$k (s/12)^a (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)	Emissions (lbs/well)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well)	Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[a]
Diesel	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	0	103	6	**5.95E-03**	**2.98E-04**	**1.01E-04**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

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_2O [a]**
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						(tpy/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_2O**
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads[a]

E (lb/VMT) =	$k\ (s/12)^a\ (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

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
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

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

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: **2** 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_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Haul Truck	42	4	1	4	1	0.27	1.10	0.00	0.03	0.11	0.00
	Pickup Truck	5	4	3	12	1	0.11	1.26	0.00	0.01	0.13	0.00
								Total	**1.73E-03**			**1.73E-04**

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

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)					Max. Annual Emissions (tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

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_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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)						Max. Annual Emissions (tpy/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_2O
Well Workover	WO Rig	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Haul Truck	HDDV	4	1	4	1	0.024	0.002	0.002	0.000	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000
	Pickup Truck	LDDT	4	3	12	1	0.061	0.003	0.002	0.000	0.165	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.01	0.000	0.000
												Total	**5.45E-05**	**3.86E-06**	**3.20E-06**	**1.90E-07**	**9.78E-05**	**3.95E-05**	**1.24E-02**	**3.53E-07**	**1.09E-06**

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).

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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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)	Emissions (tpy/well)	Emission Factor (lb/VMT)	Emissions (lbs/ well/yr)	Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	4	12	48	1	0.08	3.87	**1.94E-03**	0.01	0.39	**1.93E-04**

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	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (lbs/well/yr)						Emissions (tpy/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_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	4	12	48	1	0.12	0.00	0.00	0.00	2.54	0.11	**5.96E-05**	**1.34E-06**	**6.19E-07**	**4.66E-07**	**1.27E-03**	**5.66E-05**	**2.52E-02**	**3.60E-06**	**9.44E-06**

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	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[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	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	**0.5**	**5**

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 (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (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_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	**2.07E-03**	**1.62E-04**	**5.71E-05**	**7.19E-04**	**1.67E-04**	**1.57E-04**	**2.55E-01**	**2.52E-06**	**2.88E-06**

[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]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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 (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	60	0.5	32	0.08	2.58	**1.29E-03**	0.01	0.26	**1.28E-04**

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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 (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	60	0.5	32	**8.16E-05**	**3.83E-06**	**3.12E-06**	**1.98E-07**	**2.20E-04**	**9.69E-05**	**1.44E-02**	**7.05E-08**	**1.87E-06**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$)
U* = Friction velocity (m/s)
U_t = threshold velocity (m/s)
U10 = fastest wind speed (m/s)

M = Disturbed area (m^2)
N = # of disturbances
k = 0.5 for PM_{10}
k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	0.50	2024.16	1.00	0.00	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	0.50	2024.16	1.00	0.00	0.00
								TOTAL	**3.25E-03**	**4.88E-04**

[a] 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[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	0.053
Annual Miles of Roads reclaimed Per Well	0.013
Number of wells reclaimed (per well)	0.053

Reclaimation 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
0.0133	6	0.00221	0.0221
		Total	**0.022**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.013	5	0.066	0.765	**2.54E-05**	0.069	**2.30E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.013	0.4238	0.0720	0.0197	0.4106	0.0629	**2.81E-06**	**4.78E-07**	**1.31E-07**	**2.73E-06**	**4.17E-07**	**4.64E-07**	**7.19E-04**	**6.46E-09**	**7.09E-09**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0022	0.133	0.08	**5.35E-06**	0.01	**5.33E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0022	0.1328	**3.38E-07**	**1.59E-08**	**1.30E-08**	**8.20E-10**	**9.14E-07**	**4.02E-07**	**5.99E-05**	**2.93E-10**	**7.76E-09**

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	0.053	10	0.053	0.53

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.32	5	1.59	0.765	**6.09E-04**	0.069	**5.52E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.32	0.5297	0.0900	0.0246	0.5132	0.0786	**8.44E-05**	**1.43E-05**	**3.92E-06**	**8.18E-05**	**1.25E-05**	**2.23E-05**	**2.11E-02**	**3.51E-07**	**2.13E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	0.05	3.19	0.081	**1.28E-04**	0.008	**1.28E-05**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	0.05	3.19	**8.12E-06**	**3.82E-07**	**3.11E-07**	**1.97E-08**	**2.19E-05**	**9.65E-06**	**1.44E-03**	**7.02E-09**	**1.86E-07**

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

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)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

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)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

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	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

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

Volume Flow:	40	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.12	MMSCF/well

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

BTU value = 994 BTU/scf

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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

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 >20º API		Heavy Oil <20º 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 =	0.00349	0.00002	0.00001	0.00310

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 (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Emission Factors for Publicly Accessible Unpaved Roads [a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

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/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)	Em. Factor (lb/VMT)	Emissions (lbs/trip)	Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	**6.15E-04**			**6.12E-05**

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle		# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip)						Emissions (tpy/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_2O
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	0.00	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	0.00	0.00289	0.00000	0.00000
												Total		**3.89E-05**	**1.83E-06**	**1.49E-06**	**9.42E-08**	**1.05E-04**	**4.62E-05**	**6.89E-03**	**3.36E-08**	**8.91E-07**

Alternative E input parameters for calculating CBNG wells emissions:

Peak Year Federal Producing Wells Drilled	7	Peak Year Non-Federal Producing Wells Drilled	47
Federal Producing Wells - Year 20 (RMP Totals)	126	Non-Federal Producing Wells - Year 2027 (RMP Totals)	885
Average Gas Production Per Well (MCFD)	45	Average Gas Production Per Well (MCFD)	45

* 47% full RFD estimates (rounded up to next higher number) for Federal, full RFD estimates (100%) for non-Federal

Federal CBNG Wells Summaries

Total Annual Emissions from Federal CBNG Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	4.13	0.41	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.08	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.03	0.02	0.33	0.01	0.73	0.06	0.01	154.51	0.00	0.00	155.07	140.72
Commuting Vehicles - Construction	0.47	0.05	0.02	0.00	0.03	0.01	0.00	4.09	0.00	0.00	4.20	3.81
Completion Venting	---	---	---	---	---	0.00	0.00	0.46	19.20	0.00	403.71	366.35
Sub-total: Construction	**4.71**	**0.49**	**0.35**	**0.01**	**0.76**	**0.07**	**0.01**	**159.05**	**19.20**	**0.00**	**562.99**	**510.88**
Natural Gas Compression - Operations	1.30	1.30	29.30	0.02	58.60	20.51	3.92	3,953.76	0.07	0.01	3,957.64	3591.32
Dehydrators	0.00	0.00	0.02	0.00	0.01	0.00	0.00	21.39	32.92	0.00	712.81	646.83
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.00	0.00	1.00	41.93	0.00	881.62	800.02
Station Visits - Operations	0.09	0.01	0.01	0.00	0.01	0.01	0.00	0.98	0.00	0.00	1.02	0.92
Well Workover - Operations	0.24	0.18	0.42	0.01	0.20	0.02	0.00	712.54	0.01	0.01	714.31	648.19
Well & Pipeline visits for Inspection & Repair - Operations	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.43	0.00	0.00	0.44	0.40
Sub-total: Operations	**1.67**	**1.49**	**29.75**	**0.03**	**58.84**	**20.54**	**3.92**	**4690.10**	**74.93**	**0.01**	**6267.84**	**5687.70**
Road Maintenance	0.20	0.02	0.03	0.00	0.01	0.00	0.00	8.24	0.00	0.00	8.27	7.50
Sub-total: Maintenance	**0.20**	**0.02**	**0.03**	**0.00**	**0.01**	**0.00**	**0.00**	**8.24**	**0.00**	**0.00**	**8.27**	**7.50**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.13
Well Reclamation	0.12	0.02	0.02	0.00	0.02	0.00	0.00	4.14	0.00	0.00	4.15	3.77
Sub-total: Reclamation	**0.13**	**0.02**	**0.02**	**0.0008**	**0.02**	**0.003**	**0.0003**	**4.2775**	**0.0001**	**0.0000**	**4.2933**	**3.8959**
Total Emissions	**6.71**	**2.02**	**30.14**	**0.04**	**59.63**	**20.62**	**3.93**	**4,861.67**	**94.14**	**0.02**	**6,843.39**	**6,209.98**

Non-Federal CBNG Wells Summaries

Total Annual Emissions from Non-Federal CBNG Wells - RMP Year - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad & Station Construction - Fugitive Dust	27.75	2.78	---	---	---	---	---	---	---	---	---	---
Wind Erosion	0.54	0.08	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.51	0.45	7.57	0.20	2.38	0.60	0.06	1,037.39	0.01	0.01	1,041.23	944.86
Commuting Vehicles - Construction	3.14	0.32	0.12	0.00	0.21	0.08	0.01	27.45	0.00	0.00	28.20	25.59
Completion Venting	---	---	---	---	---	0.00	0.00	3.07	128.93	0.00	2,710.66	2459.76
Sub-total: Construction	**31.94**	**3.63**	**7.69**	**0.20**	**2.59**	**0.69**	**0.07**	**1067.91**	**128.94**	**0.01**	**3780.09**	**3430.20**
Natural Gas Compression - Operations	9.12	9.12	205.80	0.14	411.61	144.06	27.52	27,770.47	0.52	0.05	27,797.71	25224.78
Dehydrators	0.01	0.01	0.13	0.00	0.11	0.01	0.00	150.27	231.22	0.00	5,006.64	4543.23
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.01	0.00	7.02	294.54	0.00	6,192.36	5619.20
Station Visits - Operations	0.61	0.06	0.04	0.00	0.10	0.05	0.00	6.86	0.00	0.00	7.13	6.47
Well Workover - Operations	5.12	1.23	62.81	21.06	4.62	3.47	0.35	4,998.14	0.07	0.07	5,021.55	4556.76
Well & Pipeline visits for Inspection & Repair - Operations	0.27	0.03	0.02	0.00	0.05	0.02	0.00	3.00	0.00	0.00	3.12	2.83
Sub-total: Operations	**15.14**	**10.45**	**268.80**	**21.20**	**416.49**	**147.62**	**27.88**	**32935.75**	**526.35**	**0.13**	**44028.51**	**39953.28**
Road Maintenance	1.41	0.15	0.20	0.01	0.09	0.03	0.00	57.87	0.00	0.00	58.08	52.71
Sub-total: Maintenance	**1.41**	**0.15**	**0.20**	**0.01**	**0.09**	**0.03**	**0.00**	**57.87**	**0.00**	**0.00**	**58.08**	**52.71**
Road Reclamation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.99	0.90
Well Reclamation	0.87	0.11	0.12	0.01	0.11	0.02	0.00	29.05	0.00	0.00	29.16	26.46
Sub-total: Reclamation	**0.91**	**0.11**	**0.12**	**0.0055**	**0.12**	**0.019**	**0.0019**	**30.0443**	**0.0005**	**0.0003**	**30.1552**	**27.3640**
Total Emissions	**49.40**	**14.35**	**276.80**	**21.42**	**419.28**	**148.35**	**27.95**	**34,091.57**	**655.29**	**0.14**	**47,896.84**	**43,463.56**

Fugitive Dust Emissions From Well Pad and Compressor Station Construction

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] 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, November 1, 2006.

Fugitive Dust Emission Estimations for Construction Activities: All Project Years

Area Disturbed for CBNG Wells	Emission Estimation Basis	Avg. Disturbed Acres per Well[a]	Construction Days	Total # of Well Pads or Stations	Total Disturbed Acres	Emissions			
						(lb/well)		(tpy/well)	
						PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Well Pad and Road Construction	Per Well	3.48	5	1	3.48	1.16E+03	1.16E+02	5.81E-01	5.81E-02
Field Compressor Station	Per Well	0.04	6	1	0.04	1.66E+01	1.66E+00	8.30E-03	8.30E-04
Sales Compressor Station	Per Well	0.01	6	1	0.01	2.77E+00	2.77E-01	1.38E-03	1.38E-04
				Total	**3.53**	**1.18E+03**	**1.18E+02**	**5.91E-01**	**5.91E-02**

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

Exhaust Emissions from Heavy Construction Equipment (Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/ Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity) NO_x	$PM_{2.5}/PM_{10}$[a]	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																	Subtotal		**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso,

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_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.0051	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.0051	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.0051	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.0051	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.0051	2.60	0.14	0.02	530.28	0.004	0.006
>750 (genset)	0.50	0.022	0.0051	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4. Generator set engines are assumed for engines greater than 750 hp.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	8.6	0.4	0.1	74.3	4.0	0.00	0.00	0.00	0.04	0.00	0.006	0.000	0.000	0.056	0.003	0.00	7.6	0.0001	0.0001
	Auxillary Pump	200	1	90	18	2	36	1.00	4.3	0.2	0.1	37.1	2.0	0.00	0.00	0.00	0.02	0.00						0.00	3.8	0.0000	0.0000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	2.9	0.1	0.0	24.8	1.3	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.021	0.001	0.00	2.5	0.0000	0.0000
	Auxillary Pump	125	1	90	18	1	18	1.00	1.3	0.1	0.0	16.5	0.6	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00	0.002	0.000	0.000	0.012	0.001	0.00	1.2	0.0000	0.0000
	Generator	1476	1	40	24	30	720	0.01	468.6	20.6	4.8	2,436.6	131.2	0.00	0.00	0.00	0.01	0.00						0.00	1.2	0.0000	0.0000
																	Subtotal		**1.09E-02**	**5.29E-04**	**1.69E-04**	**8.85E-02**	**4.64E-03**	**5.29E-04**	**1.76E+01**	**1.43E-04**	**1.99E-04**
																	Total		**1.86E-02**	**1.21E-03**	**3.99E-04**	**9.16E-02**	**5.43E-03**	**1.27E-03**	**1.88E+01**	**1.55E-04**	**2.12E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well) NO_x	PM_{10}	SO_2	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.0000	0.0000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Exhaust Emissions from Heavy Construction Equipment (Non-Federal)

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.1	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.1	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.1	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.2	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.3	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.3	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.9	0.006	0.006

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

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Construction Equipment - Based on Peak Wells Drilled each Alternative (using 2008 emission factors)

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Activity	# of Oper. Hours/ Activity	# of Activities / Well	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	$PM_{2.5}/PM_{10}$	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Drilling Roads	Blade	150	1	43	10	0.2	2	1.00	1.0	0.1	0.0	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	1	43	10	0.1	1	1.00	0.3	0.0	0.0	0.2	0.0	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Drilling Well Pad	Backhoe	80	1	43	10	0.5	5	1.00	1.4	0.2	0.0	0.8	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.1	0.000	0.000
Water Disposal well pad	Backhoe	80	1	43	10	2	20	0.01	5.7	0.6	0.2	3.1	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
New Pipeline Intermediate	Blade	150	1	43	10	5	50	0.11	25.4	1.9	0.7	7.1	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.2	0.000	0.000
	Trencher	175	1	43	10	5	50	0.11	28.0	1.9	0.8	6.9	2.6	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
	Backhoe	80	1	43	10	10	100	0.11	28.4	3.2	0.9	15.4	3.2	0.00	0.00	0.00	0.00	0.00						0.00	0.2	0.000	0.000
New Sales Pipeline	Blade	150	1	43	10	43	430	0.0002	218.4	16.3	6.3	60.8	25.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.000	0.000
	Trencher	175	1	43	10	43	430	0.0002	240.7	16.2	7.2	59.3	22.3	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
	Backhoe	80	1	43	10	65	650	0.0002	184.7	20.7	5.6	100.1	20.6	0.00	0.00	0.00	0.00	0.00						0.00	0.0	0.000	0.000
Booster Compression Station	Dozer	175	1	43	10	2	20	0.11	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.11	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.1	0.000	0.000
Sales Compression Station	Dozer	175	1	43	10	2	20	0.01	12	1	0	4	0.9	0.00	0.000	0.000	0.00	0.000	0.00	0.000	0.000	0.00	0.000	0.00	0.0	0.000	0.000
	Backhoe	80	2	43	10	3	30	0.01	17	2	1	9	1.9	0.00	0.000	0.000	0.00	0.000						0.00	0.0	0.000	0.000
																		Subtotal	**7.73E-03**	**6.84E-04**	**2.30E-04**	**3.03E-03**	**7.99E-04**	**7.41E-04**	**1.21E+00**	**1.21E-05**	**1.30E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

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_2O[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] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines - Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/ Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/activity)					Emissions (tpy/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	1	60	18	3	54	1.00	103.2	6.1	2.9	30.2	7.4	0.05	0.00	0.00	0.02	0.00	0.076	0.005	0.002	0.021	0.006	0.00	7.6	0.000	0.000
	Auxillary Pump	200	1	90	18	2	36	1.00	48.2	3.2	1.5	11.9	4.1	0.02	0.00	0.00	0.01	0.00						0.00	3.8	0.000	0.000
Well Completion, Fracing & Testing	Main Deck	400	1	60	18	1	18	1.00	34.4	2.0	1.0	10.1	2.5	0.02	0.00	0.00	0.01	0.00	0.025	0.002	0.001	0.007	0.002	0.00	2.5	0.000	0.000
	Auxillary Pump	125	1	90	18	1	18	1.00	15.9	1.2	0.5	4.4	1.4	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
Water Disposal well drilling	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00	0.024	0.001	0.000	0.006	0.002	0.00	1.2	0.000	0.000
	Generator	1476	1	40	24	30	720	0.01	4,811.0	243.5	95.7	1,207.7	348.3	0.01	0.00	0.00	0.00	0.00						0.00	1.2	0.000	0.000
																		Subtotal	**1.25E-01**	**7.52E-03**	**3.38E-03**	**3.43E-02**	**9.43E-03**	**7.30E-03**	**1.76E+01**	**1.43E-04**	**2.00E-04**
																		Total	**1.33E-01**	**8.21E-03**	**3.61E-03**	**3.73E-02**	**1.02E-02**	**8.04E-03**	**1.88E+01**	**1.55E-04**	**2.13E-04**

Equipment type, Hp ratings, and operational hours based on information shown in SEIS. No flaring per Montana BLM (Laakso, 2010). Water disposal well pad development rates provided by Montana BLM (Laakso, 2010).

Temporary Emission Estimations for Field Generators: Based on Peak Wells Drilled each Alternative

Construction Activity	Equipment Type	Capacity (hp)	# of Wells Served[a]	Avg. Load Factor (%)	# of Oper. Hours/Day	# of Oper. Days/Well	# of Oper. Hours/Well	# of Wells	Emissions (lbs/well)					Emissions (tpy/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Field Generators	Field Generators for Pumps & Lighting	21	1	75	24	15	360	1	56.7	5.1	1.4	26.6	5.2	0.03	0.00	0.00	0.01	0.00	0.00	3.3	0.000	0.000
													Total	**2.84E-02**	**2.54E-03**	**7.24E-04**	**1.33E-02**	**2.62E-03**	**1.61E-03**	**3.31E+00**	**2.96E-05**	**3.77E-05**

Values shown in SEIS per well.

