Final Report

DEVELOPMENT OF 2015 OIL AND GAS EMISSIONS PROJECTIONS FOR THE WILLISTON BASIN

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Phase III Oil & Gas Emissions Inventory Project

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INTRODUCTION

This document outlines the projection methodologies used in generating the 2015 emissions projections from oil and gas sources in the Williston Basin. These methodologies will use as a starting point the 2009 baseline Williston Basin oil and gas emissions inventory, described in the baseline emissions report entitled "Development of Baseline 2009 Emissions from Oil and Gas Activity in the Williston Basin". Like the midterm inventory for the Powder River Basin, the Williston Basin projected inventory is for calendar year 2015 rather than 2012. The 2015 calendar year was chosen because of the long duration of the project and the Montana Department of Natural Resources (MTDNR) and North Dakota Department of Health (NDDOH) need for a farther future year projection than 2012.

The methodology used to develop the 2015 projections for the Williston Basin is described below in subsections:

- Geographic grouping of data – regional differences in production or activity are factored into the projection methodology by geographic region;
- Projected parameters – seven basic parameters are projected forward to 2015 for purposes of developing scaling factors: total well counts, conventional gas well counts, spud counts, total gas production, oil well oil production, condensate production and total gas processed;
- Scaling factors and developing uncontrolled emissions projections – the projected parameters are used to develop scaling factors (incorporating geographic groupings), and these scaling factors are applied to the 2009 baseline emissions;
- Application of "on-the-books" regulations and control measures – existing regulations are summarized for their impacts on the future year emissions and applied to adjust the uncontrolled 2015 inventory.

Projections for years beyond 2015 (not addressed in this methodology) will likely include additional parameters and will be based on these 2015 projections as the start year. The methodology for developing far future year projections will be detailed in a separate analysis.

Following the discussion of the methodology, the results of the 2015 emissions projections for the Williston Basin are presented in graphical and tabular formats.

GEOGRAPHIC GROUPING

The projections for 2015 have been conducted for three geographic groupings in the Williston Basin. These include:

- Bakken Formation Counties – this grouping represents the core Bakken oil development area in the basin including Daniels, McCone, Richland, Roosevelt, Sheridan, and Valley Counties in Montana and Billings, Bottineau, Burke, Divide, Dunn, Golden Valley, McHenry, McKenzie, Mclean, Mercer, Morton, Mountrail, Oliver, Pierce, Renville, Rolette, Sheridan, Stark, Ward and Williams Counties in North Dakota;
- Cedar Creek Anticline – this grouping represents the other major concentrated development area in the basin including Dawson, Fallon, Prairie and Wibaux Counties in Montana, Bowman and Slope Counties in North Dakota, and Harding County in South Dakota;
- All Other Counties – this grouping contains primarily conventional gas and oil production areas outside of the Bakken and Cedar Creek Anticline and includes all remaining counties in the basin in Montana, North Dakota and South Dakota;

As noted above, the geographic groupings were constructed to group similar production types or to group counties that do not represent significant fractions of the total production in the Williston Basin. The Williston Basin contains the core Bakken oil shale production area, representing significantly greater oil production than any other Phase III basin studied to date (Bar-Ilan, et al., 2009a; Bar-Ilan, et al., 2009b; Bar-Ilan, et al., 2009c; Bar-Ilan, et al., 2008). In addition to the Bakken formation, the Cedar Creek Anticline represents another major concentration of development and thus was projected independently of the Bakken formation. Finally all other counties in the basin were grouped together as “minor” counties, not representing significant fractions of basin-wide oil or gas production. This approach of identifying a core production area and a larger grouping of “minor” production counties is similar to that used for the Piceance Basin (Bar-Ilan, et al., 2009d).

PARAMETERS PROJECTED

The 2015 projections for oil and gas emissions in the Powder River Basin rely on scaling 7 parameters:

- Total well counts
- Spud counts
- Total gas production
- Oil well oil production
- Condensate production
- Total gas processed
- Total casinghead gas flared

These seven parameters are considered because each parameter applies to the emissions projections of one or more source categories. Note that the analysis uses data from the IHS database, which defines condensate production as liquid hydrocarbon production from wells which are classified as gas wells. Similarly, oil well oil production is defined as liquid hydrocarbon production from wells which are classified as oil wells. The classification of gas vs. oil wells is obtained directly from the IHS database is based on the gas-oil ratio (GOR) of the well, using a cutoff GOR defined either by the Montana Board of Oil and Gas or North Dakota Industrial Commission Division of Oil and Gas. This is the distinction made between condensate and oil production. Because of the large amount of primary oil production in the Bakken formation, the effect of this definition of condensate and oil is minor. Most of the liquid hydrocarbon production in the basin is in the form of primary oil.

The mapping of source category to projection parameter is shown below in Table 1.

Table 1. Scaling parameter for each oil and gas source category considered in this inventory.

Source	SCC	Description	Projection Parameter
Unpermitted	2310000100	Heaters	Total Well Count
Unpermitted	2310000220	Drill rigs	Spuds
Unpermitted	2310000230	Workover rigs	Total Well Count
Unpermitted	2310000300	Pneumatic devices	Total Well Count
Unpermitted	2310000700	Unpermitted Fugitives	Total Well Count
Unpermitted	2310000801	Gas Well Truck Loading	Gas Well Condensate Production
Unpermitted	2310000802	Oil Well Truck Loading	Oil Well Oil Production
Unpermitted	2310000820	Gas Plant Truck Loading	Gas Well Condensate Production
Unpermitted	2310001610	Venting - initial completions	Spuds
Unpermitted	2310001620	Venting - recompletions	Spuds
Unpermitted	2310001630	Venting - blowdowns	Total Gas Production
Unpermitted	2310001640	Venting - Compressor Startup	Total Gas Production
Unpermitted	2310001650	Venting - Compressor Shutdown	Total Gas Production
Unpermitted	2310002230	Condensate tank	Gas Well Condensate Production
Unpermitted	2310002240	Oil Tank	Oil Well Oil Production
Unpermitted	2310002231	Condensate tank flaring	Gas Well Condensate Production
Unpermitted	2310003100	Miscellaneous engines	Total Well Count
Unpermitted	2310003200	Pneumatic pumps	Total Well Count
Unpermitted	2310020600	Compressor engines	Total Gas Production

Source	SCC	Description	Projection Parameter
Unpermitted	2310021410	Dehydrator	Total Gas Production
Unpermitted	2310000330	Artificial Lift	Oil Well Oil Production
Unpermitted	2310002241	Oil Tank Flaring	Oil Well Oil Production
Unpermitted	2310003500	Other Flaring	Total Gas Production
Unpermitted	2310003501	Associated Gas Flaring	Based on volume of gas flared in 2015
MTDEQ Permitted Sources	10200603	Process Heaters	Total Gas Processed
MTDEQ Permitted Sources	10500106	Process Heaters	Total Gas Processed
MTDEQ Permitted Sources	20100202	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	20200102	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	20200201	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	20200202	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	20200253	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	20200254	Compressor Engines	Total Gas Processed
MTDEQ Permitted Sources	30200699	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	30301012	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	30501050	Natural Gas Production, Other Not Classified	Total Gas Processed
MTDEQ Permitted Sources	30502504	Natural Gas Production, Other Not Classified	Total Gas Processed
MTDEQ Permitted Sources	31000101	Permitted Fugitives	Total Gas Processed
MTDEQ Permitted Sources	31000107	Natural Gas Production, Other Not Classified	Total Gas Processed
MTDEQ Permitted Sources	31000129	Oil Production, Gas/Liquid Separation	Total Gas Processed
MTDEQ Permitted Sources	31000202	Natural Gas Production, Gas Stripping Operations	Total Gas Processed
MTDEQ Permitted Sources	31000205	Natural Gas Production, Flares	Total Gas Processed
MTDEQ Permitted Sources	31000207	Permitted Fugitives	Total Gas Processed
MTDEQ Permitted Sources	31000220	Permitted Fugitives	Total Gas Processed
MTDEQ Permitted Sources	31000227	Dehydrator	Total Gas Processed
MTDEQ Permitted Sources	31000228	Dehydrator	Total Gas Processed
MTDEQ Permitted Sources	31000301	Dehydrator	Total Gas Processed
MTDEQ Permitted Sources	31000404	Process Heaters	Total Gas Processed
MTDEQ Permitted Sources	31000405	Process Heaters	Total Gas Processed
MTDEQ Permitted Sources	40301008	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40301009	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40301010	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40301012	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40301021	Permitted Tank Losses	Total Gas Processed

Source	SCC	Description	Projection Parameter
MTDEQ Permitted Sources	40301117	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400116	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400140	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400151	Permitted Fugitives	Total Gas Processed
MTDEQ Permitted Sources	40400250	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400302	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400311	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40400312	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40600131	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40600132	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40600135	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40700809	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40700810	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40781602	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40781604	Permitted Tank Losses	Total Gas Processed
MTDEQ Permitted Sources	40781605	Permitted Tank Losses	Total Gas Processed
NDDOH Permitted Sources	20200201	Compressor Engines	Total Gas Processed
NDDOH Permitted Sources	20200202	Compressor Engines	Total Gas Processed
NDDOH Permitted Sources	31000205	Natural Gas Production, Flares	Total Gas Processed
NDDOH Permitted Sources	31000299	Natural Gas Production, Other Not Classified	Total Gas Processed
NDDOH Permitted Sources	31000301	Dehydrator	Total Gas Processed
NDDOH Permitted Sources	31000404	Process Heaters	Total Gas Processed
NDDOH Permitted Sources	40400302	Permitted Tank Losses	Total Gas Processed

PROJECTION METHODOLOGIES FOR THE WILLISTON BASIN

For the Williston Basin, the methodology for obtaining the 2015 value of each projection parameter (total well counts, spud counts, total gas production, oil well oil production, condensate production, total gas processed, and casinghead gas flared) is described below. In general, spud count projections were developed by obtaining the historical spud count and well count data for the geographic grouping using the IHS database, and reviewing the historic rate of spuds to new wells added in each geographic grouping. Well count and production projections for the basin were developed by developing extrapolated trend lines from historical data, or conservatively holding well counts and project constant into the future if historic data indicated decline. Condensate production projections were assumed to follow the trends for gas production. "Total gas processed" and "casinghead gas flared" are related parameters. The "total gas processed" projection factor applies to permitted midstream gas gathering and processing sources, and the "casinghead gas flared" projection factor applies only to the casinghead gas flaring source category. These are described below as they are not projected similarly to the other parameters.

Because of the recent increase in activity in the Bakken formation, additional annual data on oil and gas production and well counts was gathered from the IHS database for calendar years 2010, 2011 and 2012 in order to better track these recent trends. Therefore extrapolations and projections were made for the period 2012-2015, but it should be noted that projection factors represent the ratio of 2015 values of the parameters to 2009 values of the parameters.

The IHS database is a tool to query oil and gas statistical well and production data, and uses as its reference data the databases maintained by various state OGCC's (or equivalent).

Associated Gas Flaring and Venting

Special consideration is given to develop projections of the total amount of gas processed in the Williston Basin in 2015, relative to the total amount of gas processed in 2009. Information obtained from the state and federal agencies as well as industry participants indicates that some associated gas produced from the Bakken formation is flared due to a lack of gas gathering and processing infrastructure. This was discussed in the technical report for the Williston Basin baseline 2009 inventory (Bar-Ilan, et al., 2013). The amount of gas sold was used as a surrogate for the amount of gas processed, as this information was tracked for the basin by the North Dakota oil and gas commission. Historic data on the fraction of gas sold was plotted and extrapolated to 2015; the 2015 fraction of gas sold was then combined with the projected total gas production to derive the projected 2015 total gas processed. The ratio of 2015 to 2009 total gas processed was used to project midstream gas gathering emission sources. The inverse of this value represents the fraction flared, and therefore a similar approach was used to derive the projection factor for the casinghead gas flaring source category. Figure 1 below shows the projected fraction of gas sold in the Williston Basin.

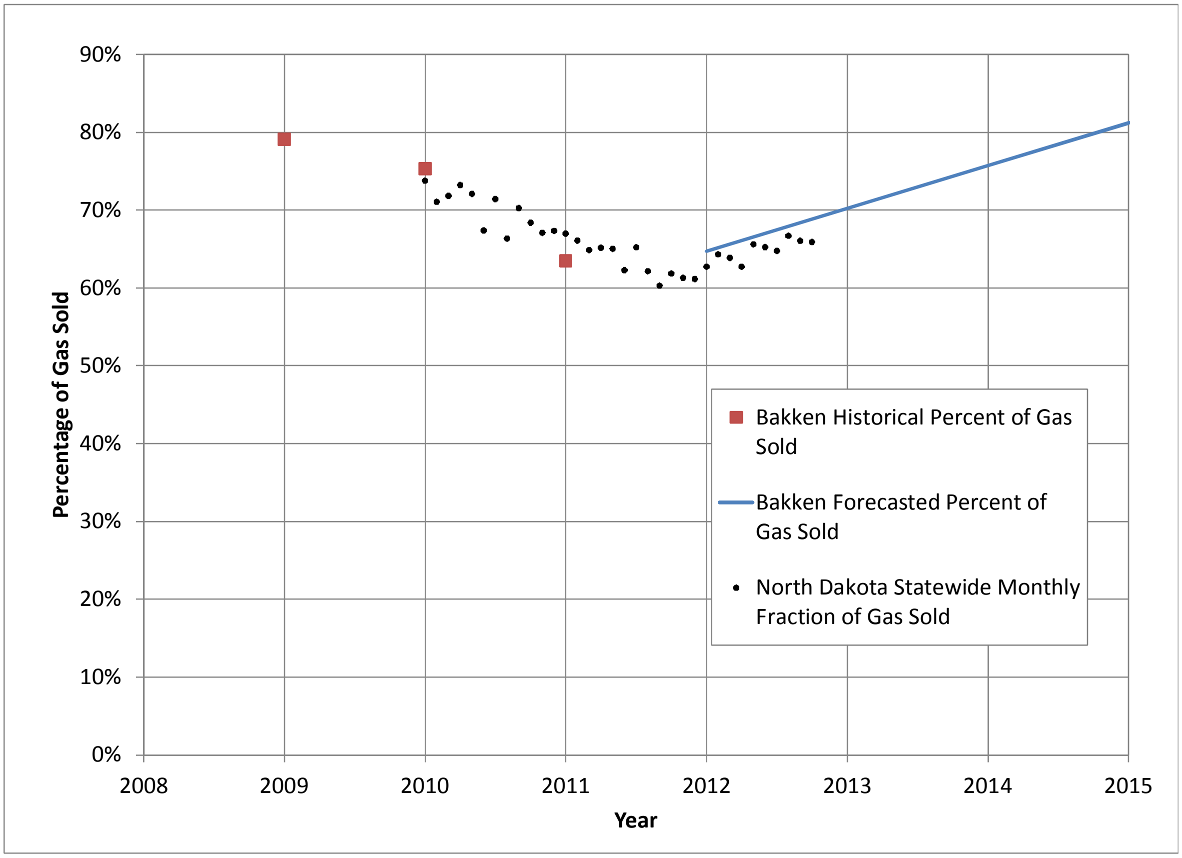

Figure 1. Fraction of gas produced that is processed and sold in the Bakken Formation in North Dakota and Montana.

