APPENDIX A-1: EMISSION INVENTORY

Buys & Associates, Inc. **Environmental Consultants**	Project: Pacific Rim Emission Inventory Date: 3/11/2004

1. Well Pad and Road Construction Emissions (Dozer and Backhoe)

Assumptions:

Well Pad and Road Area	2.30	acres (Proposed Action)
Hours of Construction	4	days per well pad (Proposed Action)
	8	hours/day
	32	hours per well pad
Watering Control Efficiency	50	percent (Recommended by Wy DEQ)
Soil Moisture Content	7.9	percent (AP-42 Table 11.9-3, 10/98)
Soil Silt Content	6.9	percent (AP-42 Table 11.9-3, 10/98)
PM10 Multiplier	0.75 * PM15	(AP-42 Table 11.9-1, 10/98)
PM2.5 Multiplier	0.105 * TSP	(AP-42 Table 11.9-1, 10/98)

Equations: From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs/hr) = 5.7 * (soil silt content %)^1.2 * (soil moisture content %)^-1.3* Control Efficiency

Emissions (PM15 lbs/hr) = 1.0 * (soil silt content %)^1.5 * (soil moisture content %)^-1.4 * Control Efficiency

Emissions = 1.97 lbs TSP/hour/piece of equipment

Emissions = 0.50 lbs PM15/hour/piece of equipment

	Dozer and Backhoe Emissions [a]		
	lbs/hr	**tons/well**	**tons/yr [b]**
TSP	3.94	0.0631	4.10
PM15	1.00	0.0161	1.04
PM10	0.75	0.0120	0.78
PM2.5	0.41	0.0066	0.43

a Assumes one dozer and one backhoe. Backhoe emissions are conservatively estimated as equivalent to Dozer emissions.

b Assumes a construction rate of 65 wells per year over two years

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2. Well Pad and Road Construction Emissions (Grader)

Assumptions:

Road Length	0.33	miles (Proposed Action)
Hours of Construction	4	days per well pad (Proposed Action)
	8	hours/day
	32	hours per well pad
Watering Control Efficiency	50	percent (Recommended by Wy DEQ)
Average Grader Speed	10	mph (Typical value)
Distance Graded	1.32	miles (2 round trips on road)
PM10 Multiplier	0.6 * PM15	(AP-42 Table 11.9-1, 10/98)
PM2.5 Multiplier	0.031 * TSP	(AP-42 Table 11.9-1, 10/98)

Equations: From AP-42 tables 11.9-1 and 11.9-3 for Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs) = $0.040 * (\text{Mean Vehicle Speed})^{2.5} * \text{Distance Graded} * \text{Control Efficiency}$

Emissions (PM15 lbs) = $0.051 * (\text{Mean Vehicle Speed})^{2.0} * \text{Distance Graded} * \text{Control Efficiency}$

Emissions = 8.35 lbs TSP/well

Emissions = 3.37 lbs PM15/well

	Grader Construction Emissions			
	lbs/well	**lbs/hr**	**tons/well**	**tons/yr [a]**
TSP	8.35	0.26	0.0042	0.27
PM15	3.37	0.11	0.0017	0.11
PM10	2.02	0.06	0.0010	0.07
PM2.5	0.26	0.01	0.0001	0.01

b Assumes a construction rate of 65 wells per year over two years

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3. Construction Traffic Fugitive Dust Emissions

Assumptions:

Average Round Trip Distance	12	miles (Estimated from Project Area and existing road system)
Hours of Construction	32	hours per site (Proposed Action)
Watering Control Efficiency	50	percent (Wy DEQ Recommendation)
Road Silt Content	5.1	percent (AP-42 Table 13.2.2-1, 9/98)
Road Moisture	0.2	percent (Default Value, AP-42 Section 13.2.2, 9/98)

Equation: From AP-42 13.2.2, Unpaved Roads, 9/98

$$E \text{ Size Spec. Factor (lb/VMT)} = \frac{k * (s/12)^a * (W/3)^b * \text{Control Efficiency}}{(M/0.2)^c}$$

Where k, a, b, and c are empirical constants listed below and

E = size-specific emission factor (lbs/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)
M = surface material moisture content (%)

Empirical Constants			
Constant	**PM2.5**	**PM10**	**PM30/TSP**
k	0.38	2.6	10.0
a	0.8	0.8	0.8
b	0.4	0.4	0.5
c	0.3	0.3	0.4

