ENVIRON

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FINAL EMISSIONS TECHNICAL MEMORANDUM No. 4d

To: Tom Moore, Western Governors' Association (WGA) (WRAP)

From: Amnon Bar-Ilan and Ralph Morris, ENVIRON International Corporation

Subject: Source of Oil and Gas Emissions for the WestJumpAQMS 2008 Photochemical Modeling

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INTRODUCTION

ENVIRON International Corporation (ENVIRON), Alpine Geophysics, LLC (Alpine) and the University of North Carolina (UNC) at Chapel Hill Institute for Environment are performing the West-wide Jump Start Air Quality Modeling Study (WestJumpAQMS) managed by the Western Governors' Association (WGA). WestJumpAQMS is setting up the CAMx and CMAQ photochemical grid models for the 2008 calendar year (plus spin up days for the end of December 2007) on a 36 km CONUS, 12 km WESTUS and several 4 km Inter-Mountain West domains. The WestJumpAQMS Team are currently compiling emissions to be used for the 2008 base case modeling, with the 2008 National Emissions Inventory (NEI) being a major data source. Thirteen Technical Memorandums discussing the sources of the 2008 emissions by major source sector are being prepared as part of the WestJumpAQMS:

1. Point Sources including Electrical Generating Units (EGUs) and Non-EGUs;
2. Area plus Non-Road Mobile Sources;
3. On-Road Mobile Sources that will be based on MOVES;
4. Oil and Gas Sources;
5. Fires Emissions including wildfire, prescribed burns and agricultural burning;
6. Fugitive Dust Sources;
7. Off-Shore Shipping Sources;
8. Ammonia Emissions;
9. Biogenic Emissions;
10. Eastern USA Emissions;
11. Mexico/Canada;
12. Sea Salt and Lightening Emissions; and
13. Emissions Modeling Parameters including spatial surrogates, temporal adjustment parameters and chemical (VOC and PM) speciation profiles.

This document forms part of WestJumpAQMS Emissions Technical Memorandum Number 4 series that discusses the methodology and results for the 2008 emissions for the oil and gas

(O&G) exploration and production source sector. Note that downstream oil and gas emissions (e.g., refining) will be addressed under the point and area source categories. The update of the 2008 O&G emissions will be performed under Task 1C of Phase I of the WestJumpAQMS. Details on the entire WestJumpAQMS are provided in the WestJumpAQMS Scope of Work[1] and Modeling Plan[2].

The O&G Emissions Technical Memoranda series are sub-divided into 5 separate documents of which this is the fourth. The 5 documents are shown below in Table 1. Because of the variation in activities and key data sources among the various states and regions in the WRAP Phase III analysis, it was determined that 5 separate memoranda would be generated to describe the development of the oil and gas projected 2008 emissions. This is discussed in more detail below.

Table 1. WestJumpAQMS O&G emissions technical memoranda.

Technical Memorandum	
4a: 2008 O&G Emissions for Colorado Basins (Denver-Julesburg, Piceance, and North San Juan)	
4b: 2008 O&G Emissions for the South San Juan (NM) and Uinta (UT) Basins	
4c: 2008 O&G Emissions for Wyoming Basins (Greater Green River, Powder River and Wind River)	
4d: 2008 O&G Emissions for the Permian Basin (NM and TX)	✓
4e: 2008 O&G Emissions for Other Areas	

BACKGROUND

The WestJumpAQMS study will develop oil and gas emissions for 2008 for use in the regional photochemical ozone modeling. The O&G emissions will be developed in stages based on the geographic region and the type of information available to develop the inventories:

1. Projections to 2008 using the WRAP Phase III project inventories for the Rocky Mountain region including the Denver-Julesburg (D-J) Basin (CO), Piceance Basin (CO), Uinta Basin (UT), North San Juan Basin (CO), South San Juan Basin (NM), Wind River Basin (WY), Powder River Basin (WY), Greater Green River Basin (WY), and the Williston Basin (MT and ND, pending);
2. Development of an independent 2008 Permian Basin (NM and TX) O&G emission inventory; and
3. For remaining Basins, use states' 2008 NEI-reported O&G emission inventories.

WRAP Phase III Inventory Projections

The WRAP Phase III 2006 baseline O&G inventories represent the results of a multiyear effort and represent the most comprehensive and complete O&G inventory ever developed for the Rocky Mountain States[3]. Alternatives include the NEI inventory[4] that is incomplete and the WRAP Phase II O&G inventory[5] that is deficient in VOC emissions since it was designed to

[1] http://www.wrapair2.org/pdf/WestJumpAQMS_SoW_July20_2011revision.pdf
[2] http://www.wrapair2.org/pdf/WestJumpAQMS_Modeling_Plan_Sep30_2011v2.pdf
[3] http://www.wrapair2.org/PhaseIII.aspx
[4] http://www.epa.gov/ttnchie1/net/2005inventory.html
[5] http://wrapair.org/forums/ogwg/documents/2007-10_Phase_II_O&G_Final%29Report%28v10-07%20rev.s%29.pdf

support baseline regional haze planning. Thus, the WRAP Phase III O&G inventory represents the best data available for the Rocky Mountain States. These projections use 2008 production statistics as surrogates to scale emissions from the various source categories considered in Phase III. Reductions in the scaled emissions resulting from controls required by on-the-books federal and state regulations are also considered.

The 2008 updated inventories for the Phase III basins will be formatted identically to the baseline 2006 inventories generated for the Phase III study. The 2008 O&G emissions for the Phase III Basins will also be processed into the IDA format used by the SMOKE emissions modeling system. The O&G emissions will include information for both area and point sources. New 2008 spatial surrogate data will also be developed that will be used to spatially allocate the O&G area source emissions to the air quality model grid cells in the SMOKE emissions modeling.

2008 emissions inventory projections for the Phase III basins have been presented in Emissions Technical Memoranda 4a, 4b, and 4c. The WRAP Phase III inventory projections are split into separate memos to reflect where similar methodologies were used for groups of basins. The Colorado basins are grouped into a single memo since the methodology for these basins uses a comprehensive permitted sources data set developed by the CDPHE which reflects the low threshold for permitting emission sources (2 tpy of any criteria pollutant) throughout Colorado. In addition, Regulation 7 in Colorado requires regionally-specific analysis of the impacts of the elements of Regulation 7 on specific O&G sources. The Uinta Basin in Utah and South San Juan Basin in New Mexico are grouped because both states have similar emissions permitting thresholds and therefore both of these Phase III inventories were developed primarily using survey data for unpermitted point and area sources. No specific state regulations were identified for O&G sources in Utah and New Mexico that would impact the 2008 projections. The Wyoming Basins, including the Wind River, Powder River and Greater Green River (Southwest Wyoming) Basins, were similarly grouped because the methodology for developing these inventories relied on unique data sets available in Wyoming through the work of the Wyoming DEQ. These include a highly detailed permitted emissions database, a specialized inventory developed for the Jonah-Pinedale Anticline Development (JPAD) area, and engine emissions databases reflecting actual emissions gathered from Wyoming DEQ field offices for various parts of the state. In addition the projections for Wyoming account for a variety of state regulations impacting emissions from specific sources. These variations in the basins led to the grouping of the 2008 WestJump projections into memos 4a, 4b, and 4c in this series.