This analysis was conducted for the Bakken geographical grouping, where the majority of new gas production is occurring in the Williston Basin in this time period. It was assumed that for the Cedar Creek Anticline and "Other Counties" geographical groupings, all gas produced was processed. In practical application, the "total gas processed" projection factor is dominated by the activities in the Bakken formation as shown in Figure 1.

The decline in the fraction of gas processed in the Bakken from 2009 through 2011 is due to the increase in associated gas production without sufficient gas gathering and processing infrastructure. During the period from 2011 through October 2012, this trend reverses as additional infrastructure is established in this geographic area; this was the time period used to project a trendline forward to 2015. There are three primary observations from this analysis:

(1) The "gas processed" projection factor is a combination of growth in the total amount of gas produced and the increase in gas gathering infrastructure;
(2) This projection factor would be lower if the increase in gas gathering and processing infrastructure were not accounted for; and
(3) Similarly the projection factor for casinghead gas flaring would be higher if the increase in gas gathering and processing infrastructure were not accounted for;

It should be noted that this analysis used the available data on recent trends in the increase in gas gathering and processing infrastructure, however more detailed survey data from industry would improve these projections.

Bakken Formation Counties

Total Well Counts

Total well counts in the Bakken Formation counties in the Williston Basin have been plotted for the years 1970 – 2012 below in Figure 2, including projections to 2015.

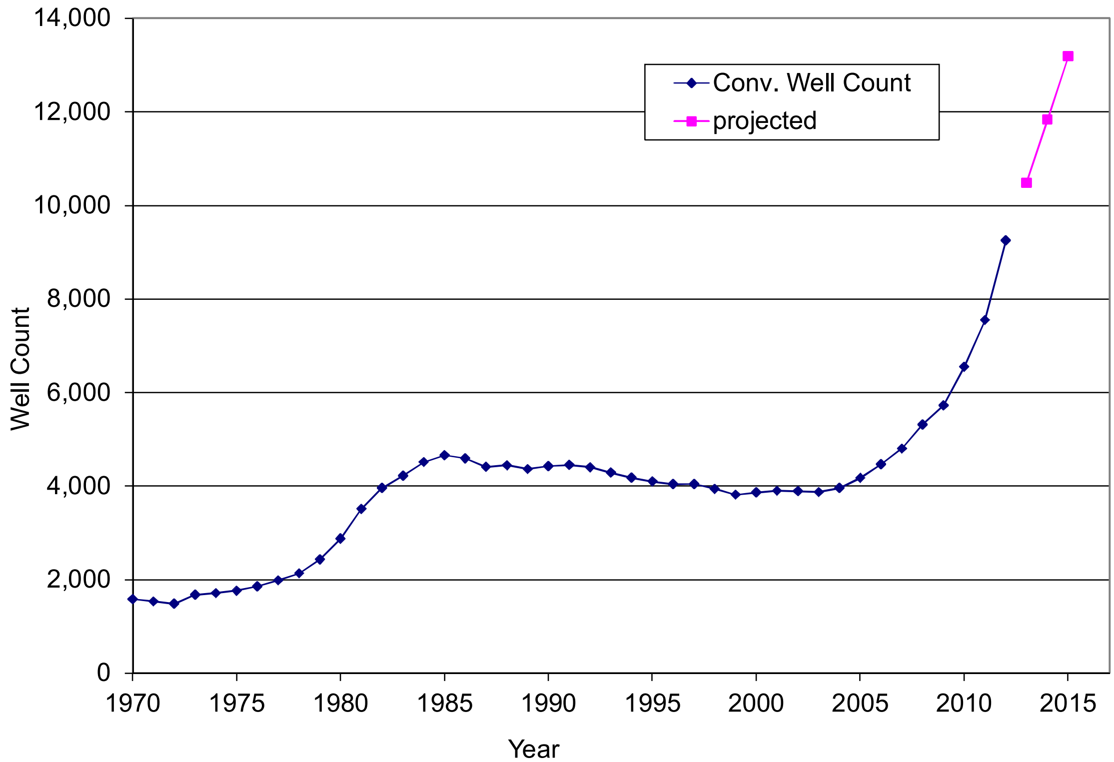

Figure 2. Total well count historical data (from the IHS database) for Bakken Formation Counties in the Williston Basin and projections to 2015.[1]

Total well count projections were developed for the period 2012 – 2015 by linear extrapolation of the well counts in the period 2010-2012. This period represented the recent historic increase in oil wells and oil production activity in the Bakken Formation and was considered a reasonable historic period from which to project the remaining data.

Spud Counts

Spud counts in the Bakken Formation Counties in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 3, including projections to 2015.

[1] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

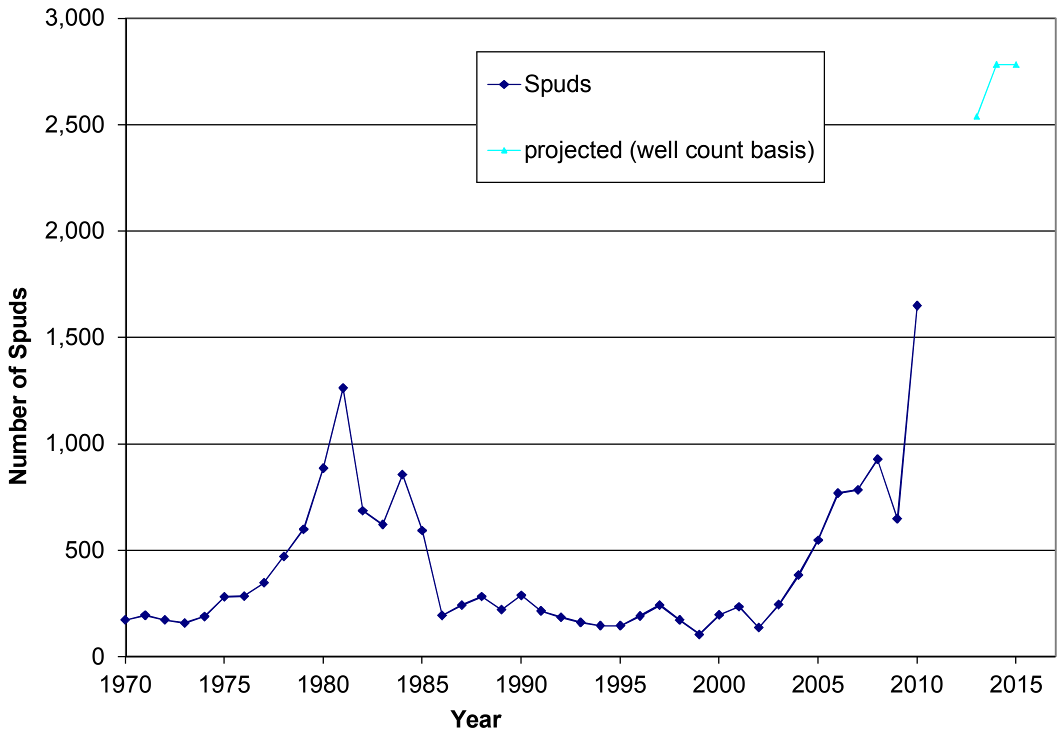

Figure 3. Spud count historical data (from the IHS database) for Bakken Formation Counties in the Williston Basin and projections to 2015. [2]

Historic spud counts in the Bakken Formation Counties, as obtained from the IHS database for the period 1970-2010 are erratic, making an extrapolation from historical data infeasible. Rather the change in the number of active wells each year in the period 2006-2010 was compared to the number of spuds that occurred in that same period. A ratio of the average number of annual spuds to the number of annual active wells added was developed. This ratio of 2.01 was then applied to the projected number of wells in the Bakken Formation Counties as described in Figure 2 above to estimate the projected number of spuds.

Total Gas Production

Total gas production in the Bakken Formation Counties in the Williston Basin has been plotted for the years 1970 – 2012 below in Figure 4, including projections to 2015.

[2] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

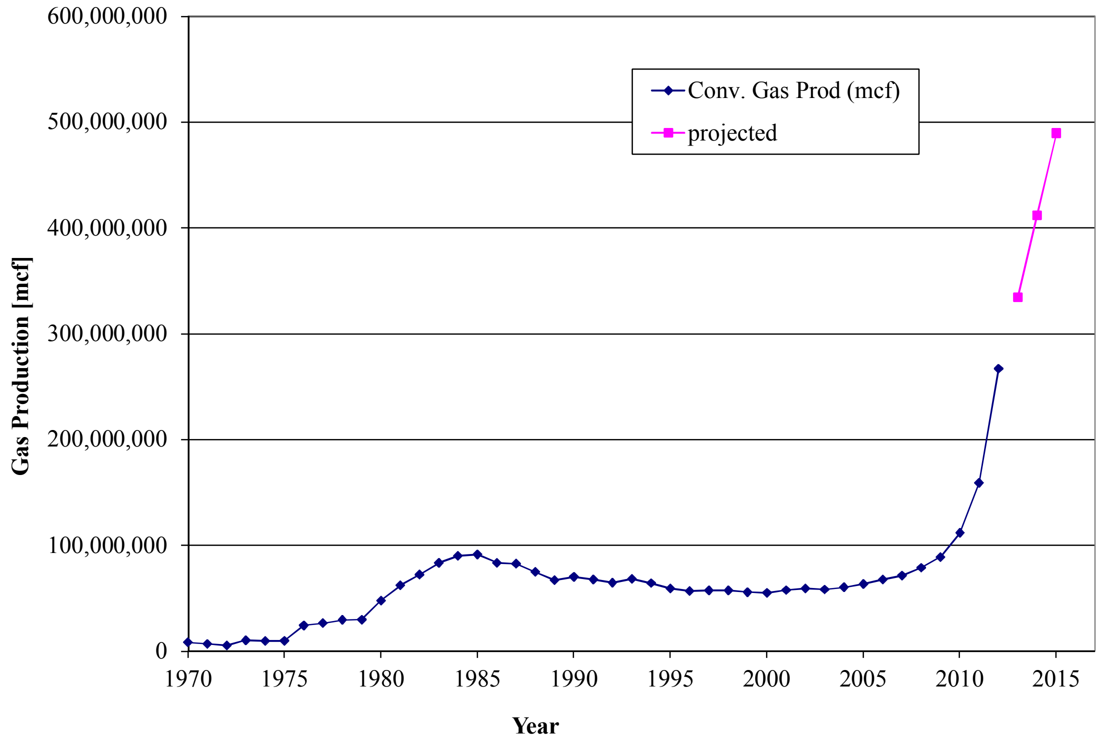

Figure 4. Total gas production historical data (from the IHS database) for Bakken Formation Counties in the Williston Basin and projections to 2015.[3]

Total gas production was linearly projected from 2012 - 2015 based on the rate of increase from the period 2010-2012 in order to account for the recent growth in Bakken Formation activity. The majority of gas production in the Bakken Formation geographical grouping is from casinghead gas production at Bakken oil wells.

Oil Well Oil Production

Oil well oil production in the Bakken Formation Counties in the Williston Basin has been plotted for the years 1970 – 2012 below in Figure 5, including projections to 2015.