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	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		
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	90	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/activity)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/activity)	$PM_{2.5}$ Emissions (tpy/well)
Drilling Roads	Semi Trucks	42	6	3	18	1.000	0.27	4.94	0.002	0.03	0.49	0.000
Drilling Well Pad	Haul Trucks	25	6	2	12	1.000	0.22	2.61	0.001	0.02	0.26	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Water Disposal Well Pad	Haul Trucks	25	10	5	50	0.005	0.22	10.87	0.000	0.02	1.09	0.000
	Pickup Trucks	5	10	5	50	0.005	0.11	5.27	0.000	0.01	0.53	0.000
New Pipeline Intermediate	Haul Trucks	25	6	40	240	0.111	0.22	52.17	0.003	0.02	5.22	0.000
	Pickup Trucks	5	6	160	960	0.111	0.11	101.14	0.006	0.01	10.11	0.001
New Sales Pipeline	Haul Trucks	25	35	94	3,290	0.000	0.22	715.10	0.000	0.02	71.51	0.000
	Pickup Trucks	5	50	94	4,700	0.000	0.11	495.14	0.000	0.01	49.51	0.000
Electric Line	Haul Trucks	25	6	1	6	1.000	0.22	1.30	0.001	0.02	0.13	0.000
	Pickup Trucks	5	6	2	12	1.000	0.11	1.26	0.001	0.01	0.13	0.000
Field Compression Station	Semi Trucks	42	10	15	150	0.111	0.27	41.18	0.002	0.03	4.12	0.000
	Haul Trucks	25	10	48	480	0.111	0.22	104.33	0.006	0.02	10.43	0.001
	Pickup Trucks	5	10	192	1,920	0.111	0.11	202.27	0.011	0.01	20.23	0.001
Sales Compression Station	Semi Trucks	42	10	19	190	0.011	0.27	52.16	0.000	0.03	5.22	0.000
	Haul Trucks	25	10	48	480	0.011	0.22	104.33	0.001	0.02	10.43	0.000
	Pickup Trucks	5	10	192	1,920	0.011	0.11	202.27	0.001	0.01	20.23	0.000
Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2								**Subtotal**	**3.56E-02**			**3.56E-03**

Fugitive Dust Emission Estimations for Road Traffic - Based on Peak Wells Drilled each Alternative

Construction Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Activity	Total # of Activities/ Well	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/well)	$PM_{2.5}$ Emissions (tpy/well)
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Fuel Haul Truck	25	6	2	12	1.00	0.22	2.61	0.001	0.022	0.261	0.000
	Mud Haul Truck, Water Hauling	25	6	7	42	1.00	0.22	9.13	0.005	0.022	0.913	0.000
	Rig Crew	25	6	3	18	1.00	0.22	3.91	0.002	0.022	0.391	0.000
	Co. Supervisor	5	6	8	48	1.00	0.11	5.06	0.003	0.011	0.506	0.000
	Tool Pusher	25	6	6	36	1.00	0.22	7.82	0.004	0.022	0.782	0.000
	Logger, Engr Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
Well Completion, Fracing & Testing	Semi Casing Haulers	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Semi Completion, Unit Rig	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Semi Fracing Blender	42	6	1	6	1.00	0.27	1.65	0.001	0.027	0.165	0.000
	Tubing Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Completion, Equip Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Perforators Logging Truck	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Tank	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Fracing Pump	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Welders	25	6	1	6	1.00	0.22	1.30	0.001	0.022	0.130	0.000
	Haul Water Truck	25	6	9	54	1.00	0.22	11.74	0.006	0.022	1.174	0.001
	Pickup Cementer, Engineer	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Co. Supervisor	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
	Pickup Miscellaneous Supplies	5	6	1	6	1.00	0.11	0.63	0.000	0.011	0.063	0.000
	Pickup Roustabout Crew	5	6	2	12	1.00	0.11	1.26	0.001	0.011	0.126	0.000
Water Disposal Well Drilling	Drill Rig Transport truck	42	6	10	60	0.01	0.27	16.47	0.000	0.027	1.647	0.000
	Mud Haul Truck, Water Hauling	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Rig Crew	25	6	10	60	0.01	0.22	13.04	0.000	0.022	1.304	0.000
	Co. Supervisor	5	6	5	30	0.01	0.11	3.16	0.000	0.011	0.316	0.000
	Tool Pusher	25	6	5	30	0.01	0.22	6.52	0.000	0.022	0.652	0.000
	Tubing Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Pump Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
	Haul Cementer, Cement Truck	25	6	1	6	0.01	0.22	1.30	0.000	0.022	0.130	0.000
								Subtotal	**3.11E-02**			**3.11E-03**
								Total	**6.67E-02**			**6.67E-03**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laaksо, 2010)

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy/well)								
	Type	Class					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_2O
Drilling Roads	Semi Trucks	HDDV	6	3	18	1.00	0.11	0.01	0.01	0.00	0.07	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.02	0.00	0.00
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Pad	Haul Trucks	HDDV	100	5	500	0.01	2.99	0.30	0.25	0.01	1.90	0.39	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	25	5	125	0.01	0.64	0.03	0.02	0.00	1.72	0.76	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
New Pipeline Intermediate	Haul Trucks	HDDV	6	40	240	0.11	1.44	0.15	0.12	0.01	0.91	0.19	0.000	0.00	0.000	0.000	0.00	0.00	0.02	0.00	0.00
	Pickup Trucks	LDDT	6	160	960	0.11	4.89	0.23	0.19	0.01	13.22	5.81	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.05	0.00	0.00
New Sales Pipeline	Haul Trucks	HDDV	35	94	3290	0.00	19.70	2.00	1.67	0.10	12.48	2.57	0.000	0.00	0.000	0.000	0.00	0.00	0.00	0.00	0.00
	Pickup Trucks	LDDT	50	94	4700	0.00	23.96	1.13	0.92	0.06	64.73	28.46	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
Electric Line	Haul Trucks	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Trucks	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Field Compression Station	Semi Trucks	HDDV	10	15	150	0.11	0.90	0.09	0.08	0.00	0.57	0.12	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.01	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.11	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.11	9.79	0.46	0.37	0.02	26.44	11.63	0.001	0.0000	0.0000	0.0000	0.00	0.001	0.10	0.00	0.00
Sales Compression Station	Semi Trucks	HDDV	10	19	190	0.01	1.14	0.12	0.10	0.01	0.72	0.15	0.000	0.0000	0.0000	0.0000	0.000	0.000	0.00	0.00	0.00
	Haul Trucks	HDDV	10	48	480	0.01	2.87	0.29	0.24	0.01	1.82	0.37	0.000	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Trucks	LDDT	10	192	1920	0.01	9.79	0.46	0.37	0.02	26.44	11.63	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Fuel Haul Truck	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	6	7	42	1.00	0.25	0.03	0.02	0.00	0.16	0.03	0.000	0.00	0.00	0.00	0.0	0.00	0.04	0.00	0.00
	Rig Crew	LDDT	6	3	18	1.00	0.09	0.00	0.00	0.00	0.25	0.11	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Rig Mechanics	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Co. Supervisor	LDDT	6	8	48	1.00	0.24	0.01	0.01	0.00	0.66	0.29	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Tool Pusher	LDDT	6	6	36	1.00	0.18	0.01	0.01	0.00	0.50	0.22	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.02	0.00	0.00
	Mud Logger	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Mud Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
	Logger, Engr	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.01	0.00	0.00
	Drill Bit Delivery	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.000	0.0000	0.0000	0.0000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**1.88E-03**	**1.23E-04**	**1.02E-04**	**6.12E-06**	**3.75E-03**	**1.55E-03**	**4.07E-01**	**9.83E-06**	**3.89E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Combustive Emissions Estimation Road Traffic

Construction Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/ Activity	Miles Traveled/ Activity	Total # of Activities / Well	Emissions														
							(lbs/well)						(tpy)								
	Type	Class					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_2O
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Completion, Unit Rig	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Fracing Blender	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Semi Pumping Tank Battery	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Tubing Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Completion, Equip Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Service Tools	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Perforators Logging Truck	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Installation	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Anchor Testing	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Tank	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Pump	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Chemical	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Fracing Sand	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Other	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Welders	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Haul Water Truck	HDDV	6	9	54	1.00	0.32	0.03	0.03	0.00	0.20	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.05	0.00	0.00
	Pickup Cementer, Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Completion Crew	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Completion Pusher	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Perforators Engineer	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	1	6	1.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Co. Supervisor	LDDT	6	2	12	1.00	0.06	0.00	0.00	0.00	0.17	0.07	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
	Pickup Misc. Supplies	LDDT	6	1	6	1.00	0.03	0.00	0.00	0.00	0.08	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	2	12	1.00	0.07	0.01	0.01	0.00	0.05	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.01	0.00	0.00
Water Disposal Well Drilling	Drill Rig Transport truck	HDDV	10	10	100	0.01	0.60	0.06	0.05	0.00	0.38	0.08	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Mud Haul Truck, Water Hauling	HDDV	10	5	50	0.01	0.30	0.03	0.03	0.00	0.19	0.04	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Rig Crew	LDDT	10	10	100	0.01	0.51	0.02	0.02	0.00	1.38	0.61	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Co. Supervisor	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tool Pusher	LDDT	10	5	50	0.01	0.25	0.01	0.01	0.00	0.69	0.30	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Tubing Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Pump Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
	Haul Cementer, Cement Truck	HDDV	10	1	10	0.01	0.06	0.01	0.01	0.00	0.04	0.01	0.00	0.000	0.000	0.000	0.00	0.000	0.00	0.00	0.00
											Subtotal		**6.51E-04**	**6.00E-05**	**5.00E-05**	**2.90E-06**	**6.39E-04**	**2.01E-04**	**1.77E-01**	**7.47E-06**	**1.14E-05**
											Total		**2.53E-03**	**1.83E-04**	**1.52E-04**	**9.02E-06**	**4.39E-03**	**1.76E-03**	**5.84E-01**	**1.73E-05**	**5.02E-05**

Activity rates based on values shown in SEIS. Water disposal well pad development rates provided by Montana BLM (Laakso, 2010)

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power	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]	N_2O[c]
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

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	12	1	12	8,760	0.12	0.01	0.00	0.24	0.08	0.01	16.2	0.00	0.01	0.00
Sales Compression Station	12	1	12	8,760	0.11	0.00	0.00	0.22	0.08	0.00	15.1	0.00	0.01	0.00
				Total	**2.33E-01**	**1.03E-02**	**1.58E-04**	**4.65E-01**	**1.63E-01**	**1.03E-02**	**3.14E+01**	**5.92E-04**	**1.48E-02**	**5.92E-05**

Sub-total: Construction

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867
CBNG wells based on BLM survey (Laakso, 2010)

Compressor Station Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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% =	0.00
CO2 Wt% =	2.28
CH4 Wt% =	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Per 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	0.291	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.003
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	0.415	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.997	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 =	3.92E-03	7.43E-08	8.95E-05	3.76E-03

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 (lb/yr)**	**VOC (tpy)**	**CO2 (lb/yr)**	**CO2 (tpy)**	**CH4 (lb/yr)**	**CH4 (tpy)**
Sub-total: Construction	1	8760	0.00	**3.25E-07**	0.78	**3.92E-04**	32.90	**1.64E-02**

Dehydrator Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
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 (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.41E-04**	**1.08E-05**	**8.49E-07**	**1.19E-04**	**7.78E-06**	**8.07E-06**	**1.70E-01**	**3.25E-06**	**1.06E-07**	**3.11E-06**

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)
16.43	0.016	**2.61E-01**	0.000	**0.00E+00**	0.000	**0.00E+00**

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

Sub-total: Construction

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

The following South Baker Compressor Station assumptions were used with CBNG specific gas composition analysis to derive dehydrator emissions: per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station ---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.5	20	0.08	1.61	0.00	0.01	0.16	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.4	20	0.08	1.61	0.00	0.01	0.16	0.00
									Total	6.92E-04			6.89E-05

Assume no dust control (watering)

Compressor Stations Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle Type	Vehicle Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
		Emission Factors (g/mi)								
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Compressor Station Inspection Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.5	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.004	0.000	0.000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	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	0.00	0.003	0.000	0.000
													Total	4.37E-05	2.06E-06	1.67E-06	1.06E-07	1.18E-04	5.20E-05	7.75E-03	3.78E-08	1.00E-06

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Emission Factors for Publicly Accessible Unpaved Roads[e]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS
Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	0.0051	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. SO2 emission factor based on ultra low sulfur fuel (15 ppm) and diesel fuel heating value. EPA NONROADS 2008a (Year 2008) used for CO2 and CH4.
[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	6.35	0.32	0.11	2.96	0.32	**3.17E-03**	**1.59E-04**	**5.40E-05**	**1.48E-03**	**1.59E-04**	**1.21E-03**	**5.61E+00**	**4.03E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03
[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Emission Factors for Publicly Accessible Unpaved Roads[e]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Ave. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Operational Wells	PM_{10}			$PM_{2.5}$		
							Emission Factor (lb/VMT)[b, c]	Emissions (lbs/trip)	Emissions (tpy/well)	Emission Factor (lb/VMT)[b]	Emissions (lbs/trip)	Emissions (tpy/well)
Well Workover	Bobtail Truck	30	50	1	50	1	0.07	3.49	**1.75E-03**	0.01	0.35	**1.74E-04**

Activity rates based on values shown in SEIS

Assume no dust control measures (watering) would be used

CBNG Well Work-Over Emissions

Emission Factors for Off-Road Engines of 300 to 600 hp

Fuel Type	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	PM2.5	SO2	CO	VOC	CO_2	CH_4	N_2O[a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source:

On-Site Exhaust Emission Estimations for Well Workover

Activity	Equipment	Capacity (hp)	Operating Hours/Day	Operational Wells	Emissions (lbs/well)					Emissions (tpy)								
					NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	400	24	1	141.65	8.05	47.59	10.25	7.81	**7.08E-02**	**4.03E-03**	**2.38E-02**	**5.13E-03**	**3.91E-03**	**1.21E-03**	**5.60E+00**	**7.79E-05**	**6.35E-05**

Activity rates based on values shown in SEIS

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source:

Sub-total: Construction

Activity	Vehicle		Round Trip Distance (miles)	Round Trips/Well	Miles Traveled/Well	Operational Wells	Emissions (lbs/trip)						Emissions (tpy)								
	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_2O
Well Workover	Bobtail Truck	HDDV	50	1	50	1	0.30	0.03	0.03	0.00	0.19	0.04	**1.50E-04**	**1.52E-05**	**1.27E-05**	**7.28E-07**	**9.49E-05**	**1.95E-05**	**4.36E-02**	**2.04E-06**	**2.44E-06**

Activity rates based on values shown in SEIS

Emissions for Well and Pipe Inspections

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Fugitive Dust Emissions Estimation for Road Traffic: Well & Pipeline

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/ Year	PM_{10}			$PM_{2.5}$		
							Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)	Em. Factor (lb/VMT)[a]	Emissions (lbs/trip/ well)	Emissions (tpy/well)
Visits for Inspection and Repair	200-hp Pickup	40	0.625	12	1	8	0.08	0.05	**3.02E-04**	0.01	0.01	**3.01E-05**

Activity rates based on values shown in SEIS
Assume no dust control (watering)

Traffic Exhaust Emissions for Well and Pipe Inspections

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a]	$PM_{2.5}$[a]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emission Estimations for Road Traffic: Well & Pipeline

Activity	Vehicle		Round Trip Distance (miles)	# of Visits/ Well/Year	Total # of Operating Wells	Miles Traveled/Year/Well	Emissions (lbs/trip/well)						Emissions (tpy/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_2O
Visits for Inspection and Repair	200-hp Pickup	LDDT	0.625	12	1	8	0.003	0.000	0.000	0.000	0.009	0.004	**1.91E-05**	**8.99E-07**	**7.32E-07**	**4.63E-08**	**5.16E-05**	**2.27E-05**	**3.39E-03**	**1.65E-08**	**4.38E-07**

Activity rates based on values shown in SEIS

Exhaust Emissions for Road Maintenance

Estimation of Total and Cumulative Length of Roads

Length of Roads Built per Well	0.25
Cumulative Length of Roads Maintained (miles)	0.25

Based on values shown in SEIS

Estimation of Total Operation Days and Hours

Season	# of Operations/ Year	Cumulative Length of Roads (miles/year)	Miles of Road Worked on/Day	# of Operating Hours/Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	0.25	6	10	0.08	0.83
Winter	1	0.25	5	10	0.05	0.50
				Total	0.13	1.33

Based on values shown in SEIS

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^{2}$	5	0.765
Sub-total: Constructi	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph

Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)[b]	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Maintenance	Grader	1	5	4	0.765	**1.53E-03**	0.069	**1.39E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 100-175 hp Off-Road Engine

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Year 2008	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.006
Year 2018	1.86	0.25	0.10	0.82	0.25	0.25	546.2	0.004	0.006
Year 2028	0.56	0.16	0.09	0.27	0.16	0.15	546.5	0.002	0.006

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)[a]	Total # of Operating Hours[a]	Emissions													
				(lb/hour)					(tpy/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_2O
Road Maintenance	Grader	135	1	0.55	0.08	0.03	0.24	0.07	**2.22E-04**	**3.01E-05**	**1.16E-05**	**9.78E-05**	**2.92E-05**	**2.92E-05**	**6.50E-02**	**4.44E-07**	**7.14E-07**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Sub-total: Construction

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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Maintenance	Pickup Truck	40	6	0.13	0.80	0.08	**3.34E-05**	0.01	**3.33E-06**

[a] Assume No dust control measures (watering) would be applied

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDV	6	0.1	0.8	**2.04E-06**	**9.59E-08**	**7.80E-08**	**4.94E-09**	**5.51E-06**	**2.42E-06**	**3.61E-04**	**1.76E-09**	**4.67E-08**

Exhaust 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	0.2500
Number of Roads Reclaimed Annually Per Well	0.0821
Annual Miles of Roads reclaimed Per Well	0.0205
Number of wells reclaimed (per well)	0.0821

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

Sub-total: Construction

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.0205	6	0.0034	0.0342
		Total	0.0342

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (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] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclaim

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.0205	5	0.1026	0.765	**3.93E-05**	0.069	**3.56E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

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_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclaim

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/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_2O
Road Reclamation	Grader	80	0.021	0.4238	0.0720	0.0197	0.4106	0.0629	**4.35E-06**	**7.39E-07**	**2.02E-07**	**4.21E-06**	**6.45E-07**	**7.17E-07**	**1.11E-03**	**9.99E-09**	**1.09E-08**

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a (S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

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 gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

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

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Road Reclamation	Pickup Truck	40	6	0.00342	0.02052	0.08	**8.28E-07**	0.01	**8.24E-08**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclaim Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclaim Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	6	0.0034	0.0205	**5.23E-08**	**2.46E-09**	**2.00E-09**	**1.27E-10**	**1.41E-07**	**6.21E-08**	**9.26E-06**	**4.52E-11**	**1.20E-09**

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	0.0821	10	0.0821	0.8210

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

Fugitive Dust Emissions Estimation for Grader: Well Reclaimation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.4926	5	2.4629	0.765	**9.42E-04**	0.069	**8.54E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions (lbs/hour)					Emissions (tpy/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_2O
Well Reclamation	Grader	100	0.4926	0.5297	0.0900	0.0246	0.5132	0.0786	**1.30E-04**	**2.22E-05**	**6.05E-06**	**1.26E-04**	**1.94E-05**	**3.44E-05**	**3.26E-02**	**5.43E-07**	**3.26E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	6	0.0821	0.4926	0.081	**1.99E-05**	0.008	**1.98E-06**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	6	0.0821	0.4926	**1.26E-06**	**5.90E-08**	**4.81E-08**	**3.04E-09**	**3.39E-06**	**1.49E-06**	**2.22E-04**	**1.09E-09**	**2.88E-08**

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; P=0 otherwise AP-42 Section 13.2.5.3 Equation 3

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

P = Erosion Potential ($gm/m^2/yr$) M = Disturbed area (m^2)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
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)	PM10 Emissions (tpy)	PM2.5 Emissions (tpy)
Well Pad, Road and Pipeline construction	26.08	1.38	1.46		1.00	3.48	14108.09	1.00	0.01	0.00
Sub-total: Construction	26.08	1.38		1.46	1.00	0.05	196.11	1.00	0.0002	0.00002
								TOTAL	**1.15E-02**	**1.72E-03**

[a] Average disturbed area for new CBNG wells shown in SEIS

Wellhead Fugitives

Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º 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 CBNG analysis

VOC Wt% =	0.00
CO2 Wt% =	2.28
Sub-total: Constı	95.72
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead 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	6	0.0099	1	0.0055	0	0.0002	0.065	0.000	0.001	0.062
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	10	0.0004	0	0.0005	0	0.0002	0.004	0.000	0.000	0.004
flanges	7	0.0009	0	0.0002	0	0.0000	0.006	0.000	0.000	0.006
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.075	0.000	0.002	0.072

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 (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	0.01	**6.26E-06**	15.08	**7.54E-03**	632.73	**3.16E-01**

Speciated Analysis - CBNG & 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	97.913	16.040	15.705	95.715	40640.682	2.743
Ethane	0.000	30.070	0.000	0.000	0.000	0.000
Nitrogen	1.172	28.020	0.328	2.001	849.791	0.057
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.851	43.990	0.374	2.281	968.723	0.065
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	99.936	---	16.408	99.998		2.866
Propane	0.000	44.100	0.000	0.000	0.000	0.000
Iso-butane	0.000	58.120	0.000	0.000	0.000	0.000
n-butane	0.000	58.120	0.000	0.000	0.000	0.000
i-pentane	0.000	72.150	0.000	0.000	0.000	0.000
n-pentane	0.000	72.150	0.000	0.000	0.000	0.000
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000
Heptanes	0.000	100.200	0.000	0.002	0.804	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
Reactive VOC	0.000	---	0.000	0.002		0.000
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
n-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	**99.936**	**---**	**16.408**	**100.000**		**2.866**

Sample taken 01-19-2010 at Holmes 14 Battery, Ft. Union.

Volume Flow:	45	MSCF/day/well
Completion activity duration:	3	days
Total Volume Flow per Well	0.135	MMSCF/well

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

BTU value = 994 BTU/scf

Forest Products **Alternative E**

Total Annual Emissions from Forest and Woodlands Projects - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Heavy Equipment - Fugitive Dust	3.97	0.40	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.27	0.26	3.57	0.09	2.44	0.36	0.04	441.03	0.00	0.00	442.63	401.66
Sub-total: Heavy Equipment	**4.24**	**0.66**	**3.57**	**0.09**	**2.44**	**0.36**	**0.04**	**441.03**	**0.00**	**0.00**	**442.63**	**401.66**
Commuting Vehicles - Fugitive Dust	6.38	0.64	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.03	0.02	0.29	0.00	0.24	0.07	0.01	83.07	0.00	0.00	84.69	76.85
Sub-total: Commuting Vehicles	**6.41**	**0.66**	**0.29**	**0.00**	**0.24**	**0.07**	**0.01**	**83.07**	**0.00**	**0.00**	**84.69**	**76.85**
Total	**10.65**	**1.32**	**3.86**	**0.10**	**2.68**	**0.42**	**0.04**	**524.10**	**0.008**	**0.010**	**527.32**	**478.51**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative E

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, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)		
				TSP	PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	550	11,000	1	11.00	3.85	0.39
			Total	**11.00**	**3.85**	**0.39**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	550.0	15	29.6	52.104	0.033	955.25	0	**0.12**	**0.01**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative E

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Forest/Woodland Forest Products	Skidder	205	1	70	8	50	400	595.14	68.02	16.19	490.96	58.29	3.0E-01	3.4E-02	8.1E-03	2.5E-01	2.9E-02	3.3E-02	3.8E+01	4.4E-04	3.8E-04
	Log Truck	450	2	60	10	50	1000	2,613.18	146.54	68.65	1,048.40	132.93	1.3E+00	7.3E-02	3.4E-02	5.2E-01	6.6E-02	7.1E-02	1.6E+02	1.0E-03	1.8E-03
	Chainsaw	6	1	80	8	50	400	5.60	41.26	0.59	1,242.48	261.96	2.8E-03	2.1E-02	3.0E-04	6.2E-01	1.3E-01	1.9E-02	1.5E+00	1.1E-03	9.1E-06
	Feller Buncher	300	1	100	8	50	400	1,244.19	142.20	33.85	1,026.39	121.87	6.2E-01	7.1E-02	1.7E-02	5.1E-01	6.1E-02	6.9E-02	7.9E+01	9.3E-04	8.0E-04
	Loader	200	1	80	10	50	500	774.28	43.42	20.34	310.64	39.39	3.9E-01	2.2E-02	1.0E-02	1.6E-01	2.0E-02	2.1E-02	4.7E+01	3.0E-04	5.3E-04
	Dozer	200	1	90	8	50	400	696.85	39.08	18.31	279.57	35.45	3.5E-01	2.0E-02	9.2E-03	1.4E-01	1.8E-02	1.9E-02	4.3E+01	2.7E-04	4.8E-04
	Delimber	250	1	100	10	50	500	1,209.81	67.84	31.78	485.37	61.54	6.0E-01	3.4E-02	1.6E-02	2.4E-01	3.1E-02	3.3E-02	7.4E+01	4.7E-04	8.3E-04
												Total	**3.6E+00**	**2.7E-01**	**9.5E-02**	**2.4E+00**	**3.6E-01**	**2.6E-01**	**4.4E+02**	**4.6E-03**	**4.8E-03**

Source of activity data: MCFO

Assume 2008 emission factors for all years = conservative estimate

ALTERNATIVE: Alternative E

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved ro		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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	70	50	3,500	1	3,500	0.61	1.06	6.38	0.06	0.11	0.64
	Log Truck	25	70	200	14,000	1	14,000	0.61	4.25		0.06	0.42	
	Pick-up Truck	25	70	50	3,500	1	3,500	0.61	1.06		0.06	0.11	
								Total	**6.38**			**0.64**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control (MCFO, 2010)

ALTERNATIVE: Alternative E

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								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_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.02	0.00	0.29	0.03	0.02	0.00	0.24	0.07	8.73	0.00	0.00
	Log Truck	HDDV	400	200	80,000	1	80,000	0.24	0.02	0.02	0.00	0.15	0.03							69.82	0.00	0.00
	Pick-up Truck	LDDT	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.07	0.03							4.51	0.00	0.00
							Total	**0.29**	**0.03**	**0.02**	**0.00**	**0.24**	**0.07**	**0.29**	**0.03**	**0.02**	**0.00**	**0.24**	**0.07**	**83.07**	**0.0037**	**0.0050**

Source of activity data: MCFO

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing **Alternative E**

Total Annual Emissions from Livestock Grazing Projects - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	1.37	0.14	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.50	0.48	7.27	0.17	3.15	0.55	0.05	775.33	0.01	0.01	778.2	**706.2**
Sub-total: Construction	**1.87**	**0.62**	**7.27**	**0.17**	**3.15**	**0.55**	**0.05**	**775.33**	**0.01**	**0.01**	**778.2**	**706.2**
Commuting Vehicles - Fugitive Dust	134.71	13.45	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.31	0.27	1.98	0.01	8.17	3.63	0.36	606.92	0.06	0.05	**623.6**	**565.9**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	2655.75	---	**55,770.7**	**50,608.6**
Sub-total: Operations and Maintenance	**135.02**	**13.71**	**1.98**	**0.01**	**8.17**	**3.63**	**0.36**	**606.92**	**2655.81**	**0.05**	**56,394.3**	**51,174.5**
Total	**136.89**	**14.34**	**9.25**	**0.18**	**11.32**	**4.17**	**0.42**	**1382.25**	**2655.82**	**0.06**	**57,172.5**	**51,880.7**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative E

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, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)		
			TSP	PM_{10}	$PM_{2.5}$
Springs	1.00	1	0.04	0.01	0.00
Reservoirs/Pits	37.00	1	0.52	0.18	0.02
Wells	3.00	1	0.12	0.04	0.00
Pipelines	48.00	1	1.92	0.67	0.07
Fences	30.00	1	1.20	0.42	0.04
Reservoirs Maintenance	1.00	1	0.04	0.01	0.00
		Total	**3.84**	**1.34**	**0.13**

[a] information from MCFO. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	120.0	15	29.6	52.104	0.033	208.42	0	**0.03**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

ALTERNATIVE: Alternative E

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	2	2.00	32.0	15	2	0	12	2	0.01	0.00	0.00	0.01	0.00	0.00	0.85	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	40.00	960.0	3,888	236	85	1,645	247	1.94	0.12	0.04	0.82	0.12	0.11	198.02	0.00	0.00
	Scraper	650	1	70	8	3	40.00	960.0	5,054	306	111	2,138	321	2.53	0.15	0.06	1.07	0.16	0.15	257.43	0.00	0.00
Wells	Drill Rig	200	1	100	8	3	10.00	240.0	463	31	12	155	38	0.23	0.02	0.01	0.08	0.02	0.01	26.81	0.00	0.00
	Water Truck	200	1	70	8	3	10.00	240.0	324	22	8	108	27	0.16	0.01	0.00	0.05	0.01	0.01	18.77	0.00	0.00
Pipelines	Dozer	200	1	75	2	25	5.00	250.0	409	31	10	153	36	0.20	0.02	0.00	0.08	0.02	0.02	22.33	0.00	0.00
	Trencher	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
	Backhoe	80	1	75	8	25	5.00	1000.0	709	86	17	549	87	0.35	0.04	0.01	0.27	0.04	0.04	39.72	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	25	8.00	1600.0	2,891	192	72	966	240	1.45	0.10	0.04	0.48	0.12	0.09	167.56	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	2	5.00	20.0	81	5	2	34	5	0.04	0.00	0.00	0.02	0.00	0.00	4.13	0.00	0.00
													Total	**7.27E+00**	**4.99E-01**	**1.67E-01**	**3.15E+00**	**5.45E-01**	**4.84E-01**	**7.75E+02**	**8.44E-03**	**8.81E-03**

Source for activity data: MCFO

all emissions calculated with year 2008 factors (conservative)

ALTERNATIVE: Alternative E

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = emission control percent for watering unpaved roads [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 Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	140	2	280	2.00	560	0.72	0.20	0.40	0.07	0.02	0.04
	Pick-up Truck	35	140	2	280	2.00	560	0.72	0.20		0.07	0.02	
Reservoirs/Pits	Tractor-Trailer	35	140	3	420	40.00	16800	0.72	6.04	12.08	0.07	0.60	1.21
	Pick-up Truck	35	140	3	420	40.00	16800	0.72	6.04		0.07	0.60	
Wells	Drill Truck	35	140	3	420	10.00	4200	0.72	1.51	6.04	0.07	0.15	0.60
	Support Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Water Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
	Pick-up Truck	35	140	3	420	10.00	4200	0.72	1.51		0.07	0.15	
Pipelines	Tractor-Trailer	35	140	25	3500	5.00	17500	0.72	6.29	12.58	0.07	0.63	1.26
	Pick-up Truck	35	140	25	3500	5.00	17500	0.72	6.29		0.07	0.63	
Fences	Support Truck	35	140	25	3500	8.00	28000	0.72	10.06	30.19	0.07	1.00	3.01
	Pick-up Truck	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
	ATV	35	140	25	3500	8.00	28000	0.72	10.06		0.07	1.00	
Reservoirs Maintenance	Tractor-Trailer	35	140	2	280	5.00	1400	0.72	0.50	1.01	0.07	0.05	0.10
	Pick-up Truck	35	140	2	280	5.00	1400	0.72	0.50		0.07	0.05	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	140	1087	152180	1.00	152180	0.72	54.70	54.70	0.07	5.46	5.46
	Pick-up-Trailer (spring calves)	35	140	352	49280	1.00	49280	0.72	17.71	17.71	0.07	1.77	1.77
							Total		**134.71**			**13.45**	

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked
for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load

ALTERNATIVE: Alternative E

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	**Class**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**CO**	**VOC**	**CO_2**	**CH_4**	**N_2O[1]**
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions														
								(tons/vehicle type)						(tons/year)								
								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_2O**
Springs	Tractor-Trailer	HDDV	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	1.05	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	300	3	900	40.00	36,000.0	0.11	0.01	0.01	0.00	0.07	0.01	0.15	0.01	0.01	0.00	1.02	0.06	31.42	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	40.00	36,000.0	0.04	0.00	0.00	0.00	0.95	0.04							18.92	0.00	0.00
Wells	Drill Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00	0.0920	0.0084	0.0070	0.0005	0.2890	0.0212	7.86	0.00	0.00
	Support Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Water Truck	HDDV	300	3	900	10.00	9,000.0	0.03	0.00	0.00	0.00	0.02	0.00							7.86	0.00	0.00
	Pick-up Truck	LDGT2	300	3	900	10.00	9,000.0	0.01	0.00	0.00	0.00	0.24	0.01							4.73	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	300	25	7500	5.00	37,500.0	0.11	0.01	0.01	0.00	0.07	0.01	0.16	0.01	0.01	0.00	1.06	0.06	32.73	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	5.00	37,500.0	0.05	0.00	0.00	0.00	0.99	0.04							19.71	0.00	0.00
Fences	Support Truck	HDDV	300	25	7500	8.00	60,000.0	0.18	0.02	0.02	0.00	0.11	0.02	0.27	0.14	0.13	0.00	4.86	3.32	52.37	0.00	0.00
	Pick-up Truck	LDGT2	300	25	7500	8.00	60,000.0	0.07	0.00	0.00	0.00	1.59	0.07							31.54	0.00	0.00
	ATV	R12S	300	25	7500	8.00	60,000.0	0.02	0.12	0.11	0.00	3.16	3.22							9.27	0.03	0.01
Reservoirs Maintenance	Tractor-Trailer	HDDV	300	2	600	5.00	3,000.0	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.08	0.00	2.62	0.00	0.00
	Pick-up Truck	LDGT2	300	2	600	5.00	3,000.0	0.00	0.00	0.00	0.00	0.08	0.00							1.58	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	300	1087	326100	1.00	326,100.0	0.98	0.10	0.08	0.00	0.62	0.13	1.29	0.13	0.11	0.01	0.82	0.17	284.62	0.01	0.02
	Pcik-up-Trailer (spring calves)	HDDV	300	352	105600	1.00	105,600.0	0.32	0.03	0.03	0.00	0.20	0.04							92.17	0.00	0.01
													TOTAL	**1.98**	**0.31**	**0.27**	**0.01**	**8.17**	**3.63**	**606.92**	**0.06**	**0.05**

Source for activity data: MCFO

For Livestock management: # of Activities/Year for spring turnout/fall gather = # of truck trips = head of cattle x 1,000 lb/head divided by 40,000 lbs/trailer truck assume 100% of cattle is semi-trucked for spring calves: # cattle - (# of cattle x 5% bulls) - (# of cattle x 15% yearlings) = # of cows = # of calves (assuming each cow gives birth to one calf). Then assume 90% survival, average weight = 450 lbs and 40,000 lbs per truck load.

ALTERNATIVE: Alternative E

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	517,828	9.74	2521.02	0.37	95.13	2616.16
Horse	17,424	3.31	28.81	0.43	3.75	32.55
Sheep	9,247	1.47	6.80	0.05	0.24	7.03
					Total Methane emissions	**2655.75**

AUM numbers provided by Dawn Doran (per direction from Todd Yeager) on 7/5/2011.

General Purpose Travel - BLM Fleet Alternative E

Total Annual Emissions from General Purpose BLM Travel - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq} tons	CO_{2eq} metric tons
Commuting Vehicles - Fugitive Dust	72.58	7.24	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.08	0.07	1.72	0.00	4.64	2.04	0.20	304.00	0.00	0.04	316.22	286.95
Sub-total: Commuting Vehicles	**72.66**	**7.31**	**1.72**	**0.00**	**4.64**	**2.04**	**0.20**	**304.00**	**0.00**	**0.04**	**316.22**	**286.95**
Total	**72.66**	**7.31**	**1.72**	**0.00**	**4.64**	**2.04**	**0.20**	**304.00**	**0.00**	**0.04**	**316.22**	**286.95**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative E

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^a\ (S/30)^d}{(M/0.5)^c} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent for applying dust suppressant to unpaved roads [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 Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/fleet group)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/fleet group)	$PM_{2.5}$ Emissions (tpy)
General Purpose BLM Travel	DM/FM Staff	25	3,329	0.61	1.01	72.58	0.06	0.10	7.24
	Support Services	25	27,597	0.61	8.38		0.06	0.84	
	Fire Management	45	97,656	0.61	29.66		0.06	2.96	
	Minerals and NRR	15	56,943	0.47	13.40		0.05	1.34	
	Renewable Resources	25	66,242	0.61	20.12		0.06	2.01	
		Total	**251,767**	**Total**	**72.58**			**7.242**	

Source of activity data: MCFO

Assume application of water ~ 50% emissions control.