2008 Emission Inventory for the Permian Basin

O&G emissions for the Permian Basin are available from the NEI, but these data are much lower quality than the WRAP Phase III database. A study prepared by Applied EnviroSolutions, Inc. (AES) on 2007 O&G emissions in the New Mexico portion of the Permian Basin is also available that is of higher quality data. The AES data has been used to develop a comprehensive inventory of the Permian Basin including activities in Texas which is described in this memo. The AES study was commissioned for the Bureau of Land Management (BLM) Carlsbad Field Office (CFO), and used a methodology developed by ENVIRON for the Central Regional Air Planning Association (CENRAP)[6]. The preparation of the 2008 inventory for the Permian Basin

[6] http://www.cenrap.org/html/presentations.php

expanded on the AES study, including both additional emissions estimates in the New Mexico portion of the basin and new emissions estimates for the Texas portion of the basin. The steps in developing the Permian Basin inventory are described in this technical memorandum.

Remainder Basins – use States' 2008 NEI-reported O&G Emissions

Oil and gas emissions for states not covered by the WRAP Phase III and Permian Basin updates (i.e., states than New Mexico, Colorado, Utah, Wyoming, North Dakota and Montana and Basins not covered by Phase III in these 6 states) will be based on the 2008 NEI emissions inventory. The 2008 NEI represents O&G area source emissions reported to the EPA for counties/states that are not part of the Phase III study or the Permian Basin inventory developed as part of the WestJump analysis. These represent the best O&G emissions data available for these states. Emissions inventories for the remaining states in the WestJump domain will be presented in Emissions Technical Memoranda 4e.

Off-Shore Oil and Gas Production Emissions

Within the WestJump modeling domains there are two main areas of off-shore oil and gas production where emissions are needed: (1) off the coast of California; and (2) within the Gulf of Mexico. Of these two, the Gulf of Mexico has by far much greater emissions. Off-shore oil and gas emissions off the coast of California are relatively close to shore and are included in the California inventories, like in the 2008 NEI. The Bureau of Ocean Energy Management (BOEM; formerly MMS) has released a draft version of 2008 oil and gas emissions in the Gulf Coast region. This inventory is superior and will replace the 2005 MMS inventory currently being used for PGM modeling. This inventory contain 2008 emissions estimate for both platform and non-platform oil and gas production emissions in the Gulf. The SMOKE modeling input files are currently under development, and will be available for use in the WestJump emissions modeling task. Emissions inventories for offshore O&G activities in the WestJump domain will also be presented in Emissions Technical Memoranda 4e.

Canada and Mexico

Canada's O&G emissions will be based on the 2006 emissions inventory developed by Environment Canada (EC) from the 2006 National Emissions Release Inventory (NPRI). The 2006 EC inventory is utilized rather than newer NPRI data (e.g., 2008) because it has been used in SMOKE emissions modeling and has added the numerous cross-reference fields to the emissions needed to support SMOKE emissions modeling. Note that higher quality O&G emissions are available for the Alberta oil sands region from Alberta Environment. However, these data are not publicly available and are far away from the western states in the most northern section of the WestJump 36 km modeling domain. For Mexico, a comprehensive emissions inventory was originally developed for the 1999 year. More recently this inventory has been projected to several future years (2008, 2012 and 2030). The O&G emissions in the 2008 Mexico emissions will be used for this study. Emissions inventories for O&G activities in Canada and Mexico in the WestJump domain will be presented in a technical memorandum for Canada/Mexico (item 11 in the WestJump emission sector list).

METHODOLOGY AND RESULTS FOR PERMIAN BASIN

Below we describe the results of the emissions inventory analysis for the fourth in the series of memos describing development of 2008 oil and gas emissions inventories. This analysis focuses on the development of a "Phase III-like" inventory for the Permian Basin in Southeast New Mexico and West Texas. Unlike the previous memos in this series which described the scaling of emissions from Phase III baseline 2006 inventories to 2008, there is no existing basin-wide inventory for the Permian Basin. This inventory is a first attempt to develop such an inventory, using the best available data to estimate emissions from key source categories. It should be noted that this inventory does not have available a detailed set of survey data from operators in the Permian Basin, and therefore other data sources were evaluated and used. A key data source is the AES data described above, which in turn relies heavily on the results of an inventory improvement project conducted for CENRAP in 2008.

The Permian inventory was developed by considering the source categories covered in the AES study, and expanding the emissions from these source categories to consider 2008 production and well/drilling statistics in both the Texas and New Mexico portions of the Permian Basin as surrogates for oil and gas activity. The CENRAP report on which the AES study relies was also reviewed and in a number of instances emissions factors or methodologies were identified as deficient or use assumptions that were not considered reasonable. Where appropriate these input data or methodologies have been updated, in some instances using broader regional factors where Permian-specific data was unavailable. In addition, data on large permitted point sources was obtained directly from the New Mexico Environment Department's (NMED) Air Quality Bureau (AQB) and the Texas Commission on Environmental Quality (TCEQ) for the New Mexico and Texas portions of the basin respectively. These large sources are generally midstream facilities, including gas compressor stations and gas processing plants. These sources are combined with the area source estimates based on the AES study to create a first-of-its-kind comprehensive inventory for the Permian Basin. Due to the lack of survey data of the level of detail used in the Phase III project, and the reliance on broader regional assumptions, this inventory for the Permian Basin has associated with it a greater level of uncertainty in the emissions estimates than previous Phase III basins.

METHODOLOGY

The 2008 projected oil and gas inventory for the Permian Basin was developed following 3 primary steps:

1. 2008 production statistics data were derived using the IHS Global Insight database including active well counts by well type, spud counts, oil production, condensate production and gas production;
2. The AES study, CENRAP study and other assumptions and regional input data were used to calculate 2008 oil and gas area source emissions using the 2008 production statistics as activity surrogates;
3. NMED and TCEQ permit data on large midstream facilities was gathered from each agency and combined with the area source data to create a comprehensive 2008 county-level inventory for the Permian Basin;

These steps are described in more detail below. The overall methodology for generating the Permian Basin inventory closely follows that used in the WRAP Phase III projects in terms of both the calculation and scale-up of emissions from individual area source categories, and the assembly of the comprehensive inventory including point sources.

2008 Production Statistics for the Permian Basin

The 2008 production statistics for the Permian Basin were derived from the IHS database, a commercial database that was used extensively in the WRAP Phase III work. The IHS database obtains well location, activity, status, production, and drilling data from state oil and gas conservation commissions (or their equivalent) in each state. The advantage of using the IHS database is that the data in the IHS database is of significantly higher quality than the raw wells and production data from the state agencies. Significant effort is placed on obtaining accurate well locations, gap-filling missing data fields, and updating data as it is reported. For these reasons the Phase III study chose to use the IHS database, and this was extended to the WestJump study.

Oil and gas related activity data for the Permian Basin were obtained from the IHS Enerdeq database queried via online interface. The IHS database uses data from the New Mexico Oil Conservation Division (NMOCD) and the Texas Railroad Commission (TRC). Two types of data were queried from the Enerdeq database: production data and well data. Production data includes information relevant to producing wells while well data includes information relevant to drilling activity ("spuds") and completions.

Production data were obtained by county for each 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 input files for each basin were loaded into the PowerTools application. From the ACCESS database created by PowerTools for each basin, extractions of the following data relevant to the emissions inventory development were made:

1. 2008 active wells, i.e. wells that reported any oil or gas production in 2008.
2. 2008 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 all counties in each 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 2008 were identified by indication that the spud occurred within 2008. 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.

A summary of the production statistics in 2008 for the Permian Basin in New Mexico and Texas is presented in Table 2. The detailed oil and gas production statistics by county in Texas and New Mexico follow in Table 3.

Table 2. Summary of 2008 O&G production statistics for the Permian Basin.

	Permian Basin
	2008
Gas Production (mcf)	1,694,636,749
Condensate Production (bbl)	6,592,154
Oil Production (bbl)	307,905,117
Well Count	121,323
Spud Count	5,316

Table 3. Detailed by county 2008 O&G production statistics for the Permian Basin.

