BLM

U.S. Department of the Interior

Bureau of Land Management

Draft Billings and Pompeys Pillar National Monument Resource Management Plan (RMP) and Environmental Impact Statement (EIS)

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

March 27, 2013

This page intentionally left blank.

Table of Contents

1.0 Introduction 1
1.1 Scope of the Emission Inventories 1
1.2 AERMOD Modeling 2
1.3 Limits of the Analysis 2
1.4 Document Organization 3
2.0 Emission Inventory Development 4
2.1 Alternative-Specific Emission Inventories 4
2.1.1 Emission Sources 4
2.1.2 Alternative-Specific Emissions 8
2.2 Emission Inventory for Near-field Modeling 13
3.0 Near-Field Modeling Methodology 14
3.1 Model Versions and Options 14
3.2 Meteorological Data and Processing 14
3.3 Modeling Domain and Receptor Locations 14
3.4 Modeled Scenarios 15
3.5 Emission Source Release Parameters 16
3.6 Background Concentrations and Ambient Air Quality Standards 17
4.0 Near-Field Modeling Results 19
4.1 Criteria Air Pollutants 19
4.2 Hazardous Air Pollutants 22
5.0 Bibliography 25

List of Figures

Figure 1. Example Well Pad and Receptor Layout for Construction Scenario 15
Figure 2. Extent of 24-hour PM_{10} Concentrations Above PSD Increments During Well Pad Construction (2010) 22

List of Tables

Table 1. Pollutants Included in Emission Inventories 1
Table 2. Summary of Well Numbers and Production Rates 5
Table 3. Summary of Drilling and Completion Equipment 7
Table 4. Alternative A Criteria Pollutant and HAP Emissions 9
Table 5. Alternative A GHG Emissions 9
Table 6. Alternative B Criteria Pollutant and HAP Emissions 10
Table 7. Alternative B GHG Emissions 10
Table 8. Alternative C Criteria Pollutant and HAP Emissions 11

List of Tables (cont.)

Table 9. Alternative C GHG Emissions 11
Table 10. Alternative D Criteria Pollutant and HAP Emissions 12
Table 11. Alternative D GHG Emissions 12
Table 12. Modeling Meteorology Data Stations 14
Table 13. Release Parameters for Emission Sources 16
Table 14. Background Concentration Data 17
Table 15. Federal and State Ambient Air Quality Standards for Modeled Pollutants 18
Table 16. Near-Field NAAQS Summary for All Alternatives 20
Table 17. Acute Short-term HAP Concentrations for All Alternatives 23
Table 18. Chronic Non-carcinogenic HAP Modeling Results for All Alternatives 23
Table 19. Carcinogenic HAP Modeling Results for All Alternatives 24

Appendices

Appendix A Alternative A Emission Inventory A-1
Appendix B Alternative B Emission Inventory B-1
Appendix C Alternative C Emission Inventory C-1
Appendix D Alternative D Emission Inventory D-1
Appendix E AERMOD Near-Field Emission Inventory E-1
Appendix F Near-Field Emission Modeling Results F-1
Appendix G Example AERMOD Input File G-1

Acronyms

AERMIC	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee
API	American Petroleum Institute
ARM	Ambient ratio method
ARMP	Air Resource Management Plan
ARTSD	Air Resource Technical Support Document
AQRV	Air quality related value
bbl/day	Barrels per day
BiFO	Billings Field Office
BLM	Bureau of Land Management
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
Mtpy	Metric tons per year
NAAQS	National Ambient Air Quality Standards
N_2O	Nitric oxide
NO_2	Nitrogen dioxide

Acronyms (cont.)

NO_x	Nitrogen oxides
PM_{10}	Particulate matter with a diameter less than or equal to 10 microns
$PM_{2.5}$	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
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 *Billings and Pompeys Pillar National Monument Resource Management Plan (RMP) 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 for the Billings Field Office (BiFO).

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 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–D. 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-D). 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 will 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 personnel representing the BiFO. Information was also provided by personnel from the Miles City Field Office (MCFO). The first type of emission inventory is the alternative-specific inventory. Alternative-specific inventories were developed for each of the four 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 and natural gas wells)
- General Purpose BLM Fleet Travel
- BLM Road Maintenance
- Coal Mining
- Fire Management
- Forestry and Woodland Products
- Livestock Grazing
- Recreation and Visitor Services
- Vegetation Management

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 mineral estate. These oil and gas emissions were used for the cumulative emission impact assessment.

Detailed calculations are provided in Appendices A, B, C, and D 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, BLM road travel and livestock grazing 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 the potential for additional well drilling and production 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 oil and conventional natural gas wells. Table 2 summarizes estimates of new oil and gas wells that could potentially be developed under the alternatives as described in the Draft RMP/EIS (BLM 2013). Each of the alternatives includes the same level of potential oil and gas activity over the life of the RMP.

Table 2. Summary of Well Numbers and Production Rates

Well Type	Mineral Estate	Alternatives A, B, C, and D	
		Oil	Natural Gas
Peak Number of Annual Wells Drilled	Federal	3	1
	Non-federal	*12*	*4*
Maximum Producing Wells (Year 20)	Federal	60	20
	Non-federal	*240*	*80*
Average Daily Oil Production (bbl/day)	Federal	20	---
	Non-federal	*20*	---
Average Daily Gas Production (MCFD)	Federal	---	40
	Non-federal	---	*40*

bbl/day = barrels per day
MCFD = thousand cubic feet per day

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 D 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. 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 (ARMP), which is an appendix to the Draft RMP/EIS (BLM 2013).

1. Roads and well pads would be constructed to reduce the amount of fugitive dust generated by traffic or other activities. 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).

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.

3. 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.

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
Natural Gas Wells						
Rig-up, Drilling, and Rig-down						
Main Deck	400	3	70	24	15	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

2.1.1.2 General Purpose BLM Fleet Travel

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

2.1.1.3 BLM 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.

2.1.1.4 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 the Signal Peak Energy, LLC mine 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 were not included in the MDEQ air quality permit, GHG emissions were estimated based on fuel usage and engine horsepower data.

2.1.1.5 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 11 emission summaries include smoke emissions from prescribed burns only. The detailed emission calculations in the appendices include smoke emissions from all fires.

2.1.1.6 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 included surface disturbance, wind erosion, and vehicle travel on unpaved roads.

2.1.1.7 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.

2.1.1.8 Recreation and Visitor Services

Emissions associated with recreation and visitor services included engine exhaust and fugitive dust from passenger vehicles, motorcycles, and all-terrain vehicles. Off-road vehicle use and travel on unpaved roads were included in the fugitive dust emission inventory.

2.1.1.9 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.

2.1.2 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 and detailed calculations are provided in Appendix A. GHG emission estimates for these activities are provided in Table 5. 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

Resource or Resource Use	Emissions (tons per year)						
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAP
Oil and Gas Activity							
Oil	67.4	30.5	241.1	0.1	11.9	4.1	15.2
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3
Oil and Gas Subtotal	**78.2**	**35.1**	**244.3**	**0.1**	**13.9**	**2.8**	**15.5**
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0
Coal Mining	11.3	23.7	1.2	0.0	29.9	3.0	—
Fire Management [1]	433.2	19.4	23.2	3.9	55.7	38.0	13.3
Forestry Management	0.6	0.8	0.1	0.0	2.9	0.3	0.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1
Vegetation Management	2.9	0.0	0.7	0.0	13.7	1.4	0.1
BLM Emission Total	536.6	80.7	271.1	4.0	488.2	83.0	29.1

[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	5,248.8	38.6	0.0	7,107.3	6,446.3
Natural Gas	1,044.1	13.9	0.0	1,333.0	1,209.0
Oil and Gas Subtotal	**7,328.9**	**52.5**	**0.0**	**8,440.3**	**7,655.3**
BLM Travel	85.6	0.0	0.0	89.0	80.7
BLM Road Maintenance	60.4	0.0	0.0	60.6	55.0
Coal Mining	274.4	0.0	0.0	274.4	248.9
Fire Management [1]	309,072.5	154.6	31.3	322,494.4	292,502.4
Forestry Management	94.1	0.0	0.0	94.5	85.7
Livestock Grazing	73.5	272.8	0.0	5,803.8	5,264.1
Recreation and Visitor Services	106.4	0.0	0.0	118.5	107.5
Vegetation Management	10.2	0.0	0.0	10.5	9.5
BLM Emission Total	**317,105.9**	**479.9**	**31.4**	**337,386.1**	**306,009.2**

[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 summarized in Table 6 and Table 7, with detailed calculations provided in Appendix B. Emissions for the following resources are the same as those for Alternative A: oil and gas management, general purpose BLM fleet travel, BLM road maintenance, coal mining, livestock grazing, and recreation and visitor services.

Table 6. Alternative B Criteria Pollutant and HAP Emissions

	Emissions (tons per year)						
Resource or Resource Use	**CO**	**NO_x**	**VOC**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**HAP**
Oil and Gas Activity							
Oil	67.4	30.5	241.1	0.1	11.9	4.1	15.2
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3
Oil and Gas Subtotal	**78.2**	**35.1**	**244.3**	**0.1**	**13.9**	**2.8**	**15.5**
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0
Coal Mining	11.3	23.7	1.2	0.0	29.9	3.0	—
Fire Management [1]	1,475.6	48.5	76.5	11.9	172.7	129.0	18.7
Forestry Management	0.9	1.2	0.1	0.0	6.3	0.7	0.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1
Vegetation Management	0.5	0.0	0.1	0.0	2.3	0.2	0.0
BLM Emission Total	1,577.0	110.2	323.8	12.0	597.4	173.1	34.4

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

Table 7. Alternative B GHG Emissions

	Emission (tpy)				
Resource or Resource Use	**CO_2**	**CH_4**	**N_2O**	**CO_2e**	**CO_2e (mtpy)**
Oil and Gas Activity					
Oil	5,248.8	38.6	0.0	7,107.3	6,446.3
Natural Gas	1,044.1	13.9	0.0	1,333.0	1,209.0
Oil and Gas Subtotal	**7,328.9**	**52.5**	**0.0**	**8,440.3**	**7,655.3**
BLM Travel	85.6	0.0	0.0	89.0	80.7
BLM Road Maintenance	60.4	0.0	0.0	60.6	55.0
Coal Mining	274.4	0.0	0.0	274.4	248.9
Fire Management 1	309,076.8	209.8	39.3	326,137.0	295,806.3
Forestry Management	148.9	0.0	0.0	149.7	135.8
Livestock Grazing	73.5	272.8	0.0	5,803.8	5,264.1
Recreation and Visitor Services	106.4	0.0	0.0	118.5	107.5
Vegetation Management	1.7	0.0	0.0	1.8	1.6
BLM Emission Total	**317,156.6**	**535.1**	**39.4**	**341,075.2**	**309,355.2**

[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, with detailed calculations provided in Appendix C. Emissions for the following resources are the same as those for Alternatives A and B: oil and gas management, general purpose BLM fleet travel, BLM road maintenance, coal mining, livestock grazing, and recreation and visitor services.

Table 8. Alternative C Criteria Pollutant and HAP Emissions

Resource or Resource Use	Emissions (tons per year)						
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAP
Oil and Gas Activity							
Oil	67.4	30.5	241.1	0.1	11.9	4.1	15.2
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3
Oil and Gas Subtotal	**78.2**	**35.1**	**244.3**	**0.1**	**13.9**	**2.8**	**15.5**
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0
Coal Mining	11.3	23.7	1.2	0.0	29.9	3.0	—
Fire Management [1]	1,477.8	48.5	76.9	11.9	164.0	128.0	18.7
Forestry Management	1.4	1.9	0.2	0.0	15.4	1.7	0.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1
Vegetation Management	2.2	0.0	0.5	0.0	10.4	1.1	0.1
BLM Emission Total	1,581.4	110.9	324.7	12.0	605.8	174.0	34.5

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

Table 9. Alternative C GHG Emissions

Resource or Resource Use	Emission (tpy)				CO_2e (mtpy)
	CO_2	CH_4	N_2O	CO_2e	
Oil and Gas Activity					
Oil	5,248.8	38.6	0.0	7,107.3	6,446.3
Natural Gas	1,044.1	13.9	0.0	1,333.0	1,209.0
Oil and Gas Subtotal	**7,328.9**	**52.5**	**0.0**	**8,440.3**	**7,655.3**
BLM Travel	85.6	0.0	0.0	89.0	80.7
BLM Road Maintenance	60.4	0.0	0.0	60.6	55.0
Coal Mining	274.4	0.0	0.0	274.4	248.9
Fire Management [1]	309,080.4	209.8	39.3	326,140.6	295,809.5
Forestry Management	243.0	0.0	0.0	244.2	221.5
Livestock Grazing	73.5	272.8	0.0	5,803.8	5,264.1
Recreation and Visitor Services	106.4	0.0	0.0	118.5	107.5
Vegetation Management	7.8	0.0	0.0	8.0	7.2
BLM Emission Total	**317,260.3**	**535.1**	**39.4**	**341,179.5**	**309,449.8**

[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, with detailed calculations provided in Appendix D. Emissions for the following resources are the same as those for Alternatives A, B, and C: oil and gas management, general purpose BLM fleet travel, BLM road maintenance, coal mining, livestock grazing, and recreation and visitor services.

Table 10. Alternative D Criteria Pollutant and HAP Emissions

	Emissions (tons per year)						
Resource or Resource Use	**CO**	**NO_x**	**VOC**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**HAP**
Oil and Gas Activity							
Oil	67.4	30.5	241.1	0.1	11.9	2.4	15.2
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3
Oil and Gas Subtotal	**78.2**	**35.1**	**244.3**	**0.1**	**13.9**	**2.8**	**15.5**
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0
Coal Mining	11.3	23.7	1.2	0.0	29.9	3.0	—
Fire Management [1]	1,475.7	48.4	76.5	11.9	171.2	128.9	18.7
Forestry Management	1.2	1.5	0.2	0.0	10.3	1.1	0.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1
Vegetation Management	1.2	0.0	0.3	0.0	5.6	0.6	0.0
BLM Emission Total	1,578.0	110.5	324.0	12.0	603.1	173.8	34.4

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

Table 11. Alternative D GHG Emissions

	Emission (tpy)				CO_2e
Resource or Resource Use	**CO_2**	**CH_4**	**N_2O**	**CO_2e**	**(mtpy)**
Oil and Gas Activity					
Oil	5,248.8	38.6	0.0	7,107.3	6,446.3
Natural Gas	1,044.1	13.9	0.0	1,333.0	1,209.0
Oil and Gas Subtotal	**7,328.9**	**52.5**	**0.0**	**8,440.3**	**7,655.3**
BLM Travel	85.6	0.0	0.0	89.0	80.7
BLM Road Maintenance	60.4	0.0	0.0	60.6	55.0
Coal Mining	274.4	0.0	0.0	274.4	248.9
Fire Management [1]	309,060.3	209.8	39.3	326,120.3	295,791.1
Forestry Management	196.0	0.0	0.0	197.0	178.6
Livestock Grazing	73.5	272.8	0.0	5,803.8	5,264.1
Recreation and Visitor Services	106.4	0.0	0.0	118.5	107.5
Vegetation Management	4.2	0.0	0.0	4.3	3.9
BLM Emission Total	**317,189.6**	**535.1**	**39.4**	**341,108.2**	**309,385.2**

[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 has the same oil and gas potential development as Alternatives B, C, and D. The AERMOD emission inventory used similar emission calculation methods as those provided in Appendix A to determine annual emissions 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 E.

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.

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 12 provides identifying data for the meteorological monitoring stations used for the modeling. Five years of data from January 2007 through December 2011 were obtained for the Billings/Logan International Airport, Montana surface station site and the Great Falls, Montana upper air station site, as provided in the AERMOD modeling protocol (BLM 2012).

Table 12. Modeling Meteorology Data Stations

Surface Station				Upper Air Station			
Name	**WBAN**	**Latitude**	**Longitude**	**Name**	**WBAN**	**Latitude**	**Longitude**
Billings/Logan Intl. Airport, MT	24033	45.806	-108.542	Great Falls, MT	04102	47.45	-111.38

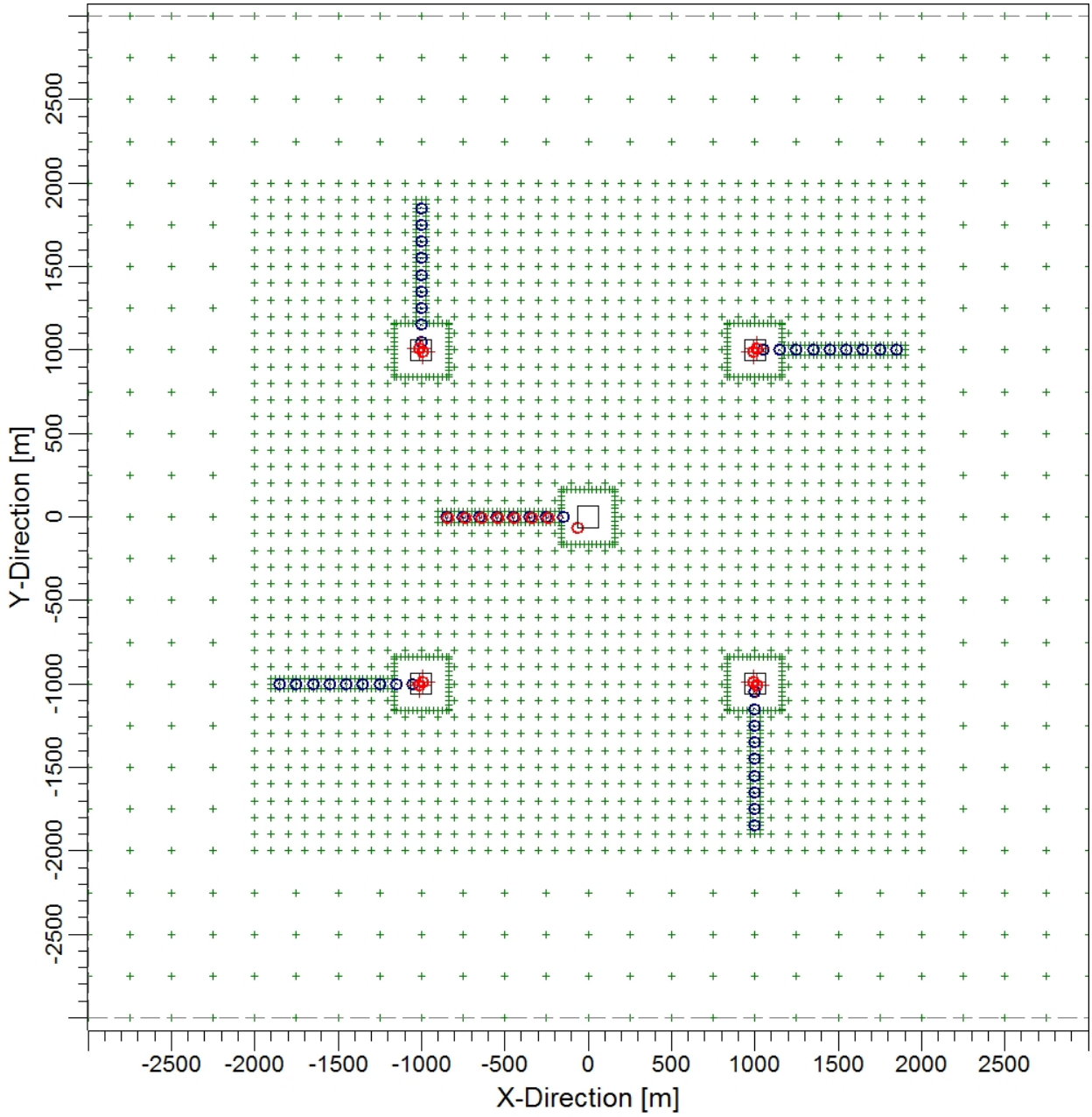
3.3 Modeling Domain and Receptor Locations

The modeling domain included five 2.1-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 two well types (oil and conventional natural gas). Near-field scenarios combined equipment from both types of wells. 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 combined oil and gas development in the planning area. It is not uncommon for an oil well to be located near a natural gas well. In order to perform conservative assessments, the highest-emitting equipment type was 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 equipment exhaust and fugitive dust.
- Drilling phase — A group of drill rig engines with the greatest horsepower, longest drilling time, and greatest emissions were modeled. Fugitive dust emissions from vehicles were also included.
- 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. Fugitive dust emissions from vehicle traffic were also modeled.
- Production phase — Equipment included a pumpjack engine and a heater at each well pad. Fugitive dust emissions from vehicles were also included.

3.5 Emission Source Release Parameters

Release parameters for emission sources are provided in Table 13.

Table 13. 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
Tanks	4.6	2.0	289	0.20
	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	---	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 MAAQS. 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 14 and reflect monitored values that can be compared directly to currently implemented NAAQS and MAAQS.