ALTERNATIVE: Alternative E

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions (tons/fleet group)						Emissions (tpy)								
				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_2O
General Purpose BLM Travel	DM/FM Staff	LDDT	22,189	0.06	0.00	0.00	0.00	0.15	0.07	1.72	0.08	0.07	0.00	4.64	2.04	10.02	0.00	0.00
	Support Services	LDDT	78,848	0.20	0.01	0.01	0.00	0.54	0.24							35.59	0.00	0.00
	Fire Management	LDDT	217,013	0.55	0.03	0.02	0.00	1.49	0.66							97.96	0.00	0.01
	Minerals and NRR	LDDT	189,810	0.48	0.02	0.02	0.00	1.31	0.57							85.68	0.00	0.01
	Renewable Resources	LDDT	165,606	0.42	0.02	0.02	0.00	1.14	0.50							74.75	0.00	0.01
			Total	**1.7163**	**0.0807**	**0.0657**	**0.00416**	**4.64**	**2.03925**	**1.72E+00**	**8.07E-02**	**6.57E-02**	**4.16E-03**	**4.64E+00**	**2.04E+00**	**3.04E+02**	**1.48E-03**	**3.93E-02**

Source of activity data: MCFO

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance **Alternative E**

Total Annual Emissions from Road Maintenance Projects - Alternative E

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.45	0.21	1.24	0.03	0.49	0.08	0.01	146.71	0.00	0.00	147.25	133.62
Total	**1.45**	**0.21**	**1.24**	**0.03**	**0.49**	**0.08**	**0.01**	**146.71**	**0.0012**	**0.0017**	**147.25**	**133.62**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative E

Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	115

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^{2}$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)

Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

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

Parameter	PM_{10}	$PM_{2.5}$
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_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		15	Source of activity data: MCFO
S = mean vehicle speed (mph)			
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		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[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.

* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	Emissions (tons/year)	Em. Factor (lb/VMT)	Emissions (tons/year)
Road Maintenance	Grader	192	5	960	0.765	0.37	0.069	0.03
Road Maintenance	Semi-truck	28	20	56	1.09	0.03	0.11	0.00
Road Maintenance	Lowboy Trailer	---	20	756	1.09	0.41	0.11	0.04
				Total	**0.81**		**0.08**	

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	1	0.10	72	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00
Backhoe	87	1	0.80	133	0.05	0.00	0.00	0.02	0.00	0.00	5.51	0.00	0.00
Semi-truck	450	1	0.50	280	0.30	0.02	0.01	0.12	0.02	0.02	37.20	0.00	0.00
Lowboy Trailer	450	1	0.50	378	0.41	0.02	0.01	0.16	0.02	0.02	50.21	0.00	0.00
Bobcat	82	1	0.80	188	0.07	0.01	0.00	0.03	0.01	0.00	7.34	0.00	0.00
Grader	165	1	0.90	192	0.16	0.01	0.00	0.06	0.01	0.01	16.97	0.00	0.00
Loader	200	1	0.75	148	0.12	0.01	0.00	0.05	0.01	0.01	13.21	0.00	0.00
Dump Truck	350	1	0.50	142	0.12	0.01	0.00	0.05	0.01	0.01	14.71	0.00	0.00
Airport Forklift	100	1	0.10	16	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Snowplow	350	1	0.25	20	0.01	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Total					**1.2E+00**	**7.8E-02**	**3.2E-02**	**4.9E-01**	**7.8E-02**	**7.5E-02**	**1.5E+02**	**1.2E-03**	**1.7E-03**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2577.3	15	29.6	52.104	0.033	4,476.30	0	**0.56**	**0.06**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* assume roadway 12 feet wide for disturbance estimation.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation (not used)
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 29.6% derived from Miles City, Montana Airport surface meteorology 1980-1989 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Appendix F

AERMOD Near-Field Emission Inventory

Summary of Criteria Air Pollutant AERMOD Inputs (g/s)

Point Source Parameters (Non flare)

ID	Activity	Emission Rate per activity (g/s)												Stack Parameters					Location							
		NO_x		CO		SO_2				PM_{10}		$PM_{2.5}$		Stack Orienta-tion	H	V	T	D	1		2		3		4	
		1 hr	annual	1 hr	8 hr	1 hr	3-hr	24-hr	annual	24-hr	annual	24-hr	annual		(m)	(m/s)	(K)	(m)	X	Y	X	Y	X	Y	X	Y
DRM	Drill Rig (Main Deck, 3)	1.39E-01	4.26E-03	7.22E-01	7.22E-01	1.43E-03	1.43E-03	9.98E-04	4.38E-05	4.28E-03	1.88E-04	4.28E-03	1.88E-04	Vertical	6.1	25.00	700	0.38	0	10	0	0	0	-10		
DRA	Drill Rig (Auxiliary, 1)	5.00E-02	5.48E-04	4.33E-01	4.33E-01	8.56E-04	8.56E-04	6.85E-04	9.38E-06	2.00E-03	2.74E-05	2.00E-03	2.74E-05	Vertical	6.1	25.00	700	0.38	-10	-10						
DRG	Drill Rig (Generator, 2)	1.25E-02	3.08E-04	1.54E-01	1.54E-01	2.14E-04	2.14E-04	1.60E-04	5.28E-06	6.88E-03	2.26E-04	6.88E-03	2.26E-04	Vertical	3.8	10.00	560	0.15	-10	10	-10	0				
DRB	Rig Boiler	5.04E-02	2.76E-04	1.26E-02	1.26E-02	5.37E-04	5.37E-04	5.37E-04	2.94E-06	5.04E-03	2.76E-05	5.04E-03	2.76E-05	Vertical	3.8	5.00	425	0.20	10	0						
CEM	Completion Engine (Main Deck, 1)	5.00E-02	1.57E-04	4.33E-01	4.33E-01	8.56E-04	8.56E-04	4.28E-04	2.69E-06	1.25E-03	7.85E-06	1.25E-03	7.85E-06	Vertical	6.1	25.00	560	0.15	0	10						
CEA	Completion Engine (Auxiliary, 1)	1.88E-02	2.74E-05	1.63E-01	1.63E-01	3.21E-04	3.21E-04	2.57E-04	4.69E-07	7.50E-04	1.37E-06	7.50E-04	1.37E-06	Vertical	6.1	25.00	560	0.15	0	0						
CEG	Completion Engine (Generator, 1)	1.71E-02	5.27E-05	2.11E-01	2.11E-01	2.92E-04	2.92E-04	2.19E-04	9.01E-07	6.41E-04	2.63E-06	6.41E-04	2.63E-06	Vertical	3.8	10.00	560	0.15	0	-10						
PPJ	Production Pumpjack Engine	1.11E-02	1.11E-02	2.22E-02	2.22E-02	1.11E-05	1.11E-05	1.11E-05	1.11E-05	4.89E-04	4.89E-04	4.89E-04	4.89E-04	Vertical	3.8	10.00	560	0.20	-990	990	990	990	990	-990	-990	-990
PH	Production Heater	6.98E-06	6.98E-06	5.86E-06	5.86E-06	4.19E-08	4.19E-08	4.19E-08	4.19E-08	5.30E-07	5.30E-07	3.98E-07	3.98E-07	Vertical	4.6	7.30	425	0.20	-1010	1010	1010	1010	1010	-1010	-1010	-1010
PF	Production Flare	8.57E-02	7.45E-03	4.66E-01	4.66E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-02	2.92E-03	3.33E-02	2.92E-03	Vertical	3.8	10.00	1273	0.38	-1000	1010	1000	1010	1000	-1010	-1000	-1010

Point Source Parameters (Flare)

ID	Activity	Emission Rate per activity (g/s)												Stack Parameters							Location	
		NO_x		CO		SO_2				PM_{10}		$PM_{2.5}$		Stack Orienta-tion	H	Q	Hv	V	T	D		
		1 hr	annual	1 hr	8 hr	1 hr	3-hr	24-hr	annual	24-hr	annual	24-hr	annual		(m)	(MMBtu/hr)					X	Y
CF	Completion Flare	8.57E-02	1.02E-04	4.66E-01	4.66E-01	-	-	-	-	3.33E-02	4.00E-05	3.33E-02	4.00E-05	Vertical	16.5	10.00	16.6	20	1273	0.5	-10	0

Area Source Parameters

ID	Activity	Emission Rate per activity (g/s-m^2)												Source Dimensions				Parameters		
		NO_x		CO		SO_2				PM_{10}		$PM_{2.5}$		X	Y	X	Y	H	angle	σ_z-init
		1 hr	annual	1 hr	8 hr	1 hr	3-hr	24-hr	annual	24-hr	annual	24-hr	annual	Coordinate (m)		Length (m)		(m)	(deg)	(m)
XE	Construction Wind Erosion - ST									1.24E-06		1.86E-07		-55.00	-55.00	110.00	110	0	0	0
XEA	Construction Wind Erosion - Annual										3.39E-07		4.74E-08	-55.00	-55.00	110.00	110	0	0	0
XM	Construction Mobile Exhaust - ST	7.55E-06		5.83E-06	4.82E-10	2.07E-07	2.07E-07	2.07E-07		8.44E-07		8.44E-07		-55.00	-55.00	110.00	110	4	0	4.6
XMA	Construction Mobile Exhaust - Annual		2.59E-08						7.10E-10		2.89E-09		2.89E-09	-55.00	-55.00	110.00	110	4	0	4.6
XA	Construction Disturbance (Pad) - ST									2.29E-05		2.29E-06		-55.00	-55.00	110.00	110	2	0	2.37
XAA	Construction Disturbance (Pad) - Annual										7.85E-08		7.85E-09	-55.00	-55.00	110.00	110	2	0	2.37
XR	Construction Disturbance (Road) - ST							Divide by 7		1.10E-05		1.10E-06		Varies		80.00	10	2	0	2.37
XRA	Construction Disturbance (Road) - Annual										3.75E-08		3.75E-09			80.00	10	2	0	2.37

Volume Source Parameters (PM Only)

ID	Activity	Emission Rate per activity (g/s) [Emissions below are total emissions for all volume sources. Divide by the # of volume sources.]												Source Dimensions				Release Parameters		
		NO_x		CO		SO_2				PM_{10}		$PM_{2.5}$		Width	Length	Area	H	σ_y-init	σ_z-init	H_r
		1 hr	annual	1 hr	8 hr	1 hr	3-hr	24-hr	annual	24-hr	annual	24-hr	annual	(m)	(m)	(m^2)	(m)	(m)		
XD	Construction Mobile Dust - ST							Divide by:	8	2.17E-01		2.17E-02		9	800	7200	2.55	2.09	2.37	2.55
XDA	Construction Mobile Dust - Annual										7.44E-04		3.72E-05	9	800	7200	2.55	2.09	2.37	2.55
DD	Drilling Mobile Dust - ST							Divide by:	9	2.87E-02		2.87E-03		9	800	7200	2.55	2.09	2.37	2.55
DDA	Drilling Mobile Dust - Annual										6.29E-04		6.29E-05	9	800	7200	2.55	2.09	2.37	2.55
CD	Completion Mobile Dust - ST							Divide by:	9	6.86E-02		6.86E-03		9	800	7200	2.55	2.09	2.37	2.55
CDA	Completion Mobile Dust - Annual										6.58E-04		6.58E-05	9	800	7200	2.55	2.09	2.37	2.55
PD	Production Mobile Dust - ST							Divide by:	9	7.51E-02		7.51E-03		9	800	7200	2.55	2.09	2.37	2.55
PDA	Production Mobile Dust - Annual										4.02E-04		4.02E-05	9	800	7200	2.55	2.09	2.37	2.55

For fugitive dust emissions, assume vehicle height is 3 meters and vehicle width is 3 meters. Top of plume is 1.7 × 3 = 5.1 m. Width of plume is vehicle width (3 m) plus 6 m for single lane roadway = 9 m.
Volume source release height is 0.5 × 5.1 = 2.55 m. Sigma z = 5.1/2.15 = 2.37 m. Sigma y = 9/4.3 = 2.09 m.

Summary of Hazardous Air Pollutant AERMOD Inputs (g/s)

Point Source Parameters (Non flare)

ID	Activity	Emission Rate per activity (g/s)												Stack Parameters					Location							
		Bz		Tl		EtBz		Xy		Fo		n-Hx		Stack	H	V	T	D	1		2		3		4	
		1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	Orienta-tion	(m)	(m/s)	(K)	(m)	X	Y	X	Y	X	Y	X	Y
DRM	Drill Rig (Main Deck, 3)	7.91E-04	2.43E-05	5.82E-04	1.79E-05	1.21E-04	3.70E-06	4.12E-04	1.26E-05	4.59E-03	1.41E-04	6.19E-05	1.90E-06	Vertical	6.1	25.00	700	0.38	0	10	0	0	0	-10		
DRA	Drill Rig (Auxiliary, 1)	4.75E-04	5.20E-06	3.49E-04	3.83E-06	7.23E-05	7.93E-07	2.47E-04	2.71E-06	2.76E-03	3.02E-05	3.71E-05	4.07E-07	Vertical	6.1	25.00	700	0.38	-10	-10						
DRG	Drill Rig (Generator, 2)	1.19E-04	2.93E-06	8.73E-05	2.15E-06	1.81E-05	4.46E-07	6.17E-05	1.52E-06	6.89E-04	1.70E-05	9.28E-06	2.29E-07	Vertical	3.8	10.00	560	0.15	-10	10	-10	0				
DRB	Rig Boiler	5.39E-07	2.95E-09	1.56E-05	8.56E-08	1.60E-07	8.78E-10	2.75E-07	1.51E-09	8.32E-05	4.56E-07	0.00E+00	0.00E+00	Vertical	3.8	5.00	425	0.20	10	0						
CEM	Completion Engine (Main Deck, 1)	4.75E-04	1.49E-06	3.49E-04	1.10E-06	7.23E-05	2.27E-07	2.47E-04	7.75E-07	2.76E-03	8.65E-06	3.71E-05	1.17E-07	Vertical	6.1	25.00	560	0.15	0	10						
CEA	Completion Engine (Auxiliary, 1)	1.78E-04	2.60E-07	1.31E-04	1.91E-07	2.71E-05	3.96E-08	9.26E-05	1.35E-07	1.03E-03	1.51E-06	1.39E-05	2.03E-08	Vertical	6.1	25.00	560	0.15	0	0						
CEG	Completion Engine (Generator, 1)	1.62E-04	5.00E-07	1.19E-04	3.68E-07	2.47E-05	7.62E-08	8.44E-05	2.60E-07	9.42E-04	2.90E-06	1.27E-05	3.91E-08	Vertical	3.8	10.00	560	0.15	0	-10						
PPJ	Production Pumpjack Engine	1.13E-04	1.13E-04	8.32E-05	8.32E-05	1.72E-05	1.72E-05	5.88E-05	5.88E-05	6.56E-04	6.56E-04	8.84E-06	8.84E-06	Vertical	3.8	10.00	560	0.20	-990	990	990	990	990	-990	-990	-990
PH	Production Heater	6.65E-08	6.65E-08	1.08E-07	1.08E-07	---	---	---	---	2.37E-06	2.37E-06	5.70E-05	5.70E-05	Vertical	4.6	7.30	425	0.20	-1010	1010	1010	1010	1010	-1010	-1010	-1010
PF	Production Flare	2.00E-04	1.75E-05	7.31E-05	6.39E-06	1.44E-02	5.53E-03	2.90E-04	1.11E-04	1.47E-03	1.29E-04	3.65E-05	3.20E-06	Vertical	3.8	10.00	1273	0.38	-1000	1010	1000	1010	1000	-1010	-1000	-1010
PT	Oil Tank	3.17E-04	3.17E-04	4.03E-04	4.03E-04	1.51E-05	1.51E-05	1.77E-04	1.77E-04	-	-	4.18E-03	4.18E-03	Vertical	4.6	2.00	289	0.20	-1000	1000	1000	1000	1000	-1000	-1000	-1000

Point Source Parameters (Flare)

ID	Activity	Emission Rate per activity (g/s)												Stack Parameters							Location	
		Bz		Tl		EtBz		Xy		Fo		n-Hx		Stack	H	Q	Hv	V	T	D		
		1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	Orienta-tion	(m)	(MMBtu/hr)					X	Y
CF	Completion Flare	2.00E-04	2.40E-07	7.31E-05	8.76E-08	1.82E-03	2.18E-06	3.65E-05	4.38E-08	1.47E-03	1.77E-06	3.65E-05	4.38E-08	Vertical	16.5	10.00	16.6	20	1273	0.5	-10	0

Area Source Parameters

ID	Activity	Emission Rate per activity (g/s-m^2)												Source Dimensions				Parameters		
		Bz		Tl		EtBz		Xy		Fo		n-Hx		X	Y	X	Y	H	angle	σ_z-init
		1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	Coordinates (m)		Length (m)		(m)	(deg)	(m)
XE	Construction Wind Erosion - ST													-55.00	-55.00	110.00	110	0	0	0
XEA	Construction Wind Erosion - Annual													-55.00	-55.00	110.00	110	0	0	0
XM	Construction Mobile Exhaust - ST	7.59E-08		5.58E-08		1.16E-08		3.95E-08		4.41E-07		5.94E-09		-55.00	-55.00	110.00	110	4	0	4.6
XMA	Construction Mobile Exhaust - Annual		1.12E-10		8.22E-11		1.70E-11		5.81E-11		6.49E-10		8.74E-12	-55.00	-55.00	110.00	110	4	0	4.6
XA	Construction Disturbance (Pad) - ST													-55.00	-55.00	110.00	110	2	0	2.37
XAA	Construction Disturbance (Pad) - Annual													-55.00	-55.00	110.00	110	2	0	2.37
XR	Construction Disturbance (Road) - ST													Varies		50.00	10	2	0	2.37
XRA	Construction Disturbance (Road) - Annual															50.00	10	2	0	2.37

Volume Source Parameters

ID	Activity	Emission Rate per activity (g/s) [Emissions below are total emissions for all volume sources. Divide by the # of volume sources.]												Source Dimensions				Release Parameters		
		Bz		Tl		EtBz		Xy		Fo		n-Hx		Width	Length	Area	H	σ_y-init	σ_z-init	H_r
		1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	1 hr	annual	(m)	(m)	(m^2)	(m)	(m)		
XD	Construction Mobile Dust - ST													9	900	8100	2.55	2.09	2.37	2.55
XDA	Construction Mobile Dust - Annual													9	900	8100	2.55	2.09	2.37	2.55
DD	Drilling Mobile Dust - ST													9	900	8100	2.55	2.09	2.37	2.55
DDA	Drilling Mobile Dust - Annual													9	900	8100	2.55	2.09	2.37	2.55
CD	Completion Mobile Dust - ST													9	900	8100	2.55	2.09	2.37	2.55
CDA	Completion Mobile Dust - Annual													9	900	8100	2.55	2.09	2.37	2.55
PD	Production Mobile Dust - ST													9	900	8100	2.55	2.09	2.37	2.55
PDA	Production Mobile Dust - Annual													9	900	8100	2.55	2.09	2.37	2.55

Summary of Criteria Air Pollutant Short-Term Emission Rates (lb/hr)

Turn off for construction during night, turn off for mobile fugitive dust during cold weather and at night.