[3] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

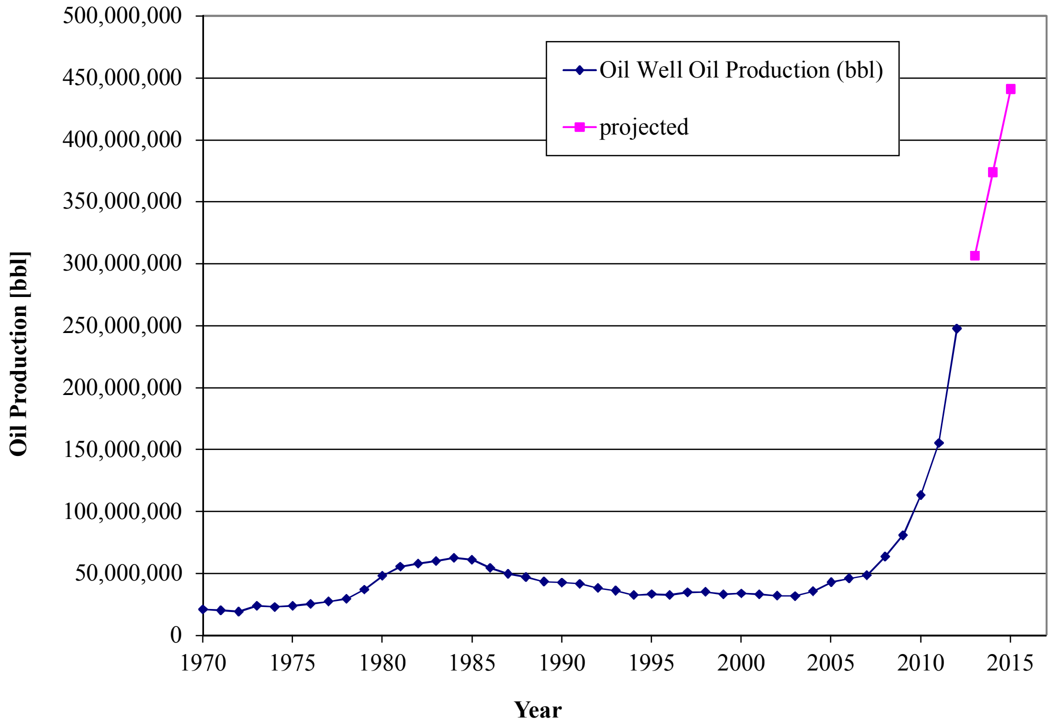

Figure 5. Oil production historical data (from the IHS database) for Bakken Formation Counties in the Williston Basin and projections to 2015.[4]

Oil production in the Bakken Formation was linearly projected forward to 2015 based on the growth period from 2010 to 2012. Because of the sensitivity of this projection to the selection of projection parameters (extrapolation type, data period from which to project) and the importance of this projection to the overall 2015 midterm emission inventory, reference data was obtained from other studies to confirm the plausibility of this projection. A study conducted by Bentek Energy for the North Dakota Pipeline Association (NDPA) and North Dakota Industrial Commission (NDIC) was used to compare the midterm projections of oil production in the Bakken Formation (Bentek, 2012). The Bentek study presented a range of oil production projections based on a variety of parameters used to define three scenarios: (1) a low scenario; (2) a base case scenario; and (3) a high growth scenario. The linearly projected oil production shown in Figure 5 falls within a reasonable range between the base case and low scenarios developed in the Bentek study for calendar year 2015, more closely approximating the base case scenario. Because the consistency with the Bentek study appeared reasonable, this linear projection was used for Bakken Formation oil production in 2015.

<u>Condensate Production</u>

Condensate production in the Bakken Formation Counties in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 6, including projections to 2015.

[4] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

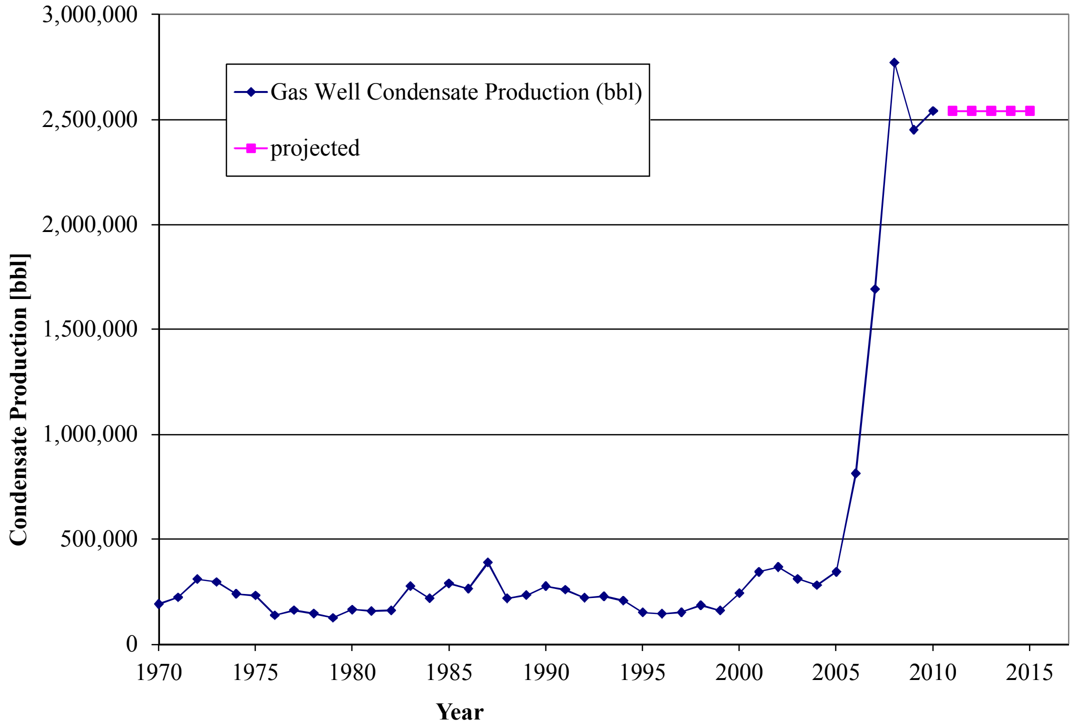

Figure 6. Condensate production historical data (from the IHS database) for the Bakken Formation Counties in the Williston Basin and projections to 2015. [5]

Condensate production in the Bakken Formation Counties is low relative to primary oil production. Large increases in annual condensate production were observed in the period 2005-2008 with subsequent decline in 2009 and a slight increase in 2010. This may reflect economic conditions which favored the development of primary oil wells over gas wells producing condensate. Given the erratic nature of recent condensate production activity in the Bakken Formation, the analysis conservatively assumed that 2010 condensate production levels would remain constant in the period 2010-2015.

Cedar Creek Anticline Counties

Total Well Counts

Total well counts in the Cedar Creek Anticline Counties in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 7, including projections to 2015.

[5] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

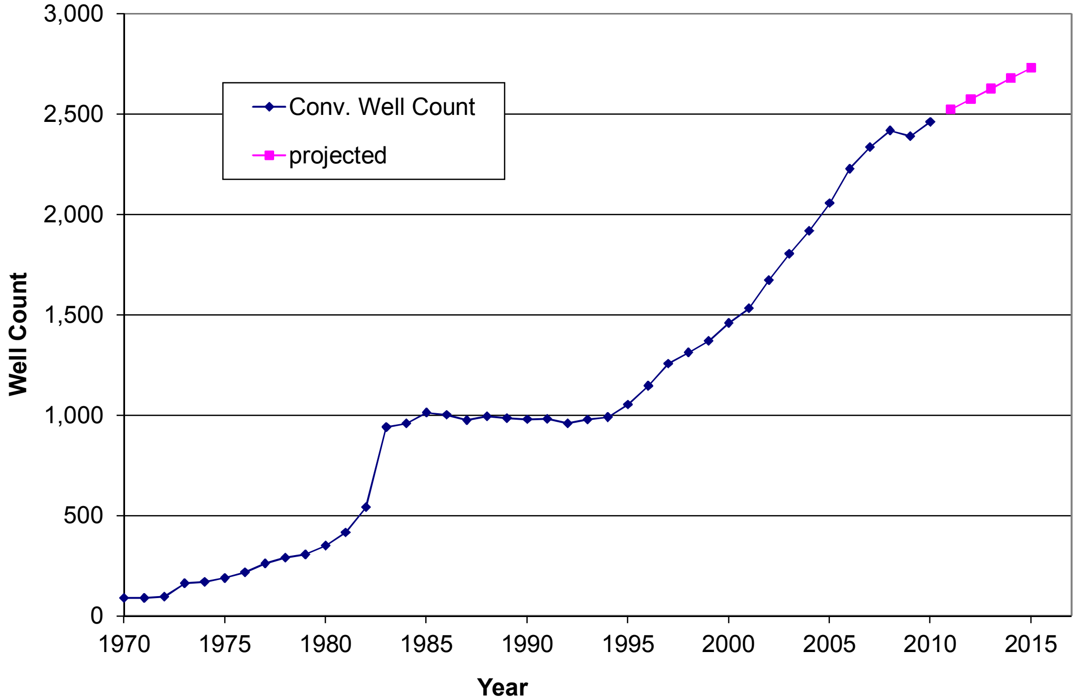

Figure 7. Total well count historical data (from the IHS database) for Cedar Creek Anticline Counties in the Williston Basin and projections to 2015.[6]

Total active well counts in the Cedar Creek Anticline formation have been steadily increasing since approximately the mid-1990's and this trend was continued. Total well counts were linearly extrapolated to 2015 based on historic data from the period 2006-2010.

Spud Counts

Spud counts in the Cedar Creek Anticline Counties in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 8, including projections to 2015.

[6] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

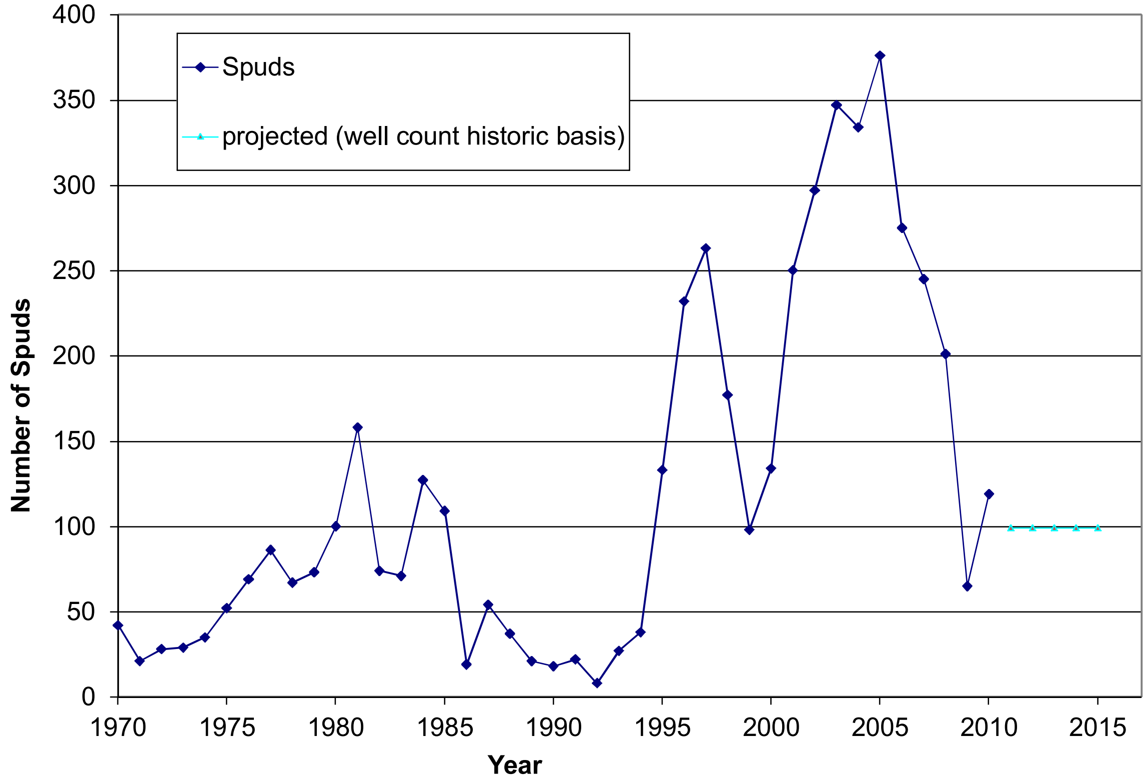

Figure 8. Spud count historical data (from the IHS database) for Cedar Creek Anticline Counties in the Williston Basin and projections to 2015. [7]

Historic spud counts in the Cedar Creek Anticline Counties, as obtained from the IHS database for the period 1970-2010 are erratic, making an extrapolation from historical data infeasible. The change in the number of active wells each year in the period 2006-2010 was compared to the number of spuds that occurred in that same period, and determined the number of spuds required to match the increase or decrease in well counts for each year in that period. An average total spud count needed to maintain the observed number of active wells in the period 2006-2010 was developed, with a value of 99 spuds per year. The annual number of spuds estimated using this methodology was held constant for the period 2011-2015.

Total Gas Production

Total gas production in the Cedar Creek Anticline Counties in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 9, including projections to 2015.

[7] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

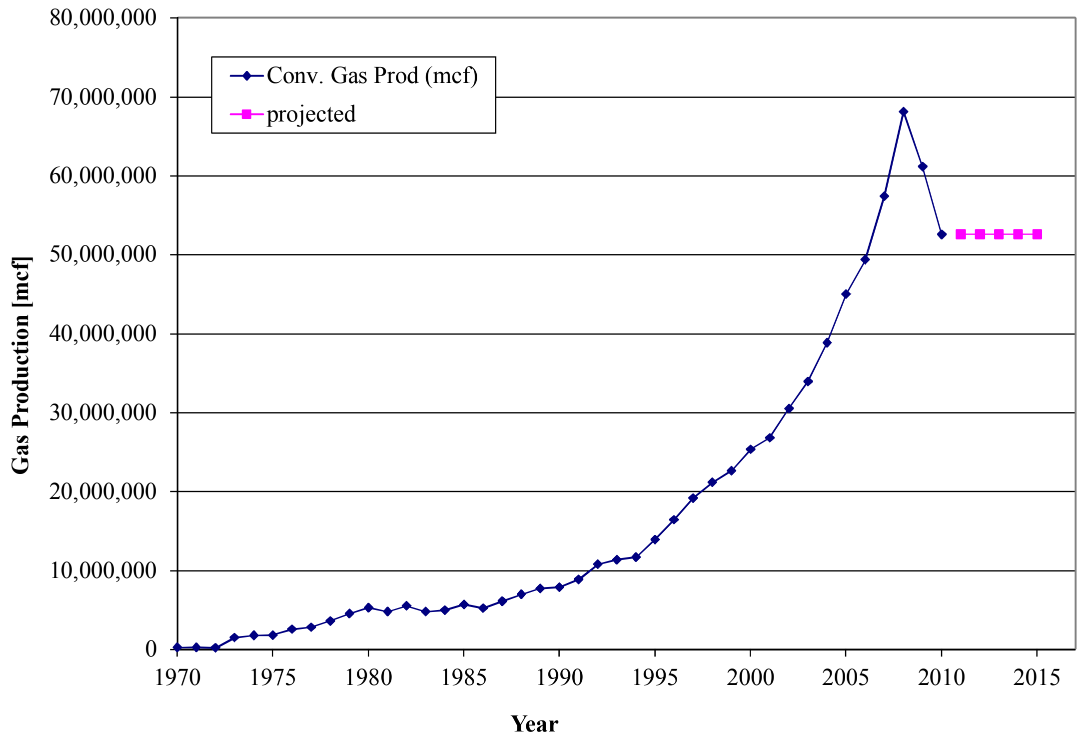

Figure 9. Total gas production historical data (from the IHS database) for Cedar Creek Anticline Counties in the Williston Basin and projections to 2015.[8]

Total gas production in the Cedar Creek Anticline Counties was generally increasing during the entire historical period tracked through 2008. Data from 2009 and 2010 show that gas production levels have declined during these past two years likely due to economic circumstances that favor oil production over gas production, and therefore this analysis conservatively assumed that gas production would remain at 2010 levels through the period 2011-2015.