NAAQS and MAAQS are provided in Table 15. 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 14. 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	7,123	Yellowstone	30-011-0085
	8-hour	H2H	Maximum year	2009-2011	2,175	Yellowstone	30-011-0085
NO_2	1-hour	98th Percentile	3-year average	---	40 [2]	---	---
	Annual	H1H	Maximum year	---	6 [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 [2]	---	---
	3-hour	H2H	Maximum year	2010	---	---	---
	24-hour	H2H [3]	Maximum year	---	11 [2]	---	---
	Annual	H2H [3]	Maximum year	---	3 [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 15. Federal and State Ambient Air Quality Standards for Modeled Pollutants

Pollutant	Averaging Period	Federal NAAQS [1]			PSD Increments		MAAQS [2]
		Concentration µg/m^3 (ppb)	Standard Type	Form of NAAQS Primary Standard	Increment (Class I / Class II) µg/m^3	Form of Increment	Concentration µg/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	12 [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]

CO = carbon monoxide
H1H = highest-first-high
H2H = highest-second-high
µg/m^3 = micrograms per cubic meter
MAAQS = Montana Ambient Air Quality Standards
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] MAAQS 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 µg/m^3 to 12 µg/m^3 based on a three-year average. The revised standard became effective on March 18, 2013 and also included 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 16 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. 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 16. Near-field modeling represents dense well pad and equipment spacing that could occur in localized areas within high potential oil and gas activity areas.

Table 16 summarizes modeled results by showing the largest modeled and total concentrations based on the three scenarios and 5 years (2007 through 2011) of meteorological data. Additional modeling results are included in the Table F-1 of Appendix F, allowing comparisons by year and by modeled scenario. For example, the maximum total 1-hour CO concentration of 7,512 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 for all modeled scenarios, as shown by the percentages in the last column of Table 16.

Table 16. Near-Field NAAQS Summary for All Alternatives

Pollu-tant.	Avg. Period	Model Output Rank	Concentration (µg/m^3)						Percen-tage of NAAQS or MAAQS (%)
			Modeled Conc.	PSD Increment Class I	PSD Increment Class II	Back-ground Conc.[1]	Total Conc.	NAAQS or MAAQS	
CO	1-hour	H2H	299.4	None	None	7,213	7,512	26,450 [6]	28%
	8-hour	H2H	221.5	None	None	2,175	2,396	10,000	24%
NO_2	1-hour	H8H [2]	57.4	None	None	40	97	188	52%
	Annual	H1H [3]	0.32	2.5	25	6	6.3	94 [6]	7%
PM_{10}	24-hour	H2H	81.5	8	30	30	112	150	74%
	Annual	H1H	1.1	4	17	8	9.1	50 [6]	18%
$PM_{2.5}$	24-hour	H8H [4] (H2H)[7]	5.0	2	9	22.5	28	35	79%
	Annual	H1H [8]	0.15	1	4	5.5	5.65	12	47%
SO_2	1-hour	H4H [5]	11.6	None	None	35	46.6	196	24%
	24-hour	H2H [3]	0.41	5	91	11	11.4	365 [6]	4%
	Annual	H1H [2]	0.0004	2	20	3	3.0	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 Five-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 Five-year average of the 98th percentile (H8H) 24-hour modeled $PM_{2.5}$ concentrations.
5 Five-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.
8 Five-year average of the annual average concentration.

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.

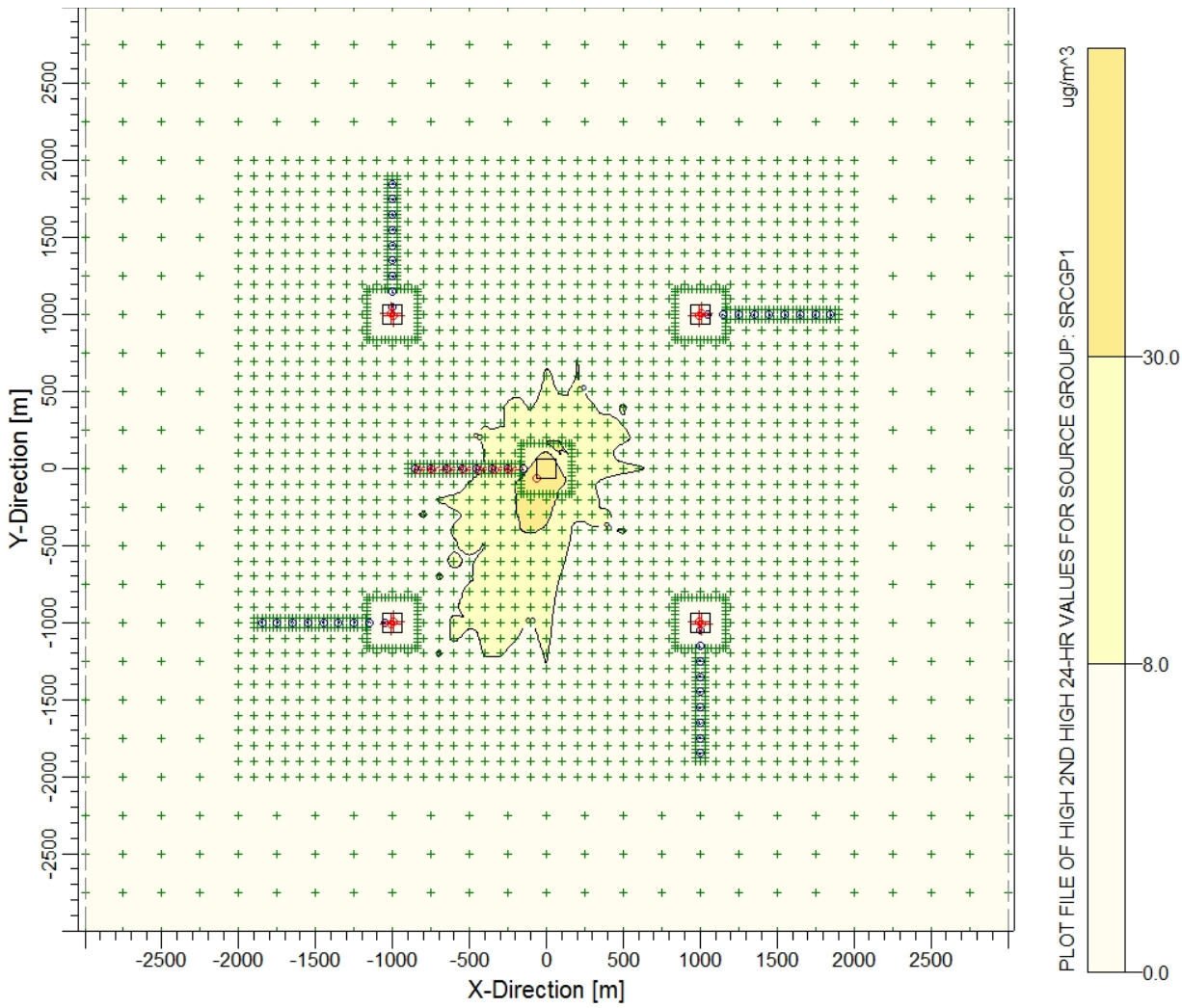
During construction activities, 24-hr PM_{10} concentrations greater than the Class I and Class II PSD increments were predicted to occur. For $PM_{2.5}$, 24-hour concentrations were predicted to be above Class I increments during construction, drilling, and completion, while $PM_{2.5}$ concentrations were predicted to be greater than Class II increments during construction activities only.

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 $\mu g/m^3$) or Class II increment (30 $\mu g/m^3$) on the day with the second-highest PM_{10} modeled concentration during 2010. Wells would be located in Class II areas and concentrations above the Class II PSD increment were predicted to extend up to approximately 120 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 1,000 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.

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.

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 was assumed to convert to NO_2 in the atmosphere. For the 1-hour NO_2 analysis, 80 percent conversion was assumed (EPA 2011b).

Figure 2. Extent of 24-hour PM_{10} Concentrations Above PSD Increments During Well Pad Construction (2010)



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. Unit Risk Factors (URFs) were used to determine incremental cancer risk for carcinogenic pollutants. Short-term (1-hour) concentrations were compared to acute RELs shown in Table 17. 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 17 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 F-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 17. Acute Short-term HAP Concentrations for All Alternatives

HAP	Modeled 1-Hour Concentration (µg/m^3)	Reference Exposure Levels (µg/m^3)	Percentage of Reference Exposure Level (%)
Benzene	1.08	1,300	<1%
Ethyl Benzene	0.17	350,000 [1]	<1%
Formaldehyde	5.70	55	10%
n-Hexane	10.36	390,000 [1]	<1%
Toluene	1.05	37,000	<1%
Xylene	0.56	22,000	<1%

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

Table 18 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 F-2.

Table 18. Chronic Non-carcinogenic HAP Modeling Results for All Alternatives

HAP	Modeled Annual Concentration (µg/m^3)	Reference Concentration (RfC) (µg/m^3)	Percentage of RfC (%)
Benzene	0.02	30	<0.1%
Ethyl Benzene	0.05	1,000	
Formaldehyde	0.03	10	
n-Hexane	0.25	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 URFs, which provide an upper bound excess probability of contracting cancer expressed per unit concentration (µg/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 19, with detailed results provided in Table F-3.

Table 19. 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	0.022	7.80×10-6	0.0949	0.02	No
Ethyl Benzene	0.050	2.50×10-6	0.0949	0.01	No
Formaldehyde	0.025	1.30×10-5	0.0949	0.03	No
Maximally Exposed Individual					
Benzene	0.022	7.80×10-6	0.71	0.12	No
Ethyl Benzene	0.050	2.50×10-6	0.71	0.09	No
Formaldehyde	0.025	1.30×10-5	0.71	0.23	No

5.0 BIBLIOGRAPHY

API 2009. Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. American Petroleum Institute (API). August. http://www.api.org/ehs/climate/new/upload/2009_ghg_compendium.pdf

BLM 2007. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (Fourth Edition), also known as the Gold Book. Bureau of Land Management (BLM). BLM/WO/ST-06/021+3071/REV 07.

BLM 2008 (SEIS). *Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans*. October.

BLM 2011a. Personal communication from Dustin Crowe (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). August 16.

BLM 2011b. Email from Tami Sabol (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). August 24.

BLM 2011c. Email from Tami Sabol (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). October 5.

BLM 2011d. Personal communication from Craig Drake (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). September 12.

BLM 2011e. Personal communication from Craig Drake (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). September 19.

BLM 2011f. Email from Bobby Flesch (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). August 28.

BLM 2011g. Personal Communication from Melissa Passes (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). September 20.

BLM 2011h. Personal Communication from Larry Padden (BLM Billings Field Office) to Susan Bassett (BLM Montana/Dakotas State Office). September 19.

BLM 2012. Near-Field Air Quality Assessment Protocol for Resource Management Plans and Environmental Impact Statements: Billings Field Office, HiLine District, Miles City Field Office, South Dakota Field Office. September 21.

BLM 2013. *Billings and Pompeys Pillar National Monument Draft RMP/EIS*. March.

EPA 1993a. *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure*. Preliminary Review Draft. U.S. Environmental Protection Agency (EPA). 1993.

EPA 1993b. User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions. U.S. Environmental Protection Agency (EPA). EPA/625/5-87/022.

EPA 1996. AP-42, Fifth Edition, Volume I. Chapter 13: Miscellaneous Sources. Section 13.1 Wildfires & Prescribed Burning (Supplement B), Table 13.1-1. U.S. Environmental Protection Agency (EPA). October.

EPA 1998a. AP-42, Fifth Edition, Volume I, Section 1.4, Natural Gas Combustion. U.S. Environmental Protection Agency (EPA). July.

EPA 1998b. AP-42, Fifth Edition, Volume I, Section 11.9, Western Surface Coal Mining. U.S. Environmental Protection Agency (EPA). October.

EPA 1998c. Control of Open Fugitive Dust Sources. U.S. Environmental Protection Agency (EPA). EPA-450/3-98-008. Section 4.1.3. September.

EPA 2006. AP 42, Fifth Edition, Volume I. U.S. Environmental Protection Agency (EPA). November.
Section 13.2.2, Unpaved Roads. Background Document.
Section 13.2.4, Aggregate Handling and Storage Piles.
Section 13.2.5, Industrial Wind Erosion.

EPA 2008. AP-42, Fifth Edition, Volume I. Section 5.2, Transportation and Marketing of Petroleum Liquids. U.S. Environmental Protection Agency (EPA). July.

EPA 2010a. Guidance Concerning the Implementation of the 1-hour NO_2 NAAQS for the Prevention of Significant Deterioration Program. U.S. Environmental Protection Agency (EPA) Memorandum from Stephen D. Page, Director, Office of Air Quality Planning and Standards to Regional Air Division Directors. June 29.

EPA 2010b. AP-42, Fifth Edition, Volume I, Section 13.2.3, Heavy Construction Operations. U.S. Environmental Protection Agency (EPA). Jan. 1995 (Errata February 2010).

EPA 2010c. AP-42, Fifth Edition, Volume I, Section 3.2, Natural Gas-fired Compressor Engines (Supplement F). U.S. Environmental Protection Agency (EPA). August.

EPA 2011a. *Acute Dose-Response Values for Screening Risk Assessments*, Table 2. U.S. Environmental Protection Agency (EPA). December 19, 2011. (http://www.epa.gov/ttn/atw/toxsource/table2.pdf).

EPA 2011b. *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard*. U.S. Environmental Protection Agency (EPA). Tyler Fox. March 1.

EPA 2012a. AirData website. U.S. Environmental Protection Agency. Accessed June 18, 2012. U.S. Environmental Protection Agency (EPA). http://www.epa.gov/airquality/airdata/.

EPA 2012b. *Prioritized Chronic Dose-Response Values.* Table 1. U.S. Environmental Protection Agency (EPA). May 21, 2012. http://www.epa.gov/ttn/atw/toxsource/table1.pdf.

GPO 2013a. National Ambient Air Quality Standards for Particulate Matter: Final Rule. U.S. Government Printing Office (GPO). 78 *Federal Register* (FR) 3086–3287. January 15.

GPO 2013b. 40 *Code of Federal Regulations (CFR)* Part 98: Mandatory Greenhouse Gas Reporting, Subpart C: General Stationary Fuel Combustion Sources. Tables C-1 and C-2. Last update was December 17, 2010 [75 *FR* 79153].

GPO 2013c. *Guideline on Air Quality Models*. U.S. Government Printing Office (GPO). 40 Code of Federal Regulations (CFR) Part 51, Appendix W. Accessed June 20, 2012. Last update was November 9, 2005.

GPO 2013d. 40 *Code of Federal Regulations (CFR)* Part 60: New Source Performance Standards, Subpart OOOO: Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution. U.S. Government Printing Office (GPO).

IPCC 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3, Reference Manual. Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

IPCC 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4, Agriculture, Forestry, and Other Land Use. Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

MDEQ 2009. Air Quality Permit #3179-04 for Signal Peak Energy, LLC. February 5.

MDEQ 2012a. Memorandum from Vickie Walsh (MDEQ) to Susan Bassett (BLM Montana/Dakotas State Office) dated July 12, 2012.

MDEQ 2012b. Email from Cyra Cain (MDEQ) to Susan Bassett (BLM Montana/Dakotas State Office) dated August 3, 2012.

MRI 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), Midwest Research Institute (MRI) Project No. 110397, November 1.

WRAP 2005. Final Report: 2002 Fire Emission Inventory for the WRAP Region - Phase II. Western Governors' Association, Western Regional Air Partnership (WRAP). July 22.

WRAP 2006. *WRAP Fugitive Dust Handbook*. Western Governors' Association, Western Regional Air Partnership (WRAP). September.

Appendix A

Alternative A Emission Inventory

Summary of Emissions A-1

Oil Development and Production A-2

Natural Gas Development and Production A-29

General Purpose BLM Fleet Travel A-55

BLM Road Maintenance A-58

Coal Mining A-61

Fire Management A-62

Forestry and Woodland Products A-67

Livestock Grazing A-72

Recreation and Visitor Services A-78

Vegetation Management A-81

Alternative A Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.5	241.1	0.1	11.9	2.4	15.2	6,284.8	38.6	0.0	7,107.3
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3	1,044.1	13.9	0.0	1,333.0
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining [1]	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management [2]	433.2	19.4	23.2	3.9	55.7	38.0	13.3	309,072.5	154.6	31.3	322,494.4
Forestry Management	0.6	0.8	0.1	0.0	2.9	0.3	0.0	94.1	0.0	0.0	94.5
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.9	0.0	0.7	0.0	13.7	1.4	0.1	10.2	0.0	0.0	10.5
Federal Emission Total	**536.6**	**80.7**	**271.1**	**4.0**	**488.2**	**83.0**	**29.1**	**317,105.9**	**479.9**	**31.4**	**337,386.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	52.1	14.3	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.4	28.7	13.1	0.2	9.0	2.2	1.3	4,168.8	55.6	0.0	5,321.4
Non-Federal Emission Total	**293.3**	**236.3**	**981.9**	**2.1**	**61.0**	**16.5**	**62.7**	**29,330.3**	**209.8**	**0.1**	**33,752.8**

tpy = short tons per year

[1] To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. $PM_{2.5}$ emissions are assumed to be 10 percent of PM_{10} emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

[2] Excludes 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	54,931	16,068	8,949	8,147	32,692	4,533
Alt. A (%) of NEI Emissions	1.0%	0.5%	3.0%	0.05%	1.5%	1.8%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. A (%) without Mine Emissions	1.0%	0.4%	3.0%	0.0%	1.4%	1.8%

Oil Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	3	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	12
Federal Producing Wells - RMP Year 20	60	Non-Federal Producing Wells - RMP Year 20	240
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

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

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternatives A, B, C, and D

	Annual Emissions (Tons)											
Activity	**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	0.09	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.08	0.08	1.59	0.02	8.23	0.44	0.04	1644.77	0.02	0.02	1650.94	1498.13
Commuting Vehicles - Construction	5.68	0.58	0.15	0.00	0.18	0.06	0.01	40.04	0.00	0.00	40.93	37.14
Wind Erosion	0.04	0.01	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**5.88**	**0.67**	**1.74**	**0.02**	**8.41**	**0.50**	**0.05**	**1,684.81**	**0.02**	**0.02**	**1,691.88**	**1,535.28**
Well Workover Operations - Fugitive Dust	0.30	0.03	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.02	0.02	0.36	0.01	3.10	0.17	0.02	630.45	0.01	0.01	632.87	574.29
Well Workover Operations - On-road Exhaust	0.00	0.00	0.03	0.00	0.06	0.02	0.002	7.44	0.00	0.00	7.65	6.94
Well Visits for Inspection & Repair - Operations	0.66	0.07	0.01	0.00	0.21	0.01	0.001	4.10	0.00	0.00	4.59	4.16
Recompletion Traffic	0.53	0.06	0.06	0.00	0.10	0.04	0.00	15.10	0.00	0.00	15.49	14.05
Water Tanks & Traffic	1.53	0.18	0.40	0.00	0.26	0.05	0.01	117.63	6.86	0.00	262.01	237.76
Oil Tanks & Traffic	0.98	0.12	0.26	0.00	0.17	212.18	12.23	87.42	24.18	0.00	595.45	540.34
Venting	---	---	---	---	---	2.34	0.19	0.08	2.93	0.00	61.53	55.83
Compression and Well Pumps	1.22	1.22	27.52	0.02	55.04	19.26	1.93	3,713.41	0.07	0.01	3717.06	3373.01
Dehydrators	0.00	0.00	0.00	0.00	0.00	6.31	0.78	4.08	4.22	0.00	92.80	84.21
Compression Station Fugitives	---	---	---	---	---	0.21	0.02	0.01	0.26	0.00	5.55	5.04
Sub-total: Operations	**5.25**	**1.69**	**28.65**	**0.03**	**58.92**	**240.59**	**15.18**	**4,579.70**	**38.54**	**0.02**	**5,394.99**	**4,895.64**
Road Maintenance	0.58	0.06	0.13	0.003	0.06	0.02	0.002	16.39	0.00	0.00	16.49	14.96
Sub-total: Maintenance	**0.58**	**0.06**	**0.13**	**0.003**	**0.06**	**0.02**	**0.002**	**16.391**	**0.000**	**0.00**	**16.49**	**14.96**
Road Reclamation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.13	0.12
Well Reclamation	0.14	0.02	0.02	0.00	0.02	0.00	0.00	3.82	0.00	0.00	3.84	3.48
Sub-total: Reclamation	**0.14**	**0.02**	**0.02**	**0.0007**	**0.02**	**0.003**	**0.0003**	**3.9514**	**0.0001**	**0.0001**	**3.9715**	**3.6039**
Total Emissions	**11.85**	**2.44**	**30.54**	**0.05**	**67.41**	**241.12**	**15.23**	**6,284.85**	**38.56**	**0.04**	**7,107.33**	**6,449.48**