Single Pad Construction

Activity	Emissions per facility constructed				
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
	1-hour (lb/hr)				
Construction Disturbance - Pad	**-**	**-**	**-**	**2.20E+00**	**2.20E-01**
Construction Disturbance - Road	**-**	**-**	**-**	**6.96E-02**	**6.96E-03**
Mobile Equipment Exhaust	**7.25E-01**	**5.60E-01**	**1.99E-02**	**8.11E-02**	**8.11E-02**
Mobile Equipment Fugitive Dust	**-**	**-**	**-**	**1.72E+00**	**1.72E-01**
Wind Erosion	**-**	**-**	**-**	**1.19E-01**	**1.78E-02**

Drilling

Activity	Emissions per well drilled				
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
	1-hour (lb/hr)				
Drill Rig (Main Deck, each of 3 engines)	**1.10E+00**	**5.73E+00**	**1.13E-02**	**4.85E-02**	**4.85E-02**
Drill Rig (Auxiliary)	**3.97E-01**	**3.44E+00**	**6.79E-03**	**1.98E-02**	**1.98E-02**
Drill Rig (Generator)	**9.92E-02**	**1.22E+00**	**1.70E-03**	**7.28E-02**	**7.28E-02**
Rig Boiler	**4.00E-01**	**1.00E-01**	**4.26E-03**	**4.00E-02**	**4.00E-02**
Drilling Mobile Equipment Fugitive Dust [1]	**-**	**-**	**-**	**2.28E-01**	**2.28E-02**

Completion

Activity	Emissions per well completed				
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
	1-hour (lb/hr)				
Completion Engine (Main Deck)	**3.97E-01**	**3.44E+00**	**6.79E-03**	**1.98E-02**	**1.98E-02**
Completion Engine (Auxiliary)	**1.49E-01**	**1.29E+00**	**2.55E-03**	**7.44E-03**	**7.44E-03**
Completion Engine (Power Swivel)	**1.36E-01**	**1.67E+00**	**2.32E-03**	**6.78E-03**	**6.78E-03**
Completion Mobile Fugitive Dust [1]	**-**	**-**	**-**	**5.45E-01**	**5.45E-02**
Completion Flaring	**0.68**	**3.70**	**-**	**0.26**	**0.26**

Production

Activity	Emissions per producing well				
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$
	1-hour (lb/hr)				
Pumpjack Engine (Oil Wells)	**8.82E-02**	**1.76E-01**	**8.82E-05**	**3.88E-03**	**3.88E-03**
Heater	**5.54E-05**	**4.65E-05**	**3.32E-07**	**4.21E-06**	**3.16E-06**
Flare	**6.80E-01**	**3.70E+00**	**-**	**2.65E-01**	**2.65E-01**
Production Mobile Fugitive Dust [1]	**-**	**-**	**-**	**5.96E-01**	**5.96E-02**

[1] In modeling domain.

Single Pad Construction

Activity	Emissions per facility constructed					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	24-hour (lb/hr)					
Construction Disturbance - Pad	**-**	**-**	**-**	**2.20E+00**	**2.20E-01**	Day only
Construction Disturbance - Road	**-**	**-**	**-**	**6.96E-02**	**6.96E-03**	Day only
Mobile Equipment Exhaust	**7.25E-01**	**5.60E-01**	**1.99E-02**	**8.11E-02**	**8.11E-02**	Day only
Mobile Equipment Fugitive Dust	**-**	**-**	**-**	**1.72E+00**	**1.72E-01**	Warm months, day only
Wind Erosion	**-**	**-**	**-**	**1.19E-01**	**1.78E-02**	Day only

Drilling

Activity	Emissions per well drilled					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	24-hour (lb/hr)					
Drill Rig (Main Deck, each of 3 engines)	**7.72E-01**	**4.01E+00**	**7.92E-03**	**3.40E-02**	**3.40E-02**	
Drill Rig (Auxiliary)	**3.17E-01**	**2.75E+00**	**5.43E-03**	**1.59E-02**	**1.59E-02**	
Drill Rig (Generator)	**7.44E-02**	**9.18E-01**	**1.27E-03**	**5.46E-02**	**5.46E-02**	
Rig Boiler	**4.00E-01**	**1.00E-01**	**4.26E-03**	**4.00E-02**	**4.00E-02**	
Drilling Mobile Equipment Fugitive Dust 1	**-**	**-**	**-**	**2.28E-01**	**2.28E-02**	Warm months, day only

Completion

Activity	Emissions per well completed					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	24-hour (lb/hr)					
Completion Engine (Main Deck)	**1.98E-01**	**1.72E+00**	**3.40E-03**	**9.92E-03**	**9.92E-03**	
Completion Engine (Auxiliary)	**1.19E-01**	**1.03E+00**	**2.04E-03**	**5.95E-03**	**5.95E-03**	
Completion Engine (Power Swivel)	**1.02E-01**	**1.25E+00**	**1.74E-03**	**5.08E-03**	**5.08E-03**	
Completion Mobile Fugitive Dust 1	**-**	**-**	**-**	**5.45E-01**	**5.45E-02**	Warm months, day only
Completion Flaring	**0.68**	**3.70**	**-**	**0.26**	**0.26**	

Production

Activity	Emissions per producing well					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	24-hour (lb/hr)					
Pumpjack Engine (Oil Wells)	**8.82E-02**	**1.76E-01**	**8.82E-05**	**3.88E-03**	**3.88E-03**	
Heater	**5.54E-05**	**4.65E-05**	**3.32E-07**	**4.21E-06**	**3.16E-06**	
Flare	**6.80E-01**	**3.70E+00**	**0.00E+00**	**2.65E-01**	**2.65E-01**	
Production Mobile Fugitive Dust 1	**-**	**-**	**-**	**5.96E-01**	**5.96E-02**	Warm months, day only

Summary of Criteria Air Pollutant Annual Emission Rates (tons)

Single Pad Construction

Activity	Emissions per facility constructed					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	(tons)					
Construction Disturbance - Pad	**-**	**-**	**-**	**3.30E-02**	**3.30E-03**	Daytime only
Construction Disturbance - Road	**-**	**-**	**-**	**1.04E-03**	**1.04E-04**	Daytime only
Mobile Equipment Exhaust	**1.09E-02**	**8.40E-03**	**2.99E-04**	**1.22E-03**	**1.22E-03**	Daytime only
Mobile Equipment Fugitive Dust	**-**	**-**	**-**	**2.59E-02**	**1.29E-03**	Warm months, daytime
Wind Erosion	**-**	**-**	**-**	**1.43E-01**	**2.00E-02**	

Drilling

Activity	Emissions per well drilled					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	(tons)					
Drill Rig (Main Deck, each of 3 engines)	**1.48E-01**	**7.70E-01**	**1.52E-03**	**6.52E-03**	**6.52E-03**	
Drill Rig (Auxiliary)	**1.90E-02**	**1.65E-01**	**3.26E-04**	**9.52E-04**	**9.52E-04**	
Drill Rig (Generator)	**1.07E-02**	**1.32E-01**	**1.83E-04**	**7.86E-03**	**7.86E-03**	
Rig Boiler	**9.60E-03**	**2.40E-03**	**1.02E-04**	**9.60E-04**	**9.60E-04**	
Drilling Mobile Equipment Fugitive Dust 1	**-**	**-**	**-**	**2.19E-02**	**2.19E-03**	Warm months, daytime

Completion

Activity	Emissions per well completed					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	(tons)					
Completion Engine (Main Deck)	**5.46E-03**	**4.73E-02**	**9.34E-05**	**2.73E-04**	**2.73E-04**	
Completion Engine (Auxiliary)	**9.52E-04**	**8.25E-03**	**1.63E-05**	**4.76E-05**	**4.76E-05**	
Completion Engine (Power Swivel)	**1.83E-03**	**2.26E-02**	**3.13E-05**	**9.15E-05**	**9.15E-05**	
Completion Mobile Fugitive Dust 1	**-**	**-**	**-**	**2.29E-02**	**2.29E-03**	Warm months, daytime
Completion Flaring	**3.55E-03**	**1.93E-02**	**-**	**1.39E-03**	**1.39E-03**	

Production

Activity	Emissions per producing well					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	
	(tons)					
Pumpjack Engine (Oil Wells)	**3.86E-01**	**7.72E-01**	**3.86E-04**	**1.70E-02**	**1.70E-02**	
Heater	**2.43E-04**	**2.04E-04**	**1.46E-06**	**1.84E-05**	**1.38E-05**	
Flare	**2.59E-01**	**1.41E+00**	**-**	**1.01E-01**	**1.01E-01**	
Production Mobile Fugitive Dust 1	**-**	**-**	**-**	**1.40E-02**	**1.40E-03**	Warm months, daytime

[1] **In modeling domain.**

Summary of Hazardous Air Pollutant Short-Term Emission Rates (lb/hr)

Single Pad Construction

Activity	Emissions per facility constructed						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	1-hour (lb/hr)						
Mobile Equipment	**7.29E-03**	**5.36E-03**	**1.11E-03**	**3.79E-03**	**4.23E-02**	**5.70E-04**	**-**

Drilling

Activity	Emissions per well drilled						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	1-hour (lb/hr)						
Drill Rig (Main Deck)	**6.28E-03**	**4.62E-03**	**9.57E-04**	**3.27E-03**	**3.65E-02**	**4.91E-04**	**-**
Drill Rig (Auxiliary)	**3.77E-03**	**2.77E-03**	**5.74E-04**	**1.96E-03**	**2.19E-02**	**2.95E-04**	**-**
Drill Rig (Generator)	**9.42E-04**	**6.93E-04**	**1.44E-04**	**4.90E-04**	**5.47E-03**	**7.37E-05**	**-**
Rig Boiler	**4.28E-06**	**1.24E-04**	**1.27E-06**	**2.18E-06**	**6.60E-04**	**-**	**-**

Completion

Activity	Emissions per well completed						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	1-hour (lb/hr)						
Completion Engine (Main Deck)	**3.77E-03**	**2.77E-03**	**5.74E-04**	**1.96E-03**	**2.19E-02**	**2.95E-04**	**-**
Completion Engine (Auxiliary)	**1.41E-03**	**1.04E-03**	**2.15E-04**	**7.35E-04**	**8.21E-03**	**1.11E-04**	**-**
Completion Engine (Power Swivel)	**1.29E-03**	**9.47E-04**	**1.96E-04**	**6.70E-04**	**7.48E-03**	**1.01E-04**	**-**
Completion Flaring	**1.59E-03**	**5.80E-04**	**1.44E-02**	**2.90E-04**	**1.17E-02**	**2.90E-04**	**-**

Production

Activity	Emissions per producing well						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	1-hour (lb/hr)						
Pumpjack Engine (Oil Wells)	**8.97E-04**	**6.60E-04**	**1.37E-04**	**4.67E-04**	**5.21E-03**	**7.02E-05**	**-**
Heater (Gas or Oil Wells)	**5.28E-07**	**8.54E-07**	**---**	**---**	**1.88E-05**	**4.52E-04**	**-**
Flare	**1.59E-03**	**5.80E-04**	**1.44E-02**	**2.90E-04**	**1.17E-02**	**2.90E-04**	**-**
Oil Tank (Oil Wells)	**2.52E-03**	**3.20E-03**	**1.20E-04**	**1.40E-03**	**-**	**3.32E-02**	**-**

Summary of Hazardous Air Pollutant Annual Emission Rates (tpy)

Single Pad Construction

Activity	Emissions per facility constructed						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	(tons)						
Mobile Equipment	**4.70E-05**	**3.46E-05**	**7.16E-06**	**2.45E-05**	**2.73E-04**	**3.68E-06**	**-**

Drilling

Activity	Emissions per well drilled						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	(tons)						
Drill Rig (Main Deck)	**8.44E-04**	**6.21E-04**	**1.29E-04**	**4.39E-04**	**4.90E-03**	**6.60E-05**	**-**
Drill Rig (Auxiliary)	**1.81E-04**	**1.33E-04**	**2.76E-05**	**9.41E-05**	**1.05E-03**	**1.41E-05**	**-**
Drill Rig (Generator)	**1.02E-04**	**7.48E-05**	**1.55E-05**	**5.29E-05**	**5.91E-04**	**7.96E-06**	**-**
Rig Boiler	**1.03E-07**	**2.98E-06**	**3.05E-08**	**5.23E-08**	**1.58E-05**	**-**	**-**

Completion

Activity	Emissions per well drilled						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	(tons)						
Completion Engine (Main Deck)	**5.18E-05**	**3.81E-05**	**7.89E-06**	**2.69E-05**	**3.01E-04**	**4.05E-06**	**-**
Completion Engine (Auxiliary)	**9.04E-06**	**6.65E-06**	**1.38E-06**	**4.70E-06**	**5.25E-05**	**7.07E-07**	**-**
Completion Engine (Generator)	**1.74E-05**	**1.28E-05**	**2.65E-06**	**9.04E-06**	**1.01E-04**	**1.36E-06**	**-**
Completion Flaring	**8.35E-06**	**3.05E-06**	**7.58E-05**	**1.52E-06**	**6.14E-05**	**1.52E-06**	**-**

Production

Activity	Emissions per producing well						
	Bz	Tl	EtBz	Xy	Fo	n-Hx	H_2S
	(tons)						
Pumpjack Engine (Oil Wells)	**3.93E-03**	**2.89E-03**	**5.99E-04**	**2.04E-03**	**2.28E-02**	**3.07E-04**	**-**
Heater (Gas or Oil Wells)	**2.31E-06**	**3.74E-06**	**---**	**---**	**8.25E-05**	**1.98E-03**	**-**
Flare	**6.09E-04**	**2.22E-04**	**5.53E-03**	**1.11E-04**	**4.48E-03**	**1.11E-04**	**-**
Oil Tank (Oil Wells)	**1.10E-02**	**1.40E-02**	**5.26E-04**	**6.14E-03**	**-**	**1.45E-01**	**---**

Construction Well Pad and Road Surface Disturbance Emission Calculations

Facility Type	Size	PM_{10} Emission Factor[1]	Duration[2]				Particulate Emissions (Controlled)					
							TSP		PM_{10} [3]		$PM_{2.5}$ [4]	
	(acres)	(tons/acre-month)	(days/acre)	(hours/day)	(days)	(hours)	(lb/hr)	(tons)	(lb/hr)	(tons)	(lb/hr)	(tons)
Single Well Pad	3.0	0.11	1.00	10	3.0	30	N/A	N/A	2.20	3.30E-02	0.220	3.30E-03
Access Road	1.0	0.11	3.00	10	3.0	30	N/A	N/A	0.73	1.10E-02	0.073	1.10E-03
								Total	**2.93E+00**	**4.40E-02**	**2.93E-01**	**4.40E-03**

Constructed Road Length[5]	Emissions per Linear Meter of Road		Completion Duration[2]		Access Road Distance	Particulate Emissions (Controlled) on Domain Road					
	PM_{10}	$PM_{2.5}$				PM_{10}			$PM_{2.5}$		
(m)	(lb/m)	(lb/m)	(days)	(hours/day)	(m)	(lb/hr/m)	(lb/hr)	(tons)	(lb/hr/m)	(lb/hr)	(tons)
1,124	2.61E-03	2.61E-04	3.0	10	800	8.70E-05	6.96E-02	1.04E-03	8.70E-06	6.96E-03	1.04E-04

[1] Western Regional Air Partnership (WRAP) Fugitive Dust Handbook, Table 3-2, Level 1, Average Conditions.
Emission factor includes assumed dust control efficiency of 50% from active watering.

[2] Estimated duration.

[3] E (tpy) = Area (acres) x EF (tons/acre-month) x duration (days) / 30 (days/month)
E (lb/hr) = Daily Work Area (acres) x EF (tons/acre-month) x duration (days) / 30 (days/month) x 2000 (lbs/ton) / Duration (hours)

[4] Western Regional Air Partnership (WRAP) Fugitive Dust Handbook, Chapter 3.3.1 (assumes 0.1 $PM_{2.5}/PM_{10}$ ratio).

[5] With road width of 12 feet (3.6 m).

Construction Heavy Duty Vehicle Exhaust Emission Calculations

Duration	3.0	(days/pad)	Operating Load Factor[1]	0.43

Heavy Equipment	Emission Factor [2,3] (g/hp-hr)				Duration (hours/day)	Engine Size (hp)	# Req'd	Pollutant Emissions (lb/hr)				Pollutant Emissions (lb/pad)			
	NO_x	CO	SO_2	PM_{10}				NO_x	CO	SO_2	PM_{10}	NO_x	CO	SO_2	PM_{10}
Dozer [4]	4.37	1.52	1.20E-01	0.340	10	175	1	7.25E-01	2.52E-01	1.99E-02	5.64E-02	2.17E+01	7.56E+00	5.97E-01	1.69E+00
Grader [5]	4.85	3.94	1.30E-01	0.570	10	150	1	6.90E-01	5.60E-01	1.85E-02	8.11E-02	2.07E+01	1.68E+01	5.55E-01	2.43E+00
							Total	**1.41E+00**	**8.12E-01**	**3.84E-02**	**1.37E-01**	**4.24E+01**	**2.44E+01**	**1.15E+00**	**4.12E+00**

[1] Taken from *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*, Table 9, 7-cycle average (7/2010).
[2] Based on EPA NONROADS 2008a.
[3] SO_2 emissions based on a sulfur balance and ultra low sulfur diesel fuel (15 ppm) and a brake-specific fuel consumption of 7500 Btu/hp-hr.
[4] Assumed CAT D8T track-type dozer (http://www.cat.com/cda/layout?m=308819&x=7).
[5] Assumed CAT 120K medium-wheeled motor grader (http://www.cat.com/cda/layout?m=324958&x=7).