Oil Well Oil Production

Oil well oil production in the Cedar Creek Anticline Counties in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 10, including projections to 2015.

[8] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

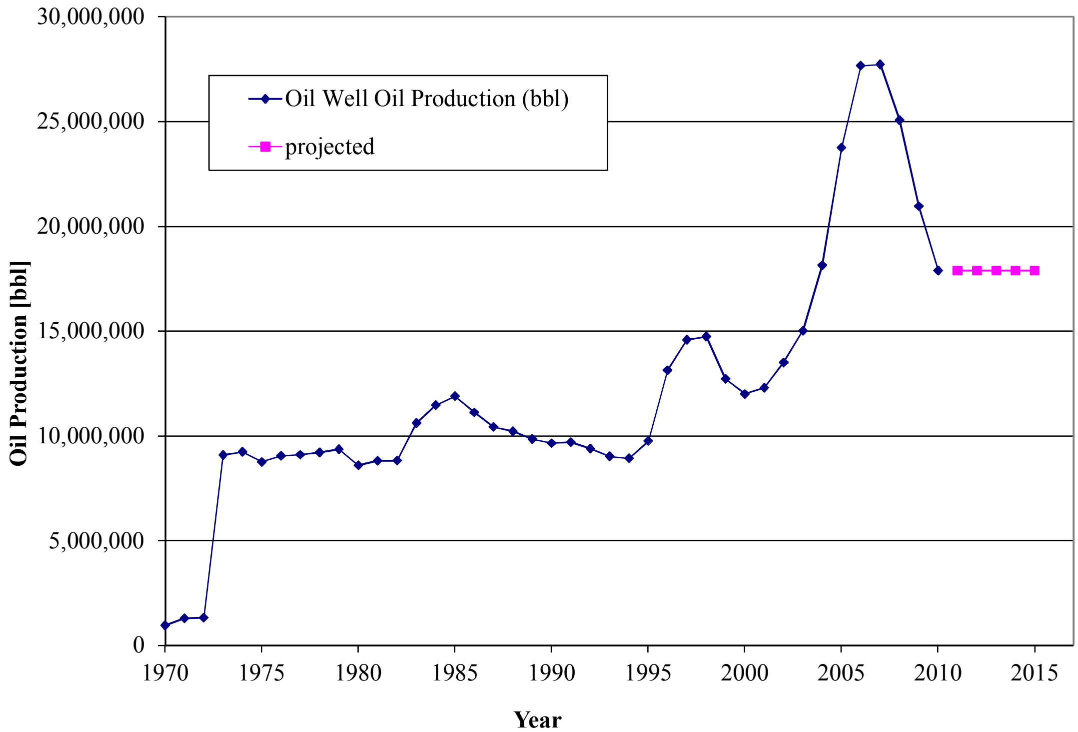

Figure 10. Oil production historical data (from the IHS database) for Cedar Creek Anticline Counties in the Williston Basin and projections to 2015.[9]

Oil production has been generally increasing in the Cedar Creek Anticline Counties in the Williston Basin throughout the historical period until 2007. During the period 2007-2010 oil production in the Cedar Creek Anticline declined by approximately 35%. Given that no additional information was available on anticipated trends in this formation, it was conservatively assumed that oil production would remain at 2010 levels in the period 2011-2015.

Condensate Production

Condensate production in the Cedar Creek Anticline Counties in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 11, including projections to 2015.

[9] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

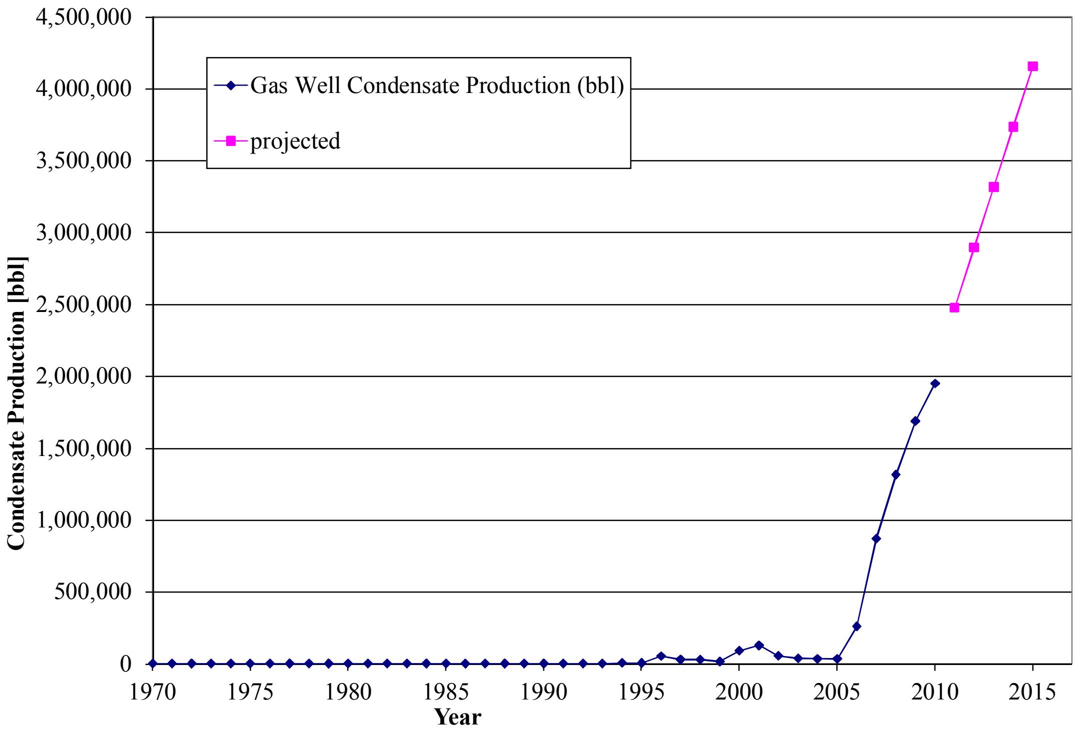

Figure 11. Condensate production historical data (from the IHS database) for Cedar Creek Anticline Counties in the Williston Basin and projections to 2015. [10]

Condensate production in the Cedar Creek Anticline has been steadily increasing in the period 2005-2010. Although gas production in the Cedar Creek Anticline experienced a decline after 2008, this trend was not observed in the condensate production. Therefore condensate production was linearly extrapolated to 2015 based on the historic data in the period 2006-2010.

Other Counties

Total Well Counts

Total well counts in the "Other Counties" grouping in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 12, including projections to 2015.

[10] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

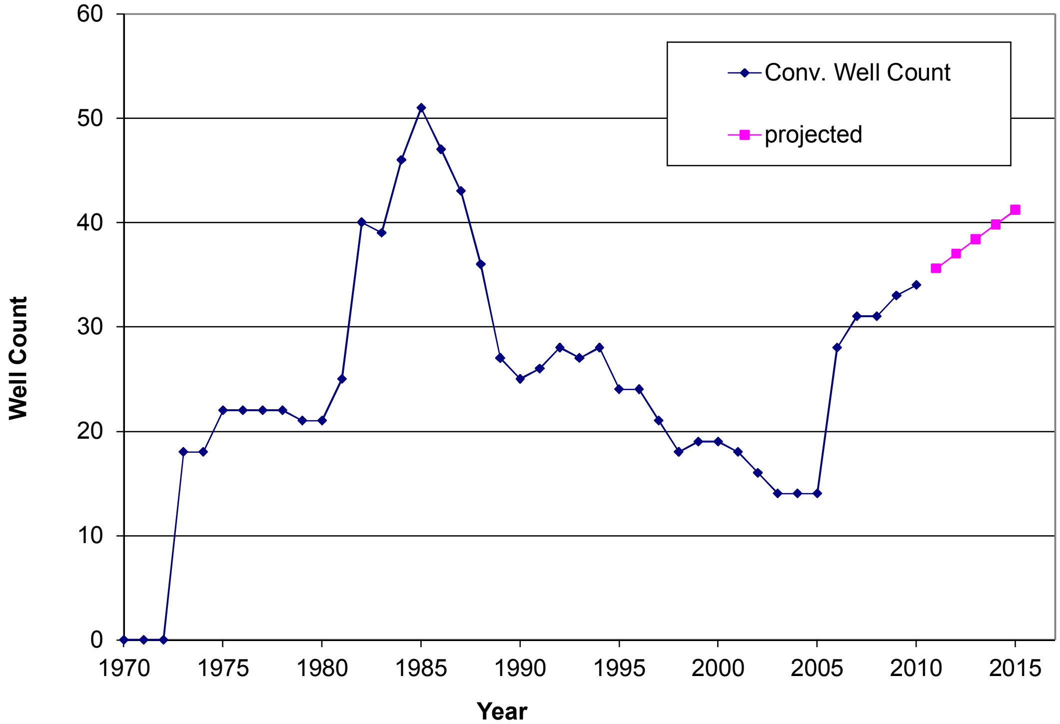

Figure 12. Total well count historical data (from the IHS database) for Other Counties in the Williston Basin and projections to 2015.[11]

Total well counts in the "Other Counties" grouping have generally increased in the period 2005-2010. Total well counts were linearly extrapolated to 2015 based on historical data in the period 2006-2010.

Spud Counts

Spud counts in the "Other Counties" grouping in the Williston Basin have been plotted for the years 1970 – 2010 below in Figure 13, including projections to 2015.

[11] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

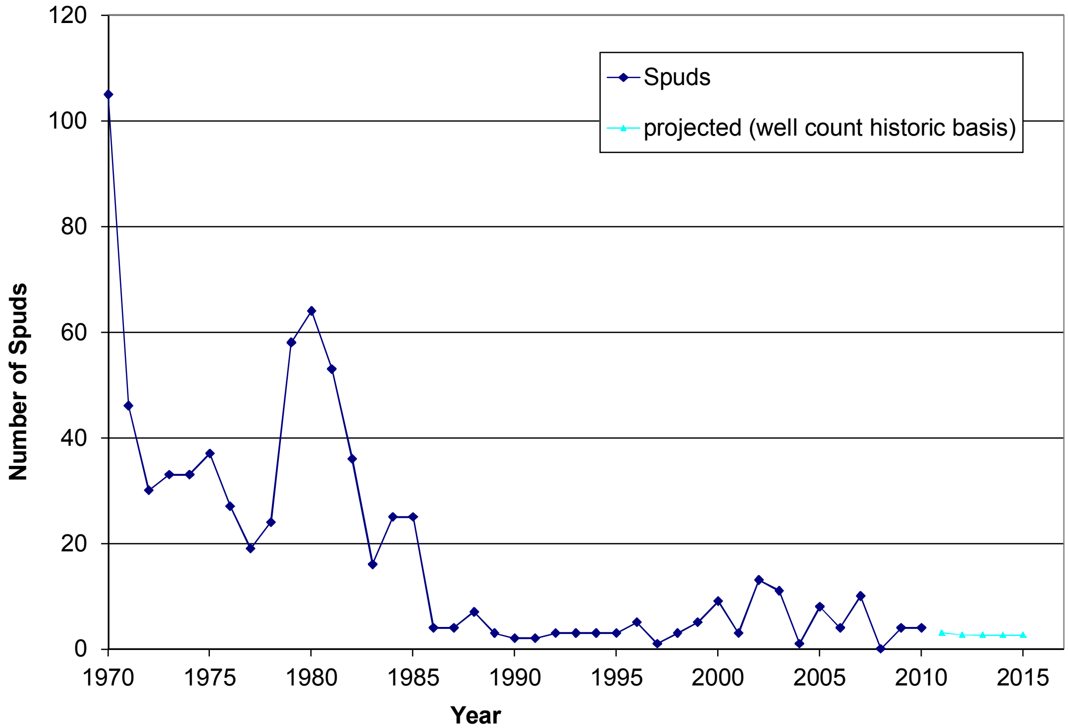

Figure 13. Spud count historical data (from the IHS database) for Other Counties in the Williston Basin and projections to 2015. [12]

Historic spud counts in the "Other Counties" grouping, as obtained from the IHS database for the period 1970-2010 are erratic, making an extrapolation from historical data infeasible. The change in the number of active wells each year in the period 2006-2010 was compared to the number of spuds that occurred in that same period, and determined the number of spuds required to match the increase or decrease in well counts for each year in that period. An average total spud count needed to maintain the observed number of active wells in the period 2006-2010 was developed, with a value of 2.7 spuds per year. The annual number of spuds estimated using this methodology was held constant for the period 2012-2015.

Total Gas Production

Total gas production in the "Other Counties" grouping in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 14, including projections to 2015.