County	Well Count		Oil/Condensate Production		Gas Production	Spuds
	Conventional Gas Wells	Conventional Oil Wells	Gas Wells (bbl)	Oil Wells (bbl)	All Wells (mcf)	
ANDREWS	184	6,803	7,445	24,333,331	28,995,286	471
BORDEN	0	613	0	3,659,560	3,607,467	24
COKE	41	336	2,412	558,417	3,769,419	19
CRANE	545	4,150	116,938	9,498,673	66,191,027	127
CROCKETT	5,689	2,147	473,871	5,411,666	108,915,675	373
CROSBY	0	413	0	563,336	50,518	17
CULBRSON	33	155	2,540	97,279	4,375,504	17
DAWSON	0	1,283	0	4,232,519	2,452,036	43
DICKENS	0	227	0	1,286,864	119,278	46
ECTOR	112	6,760	46,802	19,908,752	42,442,750	235
GAINES	115	3,979	15,625	25,590,566	35,253,556	134
GARZA	0	2,104	0	3,669,527	764,312	55
GLASSCCK	122	1,548	16,627	3,675,653	12,993,116	86
HOCKLEY	16	4,198	2,049	18,390,119	9,255,583	92
HOWARD	41	3,520	15,725	5,477,966	6,778,458	93
HUDSPETH	6	0	61	0	3,255	4
IRION	302	1,606	52,288	2,495,435	15,328,130	206
JEFF DAV	1	0	77	0	0	0
KENT	0	493	0	4,074,905	7,771,545	43
KING	45	473	6,743	1,958,572	872,036	45
LOVING	217	745	211,496	1,402,904	108,919,810	67
LUBBOCK	0	453	0	1,426,188	55,658	14
LYNN	0	78	0	267,939	103,597	4
MARTIN	3	2,416	161	9,215,592	13,617,473	308
MIDLAND	170	4,193	237,655	11,150,508	46,553,713	249
MITCHELL	0	2,550	0	3,756,146	372,832	207
PECOS	1,349	3,079	234,761	12,248,891	295,548,993	0
REAGAN	71	4,514	42,928	6,004,606	28,748,367	262
REEVES	284	751	33,321	983,390	30,330,106	70
COCHRAN	32	2,021	1,450	3,844,783	2,519,403	41
SCHLECHR	797	307	86,803	387,912	13,370,928	66
SCURRY	0	2,778	0	14,844,162	31,083,426	119
STERLING	688	1,337	43,485	1,037,858	13,382,040	30
SUTTON	6,172	24	86,815	13,266	83,386,832	335
TERRY	0	870	0	4,190,309	1,115,033	33
TOM GREN	82	610	22,629	634,504	3,112,545	29
UPTON	366	3,322	937,124	14,179,148	76,341,250	0
WARD	272	2,884	102,387	7,664,992	49,100,431	161
WINKLER	347	2,165	68,300	3,618,558	38,564,143	95

County	Well Count		Oil/Condensate Production		Gas Production	Spuds
	Conventional Gas Wells	Conventional Oil Wells	Gas Wells (bbl)	Oil Wells (bbl)	All Wells (mcf)	
YOAKUM	2	3,282	121	23,521,798	27,818,224	108
Total TX	**18,104**	**79,187**	**2,868,639**	**255,276,594**	**1,213,983,755**	**4,328**
CHAVES	1,432	877	34,649	544,904	26,528,137	104
EDDY	2,836	7,412	2,124,684	19,322,599	246,813,834	505
LEA	1,307	9,907	1,534,332	32,510,481	204,904,073	378
ROOSEVLT	40	221	29,850	250,539	2,406,950	1
Total NM	**5,615**	**18,417**	**3,723,515**	**52,628,523**	**480,652,994**	**988**
Permian Basin	**23,719**	**97,604**	**6,592,154**	**307,905,117**	**1,694,636,749**	**5,316**

No tribal land was identified within the Permian Basin and therefore no tribal fractions were considered in the analysis.

As shown in Tables 2 and 3, the Permian Basin has a significant amount of oil production, greater by approximately one order of magnitude than any other Phase III basin in the WestJump study. The Permian Basin also has significant gas production, primarily in the form of associated gas from oil wells, with slightly more gas production than the Southwest Wyoming Basin (the largest gas production basin in the Phase III study area). There is significant drilling occurring in the Permian Basin, covering a very large geographic area. The production activity in the Permian is greater in Texas than New Mexico, with approximately 83% of oil production and 72% of gas production occurring in the Texas portion of the Permian Basin, and 81% of active drilling occurring in the Texas portion of the Permian Basin.

Methodology for Area Sources

The development of oil and gas area source emissions in the Permian Basin followed the same general methodology as used for other Phase III basins, however no detailed survey of operators in the Permian Basin was conducted for the WestJump study. Instead the area source emissions estimates relied on a combination of data obtained from the CENRAP and AES studies, methodologies developed for the WRAP Phase III basins, and other data and activity inputs where gap-filling was needed.

The CENRAP and AES studies which formed the basis for the methodology and input data for many of the area source categories in the Permian Basin are themselves linked to the original Phase III study. Figure 1 below presents a flow diagram of data and methodologies used in the development of the Permian Basin inventory for oil and gas area sources.

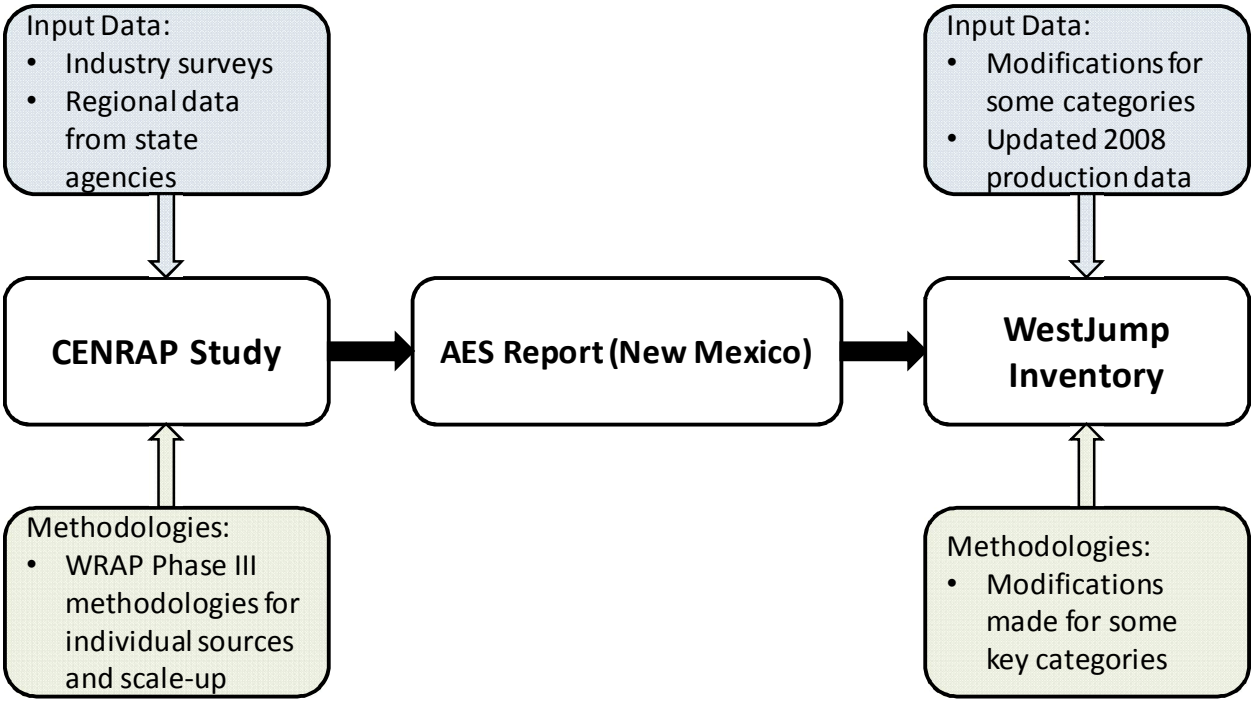

Figure 1. Flow diagram of methodology for developing the Permian Basin oil and gas area source emissions inventory.

