Final Report

DEVELOPMENT OF BASELINE 2006 EMISSIONS FROM OIL AND GAS ACTIVITY IN THE PICEANCE BASIN

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EXECUTIVE SUMMARY

This study provides an analysis of the criteria pollutant emissions for oil and gas exploration and production operations in the Piceance Basin in Northwestern and West Central Colorado. The analysis is part of an effort sponsored by the Independent Petroleum Association of Mountain States (IPAMS) jointly with the Western Regional Air Partnership (WRAP) for the development of a Phase III regional oil and gas emission inventory for the inter-Mountain West. The overall effort will build on the Phase I and Phase II oil and gas inventory projects previously sponsored by WRAP. The Piceance Basin emissions inventory is part of an overall effort that is focused on creating a comprehensive criteria pollutant emissions inventory for all activities associated with oil and gas field operations in the basins throughout the study region for year 2006 as well as future projection years; that includes all point and area sources related to the oil and gas industry.

The primary source of information was a survey outreach effort to the producers in the Piceance Basin. Survey forms consisting of 16 Excel spreadsheets were forwarded to major participating operators in the Piceance Basin. Each spreadsheet contained a request for specific data related to the identified oil and gas source categories. All data requested from participating companies were for these companies' activities in the calendar year 2006. Well count and production data for the basin were obtained from a commercially available database of oil and gas data maintained by IHS Corporation ("the IHS database"). As with the emissions estimates, the focus of the IHS database was calendar year 2006.

The companies participating in the survey process for the Piceance Basin represented 75% of well ownership in the basin, 84% of gas production in the basin, and 91% of oil production in the basin. This large percentage of oil and gas activity in the basin made it possible to obtain an excellent representation of oil and gas operations in the basin. For some source categories, detailed information was unavailable due to the participating companies not having access to this data or being unable to provide this data. These source categories – which include salt water disposal engines, CBM pump engines, water tanks, amine units and water disposal pits – were therefore excluded from this study. In addition, this study does not consider fugitive emissions from oil and gas pipelines from well heads to the main compressor stations. Accurate quantitative information on the length of pipeline in the basin was not available from sources queried as part of this effort or other data bases that were analyzed, and therefore a reasonable estimate of basin-wide pipeline fugitive emissions could not be derived.

Overall, the results show that most oil and gas activities are concentrated in Garfield and Rio Blanco counties. Garfield County accounts for the majority of gas and condensate production, while Rio Blanco County accounts for the majority of oil production. Accordingly, these two counties also represent the most significant portion of NOx and VOC emissions. Total emissions of NOx in the Piceance Basin were 12,390 in 2006 while total emissions of VOCs in the Piceance Basin were 27,464 tons in 2006. It should be noted that Coal Bed Methane (CBM) wells and associated production in the Piceance Basin in 2006 were sufficiently small to be considered negligible for purposes of this study. Overall, drilling rigs and compressor engines accounted for almost 90% of NOx emissions basin-wide. Similarly, completion venting, condensate tanks, dehydrators, and blowdown venting accounted for approximately 65% of VOC emissions. As with the findings of the inventory for the Denver-Julesburg Basin, a significant fraction of the Piceance Basin emissions are from unpermitted sources.

Table ES-1 below contains a summary of the total emissions from oil and gas operations in the Piceance Basin.

Table ES-1. Summary of emissions from oil and gas operations in Piceance Basin.

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
Chaffee	0	0	0	0	0
Delta	34	57	46	0	1
Eagle	0	0	0	0	0
Garfield	6,908	19,049	4,147	185	664
Gunnison	46	138	27	1	5
Lake	0	0	0	0	0
Mesa	1,399	2,404	967	32	116
Moffat	1,111	1,930	780	11	48
Pitkin	0	15	0	0	0
Rio Blanco	2,859	3,823	1,941	84	156
Routt	33	47	14	1	2
Totals	**12,390**	**27,464**	**7,921**	**314**	**992**

Table ES-2 below shows a summary of the emissions inventory results for the basins which have already been inventoried as part of this Phase III effort – the D-J, Uinta and Piceance Basins. This table is intended for comparison purposes and therefore should be considered in conjunction with Table ES-3, which shows a summary of the production and well count characteristics of each of these basins. As these two tables show, significant differences in production characteristics are observed among these basins, with subsequent effects on the emissions inventories for NOx and VOC. It should also be noted that significant variations in gas compositions and operational practices were observed among these basins, which also account for differences in the final basin-wide emissions.

Table ES-2. Comparison of Piceance Basin emissions with those of other basins in this study.

Basin	Emissions (tons/yr)				
	NOx	VOC	CO	SOx	PM
D-J Basin	20,783	81,758	12,941	226	636
Piceance Basin	12,390	27,464	7,921	314	992

Table ES-3. Comparison of production characteristics of all basins inventoried in this study to date.

Basin	Well Count			Oil Production (bbl)			Gas Production (MCF)			Spud Counts
	Total	Conv.	CBM	Total	Oil Well Oil	Gas Well Condensate	Total	Conv.	CBM	Total
D-J Basin	19,841	19,841	0	14,242,088	0	14,242,088	234,630,779	234,630,779	0	1500
Piceance Basin	6,315	6,255	60	7,158,305	5,755,076	1,403,229	421,358,666	420,165,237	1,193,429	1186

INTRODUCTION

The Independent Petroleum Association of Mountain States (IPAMS) is sponsoring the development of a Phase III regional oil and gas emission inventory for the inter-Mountain West jointly with the Western Regional Air Partnership (WRAP), to build on the WRAP Phase I and Phase II inventory projects (Russell, et al., 2005; Bar-Ilan, et al., 2007). This effort is focused on creating a comprehensive criteria pollutant emissions inventory for all activities associated with oil and gas field operations in the basins throughout the study region for year 2006 as well as future projection years; that includes all point and area sources related to the oil and gas industry.

The inventory presented in this analysis is for the Piceance Basin in Northwestern and West Central Colorado, and is the third such inventory conducted to date as part of this work, including the Denver-Julesburg Basin and Uinta Basin. The 2006 baseline inventory consists of two primary categories: sources subject to Air Pollution Emission Notice (APEN) reporting requirements according to State of Colorado regulations, and sources exempt from APEN reporting, which are collectively termed "unpermitted" sources in this document. This document describes the methodologies by which the 2006 inventory was constructed. This methodology is specific to the Piceance Basin and will have additions and changes for other basins in the Phase III project as they are completed. For each source category, a basic description is given of the methodology used to estimate emissions from a single source or from all sources belonging to companies that participated in the survey effort ("participating companies"), and a description of how those emissions were scaled up to the county and basin-wide level.

In general, the inventory was developed using a combination of well count and production activity from a commercially available database of oil and gas data maintained by IHS Corporation ("the IHS database"), the State of Colorado's database of permitted sources subject to APENs reporting requirements, and detailed survey responses of oil and gas activity from several major participating companies that operate in the Piceance Basin. Some additional data sources were also used, including the US Environmental Protection Agency's (EPA) AP-42 emissions factor technical guidance (EPA, 1995), the US EPA's NONROAD emissions model (EPA, 2005), and the US EPA's Natural Gas Star program technical guidance (EPA, 2008).

Temporal and Geographic Scope

This inventory considers a base year of 2006 for purposes of estimating emissions, consistent with the baseline inventories for all basins in this Phase III effort. All data requested from participating companies were for these companies' activities in the calendar year 2006. Similarly, all well count and production data for the basin obtained from the IHS database were for the calendar year 2006. Emissions from all source categories are assumed to be uniformly distributed throughout the year except for heaters and pneumatic pumps, which are assigned seasonality fractions as they are typically used primarily in winter.

The geographic scope of this inventory is the Piceance Basin in Colorado. For the purposes of this study, the boundaries for the Piceance Basin were modified from those of the US Geological Survey (USGS) (USGS, 2008) to wholly include the counties of Chaffee, Delta, Eagle, Garfield, Gunnison, Lake, Mesa, Moffatt, Pitkin, Rio Blanco and Routt. It should be noted that frequently the Uinta and Piceance Basins are referred to collectively as a single basin (the "Uinta-Piceance Basin"). However, for purposes of this study, it is useful to define the borders of the Piceance

Basin to be the portion of the Uinta-Piceance Basin that lies entirely within Colorado and the Uinta Basin to be the portion of the Uinta-Piceance Basin that lies entirely within Utah. This is primarily due to the differing permitting requirements in each state, which make the development of separate inventories for each of these two basins more tractable.