[12] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

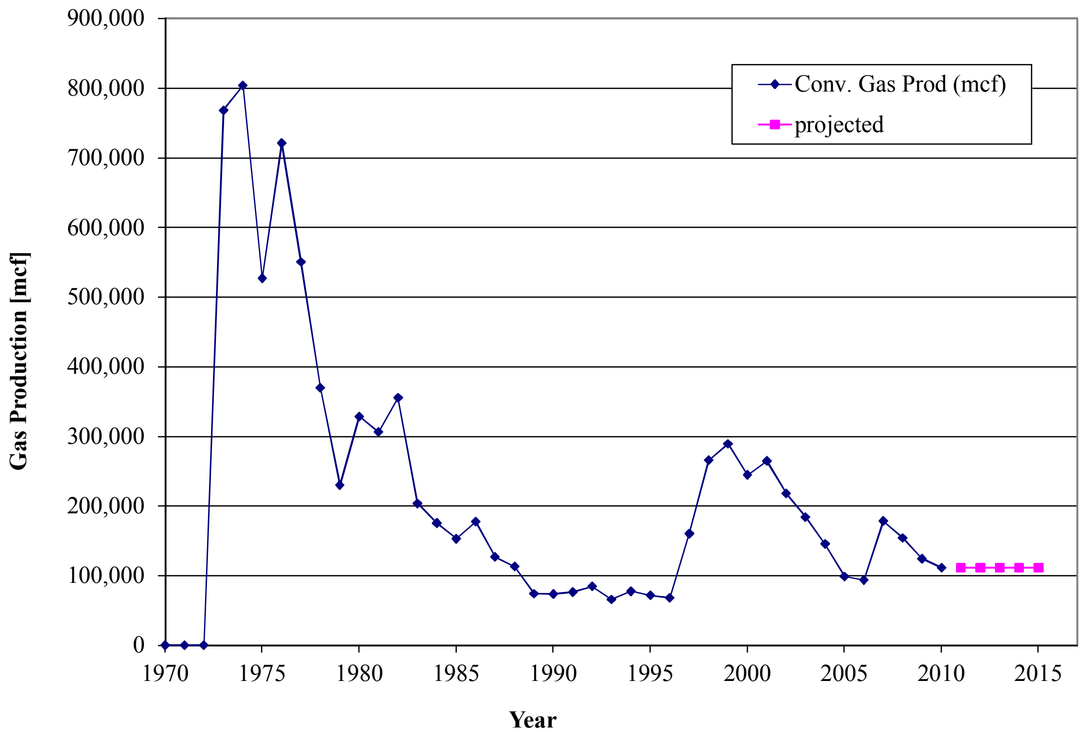

Figure 14. Total gas production historical data (from the IHS database) for Other Counties in the Williston Basin and projections to 2015.[13]

Total gas production in the "Other Counties" grouping has been generally in decline from a peak in the early 1970's, although gas production levels in this grouping are minimal compared to the other geographic groupings in the Williston Basin. This analysis conservatively assumed that total gas production would remain at 2010 levels through the period 2011-2015.

Oil Well Oil Production

Oil well oil production in the "Other Counties" grouping in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 15, including projections to 2015.

[13] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

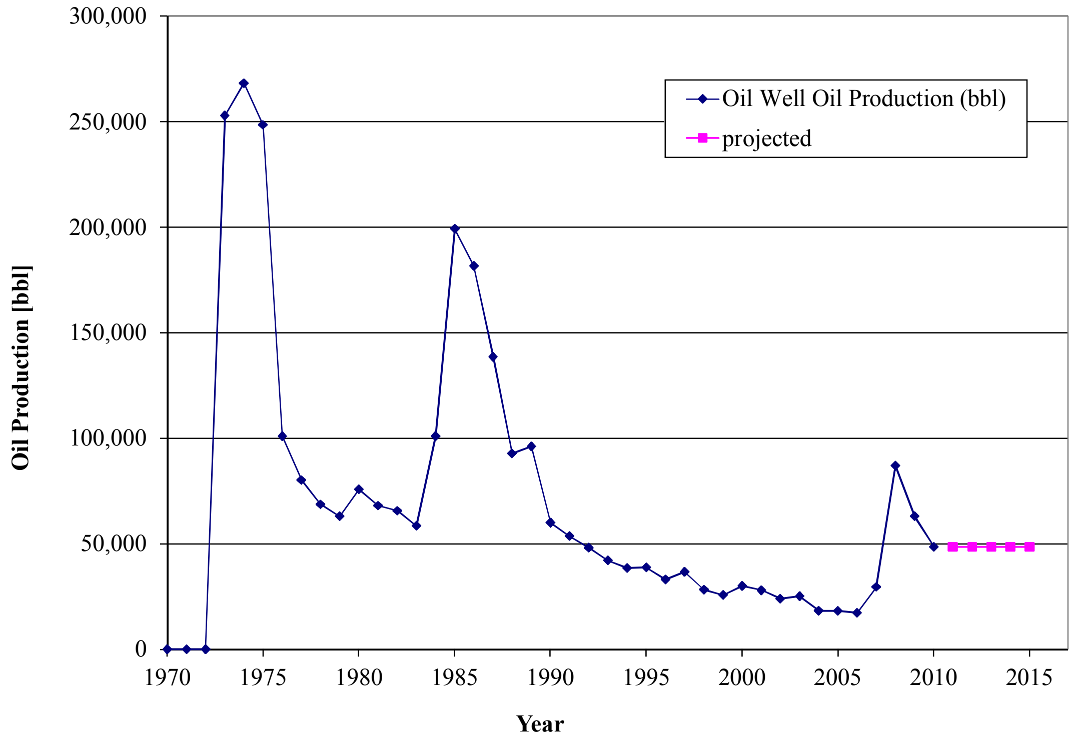

Figure 15. Oil production historical data (from the IHS database) for Other Counties in the Williston Basin and projections to 2015. [14]

Oil production in the "Other Counties" grouping has been generally decreasing since a peak in the mid-1970's. This analysis conservatively assumed that oil production would remain at 2010 levels through the period 2011-2015.

Condensate Production

Condensate production in the "Other Counties" grouping in the Williston Basin has been plotted for the years 1970 – 2010 below in Figure 16, including projections to 2015.

[14] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

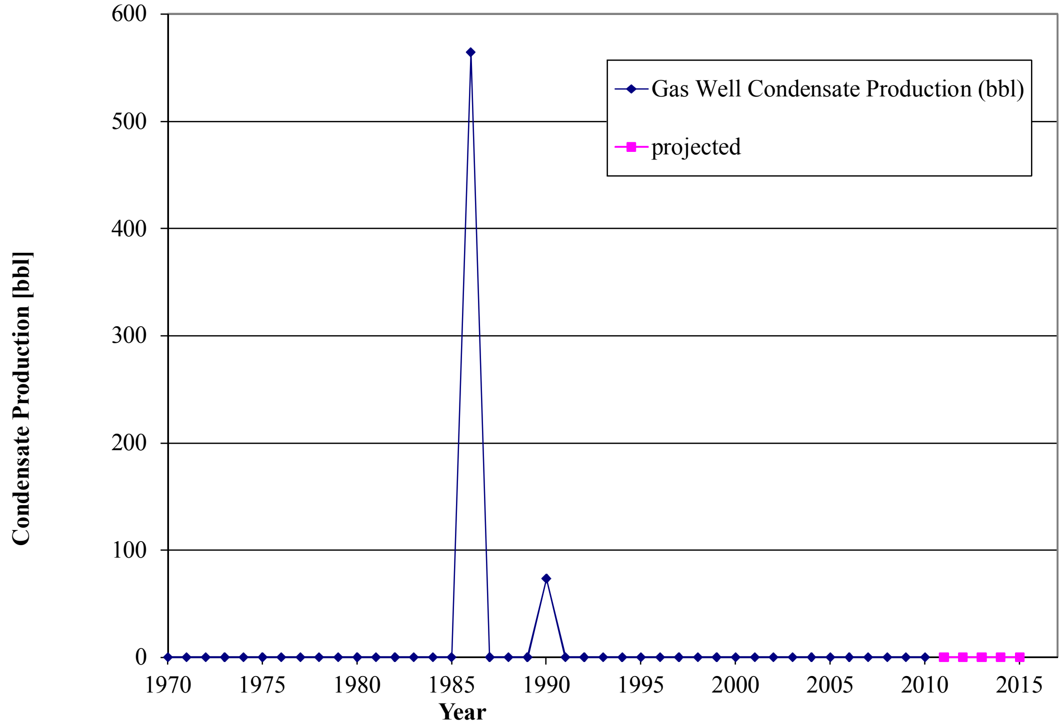

Figure 16. Condensate production historical data (from the IHS database) for Other Counties in the Williston Basin and projections to 2015. [15]

There has been negligible condensate production in the "Other Counties" grouping in the Williston Basin throughout the historical period from 1970-2010. It was assumed that there would be no condensate production in 2015 in this geographical grouping.

[15] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2011) all rights reserved).

SCALING FACTOR DEVELOPMENT AND UNCONTROLLED 2015 EMISSIONS

Scaling factors were generated for the Williston Basin geographic groupings described above, for each parameter considered here: total well counts, spud counts, total gas production, oil well oil production, and condensate production. Total gas processed and casinghead gas flared are not projected in a similar methodology to the other parameters, as described above. These are presented for each county below, and it is noted that all geographic groupings are comprised of more than one county in which the scaling factors for each parameter are identical for all counties in the grouping. The ratio of the value of each of these parameters in 2015 to their values in 2009 is the scaling factor for that parameter for purposes of this projection. This is shown in Equation 1 below:

$$f_{i,j} = W_{i,j,2015} / W_{i,j,2009} \qquad \text{Equation (1)}$$

where:

$f_{i,j}$ is the scaling factor for geographic grouping *j* in the Williston Basin for parameter *i* (total well count, spud count, total gas production, oil well oil production, and condensate production)

$W_{i,j,2006}$ is the value of parameter *i* in geographic grouping *j* in 2009

$W_{i,j,2012}$ is the projected value of parameter *i* in geographic grouping *j* in 2015

The scaling factor based on the appropriate parameter is selected for each source category as described in Table 1. The scaling factors for the eight parameters used in this analysis for each county in the Williston Basin are presented in Table 2 below.

Table 2. Scaling factors for five parameters used in the projection analysis for all counties in the Williston Basin.

County	Total Well Count	Spud Count	Total Gas Production	Oil Production	Condensate Production
Carter (MT)	1.25	0.67	0.90	0.77	1.00
Custer (MT)	1.25	0.67	0.90	0.77	1.00
Daniels (MT)	2.30	4.30	5.51	5.46	1.04
Dawson (MT)	1.14	1.53	0.86	0.85	2.46
Fallon (MT)	1.14	1.53	0.86	0.85	2.46
Garfield (MT)	1.25	0.67	0.90	0.77	1.00
McCone (MT)	2.30	4.30	5.51	5.46	1.04
Prairie (MT)	1.14	1.53	0.86	0.85	2.46
Richland (MT)	2.30	4.30	5.51	5.46	1.04
Roosevelt (MT)	2.30	4.30	5.51	5.46	1.04
Sheridan (MT)	2.30	4.30	5.51	5.46	1.04
Valley (MT)	2.30	4.30	5.51	5.46	1.04
Wibaux (MT)	1.14	1.53	0.86	0.85	2.46
Barnes (ND)	1.25	0.67	0.90	0.77	1.00
Billings (ND)	2.30	4.30	5.51	5.46	1.04
Bottineau (ND)	2.30	4.30	5.51	5.46	1.04
Bowman (ND)	1.14	1.53	0.86	0.85	2.46
Burke (ND)	2.30	4.30	5.51	5.46	1.04

County	Total Well Count	Spud Count	Total Gas Production	Oil Production	Condensate Production
Burleigh (ND)	1.25	0.67	0.90	0.77	1.00
Divide (ND)	2.30	4.30	5.51	5.46	1.04
Dunn (ND)	2.30	4.30	5.51	5.46	1.04
Golden Valley (ND)	2.30	4.30	5.51	5.46	1.04
McHenry (ND)	2.30	4.30	5.51	5.46	1.04
McIntosh (ND)	1.25	0.67	0.90	0.77	1.00
McKenzie (ND)	2.30	4.30	5.51	5.46	1.04
McLean (ND)	2.30	4.30	5.51	5.46	1.04
Mercer (ND)	2.30	4.30	5.51	5.46	1.04
Morton (ND)	2.30	4.30	5.51	5.46	1.04
Mountrail (ND)	2.30	4.30	5.51	5.46	1.04
Renville (ND)	2.30	4.30	5.51	5.46	1.04
Slope (ND)	1.14	1.53	0.86	0.85	2.46
Stark (ND)	2.30	4.30	5.51	5.46	1.04
Stutsman (ND)	1.25	0.67	0.90	0.77	1.00
Ward (ND)	2.30	4.30	5.51	5.46	1.04
Williams (ND)	2.30	4.30	5.51	5.46	1.04
Butte (SD)	1.25	0.67	0.90	0.77	1.00
Harding (SD)	1.14	1.53	0.86	0.85	2.46

CONTROLLED 2015 EMISSIONS

This methodology considered any "on-the-books" federal or state regulations that would affect the uncontrolled 2015 emissions projections described above. Table 3 below lists the "on-the-books" federal and state regulations that affect emissions source categories in the oil and gas industry, and the action taken to adjust the 2015 emissions inventory appropriately. A more detailed description follows of the methodology used to address each of these regulations as they affected the uncontrolled 2015 Williston Basin emissions projections. The uncontrolled 2015 emissions were adjusted based on the proposed actions or control factors developed for each regulation described in Table 3 to account for how these regulations may affect any oil and gas source category considered in this inventory.

Table 3. Summary of federal and state "on-the-books" regulations affecting the oil and gas source categories considered in this inventory.