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4. Construction Traffic Fugitive Dust Emissions continued

Vehicle Type	Ave. Weight (lbs)	Round Trips per Well	Hours Per Activity	Controlled Emission Factors (lbs/VMT)			TSP Emissions		PM10 Emissions		PM2.5 Emissions	
				TSP	PM10	PM2.5	Max. lb/hr	Tons/well	Max. lb/hr	Tons/well	Max. lb/hr	Tons/well
Construction Activities												
Semi: Hvy Equip Hauler	74,000	3										
Haul Truck:Gravel	48,000	4										
Pickup Truck: Crew	7,000	4										
Construction Total	40,182	11	32	6.53	1.40	0.21	26.92	0.43	5.79	0.09	0.85	0.01
Drilling Activities												
Semi: Rig Transport	60,000	6										
Haul Truck:Fuel	48,000	5										
Haul Truck: Mud	48,000	2										
Haul Truck: Water	20,000	20										
Haul Truck: Supplies	48,000	2										
Logging Trucks	48,000	4										
Pickup Truck: Rig Crew	7,000	20										
Pickup Truck: Mechanic	8,000	6										
Pickup Truck: Supervisor	7,000	10										
Pickup Truck: Mud Logger	8,000	10										
Pickup: Bit/Tool Delivery	8,000	2										
Pickup: Mud Engineer	7,000	2										
Total Drilling	19,685	89	240	4.57	1.05	0.15	20.33	2.44	4.69	0.56	0.69	0.08
Completion Activities												
Semi: Casing	74,000	3										
Cement Haul Trucks	74,000	2										
Cement Pump Truck	48,000	2										
Completion Rig	74,000	1										
Completion Rig Equip Truck	48,000	3										
Frac Trucks	80,000	3										
Haul: Tanks	48,000	3										
Haul: Sand	44,000	3										
Haul: Chemicals	44,000	3										
Logging/Perf. Truck	48,000	3										
Pickup: Comp.Foreman	7,000	3										
Pickup: Casing Crews	7,000	3										
Pickup: Cement Crew	8,000	2										
Pickup: Completion Rig Crew	7,000	3										
Pickup: Logging/Perf Crew	7,000	3										
Pickup: Frac Crew	7,000	3										
Pickup: Consultants	7,000	3										
Total Completion	35,174	46	24	6.11	1.33	0.19	140.42	1.69	30.59	0.37	4.47	0.05
Field Development												
Gathering Sys. Const. Crew	8,000	4										
Haul Truck: Trencher	48,000	4										
Haul Truck: Pipe	48,000	4										
Surveyor	7,000	4										
Welder	8,000	4										
Reclamation Crew	8,000	4										
Total Field Development	21,167	24	16	4.74	1.09	0.16	85.25	0.68	19.54	0.16	2.86	0.02
Total Well Traffic Emissions (per/well)							272.92	5.24	60.61	1.18	8.86	0.17
Annual Traffic Emissions (Tons/year for 65 wells)								340.39		76.64		11.20

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5. Wind Erosion Fugitive Dust Emissions

Assumptions

Threshold Friction Velocity U_t*	1.02	m/s (2.28 mph) for well pads (AP-42 Table 13.2.5-2 Overburden - Western Surface Coal Mine
	1.33	m/s (2.97 mph) for roads (AP-42 Table 13.2.5-2 Roadbed material)
Initial Disturbance Area	144.0	acres total initial disturbance for roads(Proposed Action)
	582,746	square meters total initial disturbance for roads
	354	acres total initial disturbance for wells, compressors, and pipelines (Proposed Action)
	1,430,561	square meters total initial disturbance for well, compressors and pipelines
	498	acres total disturbance
Exposed Surface Type	Flat	
Meteorological Data	2002	Rock Springs Airport (obtained from NCDC website)
Fastest Mile Wind Speed U_{10}^+	24.1	meters/sec (54 mph) reported as fastest 2-minute wind speed for Rock Springs
Number soil of disturbances	2	for well pads and pipelines (Assumption, disturbance at construction and reclamation)
	Constant	for dirt roads
Development Period	2	years (Proposed Action)