Figure 1 shows the boundaries of the Piceance Basin, with the 2006 well locations extracted from the IHS database overlaid. It should be noted that there is no tribal land in the Piceance Basin, and therefore no tribal airshed for which sources would be tracked separately from private or state-owned land.

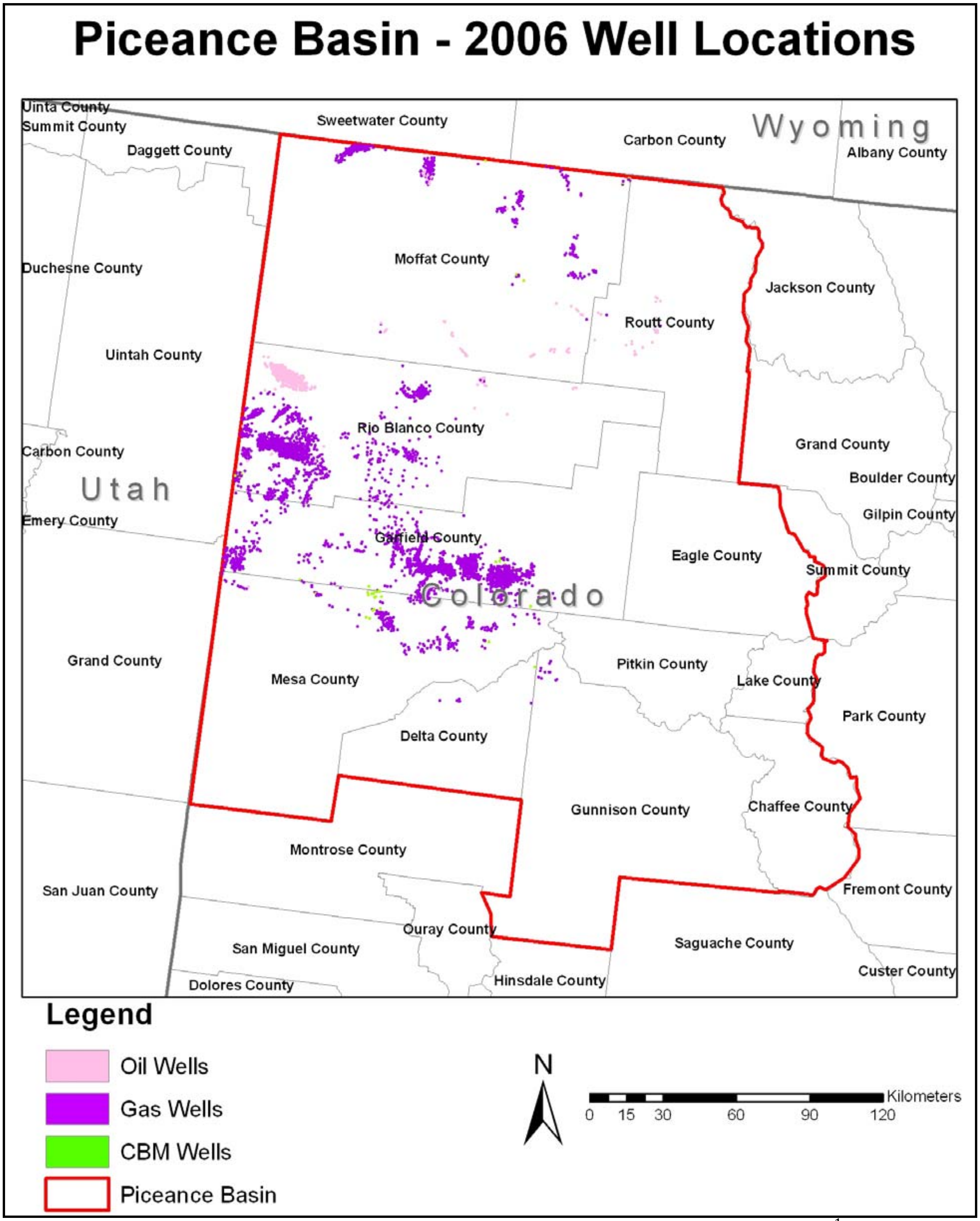

Figure 1. Piceance Basin boundaries overlaid and 2006 oil and gas well locations.[1]

[1] Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved.

Well Count and Production Data

Oil and gas related activity data across the entire Piceance Basin were obtained from the IHS Enerdeq database queried via online interface. The IHS database uses data from the Colorado Oil and Gas Conservation Commission (COGCC) as a source of information for Colorado oil and gas activity. Two types of data were queried from the Enerdeq database: production data and well data. Production data includes information relevant to producing wells in the basin while well data includes information relevant to drilling activity ("spuds") and completions in the basin.

Production data were obtained for the counties that make up the Piceance Basin in the form of PowerTools input files. PowerTools is an IHS application which, given PowerTools inputs queried from an IHS database, analyzes, integrates, and summarizes production data in an ACCESS database. The Piceance Basin PowerTools input files were loaded into the PowerTools application. From ACCESS database created by PowerTools, extractions of the following data relevant to the emissions inventory development were made:

1. 2006 active wells, i.e. wells that reported any oil or gas production in 2006.
2. 2006 oil, gas, and water production by well and by well type.

The production data are available by API number. The API number in the IHS database consists of 14 digits as follows:

- Digits 1 to 2: state identifier
- Digits 3 to 5: county identifier
- Digits 6 to 10: borehole identifier
- Digits 11 to 12: sidetracks
- Digits 13 to 14: event sequence code (recompletions)

Based on the expectation that the first 10 digits, which include geographic and borehole identifiers, would predict unique sets of well head equipment, the unique wells were identified by the first 10 digits of the API number.

Well data were also obtained from the IHS Enerdeq database for the counties that make up the Piceance Basin in the form of "297" well data. The "297" well data contain information regarding spuds and completions. The "297"well data were processed with a PERL script to arrive at a database of by-API-number, spud and completion dates with latitude and longitude information. Drilling events in 2006 were identified by indication that the spud occurred within 2006. If the well API number indicated the well was a recompletion, it was not counted as a drilling event, though if the API number indicated the well was a sidetrack, it was counted as a drilling event.

The well counts and oil, gas and water production by county for the basin are presented in Table 1, and the spuds by county are presented in Table 2. It should be noted that there is no significant CBM gas production in the Piceance Basin, the total CBM gas production in 2006 accounted for 0.2% of gas production in the basin as a whole. It was therefore determined that for ease of calculation the CBM gas production would not be tracked separately from conventional gas production for this basin.

Table 1. 2006 well count and oil, gas and water production by county for the Piceance Basin.

County	Well Count	Oil Production [bbl]	Gas Production [mcf]	Water Production [bbl]
Chaffee	0	0	0	0
Delta	7	74	64,774	9,234
Eagle	0	0	0	0
Garfield	3,825	1,126,818	342,879,746	9,484,869
Gunnison	11	2,239	556,228	65
Lake	0	0	0	0
Mesa	352	36,588	14,891,040	669,448
Moffat	399	242,889	19,427,697	15,334,330
Pitkin	0	0	0	0
Rio Blanco	1,696	5,639,030	43,500,513	105,008,584
Routt	25	110,667	38,668	103,346
Total	6,315	7,158,305	421,358,666	130,609,876

Table 2. 2006 spud counts by county for the Piceance Basin.

County	Total Number of Spuds in 2006
Chaffee	0
Delta	1
Eagle	0
Garfield	883
Gunnison	7
Lake	0
Mesa	149
Moffat	50
Pitkin	0
Rio Blanco	93
Routt	3
Total	**1,186**

SOURCES SUBJECT TO APEN REPORTING

The emissions threshold for reporting emissions through the APEN permitting process in the State of Colorado is 2 tpy of any criteria pollutant, which is a lower general threshold than for any other state in the Intermountain West. Therefore it was assumed that the APENs database would capture the majority of oil and gas sources in the Piceance Basin, particularly all of the large sources associated with midstream gathering activities (such as compressor stations and gas processing plants). In addition, there is no tribal airshed in the Piceance Basin and therefore no emissions sources which would be exclusively under EPA jurisdiction, rather than the Colorado APCD.