Construction Mobile Equipment Unpaved Road Fugitive Dust Calculations

Facility Type	Annual Emissions [1]		Distance Traveled	Emissions per Linear Mile of Road		Emissions per Linear Meter of Road		Construction Duration[2]		Access Road Distance in Domain	Particulate Emissions (Controlled)					
	PM_{10}	$PM_{2.5}$		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$				PM_{10}			$PM_{2.5}$		
	(tons)	(tons)	(miles)	(tons/mi)	(tons/mi)	(tons/m)	(tons/m)	(days)	(hours/day)	(m)	(lb/hr/m)	(lb/hr)	(tons)	(lb/hr/m)	(lb/hr)	(tons)
Single Well Pad and Access Road	2.60E-01	2.60E-02	10	2.60E-02	2.60E-03	1.62E-05	1.62E-06	3.0	10	800	2.15E-03	1.72E+00	2.59E-02	2.15E-04	1.72E-01	1.29E-03
											x2	x2	x2	x2	x2	x2

[1] From detailed Oil Well Emission Spreadsheets describing vehicle types, vehicle weights, and distances traveled. Emissions would not occur during winter when roads are frozen. Pound/hr emissions are multiplied by 2 to account for seasonality. In AERMOD specify Nov, Dec, Jan, Feb, March, April with no emissions and no emissions during night.

[2] Estimated duration.

Construction Short-Term Wind Erosion Emission Calculations

Parameter			
Fastest Mile (10 m) [1]	u_{10}	20.1	m/s
Friction Velocity [2]	u*	1.07	m/s
Threshold Friction Velocity [3]	u_t	1.02	m/s
Excess Friction Velocity	$u^* - u_t$	0.05	m/s
Erosion Potential [4]	P	1.28	g/m^2
Erodable Area [5]		1.0	acres
	A	4047.0	m^2
Number of Erosion Events [6]	n	1	per day
Control Efficiency [7]	CE	50%	%

Factor is 0.44704 for converting from mph to m/s.

Emissions			
	Event	Daily	24 hr
Pollutant	(lb/event)	(lb/day)	(lb/hr)
TSP [8, 9]	5.70	5.70	2.38E-01
PM_{10} [10]	2.85	2.85	1.19E-01
$PM_{2.5}$ [11]	0.43	0.43	1.78E-02

Notes:

[1] The average fastest mile at Billings, MT was 58.3 mph (1942-1984) from http://www.itl.nist.gov/div898/winds/nondirectional.htm. However, wind speed calculations are based on a maximum wind speed of 45 mph. Construction activities will not be allowed if wind speeds are predicted to exceed 40 mph. The 5 mph difference allows for inaccuracies in weather prediction.

[2] $u^* = 0.053 \times u_{10}$; Equation 4, AP-42, Ch. 13.2.5 Industrial Wind Erosion, dated November 2006.

[3] Threshold friction velocity for scoria, USEPA AP-42, Ch. 13.2.5 Industrial Wind Erosion, Table 13.2.5-2 for overburden, dated November 2006.

[4] $P(g/m^2) = 58 (u^*-u_t)^2 + 25 (u^*-u_t)$; where $u^*>u_t$; Equation 3, USEPA AP-42, Ch. 13.2.5 Industrial Wind Erosion, dated November 2006.

[5] Daily working area.

[6] One event per day for each day of construction.

[7] Assumed control efficiency for active watering.

[8] $E (lb) = P (g/m^2) \times A (m^2) / 453.5924 (g/lb) \times (1-CE)$

[9] E (lb/day) = E (lb) x n, E (lb/day) = E (lb) x n; E (lb/hr) = E (lb/day) / 24 (hr/day)

[10] $E_{PM10} = 0.5 \times E_{TSP}$; Equation 2, USEPA AP-42 Ch. 13.2.5 Industrial Wind Erosion, dated November 2006

[11] $E_{PM2.5} = 0.075 \times E_{TSP}$; Equation 2, USEPA AP-42 Ch. 13.2.5 Industrial Wind Erosion, dated November 2006

Construction Annual Wind Erosion Emission Calculations

Facility Type	TSP Emission Factor			Control Efficiency [4]	Size	Particulate Emissions		
	TSP [1]	PM_{10} [2]	$PM_{2.5}$ [3]			TSP	PM_{10}	$PM_{2.5}$
	(tons/acre-year)			(%)	(acres)	(tons/facility-year)		
Single Well Pad	0.38	0.29	0.04	50%	1.00	0.19	1.43E-01	2.00E-02

[1] AP-42 (EPA 1998), Table 11.9-4 for Wind Erosion of Exposed Areas.

[2] No PM_{10} emission factor is provided in AP-42 Table 11.9-4. A PM_{10} scaling factor of 0.75 is listed in AP-42 Table 11.9-1 for bulldozing of overburden. Therefore, TSP emission factor multiplied by 0.75 to estimate the PM_{10} emission factor.

[3] No $PM_{2.5}$ emission factor is provided in AP-42 Table 11.9-4. A $PM_{2.5}$ scaling factor of 0.105 is listed in AP-42 Table 11.9-1 for bulldozing of overburden. Therefore, the TSP emission factor is multiplied by 0.105 to estimate the $PM_{2.5}$ emission factor.

[4] Assumed control efficiency for active watering.

Construction Mobile Equipment Exhaust HAP Emission Calculations

Total Horsepower [1]		(hp)	325.0
Total Horsepower Hours [2]		(hp-hr/day)	1397.5
Construction Duration		(days/pad)	3.0
Pollutant	**Emission Factor**	**Emission Rate**	
	(g/hp-hr)	**(lb/pad)**	**(lb/hr)**
VOC [3]	0.5	4.62E+00	3.58E-01

Pollutant	**Emission Factor**	**Emission Rate**		
	(g/g VOC)	**(lb/pad)**	**(lb/hr)**	**(tpy)**
Benzene [4]	2.0E-02	9.4E-02	7.3E-03	4.7E-05
Toluene [4]	1.5E-02	6.9E-02	5.4E-03	3.5E-05
Ethyl Benzene [4]	3.1E-03	1.4E-02	1.1E-03	7.2E-06
Xylene [4]	1.1E-02	4.9E-02	3.8E-03	2.4E-05
Formaldehyde [4]	1.2E-01	5.5E-01	4.2E-02	2.7E-04
Hexane [4]	1.6E-03	7.4E-03	5.7E-04	3.7E-06
H_2S [5]	-	-	-	-

[1] Total horsepower = Σ [Engine size per equipment x number of each equipment].
[2] Total horsepower hours = Σ [Engine size per equipment x number of each equipment x operating hours per day x operating load factor].
[3] Based on EPA NONROAD 2008a.
[4] HAP factors for diesel combustion taken from Nonroad Mobile Inventory Model database (Version 20090720).
[5] No data available; H_2S assumed negligible for diesel combustion.

Drilling Rig Engine Emission Calcluations

Purpose		Main Deck (each of 3 gensets)				Auxiliary (1 engine)				Generator (2 engines)			
Rig Size [1]	(hp)	1,000				600				150			
BSFC	(Btu/hp-hr)	7,500				7,500				7,500			
Overall Load Factor [2]		0.70				0.80				0.75			
Duration [1]	(days/well)	16				15				12			
	(hours/day)	24				8				24			
Pollutant	Emission Factor	Emission Rate			Emission Factor	Emission Rate			Emission Factor	Emission Rate			
	Tier 4 (g/hp-hr)	Hourly (lb/hr-rig)	24-hr (lb/hr-rig)	Annual (tons/well)	Tier 4 (g/hp-hr)	Hourly (lb/hr-rig)	24-hr (lb/hr-rig)	Annual (tons/well)	Tier 2 (g/hp-hr)	Hourly (lb/hr-rig)	24-hr (lb/hr-rig)	Annual (tons/well)
NO_x [3]	5.00E-01	1.10E+00	7.72E-01	1.48E-01	3.00E-01	3.97E-01	3.17E-01	1.90E-02	3.00E-01	9.92E-02	7.44E-02	1.07E-02
CO [3]	2.60E+00	5.73E+00	4.01E+00	7.70E-01	2.60E+00	3.44E+00	2.75E+00	1.65E-01	3.70E+00	1.22E+00	9.18E-01	1.32E-01
SO_2 [4]	5.13E-03	1.13E-02	7.92E-03	1.52E-03	5.13E-03	6.79E-03	5.43E-03	3.26E-04	5.13E-03	1.70E-03	1.27E-03	1.83E-04
PM_{10} [3]	2.20E-02	4.85E-02	3.40E-02	6.52E-03	1.50E-02	1.98E-02	1.59E-02	9.52E-04	2.20E-01	7.28E-02	5.46E-02	7.86E-03
Benzene [5]	2.85E-03	6.28E-03	4.40E-03	8.44E-04	2.85E-03	3.77E-03	3.01E-03	1.81E-04	2.85E-03	9.42E-04	7.06E-04	1.02E-04
Toluene [5]	2.10E-03	4.62E-03	3.23E-03	6.21E-04	2.10E-03	2.77E-03	2.22E-03	1.33E-04	2.10E-03	6.93E-04	5.20E-04	7.48E-05
Ethylbenzene [5]	4.34E-04	9.57E-04	6.70E-04	1.29E-04	4.34E-04	5.74E-04	4.59E-04	2.76E-05	4.34E-04	1.44E-04	1.08E-04	1.55E-05
Xylene [5]	1.48E-03	3.27E-03	2.29E-03	4.39E-04	1.48E-03	1.96E-03	1.57E-03	9.41E-05	1.48E-03	4.90E-04	3.67E-04	5.29E-05
Formaldehyde [5]	1.65E-02	3.65E-02	2.55E-02	4.90E-03	1.65E-02	2.19E-02	1.75E-02	1.05E-03	1.65E-02	5.47E-03	4.10E-03	5.91E-04
n-Hexane [5]	2.23E-04	4.91E-04	3.44E-04	6.60E-05	2.23E-04	2.95E-04	2.36E-04	1.41E-05	2.23E-04	7.37E-05	5.53E-05	7.96E-06
H_2S [6]	-	-	-	-	-	-	-	-	-	-	-	-

Fuel Data		
Fuel Heating Value	(Btu/gal)	140,000
Sulfur Content [7]	(ppmw)	15
	(%)	0.0015
Fuel Density [8]	(lb/gal)	7.05

[1] Assumptions provided by the Charles Laakso (BLM).

[2] Provided by Charles Laakso (BLM) or taken from *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*, Table 9, 7-cycle average (7/2010).

[3] For engines >200 hp, emission factors are based on Tier 4 emission standards (40 CFR 89.112) for 2013 and later.

[4] EF (g/hp-hr) = BSFC (Btu/bhp-hr) / Heating Value (Btu/gal) x Fuel Sulfur Content (lb S/lb fuel) *453.5924 (g/lb) x MW (SO_2)/MW (S).

[5] HAP factors for diesel combustion taken from Nonroad Mobile Inventory Model database (Version 20090720) and multiplied by the Tier 4 NMHC emission standard.
The NMHC (VOC) standard is 0.14 g/hp-hr. The fraction of VOC for each HAP is: benzene=0.02034; toluene=0.0150; ethylbenzene 0.0031; xylene = 0.0106; formaldehyde = 0.1182; n-hexane = 0.0016.

[6] No data available; H_2S assumed negligible for diesel combustion.

[7] Based on fuel sulfur standards for nonroad engines in 40 CFR 80.510.

[8] Based on fuel sulfur density listed for No. 2 Distillate Fuel in AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-12.

Drilling Diesel Fired Rig Boiler Emission Calculations

Design Firing Rate [1]	(MMBtu/hr)	2.8
	(gal/hr)	20.0
Operating hours per well	(hr/well)	48
Duration [1]	(days/well)	2
	(hours/day)	24

Pollutant	Emission Factor	Emission Rate	
	(lb/10^3 gal)	(lb/hr)	(tons/well)
NO_x [2]	20.0	0.40	9.6E-03
CO [2]	5.0	0.10	2.4E-03
SO_2 [2]	0.2	4.3E-03	1.0E-04
PM_{10} [3]	2.0	0.04	9.6E-04
Benzene [4]	2.14E-04	4.3E-06	1.0E-07
Toluene [4]	6.20E-03	1.2E-04	3.0E-06
Ethylbenzene [4]	6.36E-05	1.3E-06	3.1E-08
Xylene [4]	1.09E-04	2.2E-06	5.2E-08
Formaldehyde [4]	3.30E-02	6.6E-04	1.6E-05
n-Hexane [5]	-	-	-
H_2S [5]	-	-	-

Fuel Data		
Fuel Heating Value	(Btu/gal)	140,000
Sulfur Content [6]	(ppmw)	15
	(%)	0.0015
Fuel Density [7]	(lb/gal)	7.05

[1] Assumptions provided by Charles Laakso (BLM).
[2] AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-1 dated May 2010 for distillate fired boilers.
[3] AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-6 dated May 2010 for TSP.
[4] AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-9 dated May 2010.
[5] No data available; H_2S and n-hexane emissions presumed negligible.
[6] Based on fuel sulfur standards for nonroad engines in 40 CFR 80.510.
[7] Based on fuel sulfur density listed for No. 2 Distillate Fuel in AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-12.

Drilling Mobile Equipment Unpaved Road Fugitive Dust Calculations

Facility Type	Annual Emissions [1]		Distance Traveled	Emissions per Linear Mile of Road		Emissions per Linear Meter of Road		Drilling Duration[2]		Access Road Distance in Domain	Particulate Emissions (Controlled)					
	PM_{10}	$PM_{2.5}$		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$				PM_{10}			$PM_{2.5}$		
	(tons)	(tons)	(miles)	(tons/mi)	(tons/mi)	(tons/m)	(tons/m)	(days)	(hours/day)	(m)	(lb/hr/m)	(lb/hr)	(tons)	(lb/hr/m)	(lb/hr)	(tons)
Single Well Pad and Access Road	2.20E-01	2.20E-02	10	2.20E-02	2.20E-03	1.37E-05	1.37E-06	16	12	800	2.85E-04	2.28E-01	2.19E-02	2.85E-05	2.28E-02	2.19E-03

[1] From detailed Oil Well Emission Spreadsheets describing vehicle types, vehicle weights, and distances traveled. Emissions would not occur during winter when roads are frozen. Pound/hr emissions are multiplied by 2 to account for seasonality. In AERMOD specify Nov, Dec, Jan, Feb, March, April with no emissions and no emissions during night.

[2] Estimated duration. Assumes deliveries occur during daytime.

Completion/Fracing Engine Emission Calculations

Purpose		Main Deck (1 engine)				Auxiliary (1 engine)				Power Swivel / Generator (I engine		
Rig Size [1]	(hp)	600				225				205		
BSFC	(Btu/hp-hr)	7,500				7,500				7,500		
Overall Load Factor [2]		0.50				0.80				0.75		
Duration [1]	(days/well)	5				2				3		
	(hours/day)	11				8				12		
Pollutant	**Emission Factor**	**Emission Rate**			**Emission Factor**	**Emission Rate**			**Emission Factor**	**Emission Rate**		
	Tier 4 (g/hp-hr)	**Hourly (lb/hr-rig)**	**24-hr (lb/hr-rig)**	**Annual (tons/well)**	**Tier 4 (g/hp-hr)**	**Hourly (lb/hr-rig)**	**24-hr (lb/hr-rig)**	**Annual (tons/well)**	**Tier 4 (g/hp-hr)**	**Hourly (lb/hr-rig)**	**24-hr (lb/hr-rig)**	**Annual (tons/well)**
NO_x [3]	0.3	0.40	0.20	5.5E-03	0.3	0.15	0.12	9.5E-04	0.3	0.14	0.10	1.8E-03
CO [3]	2.6	3.44	1.72	4.7E-02	2.6	1.29	1.03	8.3E-03	3.7	1.67	1.25	2.3E-02
SO_2 [4]	5.1E-03	6.8E-03	3.4E-03	9.3E-05	5.1E-03	2.5E-03	2.0E-03	1.6E-05	5.1E-03	2.3E-03	1.7E-03	3.1E-05
PM_{10} [3]	0.015	1.98E-02	9.92E-03	2.7E-04	0.015	7.4E-03	6.0E-03	4.8E-05	0.015	6.8E-03	5.1E-03	9.2E-05
Benzene [5]	2.85E-03	3.8E-03	1.9E-03	5.2E-05	2.85E-03	1.4E-03	1.1E-03	9.0E-06	2.85E-03	1.3E-03	9.7E-04	1.7E-05
Toluene [5]	2.10E-03	2.8E-03	1.4E-03	3.8E-05	2.10E-03	1.0E-03	8.3E-04	6.7E-06	2.10E-03	9.5E-04	7.1E-04	1.3E-05
Ethylbenzene [5]	4.34E-04	5.7E-04	2.9E-04	7.9E-06	4.34E-04	2.2E-04	1.7E-04	1.4E-06	4.34E-04	2.0E-04	1.5E-04	2.6E-06
Xylene [5]	1.48E-03	2.0E-03	9.8E-04	2.7E-05	1.48E-03	7.3E-04	5.9E-04	4.7E-06	1.48E-03	6.7E-04	5.0E-04	9.0E-06
Formaldehyde [5]	1.65E-02	2.2E-02	1.1E-02	3.0E-04	1.65E-02	8.2E-03	6.6E-03	5.3E-05	1.65E-02	7.5E-03	5.6E-03	1.0E-04
n-Hexane [5]	2.23E-04	2.9E-04	1.5E-04	4.1E-06	2.23E-04	1.1E-04	8.8E-05	7.1E-07	2.23E-04	1.0E-04	7.6E-05	1.4E-06
H_2S [6]	-	-	-	-	-	-	-	-	-	-	-	-

Fuel Data		
Fuel Heating Value	(Btu/gal)	140,000
Sulfur Content [7]	(ppmw)	15
	(%)	0.0015
Fuel Density [8]	(lb/gal)	7.05

[1] Assumptions provided by Charles Laakso (BLM).
[2] Taken from *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*, Table 9, 7-cycle average (7/2010).
[3] Based on Tier 4 emission standards (40 CFR 89.112) for 2013 and later.
[4] EF (g/hp-hr) = BSFC (Btu/bhp-hr) / Heating Value (Btu/gal) x Fuel Sulfur Content (lb S/lb fuel) *453.5924 (g/lb) x MW (SO_2)/MW (S).
[5] HAP factors for diesel combustion taken from Nonroad Mobile Inventory Model database (Version 20090720) and multiplied by the Tier 4 NMHC emission standard.
[6] No data available; H_2S assumed negligible for diesel combustion.
[7] Based on fuel sulfur standards for nonroad engines in 40 CFR 80.510.
[8] Based on fuel sulfur density listed for No. 2 Distillate Fuel in AP-42, Ch 1.3, *Fuel Oil Combustion*, Table 1.3-12.