Equations

Friction Velocity $U^* = 0.053\ U_{10}^+$

Erosion Potential $P\ (g/m^2/\text{period}) = 58*(U^*-U_t^*)^2 + 25*(U^*-U_t^*)$ for $U^*>U_t^*$, $P = 0$ for $U^*< U_t^*$

Emissions (tons/year) = Erosion Potential(g/m^2/period)*Disturbed Area(m^2)*Disturbances/year*(k)/(453.6 g/lb)/2000 lbs/ton/Develop Period

Particle Size Multiplier (k)		
30 um	**<10 um**	**<2.5 um**
1.0	0.5	0.2

Maxium U_{10}^+ Wind Speed (m/s)	Maximum U* Friction Velocity m/s	Well/Pipeline U_t* Threshold Velocity[a] m/s	Well Pad Erosion Potential g/m^2	Road U_t* Threshold Velocity[a] m/s	Road Erosion Potential g/m^2
24.10	1.28	1.02	10.27	1.33	0.00

Wind Erosion Emissions

Particulate Species	Wells/Pipelines (tons/year)	Roads (tons/year)
TSP	16.20	0.00
PM10	8.10	0.00
PM2.5	3.24	0.00

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6. Construction Tailpipe Emissions

Assumptions:

Average Round Trip Distance	12.0	miles (Estimated from project area and existing road system)
Hours of Construction	32	hours per site (4 days @ 8 hrs/day - Proposed Action)
Number of Heavy Diesel Truck Trips	7	(Proposed Action)
Number of Pickup Trips	4	(Proposed Action)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \#\text{ Trips} * \text{Trip Distance (miles)}}{453.6\text{ (g/lb)} * 2000\text{ (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\text{ (g/lb)} * \text{Fuel Sulfur Content} * 2\text{ (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Construction Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total** [d]	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.047	0.001	3.03	0.010	0.000	0.057	0.059
CO	17.09	0.099	0.002	33.64	0.111	0.002	0.210	0.219
VOC [c]	4.83	0.028	0.000	1.84	0.006	0.000	0.034	0.035
SO2	0.32	0.002	0.000	0.21	0.001	0.000	0.003	0.003

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes a construction rate of 65 wells per year over two years

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7. Drilling Tailpipe Emissions

Assumptions:

Average Round Trip Distance	12.0	miles (Estimated from project area and existing road system)
Hours of Operation	240	hours per site (10 days @ 24 hrs/day - Proposed Action)
Number of Heavy Diesel Truck Trips	39	(Proposed Action)
Number of Pickup Trips	50	(Proposed Action)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \#\text{ Trips} * \text{Trip Distance (miles)}}{453.6\text{ (g/lb)} * 2000\text{ (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\text{ (g/lb)} * \text{Fuel Sulfur Content} * 2\text{ (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Drilling Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.035	0.004	3.03	0.017	0.002	0.052	0.403
CO	17.09	0.073	0.009	33.64	0.185	0.022	0.259	2.019
VOC [c]	4.83	0.021	0.002	1.84	0.010	0.001	0.031	0.241
SO2	0.32	0.001	0.000	0.21	0.001	0.000	0.003	0.020

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes a construction rate of 65 wells per year over two years

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8. Completion Tailpipe Emissions

Assumptions:

Average Round Trip Distance	12.0	miles (Estimated from project area and existing road system)
Hours of Operation	24	hours per site (3 days @ 8 hrs/day - Assumption)
Number of Heavy Diesel Truck Trips	26	(Proposed Action)
Number of Pickup Trips	20	(Proposed Action)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \#\text{ Trips} * \text{Trip Distance (miles)}}{453.6\text{ (g/lb)} * 2000\text{ (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\text{ (g/lb)} * \text{Fuel Sulfur Content} * 2\text{ (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Completion Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.233	0.003	3.03	0.067	0.001	0.300	0.234
CO	17.09	0.490	0.006	33.64	0.742	0.009	1.231	0.961
VOC [c]	4.83	0.138	0.002	1.84	0.041	0.000	0.179	0.140
SO2	0.32	0.009	0.000	0.21	0.005	0.000	0.014	0.011

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes a construction rate of 65 wells per year over two years

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9. Development Tailpipe Emissions

Assumptions:

Average Round Trip Distance	12.0	miles (Estimated from project area and existing road system)
Hours of Operation	16	hours per site (2 days @ 8 hrs/day - Assumption)
Number of Heavy Diesel Truck Trips	4	(Assumption)
Number of Pickup Trips	3	(Assumption)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \#\text{ Trips} * \text{Trip Distance (miles)}}{453.6\text{ (g/lb)} * 2000\text{ (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\text{ (g/lb)} * \text{Fuel Sulfur Content} * 2\text{ (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Development Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr/well)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	8.13	0.054	0.000	3.03	0.015	0.000	0.069	0.036
CO	17.09	0.113	0.001	33.64	0.167	0.001	0.280	0.146
VOC [c]	4.83	0.032	0.000	1.84	0.009	0.000	0.041	0.021
SO2	0.32	0.002	0.000	0.21	0.001	0.000	0.003	0.002

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes a construction rate of 65 wells per year over two years

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10. Construction Heavy Equipment Tailpipe Emissions

Assumptions:

Hours of Operation	32	hours/site (4 days @ 8 hrs/day - Proposed Action)
Development Rate	65	wells per year (Proposed Action)
Load Factor	0.4	(Assumed typical value)
Backhoe Size	100	hp (Assumed Typical value)
Dozer Size	150	hp (Assumed Typical value)
Motor Grader Size	135	hp (Assumed Typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

Heavy Const. Vehicles	Backhoe			Dozer			Grader		
	E. Factor [a] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)	E. Factor [a] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)	E. Factor [b] (g/hp-hr)	Emissions (lb/hr)	Emissions[e] (tons/yr)
NOx	8.15	0.719	0.747	8.15	1.078	1.121	7.14	0.850	0.884
CO	2.28	0.201	0.209	2.28	0.302	0.314	1.54	0.183	0.191
VOC [c]	0.37	0.033	0.034	0.37	0.049	0.051	0.36	0.043	0.045
PM10 [d]	0.5	0.044	0.046	0.5	0.066	0.069	0.63	0.075	0.078
PM2.5 [d]	0.5	0.044	0.046	0.5	0.066	0.069	0.63	0.075	0.078
SO2	0.22	0.019	0.020	0.22	0.029	0.030	0.22	0.026	0.027
Formaldehyde	0.22	0.019	0.020	0.22	0.029	0.030	0.12	0.014	0.015

Heavy Const. Vehicles	Total	
	Emissions (lb/hr)	Emissions[e] (tons/yr)
NOx	2.647	2.753
CO	0.686	0.713
VOC [c]	0.124	0.129
PM10 [d]	0.185	0.193
PM2.5 [d]	0.185	0.193
SO2	0.075	0.078
Formaldehyde	0.063	0.065

a AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Off-highway truck
b AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Motor Grader
c Emission Factor represents total Hydrocarbon Emissions
d All emitted particulate matter assumed to be PM2.5
e Assumes a construction rate of 65 wells per year over two years

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11. Pumper Tailpipe Emissions

Assumptions:

Number of New Pumpers:	4	(Assumption)
Pumper Mileage:	1,000	miles/pumper/month (Assumption)
Total Annual New Pumper Mileage:	48,000	miles/year
Hours of Pumper Operation:	8	hours per day (Assumption)
Hours of Pumper Operation:	2080	hours per year
Fuel sulfur content	0.05	% (Typical value)
Fuel density	7.08	lbs/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{Vehicle Miles Traveled (miles/yr)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ \text{(S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Pumper Vehicles	Heavy Duty Pickups		
	E. Factor [a] (g/mile)	Emissions (lb/hr)	Emissions (tons/yr)
NOx	3.03	0.154	0.160
CO	33.64	1.711	1.780
VOC [b]	1.84	0.094	0.097
SO2	0.21	0.011	0.011

a AP-42 Append H Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
b Emission factor is for total Hydrocarbons.