On October 31, 2007 a request was made to the APCD for the 2006 Colorado APEN database for all oil and gas related emission sources covered by the following SCC and SIC codes:

- All of the SCCs 202002*, 310*, 404003* (where * indicates all sub-SCCs for the SCC)
- And only those with the following SICs: 13*, 492*, 4612.

APEN data for the Piceance basin were extracted and sorted by operator. Company specific APEN source data were forwarded to participating operators for a completeness review that included the following three issues:

1) Source Categories that were missing from the APEN database,
2) Specific sources missing from the database, and
3) Sources within the database known to be no longer operating.

Following the completeness review and the addition or deletion of sources as appropriate, emission rates were reviewed. Emission rates were updated to reflect 2006 actual emissions in cases where supporting data were available. Actual emission updates provided by operators followed the APCD calculation methodologies from existing permits or required Operation and Maintenance Plans. The APCD methodologies are used to update Annual Emission Calculations (Minor Sources) and 12-Month Rolling Emission Totals (Synthetic Minor and Major Sources).

It should be noted that although the APENs database tracks VOC emissions from flashing and working & breathing losses from condensate and oil tanks, it does not provide this data for tanks with VOC emissions below the reporting threshold defined by the Colorado APCD ("unpermitted" tanks). However, the APENs database does not contain a reliable estimate of the actual condensate or oil throughput at specific tanks or tank batteries; therefore, it is not possible to use the APENs database to determine the throughput to permitted condensate and oil tanks. Without this data, it is therefore not possible to determine the throughput to unpermitted tanks, and the VOC emissions from these unpermitted tanks. To resolve this issue, for condensate and oil tank emissions, separate bottom-up calculations were conducted to determine emissions from all tanks using an appropriate methodology for estimating flashing and working & breathing losses (described below). The tank emissions from the APENs database were therefore not used.

The APENs database contained a record of the county location of each source, and this was used to allocate the sources' emissions to the county-level for purposes of generating the county-level emissions summaries of the permitted sources for the entire Piceance Basin.

APEN EXEMPT SOURCES

Survey forms consisting of 16 Excel spreadsheets (attached) were forwarded to participating operators in the Piceance basin. Each spreadsheet contained a request for specific data related to one of the following APEN exempt source categories:

- Well blowdowns
- Well completions
- Drilling rigs
- Workover rigs
- Exempt engines
- Fugitive emissions
- Heaters
- Gas composition analysis for the basin
- Pneumatic devices
- Pneumatic pumps
- Water tanks
- Natural Gas Plant truck loading
- Natural Gas Liquid truck loading
- Oil and Gas well truck loading
- Condensate tanks
- Flaring

The companies participating in the survey process for the Piceance Basin represented 75% of well ownership in the basin, 84% of gas production in the basin, and 91% of oil production in the basin. This represented a sufficiently large percentage of oil and gas activity in the basin that it was felt that the responses obtained from the participating companies would be representative of all oil and gas operations in the basin.

Detailed inventory methodologies for each of the source categories follow. Extrapolation of these data was necessary to account for emissions from all oil and gas activity in the basin. The extrapolation methodology to obtain county-level and basin-wide emissions for each source category is described below, but is largely based on scaling by the proportional representation of the respondents of basin-wide well count or oil or gas production, as appropriate.

For emissions from those source categories that relied on estimates of volume of gas vented or leaked, such as well blowdowns, completions, and fugitive emissions, gas composition analyses were requested from all participating companies. These composition analyses were averaged to derive a single basin-wide produced gas composition analysis for gas production-related sources, and a single gas composition analysis for associated gas from oil production-related sources. The average composition analysis was used to determine the average VOC volume and mass fractions of the vented gas basin-wide.

It should be noted that the emission estimates calculated for APEN exempt sources rely on data that is not as rigorously documented as permitted sources. Much of the data provided for the APEN exempt sources is based upon estimates and extrapolation from the survey responses. However the level of detail of the surveys and the extent of participation in the survey effort allow for emissions estimates of unpermitted sources which are an improvement on the previous WRAP Phase I and Phase II emissions inventory efforts for the Piceance Basin.

APEN EXEMPT EMISSION CALCULATION METHODOLOGIES

Well Blowdowns

Methodology

Emissions from well blowdowns were calculated using the estimated volume of gas vented during blowdown events, the frequency of the blowdowns, and the VOC content of the vented gas as documented by representative compositional analyses.

The calculations applied the ideal gas law and gas characteristics defined from a laboratory analysis to estimate emissions according to Equations 1 and 2:

Equation (1) $V_{vented} \times f = V_{vented,TOTAL}$

where:
- V_{vented} is the volume of vented gas per blowdown [mscf/event]
- f is the frequency of blowdowns [events/year]
- $V_{vented,TOTAL}$ is the total volume of vented gas from the participating companies [mscf/year]

Equation (2) $E_{blowdown} = V_{vented,TOTAL} \times 1000 \times MW_{VOC} \times R \times Y_{VOC}$

where:
- $E_{blowdown}$ is the total VOC emissions from blowdowns conducted by the participating companies [lb-VOC/yr]
- MW_{VOC} is the molecular weight of the VOC [lb/lb-mol]
- R is the universal gas constant [lb-mol/379scf]
- Y is the volume fraction of VOC in the vented gas

The conversion from volume of gas vented to mass of VOC produced was evaluated at standard temperature and pressure.

Extrapolation to Basin-Wide Emissions

The total VOC emissions from all blowdowns reported by participating companies were scaled by the proportional production ownership of the participating companies according to Equation 3:

Equation (3) $E_{blowdown,TOTAL} = E_{blowdown} \times {}^{P_{TOTAL}}\!/_{P}$

where:
- $E_{blowdown,TOTAL}$ are the total emissions basin-wide from blowdowns [tons/year]
- $E_{blowdown}$ are the blowdown emissions from the participating companies [tons/year]
- P_{TOTAL} is the total gas production in the basin in 2006 [mscf]
- P is the total gas production in the basin in 2006 by the participating companies [mscf]

County-level emissions were estimated by allocating the total basin-wide blowdown emissions into each county according to the fraction of total 2006 gas production occurring in that county.

Well Completions and Recompletions

Methodology

Emissions from well completions were estimated on the basis of the volume of gas vented during completion and the average VOC content of that gas, obtained from the gas composition analyses.

The calculation methodology for completion emissions is identical to the method for blowdown emissions, and follows Equations 4 and 5:

Equation (4) $$V_{vented} \times f = V_{vented,TOTAL}$$

where:

V_{vented} is the volume of vented gas per initial completion or re-completion [mscf/event]
f is the frequency of completions [events/year]
$V_{vented,TOTAL}$ is the total volume of vented gas from completions for participating companies [mscf/year]

Equation (5) $$E_{completion} = V_{vented,TOTAL} \times 1000 \times MW_{VOC} \times R \times Y_{VOC}$$

where:

$E_{completions}$ is the total VOC emissions from completions conducted by all participating companies [lb-VOC/yr]
MW_{VOC} is the molecular weight of the VOC [lb/lb-mol]
R is the universal gas constant [lb-mol/379scf]
Y is the volume fraction of VOC in the vented gas

The conversion from volume of gas vented to mass of VOC produced was evaluated at standard temperature and pressure.

Extrapolation to Basin-Wide Emissions

The total VOC emissions from all completions reported by participating companies was scaled by the total number of completions in the basin to the number of completions conducted by the participating companies according to Equation 6:

Equation (6) $$E_{completion,TOTAL} = E_{completion} \times {C_{TOTAL}}/{C}$$

where:

$E_{completion,TOTAL}$ are the total emissions basin-wide from completions [tons/year]
$E_{completion}$ are the completion emissions from the participating companies [tons/year]
C_{TOTAL} is the total number of completions in the basin in 2006
C is the total number of completions in the basin in 2006 by the participating companies.

County-level emissions were estimated by allocating the total basin-wide completion emissions into each county according to the fraction of total 2006 completions that occurred in each county.