Oil Wells - Alternatives A, B, C, and D

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternatives A, B, C, and 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	0.34	0.03	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	3.22	3.14	61.28	1.27	15.85	4.48	0.45	6601.19	0.07	0.02	6608.46	5996.79
Commuting Vehicles - Construction	22.71	2.31	0.61	0.00	0.73	0.25	0.03	160.16	0.01	0.00	161.15	146.24
Wind Erosion	0.18	0.03	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**26.45**	**5.51**	**61.90**	**1.28**	**16.58**	**4.74**	**0.47**	**6,761.35**	**0.07**	**0.02**	**6,769.61**	**6,143.03**
Well Workover Operations - Fugitive Dust	1.22	0.12	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	1.81	1.76	31.87	0.54	10.71	2.31	0.23	2521.79	0.04	0.03	2531.46	2297.15
Well Workover Operations - On-road Exhaust	0.01	0.01	0.13	0.00	0.23	0.09	0.009	29.76	0.00	0.00	30.59	27.76
Well Visits for Inspection & Repair - Operations	2.65	0.27	0.04	0.00	0.82	0.04	0.004	16.40	0.00	0.01	18.35	16.65
Recompletion Traffic	2.11	0.22	0.25	0.00	0.40	0.16	0.02	60.38	0.00	0.00	61.94	56.21
Water Tanks & Traffic	6.12	0.73	1.61	0.01	1.02	0.21	0.02	470.50	27.45	0.00	1048.06	951.05
Oil Tanks & Traffic	3.93	0.47	1.05	0.01	0.66	848.73	48.92	349.66	96.73	0.00	2381.81	2161.35
Venting	---	---	---	---	---	9.35	0.76	0.30	11.71	0.00	246.12	223.34
Compression and Well Pumps	4.88	4.88	110.08	0.07	220.16	77.06	7.71	14,853.66	0.28	0.03	14868.23	13492.04
Dehydrators	0.00	0.00	0.01	0.00	0.01	25.23	3.13	16.30	16.90	0.00	371.19	336.84
Compression Station Fugitives	---	---	---	---	---	0.84	0.08	0.03	1.06	0.00	22.21	20.16
Sub-total: Operations	**22.72**	**8.46**	**145.05**	**0.63**	**234.02**	**964.01**	**60.87**	**18,318.79**	**154.16**	**0.08**	**21,579.96**	**19,582.54**
Road Maintenance	2.32	0.25	0.52	0.014	0.24	0.07	0.007	65.56	0.00	0.00	65.97	59.86
Sub-total: Maintenance	**2.32**	**0.25**	**0.52**	**0.014**	**0.24**	**0.07**	**0.007**	**65.564**	**0.001**	**0.00**	**65.97**	**59.86**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	0.48
Well Reclamation	0.56	0.07	0.06	0.00	0.07	0.01	0.00	15.28	0.00	0.00	15.36	13.94
Sub-total: Reclamation	**0.58**	**0.07**	**0.06**	**0.0028**	**0.07**	**0.014**	**0.0014**	**15.8057**	**0.0003**	**0.0002**	**15.8859**	**14.4155**
Total Emissions	**52.07**	**14.29**	**207.53**	**1.93**	**250.91**	**968.83**	**61.36**	**25,161.51**	**154.24**	**0.10**	**28,431.42**	**25,799.84**

Oil Wells - Alternatives A, B, C, and D

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	1.5	0.8	1	1.5	8.80E+00	8.80E-01	4.40E-03	4.40E-04
Well Pad and other structures	3.0	2.2	1	3.0	4.84E+01	4.84E+00	2.42E-02	2.42E-03
			Total		**5.72E+01**	**5.72E+00**	**2.86E-02**	**2.86E-03**

Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

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
Well Pad	Blade	150	1	75	10	3	30	1	36.09	4.24	0.97	29.32	3.72	0.02	0.00	0.00	0.01	0.00	0.00	2.21	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	**3.83E-02**	**3.69E-03**	**1.04E-03**	**2.17E-02**	**3.48E-03**	**4.59E-03**	**4.97E+00**	**6.30E-05**	**5.05E-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	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. EPA NONROADS 2008a (Year 2008) 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	39	9	4,622	249	0.44	0.02	0.00	2.31	0.12	0.02	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**	**2.16E-02**	**5.23E-03**	**2.72E+00**	**1.43E-01**	**2.16E-02**	**5.43E+02**	**5.60E-03**	**6.20E-03**
													Total	**5.29E-01**	**2.53E-02**	**6.27E-03**	**2.74E+00**	**1.47E-01**	**2.62E-02**	**5.48E+02**	**5.66E-03**	**6.26E-03**

Oil Wells - Alternatives A, B, C, and D

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	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.47	0.000	0.000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.58	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	**5.33E-02**	**5.46E-03**	**1.44E-03**	**3.39E-02**	**5.03E-03**	**6.30E-03**	**6.81E+00**	**8.64E-05**	**6.93E-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	**5.11E+00**	**2.69E-01**	**1.06E-01**	**1.32E+00**	**3.74E-01**	**2.62E-01**	**5.50E+02**	**5.69E-03**	**6.27E-03**

Oil Wells - Alternatives A, B, C, and D

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 (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	6	47	282	1	0.54	151.07	0.08	0.08	0.05	15.11	0.01	0.01
	Pickup Trucks	5	6	3	18	1	0.21	3.70	0.00		0.02	0.37	0.00	
Well Pad	Semi Trucks	42	6	5	30	1	0.54	16.07	0.01	0.01	0.05	1.61	0.00	0.00
	Pickup Trucks	5	6	4	24	1	0.21	4.93	0.00		0.02	0.49	0.00	
Other Construction Activities	Semi Trucks	42	6	2	12	1	0.54	6.43	0.00	0.01	0.05	0.64	0.00	0.00
	Haul Trucks	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
	Pickup Trucks	5	6	1	6	1	0.21	1.23	0.00		0.02	0.12	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	6	44	264	1	0.54	141.43	0.07	0.17	0.05	14.14	0.01	0.02
	Fuel Haul Truck	25	6	6	36	1	0.42	15.27	0.01		0.04	1.53	0.00	
	Mud Haul Truck, Water Hauling	25	6	4	24	1	0.42	10.18	0.01		0.04	1.02	0.00	
	Rig Crew	5	6	51	306	1	0.21	62.91	0.03		0.02	6.29	0.00	
	Rig Mechanics	5	6	2	12	1	0.21	2.47	0.00		0.02	0.25	0.00	
	Co. Supervisor	5	6	20	120	1	0.21	24.67	0.01		0.02	2.47	0.00	
	Tool Pusher	25	6	8	48	1	0.42	20.36	0.01		0.04	2.04	0.00	
	Mud Logger	25	6	6	36	1	0.42	15.27	0.01		0.04	1.53	0.00	
	Mud Engineer	25	6	15	90	1	0.42	38.18	0.02		0.04	3.82	0.00	
	Logger, Engr Truck	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Drill Bit Delivery	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	6	6	36	1	0.54	19.29	0.01	0.03	0.05	1.93	0.00	0.00
	Semi Completion, Unit Rig	42	6	1	6	1	0.54	3.21	0.00		0.05	0.32	0.00	
	Semi Fracing, Blender	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	0.42	15.27	0.01		0.04	1.53	0.00	
	Tubing Truck	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
									Subtotal	**2.89E-01**				**2.89E-02**

Oil Wells - Alternatives A, B, C, and D

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	40	3	120	1	0.42	50.90	0.03		0.04	5.09	0.00	
	Haul Completion,	25	40	3	120	1	0.42	50.90	0.03		0.04	5.09	0.00	
	Haul Service Tools	25	40	2	80	1	0.42	33.93	0.02		0.04	3.39	0.00	
	Haul Perforators Logging Truck	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Anchor, Installation	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Anchor, Testing	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Fracing, Tank	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Fracing, Pump	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Fracing, Chemical	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Fracing, Sand	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Fracing, Other	25	40	1	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Haul Welders	25	40	6	240	1	0.42	101.80	0.05		0.04	10.18	0.01	
	Haul Water Truck	25	40	150	6000	1	0.42	2,545.05	1.27	1.60	0.04	254.50	0.13	0.16
	Pickup Cementer, Engineer	5	40	2	80	1	0.21	16.45	0.01		0.02	1.64	0.00	
	Pickup Casing Crew	5	40	2	80	1	0.21	16.45	0.01		0.02	1.64	0.00	
	Pickup Completion Crew	5	40	5	200	1	0.21	41.12	0.02		0.02	4.11	0.00	
	Pickup Completion, Pusher	5	40	5	200	1	0.21	41.12	0.02		0.02	4.11	0.00	
	Pickup Perforators, Engineer	5	40	2	80	1	0.21	16.45	0.01		0.02	1.64	0.00	
	Pickup Fracing, Engineer	5	40	1	40	1	0.21	8.22	0.00		0.02	0.82	0.00	
	Pickup Co. Supervisor	5	40	10	400	1	0.21	82.24	0.04		0.02	8.22	0.00	
	Pickup Miscellaneous Supplies	5	40	3	120	1	0.21	24.67	0.01		0.02	2.47	0.00	
	Pickup Roustabout Crew	5	40	4	160	1	0.21	32.89	0.02		0.02	3.29	0.00	
									Subtotal	**1.60E+00**				**1.60E-01**
									Total	**1.89E+00**				**1.89E-01**

Oil Wells - Alternatives A, B, C, and D

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	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007	0.006	0.001	0.000	0.000	0.004	0.001	1.6	0.0001	0.0001
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.001	0.001	0.2	0.0000	0.0000
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.1	0.0000	0.0000
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Trucks	LDDT	40	1	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
																		Subtotal	**7.52E-03**	**7.18E-04**	**5.98E-04**	**3.46E-05**	**6.45E-03**	**1.84E-03**	**2.10E+00**	**9.21E-05**	**1.28E-04**

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	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007	0.02	0.00	0.00	0.00	0.03	0.01	1.5	0.0001	0.0001
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Tool Pusher	LDDT	40	8	320	1	1.6310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.0000	0.0000
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.0000	0.0000
	Mud Engineer	LDDT	40	15	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.0000	0.0000
	Logger, Engr Truck	HDDV	40	1	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
	Drill Bit Delivery	LDDT	40	2	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

Oil Wells - Alternatives A, B, C, and D

Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.03	0.00	0.00	0.00	0.02	0.01	0.2	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	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
	Semi Fracing, Blender	HDDV	40	1	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
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	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
	Haul Perforators Logging Truck	HDDV	40	1	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
	Haul Anchor, Installation	HDDV	40	1	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
	Haul Anchor, Testing	HDDV	40	1	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
	Haul Fracing, Tank	HDDV	40	1	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
	Haul Fracing, Pump	HDDV	40	1	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
	Haul Fracing, Chemical	HDDV	40	1	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
	Haul Fracing, Sand	HDDV	40	1	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
	Haul Fracing, Other	HDDV	40	1	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
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0180	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.0002	0.0003
	Pickup Cementer, Engineer	LDDT	40	2	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
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	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
	Pickup Perforators, Engineer	LDDT	40	2	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
	Pickup Fracing, Engineer	HDDV	40	1	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
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																	Subtotal		**4.36E-02**	**3.72E-03**	**3.09E-03**	**1.81E-04**	**5.42E-02**	**1.93E-02**	**1.12E+01**	**4.30E-04**	**7.97E-04**
																	Total		**5.11E-02**	**4.44E-03**	**3.69E-03**	**2.15E-04**	**6.07E-02**	**2.11E-02**	**1.33E+01**	**5.22E-04**	**9.25E-04**

Oil Wells - Alternatives A, B, C, and D

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 (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	84%	Based on gravel or scoria surfacing per the BLM Gold Book[a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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: **6** 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	6	1	6	1	0.54	3.21	0.00	0.05	0.32	0.00
	Haul Truck	42	6	1	6	1	0.54	3.21	0.00	0.05	0.32	0.00
	Pickup Truck	5	6	3	18	1	0.21	3.70	0.00	0.02	0.37	0.00
								Total	**5.06E-03**			**5.06E-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	0.02	0.0051	2.60	0.14	0.02	529.58	0.007	0.006

Source: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) 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**	**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	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

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).

Oil Wells - Alternatives A, B, C, and D

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 (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	50%	Based on watering

[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: **6** 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	6	1	6	1	1.67	10.04	0.01	0.17	1.00	0.00
	Haul Truck	42	6	1	6	1	1.67	10.04	0.01	0.17	1.00	0.00
	Pickup Truck	5	6	3	18	1	0.64	11.56	0.01	0.06	1.16	0.00
								Total	**1.58E-02**			**1.58E-03**

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	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

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).

Oil Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

Assumption:
Frequency of visit: once/week/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/20 wells = **2.5** 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	2.5	52	130	1	0.17	22.10	**1.11E-02**	0.02	2.21	**1.10E-03**

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	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Oil Wells - Alternatives A, B, C, and D

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 (BLM 2008).
[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.

Oil Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	40	1.0	40	0.17	6.80	**3.40E-03**	0.02	0.68	**3.39E-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	40	1.0	40	**1.02E-04**	**4.79E-06**	**3.90E-06**	**2.47E-07**	**2.75E-04**	**1.21E-04**	**1.81E-02**	**8.82E-08**	**2.34E-06**

Oil Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	6	56	337	1	0.15	49.61	**2.48E-02**	0.01	4.95	**2.47E-03**

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	40	56	2246	1	13.449	1.363	1.137	0.065	8.522	1.753	**6.72E-03**	**6.81E-04**	**5.69E-04**	**3.27E-05**	**4.26E-03**	**8.76E-04**	**1.96E+00**	**9.16E-05**	**1.50E-05**

Oil Wells - Alternatives A, B, C, and D

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**

Benzene (tpy/well)	Ethyl-benzene (tpy/well)	n-Hexane (tpy/well)	Toluene (tpy/well)	Xylenes (tpy/well)
1.10E-02	**7.96E-05**	**2.20E-02**	**2.12E-03**	**9.28E-04**

[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	VOC 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**

Benzene (tpy/well)	Ethyl-benzene (tpy/well)	n-Hexane (tpy/well)	Toluene (tpy/well)	Xylenes (tpy/well)
1.67E-03	**7.96E-05**	**2.20E-02**	**2.12E-03**	**9.28E-04**

[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 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		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*
[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.

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emission Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Well	Total # of Wells	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lb/well)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/well)	$PM_{2.5}$ Emissions (tpy)
Produced Oil Hauling	Haul Truck (200 bbl)	30	2	37	73	1	0.44	31.86	0.02	0.04	3.17	0.00
								Total	**0.02**			**0.00**

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 Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/ Well	Total # of Wells	Emissions (lb/well) 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
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	40	37	1460	1	8.742	0.886	0.739	0.042	5.539	1.139	0.0044	0.0004	0.0004	0.0000	0.0028	0.0006	1.274	0.000	0.000
						TOTAL							**4.37E-03**	**4.43E-04**	**3.70E-04**	**2.12E-05**	**2.77E-03**	**5.70E-04**	**1.27E+00**	**5.95E-05**	**9.74E-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)

Oil Wells - Alternatives A, B, C, and D

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 (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	6	6	36	1	0.42	15.27	0.01	0.17	0.04	1.53	0.00	0.02
	Mud Haul Truck, Water Hauling	25	6	4	24	1	0.42	10.18	0.01		0.04	1.02	0.00	
	Rig Crew	5	6	51	306	1	0.21	62.91	0.03		0.02	6.29	0.00	
	Rig Mechanics	5	6	1	6	1	0.21	1.23	0.00		0.02	0.12	0.00	
	Co. Supervisor	5	6	20	120	1	0.21	24.67	0.01		0.02	2.47	0.00	
	Semi Completion, Unit Rig	42	6	1	6	1	0.54	3.21	0.00		0.05	0.32	0.00	
	Semi Fracing, Blender	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	0.42	15.27	0.01		0.04	1.53	0.00	
	Tubing Truck	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
	Haul Cementer, Cement Truck	25	6	3	18	1	0.42	7.64	0.00		0.04	0.76	0.00	
	Haul Completion,	25	6	3	18	1	0.42	7.64	0.00		0.04	0.76	0.00	
	Haul Service Tools	25	6	2	12	1	0.42	5.09	0.00		0.04	0.51	0.00	
	Haul Perforators Logging Truck	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Fracing, Tank	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Fracing, Pump	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Fracing, Chemical	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Fracing, Sand	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Fracing, Other	25	6	1	6	1	0.42	2.55	0.00		0.04	0.25	0.00	
	Haul Water Truck	25	6	50	300	1	0.42	127.25	0.06		0.04	12.73	0.01	
	Pickup Cementer, Engineer	5	6	2	12	1	0.21	2.47	0.00		0.02	0.25	0.00	
	Pickup Casing Crew	5	6	5	30	1	0.21	6.17	0.00		0.02	0.62	0.00	
	Pickup Completion, Pusher	5	6	5	30	1	0.21	6.17	0.00		0.02	0.62	0.00	
	Pickup Perforators, Engineer	5	6	2	12	1	0.21	2.47	0.00		0.02	0.25	0.00	
	Pickup Fracing, Engineer	5	6	1	6	1	0.21	1.23	0.00		0.02	0.12	0.00	
	Pickup Co. Supervisor	5	6	10	60	1	0.21	12.34	0.01		0.02	1.23	0.00	
	Pickup Miscellaneous Supplies	5	6	3	18	1	0.21	3.70	0.00		0.02	0.37	0.00	
	Pickup Roustabout Crew	5	6	4	24	1	0.21	4.93	0.00		0.02	0.49	0.00	
									Subtotal	**1.74E-01**				**1.74E-02**
									Total	**1.74E-01**				**1.74E-02**

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

Oil Wells - Alternatives A, B, C, and D

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	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.02	0.00	0.00	0.00	0.03	0.01	0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	1	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
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	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
	Semi Fracing, Blender	HDDV	40	1	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
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	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
	Haul Perforators Logging Truck	HDDV	40	1	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
	Haul Fracing, Tank	HDDV	40	1	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
	Haul Fracing, Pump	HDDV	40	1	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
	Haul Fracing, Chemical	HDDV	40	1	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
	Haul Fracing, Sand	HDDV	40	1	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
	Haul Fracing, Other	HDDV	40	1	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
	Haul Water Truck	HDDV	40	50	2000	1	11.9753	1.2134	1.0128	0.0582	7.5882	1.5608	0.0060	0.0006	0.0005	0.0000	0.0038	0.0008							1.7	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	40	2	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
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	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
	Pickup Perforators, Engineer	LDDT	40	2	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
	Pickup Fracing, Engineer	HDDV	40	1	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
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																	Subtotal		**2.11E-02**	**1.61E-03**	**1.33E-03**	**7.87E-05**	**3.34E-02**	**1.30E-02**	**5.03E+00**	**1.63E-04**	**4.08E-04**
																	Total		**2.11E-02**	**1.61E-03**	**1.33E-03**	**7.87E-05**	**3.34E-02**	**1.30E-02**	**5.03E+00**	**1.63E-04**	**4.08E-04**

Oil Wells - Alternatives A, B, C, and D

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).

Oil Wells - Alternatives A, B, C, and D

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

Oil Wells - Alternatives A, B, C, and D

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**

Oil Wells - Alternatives A, B, C, and D

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 [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	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	4.88E-03	7.32E-04
								TOTAL	**1.46E-02**	**2.20E-03**

[a] Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

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 (BLM 2008).

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.250
Number of Roads Reclaimed Annually Per Well	0.153
Annual Miles of Roads Reclaimed Per Well	0.038
Number of wells reclaimed (per well)	0.153

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

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.038	6	0.0064	0.0639
		Total	**0.0639**

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 Reclamation

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	0.038	5	0.192	0.765	**7.33E-05**	0.069	**6.64E-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

[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 Reclamation

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	0.038	0.4238	0.0720	0.0197	0.4106	0.0629	**8.12E-06**	**1.38E-06**	**3.77E-07**	**7.87E-06**	**1.20E-06**	**1.34E-06**	**2.08E-03**	**1.87E-08**	**2.05E-08**

Oil Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book[a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	0.0064	0.0383	0.170	**3.26E-06**	0.017	**3.25E-07**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation 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 Reclamation 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	40	0.0064	0.2556	**6.51E-07**	**3.06E-08**	**2.49E-08**	**1.58E-09**	**1.76E-06**	**7.74E-07**	**1.15E-04**	**5.63E-10**	**1.49E-08**

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	0.153	10	0.153	1.53

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

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

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	0.9200	5	4.600	0.765	**1.76E-03**	0.069	**1.59E-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.