The primary data source for the development of the area source inventory was the CENRAP report. This study conducted a series of surveys of operators in the Central States, including Texas and specifically the Permian Basin. The CENRAP study then assembled the survey data and gap-filled with other regional data to develop a set of recommended methodologies and input data for estimating oil and gas area source emissions in the Permian Basin. The survey process and the methodologies for sources were based largely on the WRAP Phase III inventories, thus ensuring consistency among these inventories. It should be noted that the CENRAP study did not provide emissions estimates, only methodologies and input/activity data for area source categories. The AES study for Southeast New Mexico made use of the CENRAP study, and developed emissions estimates for the New Mexico portion of the Permian Basin using production statistics and the CENRAP methodologies and input data. Where appropriate, the WestJump inventory relied on both the CENRAP study and the AES study, which were internally consistent.

The CENRAP study was completed November 2008. Since the completion of that study, significant work has been conducted at the state, regional and national level to improve emissions inventories of oil and gas area sources. As part of the WestJump study, the assumptions, methodology and input data from CENRAP and AES were reviewed. In some instances, it was determined that assumptions for certain source categories were not reasonable and these were modified. A list of the oil and gas area source categories included in the inventory for the Permian are presented below in Table 4, indicating whether modifications were made to the methodology or input data for each source category or whether the original

CENRAP/AES assumptions were used. For those source categories where revisions were made to the input data or methodologies, detailed descriptions of these revisions follow. For source categories where the original CENRAP/AES assumptions were used, the reader is referred to those studies for details on the emissions estimates.

Table 4. Data and methodology sources for Permian Basin oil and gas area source categories.

Source Category	Data/Methodology Sources
Blowdown Flaring	Revised data/methodology (see below)
Compressor engines	CENRAP/AES
Condensate tank	CENRAP/AES
Dehydrator	CENRAP/AES
Drill rigs	CENRAP/AES
Gas well - truck loading	Revised data/methodology (see below)
Heaters	CENRAP/AES
Oil Tank	CENRAP/AES
Oil Well Truck Loading	Revised data/methodology (see below)
Other Flaring	CENRAP/AES
Pneumatic devices	Revised data/methodology (see below)
Pneumatic pumps	Revised data/methodology (see below)
Unpermitted Fugitives	CENRAP/AES
Venting - blowdowns	Revised data/methodology (see below)
Venting - initial completions*	CENRAP/AES
Workover rigs	Revised data/methodology (see below)

*See note below on well completion emissions

For those source categories with revised input data or methodologies, more detailed descriptions are provided below on the input data and/or methodology changes that were implemented.

Well Blowdowns and Blowdown Flaring

No revisions were made to the methodology for estimating emissions from well blowdowns or flaring of well blowdowns in the WestJump inventory. The CENRAP and AES study inputs indicated that all well blowdowns were uncontrolled. This was a conservative assumption used in the previous studies because no data was provided on controls. ENVIRON queried a number of operators in the Permian Basin and based on the responses assumed that 50% of well blowdowns would be flared. This resulted in modification of the blowdown emissions inputs as well as calculation of flaring emissions from blowdowns. Table 5 summarizes the inputs used in the well blowdown emissions estimates.

Table 5. Input data for Permian Basin well blowdown emissions.

Property	Value	Source
Blowdown Frequency (events/well/year)	5	CENRAP 2008 - Permian Basin
Volume of Gas Vented Per Blowdown (MCF)	50	CENRAP 2008 - Permian Basin
Fraction of blowdowns in the formation controlled by flares	50%	Revised based on operator query
Fraction of blowdowns in the formation controlled by green techniques	0%	CENRAP 2008 - Permian Basin

Chemical Injection Pumps

This source category was not included in the CENRAP and AES studies. Because of the large number of active wells in the Permian Basin, it was determined that inclusion of this source category was necessary for a complete inventory. The methodology for estimating emissions from chemical injection pumps was derived from the Phase III inventory, and the input data for was taken from the South San Juan Basin Phase III inventory[7]. Table 6 summarizes the inputs used in the chemical injection pump emissions estimates.

Table 6. Input data for Permian Basin chemical injection pump emissions.

Property		Value	Source
Emission Factors (tons/well)	VOC	0.01	WRAP Phase III, 2006 South San Juan Basin EI

Gas and Oil Well Truck Loading

This source category was not included in the CENRAP and AES studies. Because of the large volume of oil and condensate production in the Permian Basin, it was determined that inclusion of this source category was necessary for a complete inventory. The methodology for estimating gas and oil well truck loading was derived from the Phase III inventory, and the input data for gas well truck loading was taken from the South San Juan Basin Phase III inventory. For oil well truck loading, use of the data from the South San Juan Basin led to unreasonably low estimates of emissions from this category. Differences in the API gravity of oil produced in the South San Juan Basin and Permian Basin and the large volume of oil production in the Permian Basin led to the use of an industry standard oil well truck loading emission factor from the 2009 API *Compendium of Greenhouse Gas Methodologies for the Oil and Gas Industry*[8]. Table 7 summarizes the inputs used in the gas and oil well truck loading emissions estimates.

Table 7. Input data for Permian Basin gas and oil well truck loading emissions.

Property		Value	Source
Gas Well Truck Loading			
Emission Factors (lb VOC/1000 gallons loaded)	VOC	3.69	WRAP Phase III, 2006 South San Juan Basin EI
Oil Well Truck Loading			
Emission Factors (lb VOC/1000 gallons loaded)	VOC	1.70	API Compendium, 2009

[7] http://www.wrapair.org/forums/ogwg/documents/SSanJuanBasin/2009-11y_06_Baseline_S_San_JuanBasin_Technical_Memo_11-25R.pdf

[8] http://www.api.org/ehs/climate/new/upload/2009_ghg_compendium.pdf

Pneumatic Devices

This source category was estimated in the CENRAP and AES studies, but was based on the limited survey data available from the CENRAP survey process for the Permian Basin. Frequently the pneumatic device source category is among the largest VOC emissions source categories in an oil and gas basin. Because of the limited survey data and the large number of active wells in the Permian Basin, it was determined that use of the original CENRAP input data would lead to unreasonably large VOC emissions. No representative data from the Phase III basins could be used in place of the survey data for the Permian Basin because of the prevalence of primary oil production. No Phase III basin had sufficient data on extensive oil field production as the majority of survey data and emissions from Phase III basins were related to primary gas production. Therefore a broader set of assumptions on the number of devices per well for oil and gas wells, and the bleed rates of the devices were obtained from the EPA national greenhouse gas inventory *U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3*[9]. The methodology for estimating pneumatic device emissions was similar to that used in the CENRAP study and the Phase III inventories. Table 8 summarizes the inputs used in the pneumatic device emission estimates.

Table 8. Input data for Permian Basin pneumatic device emissions.