Source Category	Regulation	Enforcing Agency	Effective Date	Implementation in the 2012 Powder River Basin Emissions Projections
Federal				
Drill Rigs, Workover Rigs	Nonroad engine Tier standards (1-4) (EPA, 2005)	US EPA	Phase in from 1996 - 2014	EPA NONROAD model used to create county-level control factors for the drill rig SCC to account for fleet turnover.
Drill Rigs, Workover Rigs	Nonroad diesel fuel sulfur standards (EPA, 2006)	US EPA	Phase in beginning in 2010	Assume 15 ppm sulfur in nonroad diesel fuel throughout Powder River Basin. Control factors derived from EPA NONROAD model (see above).
All New Spark-Ignited Stationary Engines	New Source Performance Stds. (NSPS) (EPA, 2008; EPA, 2012)	US EPA	Phase in from 2008 - 2011	Control factors developed considering the specific composition of engines in the inventory (described in more detail below). Insufficient information to determine the mix of wet/dry seals on compressors therefore no additional control factor applied due to Subpart OOOO requirements.
Pneumatic Controllers	New Source Performance Stds. Subpart OOOO (NSPS) (EPA, 2012)	US EPA	Beginning Sep. 2011	Assume all new pneumatic controllers after September 2011 are low-bleed devices.
Condensate and Crude Oil Tanks	New Source Performance Stds. Subpart OOOO (NSPS) (EPA, 2012)	US EPA	Oct. 15, 2013	Control factors developed for tanks by region (described in more detail below)
Gas Well Completions	New Source Performance Stds. Subpart OOOO (NSPS) (EPA, 2012)	US EPA	Oct. 2012 (low pressure) / Jan. 2015 (all other)	Insufficient information to estimate the impact of this regulation requiring reduced emission completions
Dehydrators	New Source Performance Stds. Subpart HH (NSPS) (EPA, 2012)	US EPA	Phase in from Oct. 2012-Oct. 2015	All dehydration assumed controlled in the baseline 2009 inventory based on limited survey data, therefore no additional effect of this regulation.
Gas Processing Plants	New Source Performance Stds. Subpart OOOO (NSPS) (EPA, 2012)	US EPA	Oct. 2013	Not enough information on detailed emissions at gas processing facilities; conservatively assumed that there would be no effect of this regulation on the 2015 inventory.
Minor Source Reporting Requirements on Indian Tribal Land	New Source Performance Stds. Subpart OOOO (NSPS) (EPA, 2012)	US EPA	Phase-In Beginning Aug. 2011	No information was available from the minor source reporting regulation.

Source Category	Regulation	Enforcing Agency	Effective Date	Implementation in the 2012 Powder River Basin Emissions Projections
State – Montana				
Well Completions	MT ARM 36.22.1221 Completion venting controls.	MTDEQ	1984	Not enough information was available in producer data; conservatively assume that there would be no effect of this regulation on the 2015 inventory.
Condensate and Crude Oil Tanks	MT ARM 17.8.1603(1)(b) VOC vapors from oil or condensate storage tanks with a PTE > 15 tpy must be controlled	MTDEQ	Jan 2006	Control factors developed for tanks by region (described in more detail below)
All VOC sources	MT ARM 17.8.1711(1)(a) VOC vapors from each piece of O&G well facility equipment with PTE >15 tpy, must be controlled	MTDEQ	Apr 2006	Not enough information to make a 2015 specific analysis. Assumed that rates of control in 2015 are similar to rates of control in 2009 for VOC sources not controlled per other regulations.
	MT ARM 17.8.1603(1)(a) VOC vapors must be captured and routed to a gas pipeline if within ½ mile to control device.	MTDEQ	Jan 2006	
	MT ARM 17.8.752 case by case BACT determination	MTDEQ	Dec 2002	
	MT ARM 17.8.1711(1)(a) VOC vapors from each piece of O&G well facility equipment, with a PTE > 15 tpy, must be controlled	MTDEQ	Apr 2006	
Truck loading	MT ARM 17.8.1711(1)(b) Submerged filling on all hydrocarbon liquid loading or unloading	MTDEQ	Apr 2006	Assumed submerged filling for all tank loading.
State – North Dakota				
Condensate and Crude Oil Tanks	NDAC 33-15-07 and Bakken Pool O&G Control Permitting & Compliance Guidance Flaring controls for tanks	NDDOH	2011	Control factors developed for tanks by region (described in more detail below)
Tank loading	NDAC 33-15-07 Submerged filling requirements for tanks > 1000gal	NDDOH	Initial 2009 Baseline and All Projection Years	Assumed submerged filling for all tank loading.

Nonroad Diesel Engine Standards and Fuel Sulfur Standards

The EPA NONROAD2005 model was run with fuel inputs based on a 2002 study entitled "WRAP Mobile Sources Emission Inventory Update" (Pollack, et al., 2006). The model outputs were used to develop county-level emissions per unit population for "other oil field equipment" (SCC 2270010010) for the calendar year 2006, and then separately for the calendar year 2012. These emissions per unit population reflect the predicted fleet mix of engines – for various tier standards from baseline uncontrolled engines through Tier IV engines – and are used as a representation of fleet turnover for drilling rigs and workover rigs. The ratios of the per unit emissions in 2012 to those in 2006 for each county of interest were taken to be the control factors accounting for federal non-road tier standards.

In addition, the NONROAD model runs with the fuel inputs used for developing the tier standards control factors were also used to develop the control factors for SOx emissions factors for drilling rigs and workover rigs. The model is capable of tracking the expected reduction in fuel sulfur content from the baseline 2006 year – assumed to be the same as the WRAP 2002 inventory – and the 2012 future year. A similar approach was used as for the federal tier standards to develop control factors. The ratio of per unit SOx emissions in 2012 to those in 2006 were taken to be a control factor to apply to uncontrolled 2012 SOx emissions for drilling rigs and workover rigs to account for federal non-road diesel fuel standards.

New Source Performance Standards for Stationary Spark-Ignited Engines

An analysis was undertaken to implement the US EPA NSPS. In previous basin analyses of NSPS application (Bar-Ilan, et al., 2009a; Bar-Ilan, et al., 2009b; Bar-Ilan, et al., 2009c; Bar-Ilan, et al., 2008), it was assumed that a flat or declining gas production projection would indicate no need for additional horsepower of compression. This was coupled with the assumption that there would be negligible turnover of engines during the period of the projections to conclude that NSPS did not need to be applied if gas production was declining in any geographic grouping. Where gas production is projected to increase – most notably in the Bakken Formation Counties, NSPS requirements were applied, similar to the assumptions made in developing projected emissions for other basins.

NSPS Regulations

The EPA has promulgated a new regulation covering new stationary, spark-ignited engines of various horsepower classes. The regulation is assumed to apply to central compressor engines, wellhead and lateral compressor engines, and artificial lift engines as well as any other miscellaneous engines that are stationary, spark-ignited natural gas engines. The regulation requires new engines of various horsepower classes to meet increasingly stringent NOx and VOC emission standards over the phase-in period of the regulation.

For engines less than 25 horsepower, Table 4 shows the requirements of the NSPS regulation.

Table 4. Federal NSPS emissions standards for engines less than 25 horsepower.

HP Range[a]	Emissions Standards Requirement in (g/hp-hr)[b]		
	HC + NOx	**NMHC + NOx[c]**	**CO**
≤ 25 Hp			
Class I	16.1 (12.0)	14.8 (11.0)	610 (455)
Class I -A	50-37	-	-
Class I -B	40 (30)	37 (27.6)	
Class II	12.1 (9.0)	11.3 (8.4)	

[a] Class I-A: Engines with displacement less than 66 cubic centimeters (cc); Class 1-B: Engines with displacement greater than or equal to 66cc and less than 100cc; Class I: Engines with displacement greater than or equal to 100 cc and less than 225 cc

[b] Modified and reconstructed engines manufactured prior to July 1, 2008, must meet the standards applicable to engines manufactured after July 1, 2008

[c] NMHC+NOX standards are applicable only to natural gas fueled engines at the option of the manufacturer, in lieu of HC+NOX standards

For engines in the horsepower range 25 – 100 horsepower, Table 5 shows the requirements of the NSPS regulation.

Table 5. Federal NSPS emissions standards for engines greater than 25 horsepower but less than 100 horsepower.

HP Range	Manufacture Date	Emissions Standards Requirement (g/hp-hr)	
		HC + NOx	CO
25<HP<100	1-Jul-08	3.8	6.5
	1-Jul-08 (severe duty)	3.8	200

For engines in the horsepower range 100 – 1,350 horsepower, Table 6 shows the requirements of the NSPS regulation.

Table 6. Federal NSPS emissions standards for engines greater than 25 horsepower but less than 100 horsepower.

Engine Type and Fuel	HP Range	Manufacture Date	Emissions Standards Requirement (g/hp-hr)		
			NOx	CO	VOC
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG	100≤HP<500	1-Jul-08	2	4	1
		1-Jan-11	1	2	1
Non-Emergency SI Lean Burn Natural Gas and LPG	500≥HP<1350	1-Jan-08	2	4	1
		1-Jul-10	1	2	1
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG (except lean burn 500≥HP<1350)	HP≥500	1-Jul-07	2	4	1

A detailed analysis was carried forward to analyze the effects of this rule on the permitted and survey-based wellhead engine fleet in the Williston Basin. Engines were sorted into bins representing horsepower ranges based on the available compressor engine data gathered as part of the baseline 2009 inventory development. Because the NSPS requirements change over the phase-in period of the regulation, the growth of compression horsepower was tracked for each year in the period 2009-2015. For each year, the additional compression horsepower was sorted into the horsepower range bins, and NSPS was applied to these engines.

New Source Performance Standards for Pneumatic Devices

Following the requirements of the NSPS Subpart OOOO, it was assumed that all new pneumatic devices installed after September 2011 would be low-bleed. This analysis assumed new pneumatic device installation tracked the increase in well counts in each geographic grouping.

New Source Performance Standards and Montana Regulations for Well Completions

Both the NSPS Subpart OOOO and Montana ARM 36.22.1221 require controls on well completions in the form of either reduced emission completions (NSPS Subpart OOOO) or combustion controls on vented gas during completions. However insufficient information was available from the baseline 2009 survey data to accurately characterize the uncontrolled fraction of well completions or the uncontrolled VOC emissions from these completions, therefore it was not possible to implement these regulations in the 2015 midterm projections for the Williston Basin.

New Source Performance Standards and Montana and North Dakota Regulations for Crude Oil and Condensate Tanks

Crude oil tanks in the Bakken Formation represent one of the largest VOC sources in the 2015 midterm projected inventory for the Williston Basin, and thus special consideration was given to this source category based on the regulatory requirements of the NSPS, and Montana and North Dakota state regulations. The regulations and control assumptions for oil tanks were considered separately for four geographic areas: (1) North Dakota non-tribal land; (2) Fort Berthold Indian Reservation (tribal land in North Dakota); (3) Montana non-tribal land; and (4) Montana tribal land (primarily the Fort Peck Indian Reservation). These are summarized in Table 7 below.

Table 7. Crude oil tank controls assumptions in the 2015 Williston Basin midterm emissions.

Geographic Area	Controls Assumptions
North Dakota Non-Tribal Land	Per NDDOH regulations, any well site with >20tpy uncontrolled emissions requires control at 98% destruction efficiency (DRE); <20tpy requires 90% DRE. Analysis conducted to determine fraction of sites with greater or less than 20tpy uncontrolled emissions: 84% would require 98% DRE, 16% would require 90% DRE, assumed average of 97% DRE at all tanks.
North Dakota Tribal Land	Based on limited survey data and information from industry participants, practices on the Fort Berthold Indian Reservation were assumed similar to those on non-tribal land. Federal Implementation Plan (FIP) and interim final rule (IFR) for the Fort Berthold reservation confirm these assumptions are reasonable.
Montana Non-Tribal Land	For production added through August 2013: Per MTDEQ regulation, any well site with >15tpy uncontrolled emissions requires control at 90% DRE. Analysis conducted to determine fraction of sites with greater or less than 15tpy uncontrolled emissions; derived average control of 94% of production at 90% DRE.
	For production added after August 2013: Subpart OOOO was assumed to apply, with a 99% rule penetration (based on fraction of sites meeting thresholds) and a 95% DRE
Montana Tribal Land	For production added through August 2013: Assumed flaring rate based on 2009 baseline survey data at a 90% DRE.
	For production added after August 2013: Subpart OOOO was assumed to apply, with a 99% rule penetration (based on fraction of sites meeting thresholds) and a 95% DRE

It should be noted that these assumptions utilized survey data provided by operators as part of the 2009 baseline inventory. Although this survey data was limited, this was the only data available for some geographic areas.

SUMMARY RESULTS

The scaling factors were applied to the baseline 2009 inventory, and "on-the-books" regulations were applied to the uncontrolled 2015 emissions projections to generate the final 2015 emissions projections and results are presented below. It should be noted that all figures showing county-level emissions only include those counties representing 1% or greater of the total emissions in the basin.

Figure 17 and Table 8 show that NOx emissions are primarily concentrated in Mountrail, Williams, McKenzie and Dunn Counties in North Dakota and Richland County in Montana, representing approximately 69% of total basin-wide NOx emissions. Additional significant NOx emissions occur in Fallon County Montana and Billings County North Dakota. Figure 18 and Table 8 show that VOC emissions are primarily concentrated in Mountrail, McKenzie, Bowman, Dunn and Williams Counties in North Dakota and Richland County in Montana, representing approximately 72% of total basin-wide VOC emissions Additional VOC emissions are observed in Billings County North Dakota and Fallon County Montana. Given the large volume of produced oil and associated gas in the Williston Basin, VOC emissions are driven by the presence of oil production and associated gas production in these counties.

Consistent with the 2009 baseline emissions analysis, compressor engines, drilling rigs and artificial lift engines remain the dominant NOx source categories in the Williston Basin, representing approximately 75% of total basin-wide NOx emissions as shown in Table 9. It is noted that drilling emissions decline over time as expected from turnover of equipment to newer engines meeting more stringent emissions standards. Therefore drilling represents a smaller fraction of basin-wide NOx in 2015 than in 2009.