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12. Drill Rig Engine Emissions

Assumptions:

Hours of Operation	240	hours/well (10 days @ 24 hrs/day - Assumption)
Development Rate	65	wells/year (Proposed Action)
Load Factor	0.4	(Assumed typical value)
Rig Size	1200	hp (Assumption)
Diesel Fuel Sulfur Content	0.05	% (typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (lb/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{2000 (lb/tons)}}$$

SO2 E. Factor (lb/hp-hr) = Fuel sulfur content * 0.00809

Species	**Drill Rig Emissions**		
	E. Factor [a]	Emissions	Emissions [e]
	(lb/hp-hr)	(lb/hr)	(tons/yr)
NOx	0.024	11.520	89.856
CO	0.0055	2.640	20.592
VOC [b]	0.000705	0.338	2.640
PM10 [c]	0.000573	0.275	2.145
PM2.5 [d]	0.000479	0.230	1.793
SO2	0.0004045	0.194	1.514

a AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-1, 10/96
b Emission Factor represents total Hydrocarbon Emissions
c Total particulate emission factor is 0.0007, PM10 fraction determined from Table 3.4-2
d Total particulate emission factor is 0.0007, PM2.5 fraction determined from Table 3.4-2
e Assumes a construction rate of 65 wells per year over two years

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PRPA
3/11/2004

13. Average Produced Gas Composition
(Almond Formation Sample 2/18/03 - Nearby CBM Project)

COMPONENT	Average Gas Composition Mole %
Carbon Dioxide	1.7793
Oxygen	
Hydrogen Sulfide	
Nitrogen	1.5041
Methane	95.4475
Ethane	0.8821
Propane	0.2754
Isobutane	0.0605
n-Butane	0.0339
Isopentane	0.0106
n-Pentane	0.0050
Hexanes	0.0017
Heptanes	
C-8 + Heavies	
Benzene	
Toluene	
Ethylbenzene	
Xylenes	
TOTAL	100.000

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14. Average Produced Gas Characteristics (Almond Formation Sample 2/18/03 - Nearby CBM Field)

Gas Heat Value (wet): 974 Btu/scf

C1-C2 Wt. Fraction: 0.918
VOC Wt. Fraction: 0.011
Non-HC Wt. Fraction: 0.071
Total: 1.000

COMPONENT	MOLE PERCENT	COMPONENT MOLE WEIGHT (lb/lb-mole)	NET MOLE WEIGHT (lb/lb-mole)	WEIGHT FRACTION	GROSS HEATING VALUE (BTU/scf)	NET DRY HEATING VALUE (BTU/scf)	LOWER HEATING VALUE (BTU/scf)	NET LOW HEATING VALUE (BTU/scf)
Methane	95.4475	16.043	15.313	0.902	1010.000	964.020	910.000	868.572
Ethane	0.8821	30.070	0.265	0.016	1769.800	15.611	1618.000	14.272
Propane	0.2754	44.097	0.121	0.007	2516.200	6.930	2316.000	6.378
i-Butane	0.0605	58.123	0.035	0.002	3252.100	1.968	3005.000	1.818
n-Butane	0.0339	58.123	0.020	0.001	3262.400	1.106	3013.000	1.021
i-Pentane	0.0106	72.150	0.008	0.000	4000.900	0.424	3698.000	0.392
n-Pentane	0.0050	72.150	0.004	0.000	4008.800	0.200	3708.000	0.185
Hexanes+	0.0017	86.177	0.000	0.000	4756.200	0.000	4404.000	0.000
Heptanes		100.204	0.000	0.000	5502.500	0.000	5100.000	0.000
Octanes		114.231	0.000	0.000	6249.100	0.000		0.000
Nonanes		128.258	0.000	0.000	6996.400	0.000		0.000
Decanes		142.285	0.000	0.000	7743.200	0.000		0.000
Benzene		78.120	0.000	0.000	3715.500	0.000		0.000
Toluene		92.130	0.000	0.000	4444.600	0.000		0.000
Ethylbenzene		106.160	0.000	0.000	5191.500	0.000		0.000
Xylenes		106.160	0.000	0.000	5183.500	0.000		0.000
n-Hexane		86.177	0.001	0.000	4756.200	0.081		0.000
Helium		4.003	0.000	0.000	0.000	0.000	0.000	0.000
Nitrogen	1.5041	28.013	0.421	0.025	0.000	0.000	0.000	0.000
Carbon Dioxide	1.7793	44.010	0.783	0.046	0.000	0.000	0.000	0.000
Oxygen		32.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydrogen Sulfide		34.080	0.000	0.000	637.100	0.000	588.000	0.000
TOTAL	100.000		16.971	1.000		990.340		892.640

Relative Mole Weight (lb/lb-mole) = [Mole Percent * Molecular weight (lb/lb-mole)] / 100

Weight Fraction = Net Mole Weight / Total Mole Weight

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15. Vented Gas Emissions

Assumptions

Amount of Gas Vented 50 Mscfd/well for 5 days (Assumption - Nearby CBM Project)