Property	Value	Source
Conventional Gas Wells Activity		
Bleed Rate for Conventional Gas Wells (scfd/device)	459	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3
Total Number of Devices per Well (#/well)	2	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3
Conventional Oil Wells Activity		
Bleed Rate for Conventional Oil Wells (scfd/device) for High Bleed Devices	419	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3
Total Number of High Bleed Devices per Well (#/well)	0.62	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3
Bleed Rate for Conventional Oil Wells (scfd/device) for Low Bleed Devices	66	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3
Total Number of Low Bleed Devices per Well (#/well)	1.15	EPA, U.S Greenhouse Gas Emissions And Sinks: 1990-2010, ANNEX 3

Workover Rigs

This source category was not included in the CENRAP and AES studies. Because of the large number of active wells in the Permian Basin, even a relatively low frequency of workover activity could result in significant emissions from this source category. The methodology for estimating emissions from workover rigs was derived from the Phase III inventory, and the input data for was taken from the South San Juan Basin Phase III inventory[7]. Table 9 summarizes the inputs used in the workover rig emission estimates.

[9] http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Annex-3-Additional-Source-or-Sink-Categories.pdf

Table 9. Input data for Permian Basin workover rig emissions.

Property		Value	Source
Frequency of Workover per well		0.14	WRAP Phase III, 2006 South San Juan Basin EI
Emission Factors (lb/well)	NOx	0.29	WRAP Phase III, 2006 South San Juan Basin EI
	CO	0.17	WRAP Phase III, 2006 South San Juan Basin EI
	VOC	0.04	WRAP Phase III, 2006 South San Juan Basin EI
	PM_{10}	0.03	WRAP Phase III, 2006 South San Juan Basin EI
	SOx	0.03	WRAP Phase III, 2006 South San Juan Basin EI

Well Completions

The inventory does not estimate venting emissions from well completions in the Permian Basin. This category would normally include venting from wells that have been hydraulically fractured. The original CENRAP study was unable to gather sufficient information to characterize well completion venting in the Permian Basin. Several efforts were made to gather this information, including direct outreach to operators, a survey process being undertaken by the Central States Air Resources Agencies (CenSARA), and discussions with state air agencies and the Federal Bureau of Land Management (BLM). The outreach efforts also did not lead to additional information on well completion venting practices in the Permian Basin. Because the Permian Basin is primarily an oil production area, it was assumed that practices for well completion would differ from those of the Phase III basins where the majority of data was gathered for tight sands gas production areas. Therefore it was determined that Phase III data could not be used as a substitute for well completion venting data in the Permian Basin. As a result, emissions could not be estimated for this source category.

Sour Gas Production in the Permian Basin

The CENRAP study assumed that any gas produced at well sites would be used directly for well-site combustion equipment. If sour gas was produced, the CENRAP study assumed that the H_2S fraction in the sour gas would be combusted and converted to SOx emissions. This assumption has been revised for the WestJump study after determining through discussions with operators that high levels of H_2S in produced gas is damaging to combustion equipment and is rarely used. It is therefore assumed that sour gas combustion occurs only for the flaring category, and no substantial SOx emissions are associated with combustion sources at sour gas production sites.

Oil and Condensate Tanks

CENRAP study estimates of emission rates and control were assumed for oil and condensate tanks. Uncontrolled emission rates of 1.6 lb-VOC/bbl and 33.3 lb-VOC/bbl were assumed for oil tanks and condensate tanks, respectively. It was assumed that 25% of both oil and condensate tank emissions are controlled by flare; the remaining 75% of tanks are assumed not subject to control.

Permitted Point Sources

Permitting thresholds in both New Mexico and Texas vary by source category but generally will include most large facilities (Title V) and a range of other midstream facilities such as compressor stations and gas processing plants that are below Title V thresholds. Separate queries were made to the NMED AQB and TCEQ for 2008 point source emissions for all oil and gas sources within the counties in the Permian Basin. Oil and gas permitted sources were identified through a search on the SCC/SIC codes associated with the upstream oil and gas sector. The SCCs and SICs for oil and gas sources are:

- 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

These queries were made for both New Mexico and Texas facilities, and the results were assembled. For the Texas point sources, data was queried from the complete list of point sources in the 2008 National Emission Inventory (NEI) database for Texas. Queries were made on the SIC codes (converted to NAICS codes) listed above and sources not associated with the upstream oil and gas sector were filtered out of the query. Similarly NMED conducted a query on the 2008 inventory of major sources (Title V) and provided this data directly. Any oil and gas point source with non-zero emissions in 2008 was included in the point source compilation. Texas point source emissions were provided for NOx and VOC only; PM, CO, and SO_2 emissions were not provided and therefore Texas point source PM, CO, and SO_2 emissions are not included in the Permian Basin emission inventory. New Mexico point sources of NOx, VOC, CO, PM10, and SO_2 were provided and are included in the emission inventory.

This filtering of the permitted sources databases identifies the upstream oil and gas exploration and production sector separately from the downstream sector which may include gas transmission, storage and distribution and/or oil refining and transmission and distribution. These downstream sectors are not part of this inventory.

OBSERVATIONS AND RESULTS

As noted above, emissions from both area sources and permitted sources were compiled considering 2008 production statistics for the Permian Basin.

The Permian Basin 2008 inventory represents an update to the production statistics used in the CENRAP and AES studies, as well as updates to key source categories based on recent inventory findings and comparison with other basins. However, it should be noted that a survey data set of the level of detail and completeness used in other Phase III basins was not available for the Permian Basin. Further refinements could be made to the input data for area source categories in the Permian Basin if additional detailed data on activities, processes, equipment and well configurations were obtained from operators. Nevertheless the inventory represents a consistent format and methodology to that used in other Phase III basins to cover the broad area of the Permian Basin.

Results

The 2008 O&G emissions for the Permian Basin are shown below in a series of tables and graphs summarizing the quantitative results by source category, by county and by pollutant. Table 10 below provides an overall summary of the Permian Basin emissions on a basin-wide level with comparison to the 2006 inventory. Tables 10, 11 and 12 below show the 2008 O&G emissions in the Permian Basin by-county and by-source-category respectively (for NOx and VOC emissions only). Figures 2 and 3 show the breakdown of the 2008 NOx and VOC emissions for the Permian Basin by source category. Figures 4 and 5 show the breakdown of the 2008 NOx and VOC emissions by county (New Mexico only). It was not possible to develop bar charts showing NOx and VOC emissions breakdown by county in Texas due to the large number of individual counties.

NOx emissions in the Permian Basin are dominated by compressor engines, with drilling rigs and heaters being the only other significant NOx sources. Collectively these sources account for approximately 97% of NOx emissions in 2008. There is a significant amount of active drilling in the Permian Basin in 2008, suggesting that drilling rig emissions should represent a larger fraction of basin-wide NOx emissions than was observed. However, the Permian Basin has a large number of active wells due to the long period of time during which oil and gas development has taken place and this high well count is the driver for very high compressor usage and compressor NOx emissions.

VOC emissions are comprised of a variety of source categories including oil and condensate tanks, pneumatic devices, venting from well blowdowns and well-site fugitive emissions. Collectively these sources account for approximately 96% of VOC emissions in 2008. Due to the large amount of oil and condensate production in this basin, these two source categories alone account for approximately 52% of VOC emissions. It should be noted that due to the lack of data to estimate well completion venting emissions in the Permian Basin, it is likely that if this source category were included the total VOC emissions would be higher than shown in Figure 3 and the percentage contributions of each category would change.

Table 10. Summary of the 2008 O&G emissions by county in the Permian Basin.