Drill Rigs – Drilling Operations

Methodology

The participating companies were surveyed for information on drilling rigs operating in 2006 in the Piceance Basin. Because many drill rigs are operated by contractors to the oil and gas producers, data were not always available to the level of detail requested in the surveys. Some of the companies surveyed were able to provide exact configurations for all rigs used in their operations, while others were able to provide information on only one or several representative rigs. In all cases, complete information for every parameter needed to estimate drilling rig emissions was not available, and in these cases engineering analysis was used to fill in missing information. Because the nature of the survey responses for drilling rigs varied so much by company, the methodology used was to first estimate each company's total drilling rig emissions given the nature of the data available for that company, and then to sum the emissions and scale up to the basin level.

In general, the emissions for an individual rig engine were estimated according to Equation 7:

Equation (7) $$E_{drilling,engine} = \frac{EF_i \times HP \times LF \times t_{drilling}}{907{,}185}$$

where:

$E_{drilling,engine}$ is the emissions from one engine on the drilling rig for drilling one well [ton/engine/spud]
EF_i is the emissions factor for the engine for pollutant i [g/hp-hr]
HP is the horsepower of the engine [hp]
LF is the load factor of the engine
$t_{drilling}$ is the actual on-time of the engine for a typical drilling event in the basin [hr/spud]

A single drilling rig may contain from 3 – 7 or more engines, including draw works, mud pump, and generator engines. The total emissions from drilling one well are thus the sum of emissions from each engine, according to Equation 8:

Equation (8) $$E_{drilling} = \sum_i E_{drilling,engine,i}$$

where:

$E_{drilling}$ is the total emissions from drilling one well [tons/spud]
$E_{drilling,engine,i}$ is the total emissions from engine i from drilling one well [tons/engine/spud]

It should be noted that SO_2 emissions were estimated using the brake-specific fuel consumption (BSFC) of the engine, as obtained from the US EPA's NONROAD model (EPA, 2005) for a similarly sized oil and gas field equipment engine, and the 2006 sulfur content of the off-road diesel fuel (500 ppm) as obtained from the WRAP Mobile Sources Emission Inventory Update (Pollack, et al., 2006). The EPA NONROAD model guidance was used to determine the fraction of fuel sulfur that would go to forming PM emissions – for drilling rig engines this was only 2.2% of sulfur content. It was assumed that the remaining sulfur in the fuel would be emitted as SO_2.

Emissions factors were either provided by the survey respondent or were obtained from US EPA's NONROAD model. For emissions factors taken from the NONROAD model, in cases where it was not possible to ascertain the engine's technology type, uncontrolled, undeteriorated oil and gas field equipment engines of the same size class were assumed. When a producer supplied emission factors for some, but not all pollutants, the technology type of the engine was estimated based on the supplied emission factors and emissions factors from the NONROAD model were taken for the estimated technology type for drill/bore rig engines of the same size class. This allowed the calculations to incorporate information about specific rig engines when it was available, and defaulted to the NONROAD model where this information was not available. Load factors were similarly estimated by using respondent information where such detailed information was available, or by using the NONROAD model or the WRAP Phase II analysis where they were not available (Bar-Ilan, et al., 2007).

The resulting rig configurations included engines of several Tier models, several different counts of number of engines per rig, and differing load factors for the different engines on a rig.

<u>Extrapolation to Basin-Wide Emissions</u>

Due to the variability in the type of information provided by the participating companies, it was decided to sum the drilling emissions for each company separately using the data and assumptions for that company, and then to sum all participating companies' drilling emissions and scale this to the basin-wide drilling emissions. Participating companies' drilling emissions were estimated using the emissions from drilling one well using that company's representative rig or rigs, and then multiplying by the number of spuds drilled by that company in 2006. If more than one representative rig was provided, all spuds drilled by that company were divided evenly among the representative rigs. In the case of one respondent, all of that company's rigs were detailed including the total hours of usage during the year for all rigs. This was used to sum the company's drilling emissions, rather than the number of spuds.

The basin-wide drilling emissions were derived by scaling up the combined participating companies' drilling emissions according to Equation 9:

Equation (9) $$E_{drilling,TOTAL} = E_{drilling} \times \frac{S_{TOTAL}}{S}$$

where:

$E_{drilling,TOTAL}$ is the total emissions in the basin from drilling activity [tons/yr]
$E_{drilling}$ is the total emissions in the basin from drilling activity conducted by the participating companies (summed as described above) [tons/yr]
S_{TOTAL} is the total number of spuds that occurred in the basin in 2006
S is the total number of spuds in the basin in 2006 drilled by the participating companies

County-level emissions were estimated by allocating the total basin-wide drilling rig emissions into each county according to the fraction of total 2006 spuds that occurred in each county.

Workover Rigs

Methodology

The nature of workover engine data provided in the survey responses for workover rigs varied significantly by company. In order to utilize the wide range of data provided, the methodology used was to first estimate each company's total workover rig emissions, and then to sum the emissions over all companies, and scale up to the basin level. When a producer supplied emission factors for some, but not all pollutants, the technology type of the engine was estimated based on the supplied emission factors and emission factors from the NONROAD model which were taken for the estimated technology type for oil and gas field equipment engines of the same size class. This allowed the calculations to incorporate information about specific rig engines when it was available, and defaulted to the NONROAD model where this information was not available. Load factors were similarly estimated by using respondent information where such detailed information was available, and defaulting to data from the NONROAD model when unavailable.

The basic methodology for estimating the emissions from a workover rig follows Equation 10:

Equation (10) $$E_{workover,engine} = \frac{EF_i \times HP \times LF \times t_{workover}}{907{,}185}$$

where:

- $E_{workover,engine}$ is the emissions from one workover [ton/workover]
- EF_i is the emissions factor of the workover rig engine of pollutant i [g/hp-hr]
- HP is the horsepower of the workover rig engine [hp]
- LF is the average load factor of the workover rig engine
- $t_{workover}$ is the average duration of a workover event [hr/workover]

It should be noted that SO_2 emissions were estimated using the BSFC of the engine, as obtained from the US EPA's NONROAD model for a similarly sized drill/bore rig engine, and and the 2006 sulfur content of the off-road diesel fuel (500 ppm) as obtained from the WRAP Mobile Sources Emission Inventory Update (Pollack, et al., 2006). The EPA NONROAD model guidance was used to determine the fraction of fuel sulfur that would go to forming PM emissions – for workover rig engines this was 2.2% of sulfur content. It was assumed that the remaining sulfur in the fuel would be emitted as SO_2.

Extrapolation to Basin-Wide Emissions

The total workover rig emissions for the participating companies were derived by multiplying the per-workover emissions above for each pollutant by the total number of workovers conducted by the participating companies. This was then scaled up by the ratio of total well count in the basin to wells owned by the participating companies, following Equation 11:

Equation (11) $$E_{workover,TOTAL} = E_{workover} \times {W_{TOTAL}}/{W}$$

where:

$E_{workover,TOTAL}$ are the total emissions basin-wide from workovers [tons/year]
$E_{workover}$ are the total workover rig emissions from the participating companies [tons/year]
W_{TOTAL} is the total number of wells in the basin
W is the number of wells owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide workover rig emissions into each county according to the fraction of total 2006 well counts that are located in each county.

APEN Exempt Engines

Methodology

The participating companies provided a complete inventory of all APEN exempt engines in use in their operations. Emission calculations for APEN exempt engines follow a similar methodology as for drilling rig or workover rig engines.

The basic methodology for estimating emissions from an exempt engine is shown in Equation 12:

Equation (12) $$E_{engine} = \frac{EF_i \times HP \times LF \times t_{annual}}{907{,}185}$$

where:
E_{engine} are emissions from an exempt engine [ton/year/engine]
EF_i is the emissions factor of pollutant i [g/hp-hr]
HP is the horsepower of the engine [hp]
LF is the load factor of the engine
t_{annual} is the annual number of hours the engine is used [hr/yr]

Note that, similar to drilling rig and workover rig engines, SO_2 emissions are estimated using the BSFC of the engine, and the assumed sulfur content of the fuel, assuming that all sulfur emissions are in the form of SO_2. For natural gas-fired exempt engines, gas composition analyses indicate no sulfur present in the natural gas; therefore SO_2 emissions are negligible from these engines.