Equations

Relative Mole Weight (lb/lb-mole) = [Molecular Weight (lb/lb-mole) * Mole Percent] / 100

Weight Percent = Relative Mole Weight * 100 / Total Relative Mole Weight

Component Flow Rate (Mscf/day) = [Flow Rate (Mscf/day) * Mole Percent] / 100

Component Flow Rate (lb/hr) = $\frac{\text{Component Flow (Mscf/day) * 1,000 scf/Mscf * Molecular Weight (lb/lb-mole)}}{\text{24 hours/day * 379.49 scf/mole}}$

Component Flow Rate (tons/well) = Component Flow (lb/hr/well) * 5 days * 24 hours/day

Component Flow Rate (tons/yr) = Component Flow (tons/well) * 60 gas wells per year

Vent Rate = 50 Mscf/day

COMPONENT	MOLECULAR WEIGHT (lb/lb-mole)	MOLE PERCENT	RELATIVE MOLE WEIGHT (lb/lb-mole)	WEIGHT PERCENT	COMPONENT FLOW RATE (Mscf/day)	COMPONENT FLOW RATE (lb/hr/well)	COMPONENT FLOW RATE (tons/well)	COMPONENT FLOW RATE (tons/year)
Methane	16.043	95.448	15.313	90.227	47.724	84.064	5.044	302.629
Ethane	30.070	0.882	0.265	1.563	0.441	1.456	0.087	5.242
Propane	44.097	0.275	0.121	0.716	0.138	0.667	0.040	2.400
i-Butane	58.123	0.061	0.035	0.207	0.030	0.193	0.012	0.695
n-Butane	58.123	0.034	0.020	0.116	0.017	0.108	0.006	0.389
i-Pentane	72.150	0.011	0.008	0.045	0.005	0.042	0.003	0.151
n-Pentane	72.150	0.005	0.004	0.021	0.003	0.020	0.001	0.071
Hexanes	86.177	0.002	0.001	0.009	0.001	0.008	0.000	0.029
Heptanes	100.204		0.000	0.000	0.000	0.000	0.000	0.000
Octanes	114.231		0.000	0.000	0.000	0.000	0.000	0.000
Nonanes	128.258		0.000	0.000	0.000	0.000	0.000	0.000
Decanes +	142.285		0.000	0.000	0.000	0.000	0.000	0.000
Benzene	78.120		0.000	0.000	0.000	0.000	0.000	0.000
Toluene	92.130		0.000	0.000	0.000	0.000	0.000	0.000
Ethylbenzene	106.160		0.000	0.000	0.000	0.000	0.000	0.000
Xylenes	106.160		0.000	0.000	0.000	0.000	0.000	0.000
n-Hexane	86.177		0.000	0.000	0.000	0.000	0.000	0.000
Helium	4.003		0.000	0.000	0.000	0.000	0.000	0.000
Nitrogen	28.013	1.504	0.421	2.483	0.752	2.313	0.139	8.327
Carbon Dioxide	44.010	1.779	0.783	4.614	0.890	4.299	0.258	15.476
Oxygen	32.000		0.000	0.000	0.000	0.000	0.000	0.000
Hydrogen Sulfide	34.080		0.000	0.000	0.000	0.000	0.000	0.000
VOC SUBTOTAL		**0.387**	**0.189**	**1.114**	**0.194**	**1.038**	**0.062**	**3.736**
HAP SUBTOTAL		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
TOTAL		**100.000**	**16.971**	**100.000**	**50.000**	**93.170**	**5.590**	**335.411**

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16. Central Station TEG Dehydrator Emissions

Assumptions

Production Rate: 0.4 MMscf/day per well
(Assumption - Nearby CBM Project)

Gas Composition: One sample dated 2/18/2003 was utilized
(Almond Formation - Nearby CBM Project)

Inlet Gas Conditions: Inlet gas was assumed to be saturated at 800 psi and 80 F
(Assumption - Nearby CBM Project)

Glycol Circulation Rate: 3 gallons/ lb of water
(Typical operating rate)