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
Andrews	5,253	27,932	1,297	272	146
Borden	447	3,416	93	23	9
Cochran	403	5,938	266	77	20
Coke	460	1,187	63	15	6
Crane	6,057	16,504	650	178	53
Crockett	3,670	26,963	1,275	301	127
Crosby	89	1,053	64	16	6
Culbrson	785	449	40	7	5
Dawson	287	4,862	187	49	16
Dickens	118	1,215	78	10	12
Ector	3,948	25,388	1,007	261	89
El Paso	254	65	0	0	0
Fisher	200	35	0	0	0
Gaines	1,949	23,672	593	156	52
Garza	392	5,867	288	80	23
Glasscck	398	5,468	279	64	29
Hockley	1,018	18,992	555	159	43
Howard	2,024	9,811	487	135	40
Hudspeth	416	21	5	0	1
Irion	989	5,826	446	76	58
Jeff Dav	0	3	0	0	0
Kent	659	3,516	103	19	13
King	156	2,246	108	20	13
Loving	310	5,506	187	38	21
Lubbock	89	1,671	64	17	6
Lynn	18	303	13	3	1
Martin	1,753	10,105	620	98	85
Midland	4,268	18,364	758	169	80
Mitchell	740	6,710	514	100	61
Nolan	0	0	0	0	0
Pecos	5,877	25,024	484	164	22
Reagan	1,805	12,445	796	177	84
Reeves	648	3,078	194	40	22
Schlechr	276	3,770	195	43	21
Scurry	882	14,362	436	106	42
Sterling	715	5,171	250	76	17
Sutton	3,773	16,187	1,055	239	110
Terry	186	4,143	131	33	12
Tom Gren	150	1,913	108	26	10
Upton	2,044	27,833	394	137	18
Ward	1,202	11,843	527	122	54
Winkler	5,201	8,002	380	96	35
Yoakum	1,685	20,753	476	125	42
TEXAS TOTAL	61,594	387,611	15,467	3,729	1,502
Chaves	859	5,846	533	89	37
De Baca	1	27	7	78	0
Eddy	5,642	59,411	4,444	1,271	202
Lea	18,110	61,787	7,414	12,123	312
Roosevlt	38	1,003	29	10	2
New Mexico Total	24,649	128,074	12,427	13,569	552
TOTAL	**86,244**	**515,686**	**27,894**	**17,298**	**2,054**

Table 11. NOx emissions by source category for the 2008 O&G emission inventory in the Permian Basin.

County	Compressor Engines	Drill Rigs	Heaters	Glycol Dehydrator	Flares	Other Categories	Totals
Andrews	3,852	889	444	2	1	99	5,253
Borden	357	45	39	0	0	30	447
Cochran	184	77	130	0	0	87	403
Coke	365	36	24	0	5	99	460
Crane	5,429	240	298	2	1	65	6,057
Crockett	2,362	704	498	4	4	6	3,670
Crosby	28	32	26	0	0	1	89
Culbrson	740	32	12	0	0	7	785
Dawson	117	81	81	0	0	2	287
Dickens	15	87	14	0	0	1	118
Ector	2,966	444	436	1	1	50	3,948
El Paso	251	0	0	0	0	12	254
Fisher	196	0	0	0	0	9	200
Gaines	1,384	253	260	1	1	60	1,949
Garza	143	104	134	0	0	83	392
Glasscck	119	162	106	0	0	0	398
Hockley	516	174	268	0	0	14	1,018
Howard	1,537	176	226	0	2	0	2,024
Hudspeth	409	8	0	0	0	12	416
Irion	463	389	121	1	0	3	989
Jeff Dav	0	0	0	0	0	5	0
Kent	522	81	31	6	5	3	659
King	35	85	33	0	0	0	156
Loving	114	127	61	3	0	19	310
Lubbock	31	26	29	0	0	43	89
Lynn	5	8	5	0	0	14	18
Martin	997	582	154	1	1	288	1,753
Midland	3,448	470	277	1	28	45	4,268
Mitchell	173	391	162	0	0	24	740
Nolan	0	0	0	0	0	12	0
Pecos	5,287	0	281	18	3	6	5,877
Reagan	973	495	291	1	1	56	1,805
Reeves	424	132	66	2	0	15	648
Schlechr	75	125	70	0	0	49	276
Scurry	423	225	176	1	1	5	882
Sterling	514	57	129	1	1	4	715
Sutton	2,689	633	394	6	3	37	3,773
Terry	63	62	55	0	0	18	186
Tom Gren	47	55	44	0	0	31	150
Upton	1,764	0	234	6	2	163	2,044
Ward	677	304	200	1	2	3	1,202
Winkler	4,827	179	160	1	3	4	5,201
Yoakum	1,104	204	209	1	4	0	1,685
Texas Total	45,623	8,173	6,179	62	69	1,488	61,594
Chaves	502	196	147	1	0	13	859
De Baca	0	0	0	0	1	208	1
Eddy	3,928	954	651	8	18	84	5,642
Lea	16,341	714	712	6	128	0	18,110
Roosevlt	18	2	17	0	0	1	38
New Mexico Total	20,788	1,866	1,526	15	147	307	24,649
Totals	**66,412**	**10,038**	**7,705**	**78**	**216**	**1,795**	**86,244**

Table 12. VOC emissions by source category for the 2008 O&G emission inventory in the Permian Basin.

County	Compressor Engines	Pneumatic Devices	Venting – Blowdowns	Glycol Dehydrator	Condensate Tanks	Oil Tanks	Unpermitted Fugitives	Permitted Fugitives	Other Categories	Totals
Andrews	345	4,424	4,464	39	94	14,697	2,721	28	526	27,932
Borden	25	377	392	7	0	2,210	239	20	50	3,416
Cochran	23	1,285	1,312	3	18	2,322	800	0	569	5,938
Coke	32	260	241	6	30	337	147	85	1,066	1,187
Crane	439	3,262	2,999	87	1,470	5,737	1,829	112	1,120	16,504
Crockett	225	8,734	5,006	152	5,957	3,269	3,052	43	146	26,963
Crosby	4	254	264	0	0	340	161	0	11	1,053
Culbrson	9	138	120	6	32	59	73	0	180	449
Dawson	14	789	820	3	0	2,556	500	0	30	4,862
Dickens	2	140	145	0	0	777	88	0	62	1,215
Ector	221	4,303	4,390	56	588	12,025	2,677	63	1,053	25,388
El Paso	1	0	0	0	0	0	0	3	173	65
Fisher	14	0	0	4	0	0	0	0	178	35
Gaines	76	2,597	2,615	53	196	15,457	1,595	30	857	23,672
Garza	20	1,294	1,344	1	0	2,216	819	0	295	5,867
Glasscck	16	1,111	1,067	17	209	2,220	650	0	1	5,468
Hockley	50	2,603	2,692	12	26	11,108	1,641	3	209	18,992
Howard	74	2,218	2,275	9	198	3,309	1,387	47	0	9,811
Hudspeth	3	8	4	0	1	0	2	2	165	21
Irion	61	1,381	1,219	25	657	1,507	743	24	90	5,826
Jeff Dav	0	1	1	0	1	0	0	0	104	3
Kent	41	303	315	27	0	2,461	192	11	61	3,516
King	5	350	331	1	85	1,183	202	0	12	2,246
Loving	21	741	615	143	2,659	847	375	2	460	5,506
Lubbock	4	279	289	0	0	861	176	0	758	1,671
Lynn	1	48	50	0	0	162	30	0	226	303
Martin	57	1,490	1,545	19	2	5,566	942	24	5,535	10,105
Midland	491	2,800	2,787	61	2,988	6,735	1,699	45	358	18,364
Mitchell	24	1,568	1,629	0	0	2,269	993	0	72	6,710
Nolan	0	0	0	0	0	0	0	0	175	0
Pecos	433	3,651	2,829	458	2,951	7,398	1,725	44	54	25,024
Reagan	220	2,869	2,929	75	540	3,627	1,786	41	729	12,445
Reeves	16	832	661	80	419	594	403	1	93	3,078
Schlechr	10	1,227	705	18	1,091	234	430	0	237	3,770