Extrapolation to Basin-Wide Emissions

Emissions from all exempt engines from the participating companies were summed. The total emissions from all participating companies were scaled by the ratio of total well count in the basin to wells owned by the participating companies according to Equation 13:

Equation (13) $$E_{engine,TOTAL} = E_{engine}\frac{W_{TOTAL}}{W}$$

where:
$E_{engine,TOTAL}$ is the total emissions from exempt engines in the basin [ton/yr]

E_{engine} is the total emissions from exempt engines owned by the participating companies [ton/yr]
W_{TOTAL} is the total number of wells in the basin
W is the number of wells owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide exempt engine emissions into each county according to the fraction of total 2006 well counts that are located in each county.

Fugitive Leaks

Methodology

Fugitive emissions from well sites were estimated using AP-42 (EPA, 1995) emissions factors and equipment counts provided in the survey responses. The participating companies provided total equipment counts for all of their operations in the basin by type of equipment and by the type of service to which the equipment applies – gas, light liquid, heavy liquid, or water.

Fugitive VOC emissions for an individual component were estimated similar to blowdown or completion emissions, according to Equations 14 and 15:

Equation (14) $V_{vented} \times N = V_{vented,TOTAL}$

where:
V_{vented} is the volume of fugitive gas leaked per component, for different service types [mscf/component]
N is the number of components of each service type
$V_{vented,TOTAL}$ is the total volume of vented gas from all components for all participating companies [mscf/year]

Equation (15) $E_{fugitive} = V_{vented,TOTAL} \times 1000 \times MW_{VOC} \times R \times Y_{VOC}$

where:
$E_{fugitive}$ is the fugitive VOC emissions for all participating companies [lb-VOC/yr]
MW_{VOC} is the molecular weight of the VOC [lb/lb-mol]
R is the universal gas constant [lb-mol/379scf]
Y is the volume fraction of VOC in the vented gas

The conversion from volume of gas vented to mass of VOC produced was evaluated at standard temperature and pressure.

The survey was provided with separate fugitive devices count on gas and oil wells. In order to account for differences in vented gas composition, emissions from fugitive devices from conventional gas and oil wells were calculated separately.

Extrapolation to Basin-Wide Emissions

Basin-wide fugitive emissions are estimated by scaling the fugitive emissions from all participating companies by the ratio of the total number of conventional gas and oil wells in the basin to the number of wells owned by the participating companies, according to Equations 16 to 18:

Equation (16) $$E_{fugitive,TOTAL,CONV} = \frac{E_{fugitive,CONV}}{2000} \times \frac{W_{TOTAL,CONV}}{W_{PCO,CONV}}$$

where:

$E_{fugitive,TOTAL,CONV}$ is the total fugitive emissions in the basin from conventional gas wells [ton/yr]
$E_{fugitive,TOTAL,CONV}$ is the fugitive VOC emissions for all participating companies' conventional gas wells [lb-VOC/yr]
$W_{TOTAL,CONV}$ is the total number of conventional gas wells in the basin
$W_{PCO,CONV}$ is the total number of conventional gas wells in the basin owned by the participating companies

Equation (17) $$E_{fugitive,TOTAL,OIL} = \frac{E_{fugitive,OIL}}{2000} \times \frac{W_{TOTAL,OIL}}{W_{PCO,OIL}}$$

where:

$E_{fugitive,TOTAL,OIL}$ is the total fugitive emissions in the basin from oil wells [ton/yr]
$E_{fugitive,OIL}$ is the fugitive VOC emissions for all participating companies' oil wells [lb-VOC/yr]
$W_{TOTAL,OIL}$ is the total number of oil wells in the basin
$W_{PCO,OIL}$ is the total number of oil wells in the basin owned by the participating companies

Equation (18) $$E_{fugitive,TOTAL} = E_{fugitive,TOTAL,CONV} + E_{fugitive,TOTAL,OIL}$$

where:

$E_{fugitive,,TOTAL}$ are the total emissions basin-wide from fugitives [tons/year]

County-level emissions from conventional gas wells were estimated by allocating the total basin-wide fugitive emissions from conventional gas wells into each county according to the fraction of conventional 2006 gas well count occurring in that county. County-level emissions from oil wells were estimated by allocating the total basin-wide fugitive emissions from oil wells into each county according to the fraction of 2006 oil well count occurring in that county.

Heater Treater

Methodology

Heater emissions were calculated on the basis of the emissions factor of the heater, and the annual flow rate of gas to the heater. The annual gas flow rate was calculated from the BTU rating of the heater and the local BTU content of the gas. The AP-42 emission factors for an uncontrolled small boiler were used for specific pollutants.

The basic methodology for estimating emissions for a single heater is shown in Equation 19:

Equation (19) $$E_{heater} = EF_{heater} \times Q_{heater} \times \frac{HV_{local}}{HV_{rated}} \times t_{annual} \times hc$$

where:

E_{heater} is the emissions from a given heater
EF_{heater} is the emission factor for a heater for a given pollutant [lb/MMBTU]
Q_{heater} is the heater MMBTU/hr rating [$MMBTU_{rated}$/hr]
HV_{local} is the local natural gas heating value [$MMBTU_{local}$/scf]
HV_{rated} is the heating value for natural gas used to derive heater MMBTU rating, Q_{heater} [MMBTU/scf]
t_{annual} is the annual hours of operation [hr/yr]
hc is a heater cycling fraction to account for the fraction of operating hours that the heater is firing (if available)

Emissions for all heaters in the basin operated by the participating companies were estimated according to Equation 20:

Equation (20) $$E_{heater,companies} = E_{heater} \times N_{heater}$$

where:

$E_{heater,companies}$ is the total emissions from all heaters operated by participating companies [lb/yr]
E_{heater} is the emissions from a single heater [lb/yr/heater]
N_{heater} is the total number of heaters owned by the participating companies

The participating companies were requested to provide seasonal utilization rates to account for changes in usage throughout the year.

Extrapolation to Basin-Wide Emissions

Basin-wide heater emissions were estimated according to Equation 21:

Equation (21) $$E_{heater,TOTAL} = \frac{E_{heater,companies}}{2000} \times \frac{W_{TOTAL}}{W}$$

where:

$E_{heater,TOTAL}$ is the total heater emissions in the basin [ton/yr]
$E_{heater,companies}$ is the total emissions from all heaters operated by participating companies [lb/yr]
W_{TOTAL} is the total number of wells in the basin
W is the total number of wells in the basin owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide heater emissions into each county according to the fraction of total 2006 well counts that are located in each county.

Pneumatic Control Devices

Methodology

Pneumatic device emissions were estimated by determining the numbers and types of pneumatic devices used at all wells in the basin owned by the participating companies. The bleed rates of these devices per unit of gas produced were determined by using guidance from the EPA's Natural Gas Star Program (EPA, 2008).

The methodology for estimating the emissions from all pneumatic devices owned by participating companies is shown in Equations 22 and 23:

Equation (22) $V_{vented,TOTAL} = \dot{V}_i \times N_i \times t_{annual}$

where:

$V_{vented,TOTAL}$ is the total volume of vented gas from all pneumatic devices for all participating companies [mscf/year]
$\dot{V}_i$ is the volumetric bleed rate from device *i* [mscf/hr/device]
N_i is the total number of device *i* owned by the participating companies
t_{annual} is the number of hours per year that devices were operating [hr/yr]

Equation (23) $E_{pneumatic} = V_{vented,TOTAL} \times 1000 \times MW_{VOC} \times R \times Y_{VOC}$

where:

$E_{pneumatic}$ is the pneumatic device VOC emissions for all participating companies [lb-VOC/yr]
MW_{VOC} is the molecular weight of the VOC [lb/lb-mol]
R is the universal gas constant [lb-mol/379scf]
Y is the volume fraction of VOC in the vented gas

The conversion from volume of gas vented to mass of VOC produced was evaluated at standard temperature and pressure.