Exhaust Emissions Estimation for Grader: Well Reclamation

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
Well Reclamation	Grader	100	0.9200	0.5297	0.0900	0.0246	0.5132	0.0786	**2.44E-04**	**4.14E-05**	**1.13E-05**	**2.36E-04**	**3.61E-05**	**6.43E-05**	**6.09E-02**	**1.01E-06**	**6.14E-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	40	0.1533	6.1333	0.170	**5.21E-04**	0.017	**5.20E-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	40	0.1533	6.1333	**1.56E-05**	**7.35E-07**	**5.98E-07**	**3.79E-08**	**4.22E-05**	**1.86E-05**	**2.77E-03**	**1.35E-08**	**3.58E-07**

Oil Wells - Alternatives A, B, C, and D

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

Natural Gas Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D, B, C, and D input parameters for calculating Natural Gas well emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	4
Federal Producing Wells - RMP Year 20	20	Non-Federal Producing Wells - RMP Year 20	80
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

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

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternatives A, B, C, and D

	Annual Emissions (Tons)											
Activity	**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	0.04	0.00	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.01	0.01	0.19	0.00	1.24	0.07	0.01	240.82	0.00	0.00	241.71	219.34
Commuting Vehicles - Construction	0.89	0.09	0.05	0.00	0.06	0.02	0.00	13.35	0.00	0.00	13.64	12.38
Wind Erosion	0.02	0.00	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.02	0.00	0.01	2.27	0.00	47.62	43.21
Sub-total: Construction	**0.95**	**0.11**	**0.24**	**0.00**	**1.30**	**0.11**	**0.01**	**254.17**	**2.27**	**0.00**	**302.97**	**274.93**
Well Workover Operations - Fugitive Dust	0.17	0.02	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.01	0.01	0.12	0.00	1.03	0.06	0.01	210.43	0.00	0.00	211.20	191.65
Well Workover Operations - On-road Exhaust	0.00	0.00	0.01	0.00	0.02	0.01	0.001	2.48	0.00	0.00	2.55	2.31
Well Visits for Inspection & Repair - Operations	0.22	0.02	0.00	0.00	0.07	0.00	0.000	1.37	0.00	0.00	1.53	1.39
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.05	0.01	0.02	7.07	0.00	148.59	134.84
Compression	0.18	0.18	4.13	0.00	8.27	2.89	0.29	557.85	0.01	0.00	558.40	506.71
Station Visits - Operations	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.13
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.02	4.54	0.00	98.27	89.18
Sub-total: Operations	**0.61**	**0.23**	**4.27**	**0.00**	**9.39**	**3.02**	**0.30**	**775.31**	**11.62**	**0.00**	**1,020.68**	**926.21**
Road Maintenance	0.16	0.02	0.04	0.001	0.02	0.00	0.000	5.30	0.00	0.00	5.32	4.83
Sub-total: Maintenance	**0.16**	**0.02**	**0.04**	**0.001**	**0.02**	**0.00**	**0.000**	**5.295**	**0.000**	**0.00**		**4.83**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.31	0.28
Well Reclamation	0.36	0.04	0.04	0.00	0.04	0.01	0.00	8.99	0.00	0.00	9.05	8.21
Sub-total: Reclamation	**0.37**	**0.04**	**0.04**	**0.0016**	**0.04**	**0.009**	**0.0009**	**9.3048**	**0.0001**	**0.0002**	**9.3591**	**8.4928**
Total Emissions	**2.09**	**0.40**	**4.59**	**0.01**	**10.75**	**3.14**	**0.31**	**1,044.08**	**13.89**	**0.01**	**1,333.02**	**1,214.46**

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternatives A, B, C, and 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	0.15	0.02	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.05	0.05	0.99	0.01	4.91	0.26	0.03	956.90	0.01	0.00	957.95	869.29
Commuting Vehicles - Construction	3.54	0.37	0.20	0.00	0.24	0.08	0.01	53.39	0.00	0.00	53.72	48.75
Wind Erosion	0.07	0.01	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.07	0.00	0.03	9.07	0.00	190.49	172.85
Sub-total: Construction	**3.82**	**0.45**	**1.19**	**0.01**	**5.15**	**0.42**	**0.03**	**1,010.32**	**9.08**	**0.00**	**1,202.16**	**1,090.89**
Well Workover Operations - Fugitive Dust	0.68	0.07	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	0.60	0.59	10.62	0.18	3.57	0.77	0.08	840.60	0.01	0.01	843.82	765.72
Well Workover Operations - On-road Exhaust	0.00	0.00	0.04	0.00	0.08	0.03	0.003	9.92	0.00	0.00	10.20	9.25
Well Visits for Inspection & Repair - Operations	0.88	0.09	0.01	0.00	0.27	0.01	0.001	5.47	0.00	0.00	6.12	5.55
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.22	0.02	0.10	28.30	0.00	594.37	539.36
Compression	0.73	0.73	16.54	0.01	33.07	11.58	1.16	2,231.40	0.04	0.00	2233.59	2026.85
Station Visits - Operations	0.10	0.01	0.00	0.00	0.01	0.00	0.00	0.55	0.00	0.00	0.57	0.52
Dehydrators	0.00	0.00	0.01	0.00	0.01	0.03	0.01	12.07	18.14	0.00	393.09	356.71
Sub-total: Operations	**3.00**	**1.49**	**27.23**	**0.19**	**37.01**	**12.63**	**1.27**	**3,100.10**	**46.49**	**0.02**	**4,081.76**	**3,703.96**
Road Maintenance	0.65	0.07	0.17	0.005	0.07	0.02	0.002	21.18	0.00	0.00	21.29	19.32
Sub-total: Maintenance	**0.65**	**0.07**	**0.17**	**0.005**	**0.07**	**0.02**	**0.002**	**21.181**	**0.000**	**0.00**		**19.32**
Road Reclamation	0.06	0.01	0.01	0.00	0.01	0.00	0.00	1.24	0.00	0.00	1.25	1.14
Well Reclamation	1.43	0.17	0.15	0.01	0.17	0.04	0.00	35.98	0.00	0.00	36.19	32.84
Sub-total: Reclamation	**1.49**	**0.17**	**0.15**	**0.0065**	**0.17**	**0.037**	**0.0037**	**37.2192**	**0.0006**	**0.0007**	**37.4362**	**33.9712**
Total Emissions	**8.96**	**2.18**	**28.75**	**0.22**	**42.40**	**13.11**	**1.31**	**4,168.82**	**55.58**	**0.02**	**5,321.35**	**4,848.13**

Natural Gas Wells - Alternatives A, B, C, and D

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	1.5	0.8	1	1.5	8.80E+00	8.80E-01	4.40E-03	4.40E-04
Well Pad and other structures	4.0	2.2	1	4.0	6.45E+01	6.45E+00	3.23E-02	3.23E-03
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		**75**	**7.55**	**3.77E-02**	**3.77E-03**

[a] Road and well pad disturbance provided by data in Billings Field Office RMP; average disturbed area data for new NG wells shown in SEIS (BLM 2008) and for Compressor Stations provided by Montana BLM (Laakso, 2010)

Natural Gas Wells - Alternatives A, B, C, and D

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	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748	0.0000	0.0000
Well Pad	Blade	150	1	75	10	3	30	1	36.09	4.24	0.97	29.32	3.72	0.02	0.00	0.00	0.01	0.00	0.00	2.2122	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	**5.03E-02**	**5.11E-03**	**1.36E-03**	**3.15E-02**	**4.72E-03**	**5.96E-03**	**6.44E+00**	**8.18E-05**	**6.56E-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	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. EPA NONROADS 2008a (Year 2008) 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		**1.88E-01**	**1.17E-02**	**3.62E-03**	**1.24E+00**	**6.66E-02**	**1.26E-02**	**2.41E+02**	**1.88E-03**	**2.74E-03**

Natural Gas Wells - Alternatives A, B, C, and D

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
Well Pad	Blade	150	1	75	10	3	30	1	36.09	4.24	0.97	29.32	3.72	0.02	0.00	0.00	0.01	0.00	0.00	2.2122	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	**3.83E-02**	**3.69E-03**	**1.04E-03**	**2.17E-02**	**3.48E-03**	**4.59E-03**	**4.97E+00**	**6.30E-05**	**5.05E-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	356	16	4	1,849	100	0.18	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 & 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	**2.09E-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		**2.47E-01**	**1.28E-02**	**3.29E-03**	**1.23E+00**	**6.53E-02**	**1.37E-02**	**2.39E+02**	**2.46E-03**	**2.73E-03**

Natural Gas Wells - Alternatives A, B, C, and D

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 (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	10	47	470	1	0.54	251.79	0.13	0.129	0.05	25.18	0.01	0.013
	Pickup Trucks	5	10	3	30	1	0.21	6.17	0.00		0.02	0.62	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	0.54	26.79	0.01	0.018	0.05	2.68	0.00	0.002
	Pickup Trucks	5	10	4	40	1	0.21	8.22	0.00		0.02	0.82	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	0.54	10.71	0.01	0.011	0.05	1.07	0.00	0.001
	Haul Trucks	25	10	2	20	1	0.42	8.48	0.00		0.04	0.85	0.00	
	Pickup Trucks	5	10	1	10	1	0.21	2.06	0.00		0.02	0.21	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	0.54	235.71	0.12	0.282	0.05	23.57	0.01	0.028
	Fuel Haul Truck	25	10	6	60	1	0.42	25.45	0.01		0.04	2.55	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	0.42	16.97	0.01		0.04	1.70	0.00	
	Rig Crew	5	10	51	510	1	0.21	104.85	0.05		0.02	10.49	0.01	
	Rig Mechanics	5	10	2	20	1	0.21	4.11	0.00		0.02	0.41	0.00	
	Co. Supervisor	5	10	20	200	1	0.21	41.12	0.02		0.02	4.11	0.00	
	Tool Pusher	25	10	8	80	1	0.42	33.93	0.02		0.04	3.39	0.00	
	Mud Logger	25	10	6	60	1	0.42	25.45	0.01		0.04	2.55	0.00	
	Mud Engineer	25	10	15	150	1	0.42	63.63	0.03		0.04	6.36	0.00	
	Logger, Engr Truck	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Drill Bit Delivery	25	10	2	20	1	0.42	8.48	0.00		0.04	0.85	0.00	
Well Completion, Fracing & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	0.54	32.14	0.02	0.042	0.05	3.21	0.00	0.004
	Semi Completion, Unit Rig	42	10	1	10	1	0.54	5.36	0.00		0.05	0.54	0.00	
	Semi Fracing, Blender	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	0.42	25.45	0.01		0.04	2.55	0.00	
	Tubing Truck	25	10	2	20	1	0.42	8.48	0.00		0.04	0.85	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	0.42	8.48	0.00		0.04	0.85	0.00	
									Subtotal	**4.81E-01**				**4.81E-02**

Natural Gas Wells - Alternatives A, B, C, and D

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	0.42	12.73	0.01	0.400	0.04	1.27	0.00	0.040
	Haul Completion,	25	10	3	30	1	0.42	12.73	0.01		0.04	1.27	0.00	
	Haul Service Tools	25	10	2	20	1	0.42	8.48	0.00		0.04	0.85	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Anchor, Installation	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Anchor, Testing	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Fracing, Tank	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Fracing, Pump	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Fracing, Sand	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Fracing, Other	25	10	1	10	1	0.42	4.24	0.00		0.04	0.42	0.00	
	Haul Welders	25	10	6	60	1	0.42	25.45	0.01		0.04	2.55	0.00	
	Haul Water Truck	25	10	150	1500	1	0.42	636.26	0.32		0.04	63.63	0.03	
	Pickup Cementer, Engineer	5	10	2	20	1	0.21	4.11	0.00		0.02	0.41	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.21	4.11	0.00		0.02	0.41	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.21	10.28	0.01		0.02	1.03	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.21	10.28	0.01		0.02	1.03	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.21	4.11	0.00		0.02	0.41	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.21	2.06	0.00		0.02	0.21	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.21	20.56	0.01		0.02	2.06	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.21	6.17	0.00		0.02	0.62	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.21	8.22	0.00		0.02	0.82	0.00	
									Subtotal	**4.00E-01**				**4.00E-02**
									Total	**8.81E-01**				**8.81E-02**

Natural Gas Wells - Alternatives A, B, C, and D

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	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007	0.006	0.001	0.000	0.000	0.004	0.001	1.6409	0.000077	0.000092
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.0542	0.000000	0.000007
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.001	0.001	0.1746	0.000008	0.000010
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.0722	0.000000	0.000009
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.0698	0.000003	0.000004
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.0698	0.000003	0.000004
	Pickup Trucks	LDDT	40	1	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							0.0181	0.000000	0.000002
																		Subtotal	**7.52E-03**	**7.18E-04**	**5.98E-04**	**3.46E-05**	**6.45E-03**	**1.84E-03**	**2.10E+00**	**9.21E-05**	**1.28E-04**

Natural Gas Wells - Alternatives A, B, C, and D

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	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007	0.02	0.00	0.00	0.00	0.03	0.01	1.5	0.000072	0.000086
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.000004	0.000119
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.000002	0.000047
	Tool Pusher	LDDT	40	8	320	1	1.6310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.000001	0.000019
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.000001	0.000014
	Mud Engineer	LDDT	40	15	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.000001	0.000035
	Logger, Engr Truck	HDDV	40	1	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	0.000002	0.000002
	Drill Bit Delivery	LDDT	40	2	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
Well Completion, Fracing & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.03	0.00	0.00	0.00	0.02	0.01	0.2	0.000010	0.000012
	Semi Completion, Unit Rig	HDDV	40	1	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	0.000002	0.000002
	Semi Fracing, Blender	HDDV	40	1	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	0.000002	0.000002
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Service Tools	LDDT	40	2	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
	Haul Perforators Logging Truck	HDDV	40	1	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	0.000002	0.000002
	Haul Anchor, Installation	HDDV	40	1	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	0.000002	0.000002
	Haul Anchor, Testing	HDDV	40	1	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	0.000002	0.000002
	Haul Fracing, Tank	HDDV	40	1	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	0.000002	0.000002
	Haul Fracing, Pump	HDDV	40	1	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	0.000002	0.000002
	Haul Fracing, Chemical	HDDV	40	1	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	0.000002	0.000002
	Haul Fracing, Sand	HDDV	40	1	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	0.000002	0.000002
	Haul Fracing, Other	HDDV	40	1	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	0.000002	0.000002
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0180	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.000245	0.000293
	Pickup Cementer, Engineer	LDDT	40	2	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
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.000008	0.000010
	Pickup Completion, Pusher	LDDT	40	5	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	0.000000	0.000012
	Pickup Perforators, Engineer	LDDT	40	2	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
	Pickup Fracing, Engineer	HDDV	40	1	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	0.000002	0.000002
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.000001	0.000023
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.000000	0.000007
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
																	Subtotal		**4.36E-02**	**3.72E-03**	**3.09E-03**	**1.81E-04**	**5.42E-02**	**1.93E-02**	**1.12E+01**	**4.30E-04**	**7.97E-04**
																	Total		**5.11E-02**	**4.44E-03**	**3.69E-03**	**2.15E-04**	**6.07E-02**	**2.11E-02**	**1.33E+01**	**5.22E-04**	**9.25E-04**

Natural Gas Wells - Alternatives A, B, C, and D

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) =	$k (s/12)^a (W/3)^b$

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

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

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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: **10** 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	0.54	5.36	0.00	0.05	0.54	0.00
	Haul Truck	42	10	1	10	1	0.54	5.36	0.00	0.05	0.54	0.00
	Pickup Truck	5	10	3	30	1	0.21	6.17	0.00	0.02	0.62	0.00
								Total	**8.44E-03**			**8.44E-04**

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

Natural Gas Wells - Alternatives A, B, C, and D

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. EPA NONROADS 2008a (Year 2008) 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	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

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).

Natural Gas Wells - Alternatives A, B, C, and D

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]

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

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

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency	50%	Based on watering.

[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: **10** 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	10	1	10	1	1.67	16.74	0.01	0.17	1.67	0.00
	Haul Truck	42	10	1	10	1	1.67	16.74	0.01	0.17	1.67	0.00
	Pickup Truck	5	10	3	30	1	0.64	19.27	0.01	0.06	1.93	0.00
								Total	**2.64E-02**			**2.64E-03**

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**

Natural Gas Wells - Alternatives A, B, C, and D

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	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

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).

Natural Gas Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book[a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

Assumption: Frequency of visit: once/week/well
Crew: **1** person and **1** light-duty truck
Av. number of wells served by a pumper per day **20**
Round trip mileage per day: 50 total/20 wells = 2**.5** 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	2.5	52	130	1	0.17	22.10	**1.11E-02**	0.02	2.21	**1.10E-03**

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	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Natural Gas Wells - Alternatives A, B, C, and D

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 yea

[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 (BLM 2008)

[b] miles of road built per well * No. of operating wells/yea

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.

Natural Gas Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/yr)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/yr)	$PM_{2.5}$ Emissions (tpy)
Road Maintenance	Pickup Truck	40	40	0.5	21	0.17	3.63	**1.81E-03**	0.02	0.36	**1.81E-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 Type	Vehicle Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	40	0.5	21	**5.44E-05**	**2.56E-06**	**2.08E-06**	**1.32E-07**	**1.47E-04**	**6.46E-05**	**9.63E-03**	**4.70E-08**	**1.25E-06**

Natural Gas Wells - Alternatives A, B, C, and D

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	4.00	16193.31	1.00	0.01	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	0.00	0.00
								TOTAL	**1.79E-02**	**2.68E-03**

[a] Average disturbed area shown in SEIS (BLM 2008).

Natural Gas Wells - Alternatives A, B, C, and D

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 (2008).

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.25
Number of Roads Reclaimed Annually Per Well	1.060
Annual Miles of Roads Reclaimed Per Well	0.265
Number of wells reclaimed (per well)	1.060

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

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.2650	6	0.04417	0.4417
		Total	**0.442**

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 Reclamation

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	0.265	5	1.325	0.765	**5.07E-04**	0.069	**4.59E-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.

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 Reclamation

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	0.265	0.4238	0.0720	0.0197	0.4106	0.0629	**5.62E-05**	**9.54E-06**	**2.61E-06**	**5.44E-05**	**8.33E-06**	**9.25E-06**	**1.43E-02**	**1.29E-07**	**1.41E-07**

Natural Gas Wells - Alternatives A, B, C, and D

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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	0.0442	2.650	0.17	**2.25E-04**	0.02	**2.25E-05**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation 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 Reclamation 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	0.0442	2.6500	**6.75E-06**	**3.18E-07**	**2.59E-07**	**1.64E-08**	**1.82E-05**	**8.02E-06**	**1.20E-03**	**5.84E-09**	**1.55E-07**

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	1.060	10	1.060	10.60

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

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

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	6.36	5	31.80	0.765	**1.22E-02**	0.069	**1.10E-03**

[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)					(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	6.36	0.5297	0.0900	0.0246	0.5132	0.0786	**1.68E-03**	**2.86E-04**	**7.82E-05**	**1.63E-03**	**2.50E-04**	**4.44E-04**	**4.21E-01**	**7.01E-06**	**4.24E-06**

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	1.06	63.60	0.170	**5.41E-03**	0.017	**5.39E-04**

[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	1.06	63.60	**1.62E-04**	**7.62E-06**	**6.20E-06**	**3.93E-07**	**4.38E-04**	**1.93E-04**	**2.87E-02**	**1.40E-07**	**3.72E-06**

Natural Gas Wells - Alternatives A, B, C, and D

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

Natural Gas Wells - Alternatives A, B, C, and D

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**

Natural Gas Wells - Alternatives A, B, C, and D

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

Natural Gas Wells - Alternatives A, B, C, and D

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

Natural Gas Wells - Alternatives A, B, C, and D

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**

Natural Gas Wells - Alternatives A, B, C, and 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 (%)		11	WRAP Fugitive Dust Handbook (9/7/2006) Table 6-2, for compacted/graded/crowned roads
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency		84%	Based on gravel or scoria surfacing per the BLM Gold Book [a], watering when necessary, and negligible emissions due to 6 months of frozen roads.

[a] *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (4th Edition, 2007), also known as the Gold Book.*

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	0.4	20	0.17	3.40	0.00	0.02	0.34	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.17	3.40	0.00	0.02	0.34	0.00
									Total	**1.30E-03**			**1.29E-04**

Compressor Station Inspection Traffic Exhaust Emissions

Emission factors for Commuting Vehicles Exhaust

Vehicle Type	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	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 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	0.4	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**

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

General Purpose Travel - BLM Fleet **Alternatives A-D**

Total Annual Emissions from General Purpose BLM Travel - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Commuting Vehicles - Fugitive Dust	54.91	5.49	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.02	0.48	0.00	1.31	0.57	0.06	85.55	0.00	0.01	88.99	80.76
Total	**54.94**	**5.51**	**0.48**	**0.00**	**1.31**	**0.57**	**0.06**	**85.55**	**0.00**	**0.01**	**88.99**	**80.76**

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

ALTERNATIVE: Alternatives A-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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control is assumed.

[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	All Vehicles	25	41,555	2.64	54.91	54.91	0.26	5.49	5.49
		Total	**41,555**	**Total**	**54.91**			**5.487**	

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).

Assumes no surfacing or water application to control dust from unpaved roads.

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-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/yr)								
				NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
General Purpose BLM Travel	All Fleets	LDDT	189,531	0.48	0.02	0.02	0.00	1.31	0.57	85.55	0.00	0.01
			Total	**0.4830**	**0.0227**	**0.0185**	**0.00117**	**1.31**	**0.57390**	**8.56E+01**	**4.18E-04**	**1.11E-02**

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance **Alternatives A-D**

Total Annual Emissions from Road Maintenance Projects - Alternatives A-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	1.65	0.19	0.53	0.01	0.20	0.04	0.00	60.42	0.00	0.00	60.64	55.03
Total	**1.65**	**0.19**	**0.53**	**0.01**	**0.20**	**0.04**	**0.00**	**60.42**	**0.0006**	**0.0007**	**60.64**	**55.03**

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

BLM Road Maintenance - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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 (%)		34.6	Source of activity data: Craig Drake of Billings Field Office, 9-19-2011.
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 emission control.

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	150	5	750	0.765	0.29	0.069	0.03
Road Maintenance	Semi-truck	100	20	200	2.51	0.25	0.25	0.03
Road Maintenance	Lowboy Trailer	100	20	756	2.51	0.95	0.25	0.09
				Total	**1.49**		**0.15**	

BLM Road Maintenance - Alternatives A, B, C, and D

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-hı

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	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Backhoe	87	0	0.80	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semi-truck	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Lowboy Trailer	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Bobcat	82	1	0.80	500	0.18	0.01	0.00	0.07	0.02	0.01	19.52	0.00	0.00
Grader	165	1	0.90	150	0.12	0.01	0.00	0.05	0.01	0.01	13.26	0.00	0.00
Loader	60	1	0.75	40	0.01	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00
Dump Truck	350	0	0.50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airport Forklift	100	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snowplow	350	0	0.25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total					**5.3E-01**	**3.6E-02**	**1.3E-02**	**2.0E-01**	**3.9E-02**	**3.5E-02**	**6.0E+01**	**5.9E-04**	**6.8E-04**

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	258.0	34.6	30	121.812	0.033	1,047.58	0	**0.13**	**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.
* 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] = 30% derived from Billings, 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).