Completion/Fracing Mobile Equipment Unpaved Road Fugitive Dust Calculations

Facility Type	Annual Emissions [1]		Distance Traveled	Emissions per Linear Mile of Road		Emissions per Linear Meter of Road		Completion Duration[2]		Access Road Distance in Domain	Particulate Emissions (Controlled)					
	PM_{10}	$PM_{2.5}$		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$				PM_{10}			$PM_{2.5}$		
	(tons)	(tons)	(miles)	(tons/mi)	(tons/mi)	(tons/m)	(tons/m)	(days)	(hours/day)	(m)	(lb/hr/m)	(lb/hr)	(tons)	(lb/hr/m)	(lb/hr)	(tons)
Single Well Pad	2.30E-01	2.30E-02	10	2.30E-02	2.30E-03	1.43E-05	1.43E-06	7	12	800	6.81E-04	5.45E-01	2.29E-02	6.81E-05	5.45E-02	2.29E-03
											2x	2x	2x	2x	2x	2x

[1] From detailed Oil Well Emission Spreadsheets describing vehicle types, vehicle weights, and distances traveled. Emissions would not occur during winter when roads are frozen. Pound/hr emissions are multiplied by 2 to account for seasonality. In AERMOD specify Nov, Dec, Jan, Feb, March, April with no emissions and no emissions during night.

[2] Estimated duration for deliveries and traffic. Assumes deliveries occur during daytime.

Completion/Fracing Flaring Emission Calculations

Flowback Duration [1]	(days/completion)	5
Gas Flared	(MMscf/day) [1]	0.02
	(MMscf/completion)	0.11
Flare Operating Time	(hr/day) [1]	24
Flare Capacity [2]	(Mscf/hr)	10
Heat Content [3]	(Btu/scf)	994
Fuel Sulfur Content [3]	(gr/scf)	-
Sulfur Conversion	(%)	98%
Firing Rate [4]	(MMBtu/hr)	10
	(MMBtu/completion)	104

Pollutant	Emission Factor		Emission Rate	
			(lb/hr)	(tpy)
NO_x [5]	0.068	(lb/MMBtu)	0.68	3.5E-03
CO [5]	0.37	(lb/MMBtu)	3.70	1.9E-02
SO_2 [3]	-	(lb/MMBtu)	-	-
PM_{10} [6,7,8]	40.0	(μg/L)	0.26	1.4E-03
Benzene [9]	0.159	(lb/MMscf)	1.6E-03	8.3E-06
Toluene [9]	0.058	(lb/MMscf)	5.8E-04	3.0E-06
Ethylbenzene [9]	1.444	(lb/MMscf)	1.4E-02	7.6E-05
Xylene [9]	0.029	(lb/MMscf)	2.9E-04	1.5E-06
Formaldehyde [9]	1.169	(lb/MMscf)	1.2E-02	6.1E-05
n-Hexane [9]	0.029	(lb/MMscf)	2.9E-04	1.5E-06
H_2S [3]	-	(lb/MMBtu)	-	-

[1] Assumptions provided by Charles Laakso (BLM).
[2] Capacity (Mscf/hr) = Gas Flared (MMscf/day) x 1000 (Mscf/MMscf).
[3] Median gas composition analysis from Charles Laakso (BLM)GHG Analysis (URS 2010); gas assumed to contain no sulfur.
[4] Hourly Firing rate = Gas flared x Heat Content round up to the nearest 10 MMBtu/hr; annual firing rate based on annual gas flared.
[5] USEPA AP-42 Ch. 13.5 *Industrial Flares* dated 9/91.
[6] USEPA AP-42 Ch. 13.5 *Industrial Flares* dated 9/91 for light smoking flares.
[7] E_{PM10} (lb/hr) = Gas Flared (scf gas/hr) x 10.6 (scf E/scf gas) x 0.0283 (m^3/scf E) x 40 (μg/L) x 1000 ($L/m^{3)}$ / 10^6 (μg/g) / 453.5924 (g/lb).
[8] E_{PM10} (tpy) = Gas Flared (MMscf gas/yr) x 10^6 (scf gas/MMscf gas) x 10.6 (scf E/scf gas) x 0.0283 (m^3/scf E) x 40 (μg/L) x 1000 ($L/m^{3)}$ / 10^6 (μg/g) / 453.5924 (g/lb) /2000 (lb/ton)
[9] Ventura County Air Pollution Control District, Natural Gas Fired External Combustion Equipment, flare, dated May 17, 2001.

Production Pumpjack Engine Emission Calculations

Total Horsepower [1]	(hp)	40.0
Total Horsepower Hours [2]	(hp-hr/day)	960.0
Duration	(days/yr)	365.00

Pollutant	Emission Factor	Emission Rate		
	(g/hp-hr)	(lb/pad)	(lb/hr)	(tpy)
NO_x	1.00E+00	7.72E+02	8.82E-02	3.86E-01
CO	2.00E+00	1.54E+03	1.76E-01	7.72E-01
SO_2	1.00E-03	7.72E-01	8.82E-05	3.86E-04
PM_{10}	4.40E-02	3.40E+01	3.88E-03	1.70E-02
$PM_{2.5}$	4.40E-02	3.40E+01	3.88E-03	1.70E-02
VOC [3]	5.00E-01	3.86E+02	4.41E-02	1.93E-01

Pollutant	Emission Factor	Emission Rate		
	(g/g VOC)	(lb/pad)	(lb/hr)	(tpy)
Benzene [4]	2.0E-02	7.9E+00	9.0E-04	3.9E-03
Toluene [4]	1.5E-02	5.8E+00	6.6E-04	2.9E-03
Ethyl Benzene [4]	3.1E-03	1.2E+00	1.4E-04	6.0E-04
Xylene [4]	1.1E-02	4.1E+00	4.7E-04	2.0E-03
Formaldehyde [4]	1.2E-01	4.6E+01	5.2E-03	2.3E-02
Hexane [4]	1.6E-03	6.1E-01	7.0E-05	3.1E-04
H_2S [5]	-	-	-	-

[1] Total horsepower = Σ [Engine size per equipment x number of each equipment]
[2] Total horsepower hours = Σ [Engine size per equipment x number of each equipment x operating hours per day]
[3] Based on EPA NONROAD 2008a.
[4] HAP factors for diesel combustion taken from Nonroad Mobile Inventory Model database (Version 20090720).
[5] No data available; H_2S assumed negligible for diesel combustion.

Production Heater Emission Calculations

Heater Size [1]	(MMBtu/hr)	1
Total Heater Fuel Usage [1]	(MMSCF/yr)	2.2
Total Operating Hours per Day [2]	(hr/day)	24.0
Duration	(days/yr)	365.00

Pollutant	Emission Factor	Emission Rate		
	(lb/MMSCF)	(lb/pad)	(lb/hr)	(tpy)
NO_x	1.00E+02	4.85E-01	5.54E-05	2.43E-04
CO	8.40E+01	4.08E-01	4.65E-05	2.04E-04
SO_2	6.00E-01	2.91E-03	3.32E-07	1.46E-06
PM_{10}	7.60E+00	3.69E-02	4.21E-06	1.84E-05
$PM_{2.5}$	5.70E+00	2.77E-02	3.16E-06	1.38E-05
VOC [3]	5.50E+00	2.67E-02	3.05E-06	1.33E-05
Pollutant	**Emission Factor**	**Emission Rate**		
	(lb/MMSCF)	**(lb/pad)**	**(lb/hr)**	**(tpy)**
Benzene [3]	2.10E-03	4.62E-03	5.28E-07	2.31E-06
Toluene [3]	3.40E-03	7.48E-03	8.54E-07	3.74E-06
Ethyl Benzene	---	---	---	---
Xylene	---	---	---	---
Formaldehyde [3]	7.50E-02	1.65E-01	1.88E-05	8.25E-05
Hexane [3]	1.80E+00	3.96E+00	4.52E-04	1.98E-03
H_2S [3]	-	-	-	-

[1] From Charles Laakso (BLM, 2010)

[2] The heater may be a reboiler on a glycol dehydrator or it may be an oil heater or heater-treater. For a conservative analysis, the heater is assumed to operate all year.

[3] EPA, AP-42 Section 1.4 Natural Gas Combustion.

Production Mobile Equipment Unpaved Road Fugitive Dust Calculations

Facility Type	Annual Emissions [1]		Distance Traveled	Emissions per Linear Mile of Road		Emissions per Linear Meter of Road		Annual Number of Trips	Access Road Distance in Domain	Particulate Emissions (Controlled in Domain)					
	PM_{10}	$PM_{2.5}$		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$			PM_{10}			$PM_{2.5}$		
	(tons)	(tons)	(miles)	(tons/mi)	(tons/mi)	(tons/m)	(tons/m)	(#/yr)	(m)	(lb/hr/m)	(lb/hr)	(tons)	(lb/hr/m)	(lb/hr)	(tons)
Water Hauling	1.59E-02	1.59E-03	2	7.95E-03	7.95E-04	4.94E-06	4.94E-07	56	900	3.52E-04	3.17E-01	8.89E-03	3.52E-05	3.17E-02	8.89E-04
Oil Hauling	9.10E-03	9.10E-04	2	4.55E-03	4.55E-04	2.83E-06	2.83E-07	37	900	3.10E-04	2.79E-01	5.09E-03	3.10E-05	2.79E-02	5.09E-04
									Total [2]	**6.62E-04**	**5.96E-01**	**1.40E-02**	**6.62E-05**	**5.96E-02**	**1.40E-03**
										2x	2x	2x	2x	2x	2x

[1] From detailed Oil Well Emission Spreadsheets describing vehicle types, vehicle weights, and distances traveled. Emissions would not occur during winter when roads are frozen. Pound/hr emissions are multiplied by 2 to account for seasonality. In AERMOD specify Nov, Dec, Jan, Feb, March, April with no emissions and no emissions during night.

[1] Assumes worst-case scenario that water hauling and oil hauling trips occur in the same hour.

Production Oil Tank Storage and Flashing Emission Calculations

Total Organic HAP Emissions [1]	(ton/yr)	1.77E-01
Total H2S Emissions [1]	(ton/yr)	---

Pollutant	Emission Rate	
	(lb/pad)	(lb/hr)
HAP	3.54E+02	4.04E-02

Pollutant	Emission Factor	Emission Rate		
	(g/g HAP)	(lb/pad)	(lb/hr)	(tpy)
Benzene [2]	0.062	2.21E+01	2.52E-03	1.10E-02
Toluene [2]	0.079	2.80E+01	3.20E-03	1.40E-02
Ethyl Benzene [2]	0.003	1.05E+00	1.20E-04	5.26E-04
Xylene [2]	0.035	1.23E+01	1.40E-03	6.14E-03
Formaldehyde [2]	-	-	-	-
Hexane [2]	0.821	2.91E+02	3.32E-02	1.45E-01
H_2S	-	---	---	---

[1] From detailed Oil Well Emission Spreadsheets.
[2] Based on oil composition provided in Oil Well Emission Spreadsheets.

Production Flaring Emission Calculations

Duration [1]	(days/year)	365
Gas Flared	(MMscf/day) [1]	0.02
	(MMscf/yr)	7.67
Flare Operating Time	(hr/day) [1]	24
Flare Capacity [2]	(Mscf/hr)	10
Heat Content [3]	(Btu/scf)	994
Fuel Sulfur Content [3]	(gr/scf)	-
Sulfur Conversion	(%)	98%
Firing Rate [4]	(MMBtu/hr)	10
	(MMBtu/completion)	7619

Pollutant	Emission Factor		Emission Rate	
			(lb/hr)	(tpy)
NO_x [5]	0.068	(lb/MMBtu)	0.68	2.6E-01
CO [5]	0.37	(lb/MMBtu)	3.70	1.4E+00
SO_2 [3]	-	(lb/MMBtu)	-	-
PM_{10} [6,7,8]	40.0	(μg/L)	0.26	1.0E-01
Benzene [9]	0.159	(lb/MMscf)	1.6E-03	6.1E-04
Toluene [9]	0.058	(lb/MMscf)	5.8E-04	2.2E-04
Ethylbenzene [9]	1.444	(lb/MMscf)	1.4E-02	5.5E-03
Xylene [9]	0.029	(lb/MMscf)	2.9E-04	1.1E-04
Formaldehyde [9]	1.169	(lb/MMscf)	1.2E-02	4.5E-03
n-Hexane [9]	0.029	(lb/MMscf)	2.9E-04	1.1E-04
H_2S [3]	-	(lb/MMBtu)	-	-

[1] Assumptions provided by Charles Laakso (BLM).
[2] Capacity (Mscf/hr) = Gas Flared (MMscf/day) x 1000 (Mscf/MMscf)
3 Median gas composition analysis from Charles Laakso (BLM)GHG Analysis (URS 2010); gas assumed to contain no sulfur.
[4] Hourly Firing rate = Gas flared x Heat Content round up to the nearest 10 MMBtu/hr; annual firing rate based on annual gas flared
[5] USEPA AP-42 Ch. 13.5 *Industrial Flares* dated 9/91
[6] USEPA AP-42 Ch. 13.5 *Industrial Flares* dated 9/91 for light smoking flares.
[7] E_{PM10} (lb/hr) = Gas Flared (scf gas/hr) x 10.6 (scf E/scf gas) x 0.0283 (m^3/scf E) x 40 (μg/L) x 1000 ($L/m^{3)}$ / 10^6 (μg/g) / 453.5924 (g/lb)
[8] E_{PM10} (tpy) = Gas Flared (MMscf gas/yr) x 10^6 (scf gas/MMscf gas) x 10.6 (scf E/scf gas) x 0.0283 (m^3/scf E) x 40 (μg/L) x 1000 ($L/m^{3)}$ / 10^6 (μg/g) / 453.5924 (g/lb) /2000 (lb/ton)
[9] Ventura County Air Pollution Control District, Natural Gas Fired External Combustion Equipment, flare, dated May 17, 2001.

Appendix G

Near-Field Modeling Results

Table G-1. Criteria Pollutant Concentrations G-2

Table G-2. Hazardous Air Pollutant Concentrations G-4

Table G-3. HAP Carcinogenic Risk Assessment G-5

Table G-1. Criteria Air Pollutant Concentrations

Pollutant	Avg. Time	Scenario	Back-ground (µg/m³)	Results (µg/m³) 2005 Modeled	2005 Total	2006 Modeled	2006 Total	2007 Modeled	2007 Total	2008 Modeled	2008 Total	2009 Modeled	2009 Total	5-Year Results (µg/m³) Maximum or Average Modeled	Total Concentration (with Background) Average	Total Concentration (with Background) Maximum	Thresholds and Standards (µg/m³) PSD Class I	PSD Class II	NAAQS	MAAQS	Percentages PSD Class I	PSD Class II	NAAQS	MAAQS
CO [1]	1-hr (H2H)	Completion	7,213	229	7,341	229	7,442	235	7,448	212	7,425	218	7,431	235		7,448			40000	26450			19%	28%
		Construction	7,213	98	7,311	99	7,312	99	7,312	99	7,312	99	7,312	99		7,312			40000	26450			18%	28%
		Drilling	7,213	310	7,523	306	7,519	318	7,531	320	7,533	321	7,534	321		7,534			40000	26450			19%	28%
	8-hr (H2H)	Completion	2,175	128	2,195	133	2,308	135	2,311	111	2,286	143	2,318	143		2,318			10000				23%	
		Construction	2,175	56	2,231	63	2,238	62	2,237	54	2,229	62	2,237	63		2,238			10000				22%	
		Drilling	2,175	229	2,404	219	2,394	211	2,386	231	2,406	210	2,385	231		2,406			10000				24%	
NO_2 [1, 2, 3, 4]	1-hr NBC (H8H, w/o ARM)	Completion		19.8		19.6		19.8		19.6		20.0												
		Construction		117.1		114.8		111.2		104.8		112.8												
		Drilling		57.3		56.4		56.5		54.3		55.2												
	1-hr w/ 0.80 ARM (H8H)	Completion	40	15.8	55.8	15.7	55.7	15.9	55.9	15.7	55.7	16.0	56.0	15.8	55.8				188				30%	
		Construction	40	93.7	133.7	91.8	131.8	89.0	129.0	83.8	123.8	90.3	130.3	89.7	129.7				188				69%	
		Drilling	40	45.8	85.8	45.1	85.1	45.2	85.2	43.5	83.5	44.1	84.1	44.8	84.8				188				45%	
	Annual w/o ARM	Completion		0.367		0.319		0.300		0.272		0.286												
		Construction		0.367		0.319		0.300		0.272		0.285												
		Drilling		0.370		0.321		0.304		0.277		0.288												
	Annual with 0.75 ARM	Completion	6	0.276	6.276	0.239	6.239	0.225	6.225	0.204	6.204	0.214	6.214	0.28		6.3	2.5	25	100	94	11%	1%	6%	7%
		Construction	6	0.275	6.275	0.239	6.239	0.225	6.225	0.204	6.204	0.214	6.214	0.28		6.3	2.5	25	100	94	11%	1%	6%	7%
		Drilling	6	0.277	6.277	0.241	6.241	0.228	6.228	0.208	6.208	0.216	6.216	0.28		6.3	2.5	25	100	94	11%	1%	6%	7%
PM_{10} [1]	24-hr (H2H, over 5 years)	Completion	30	26.24	56.24	27.04	57.04	29.52	59.52	33.90	63.90	35.81	65.81	30.5	60.5		8	30	150	---	381%	102%	40%	
		Construction	30	113.86	143.86	112.41	142.41	100.08	130.08	104.71	134.71	108.77	138.77	108.0	138.0		8	30	150	---	1350%	360%	92%	
		Drilling	30	11.91	41.91	11.38	30.06	29.52	59.52	33.89	63.89	35.66	65.66	24.5	52.2		8	30	150	---	306%	82%	35%	
	Annual	Completion	8	0.065	8.065	0.062	8.062	0.060	8.060	0.064	8.064	0.059	8.059	0.1		8.1	4	17		50	2%	0%		16%
		Construction	8	0.608	8.608	0.613	8.613	0.610	8.610	0.548	8.548	0.564	8.564	0.6		8.6	4	17		50	15%	4%		17%
		Drilling	8	0.064	8.064	0.061	8.061	0.058	8.058	0.063	8.063	0.059	8.059	0.1		8.1	4	17		50	2%	0%		16%

Table G-1. Criteria Air Pollutant Concentrations (Cont.)