Extrapolation to Basin-Wide Emissions

Basin-wide pneumatic device emissions were estimated according to Equation 24:

Equation (24) $E_{pneumatic,TOTAL} = \frac{E_{pneumatic}}{2000} \times \frac{W_{TOTAL}}{W}$

where:

$E_{pneumatic,TOTAL}$ is the total pneumatic device emissions in the basin [ton/yr]
$E_{pneumatic}$ is the pneumatic device VOC emissions for all participating companies [lb-VOC/yr]
W_{TOTAL} is the total number of gas wells in the basin
W is the total number of gas wells in the basin owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide pneumatic device emissions into each county according to the fraction of total 2006 gas well counts that are located in each county.

Gas Actuated Pumps

Methodology

Participating companies provided data indicating either the average gas consumption rate per gallon of chemical or compound pumped, or the volume rate of gas consumption per day per pump.

If the gas consumption rate per pump per day was specified, this was multiplied by the number of pumps owned by the respondent and the total annual usage to derive total gas consumption from gas-actuated pumps for the respondent. If the gas consumption rate per gallon of chemical pumped was specified, this was multiplied by the total volume of chemical pumped by the respondent in the basin in 2006 to derive total gas consumption from gas-actuated pumps for the respondent.

VOC emissions were estimated similarly to pneumatic devices, following Equation 25:

Equation (25) $$E_{pump} = V_{vented,TOTAL} \times 1000 \times MW_{VOC} \times R \times Y_{VOC}$$

where:

E_{pump} is the gas-actuated pump VOC emissions for all participating companies [lb-VOC/yr]
$V_{vented,TOTAL}$ is the total volume of vented gas from all gas-actuated pumps for all participating companies [mscf/year]
MW_{VOC} is the molecular weight of the VOC [lb/lb-mol]
R is the universal gas constant [lb-mol/379scf]
Y is the volume fraction of VOC in the vented gas

The participating companies were requested to provide seasonal utilization rates to account for changes in usage throughout the year.

Extrapolation to Basin-Wide Emissions

Basin-wide gas-actuated pump emissions were estimated according to Equation 26:

Equation (26) $$E_{pump,TOTAL} = \frac{E_{pump}}{2000} \times \frac{W_{TOTAL}}{W}$$

where:

$E_{pump,TOTAL}$ is the total pneumatic pump emissions in the basin [ton/yr]
E_{pump} is the gas-actuated pump VOC emissions for all participating companies [lb-VOC/yr]
W_{TOTAL} is the total number of wells in the basin
W is the total number of wells in the basin owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide gas-actuated pump emissions into each county according to the fraction of total 2006 well counts that are located in each county.

Flaring

Methodology

For this source category the AP-42 methodology (EPA, 1995) was applied to estimate flare emissions associated with condensate tanks and initial completions as provided in survey responses by participating companies. Vent rates were combined with the heat content of the gas being flared and the appropriate AP-42 emission factor to determine the NOx and CO emissions.

Emissions were estimated according to AP-42 methodology, following Equation 27.

Equation (27) $E_{flare} = EF_i \times P_{flare} \times Q \times HV$

where:

E_{flare} is the basinwide flaring emissions [lb/yr]
EF_i is the emissions factor for pollutant *i* [lb/MMBtu]
Q is the vent rate as supplied by participating companies [scf/bbl]
HV is the heating value of the gas as estimated by participating companies [BTU/scf]
P_{flare} is the condensate production that is controlled by flare [bbl]

Extrapolation to Basin-Wide Emissions

Basin-wide flaring emissions were estimated according to Equation 28:

Equation (28) $E_{flare,TOTAL} = \frac{E_{flare}}{2000} \times \frac{S_{TOTAL}}{S}$

where:

$E_{flare,TOTAL}$ is the total flaring emissions in the basin [ton/yr]
E_{flare} is the flaring emissions for all participating companies [lb/yr]
S_{TOTAL} is the participating company ownership of the surrogate appropriate for each flaring source (oil production, gas production, and spuds for condensate tank, dehydrator and initial completions, respectively)
S is the total surrogate ownership in the basin owned by the participating companies

County-level emissions were estimated by allocating the total basin-wide flaring emissions into each county according to the fraction of total surrogate (oil production, gas production, and spuds for condensate tank, dehydrator and initial completions, respectively) that are located in each county.

Truck Loading: Oil and Gas Well and Gas Plant

Methodology

Based on surveyed producer responses, oil and gas well and gas plant truck loading emissions were estimated based on loading losses per EPA AP-42, Section 5.2 methodology (EPA, 1995) combined with survey provided oil product volume loaded. The surveyed producer loading loss rate was estimated based on EPA AP-42, Section 5.2 methodology, following Equation 29:

Equation (29) $$L = 12.46 \times \left(\frac{S \times V \times M}{T} \right)$$

where:

L is the loading loss rate [lb/1000gal]
S is the saturation factor taken from AP-42 default values based on operating mode
V is the true vapor pressure of liquid loaded [psia]
M is the molecular weight of the vapor [lb/lb-mole]
T is the temperature of the bulk liquid [^{o}R]

Truck loading emissions for participating companies were then estimated by combining, separately for oil well, gas well, and gas plant truck loading, the calculated loading loss rate with surveyed producer provided annual volume of product loaded as shown in Equation 30:

Equation (30) $$E_{loading} = L \times P \times \frac{42}{1000}$$

where:

E is the oil well, gas well, or gas plant truck loading emissions [lb/yr]
L is the oil well, gas well, or gas plant loading loss rate [lb/1000gal]
P is the oil well, gas well, or gas plant product loaded for the surveyed producers [bbl]

Extrapolation to Basin-Wide Emissions

Basin-wide oil and gas well and gas plant truck loading emissions were estimated separately according to Equation 31:

Equation (31) $$E_{loading,TOTAL} = \frac{E_{loading}}{2000} \times \frac{P_{TOTAL}}{P}$$

where:

$E_{loading,,TOTAL}$ is the oil well, gas well, or gas plant total truck loading emissions in the basin [ton/yr]
$E_{loading}$ is the oil well, gas well, or gas plant truck loading pump VOC emissions for all participating companies
[lb-VOC/yr]
P_{TOTAL} is the total oil (for oil wells) or condensate (for gas wells or gas plants) production in the basin
P is the oil (for oil wells) or condensate (for gas wells or gas plants) production for the surveyed producers [bbl]

County-level emissions were estimated by allocating the total basin-wide truck loading emissions into each county according to the fraction of oil or condensate production for each county.

Natural Gas Liquid Plant Truck Loading

Emissions from this source category were assumed negligible. Surveyed producers either indicated that vapors were captured in a closed-loop system during truck load-outs at NGL plants, or indicated a negligible total venting during trucking loading at these plants. The majority of participating companies did not operate these plants in the Piceance Basin.

Water Tanks

Emissions from this source category were assumed negligible. This assumption is based on the extremely small emissions factors and emissions from water tanks as estimated for the DJ Basin. In addition, detailed speciation data is not generally available for produced water tanks in the Piceance Basin to support a methodology for emissions estimation.

Condensate and Oil Tanks

Methodology

VOC emissions factors for typical condensate storage tanks in the Piceance Basin were provided by participating companies separately for their operations. These were primarily derived from the companies' ongoing analyses of condensate production which are submitted to Colorado APCD as part of the APENs submission for these condensate tanks. Survey respondents indicated whether controls were used on these tanks, which controls were used, and information on the fraction of such production that was controlled. Condensate tanks controlled by flares were assumed to have a 95% control efficiency; condensate tanks controlled by vapor recovery units (VRU) were assumed to have a 100% control efficiency. The uncontrolled factors ranged from 5.0 lb-VOC/bbl-condensate to approximately 14.0 lb-VOC/bbl-condensate. Where company-specific emissions factors were not available, the default state-wide condensate tank emissions factor derived by APCD was used – 10 lb-VOC/bbl-condensate (CDPHE, 2008).

The condensate tank emissions factors were applied to the total basin-wide condensate production that was uncontrolled for each participating company, and an additional 5% of these emissions were applied to the condensate production from tanks controlled by flares. These emissions were totaled for all participating companies.

Oil production in the Piceance Basin is concentrated primarily in several oil fields in Rio Blanco County, and ownership is concentrated in one of the participating companies. Data from these oil operations indicated that this field uses pipeline to directly transfer produced oil to refineries. Oil tanks are used minimally, and therefore their emissions were assumed negligible for the Piceance Basin.