Coal Mining - Alternatives A, B, C, and D

BiFO Coal Mining Emission Estimates

Mine	Emissions (tpy)						
	CO [1]	NOx [1]	VOC [1]	SO2 [1]	PM10 [2]	PM2.5 [2]	CO2 [3]
Signal Peak Energy LLC (Bull Mountains Mine No. 1)	11.3	23.7	1.2	0.0	29.9	3.0	274.4

1. Non-particulate criteria air pollutants are based on emissions reported in the 2008 NEI.

2. PM10 emissions are based on Montana Department of Environmental Quality Permit Number #3179-04 (February 5, 2009) for the facility. PM2.5 emissions are assumed to be equal to 10 percent of PM10 emissions.

3. CO2 emissions are estimated from fuel use based on information in the Bull Mountains Mine No. 1 Environmental Assessment (DOI-BLM-MT-C010-2009-0010-EA, April, 2011) and information from the air quality permit. See calculations below for GHG emissions.

Non-Boiler Liquid Fuel Combustion GHG Emissions

Fuel Type	Annual Usage (gal/yr)	Emissions (lb/gal)			Emissions (tpy)		
		CO2	CH4	N2O	CO2	CH4	N2O
Gaoline	11,000	19.4	Negl.	Negl.	106.7	Negl.	Negl.
Diesel	181,000	22.2	Negl.	Negl.	122.1	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.

Boiler GHG Emissions

Fuel Type	Annual Usage		Heating Value [2]		CO2 Emission Factors		CO2 Emissions
	Quantity	Usage Units	High Heat Value	High Heat Value Units	(kg CO2/ MMBtu) [2]	(ton CO2/ MMBtu)	(tpy)
Sub-bituminous coal [1]	26	short ton/yr	17.25	MMBtu/short ton	97.02	0.05	21.8
Propane	8517	gal/yr	0.09	MMBtu/gal	61.46	0.03	23.8

[1] The air quality permit allows combustoin of up to 26 tons per year of coal in facility boilers, which include two 35,000 Btu/hr boilers. Propane is used for remaining fuel. Based on 80% boiler efficiency, total fuel needed is estimated to be 767 MMBtu/yr. Based on maximum allowable coal combustion, propane usage would be 8,517 gal/yr.

[2] Source: 40 CFR Part 98, Subpart C. Table C-1.

Fire Management and Ecology **Alternative A**

Total Annual Emissions from Fire Management 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	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	258.88	222.33	72.09	19.76	2,581.48	131.66	13.17	0.00	136.73	19.81	9,012.40	8,178.22
Heavy Equipment Exhaust	0.18	0.23	7.43	0.65	9.55	1.58	0.16	309,157.85	34.39	11.52	313,452.58	284,439.72
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.11	0.06	0.01	28.91	0.00	0.00	29.45	26.72
Total	**267.8**	**223.4**	**79.6**	**20.4**	**2,591.1**	**133.3**	**13.3**	**309,186.8**	**171.1**	**31.3**	**322,494.4**	**292,644.7**
Emissions Without Wildfire Smoke	**55.7**	**38.0**	**19.4**	**3.9**	**433.2**	**23.2**	**13.3**	**309,072.5**	**154.6**	**31.3**	**322,494.4**	**292,644.7**
% of Emissions From Wildfire Smoke	**79%**	**83%**	**76%**	**81%**	**83%**	**83%**	**0%**	**0%**	**10%**	**0%**	**0%**	**0%**

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

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	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 Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10} [c]	$PM_{2.5}$ [c]
Mechanical Treatments (Hand Work)	157	1	0.20	0.02
Prescribed Fire	471	1	0.61	0.06
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**3.94**	**0.39**

[a] Source: BiFO

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

[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	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 CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from 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	471	41.64	36.39	11.83	3.24	423.50	21.60	0.00	22.43	3.2499
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**253.81**	**221.82**	**72.09**	**19.76**	**2581.48**	**131.66**	**0.00**	**136.73**	**19.81**

[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	3,028	34.6	30	89.673	0.033	9,051.03	0	**1.13**	**0.11**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), 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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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 (2006)

Fire Management Resource - Alternative A

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									
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)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

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	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	50	6	20	1	2400	18.90	139.26	2.00	4,193.36	884.12	0.01	0.07	0.00	2.10	0.44	0.13	4.25	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Underground Coal Seam Fire	Excavator	100	1	80	8	5	1	40	33.18	3.79	0.90	27.37	3.25	0.02	0.00	0.00	0.01	0.00	0.00	2.10	0.00	0.00
	Water Tender	75	1	50	8	5	1	40	15.55	1.78	0.42	12.83	1.52	0.01	0.00	0.00	0.01	0.00	0.00	0.98	0.00	0.00
													Total	**0.26**	**0.18**	**0.01**	**4.89**	**1.01**	**0.23**	**39.28**	**0.00**	**0.00**

Activity data source: BiFO. 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	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

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

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2011 (BLM 2011a).
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[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} 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)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**8.76**			**0.88**	

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative A

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: 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	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Fuel Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Water Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Support Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.11**	**0.06**	**28.91**	**0.00**	**0.00**

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.86	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.06	0.06	0.74	0.02	0.52	0.08	0.01	86.70	0.00	0.00	87.01	78.96
Sub-total: Heavy Equipment	**1.92**	**0.24**	**0.74**	**0.02**	**0.52**	**0.08**	**0.01**	**86.70**	**0.00**	**0.00**	**87.01**	**78.96**
Commuting Vehicles - Fugitive Dust	0.95	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.03	0.00	0.03	0.01	0.00	7.37	0.00	0.00	7.53	6.83
Sub-total: Commuting Vehicles	**0.95**	**0.10**	**0.03**	**0.00**	**0.03**	**0.01**	**0.00**	**7.37**	**0.00**	**0.00**	**7.53**	**6.83**
Total	**2.87**	**0.34**	**0.76**	**0.02**	**0.55**	**0.09**	**0.01**	**94.07**	**0.001**	**0.001**	**94.54**	**85.79**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

ALTERNATIVE: Alternative A

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.

Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	42	840	12	1.85	0.18
			Total	**1.85**	**0.18**

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	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	42.0	34.6	30	96.3	89.673	0.033	125.54	0	**0.02**	**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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Forestry and Woodland Products - Alternative A

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	12	96	142.83	16.32	3.89	117.83	13.99	7.1E-02	8.2E-03	1.9E-03	5.9E-02	7.0E-03	7.9E-03	9.0E+00	1.1E-04	9.2E-05
	Log Truck	450	1	60	10	12	120	335.93	17.59	8.24	125.81	15.95	1.7E-01	8.8E-03	4.1E-03	6.3E-02	8.0E-03	8.5E-03	1.9E+01	1.2E-04	2.2E-04
	Chainsaw	6	1	80	8	12	96	4.78	9.90	0.14	298.19	62.87	2.4E-03	5.0E-03	7.1E-05	1.5E-01	3.1E-02	4.6E-03	3.5E-01	2.7E-04	2.2E-06
	Feller Buncher	300	1	100	8	12	96	298.61	34.13	8.12	246.33	29.25	1.5E-01	1.7E-02	4.1E-03	1.2E-01	1.5E-02	1.7E-02	1.9E+01	2.2E-04	1.9E-04
	Loader	200	1	80	10	12	120	199.07	10.42	4.88	74.55	9.45	1.0E-01	5.2E-03	2.4E-03	3.7E-02	4.7E-03	5.1E-03	1.1E+01	7.2E-05	1.3E-04
	Dozer	200	1	90	8	12	96	179.16	9.38	4.39	67.10	8.51	9.0E-02	4.7E-03	2.2E-03	3.4E-02	4.3E-03	4.5E-03	1.0E+01	6.5E-05	1.2E-04
	Delimber	250	1	100	10	12	120	311.05	16.28	7.63	116.49	14.77	1.6E-01	8.1E-03	3.8E-03	5.8E-02	7.4E-03	7.9E-03	1.8E+01	1.1E-04	2.0E-04
												Total	**7.4E-01**	**5.7E-02**	**1.9E-02**	**5.2E-01**	**7.7E-02**	**5.5E-02**	**8.7E+01**	**9.7E-04**	**9.5E-04**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume 2008 emission factors for all years; this is a 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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
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	30	12	360	1	360	1.32	0.24	0.95	0.13	0.02	0.10
	Log Truck	25	30	24	720	1	720	1.32	0.48		0.13	0.05	
	Pick-up Truck	25	30	12	360	1	360	1.32	0.24		0.13	0.02	
							Total		**0.95**			**0.10**	

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative A

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	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.01	2.09	0.00	0.00
	Log Truck	HDDV	200	24	4,800	1	4,800	0.01	0.00	0.00	0.00	0.01	0.00							4.19	0.00	0.00
	Pick-up Truck	LDDT	200	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.02	0.01							1.08	0.00	0.00
							Total	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**	**0.01**	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**	**0.01**	**7.37**	**0.0003**	**0.0005**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

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

Livestock Grazing - Alternatives A, B, C, and D

Livestock Grazing **Alternatives A-D**

Total Annual Emissions from Livestock Grazing Projects - Alternatives A-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
Heavy Equipment - Fugitive Dust	0.39	0.04	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.02	0.29	0.01	0.12	0.02	0.00	29.80	0.00	0.00	29.9	**27.1**
Sub-total: Construction	**0.41**	**0.06**	**0.29**	**0.01**	**0.12**	**0.02**	**0.00**	**29.80**	**0.00**	**0.00**	**29.9**	**27.1**
Commuting Vehicles - Fugitive Dust	88.25	8.82	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.01	0.15	0.00	0.29	0.10	0.01	43.68	0.00	0.00	**44.6**	**40.5**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	272.82	---	**5,729.3**	**5,199.0**
Sub-total: Operations and Maintenance	**88.26**	**8.83**	**0.15**	**0.00**	**0.29**	**0.10**	**0.01**	**43.68**	**272.83**	**0.00**	**5,773.9**	**5,239.5**
Total	**88.67**	**8.89**	**0.43**	**0.01**	**0.41**	**0.12**	**0.01**	**73.48**	**272.83**	**0.00**	**5,803.8**	**5,266.6**

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

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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 Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)	
			PM_{10}	$PM_{2.5}$
Springs	1.00	1	3.67E-03	3.67E-04
Reservoirs/Pits	10.00	1	3.67E-02	3.67E-03
Wells	5.00	1	1.83E-02	1.83E-03
Pipelines	50.00	1	1.83E-01	1.83E-02
Fences	25.00	1	9.17E-02	9.17E-03
Reservoirs Maintenance	6.00	1	2.20E-02	2.20E-03
		Total	**3.56E-01**	**3.56E-02**

a information from Billings Field Office. 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	97.0	34.6	30	89.673	0.033	289.94	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.

* "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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs, Montana surface meteorology 2004-2011 dataset from Western Research Climate Center.

* 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)

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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	3	1.00	24.0	11	1	0	9	1	0.01	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	2.00	48.0	194	12	4	82	12	0.10	0.01	0.00	0.04	0.01	0.01	9.90	0.00	0.00
	Scraper	650	1	70	8	3	2.00	48.0	253	15	6	107	16	0.13	0.01	0.00	0.05	0.01	0.01	12.87	0.00	0.00
Wells	Drill Rig	200	1	100	8	1	1.00	8.0	15	1	0	5	1	0.01	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00
	Water Truck	200	1	70	8	1	1.00	8.0	11	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00
Pipelines	Dozer	200	1	75	1	1	1.00	1.0	2	0	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
	Trencher	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
	Backhoe	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	1	2.00	16.0	29	2	1	10	2	0.01	0.00	0.00	0.00	0.00	0.00	1.68	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	3	2.00	12.0	49	3	1	21	3	0.02	0.00	0.00	0.01	0.00	0.00	2.48	0.00	0.00
													Total	**2.88E-01**	**1.83E-02**	**6.41E-03**	**1.23E-01**	**1.95E-02**	**1.78E-02**	**2.98E+01**	**2.98E-04**	**3.38E-04**

Source for activity data: Billings Field Office

all emissions calculated with year 2008 factors (conservative)

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Billings Field Office.

[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	75	2	150	1.00	150	1.56	0.12	0.23	0.16	0.01	0.02
	Pick-up Truck	35	75	2	150	1.00	150	1.56	0.12		0.16	0.01	
Reservoirs/Pits	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Wells	Drill Truck	35	75	3	225	1.00	225	1.56	0.18	0.70	0.16	0.02	0.07
	Support Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Water Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Pick-up Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
Pipelines	Tractor-Trailer	35	75	1	75	1.00	75	1.56	0.06	0.35	0.16	0.01	0.04
	Pick-up Truck	35	75	5	375	1.00	375	1.56	0.29		0.16	0.03	
Fences	Support Truck	35	75	1	75	2.00	150	1.56	0.12	1.17	0.16	0.01	0.12
	Pick-up Truck	35	75	4	300	2.00	600	1.56	0.47		0.16	0.05	
	ATV	35	75	5	375	2.00	750	1.56	0.59		0.16	0.06	
Reservoirs Maintenance	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	75	1087	81525	1.00	81525	1.56	63.74	63.74	0.16	6.37	6.37
	Pick-up-Trailer (spring calves)	35	75	352	26400	1.00	26400	1.56	20.64	20.64	0.16	2.06	2.06
							Total		**88.25**			**8.82**	

Source for activity data: Billings Field Office, Larry Padden, 9-19-2011 (BLM 2011h).

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.01	0.00							0.16	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Wells	Drill Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0046	0.0004	0.0003	0.0000	0.0145	0.0011	0.39	0.00	0.00
	Support Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Water Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.01	0.00							0.24	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	150	1	150	1.00	150.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.13	0.00	0.00
	Pick-up Truck	LDGT2	150	5	750	1.00	750.0	0.00	0.00	0.00	0.00	0.02	0.00							0.39	0.00	0.00
Fences	Support Truck	HDDV	150	1	150	2.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.08	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	4	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
	ATV	R12S	150	5	750	2.00	1,500.0	0.00	0.00	0.00	0.00	0.08	0.08							0.23	0.00	0.00
Reservoirs Maintenance	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	30	1087	32610	1.00	32,610.0	0.10	0.01	0.01	0.00	0.06	0.01	0.13	0.01	0.01	0.00	0.08	0.02	28.46	0.00	0.00
	Pcik-up-Trailer (spring calves)	HDDV	30	352	10560	1.00	10,560.0	0.03	0.00	0.00	0.00	0.02	0.00							9.22	0.00	0.00
													TOTAL	**0.15**	**0.02**	**0.01**	**0.00**	**0.29**	**0.10**	**43.68**	**0.00**	**0.00**

Source for activity data: Billings Field Office

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

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	53,776	9.74	261.80	0.37	9.88	271.68
Horse	274	3.31	0.45	0.43	0.06	0.51
Sheep	823	1.47	0.60	0.05	0.02	0.63
					Total Methane emissions	**272.82**

BiFO total AUMs (excluding suspended units) are 54,873 for each Alternative. More than 97% of allocations are for cattle, with the remainder for sheep and horses. Because cattle authorizations are larger than sheep and horse authorizations, cattle/sheep/horse AUMs are estimated to be 99%/0.75%/0.25 respectively. Total AUMs and authorization numbers provided by Larry Padden on 9-19-2011 (BLM 2011h).

Trails and Travel Management **Alternatives A-D**

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

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Recreation Vehicles - Fugitive Dust	226.76	22.66	---	---	---	---	---	---	---	---	---	---
Recreation Vehicles - Vehicle Exhaust	0.16	0.14	0.24	0.00	8.64	0.86	0.09	106.41	0.05	0.036	118.51	107.54
Sub-total: Vehicles	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.05**	**0.04**	**118.51**	**107.54**
Total	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.048**	**0.036**	**118.51**	**107.54**

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

ALTERNATIVE: Alternatives A-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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control

[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 Location	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Number of Trips	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/year)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/year)
Shapard Ah-Nei	ATV	15	25	365	9,113	2.05	9.33	45.74	0.20	0.93	4.57
	Off-Road Motorcyles	25	25	365	9,113	2.64	12.04		0.26	1.20	
	Pickup Truck	40	10	1458	14,580	3.34	24.37		0.33	2.44	
South Hills	ATV	15	10	900	9,000	2.05	9.21	27.12	0.20	0.92	2.71
	Off-Road Motorcyles	25	10	900	9,000	2.64	11.89		0.26	1.19	
	Pickup Truck	40	2	1800	3,600	3.34	6.02		0.33	0.60	
Pryor Mountain	ATV	15	30	306	9,180	2.05	9.40	135.96	0.20	0.94	13.59
	Off-Road Motorcyles	25	60	306	18,360	2.64	24.26		0.26	2.42	
	Pickup Truck	40	60	1020	61,200	3.34	102.30		0.33	10.22	
Elk Basin Motorcycle Race	ATV	15	0	0	0	2.05	0.00	17.94	0.20	0.00	1.79
	Off-Road Motorcyles	50	75	125	9,375	3.74	17.52		0.37	1.75	
	Pickup Truck	40	2	125	250	3.34	0.42		0.33	0.04	
							Total	**226.76**			**22.66**

Source of activity data: Craig Drake, Billings Field Office, September 2011 (BLM 2011d, 2011e), based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Basin Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Recreation and Visitor Services - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Off-Road Recreation Vehicles

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_2	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
Gasoline Light-Duty Truck	LDDT	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

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 Tripsper Year	Total Annual Vehicle Miles Traveled	Emissions (tons/year)								
						NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Shapard Ah-Nei	ATV	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Off-Road Motorcyles	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Pickup Truck	LDDT	40	1458	58,320	0.07	0.00	0.00	0.00	1.54	0.07	30.66	0.00	0.01
South Hills	ATV	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Off-Road Motorcyles	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Pickup Truck	LDDT	20	1800	36,000	0.04	0.00	0.00	0.00	0.95	0.04	18.92	0.00	0.01
Pryor Mountain	ATV	R12S	30	306	9,180	0.00	0.02	0.02	0.00	0.48	0.49	1.42	0.00	0.00
	Off-Road Motorcyles	R12S	60	306	18,360	0.01	0.04	0.03	0.00	0.97	0.99	2.84	0.01	0.00
	Pickup Truck	LDDT	80	1020	81,600	0.10	0.00	0.00	0.00	2.16	0.10	42.90	0.01	0.02
Elk Basin Motorcycle Race	ATV	R12S	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Off-Road Motorcyles	R12S	75	125	9,375	0.00	0.02	0.02	0.00	0.49	0.50	1.45	0.00	0.00
	Pickup Truck	LDDT	40	125	5,000	0.01	0.00	0.00	0.00	0.13	0.01	2.63	0.00	0.00
					Total	0.24	0.16	0.14	0.00	8.64	4.14	106.41	0.05	0.04

Source of activity data: Craig Drake, Billings Field Office, September 2011 (BLM 2011d, 2011e), based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Basin Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Vegetation Management Resource - Alternative A

Weed Treatment **Alternative A**

Total Annual Emissions for Weed Treatment - RMP Year - 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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	11.09	1.11	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	0.01	0.00	2.80	0.59	0.06	6.53	0.01	0.00	6.65	6.04
Sub-total: Heavy Equipment	**11.18**	**1.19**	**0.01**	**0.00**	**2.80**	**0.59**	**0.06**	**6.53**	**0.01**	**0.0000**	**6.65**	**6.04**
Commuting Vehicles - Fugitive Dust	2.48	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.11	0.08	0.01	3.69	0.00	0.00	3.84	3.49
Sub-total: Commuting Vehicles	**2.48**	**0.25**	**0.02**	**0.00**	**0.11**	**0.08**	**0.01**	**3.69**	**0.00**	**0.0005**	**3.84**	**3.49**
Total	**13.66**	**1.44**	**0.03**	**0.00**	**2.91**	**0.67**	**0.07**	**10.22**	**0.01**	**0.000**	**10.49**	**9.52**

[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	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 Weed Treatment - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Weed Treatment	2744	54,880	1	10.06	1.01
			Total	**10.06**	**1.01**

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	2744.0	34.6	30	89.673	0.033	8,202.13	0	**1.03**	**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.

* "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
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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)

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Equipment

Year 2008	Emission Factors (g/hp-hr)								
	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 Weed Management 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)					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
Weed Treatment	Spray Vehicle	40	---	100	---	---	216	25.20	185.68	2.67	5,591.15	1,178.83	0.01	0.09	0.00	2.80	0.59	0.09	6.53	0.01	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	**1.26E-02**	**9.28E-02**	**1.34E-03**	**2.80E+00**	**5.89E-01**	**8.54E-02**	**6.53E+00**	**5.13E-03**	**4.09E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Hours estimated by dividing total vehicle miles traveled by speed.

Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative A

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 (%)		34.6	Source of activity data: Billings Field Office.
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		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		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.

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)
Weed Treatment	ATV and Other Equipment	5	---	---	4,200	1	4,200	1.18	2.48	2.48	0.12	0.25	0.25
							Total		**2.48**			**0.25**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

[a] Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative A

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. 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
Weed Treatment	ATV	R12S	---	---	---	---	1,080	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.06	0.06	0.17	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	7,800	0.02	0.00	0.00	0.00	0.05	0.02	0.02	0.00	0.00	0.00	0.05	0.02	3.52	0.00	0.00
							Total	**0.02**	**0.00**	**0.00**	**0.00**	**0.11**	**0.08**	**0.02**	**0.00**	**0.00**	**0.00**	**0.11**	**0.08**	**3.69**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled.