VOC emissions in the 2009 baseline inventory are dominated by oil tanks; but in the 2015 midterm projected inventory VOC emissions are comprised of a number of source categories including oil tanks, casinghead gas venting and flaring, and pneumatic devices and pneumatic pumps as shown in Table 10, representing approximately 75% of basin-wide VOC emissions. Oil tank flashing VOC emissions are still projected to be the largest source category, but represent a significantly smaller fraction of the total basin-wide VOC emissions in 2015 than in 2009 as a result of increasing control of these emissions through the use of flares. Venting of casinghead gas is observed to increase significantly from 2009 to 2015, driven by the large growth in associated gas production despite increasing gas gathering and processing infrastructure. Venting from pneumatic devices and pneumatic pumps is observed to increase as a percentage of total basin-wide VOC emissions in 2015 relative to 2009, driven mainly by the large increase in the number of new wells projected to be added to the basin. It should be noted that the VOC emissions are very sensitive to the selection of a "fraction of gas processed" factor, which is based on a limited set of available data on gas gathering infrastructure development. Additional information on the development of gas gathering infrastructure would help to improve this estimate.

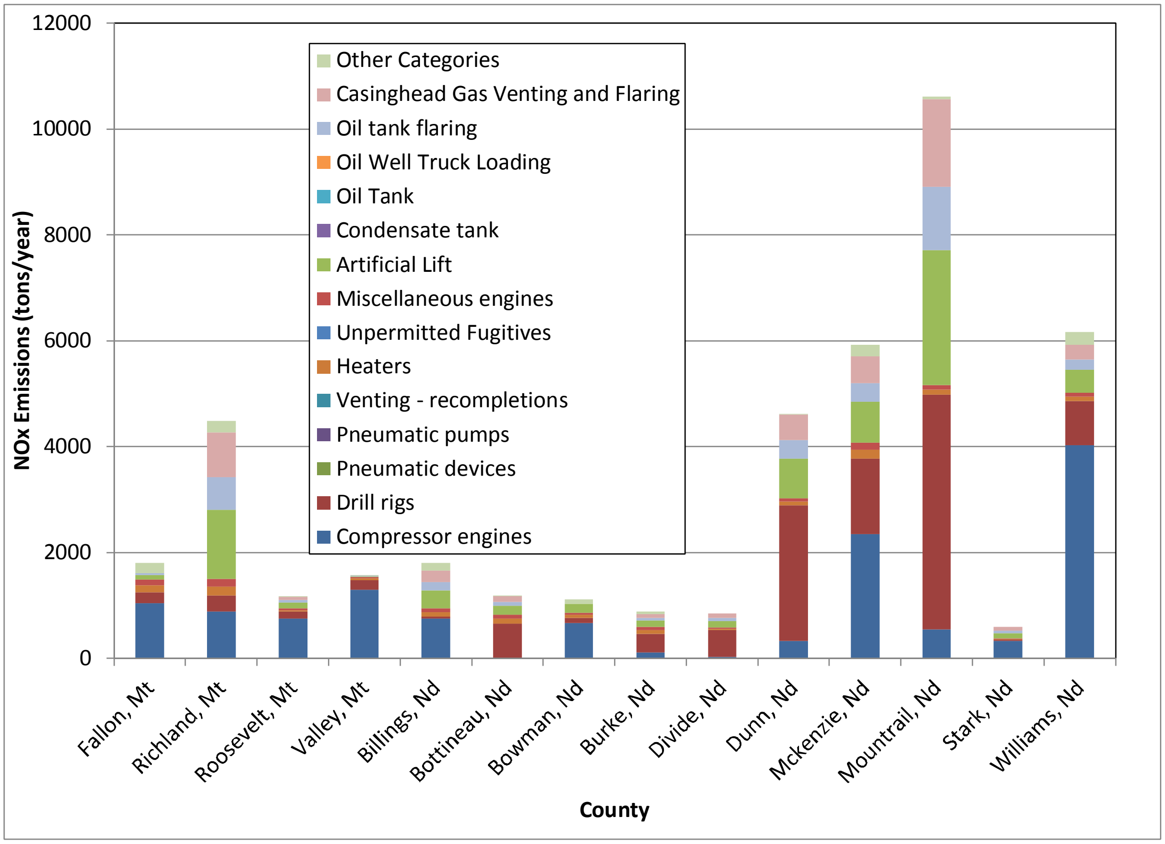

Figure 17. 2015 NOx emissions by source category and by county in the Williston Basin.

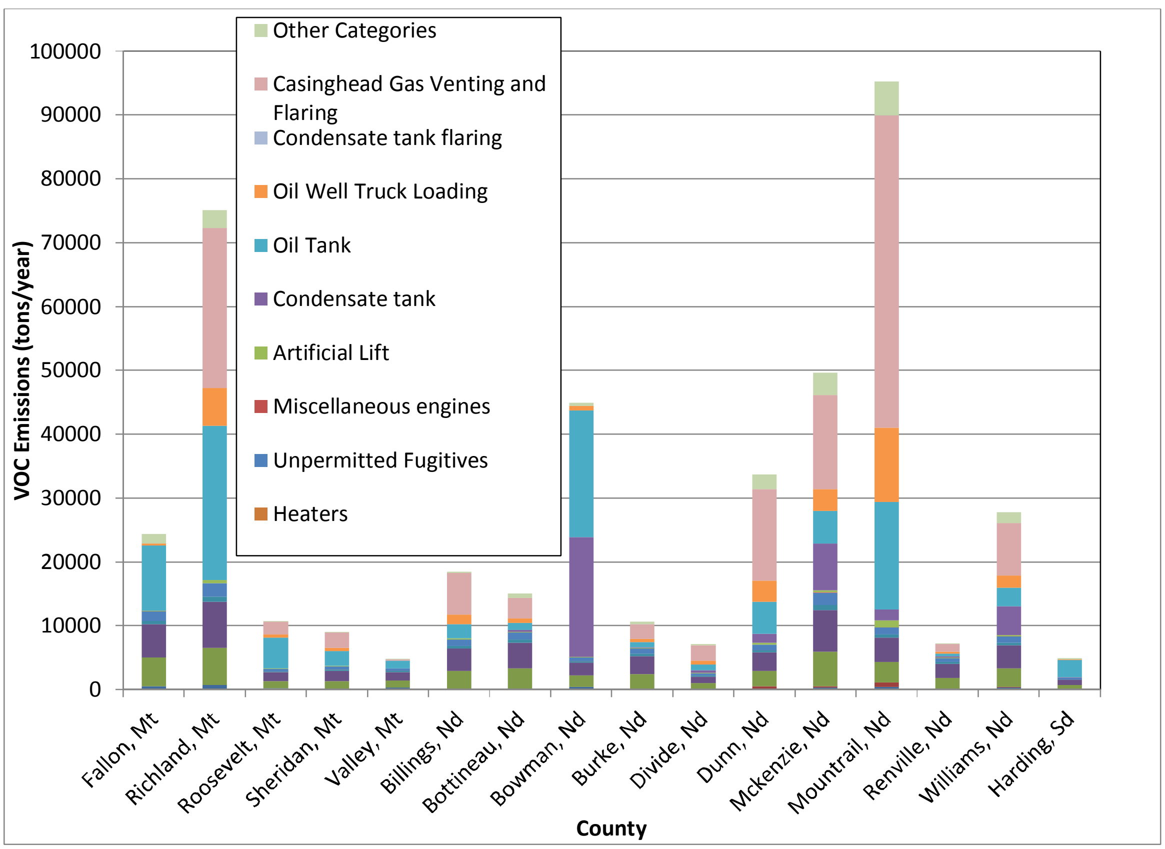

Figure 18. 2015 VOC emissions by source category and by county in the Williston Basin.

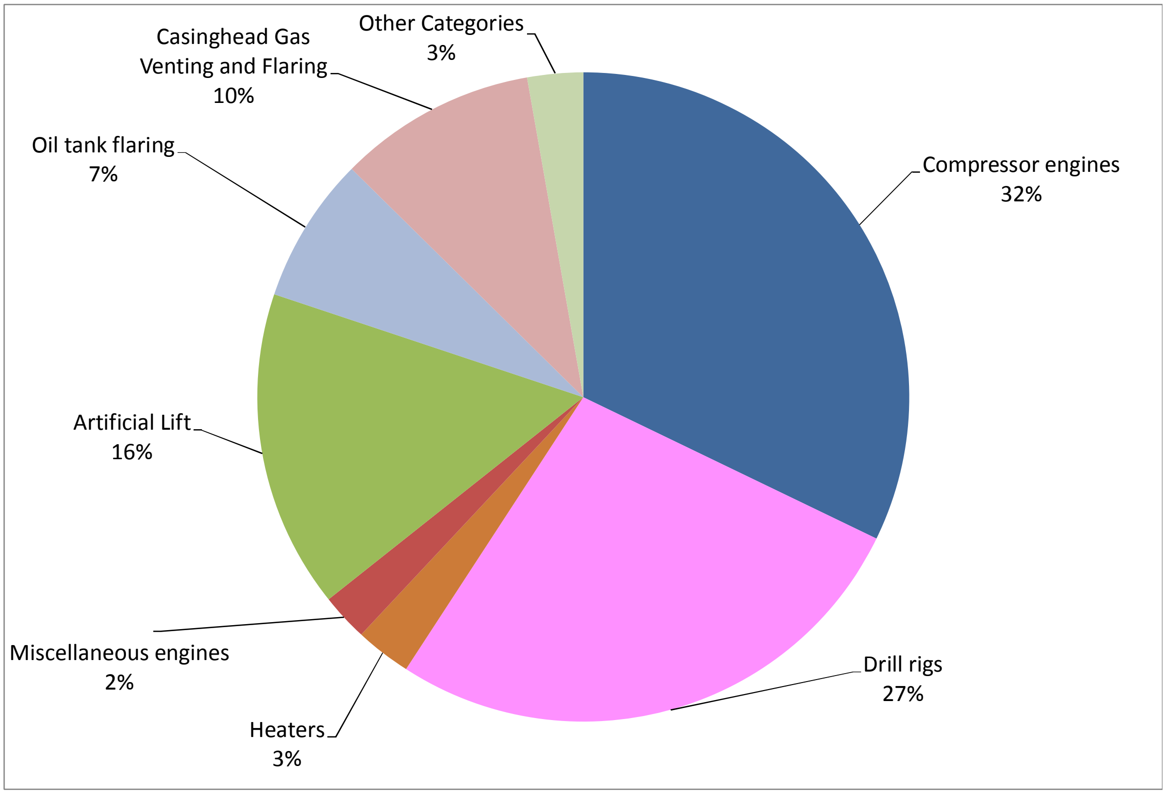

Figure 19. 2015 NOx emissions contributions by source category in the Williston Basin.

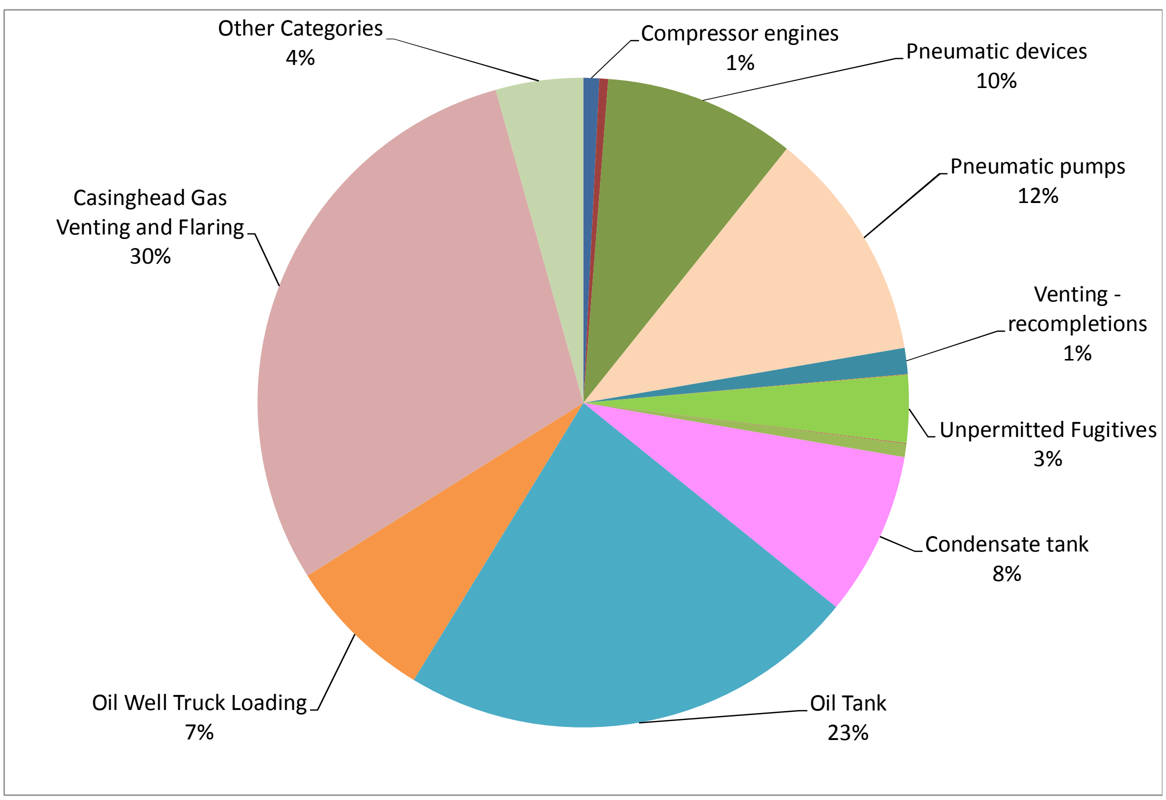

Figure 20. 2015 VOC emissions contributions by source category in the Williston Basin.