Extrapolation to Basin-Wide Emissions

Basin-wide oil and gas well and gas plant truck loading emissions were estimated separately according to Equation 32:

Equation (32) $$E_{tanks,TOTAL} = \frac{E_{tanks}}{2000} \times \frac{P_{TOTAL}}{P}$$

where:

$E_{tanks,,TOTAL}$ is the total condensate tank emissions in the basin [ton/yr]
E_{tanks} is the total condensate tank emissions for all participating companies [lb-VOC/yr]
P_{TOTAL} is the total condensate production in the basin
P is the total condensate production for the surveyed producers [bbl]

County-level emissions were estimated by allocating the total basin-wide condensate tank emissions into each county according to the fraction of condensate production for each county.

SUMMARY RESULTS

Results from the combined permitted sources (APENs sources excluding condensate tanks, which were estimated separately), and the combined unpermitted sources are presented below on a county level and as summaries for the entire Piceance Basin as a series of pie charts and bar graphs. The quantitative emissions summaries are presented at the end of this document in Tables 3 through 5.

Figure 2 shows that NOx emissions are primarily concentrated in Garfield and Rio Blanco Counties, with additional minor emissions in Moffat and Mesa Counties. Figure 3 shows that VOC emissions are primarily concentrated in Garfield County only. Garfield County accounts for the majority of gas and condensate production in the Piceance Basin, whereas the oil production occurring in Rio Blanco County is primarily sent directly to pipeline and does not contribute significant VOC emissions to the basin-wide VOC inventory.

Figure 4 shows that compressor engines and drilling rigs combined account for almost 90% of NOx emissions in the Piceance Basin, consistent with results from other basin inventories which indicate that these two source categories are the predominant NOx sources. Figure 5 shows that completion venting accounts for approximately one third of the basin-wide VOC emissions in the Piceance Basin in 2006. Other significant VOC emissions source categories include condensate tanks, glycol dehydrators and venting from well blowdowns.

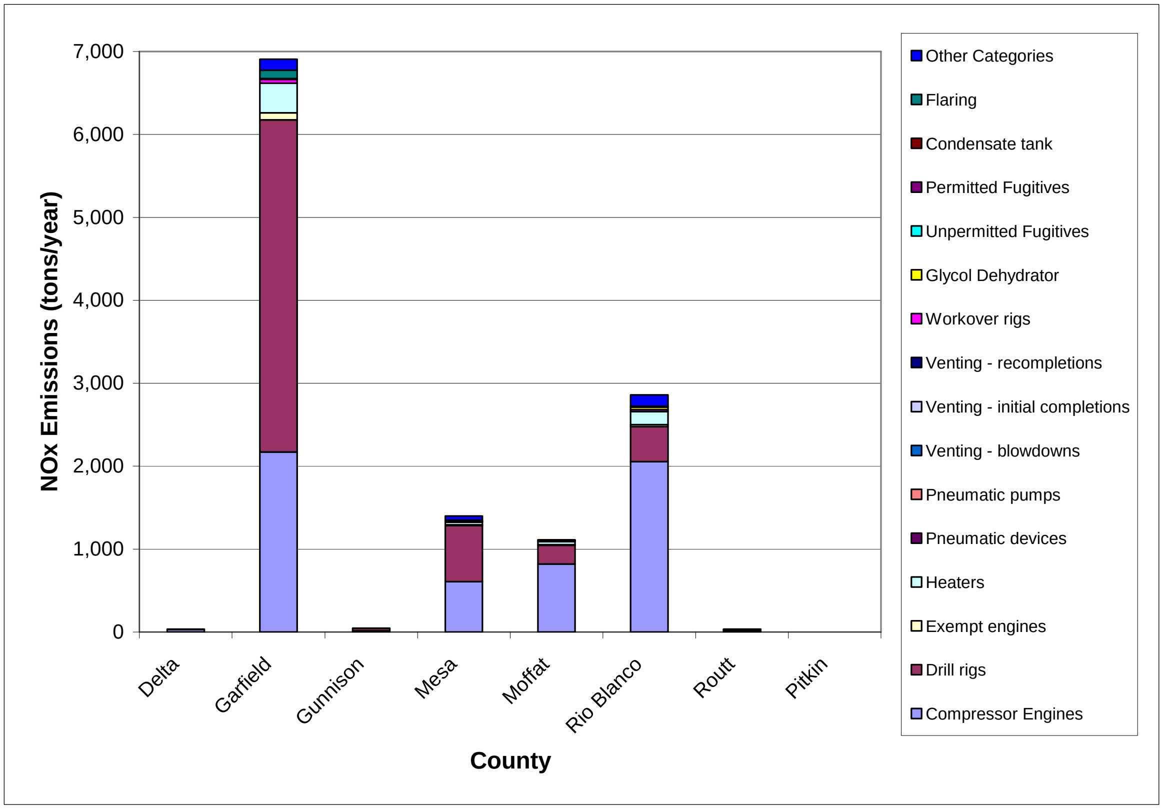

Figure 2. 2006 NOx emissions by source category and by county in the Piceance Basin.

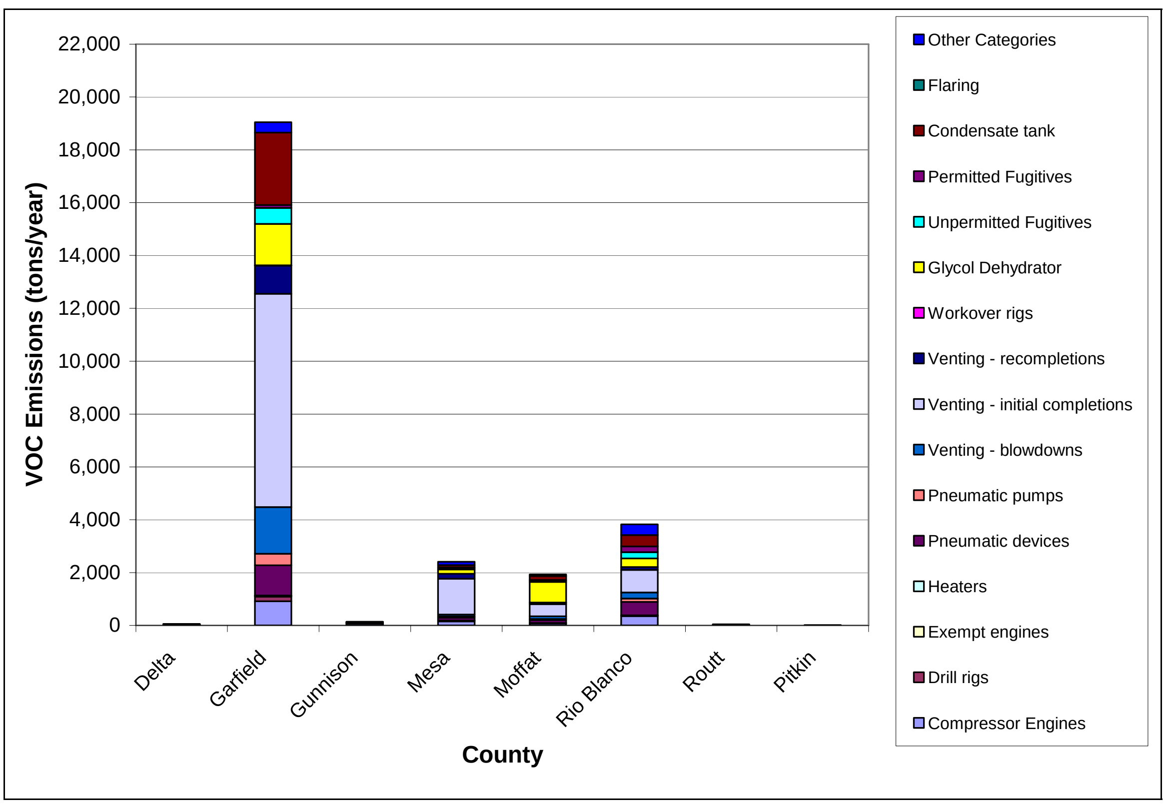

Figure 3. 2006 VOC emissions by source category and by county in the Piceance Basin.