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

Appendix B

Alternative B Emission Inventory

Summary of Emissions B-1

Oil Development and Production ..... (*see pages A-2 through A-28*)

Natural Gas Development and Production . (*see pages A-29 through A-54*)

General Purpose BLM Fleet Travel ..... (*see pages A-55 through A-57*)

BLM Road Maintenance ..... (*see pages A-58 through A-60*)

Coal Mining..... (*see page A-61)*

Fire Management B-2

Forestry and Woodland Products B-7

Livestock Grazing ..... (*see pages A-72 through A-77*)

Recreation and Visitor Services..... (*see pages A-78 through A-80*)

Vegetation Management B-12

Alternative B Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.5	241.1	0.1	11.9	2.4	15.2	6,284.8	38.6	0.0	7,107.3
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3	1,044.1	13.9	0.0	1,333.0
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.6	48.5	76.5	11.9	172.7	129.0	18.7	309,076.8	209.8	39.3	326,137.0
Forestry Management	0.9	1.2	0.1	0.0	6.3	0.7	0.0	148.9	0.0	0.0	149.7
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	0.5	0.0	0.1	0.0	2.3	0.2	0.0	1.7	0.0	0.0	1.8
Federal Emission Total	**1,577.0**	**110.2**	**323.8**	**12.0**	**597.4**	**173.1**	**34.4**	**317,156.6**	**535.1**	**39.4**	**341,075.2**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	52.1	14.3	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.4	28.7	13.1	0.2	9.0	2.2	1.3	4,168.8	55.6	0.0	5,321.4
Non-Federal Emission Total	**293.3**	**236.3**	**981.9**	**2.1**	**61.0**	**16.5**	**62.7**	**29,330.3**	**209.8**	**0.1**	**33,752.8**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes 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	54931	16068	8949	8147	32692	4533
Alt. B (%) of NEI Emissions	2.9%	0.7%	3.6%	0.1%	1.8%	3.8%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. B (%) without Mine Emissions	2.9%	0.5%	3.6%	0.1%	1.7%	3.8%

Fire Management Resource - Alternative B

Fire Management and Ecology **Alternative B**

Total Annual Emissions from Fire Management 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	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	372.72	313.01	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.20	0.18	7.46	0.65	9.84	1.64	0.16	309,161.89	34.39	11.52	313,456.62	284,443.40
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**384.9**	**314.4**	**108.8**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,191.1**	**226.3**	**39.3**	**326,137.0**	**295,950.1**
Emissions Without Wildfire Smoke	**172.7**	**129.0**	**48.5**	**11.9**	**1,475.6**	**76.5**	**18.7**	**309,076.8**	**209.8**	**39.3**	**326,137.0**	**295,950.1**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

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

Fire Management and Ecology **Alternative B Compared to Alternative A**

Total Annual Emissions from Fire Management 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	$CO2_{eq}$	CO_{2eq} metric Tonnes
Increase From Alternative A	**68%**	**71%**	**60%**	**67%**	**71%**	**70%**	**29%**	**0%**	**26%**	**20%**	**1%**	**1%**

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

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	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 Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10} [c]	$PM_{2.5}$ [c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	5,254	1	6.83	0.68
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**12.77**	**1.28**

[a] Source: BiFO

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

[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	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 CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from 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	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[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	9,824	34.6	30	89.673	0.033	29,365.04	0	**3.67**	**0.37**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), 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
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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 (2006)

Fire Management Resource - Alternative B

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									
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)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

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	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.10	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.01	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	2	60	6	20	1	240	2.27	16.71	0.24	503.20	106.09	0.00	0.01	0.00	0.25	0.05	0.01	0.51	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	20	1	240	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.00	0.21	0.00	0.00
	Pumps	25	2	15	8	20	1	320	12.44	1.42	0.34	10.26	1.22	0.01	0.00	0.00	0.01	0.00	0.00	0.79	0.00	0.00
													Total	**0.29**	**0.20**	**0.01**	**5.19**	**1.07**	**0.18**	**43.32**	**0.00**	**0.00**

Activity data source: BiFO. 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	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

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

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2011 (BLM 2011a).
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[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} 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)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**11.98**			**1.20**	

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative B

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: 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	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Forestry and Woodland Products - Alternative B

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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.69	0.47	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	1.11	0.03	0.83	0.12	0.01	137.27	0.00	0.00	137.77	125.02
Sub-total: Heavy Equipment	**4.78**	**0.56**	**1.11**	**0.03**	**0.83**	**0.12**	**0.01**	**137.27**	**0.00**	**0.00**	**137.77**	**125.02**
Commuting Vehicles - Fugitive Dust	1.51	0.15	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.04	0.00	0.05	0.02	0.00	11.67	0.00	0.00	11.92	10.81
Sub-total: Commuting Vehicles	**1.51**	**0.15**	**0.04**	**0.00**	**0.05**	**0.02**	**0.00**	**11.67**	**0.00**	**0.00**	**11.92**	**10.81**
Total	**6.29**	**0.71**	**1.15**	**0.03**	**0.88**	**0.14**	**0.01**	**148.94**	**0.002**	**0.002**	**149.69**	**135.83**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

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.

Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	67	1,340	19	4.67	0.47
			Total	**4.67**	**0.47**

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	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	67.0	34.6	30	96.3	89.673	0.033	200.27	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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Forestry and Woodland Products - Alternative B

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	19	152	226.15	25.85	6.15	186.56	22.15	1.1E-01	1.3E-02	3.1E-03	9.3E-02	1.1E-02	1.3E-02	1.4E+01	1.7E-04	1.5E-04
	Log Truck	450	1	60	10	19	190	496.50	27.84	13.04	199.20	25.26	2.5E-01	1.4E-02	6.5E-03	1.0E-01	1.3E-02	1.4E-02	3.0E+01	1.9E-04	3.4E-04
	Chainsaw	6	1	80	8	19	152	2.13	15.68	0.23	472.14	99.55	1.1E-03	7.8E-03	1.1E-04	2.4E-01	5.0E-02	7.2E-03	5.5E-01	4.3E-04	3.5E-06
	Feller Buncher	300	1	100	8	19	152	472.79	54.04	12.86	390.03	46.31	2.4E-01	2.7E-02	6.4E-03	2.0E-01	2.3E-02	2.6E-02	3.0E+01	3.5E-04	3.0E-04
	Loader	200	1	80	10	19	190	294.23	16.50	7.73	118.04	14.97	1.5E-01	8.2E-03	3.9E-03	5.9E-02	7.5E-03	8.0E-03	1.8E+01	1.1E-04	2.0E-04
	Dozer	200	1	90	8	19	152	264.80	14.85	6.96	106.24	13.47	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
	Delimber	250	1	100	10	19	190	459.73	25.78	12.08	184.44	23.39	2.3E-01	1.3E-02	6.0E-03	9.2E-02	1.2E-02	1.3E-02	2.8E+01	1.8E-04	3.2E-04
												Total	**1.1E+00**	**9.0E-02**	**3.0E-02**	**8.3E-01**	**1.2E-01**	**8.7E-02**	**1.4E+02**	**1.5E-03**	**1.5E-03**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume 2008 emission factors for all years; this is a 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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
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	30	19	570	1	570	1.32	0.38	1.51	0.13	0.04	0.15
	Log Truck	25	30	38	1,140	1	1,140	1.32	0.75		0.13	0.08	
	Pick-up Truck	25	30	19	570	1	570	1.32	0.38		0.13	0.04	
								Total	**1.51**			**0.15**	

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative B

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)						(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	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.05	0.02	3.32	0.00	0.00
	Log Truck	HDDV	200	38	7,600	1	7,600	0.02	0.00	0.00	0.00	0.01	0.00							6.63	0.00	0.00
	Pick-up Truck	LDDT	200	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.03	0.01							1.72	0.00	0.00
							Total	**0.04**	**0.00**	**0.00**	**0.00**	**0.05**	**0.02**	**0.04**	**0.00**	**0.00**	**0.00**	**0.05**	**0.02**	**11.67**	**0.0005**	**0.0008**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

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

Vegetation Management Resource - Alternative B

Weed Treatment **Alternative B**

Total Annual Emissions for Weed Treatment - RMP Year - 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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.87	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.01	0.00	0.00	0.48	0.10	0.01	1.11	0.00	0.00	1.13	1.03
Subtotal: Heavy Equipment	**1.89**	**0.20**	**0.00**	**0.00**	**0.48**	**0.10**	**0.01**	**1.11**	**0.00**	**0.0000**	**1.13**	**1.03**
Commuting Vehicles - Fugitive Dust	0.42	0.04	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.63	0.00	0.00	0.65	0.59
Subtotal: Commuting Vehicles	**0.42**	**0.04**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.63**	**0.00**	**0.0001**	**0.65**	**0.59**
Total	**2.31**	**0.24**	**0.01**	**0.00**	**0.49**	**0.11**	**0.01**	**1.74**	**0.00**	**0.000**	**1.78**	**1.62**

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

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

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 Weed Treatment - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Weed Treatment	464	9,280	1	1.70	0.17
			Total	**1.70**	**0.17**

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	464.0	34.6	30	89.673	0.033	1,386.95	0	**0.17**	**0.02**

* 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
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

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 Weed Management 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)					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**
Weed Treatment	Spray Vehicle	40	---	100	---	---	37	4.28	31.57	0.45	950.50	200.40	0.00	0.02	0.00	0.48	0.10	0.01	1.11	0.00	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	**2.14E-03**	**1.58E-02**	**2.27E-04**	**4.75E-01**	**1.00E-01**	**1.45E-02**	**1.11E+00**	**8.72E-04**	**6.95E-06**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Hours estimated by dividing total vehicle miles traveled by speed.

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 (%)		34.6	Source of activity data: Billings Field Office.
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		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		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.

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)
Weed Treatment	ATV and Other Equipment	5	---	---	714	1	714	1.18	0.42	0.42	0.12	0.04	0.04
								Total	**0.42**			**0.04**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

[a] Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative B

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. 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
Weed Treatment	ATV	R12S	---	---	---	---	184	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	1,326	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.60	0.00	0.00
							Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.63**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative B acreage is 17% of Alternative A acreage.

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

Appendix C

Alternative C Emission Inventory

Summary of Emissions C-1

Oil Development and Production ..... (*see pages A-2 through A-28*)

Natural Gas Development and Production . (*see pages A-29 through A-54*)

General Purpose BLM Fleet Travel ..... (*see pages A-55 through A-57*)

BLM Road Maintenance ..... (*see pages A-58 through A-60*)

Coal Mining..... (*see page A-61)*

Fire Management C-2

Forestry and Woodland Products C-7

Livestock Grazing ..... (*see pages A-72 through A-77*)

Recreation and Visitor Services..... (*see pages A-78 through A-80*)

Vegetation Management C-12

Alternative C Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.5	241.1	0.1	11.9	2.4	15.2	6,284.8	38.6	0.0	7,107.3
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3	1,044.1	13.9	0.0	1,333.0
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,477.8	48.5	76.9	11.9	164.0	128.0	18.7	309,080.4	209.8	39.3	326,140.6
Forestry Management	1.4	1.9	0.2	0.0	15.4	1.7	0.0	243.0	0.0	0.0	244.2
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.2	0.0	0.5	0.0	10.4	1.1	0.1	7.8	0.0	0.0	8.0
Federal Emission Total	**1,581.4**	**110.9**	**324.7**	**12.0**	**605.8**	**174.0**	**34.5**	**317,260.3**	**535.1**	**39.4**	**341,179.5**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	52.1	14.3	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.4	28.7	13.1	0.2	9.0	2.2	1.3	4,168.8	55.6	0.0	5,321.4
Non-Federal Emission Total	**293.3**	**236.3**	**981.9**	**2.1**	**61.0**	**16.5**	**62.7**	**29,330.3**	**209.8**	**0.1**	**33,752.8**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes 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	54931	16068	8949	8147	32692	4533
Alt. C (%) of NEI Emissions	2.9%	0.7%	3.6%	0.1%	1.9%	3.8%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. C (%) without Mine Emissions	2.9%	0.5%	3.6%	0.1%	1.8%	3.8%

Fire Management and Ecology **Alternative C**

Total Annual Emissions from Fire Management 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	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	363.92	312.13	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.27	0.07	7.46	0.66	12.00	2.10	0.21	309,165.48	34.39	11.52	313,460.22	284,446.67
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**376.2**	**313.4**	**108.8**	**28.4**	**3,635.7**	**187.0**	**18.7**	**309,194.7**	**226.3**	**39.3**	**326,140.6**	**295,953.4**
Emissions Without Wildfire Smoke	**164.0**	**128.0**	**48.5**	**11.9**	**1,477.8**	**76.9**	**18.7**	**309,080.4**	**209.8**	**39.3**	**326,140.6**	**295,953.4**
% of Emissions From Wildfire Smoke	**56%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

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

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	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 Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10} [c]	$PM_{2.5}$ [c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**5.94**	**0.59**

[a] Source: BiFO

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

[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	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 CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from 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	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[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	4,570	34.6	30	89.673	0.033	13,660.25	0	**1.71**	**0.17**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), 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
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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 (2006)

Fire Management Resource: Alternative C

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									
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)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

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	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.00	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.01	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	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
	Pump	25	2	15	8	0	1	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	**0.29**	**0.27**	**0.01**	**7.34**	**1.53**	**0.07**	**46.91**	**0.00**	**0.00**

Activity data source: BiFO. 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	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

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

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2011 (BLM 2011a).
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[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} 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)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**11.98**			**1.20**	

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative C

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: 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	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Forestry and Woodland Products - Alternative C

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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	12.77	1.28	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.15	0.14	1.81	0.05	1.35	0.20	0.02	223.97	0.00	0.00	224.78	203.98
Sub-total: Heavy Equipment	**12.92**	**1.42**	**1.81**	**0.05**	**1.35**	**0.20**	**0.02**	**223.97**	**0.00**	**0.00**	**224.78**	**203.98**
Commuting Vehicles - Fugitive Dust	2.46	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.07	0.00	0.08	0.03	0.00	19.03	0.00	0.00	19.44	17.64
Sub-total: Commuting Vehicles	**2.46**	**0.25**	**0.07**	**0.00**	**0.08**	**0.03**	**0.00**	**19.03**	**0.00**	**0.00**	**19.44**	**17.64**
Total	**15.38**	**1.67**	**1.88**	**0.05**	**1.43**	**0.23**	**0.02**	**243.01**	**0.003**	**0.004**	**244.23**	**221.62**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

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.

Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	112	2,240	31	12.73	1.27
			Total	**12.73**	**1.27**

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	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	112.0	34.6	30	96.3	89.673	0.033	334.78	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.

* "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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Forestry and Woodland Products - Alternative C

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	31	248	368.99	42.17	10.04	304.39	36.14	1.8E-01	2.1E-02	5.0E-03	1.5E-01	1.8E-02	2.0E-02	2.3E+01	2.7E-04	2.4E-04
	Log Truck	450	1	60	10	31	310	810.09	45.43	21.28	325.00	41.21	4.1E-01	2.3E-02	1.1E-02	1.6E-01	2.1E-02	2.2E-02	4.9E+01	3.1E-04	5.6E-04
	Chainsaw	6	1	80	8	31	248	3.47	25.58	0.37	770.34	162.42	1.7E-03	1.3E-02	1.8E-04	3.9E-01	8.1E-02	1.2E-02	9.0E-01	7.1E-04	5.6E-06
	Feller Buncher	300	1	100	8	31	248	771.40	88.16	20.98	636.36	75.56	3.9E-01	4.4E-02	1.0E-02	3.2E-01	3.8E-02	4.3E-02	4.9E+01	5.7E-04	5.0E-04
	Loader	200	1	80	10	31	310	480.05	26.92	12.61	192.59	24.42	2.4E-01	1.3E-02	6.3E-03	9.6E-02	1.2E-02	1.3E-02	2.9E+01	1.9E-04	3.3E-04
	Dozer	200	1	90	8	31	248	432.05	24.23	11.35	173.34	21.98	2.2E-01	1.2E-02	5.7E-03	8.7E-02	1.1E-02	1.2E-02	2.6E+01	1.7E-04	3.0E-04
	Delimber	250	1	100	10	31	310	750.08	42.06	19.71	300.93	38.16	3.8E-01	2.1E-02	9.9E-03	1.5E-01	1.9E-02	2.0E-02	4.6E+01	2.9E-04	5.2E-04
												Total	**1.8E+00**	**1.5E-01**	**4.8E-02**	**1.4E+00**	**2.0E-01**	**1.4E-01**	**2.2E+02**	**2.5E-03**	**2.4E-03**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume 2008 emission factors for all years; this is a 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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
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	30	31	930	1	930	1.32	0.61	2.46	0.13	0.06	0.25
	Log Truck	25	30	62	1,860	1	1,860	1.32	1.23		0.13	0.12	
	Pick-up Truck	25	30	31	930	1	930	1.32	0.61		0.13	0.06	
							Total		**2.46**			**0.25**	

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative C

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	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.01	0.00	0.07	0.01	0.01	0.00	0.08	0.03	5.41	0.00	0.00
	Log Truck	HDDV	200	62	12,400	1	12,400	0.04	0.00	0.00	0.00	0.02	0.00							10.82	0.00	0.00
	Pick-up Truck	LDDT	200	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.04	0.02							2.80	0.00	0.00
							Total	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**19.03**	**0.0008**	**0.0013**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

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

Vegetation Management Resource - Alternative C

Weed Treatment **Alternative C**

Total Annual Emissions for Weed Treatment - RMP Year - 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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.44	0.84	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.07	0.06	0.01	0.00	2.12	0.45	0.04	4.97	0.00	0.00	5.06	4.59
Sub-total: Heavy Equipment	**8.51**	**0.91**	**0.01**	**0.00**	**2.12**	**0.45**	**0.04**	**4.97**	**0.00**	**0.0000**	**5.06**	**4.59**
Commuting Vehicles - Fugitive Dust	1.89	0.19	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.08	0.06	0.01	2.80	0.00	0.00	2.92	2.65
Sub-total: Commuting Vehicles	**1.89**	**0.19**	**0.02**	**0.00**	**0.08**	**0.06**	**0.01**	**2.80**	**0.00**	**0.0003**	**2.92**	**2.65**
Total	**10.40**	**1.10**	**0.02**	**0.00**	**2.21**	**0.51**	**0.05**	**7.77**	**0.00**	**0.000**	**7.98**	**7.24**

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

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

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 Weed Treatment - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Weed Treatment	2088	41,760	1	7.66	0.77
			Total	**7.66**	**0.77**

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	2088.0	34.6	30	89.673	0.033	6,241.27	0	**0.78**	**0.08**

* 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
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

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 Weed Management 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)					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**
Weed Treatment	Spray Vehicle	40	---	100	---	---	164	19.15	141.12	2.03	######	895.91	0.01	0.07	0.00	2.12	0.45	0.06	4.97	0.00	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						**9.58E-03**	**7.06E-02**	**1.01E-03**	**2.12E+00**	**4.48E-01**	**6.49E-02**	**4.97E+00**	**3.90E-03**	**3.11E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Hours estimated by dividing total vehicle miles traveled by speed.

Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative C

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 (%)		34.6	Source of activity data: Billings Field Office.
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		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		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.

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)
Weed Treatment	ATV and Other Equipment	5	---	---	3,192	1	3,192	1.18	1.89	1.89	0.12	0.19	0.19
							Total		**1.89**			**0.19**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

[a] Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative C

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. 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
Weed Treatment	ATV	R12S	---	---	---	---	821	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.04	0.04	0.13	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	5,928	0.02	0.00	0.00	0.00	0.04	0.02	0.02	0.00	0.00	0.00	0.04	0.02	2.68	0.00	0.00
							Total	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**2.80**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative C acreage is 76% of Alternative A acreage.