Table 8. 2015 emissions of all criteria pollutants by county for the Williston Basin.

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
Carter (MT)	79	178	129	0	1
Custer (MT)	120	28	104	0	3
Daniels (MT)	2	112	4	0	0
Dawson (MT)	99	1,383	108	0	8
Fallon (MT)	1,798	24,357	2,943	45	97
Garfield (MT)	5	112	6	0	0
McCone (MT)	121	187	65	0	2
Prairie (MT)	4	238	4	0	0
Richland (MT)	4,488	75,047	10,633	15	208
Roosevelt (MT)	1,174	10,743	1,524	112	88
Sheridan (MT)	441	9,004	1,009	0	28
Valley (MT)	1,573	4,813	1,494	30	73
Wibaux (MT)	37	2,218	36	0	2
Barnes (ND)	316	6	24	10	20
Billings (ND)	1,808	18,505	3,388	1,216	51
Bottineau (ND)	1,189	15,018	1,908	1	105
Bowman (ND)	1,111	44,884	1,499	1	43
Burke (ND)	889	10,601	1,433	191	65
Burleigh (ND)	63	17	60	0	0
Divide (ND)	853	7,147	1,456	0	74
Dunn (ND)	4,615	33,667	8,113	11	385
Golden Valley (ND)	187	2,560	411	0	11
McHenry (ND)	365	382	38	10	20
McIntosh (ND)	134	17	134	7	10
McKenzie (ND)	5,919	49,616	9,035	1,552	274
McLean (ND)	196	635	238	0	22
Mercer (ND)	56	32	55	0	7
Morton (ND)	386	77	444	21	21
Mountrail (ND)	10,611	95,234	22,775	1	701
Renville (ND)	337	7,221	620	0	23
Slope (ND)	36	2,721	49	0	3
Stark (ND)	597	4,478	880	0	10
Stutsman (ND)	28	10	42	0	0
Ward (ND)	128	507	149	0	15
Williams (ND)	6,161	27,813	5,476	3,822	210
Butte (SD)	12	2	11	0	1
Harding (SD)	176	4,874	186	0	15
TOTAL	**46,114**	**454,443**	**76,480**	**7,046**	**2,596**
Daniels, (MT) (Tribal)	2	94	3	0	0
Roosevelt, (MT) (Tribal)	342	5,259	606	89	41
Sheridan, (MT) (Tribal)	2	143	6	0	0
Valley, MT (Tribal)	54	2,075	95	0	4
Dunn, ND (Tribal)	667	2,829	951	0	70
McKenzie, ND (Tribal)	112	876	168	0	11
McLean, ND (Tribal)	196	635	238	0	22
Mountrail, ND (Tribal)	2,345	17,868	4,541	0	187
TOTAL (Tribal)	**3,720**	**29,779**	**6,609**	**90**	**335**
Daniels, (MT) (Non-Tribal)	0	17	0	0	0
Roosevelt, (MT) (Non-Tribal)	832	5,484	919	23	47
Sheridan, (MT) (Non-Tribal)	438	8,861	1,003	0	28
Valley, MT (Non-Tribal)	1,519	2,738	1,399	30	69
Dunn, ND (Non-Tribal)	3,948	30,838	7,163	11	315
McKenzie, ND	5,807	48,740	8,866	1,552	264

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
(Non-Tribal)					
McLean, ND (Non-Tribal)	0	0	0	0	0
Mountrail, ND (Non-Tribal)	8,266	77,367	18,233	1	514

Table 9. 2015 NOx emissions by county and by source category for the Williston Basin.

County	Compressor Engines	Drill Rigs	Heaters	Miscellaneous Engines	Artificial Lift Engines	Oil Tank Flaring	Casinghead Gas Flaring	Other Categories	Totals
Carter (MT)	75	0	2	2	1	0	0	0	79
Custer (MT)	119	0	0	0	0	0	0	0	120
Daniels (MT)	0	0	1	0	0	0	0	0	2
Dawson (MT)	55	20	6	5	5	2	0	6	99
Fallon (MT)	1,046	204	129	109	82	38	0	190	1,798
Garfield (MT)	2	0	1	1	0	0	0	0	5
McCone (MT)	117	0	1	1	1	0	0	0	121
Prairie (MT)	0	0	1	1	1	0	0	0	4
Richland (MT)	887	297	174	147	1,307	612	846	218	4,488
Roosevelt (MT)	750	130	33	28	107	50	69	6	1,174
Sheridan (MT)	12	93	39	33	122	57	79	6	441
Valley (MT)	1,298	186	33	28	9	4	6	9	1,573
Wibaux (MT)	1	0	11	9	9	4	0	1	37
Barnes (ND)	316	0	0	0	0	0	0	0	316
Billings (ND)	752	37	85	72	335	157	217	154	1,808
Bottineau (ND)	1	649	97	82	164	77	106	12	1,189
Bowman (ND)	672	99	51	43	160	10	0	77	1,111
Burke (ND)	114	353	69	59	116	55	75	48	889
Burleigh (ND)	63	0	0	0	0	0	0	0	63
Divide (ND)	29	501	26	22	128	60	83	4	853
Dunn (ND)	331	2,560	71	60	747	350	484	12	4,615
Golden Valley (ND)	9	56	12	10	47	22	31	2	187
McHenry (ND)	353	0	3	3	3	1	2	0	365
McIntosh (ND)	134	0	0	0	0	0	0	0	134
McKenzie (ND)	2,350	1,429	161	136	768	360	498	218	5,919
McLean (ND)	1	167	3	3	10	5	7	0	196
Mercer (ND)	0	56	0	0	0	0	0	0	56
Morton (ND)	386	0	0	0	0	0	0	0	386
Mountrail (ND)	549	4,434	94	80	2,553	1,196	1,653	52	10,611
Renville (ND)	1	93	54	46	65	30	42	7	337
Slope (ND)	5	20	2	2	5	0	0	3	36
Stark (ND)	333	19	13	11	104	49	67	2	597
Stutsman (ND)	28	0	0	0	0	0	0	0	28
Ward (ND)	0	111	3	3	5	2	3	0	128
Williams (ND)	4,024	835	86	73	427	200	277	238	6,161
Butte (SD)	0	12	0	0	0	0	0	0	12
Harding (SD)	28	86	19	16	22	1	0	3	176
TOTAL	**14,839**	**12,444**	**1,281**	**1,086**	**7,305**	**3,345**	**4,545**	**1,269**	**46,114**
Daniels, (MT) (Tribal)	0	0	0	0	0	0	0	0	2
Roosevelt, (MT) (Tribal)	221	37	12	11	28	13	18	2	342
Sheridan, (MT) (Tribal)	0	0	0	0	1	0	1	0	2
Valley, MT (Tribal)	0	19	8	7	9	4	6	1	54

County	Compressor Engines	Drill Rigs	Heaters	Miscellaneous Engines	Artificial Lift Engines	Oil Tank Flaring	Casinghead Gas Flaring	Other Categories	Totals
Dunn, ND (Tribal)	7	520	4	4	62	29	40	1	667
McKenzie, ND (Tribal)	5	74	4	3	12	6	8	1	112
McLean, ND (Tribal)	1	167	3	3	10	5	7	0	196
Mountrail, ND (Tribal)	35	1,280	21	18	467	219	302	3	2,345
TOTAL (Tribal)	**270**	**2,097**	**53**	**45**	**590**	**276**	**382**	**8**	**3,720**
Daniels, (MT) (Non-Tribal)	0	0	0	0	0	0	0	0	0
Roosevelt, (MT) (Non-Tribal)	529	93	21	18	79	37	51	5	832
Sheridan, (MT) (Non-Tribal)	12	93	39	33	121	57	78	6	438
Valley, MT (Non-Tribal)	1,298	167	25	21	0	0	0	8	1,519
Dunn, ND (Non-Tribal)	324	2,041	67	57	685	321	443	11	3,948
McKenzie, ND (Non-Tribal)	2,344	1,354	157	133	757	354	490	218	5,807
McLean, ND (Non-Tribal)	0	0	0	0	0	0	0	0	0
Mountrail, ND (Non-Tribal)	513	3,154	74	62	2,086	977	1,351	49	8,266

Table 10. 2015 VOC emissions by county and by source category for the Williston Basin.

County	Pneumatic Devices	Pneumatic Pumps	Recompletion Venting	Fugitives	Condensate Tanks	Oil Tanks	Oil Well Truck Loading	Casinghead Gas Venting	Other Categories	Totals
Carter (MT)	62	74	3	22	0	13	3	0	2	178
Custer (MT)	10	12	0	4	0	0	0	0	1	28
Daniels (MT)	19	23	3	7	0	50	2	8	0	112
Dawson (MT)	203	241	20	70	3	650	24	0	171	1,383
Fallon (MT)	4,462	5,290	448	1,545	16	10,222	375	0	1,999	24,357
Garfield (MT)	41	49	2	14	0	4	1	0	0	112
McCone (MT)	31	38	4	11	0	10	2	10	80	187
Prairie (MT)	41	49	4	14	0	124	5	0	1	238
Richland (MT)	5,830	7,129	843	2,081	12	24,126	5,964	25,063	3,999	75,047
Roosevelt (MT)	1,118	1,368	162	399	0	4,814	489	2,054	340	10,743
Sheridan (MT)	1,316	1,611	190	470	4	2,334	555	2,333	190	9,004
Valley (MT)	1,105	1,353	160	394	0	1,125	43	181	451	4,813
Wibaux (MT)	384	456	39	133	0	1,155	42	0	9	2,218
Barnes (ND)	0	0	0	0	0	0	0	0	6	6
Billings (ND)	2,844	3,481	411	1,015	73	2,205	1,528	6,421	528	18,505
Bottineau (ND)	3,247	3,975	469	1,159	324	1,080	749	3,146	869	15,018
Bowman (ND)	1,759	2,089	177	609	18,740	19,885	730	0	894	44,884
Burke (ND)	2,328	2,850	337	831	167	767	531	2,233	557	10,601
Burleigh (ND)	0	0	0	0	0	0	0	0	17	17
Divide (ND)	888	1,087	128	317	482	840	582	2,446	377	7,147
Dunn (ND)	2,391	2,926	346	853	1,432	4,921	3,410	14,330	3,060	33,667
Golden Valley (ND)	391	479	57	140	0	310	215	903	65	2,560
McHenry (ND)	106	129	15	38	0	19	13	54	9	382
McIntosh (ND)	0	0	0	0	0	0	0	0	17	17
McKenzie (ND)	5,390	6,597	779	1,924	7,348	5,060	3,506	14,734	4,280	49,616
McLean (ND)	106	129	15	38	0	67	46	194	40	635
Mercer (ND)	6	8	1	2	0	1	1	4	9	32
Morton (ND)	0	0	0	0	0	0	0	0	77	77
Mountrail (ND)	3,167	3,876	458	1,130	1,720	16,809	11,648	48,949	7,477	95,234
Renville (ND)	1,807	2,212	261	645	222	426	295	1,241	112	7,221
Slope (ND)	67	79	7	23	1,856	632	23	0	34	2,721
Stark (ND)	441	540	64	157	0	684	474	1,991	128	4,478
Stutsman (ND)	0	0	0	0	0	0	0	0	10	10
Ward (ND)	99	122	14	35	0	34	24	100	77	507
Williams (ND)	2,900	3,549	419	1,035	4,566	2,814	1,950	8,195	2,385	27,813
Butte (SD)	0	0	0	0	0	0	0	0	2	2
Harding (SD)	670	796	67	232	152	2,709	99	0	150	4,874
TOTAL	**43,230**	**52,616**	**5,903**	**15,348**	**37,116**	**103,890**	**33,329**	**134,590**	**28,422**	**454,443**
Daniels, (MT) (Tribal)	12	15	2	4	0	50	2	8	0	94
Roosevelt, (MT) (Tribal)	416	509	60	148	0	3,358	129	541	97	5,259

County	Pneumatic Devices	Pneumatic Pumps	Recompletion Venting	Fugitives	Condensate Tanks	Oil Tanks	Oil Well Truck Loading	Casinghead Gas Venting	Other Categories	Totals
Sheridan, (MT) (Tribal)	6	8	1	2	0	105	4	17	1	143
Valley, MT (Tribal)	261	319	38	93	0	1,125	43	181	15	2,075
Dunn, ND (Tribal)	149	182	22	53	0	411	285	1,197	531	2,829
McKenzie, ND (Tribal)	130	160	19	47	0	78	54	226	163	876
McLean, ND (Tribal)	106	129	15	38	0	67	46	194	40	635
Mountrail, ND (Tribal)	695	851	101	248	0	3,074	2,130	8,951	1,818	17,868
TOTAL (Tribal)	**1,776**	**2,174**	**257**	**634**	**0**	**8,268**	**2,693**	**11,315**	**2,664**	**29,779**
Daniels, (MT) (Non-Tribal)	6	8	1	2	0	0	0	0	0	17
Roosevelt, (MT) (Non-Tribal)	702	859	101	250	0	1,456	360	1,513	243	5,484
Sheridan, (MT) (Non-Tribal)	1,310	1,604	189	468	4	2,229	551	2,316	189	8,861
Valley, MT (Non-Tribal)	844	1,034	122	301	0	0	0	0	436	2,738
Dunn, ND (Non-Tribal)	2,242	2,744	324	800	1,432	4,510	3,125	13,133	2,529	30,838
McKenzie, ND (Non-Tribal)	5,259	6,437	760	1,877	7,348	4,982	3,452	14,507	4,117	48,740
McLean, ND (Non-Tribal)	0	0	0	0	0	0	0	0	0	0
Mountrail, ND (Non-Tribal)	2,471	3,025	357	882	1,720	13,736	9,518	39,998	5,659	77,367

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