County	Compressor Engines	Pneumatic Devices	Venting – Blowdowns	Glycol Dehydrator	Condensate Tanks	Oil Tanks	Unpermitted Fugitives	Permitted Fugitives	Other Categories	Totals
Scurry	61	1,708	1,775	41	0	8,966	1,082	0	172	14,362
Sterling	67	1,719	1,294	28	547	627	789	8	41	5,171
Sutton	242	8,057	3,958	134	1,091	8	2,413	45	760	16,187
Terry	8	535	556	1	0	2,531	339	0	399	4,143
Tom Gren	7	482	442	4	284	383	270	0	309	1,913
Upton	254	2,520	2,356	110	11,780	8,564	1,436	52	1,007	27,833
Ward	85	2,128	2,016	64	1,287	4,630	1,229	4	61	11,843
Winkler	220	1,784	1,605	51	859	2,186	978	11	17	8,002
Yoakum	55	2,021	2,098	36	2	14,207	1,279	47	0	20,753
Texas Total	3,979	72,290	62,153	1,832	36,061	154,187	37,893	795	18,422	387,611
Chaves	65	2,405	1,475	143	436	329	899	3	91	5,846
De Baca	0	0	0	0	0	0	0	25	1,806	27
Eddy	400	8,254	6,547	362	26,709	11,671	3,991	236	1,240	59,411
Lea	1,030	7,796	7,164	287	19,288	19,636	4,368	413	3	61,787
Roosevlt	2	188	167	3	375	151	102	0	15	1,003
New Mexico Total	1,498	18,643	15,353	796	46,807	31,788	9,360	676	3,154	128,074
Totals	5,477	90,933	77,506	2,627	82,868	185,975	47,253	1,471	21,575	515,686

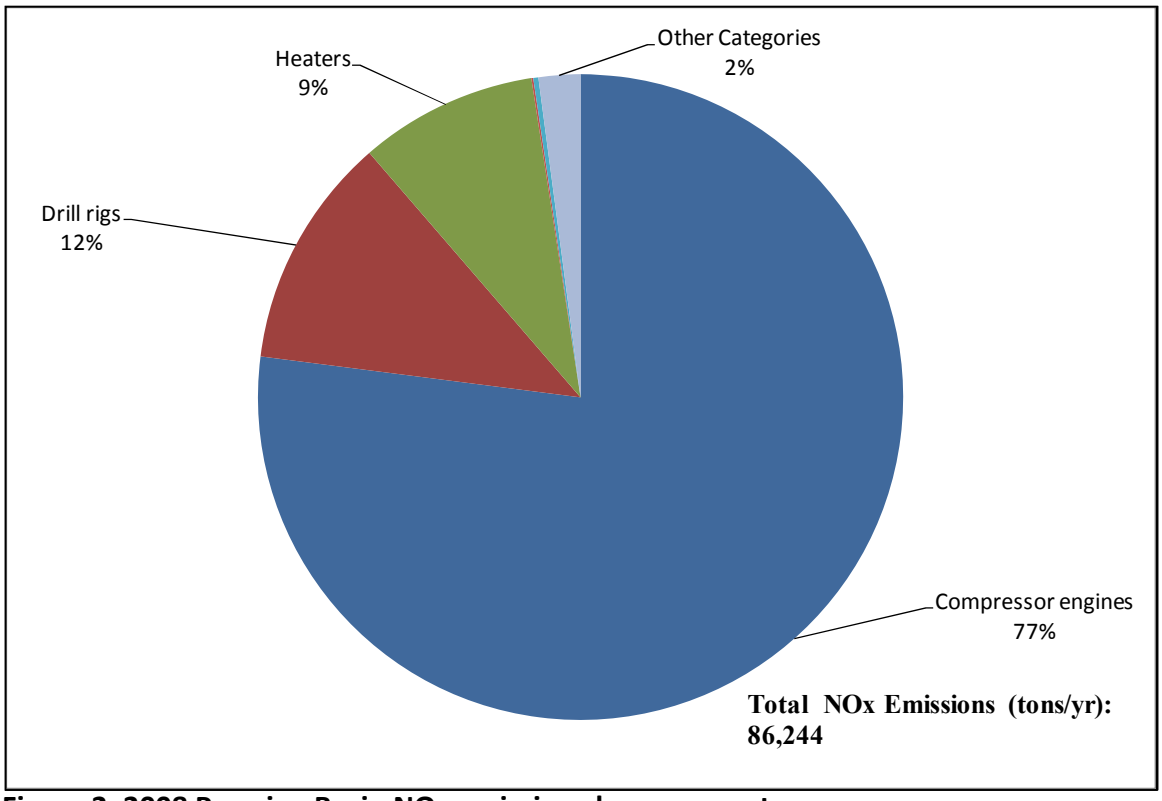

Figure 2. 2008 Permian Basin NOx emissions by source category.

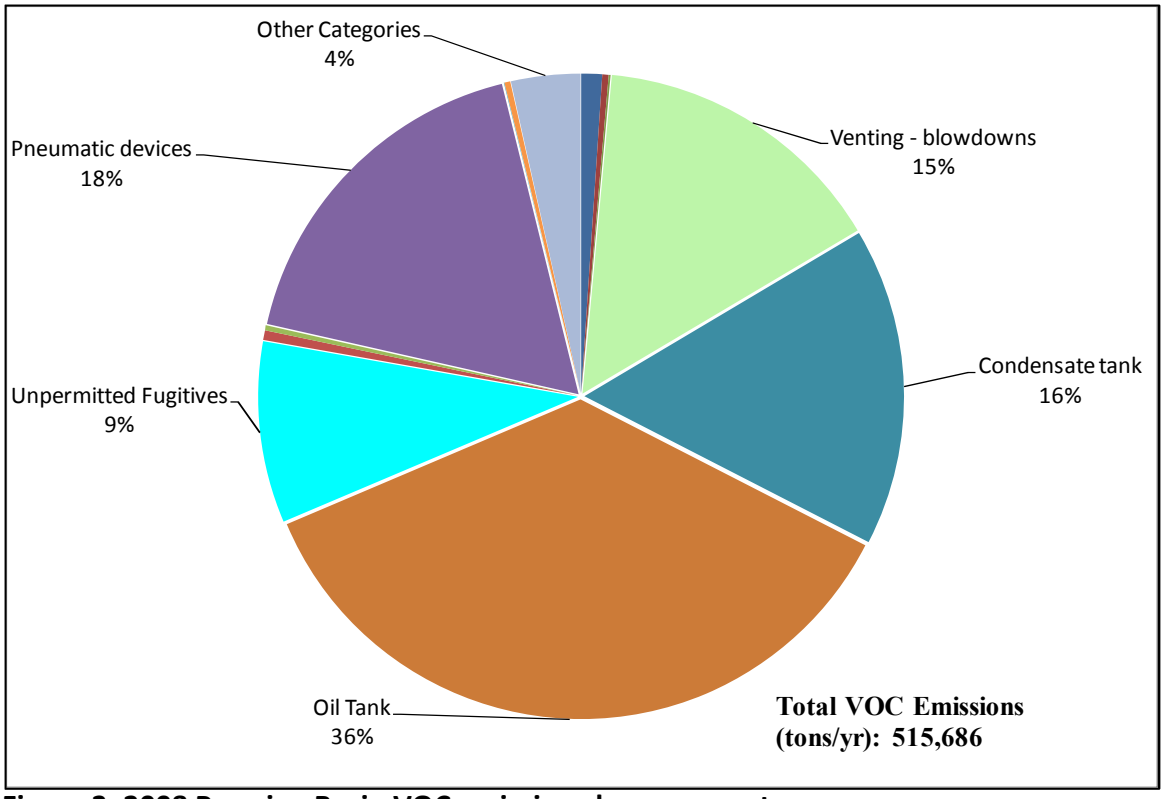

Figure 3. 2008 Permian Basin VOC emissions by source category.