Calculations

Dehydrator emissions were simulated using GRI GlyCalc version 4.0

Emissions

Species	Central Dehydrator Emissions [a] (tons/year)	Total Project Emissions [b] (tons/year)
VOC	0.51	2.54
Benzene	0.00	0
Toluene	0.00	0
Ethylbenzene	0.00	0
Xylenes	0.00	0
n-Hexane	0.00	0
Total HAPs	0.00	0

a Assumes each central station processes 9.6MMscf/day gas
(Assumption - Nearby CBM Project well production rate)
b Assumes five central stations process a total of 48MMscf/day gas
(Required number of stations and dehydrators based on Proposed Action, assumes equal gas volume distribution)

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17. Central Dehydrator Reboiler Emissions

Assumptions

Central Dehydrator Reboiler Size	1000	MBTU/hr (Assumption based on exisitng permitted equipment)
Firing Rate	8760	hours/year (Typical Value)
Fuel Gas Heat Content	893	Btu/scf (Almond Formation - Nearby CBM Project)
Fuel Gas VOC Content	0.011	by weight (Almond Formation - Nearby CBM Project)
Number of Dehydrators	5	(Proposed Action)

Equations

$$\text{Fuel Consumption (MMscf/yr)} = \frac{\text{Heater Size (MBtu/hr)} * 1{,}000\ (\text{Btu/MBtu}) * \text{Hours of Operation (hrs/yr)}}{\text{Fuel Heat Value (Btu/scf)} * 1{,}000{,}000\ (\text{scf/MMscf})}$$

$$\text{NOx/CO/TOC Emissions (tons/yr)} = \frac{\text{AP-42 E.Factor (lbs/MMscf)} * \text{Fuel Consumption (MMscf/yr)} * \text{Fuel heating Value (Btu/scf)}}{2{,}000\ (\text{lbs/ton}) * 1{,}000\ (\text{Btu/scf} - \text{Standard Fuel Heating Value})}$$

$$\text{VOC Emissions (tons/yr)} = \text{TOC Emissions (tons/yr)} * \text{VOC wt. fraction}$$

	Dehydrator Reboiler Emissions		
	Emission Factor (lb/MMscf)	Dehy Emissions (lb/hr/dehy)	Total Emissions [e] (tons/yr)
NOx [a]	94	0.094	2.059
CO [a]	40	0.040	0.876
TOC [c]	11	0.011	0.241
VOC	N.A.	0.000	0.003
SOx [b]	0.00	0.000	0.000
TSP [c]	7.6	0.008	0.166
PM10 [c]	7.6	0.008	0.166
PM2.5 [c]	7.6	0.008	0.166
Benzene [d]	0.0021	0.000	0.000
Toluene [d]	0.0034	0.000	0.000
Hexane [d]	1.8	0.002	0.039
Formaldehyde [d]	0.075	0.000	0.002

a AP-42 Table 1.4-1, Emission Factors for Natural Gas Combustion, 2/98
b Assumes produced gas contains no sulfur
c AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 3/98 (All Particulates are PM1.0)
d AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 3/98
e Total heater emissions for project assuming full development of all wells

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18. Gas Compression and Processing

Assumptions:

Gas Compression Power: 11,500 Horsepower (Proposed Action)

Equations:

$$\text{Emissions (lbs/hr)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Power (hp)}}{453.6 \text{ g/lb}}$$

Pollutant	Emission Factor (g/hp-hr)	Emissions (lb/hr)	Emissions (tons/yr)
NOx [1]	1.5	38.03	166.6
CO [1]	0.5	12.68	55.5
VOC [1]	1.0	25.35	111.0
Formaldehyde [1]	0.07	1.77	7.8

1 - Emission rates based on Caterpillar 3516LE lean-burn natural gas-fired compressor engine with oxidation catalyst. (Assumption based on existing permitted equipment)

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19. Generator Engine Sources

Assumptions:

Power Requirement: 3,900 Horsepower
(30 hp per well @130 wells - Assumption from nearby CBM Project)

Equations:

$$\text{Emissions (lbs/hr)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Power (hp)}}{453.6 \text{ g/lb}}$$

Pollutant	Emission Factor (g/hp-hr)	Emissions (lb/hr)	Emissions (tons/yr)
NOx [1]	1.0	8.60	37.7
CO [1]	1.0	8.60	37.7
VOC [1]	1.0	8.60	37.7
Formaldehyde [1]	0.05	0.43	1.9