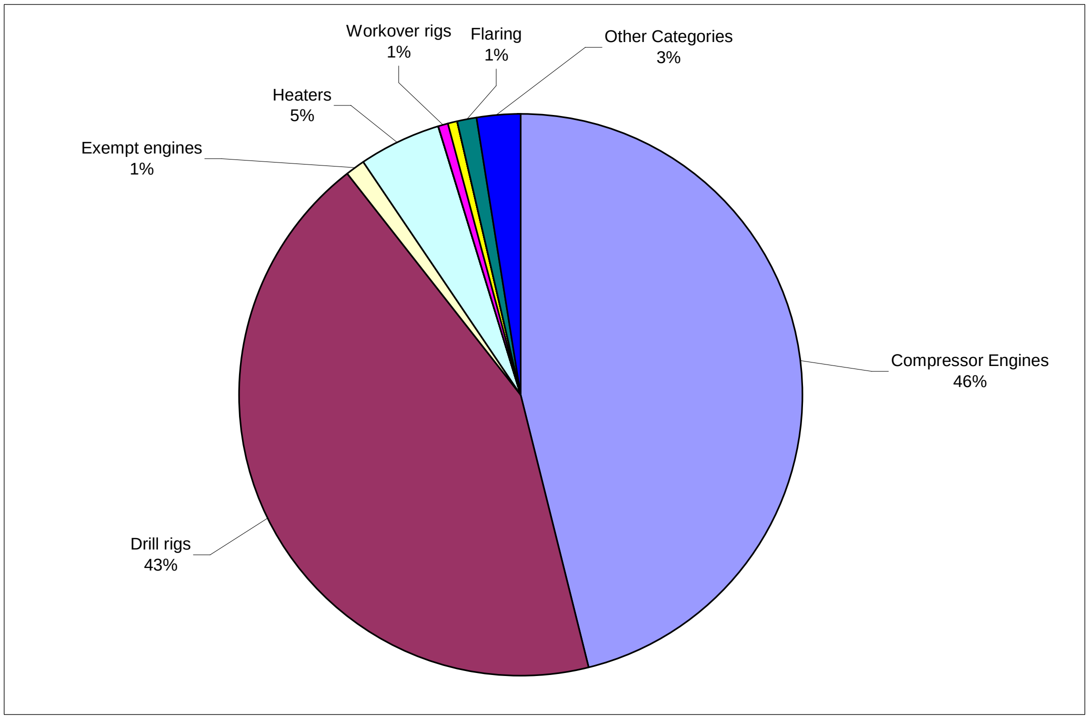

Figure 4. Piceance Basin NOx emissions proportional contributions by source category.

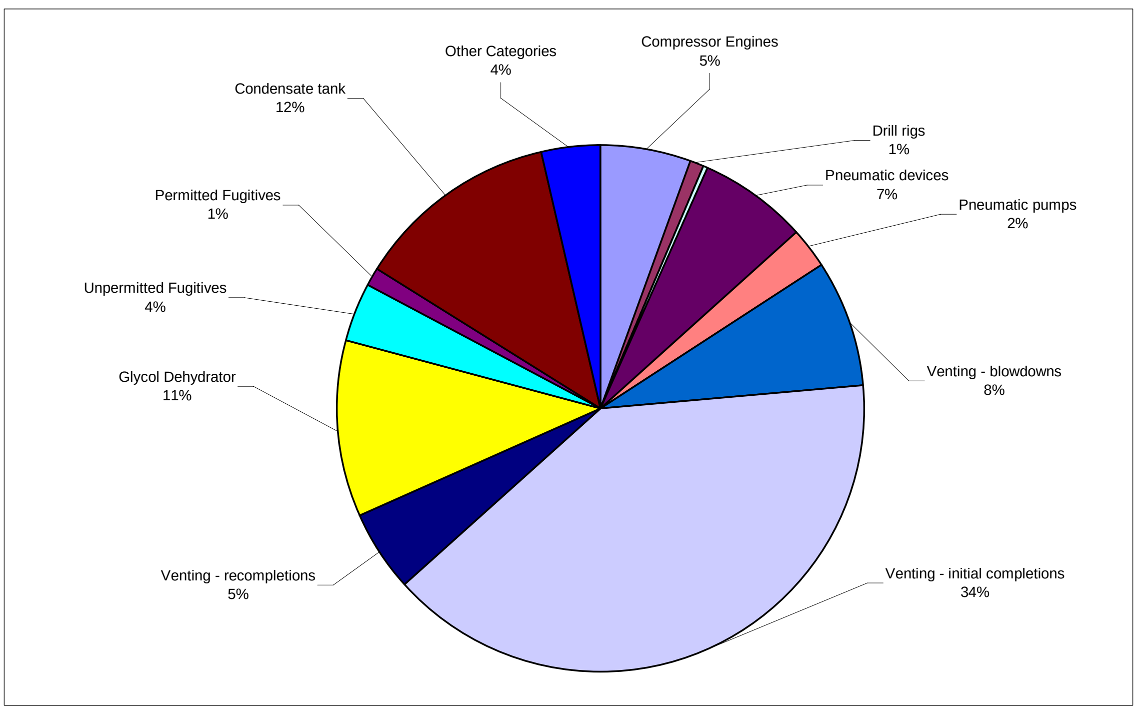

Figure 5. Piceance Basin VOC emissions proportional contributions by source category.

Table 3. 2006 emissions of all criteria pollutants by county for the Piceance Basin.

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
Chaffee	0	0	0	0	0
Delta	34	57	46	0	1
Eagle	0	0	0	0	0
Garfield	6,908	19,049	4,147	185	664
Gunnison	46	138	27	1	5
Lake	0	0	0	0	0
Mesa	1,399	2,404	967	32	116
Moffat	1,111	1,930	780	11	48
Pitkin	0	15	0	0	0
Rio Blanco	2,859	3,823	1,941	84	156
Routt	33	47	14	1	2
Totals	**12,390**	**27,464**	**7,921**	**314**	**992**

Table 4. 2006 NOx emissions by county and by source category for the Piceance Basin.

County	Compressor Engines	Drill Rigs	Exempt engines	Flaring	Glycol Dehydrator	Heaters	Workover Rigs	Other Categories	Totals
Chaffee	0	0	0	0	0	0	0	0	**0**
Delta	29	5	0	0	0	1	0	0	**34**
Eagle	0	0	0	0	0	0	0	0	**0**
Garfield	2,169	4,007	86	101	9	357	46	134	**6,908**
Gunnison	12	32	0	1	0	1	0	0	**46**
Lake	0	0	0	0	0	0	0	0	**0**
Mesa	607	676	8	17	4	33	4	50	**1,399**
Moffat	819	227	7	6	9	37	5	1	**1,111**
Pitkin	0	0	0	0	0	0	0	0	**0**
Rio Blanco	2,053	422	26	11	31	158	20	137	**2,859**
Routt	17	14	0	0	0	2	0	0	**33**
Totals	**5,705**	**5,382**	**128**	**136**	**53**	**589**	**75**	**323**	**12,390**

Table 5. 2006 VOC emissions by county and by source category for the Piceance Basin.

County	Drill Rigs	Unpermitted Fugitives	Permitted Fugitives	Condensate Tanks	Pneumatic Devices	Pneumatic Pumps	Venting – Blowdown	Venting - Initial Completion	Venting - Recompletion	Compressor Engines	Glycol Dehydrator	Other Categories	Totals
Chaffee	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Delta	0	1	0	0	2	1	0	9	1	7	26	9	**57**
Eagle	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Garfield	182	608	108	2,734	1,141	436	1,767	8,075	1,067	910	1,571	449	**19,049**
Gunnison	1	2	0	5	3	1	3	64	8	2	42	5	**138**
Lake	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Mesa	31	56	29	87	105	40	77	1,363	180	155	162	121	**2,404**
Moffat	10	59	8	150	119	37	100	457	60	74	789	66	**1,930**
Pitkin	0	0	0	0	0	0	0	0	0	0	15	0	**15**
Rio Blanco	19	238	219	426	506	133	224	850	112	350	324	421	**3,823**
Routt	1	3	0	2	7	0	0	27	4	3	0	0	**47**
Totals	**244**	**967**	**364**	**3,405**	**1,883**	**648**	**2,172**	**10,845**	**1,434**	**1,501**	**2,929**	**1,072**	**27,464**

ENVIRON

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