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

Appendix D

Alternative D Emission Inventory

Summary of Emissions D-1

Oil Development and Production ..... (*see pages A-2 through A-28*)

Natural Gas Development and Production . (*see pages A-29 through A-54*)

General Purpose BLM Fleet Travel ..... (*see pages A-55 through A-57*)

BLM Road Maintenance ..... (*see pages A-58 through A-60*)

Coal Mining..... (*see page A-61)*

Fire Management D-2

Forestry and Woodland Products D-7

Livestock Grazing ..... (*see pages A-72 through A-77*)

Recreation and Visitor Services..... (*see pages A-78 through A-80*)

Vegetation Management D-12

Alternative D Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.5	241.1	0.1	11.9	2.4	15.2	6,284.8	38.6	0.0	7,107.3
Natural Gas	10.8	4.6	3.1	0.0	2.1	0.4	0.3	1,044.1	13.9	0.0	1,333.0
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.7	48.4	76.5	11.9	171.2	128.9	18.7	309,060.3	209.8	39.3	326,120.3
Forestry Management	1.2	1.5	0.2	0.0	10.3	1.1	0.0	196.0	0.0	0.0	197.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	1.2	0.0	0.3	0.0	5.6	0.6	0.0	4.2	0.0	0.0	4.3
Federal Emission Total	**1,578.0**	**110.5**	**324.0**	**12.0**	**603.1**	**173.8**	**34.4**	**317,189.6**	**535.1**	**39.4**	**341,108.2**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	52.1	14.3	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.4	28.7	13.1	0.2	9.0	2.2	1.3	4,168.8	55.6	0.0	5,321.4
Non-Federal Emission Total	**293.3**	**236.3**	**981.9**	**2.1**	**61.0**	**16.5**	**62.7**	**29,330.3**	**209.8**	**0.1**	**33,752.8**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes 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	54931	16068	8949	8147	32692	4533
Alt. D (%) of NEI Emissions	2.9%	0.7%	3.6%	0.1%	1.8%	3.8%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. D (%) without Mine Emissions	2.9%	0.5%	3.6%	0.1%	1.8%	3.8%

Fire Management Resource - Alternative D

Fire Management and Ecology **Alternative D**

Total Annual Emissions from Fire Management 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	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	374.45	313.19	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.19	0.23	7.41	0.65	9.95	1.67	0.17	309,155.62	34.39	11.52	313,450.34	284,437.69
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.06	0.00	0.08	0.05	0.01	18.96	0.00	0.00	19.32	17.53
Total	**383.4**	**314.3**	**108.7**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,174.6**	**226.3**	**39.3**	**326,120.3**	**295,934.9**
Emissions Without Wildfire Smoke	**171.2**	**128.9**	**48.4**	**11.9**	**1,475.7**	**76.5**	**18.7**	**309,060.3**	**209.8**	**39.3**	**326,120.3**	**295,934.9**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

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

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	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 Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10} [c]	$PM_{2.5}$ [c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	6,293	1	8.18	0.82
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**14.12**	**1.41**

[a] Source: BiFO

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

[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	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 CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from 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	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[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	10,863	34.6	30	89.673	0.033	32,470.73	0	**4.06**	**0.41**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), 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
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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 (2006)

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

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)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

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	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.13	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	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
	Pumps	25	2	15	8	0	1	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	**0.23**	**0.19**	**0.01**	**5.29**	**1.10**	**0.23**	**37.05**	**0.00**	**0.00**

Activity data source: BiFO. 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	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

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

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2011 (BLM 2011a)
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[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} 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)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**8.76**			**0.88**	

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative D

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: 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	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	1050	1	1,050	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.06**	**0.01**	**0.01**	**0.00**	**0.08**	**0.05**	**18.96**	**0.00**	**0.00**

Source of activity data: Billings Field Office, Bobby Flesch email dated August 28, 2011 (BLM 2011f). Activities were determined on an annual rather than a project basis.

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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.19	0.82	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.12	0.11	1.46	0.04	1.09	0.16	0.02	180.62	0.00	0.00	181.28	164.50
Sub-total: Heavy Equipment	**8.31**	**0.93**	**1.46**	**0.04**	**1.09**	**0.16**	**0.02**	**180.62**	**0.00**	**0.00**	**181.28**	**164.50**
Commuting Vehicles - Fugitive Dust	1.98	0.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.00	0.06	0.00	0.06	0.02	0.00	15.35	0.00	0.00	15.68	14.23
Sub-total: Commuting Vehicles	**1.99**	**0.20**	**0.06**	**0.00**	**0.06**	**0.02**	**0.00**	**15.35**	**0.00**	**0.00**	**15.68**	**14.23**
Total	**10.30**	**1.14**	**1.52**	**0.04**	**1.15**	**0.18**	**0.02**	**195.97**	**0.003**	**0.003**	**196.96**	**178.73**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

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.

Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Forest/Woodland Forest Products	89	1,780	25	8.16	0.82
			Total	**8.16**	**0.82**

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	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	89.0	34.6	30	96.3	89.673	0.033	266.03	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

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Forestry and Woodland Products - Alternative D

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	25	200	297.57	34.01	8.09	245.48	29.15	1.5E-01	1.7E-02	4.0E-03	1.2E-01	1.5E-02	1.6E-02	1.9E+01	2.2E-04	1.9E-04
	Log Truck	450	1	60	10	25	250	653.30	36.64	17.16	262.10	33.23	3.3E-01	1.8E-02	8.6E-03	1.3E-01	1.7E-02	1.8E-02	4.0E+01	2.5E-04	4.5E-04
	Chainsaw	6	1	80	8	25	200	2.80	20.63	0.30	621.24	130.98	1.4E-03	1.0E-02	1.5E-04	3.1E-01	6.5E-02	9.5E-03	7.3E-01	5.7E-04	4.5E-06
	Feller Buncher	300	1	100	8	25	200	622.10	71.10	16.92	513.19	60.93	3.1E-01	3.6E-02	8.5E-03	2.6E-01	3.0E-02	3.4E-02	3.9E+01	4.6E-04	4.0E-04
	Loader	200	1	80	10	25	250	387.14	21.71	10.17	155.32	19.69	1.9E-01	1.1E-02	5.1E-03	7.8E-02	9.8E-03	1.1E-02	2.4E+01	1.5E-04	2.7E-04
	Dozer	200	1	90	8	25	200	348.42	19.54	9.15	139.79	17.72	1.7E-01	9.8E-03	4.6E-03	7.0E-02	8.9E-03	9.5E-03	2.1E+01	1.3E-04	2.4E-04
	Delimber	250	1	100	10	25	250	604.90	33.92	15.89	242.69	30.77	3.0E-01	1.7E-02	7.9E-03	1.2E-01	1.5E-02	1.6E-02	3.7E+01	2.3E-04	4.2E-04
												Total	**1.5E+00**	**1.2E-01**	**3.9E-02**	**1.1E+00**	**1.6E-01**	**1.1E-01**	**1.8E+02**	**2.0E-03**	**2.0E-03**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume 2008 emission factors for all years; this is a 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 (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
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		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
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	30	25	750	1	750	1.32	0.50	1.98	0.13	0.05	0.20
	Log Truck	25	30	50	1,500	1	1,500	1.32	0.99		0.13	0.10	
	Pick-up Truck	25	30	25	750	1	750	1.32	0.50		0.13	0.05	
							Total		**1.98**			**0.20**	

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative D

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	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.01	0.00	0.06	0.01	0.00	0.00	0.06	0.02	4.36	0.00	0.00
	Log Truck	HDDV	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.02	0.00							8.73	0.00	0.00
	Pick-up Truck	LDDT	200	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.03	0.02							2.26	0.00	0.00
							Total	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**15.35**	**0.0006**	**0.0010**

Source of activity data: Tami Sabol, Billings Field Office (BLM 2011b, 2011c).

7

Vegetation Management Resource - Alternative D

Weed Treatment **Alternative D**

Total Annual Emissions for Weed Treatment - RMP Year - 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	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.50	0.45	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.04	0.04	0.01	0.00	1.15	0.24	0.02	2.68	0.00	0.00	2.73	2.48
Sub-total: Heavy Equipment	**4.54**	**0.49**	**0.01**	**0.00**	**1.15**	**0.24**	**0.02**	**2.68**	**0.00**	**0.0000**	**2.73**	**2.48**
Commuting Vehicles - Fugitive Dust	1.02	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.01	0.00	0.05	0.03	0.00	1.51	0.00	0.00	1.57	1.43
Sub-total: Commuting Vehicles	**1.02**	**0.10**	**0.01**	**0.00**	**0.05**	**0.03**	**0.00**	**1.51**	**0.00**	**0.0002**	**1.57**	**1.43**
Total	**5.56**	**0.59**	**0.01**	**0.00**	**1.19**	**0.28**	**0.03**	**4.19**	**0.00**	**0.000**	**4.30**	**3.90**

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

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

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 Weed Treatment - All Project Years

Construction Activity	Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year)	
				PM_{10}	$PM_{2.5}$
Weed Treatment	1114	22,280	1	4.08	0.41
			Total	**4.08**	**0.41**

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	1114.0	34.6	30	89.673	0.033	3,329.87	0	**0.42**	**0.04**

* 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
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 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).

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

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 Weed Management 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)					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**
Weed Treatment	Spray Vehicle	40	---	100	---	---	89	10.33	76.13	1.09	2,292.37	483.32	0.01	0.04	0.00	1.15	0.24	0.04	2.68	0.00	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	**5.17E-03**	**3.81E-02**	**5.47E-04**	**1.15E+00**	**2.42E-01**	**3.50E-02**	**2.68E+00**	**2.10E-03**	**1.68E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Hours estimated by dividing total vehicle miles traveled by speed.

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 (%)		34.6	Source of activity data: Billings Field Office.
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		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		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.

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)
Weed Treatment	ATV and Other Equipment	5	---	---	1,722	1	1,722	1.18	1.02	1.02	0.12	0.10	0.10
							Total		**1.02**			**0.10**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

[a] Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative D

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. 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
Weed Treatment	ATV	R12S	---	---	---	---	443	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.07	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	3,198	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.01	1.44	0.00	0.00
							Total	**8.27E-03**	**1.29E-03**	**1.15E-03**	**3.34E-05**	**4.54E-02**	**3.35E-02**	**8.27E-03**	**1.29E-03**	**1.15E-03**	**3.34E-05**	**4.54E-02**	**3.35E-02**	**1.51E+00**	**2.14E-04**	**1.88E-04**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011 (BLM 2011g). Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative D treated acreage is 41% of Alternative A treated acreage.

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

Appendix E

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	2.05E-04	1.54E-01	1.54E-01	2.14E-04	2.14E-04	1.60E-04	3.52E-06	6.88E-03	1.51E-04	6.88E-03	1.51E-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)	1.25E-02	1.71E-05	1.54E-01	1.54E-01	2.14E-04	2.14E-04	1.60E-04	2.93E-07	4.69E-04	8.56E-07	4.69E-04	8.56E-07	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

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	5.83E-05	4.66E-01	4.66E-01	-	-	-	-	3.33E-02	2.28E-05	3.33E-02	2.28E-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	Coordinates (m)		Length (m)		(m)	(deg)	(m)
XE	Construction Wind Erosion - ST									1.98E-06		2.97E-07		-62.50	-62.50	125.00	125	0	0	0
XEA	Construction Wind Erosion - Annual										1.05E-06		1.47E-07	-62.50	-62.50	125.00	125	0	0	0
XM	Construction Mobile Exhaust - ST	5.85E-06		4.52E-06	2.89E-10	1.61E-07	1.61E-07	1.61E-07		6.54E-07		6.54E-07		-62.50	-62.50	125.00	125	4	0	4.6
XMA	Construction Mobile Exhaust - Annual		2.42E-08						6.65E-10		2.71E-09		2.71E-09	-62.50	-62.50	125.00	125	4	0	4.6
XA	Construction Disturbance (Pad) - ST									1.97E-05		1.97E-06		-62.50	-62.50	125.00	125	2	0	2.37
XAA	Construction Disturbance (Pad) - Annual										5.94E-08		5.94E-09	-62.50	-62.50	125.00	125	2	0	2.37
XR	Construction Disturbance (Road) - ST							Divide by 7		4.06E-05		4.06E-06		Varies		50.00	10	2	0	2.37
XRA	Construction Disturbance (Road) - Annual										4.59E-08		4.59E-09			50.00	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		1.08E-01		1.08E-02		9	800	7200	2.55	2.09	2.37	2.55
XDA	Construction Mobile Dust - Annual										4.49E-04		2.25E-05	9	800	7200	2.55	2.09	2.37	2.55
DD	Drilling Mobile Dust - ST							Divide by 9		3.68E-02		3.68E-03		9	800	7200	2.55	2.09	2.37	2.55
DDA	Drilling Mobile Dust - Annual										8.07E-04		8.07E-05	9	800	7200	2.55	2.09	2.37	2.55
CD	Completion Mobile Dust - ST							Divide by 9		3.33E-02		3.33E-02		9	800	7200	2.55	2.09	2.37	2.55
CDA	Completion Mobile Dust - Annual										1.20E-04		1.20E-05	9	800	7200	2.55	2.09	2.37	2.55
PD	Production Mobile Dust - ST							Divide by 9		4.13E-02		4.11E-03		9	800	7200	2.55	2.09	2.37	2.55
PDA	Production Mobile Dust - Annual										2.18E-04		2.18E-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	1.95E-06	8.73E-05	1.44E-06	1.81E-05	2.97E-07	6.17E-05	1.01E-06	6.89E-04	1.13E-05	9.28E-06	1.53E-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)	1.19E-04	1.63E-07	8.73E-05	1.20E-07	1.81E-05	2.48E-08	6.17E-05	8.46E-08	6.89E-04	9.44E-07	9.28E-06	1.27E-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
PT	Oil Tank	3.65E-04	3.65E-04	4.64E-04	4.64E-04	1.74E-05	1.74E-05	2.03E-04	2.03E-04	-	-	4.81E-03	4.81E-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	1.37E-07	7.31E-05	5.01E-08	1.82E-03	1.25E-06	3.65E-05	2.50E-08	1.47E-03	1.01E-06	3.65E-05	2.50E-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													-62.50	-62.50	125.00	125	0	0	0
XEA	Construction Wind Erosion - Annual													-62.50	-62.50	125.00	125	0	0	0
XM	Construction Mobile Exhaust - ST	5.88E-08		4.32E-08		8.96E-09		3.06E-08		3.41E-07		4.60E-09		-62.50	-62.50	125.00	125	4	0	4.6
XMA	Construction Mobile Exhaust - Annual		1.05E-10		7.70E-11		1.60E-11		5.45E-11		6.08E-10		8.19E-12	-62.50	-62.50	125.00	125	4	0	4.6
XA	Construction Disturbance (Pad) - ST													-62.50	-62.50	125.00	125	2	0	2.37
XAA	Construction Disturbance (Pad) - Annual													-62.50	-62.50	125.00	125	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	4.19	2.37	2.55
XDA	Construction Mobile Dust - Annual													9	900	8100	2.55	4.19	2.37	2.55
DD	Drilling Mobile Dust - ST													9	900	8100	2.55	4.19	2.37	2.55
DDA	Drilling Mobile Dust - Annual													9	900	8100	2.55	4.19	2.37	2.55
CD	Completion Mobile Dust - ST													9	900	8100	2.55	4.19	2.37	2.55
CDA	Completion Mobile Dust - Annual													9	900	8100	2.55	4.19	2.37	2.55
PD	Production Mobile Dust - ST													9	900	8100	2.55	4.19	2.37	2.55
PDA	Production Mobile Dust - Annual													9	900	8100	2.55	4.19	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	-	-	-	2.44E+00	2.44E-01
Construction Disturbance - Road	-	-	-	1.61E-01	1.61E-02
Mobile Equipment Exhaust	7.25E-01	5.60E-01	1.99E-02	8.11E-02	2.63E+01
Mobile Equipment Fugitive Dust	-	-	-	8.61E-01	8.61E-02
Wind Erosion	-	-	-	2.46E-01	3.69E-02

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	-	-	-	2.44E+00	2.44E-01
Construction Disturbance - Road	-	-	-	1.61E-01	1.61E-02
Mobile Equipment Exhaust	7.25E-01	5.60E-01	1.99E-02	8.11E-02	8.11E-02
Mobile Equipment Fugitive Dust	-	-	-	8.61E-01	8.61E-02
Wind Erosion	-	-	-	2.46E-01	3.69E-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]	-	-	-	2.92E-01	2.92E-02

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	-	-	-	2.92E-01	2.92E-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)	9.92E-02	1.22E+00	1.70E-03	4.96E-03	4.96E-03
Completion Mobile Fugitive Dust [1]	-	-	-	1.52E-01	1.52E-02
Completion Flaring	0.68	3.70	-	0.26	0.26

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)	7.44E-02	9.18E-01	1.27E-03	3.72E-03	3.72E-03
Completion Mobile Fugitive Dust 1	-	-	-	1.52E-01	1.52E-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
Production Mobile Fugitive Dust [1]	-	-	-	3.27E-01	3.26E-02

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
Production Mobile Fugitive Dust 1	-	-	-	3.27E-01	3.26E-02

[1] In modeling domain.

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	**-**	**-**	**-**	**3.23E-02**	**3.23E-03**	Daytime only
Construction Disturbance - Road	**-**	**-**	**-**	**7.97E-04**	**7.97E-05**	Daytime only
Mobile Equipment Exhaust	**1.32E-02**	**1.02E-02**	**3.61E-04**	**1.47E-03**	**1.47E-03**	Daytime only
Mobile Equipment Fugitive Dust	**-**	**-**	**-**	**1.56E-02**	**7.81E-04**	Warm months, daytime
Wind Erosion	**-**	**-**	**-**	**5.70E-01**	**7.98E-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)	**7.14E-03**	**8.81E-02**	**1.22E-04**	**5.24E-03**	**5.24E-03**
Rig Boiler	**9.60E-03**	**2.40E-03**	**1.02E-04**	**9.60E-04**	**9.60E-04**
Drilling Mobile Equipment Fugitive Dust 1	**-**	**-**	**-**	**2.80E-02**	**2.80E-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)	**5.95E-04**	**7.34E-03**	**1.02E-05**	**2.98E-05**	**2.98E-05**	
Completion Mobile Fugitive Dust 1	**-**	**-**	**-**	**4.18E-03**	**4.18E-04**	Warm months, daytime
Completion Flaring	**2.03E-03**	**1.10E-02**	**-**	**7.94E-04**	**7.94E-04**	

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**	
Production Mobile Fugitive Dust 1	**-**	**-**	**-**	**7.59E-03**	**7.57E-04**	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)	**9.42E-04**	**6.93E-04**	**1.44E-04**	**4.90E-04**	**5.47E-03**	**7.37E-05**	**-**
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**	**-**
Oil Tank (Oil Wells)	**2.90E-03**	**3.68E-03**	**1.38E-04**	**1.61E-03**	**-**	**3.82E-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	**5.69E-05**	**4.18E-05**	**8.67E-06**	**2.96E-05**	**3.30E-04**	**4.45E-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)	**6.78E-05**	**4.99E-05**	**1.03E-05**	**3.53E-05**	**3.94E-04**	**5.30E-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)	**5.65E-06**	**4.16E-06**	**8.61E-07**	**2.94E-06**	**3.28E-05**	**4.42E-07**	**-**
Completion Flaring	**4.77E-06**	**1.74E-06**	**4.33E-05**	**8.70E-07**	**3.51E-05**	**8.70E-07**	**-**

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**	**-**
Oil Tank (Oil Wells)	**1.27E-02**	**1.61E-02**	**6.06E-04**	**7.07E-03**	**-**	**1.67E-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	4	0.11	0.55	12	2.2	26	N/A	N/A	2.44	3.23E-02	0.244	3.23E-03
Access Road	1.5	0.11	0.55	12	0.8	10	N/A	N/A	0.92	4.54E-03	0.092	4.54E-04
								Total	**3.36E+00**	**3.68E-02**	**3.36E-01**	**3.68E-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)
1,686	1.99E-03	1.99E-04	0.8	12	800	2.01E-04	1.61E-01	7.97E-04	2.01E-05	1.61E-02	7.97E-05

[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	12	175	1	7.25E-01	2.52E-01	1.99E-02	5.64E-02	2.63E+01	9.15E+00	7.23E-01	2.05E+00
Grader [5]	4.85	3.94	1.30E-01	0.570	12	150	1	6.90E-01	5.60E-01	1.85E-02	8.11E-02	2.50E+01	2.03E+01	6.71E-01	2.94E+00
							Total	**1.41E+00**	**8.12E-01**	**3.84E-02**	**1.37E-01**	**5.14E+01**	**2.95E+01**	**1.39E+00**	**4.99E+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	9.43E-02	9.43E-03	6	1.57E-02	1.57E-03	9.76E-06	9.76E-07	3.0	12	800	1.08E-03	8.61E-01	1.56E-02	1.08E-04	8.61E-02	7.81E-04
											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}	26.1	m/s
Friction Velocity [2]	u*	1.38	m/s
Threshold Friction Velocity [3]	u_t	1.33	m/s
Excess Friction Velocity	$u^* - u_t$	0.05	m/s
Erosion Potential [4]	P	1.45	g/m^2
Erodable Area [5]		1.8	acres
	A	7358.2	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]	11.80	11.80	4.92E-01
PM_{10} [10]	5.90	5.90	2.46E-01
$PM_{2.5}$ [11]	0.89	0.89	3.69E-02

Notes:

[1] Calculated from average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm.

[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 scoria, 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%	4.0	0.76	5.70E-01	7.98E-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, we multiplied the TSP emission factor 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)	1677.0
Construction Duration	(days/pad)	3.0

Pollutant	Emission Factor	Emission Rate	
	(g/hp-hr)	(lb/pad)	(lb/hr)
VOC [3]	0.5	5.59E+00	3.58E-01

Pollutant	Emission Factor	Emission Rate		
	(g/g VOC)	(lb/pad)	(lb/hr)	(tpy)
Benzene [4]	2.0E-02	1.1E-01	7.3E-03	5.7E-05
Toluene [4]	1.5E-02	8.4E-02	5.4E-03	4.2E-05
Ethyl Benzene [4]	3.1E-03	1.7E-02	1.1E-03	8.7E-06
Xylene [4]	1.1E-02	5.9E-02	3.8E-03	3.0E-05
Formaldehyde [4]	1.2E-01	6.6E-01	4.2E-02	3.3E-04
Hexane [4]	1.6E-03	8.9E-03	5.7E-04	4.4E-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				8			
	(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	7.14E-03
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	8.81E-02
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	1.22E-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	5.24E-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	6.78E-05
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	4.99E-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	1.03E-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	3.53E-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	3.94E-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	5.30E-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	1.69E-01	1.69E-02	6	2.82E-02	2.82E-03	1.75E-05	1.75E-06	16	12	800	3.65E-04	2.92E-01	2.80E-02	3.65E-05	2.92E-02	2.80E-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. Assumes deliveries occur during daytime.