Pollutant	Avg. Time	Scenario	Back-ground (µg/m³)	Results (µg/m³) 2005 Modeled	2005 Total	2006 Modeled	2006 Total	2007 Modeled	2007 Total	2008 Modeled	2008 Total	2009 Modeled	2009 Total	5-Year Results (µg/m³) Maximum or Average Modeled	Total Concentration (with Background) Average	Total Concentration (with Background) Maximum	Thresholds and Standards (µg/m³) PSD Class I	PSD Class II	NAAQS	MAAQS	Percentages PSD Class I	PSD Class II	NAAQS	MAAQS
$PM_{2.5}$ [1]	24-hr [5] (H8H)	Completion	22.5	2.00	24.50	2.20	24.70	2.09	24.59	2.28	24.78	2.19	24.69	2.2	24.7				35				70%	
		Construction	22.5	9.62	32.12	10.56	33.06	8.91	31.41	7.40	29.90	9.73	32.23	9.2	31.7				35				91%	
		Drilling	22.5	3.45	25.95	3.49	25.99	3.13	25.63	3.11	25.61	3.47	25.97	3.3	25.8				35				74%	
	24-hr (H2H, PSD only)	Completion		2.94		2.78		2.83		2.76		3.08		3.1			2	9			154%	34%		
		Construction		14.10		14.05		12.62		13.12		14.20		14.2			2	9			710%	158%		
		Drilling		5.65		4.97		4.46		4.28		5.50		5.6			2	9			282%	63%		
	Annual	Completion	5.5	0.07	5.57	0.07	5.57	0.06	5.56	0.07	5.57	0.06	5.56	0.07	5.57		1	4	15		7%	2%	37%	
		Construction	5.5	0.85	6.35	0.87	6.37	0.87	6.37	0.84	6.34	0.89	6.39	0.86	6.36		1	4	15		86%	22%	42%	
		Drilling	5.5	0.08	5.58	0.07	5.57	0.06	5.56	0.07	5.57	0.06	5.56	0.07	5.57		1	4	15		7%	2%	37%	
SO_2 [1]	1-hr (99th %, 5-yr avg) (H4H)	Completion	35	0.37	35.37	0.36	35.36	0.34	35.34	0.35	35.35	0.35	35.35	0.4	35.4				196				18%	
		Construction	35	3.36	38.36	3.51	38.51	3.30	38.30	3.15	38.15	3.35	38.35	3.3	38.3				196				20%	
		Drilling	35	0.67	35.67	0.69	35.69	0.69	35.69	0.67	35.67	0.67	35.67	0.7	35.7				196				18%	
	24-hr (H2H)	Completion	11	0.085	11.085	0.100	11.100	0.088	11.088	0.072	11.072	0.105	11.105	0.11		11.1	5	91	365	262	2%	0%		4%
		Construction	11	0.584	11.584	0.584	11.584	0.516	11.516	0.516	11.516	0.575	11.575	0.58		11.6	5	91	365	262	12%	1%		4%
		Drilling	11	0.253	11.253	0.238	11.238	0.238	11.238	0.218	11.218	0.253	11.253	0.25		11.3	5	91	365	262	5%	0%		4%
	Annual	Completion	3	0.00028	3.00028	0.00024	3.00024	0.00026	3.00026	0.00023	3.00023	0.00022	3.00022	2.80E-04		3.0	2	20	80	52	0%	0%		6%
		Construction	3	0.00065	3.00065	0.00065	3.00065	0.00069	3.00069	0.00065	3.00065	0.00063	3.00063	6.90E-04		3.0	2	20	80	52	0%	0%		6%
		Drilling	3	0.00112	3.00112	0.00110	3.00110	0.00098	3.00098	0.00102	3.00102	0.00103	3.00103	1.12E-03		3.0	2	20	80	52	0%	0%		6%

[1] Default concentrations for all pollutants except CO were provided by MDEQ in an emailed memorandum from Vickie Walsh to Susan Bassett (BLM) dated July 12, 2012. Ambient CO concentrations are based on 2009-2011 monitoring data from the Billings St. Luke's monitor (30-111-0085).

[2] Tier 2 Ambient Ratio Method (ARM) modeling was performed for the 1-hour NO_2 standard. Modeled concentrations were multipled by a NO_2-to-NO_x ratio of 0.80 to estimated 1-hr NO_2 concentrations ("Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard", Tyler Fox of EPA, March 1, 2011).

[3] Tier 2 ARM modeling was performed for the annual NO_2 standard. Modeled concentrations were mulitplied by a NO_2-to-NO_x ratio of 0.75 ratio to estimate annual concentrations ("Guidance Concerning the Implementation of the 1-hour NO2 NAAQS for the Prevention of Significant Deterioration Program", Stephen D. Page of EPA, June 29, 2010).

[4] Total concentration (modeled plus background) was determined using default hourly background NO_2 concentrations recommended by the MDEQ. These concentrations are considered by MDEQ to be more conservative than the values calculated from available monitoring data (due to incomplete monitoring data for several years).

[5] Based on a January 15, 2013 final rule (78 *Federal Register* 3086), the annual $PM_{2.5}$ NAAQS will decrease from 15 µg/m³ to 12 µg/m³ on March 18, 2013.

Table G-2. Hazardous Air Pollutant Concentrations

Pollutant	Avg. Time	Scenario	Modeled Concentration (μg/m³) 2005	2006	2007	2008	2009	Maximum Modeled (μg/m³)	Maximum Modeled (mg/m³)	Threshold Type	Threshold Value (mg/m³)	Maximum Percentage of Threshold
Benzene	1-hr	Completion	0.766	0.763	0.738	0.756	0.758	7.66E-01	7.66E-04	REL	1.3	0.059%
		Construction	1.291	1.351	1.345	1.332	1.368	1.37E+00	1.37E-03	REL	1.3	0.105%
		Drilling	0.766	0.763	0.738	0.756	0.758	7.66E-01	7.66E-04	REL	1.3	0.059%
	Annual	Completion	0.021	0.022	0.025	0.025	0.019	2.47E-02	2.47E-05	RfC	0.03	0.082%
		Construction	0.021	0.022	0.025	0.021	0.019	2.47E-02	2.47E-05	RfC	0.03	0.082%
		Drilling	0.021	0.022	0.025	0.021	0.019	2.47E-02	2.47E-05	RfC	0.03	0.082%
Ethyl Benzene	1-hr	Completion	2.907	2.866	2.869	2.891	2.877	2.91E+00	2.91E-03	REL	350.0	0.001%
		Construction	2.907	2.866	2.869	2.891	2.877	2.91E+00	2.91E-03	REL	350.0	0.001%
		Drilling	2.907	2.866	2.869	2.891	2.877	2.91E+00	2.91E-03	REL	350.0	0.001%
	Annual	Completion	0.064	0.060	0.056	0.057	0.055	6.43E-02	6.43E-05	RfC	1.0	0.006%
		Construction	0.064	0.060	0.056	0.057	0.055	6.42E-02	6.42E-05	RfC	1.0	0.006%
		Drilling	0.064	0.060	0.056	0.057	0.055	6.42E-02	6.42E-05	RfC	1.0	0.006%
Formalde-hyde	1-hr	Completion	1.386	1.369	1.440	1.273	1.359	1.44E+00	1.44E-03	REL	0.055	2.618%
		Construction	7.484	7.480	7.495	7.475	7.488	7.49E+00	7.49E-03	REL	0.055	13.627%
		Drilling	1.918	1.934	1.942	1.981	1.983	1.98E+00	1.98E-03	REL	0.055	3.606%
	Annual	Completion	0.018	0.016	0.016	0.014	0.014	1.82E-02	1.82E-05	RfC	0.0098	0.186%
		Construction	0.018	0.016	0.016	0.014	0.014	1.82E-02	1.82E-05	RfC	0.0098	0.186%
		Drilling	0.018	0.016	0.016	0.014	0.014	1.83E-02	1.83E-05	RfC	0.0098	0.187%
n-Hexane	1-hr	Completion	9.978	9.976	9.945	9.846	9.876	9.98E+00	9.98E-03	REL	390.0	0.003%
		Construction	9.978	9.936	9.625	9.846	9.876	9.98E+00	9.98E-03	REL	390.0	0.003%
		Drilling	9.978	9.936	9.625	9.846	9.876	9.98E+00	9.98E-03	REL	390.0	0.003%
	Annual	Completion	0.315	0.329	0.360	0.301	0.282	3.60E-01	3.60E-04	RfC	0.7	0.051%
		Construction	0.253	0.263	0.293	0.249	0.224	2.93E-01	2.93E-04	RfC	0.7	0.042%
		Drilling	0.253	0.263	0.293	0.249	0.224	2.93E-01	2.93E-04	RfC	0.7	0.042%
Toluene	1-hr	Completion	0.968	0.964	0.933	0.956	0.958	9.68E-01	9.68E-04	REL	37.0	0.003%
		Construction	0.972	1.040	1.032	1.008	1.054	1.05E+00	1.05E-03	REL	37.0	0.003%
		Drilling	0.968	0.964	0.933	0.956	0.958	9.68E-01	9.68E-04	REL	37.0	0.003%
	Annual	Completion	0.026	0.027	0.030	0.025	0.023	2.99E-02	2.99E-05	RfC	5	0.001%
		Construction	0.026	0.027	0.030	0.025	0.023	2.99E-02	2.99E-05	RfC	5	0.001%
		Drilling	0.026	0.027	0.030	0.026	0.023	3.00E-02	3.00E-05	RfC	5	0.001%
Xylene	1-hr	Completion	0.428	0.427	0.413	0.423	0.425	4.28E-01	4.28E-04	REL	22.0	0.002%
		Construction	0.672	0.706	0.703	0.695	0.715	7.15E-01	7.15E-04	REL	22.0	0.003%
		Drilling	0.428	0.427	0.413	0.423	0.425	4.28E-01	4.28E-04	REL	22.0	0.002%
	Annual	Completion	0.012	0.011	0.014	0.012	0.011	1.43E-02	1.43E-05	RfC	0.1	0.014%
		Construction	0.012	0.013	0.014	0.012	0.011	1.43E-02	1.43E-05	RfC	0.1	0.014%
		Drilling	0.012	0.012	0.014	0.012	0.011	1.43E-02	1.43E-05	RfC	0.1	0.014%

Background concentrations are not included due to lack of data.

Table G-3. HAP Carcinogenic Risk Assessment

Pollutant	Analysis	Year	Annual Maximum Modeled (µg/m^3)	Carcinogenic Unit Risk Factor (µg/m^3)$^{-1}$	Exposure Adjustment Factor	Cancer Risk (per million)
Benzene	MLE	2005	2.15E-02	7.8E-06	0.0949	0.02
		2006	2.22E-02	7.8E-06	0.0949	0.02
		2007	2.47E-02	7.8E-06	0.0949	0.02
		2008	2.47E-02	7.8E-06	0.0949	0.02
		2009	1.89E-02	7.8E-06	0.0949	0.01
	MEI	2005	2.15E-02	7.8E-06	0.71	0.12
		2006	2.22E-02	7.8E-06	0.71	0.12
		2007	2.47E-02	7.8E-06	0.71	0.14
		2008	2.47E-02	7.8E-06	0.71	0.14
		2009	1.89E-02	7.8E-06	0.71	0.10
Ethyl Benzene	MLE	2005	6.43E-02	2.5E-06	0.0949	0.02
		2006	6.01E-02	2.5E-06	0.0949	0.01
		2007	5.58E-02	2.5E-06	0.0949	0.01
		2008	5.72E-02	2.5E-06	0.0949	0.01
		2009	5.49E-02	2.5E-06	0.0949	0.01
	MEI	2005	6.43E-02	2.5E-06	0.71	0.11
		2006	6.01E-02	2.5E-06	0.71	0.11
		2007	5.58E-02	2.5E-06	0.71	0.10
		2008	5.72E-02	2.5E-06	0.71	0.10
		2009	5.49E-02	2.5E-06	0.71	0.10
Formaldehyde	MLE	2005	1.83E-02	1.3E-05	0.0949	0.02
		2006	1.58E-02	1.3E-05	0.0949	0.02
		2007	1.60E-02	1.3E-05	0.0949	0.02
		2008	1.42E-02	1.3E-05	0.0949	0.02
		2009	1.41E-02	1.3E-05	0.0949	0.02
	MEI	2005	1.83E-02	1.3E-05	0.71	0.17
		2006	1.58E-02	1.3E-05	0.71	0.15
		2007	1.60E-02	1.3E-05	0.71	0.15
		2008	1.42E-02	1.3E-05	0.71	0.13
		2009	1.41E-02	1.3E-05	0.71	0.13

MEI = Maximally exposed individual.
MLE = Most likely exposure.
Background concentrations are not included due to lack of data.

Appendix H

Example AERMOD Input File

1-hr NO_2 Well Drilling Scenario 2009 Modeled Year

```
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 7.6.1
** Lakes Environmental Software Inc.
** Date: 9/22/2012
** File: C:\Lakes\AERMOD View\MCFO\2009\MCFO 2009 Drilling NO2 1-hr\MCFO 2009
Drilling NO2 1-hr.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE MCFO 2009 Drilling NO2 1-hr
   MODELOPT CONC FLAT
   AVERTIME 1
   POLLUTID NO2
   RUNORNOT RUN
** Error File Path: C:\Lakes\AERMOD View\MCFO\2009\MCFO 2009 Drilling NO2 1-
hr\
   ERRORFIL "MCFO 2009 Drilling NO2 1-hr.err"
CO FINISHED
**
****************************************
** AERMOD Source Pathway
****************************************
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION DRM1         POINT           0.000       10.000          0.0
** DESCRSRC Drill Rig Main 1
   LOCATION DRM2         POINT           0.000        0.000          0.0
** DESCRSRC Drill Rig Main 2
   LOCATION DRM3         POINT           0.000      -10.000          0.0
** DESCRSRC Drill Rig Main 3
   LOCATION DRA          POINT         -10.000      -10.000          0.0
** DESCRSRC Drill Rig Auxiliary
   LOCATION DRG1         POINT         -10.000       10.000          0.0
** DESCRSRC Drill Rig Generator 1
   LOCATION PPJ1         POINT        -990.000      990.000          0.0
** DESCRSRC Pumpjack Engine NW Pad
   LOCATION PPJ2         POINT         990.000      990.000          0.0
** DESCRSRC Pumpjack Engine NE Pad
   LOCATION PPJ3         POINT         990.000     -990.000          0.0
** DESCRSRC Pumpjack Engine SE Pad
   LOCATION PPJ4         POINT        -990.000     -990.000          0.0
** DESCRSRC Pumpjack Engine SW Pad
   LOCATION PH1          POINT       -1010.000     1010.000          0.0
```

```
** DESCRSRC Production Heater NW
   LOCATION PH2          POINT        1010.000     1010.000          0.0
** DESCRSRC Production Heater NE
   LOCATION PH3          POINT        1010.000    -1010.000          0.0
** DESCRSRC Production Heater SE
   LOCATION PH4          POINT       -1010.000    -1010.000          0.0
** DESCRSRC Production Heater SW
   LOCATION DRB          POINT          10.000        0.000          0.0
** DESCRSRC Drill Rig Boilder
   LOCATION DRG2         POINT         -10.000        0.000          0.0
** DESCRSRC Drill Rig Generator 2
   LOCATION PF1          POINT       -1000.000     1010.000          0.0
** DESCRSRC Production Flare NW
   LOCATION PF2          POINT        1000.000     1010.000          0.0
** DESCRSRC Production Flare NE
   LOCATION PF3          POINT        1000.000    -1010.000          0.0
** DESCRSRC Production Flare SE
   LOCATION PF4          POINT       -1000.000    -1010.000          0.0
** DESCRSRC Production Flare SW
** Source Parameters **
   SRCPARAM DRM1             0.139     6.100   700.000  25.00000     0.380
   SRCPARAM DRM2             0.139     6.100   700.000  25.00000     0.380
   SRCPARAM DRM3             0.139     6.100   700.000  25.00000     0.380
   SRCPARAM DRA               0.05     6.100   700.000  25.00000     0.380
   SRCPARAM DRG1            0.0125     3.800   560.000  10.00000     0.150
   SRCPARAM PPJ1            0.0111     3.800   560.000  10.00000     0.200
   SRCPARAM PPJ2            0.0111     3.800   560.000  10.00000     0.200
   SRCPARAM PPJ3            0.0111     3.800   560.000  10.00000     0.200
   SRCPARAM PPJ4            0.0111     3.800   560.000  10.00000     0.200
   SRCPARAM PH1           6.98E-06     4.600   425.000   7.30000     0.200
   SRCPARAM PH2           6.98E-06     4.600   425.000   7.30000     0.200
   SRCPARAM PH3           6.98E-06     4.600   425.000   7.30000     0.200
   SRCPARAM PH4           6.98E-06     4.600   425.000   7.30000     0.200
   SRCPARAM DRB             0.0504     3.800   425.000   5.00000     0.200
   SRCPARAM DRG2            0.0125     3.800   560.000  10.00000     0.150
   SRCPARAM PF1             0.0857     0.380  1273.000  10.00000     0.380
   SRCPARAM PF2             0.0857     0.380  1273.000  10.00000     0.380
   SRCPARAM PF3             0.0857     0.380  1273.000  10.00000     0.380
   SRCPARAM PF4             0.0857     0.380  1273.000  10.00000     0.380
   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
** DESCRREC "" ""
   DISCCART     -2000.00      2000.00
   DISCCART     -1900.00      2000.00
   DISCCART     -1800.00      2000.00
   DISCCART     -1700.00      2000.00
   DISCCART     -1600.00      2000.00
```

[Remaining discrete receptors are not shown in order to save paper. All receptors can be seen in the AERMOD input file.]

```
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
**
ME STARTING
** Surface File Path: C:\MET Data\
   SURFFILE "..\..\..\..\..\MET Data\SDY_09.SFC"
** Profile File Path: C:\MET Data\
   PROFFILE "..\..\..\..\..\MET Data\SDY_09.PFL"
   SURFDATA 94028 2009
   UAIRDATA 94008 2009 GLASGOW/INT'L_ARPT
   PROFBASE 588.6 METERS
ME FINISHED
**
****************************************
** AERMOD Output Pathway
****************************************
**
**
OU STARTING
   RECTABLE ALLAVE 1ST 8TH
   RECTABLE 1 1ST 8TH
** Auto-Generated Plotfiles
** Plotfile Path: C:\Lakes\AERMOD View\MCFO\2009\MCFO 2009 Drilling NO2 1-
hr\MCFO 2009 DRILLING NO2 1-HR.AD\
   PLOTFILE 1 ALL 1ST 01H1GALL.PLT 31
   PLOTFILE 1 ALL 8TH 01H8GALL.PLT 32
   FILEFORM EXP
   SUMMFILE "MCFO 2009 Drilling NO2 1-hr.sum"
OU FINISHED
**
****************************************
** Project Parameters
****************************************
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse Mercator
** DATUM    World Geodetic System 1984
** DTMRGN   Global Definition
** UNITS    m
** ZONE     11
** ZONEINX  0
**
```