1 - Emission rates based on Caterpillar G3516SITA rich-burn natural gas-fired generator engine with AFRC/NSCR. (Assumption based on existing permitted equipment)

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20. Maximum Short-Term Construction Emission Summary

Pollutant	Short-Term Construction Emissions (lb/hr/well)					Wind Erosion	Max. Total (lb/hr/well)
	Construction	Drilling	Completion	Development	Maximum		
NO_X	2.70	11.57	0.30	0.07	11.57		11.57
CO	0.90	2.90	1.23	0.28	2.90		2.90
VOC	0.16	0.37	1.22	0.04	1.22		1.22
SO_2	0.08	0.20	0.01	0.00	0.20		0.20
PM_{10}	6.79	4.97	30.59	19.54	30.59	0.04	30.63
$PM_{2.5}$	1.45	0.92	4.47	2.86	4.47	0.02	4.49
Benzene							
Toluene							
Ethylbenzene							
Xylene							
n-Hexane							
Formaldehyde	0.06				0.06		0.06

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21. Long-Term Construction Emissions Sumary

Pollutant	Long-Term Construction Emissions (tons/year) [a]				Wind Erosion	Total (tons/yr)
	Construction	Drilling	Completion	Development		
NO_X	2.81	90.26	0.23	0.04		93.34
CO	0.93	22.61	0.96	0.15		24.65
VOC	0.16	2.88	3.88	0.02		6.94
SO_2	0.08	1.53	0.01	0.00		1.63
PM_{10}	5.21	38.75	23.86	10.16	8.10	86.08
$PM_{2.5}$	1.24	7.14	3.49	1.49	3.24	16.60
Benzene						
Toluene						
Ethylbenzene						
Xylene						
n-Hexane						
Formaldehyde	0.07					0.07

a - Assumes a well development rate of 65 wells per year for two years

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22. Total Project Production Related Emissions Summary

Pollutant	Total Project Production Emissions (tons/year)				Total Production (tons/year)
	Dehydrators	Generator Engines	Pumper Vehicle	Central Compression	
NO_X	2.06	37.66	0.16	166.57	206.45
CO	0.88	37.66	1.78	55.52	95.84
VOC	2.54	37.66	0.10	111.04	151.34
SO_2			0.01		0.01
PM_{10}	0.17				0.17
$PM_{2.5}$	0.17				0.17
Benzene					0.00
Toluene					0.00
Ethylbenzene					0.00
Xylene					0.00
n-Hexane					0.00
Formaldehyde		1.88		7.77	9.66

Assumes 120 gas wells are producing 48 MMscf/day of gas

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23. Total Project Emissions Summary

Pollutant	Project Emissions (tons/year)				Total Emissions (tons/year)
	Well Development	Well Production	Well Subtotal	Gas Compression and Dehydration	
NO_X	93.3	37.8	131.2	168.6	299.8
CO	24.6	39.4	64.1	56.4	120.5
VOC	6.9	37.8	44.7	113.6	158.3
SO_2	1.6	0.0	1.6	0.0	1.6
PM_{10}	86.1	0.0	86.1	0.2	86.2
$PM_{2.5}$	16.6	0.0	16.6	0.2	16.8
Benzene	0.0	0.0	0.0	0.0	0.0
Toluene	0.0	0.0	0.0	0.0	0.0
Ethylbenzene	0.0	0.0	0.0	0.0	0.0
Xylene	0.0	0.0	0.0	0.0	0.0
n-Hexane	0.0	0.0	0.0	0.0	0.0
Formaldehyde	0.1	1.9	1.9	7.8	9.7

Assumes previously specified development and production rates

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24. Existing Permitted Source Emission Summary

Company	Facility	UTM Easting (m)	UTM Northing (m)	Approximate Distance to PRPA (km)	Estimated Annual Emissions (tons/year)	
					NO_x	CO
Wexpro Company	Canyon Creek/Vermillion Complex	688400	4547700	15	134.0	195.7
Pamco Services International Incorporated[1]	Compressor CT-1215 (Canyon Creek)	700319	4553962	17	17.4	17.4
Questar Gas Management Company	Big Drop Compressor Station	701200	4554000	18	3.9	3.9
Total Emissions					**155.2**	**217.0**

[1]Estimated UTM Coordinates

Includes all significant sources within 20 km of PRPA Center (Source: WDEQ)
Excludes well production sources with emissions < 2 tons per year