Completion/Fracking Engine Emission Calculations

Purpose		Main Deck (1 engine)				Auxiliary (1 engine)				Power Swivel (I engine)			
Rig Size [1]	(hp)	600				225				150			
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				2			
	(hours/day)	11				8				8			
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	0.10	0.07	6.0E-04
CO [3]	2.6	3.44	1.72	4.7E-02	2.6	1.29	1.03	8.3E-03	3.7	1.22	0.92	7.3E-03
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	1.7E-03	1.3E-03	1.0E-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	5.0E-03	3.7E-03	3.0E-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	9.4E-04	7.1E-04	5.7E-06
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	6.9E-04	5.2E-04	4.2E-06
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	1.4E-04	1.1E-04	8.6E-07
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	4.9E-04	3.7E-04	2.9E-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	5.5E-03	4.1E-03	3.3E-05
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	7.4E-05	5.5E-05	4.4E-07
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/Fracking 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	2.52E-02	2.52E-03	6	4.21E-03	4.21E-04	2.62E-06	2.62E-07	5	11	800	1.90E-04	1.52E-01	4.18E-03	1.90E-05	1.52E-02	4.18E-04
											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. Assumes deliveries occur during daytime.

Completion/Fracking Flaring Emission Calculations

Flowback Duration [1]	(days/completion)	1
Gas Flared	(MMscf/day) [1]	0.06
	(MMscf/completion)	0.06
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)	60

Pollutant	Emission Factor		Emission Rate	
			(lb/hr)	(tpy)
NO_x [5]	0.068	(lb/MMBtu)	0.68	2.0E-03
CO [5]	0.37	(lb/MMBtu)	3.70	1.1E-02
SO_2 [3]	-	(lb/MMBtu)	-	-
PM_{10} [6,7,8]	40.0	(μg/L)	0.26	7.9E-04
Benzene [9]	0.159	(lb/MMscf)	1.6E-03	4.8E-06
Toluene [9]	0.058	(lb/MMscf)	5.8E-04	1.7E-06
Ethylbenzene [9]	1.444	(lb/MMscf)	1.4E-02	4.3E-05
Xylene [9]	0.029	(lb/MMscf)	2.9E-04	8.7E-07
Formaldehyde [9]	1.169	(lb/MMscf)	1.2E-02	3.5E-05
n-Hexane [9]	0.029	(lb/MMscf)	2.9E-04	8.7E-07
H_2S [3]	-	(lb/MMBtu)	-	-

[1] Assumptions provided by Charles Laakso (BLM).
[2] Capacity (Mscf/hr) = Gas Flared (MMscf/day) x 1000 (Mscf/MMscf); rounded up to nearest 10 Mscf/hr.
[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	2.48E-02	2.47E-03	6	4.13E-03	4.12E-04	2.57E-06	2.56E-07	56	900	1.83E-04	1.65E-01	4.62E-03	1.83E-05	1.64E-02	4.61E-04
Oil Hauling	1.59E-02	1.58E-03	2	2.66E-03	2.64E-04	1.65E-06	1.64E-07	37	900	1.81E-04	1.63E-01	2.97E-03	1.80E-05	1.62E-02	2.95E-04
									Total [2]	**3.64E-04**	**3.27E-01**	**7.59E-03**	**3.62E-05**	**3.26E-02**	**7.57E-04**
										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)	2.04E-01
Total H2S Emissions [1]	(ton/yr)	---

Pollutant	Emission Rate	
	(lb/pad)	(lb/hr)
HAP	4.08E+02	4.65E-02

Pollutant	Emission Factor	Emission Rate		
	(g/g HAP)	(lb/pad)	(lb/hr)	(tpy)
Benzene [2]	0.062	2.54E+01	2.90E-03	1.27E-02
Toluene [2]	0.079	3.22E+01	3.68E-03	1.61E-02
Ethyl Benzene [2]	0.003	1.21E+00	1.38E-04	6.06E-04
Xylene [2]	0.035	1.41E+01	1.61E-03	7.07E-03
Formaldehyde [2]	-	-	-	-
Hexane [2]	0.821	3.35E+02	3.82E-02	1.67E-01
H_2S	-	---	---	---

[1] From detailed Oil Well Emission Spreadsheets.

[2] Based on oil composition provided in Oil Well Emission Spreadsheets.

Appendix F

Near-Field Modeling Results

Table F-1. Criteria Pollutant Concentrations F-1

Table F-2. Hazardous Air Pollutant Concentrations F-3

Table F-3. HAP Carcinogenic Risk Assessment F-4

Criteria Air Pollutant Concentrations

Pollutant	Avg. Time	Scenario	Back-ground (µg/m³)	Results (µg/m³) 2007 Modeled	2007 Total	2008 Modeled	2008 Total	2009 Modeled	2009 Total	2010 Modeled	2010 Total	2011 Modeled	2011 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	194	7,407	180	7,393	190	7,403	177	7,390	200	7,413	199.7		7,413			40000	26450			19%	28%
		Construction	7,213	74	7,287	69	7,282	73	7,286	73	7,286	72	7,285	73.9		7,287			40000	26450			18%	28%
		Drilling	7,213	294	7,507	297	7,510	299	7,512	295	7,508	298	7,511	299.4		7,512			40000	26450			19%	28%
	8-hr (H2H)	Completion	2,175	105	2,280	98	2,273	107	2,282	102	2,277	104	2,279	106.7		2,282			10000				23%	
		Construction	2,175	6	2,181	5	2,180	4	2,179	4	2,179	5	2,180	5.7		2,181			10000				22%	
		Drilling	2,175	221	2,396	219	2,394	211	2,386	206	2,381	221	2,396	221.5		2,396			10000				24%	
NO_2 [1, 2, 3, 4]	1-hr NBC (H8H, w/o ARM)	Completion		9.5		9.3		9.5		9.4		9.3												
		Construction		83.3		66.4		71.8		82.5		54.5												
		Drilling		55.6		56.2		55.5		56.4		56.4												
	1-hr w/ 0.80 ARM (H8H)	Completion	40	7.6	47.6	7.4	47.4	7.6	47.6	7.5	47.5	7.5	47.5	7.5	48				188				25%	
		Construction	40	66.6	106.6	53.1	93.1	57.5	97.5	66.0	106.0	43.6	83.6	57.4	97				188				52%	
		Drilling	40	44.5	84.5	44.9	84.9	44.4	84.4	45.1	85.1	45.1	85.1	44.8	85				188				45%	
	Annual w/o ARM	Completion		0.410		0.393		0.384		0.366		0.422												
		Construction		0.340		0.392		0.382		0.364		0.422												
		Drilling		0.413		0.396		0.387		0.369		0.425												
	Annual with 0.75 ARM	Completion	6	0.307	6.307	0.295	6.295	0.288	6.288	0.274	6.274	0.317	6.317	0.32		6.3	2.5	25	100	94	13%	1%	6%	7%
		Construction	6	0.255	6.255	0.294	6.294	0.287	6.287	0.273	6.273	0.316	6.316	0.32		6.3	2.5	25	100	94	13%	1%	6%	7%
		Drilling	6	0.310	6.310	0.297	6.297	0.290	6.290	0.277	6.277	0.319	6.319	0.32		6.3	2.5	25	100	94	13%	1%	6%	7%
PM_{10} [1]	24-hr (H2H, over 5 years)	Completion	30	4.31	34.31	3.79	33.79	4.30	34.30	3.99	33.99	3.22	33.22	3.9	34		8	30	150	---	49%	13%	23%	
		Construction	30	76.07	106.07	75.31	105.31	77.82	107.82	107.24	137.24	71.27	101.27	81.5	112		8	30	150	---	1019%	272%	74%	
		Drilling	30	4.32	34.32	3.81	30.02	4.56	34.56	4.05	34.05	3.23	33.23	4.0	33		8	30	150	---	50%	13%	22%	
	Annual	Completion	8	0.018	8.018	0.017	8.017	0.017	8.017	0.016	8.016	0.019	8.019	0.0		8.0	4	17		50	0%	0%		16%
		Construction	8	1.011	9.011	0.998	8.998	0.998	8.998	1.130	9.130	1.026	9.026	1.1		9.1	4	17		50	28%	7%		18%
		Drilling	8	0.019	8.019	0.018	8.018	0.018	8.018	0.017	8.017	0.019	8.019	0.0		8.0	4	17		50	0%	0%		16%

Criteria Air Pollutant Concentrations

Pollutant	Avg. Time	Scenario	Back-ground (µg/m³)	Results (µg/m³) 2007 Modeled	2007 Total	2008 Modeled	2008 Total	2009 Modeled	2009 Total	2010 Modeled	2010 Total	2011 Modeled	2011 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 (H8H, over 5 years)	Completion	22.5	1.81	24.31	2.01	24.51	2.35	24.85	1.84	24.34	1.81	24.31	2.0	24				35				70%	
		Construction	22.5	5.97	28.47	4.83	27.33	4.67	27.17	5.81	28.31	3.74	26.24	5.0	28				35				79%	
		Drilling	22.5	3.00	25.50	2.73	25.23	2.40	24.90	2.50	25.00	2.61	25.11	2.7	25				35				72%	
	24-hr (H2H, PSD only)	Completion		3.81		3.21		3.82		2.78		2.68		3.3			2	9			163%	36%		
		Construction		9.65		9.22		9.72		13.64		8.80		10.2			2	9			510%	113%		
		Drilling		3.28		3.08		3.34		3.09		2.88		3.1			2	9			157%	35%		
	Annual [5]	Completion	5.5	0.02	5.52	0.02	5.52	0.02	5.52	0.02	5.52	0.02	5.52	0.02	5.52		1	4	12		2%	0%	46%	
		Construction	5.5	0.14	5.64	0.14	5.64	0.14	5.64	0.16	5.66	0.15	5.65	0.15	5.65		1	4	12		15%	4%	47%	
		Drilling	5.5	0.08	5.58	0.02	5.52	0.02	5.52	0.02	5.52	0.02	5.52	0.03	5.53		1	4	12		3%	1%	46%	
SO_2 [1]	1-hr (99th %, 5-yr avg) (H4H)	Completion	35	11.74	46.74	11.59	46.59	11.59	46.59	11.37	46.37	11.57	46.57	11.6	46.6				196				24%	
		Construction	35	2.43	FALSE	2.31	37.31	2.41	37.41	2.48	37.48	2.25	37.25	2.4	37.4				196				19%	
		Drilling	35	0.64	35.64	0.65	35.65	0.65	35.65	0.65	35.65	0.65	35.65	0.6	35.6				196				18%	
	24-hr (H2H)	Completion	11	0.086	11.086	0.085	11.085	0.075	11.075	0.083	11.083	0.075	11.075	0.09		11.1	5	91	365	262	2%	0%		4%
		Construction	11	0.391	11.391	0.302	11.302	0.291	11.291	0.408	11.408	0.275	11.275	0.41		11.4	5	91	365	262	8%	0%		4%
		Drilling	11	0.295	11.295	0.276	11.276	0.264	11.264	0.257	11.257	0.273	11.273	0.30		11.3	5	91	365	262	6%	0%		4%
	Annual	Completion	3	0.00041	3.00041	0.00040	3.00040	0.00039	3.00039	0.00037	3.00037	0.00042	3.00042	4.20E-04		3.0	2	20	80	52	0%	0%		6%
		Construction	3	0.00034	3.00034	0.00040	3.00040	0.00039	3.00039	0.00037	3.00037	0.00042	3.00042	4.20E-04		3.0	2	20	80	52	0%	0%		6%
		Drilling	3	0.00183	3.00183	0.00162	3.00162	0.00166	3.00166	0.00145	3.00145	0.00185	3.00185	1.85E-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 decreased from 15 µg/m³ to 12 µg/m³ on March 18, 2013.

Hazardous Air Pollutant Concentrations

Pollutant	Avg. Time	Scenario	Modeled Concentration (µg/m³) 2007	2008	2009	2010	2011	Maximum Modeled (µg/m³)	Maximum Modeled (mg/m³)	Threshold Type	Threshold Value (mg/m³)	Maximum Percentage of Threshold
Benzene	1-hr	Completion	0.791	0.793	0.791	0.794	0.766	7.94E-01	7.94E-04	REL	1.3	0.061%
		Construction	1.069	1.042	0.989	1.076	1.064	1.08E+00	1.08E-03	REL	1.3	0.083%
		Drilling	0.783	0.769	0.765	0.767	0.750	7.83E-01	7.83E-04	REL	1.3	0.060%
	Annual	Completion	0.020	0.021	0.020	0.020	0.022	2.20E-02	2.20E-05	RfC	0.03	0.073%
		Construction	0.020	0.021	0.020	0.020	0.022	2.20E-02	2.20E-05	RfC	0.03	0.073%
		Drilling	0.020	0.021	0.020	0.020	0.022	2.20E-02	2.20E-05	RfC	0.03	0.073%
Ethyl Benzene	1-hr	Completion	0.153	0.051	0.050	0.051	0.049	1.53E-01	1.53E-04	REL	350.0	0.000%
		Construction	0.166	0.151	0.147	0.154	0.154	1.66E-01	1.66E-04	REL	350.0	0.000%
		Drilling	0.115	0.113	0.114	0.116	0.117	1.17E-01	1.17E-04	REL	350.0	0.000%
	Annual	Completion	0.001	0.001	0.050	0.001	0.002	5.01E-02	5.01E-05	RfC	1.0	0.005%
		Construction	0.001	0.001	0.001	0.001	0.002	1.50E-03	1.50E-06	RfC	1.0	0.000%
		Drilling	0.001	0.001	0.001	0.001	0.002	1.50E-03	1.50E-06	RfC	1.0	0.000%
Formalde-hyde	1-hr	Completion	1.240	1.180	1.179	1.162	1.234	1.24E+00	1.24E-03	REL	0.055	2.255%
		Construction	5.657	5.604	5.569	5.690	5.696	5.70E+00	5.70E-03	REL	0.055	10.356%
		Drilling	1.829	1.860	1.848	1.850	1.895	1.89E+00	1.89E-03	REL	0.055	3.445%
	Annual	Completion	0.024	0.023	0.023	0.022	0.025	2.50E-02	2.50E-05	RfC	0.0098	0.255%
		Construction	0.024	0.023	0.023	0.022	0.025	2.50E-02	2.50E-05	RfC	0.0098	0.255%
		Drilling	0.024	0.023	0.023	0.022	0.025	2.50E-02	2.50E-05	RfC	0.0098	0.255%
n-Hexane	1-hr	Completion	10.321	10.346	10.319	10.358	9.989	1.04E+01	1.04E-02	REL	390.0	0.003%
		Construction	10.207	10.013	9.979	9.986	9.783	1.02E+01	1.02E-02	REL	390.0	0.003%
		Drilling	10.207	10.013	9.980	9.986	9.784	1.02E+01	1.02E-02	REL	390.0	0.003%
	Annual	Completion	0.222	0.239	0.231	0.224	0.247	2.47E-01	2.47E-04	RfC	0.7	0.035%
		Construction	0.216	0.227	0.219	0.213	0.239	2.39E-01	2.39E-04	RfC	0.7	0.034%
		Drilling	0.216	0.227	0.219	0.213	0.239	2.39E-01	2.39E-04	RfC	0.7	0.034%
Toluene	1-hr	Completion	1.001	1.004	1.001	1.005	0.969	1.01E+00	1.01E-03	REL	37.0	0.003%
		Construction	0.990	0.972	1.049	0.969	0.949	1.05E+00	1.05E-03	REL	37.0	0.003%
		Drilling	0.990	0.972	0.968	0.970	0.949	9.90E-01	9.90E-04	REL	37.0	0.003%
	Annual	Completion	0.024	0.025	0.024	0.024	0.026	2.63E-02	2.63E-05	RfC	5	0.001%
		Construction	0.024	0.024	0.024	0.023	0.026	2.58E-02	2.58E-05	RfC	5	0.001%
		Drilling	0.024	0.024	0.024	0.023	0.026	2.58E-02	2.58E-05	RfC	5	0.001%
Xylene	1-hr	Completion	0.440	0.441	0.439	0.441	0.426	4.41E-01	4.41E-04	REL	22.0	0.002%
		Construction	0.560	0.545	0.516	0.563	0.557	5.63E-01	5.63E-04	REL	22.0	0.003%
		Drilling	0.435	0.427	0.425	0.426	0.417	4.35E-01	4.35E-04	REL	22.0	0.002%
	Annual	Completion	0.011	0.012	0.011	0.011	0.012	1.22E-02	1.22E-05	RfC	0.1	0.012%
		Construction	0.011	0.011	0.011	0.011	0.012	1.21E-02	1.21E-05	RfC	0.1	0.012%
		Drilling	0.011	0.011	0.011	0.011	0.012	1.21E-02	1.21E-05	RfC	0.1	0.012%

Background concentrations are not included due to lack of data.

HAP Carcinogenic Risk Assessment

Pollutant	Analysis	Year	Annual Maximum Modeled (ug/m^3)	Carcinogenic Unit Risk Factor (ug/m^3)$^{-1}$	Exposure Adjustment Factor	Cancer Risk (per million)
Benzene	MLE	2007	2.04E-02	7.8E-06	0.0949	0.02
		2008	2.08E-02	7.8E-06	0.0949	0.02
		2009	2.04E-02	7.8E-06	0.0949	0.02
		2010	1.97E-02	7.8E-06	0.0949	0.01
		2011	2.20E-02	7.8E-06	0.0949	0.02
	MEI	2007	2.04E-02	7.8E-06	0.71	0.11
		2008	2.08E-02	7.8E-06	0.71	0.12
		2009	2.04E-02	7.8E-06	0.71	0.11
		2010	1.97E-02	7.8E-06	0.71	0.11
		2011	2.20E-02	7.8E-06	0.71	0.12
Ethyl Benzene	MLE	2007	1.41E-03	2.5E-06	0.0949	0.00
		2008	1.41E-03	2.5E-06	0.0949	0.00
		2009	5.01E-02	2.5E-06	0.0949	0.01
		2010	1.33E-03	2.5E-06	0.0949	0.00
		2011	1.50E-03	2.5E-06	0.0949	0.00
	MEI	2007	1.41E-03	2.5E-06	0.71	0.00
		2008	1.41E-03	2.5E-06	0.71	0.00
		2009	5.01E-02	2.5E-06	0.71	0.09
		2010	1.33E-03	2.5E-06	0.71	0.00
		2011	1.50E-03	2.5E-06	0.71	0.00
Formaldehyde	MLE	2007	2.43E-02	1.3E-05	0.0949	0.03
		2008	2.33E-02	1.3E-05	0.0949	0.03
		2009	2.27E-02	1.3E-05	0.0949	0.03
		2010	2.17E-02	1.3E-05	0.0949	0.03
		2011	2.50E-02	1.3E-05	0.0949	0.03
	MEI	2007	2.43E-02	1.3E-05	0.71	0.22
		2008	2.33E-02	1.3E-05	0.71	0.21
		2009	2.27E-02	1.3E-05	0.71	0.21
		2010	2.17E-02	1.3E-05	0.71	0.20
		2011	2.50E-02	1.3E-05	0.71	0.23

MEI = Maximally exposed individual.

MLE = Most likely exposure.

Background concentrations are not included due to lack of data.

Appendix G

Example AERMOD Input File

1-hr NO_2 Well Drilling Scenario 2011 Modeled Year

```
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 7.6.1
** Lakes Environmental Software Inc.
** Date: 8/1/2012
** File: C:\Lakes\AERMOD View\BiFO\2011\BiFO 2011 Drilling NO2 1-
hr\BiFO 2011 Drilling NO2 1-hr.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE C:\Lakes\AERMOD View\BiFO\BiFO 2011 Drilling NO2 1-hr
   MODELOPT CONC FLAT
   AVERTIME 1
   POLLUTID NO2
   RUNORNOT RUN
** Error File Path: C:\Lakes\AERMOD View\BiFO\2011\BiFO 2011 Drilling
NO2 1-hr\
   ERRORFIL "BiFO 2011 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
** 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
   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
** DESCRREC "" ""
   DISCCART      -150.00       162.50
   DISCCART      -125.00       162.50
   DISCCART      -100.00       162.50
   DISCCART       -75.00       162.50
   DISCCART       -50.00       162.50
```

[Additional receptors have been omitted to save space.]

```
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
**
ME STARTING
** Surface File Path: \\ilmmtso3ds1\so\Users\sbassett\My
Documents\Modeling\AERMOD Inputs for MT, ND, SD\MET Data\BiFO\Lakes
Met
Files\AERMOD_MET122412_24033_4102_2007_2011\AERMOD_MET122412_24033_410
2_2007_2011\
   SURFFILE MET122412_2011.SFC
** Profile File Path: \\ilmmtso3ds1\so\Users\sbassett\My
Documents\Modeling\AERMOD Inputs for MT, ND, SD\MET Data\BiFO\Lakes
Met
Files\AERMOD_MET122412_24033_4102_2007_2011\AERMOD_MET122412_24033_410
2_2007_2011\
   PROFFILE MET122412_2011.PFL
   SURFDATA 24033 2011 BILLINGS/LOGAN_INT'L_ARPT
   UAIRDATA 4102 2011
   PROFBASE 1091.6 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\BiFO\2011\BiFO 2011 Drilling
NO2 1-hr\BIFO 2011 DRILLING NO2 1-HR.AD\
   PLOTFILE 1 ALL 1ST 01H1GALL.PLT 31
   PLOTFILE 1 ALL 8TH 01H8GALL.PLT 32
   FILEFORM EXP
   SUMMFILE "BiFO 2011 Drilling NO2 1-hr.sum"
OU FINISHED
```