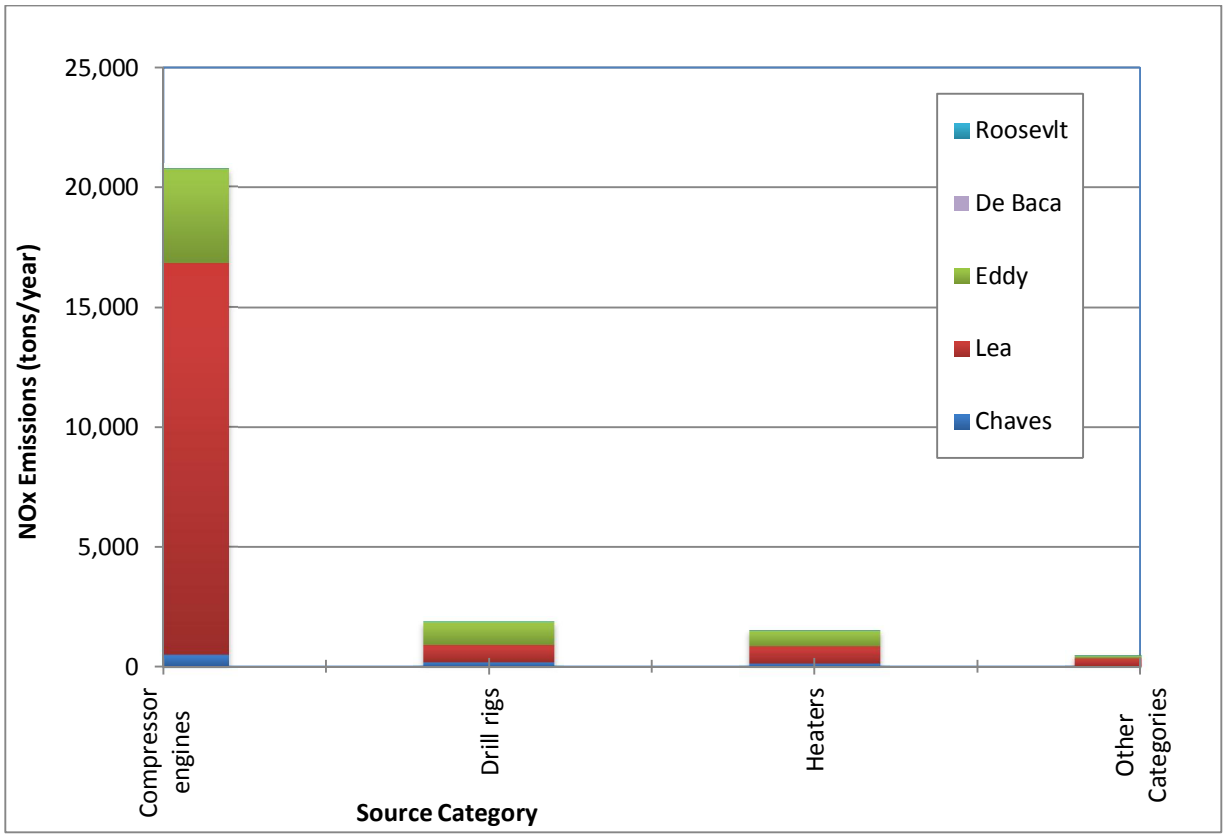

Figure 4. 2008 Permian Basin NOx emissions by county (New Mexico only).

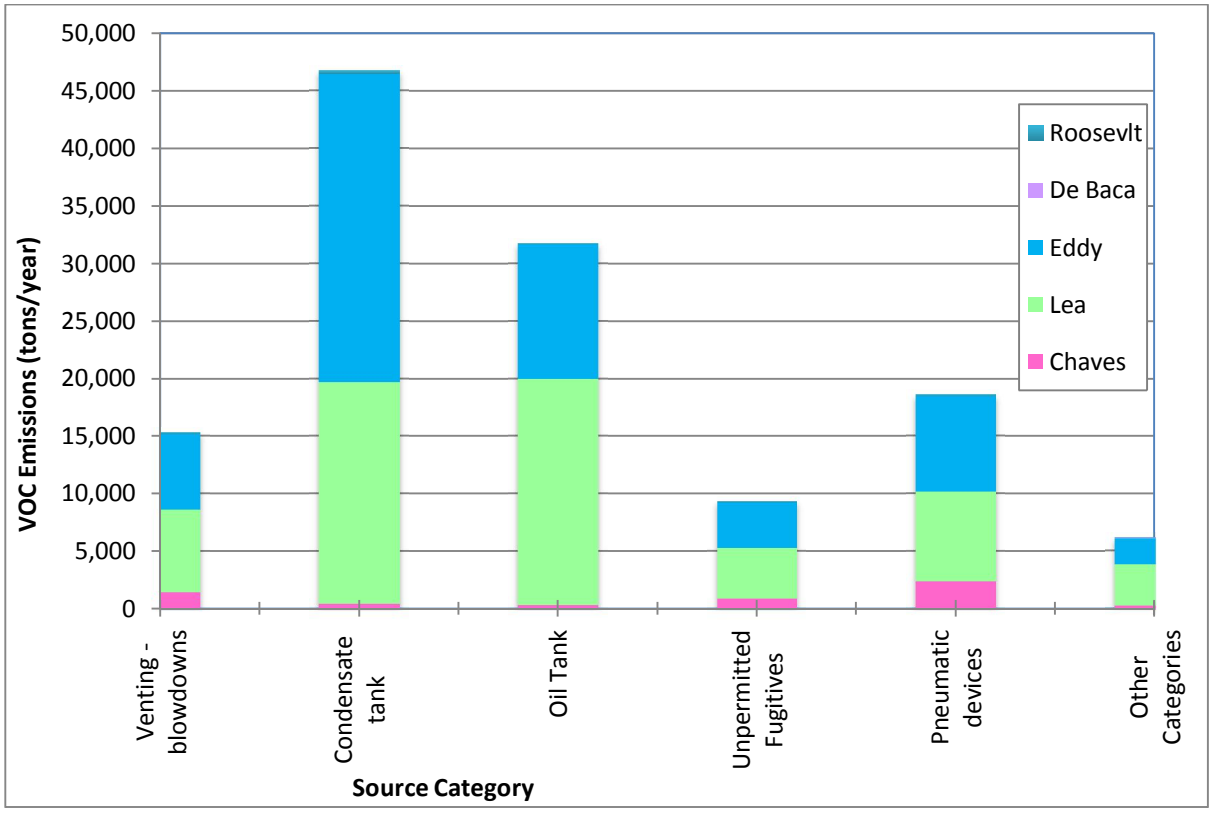

Figure 5. 2008 Permian Basin VOC emissions by county (New Mexico only).

ENVIRON

APPENDIX A

Detailed Emission Inventory Spreadsheets

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Detailed Emission Inventory Spreadsheets

Detailed spreadsheets accompany the 2008 WestJump projected emission inventories for each basin. These spreadsheets contain greater detail on the emissions inventory including control factors, and more detailed breakdown of emissions by all source categories within a basin. The reader is referred to these accompanying spreadsheets for more quantitative information on the inventory results.