**Draft Final Report**

# DEVELOPMENT OF 2015 OIL AND GAS EMISSIONS PROJECTIONS FOR THE POWDER RIVER 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 Powder River Basin. These methodologies will use as a starting point the 2006 baseline Powder River Basin oil and gas emissions inventory, described in the baseline emissions report entitled "Development of Baseline 2006 Emissions from Oil and Gas Activity in the Powder River Basin". Unlike previous Phase III project midterm inventories, the Powder River 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 Wyoming Department of Environmental Quality's (WYDEQ) need for a father future year projection than 2012.

The methodology used to develop the 2015 projections for the Powder River 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 – eight 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, CBM gas production, total oil production, oil well oil production and condensate production;
- 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 2006 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 Powder River Basin are presented in graphical and tabular formats.

## GEOGRAPHIC GROUPING

The projections for 2015 have been conducted for four (4) geographic groupings in the Powder River Basin. These include:

- Johnson and Sheridan Counties – this grouping represents the core CBM gas development area in the basin;
- Campbell County – this County includes major CBM gas development areas adjacent to Johnson and Sheridan Counties, but also significant oil production and some conventional gas production – therefore Campbell County was projected separately;
- Converse and Natrona Counties – this grouping contains primarily conventional gas and oil production areas;
- "Minor" Production Counties – this grouping includes Crook, Niobrara and Weston Counties in Wyoming and Big Horn and Powder River Counties in Montana – very little gas or oil production occurs in these counties relative to total basin-wide production;

As noted above, the geographic groupings were constructed to group similar production types or to highlight specific counties that were not similar to adjacent counties. The Powder River Basin contains both significant CBM gas production, and significant oil production as compared to other Phase III basins (Bar-Ilan, et al., 2009a; Bar-Ilan, et al., 2009b; Bar-Ilan, et al., 2009c; Bar-Ilan, et al., 2008). The core CBM gas production areas include Johnson and Sheridan Counties, and parts of adjacent Campbell County. Converse and Natrona Counties account for significant conventional gas and oil production, including parts of adjacent Campbell County. Campbell County was projected individually because it contains a mix of production types. 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 8 parameters:

- Total well counts
- Conventional gas well counts
- Spud counts
- Total gas production
- CBM gas production
- Total oil production
- Oil well oil production
- Condensate production

These eight 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 by the Wyoming Oil and Gas Conservation Commission (WYOGCC) (WYOGCC, 2012). This is the only distinction made between condensate and oil production. The IHS database distinguishes CBM wells from conventional gas wells based on reported CBM production.

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 |
|---|---|---|---|
| Survey-Based | 2310000100 | Heaters | Total Well Count |
| Survey-Based | 2310000220 | Drill rigs | Spuds |
| Survey-Based | 2310000230 | Workover rigs | Total Well Count |
| Survey-Based | 2310000300 | Pneumatic devices | Total Well Count |
| Survey-Based | 2310000700 | Fugitives | Total Well Count |
| Survey-Based | 2310000801 | Gas well truck loading | Gas Well Condensate Production |
| Survey-Based | 2310000802 | Oil well truck loading | Oil Well Oil Production |
| Survey-Based | 2310000820 | Gas plant truck loading | Gas Well Condensate Production |
| Survey-Based | 2310001610 | Venting - initial completions | Spuds |
| Survey-Based | 2310001611 | Initial completion flaring | Spuds |
| Survey-Based | 2310001620 | Venting - recompletions | Spuds |
| Survey-Based | 2310001630 | Venting - blowdowns | Total Gas Production |
| Survey-Based | 2310001640 | Venting - compressor startup | Total Gas Production |
| Survey-Based | 2310001650 | Venting - compressor shutdown | Total Gas Production |
| Survey-Based | 2310002230 | Condensate tank | Gas Well Condensate Production |
| Survey-Based | 2310002240 | Oil tank | Oil Well Oil Production |
| Survey-Based | 2310002231 | Condensate tank flaring | Gas Well Condensate Production |
| Survey-Based | 2310003100 | Miscellaneous engines | Total Well Count |
| Survey-Based | 2310003200 | Pneumatic pumps | Conv. Well Count |

| Source | SCC | Description | Projection Parameter |
|---|---|---|---|
| Survey-Based | 2310020600 | Compressor engines | Total Gas Production |
| Survey-Based | 2310021410 | Dehydrator | Total Gas Production |
| Survey-Based | 2310022000 | Amine units | Total Gas Production |
| Survey-Based | 2310000330 | Artificial lift | Oil Well Oil Production |
| Survey-Based | 2310001631 | Blowdown flaring | Total Gas Production |
| Survey-Based | 2310002241 | Oil tank flaring | Oil Well Oil Production |
| Survey-Based | 2310021411 | Dehydrator flaring | Total Gas Production |
| Permitted Sources | 20200202 | Compressor engines | Total Gas Production |
| Permitted Sources | 31000205 | Natural gas production, flares | Total Gas Production |
| Permitted Sources | 31000220 | Natural gas production, all equipment leak fugitives | Total Gas Production |
| Permitted Sources | 31000404 | Process heaters | Total Gas Production |
| Permitted Sources | 40400301 | Permitted tank losses | Gas Well Condensate Production |
| Permitted Sources | 20200200 | Compressor engines | Total Gas Production |
| Permitted Sources | 20200252 | Compressor engines | Total Gas Production |
| Permitted Sources | 20200253 | Compressor engines | Total Gas Production |
| Permitted Sources | 31000215 | Natural gas production, flares combusting gases >1000 BTU/scf | Total Gas Production |
| Permitted Sources | 31000227 | Dehydrator | Total Gas Production |
| Permitted Sources | 31000301 | Dehydrator | Total Gas Production |
| Permitted Sources | 31000302 | Dehydrator | Total Gas Production |
| Permitted Sources | 31000502 | Liquid separator | Total Gas Production |
| Permitted Sources | 31088800 | Permitted fugitives | Total Gas Production |
| Permitted Sources | 31000203 | Compressor engines | Total Gas Production |
| Permitted Sources | 20101020 | Compressor blowdown | Total Gas Production |
| Permitted Sources | 31000299 | Natural gas production, other not classified | Total Gas Production |
| Permitted Sources | 20200204 | Compressor start-ups | Total Gas Production |
| Permitted Sources | 31000201 | Natural gas processing facilities, gas sweeting: amine process | Total Gas Production |
| Survey-Based | 2310003000 | Dewatering engines | CBM Gas Production |
| Survey-Based | 2310003500 | Other flaring | Total Gas Production |
| Permitted Sources | 31000300 | Dehydrator | Total Gas Production |
| Permitted Sources | 31000400 | Process heaters | Total Gas Production |
| WYDEQ Permitted Sources | 10200603 | Dehydrator | Total Gas Production |
| WYDEQ Permitted Sources | 10201701 | Dehydrator | Total Gas Production |
| WYDEQ Permitted Sources | 10500110 | Process heaters | Total Gas Production |
| WYDEQ Permitted Sources | 10500210 | Process heaters | Total Gas Production |
| WYDEQ Permitted Sources | 20200102 | Compressor engines | Total Gas Production |
| WYDEQ Permitted Sources | 20200201 | Compressor engines | Total Gas Production |
| WYDEQ Permitted Sources | 20200254 | Compressor engines | Total Gas Production |
| WYDEQ Permitted Sources | 20200301 | Compressor engines | Total Gas Production |
| WYDEQ Permitted Sources | 20200401 | Compressor engines | Total Gas Production |
| WYDEQ Permitted Sources | 30600904 | Natural gas production, flares | Total Gas Production |
| WYDEQ Permitted Sources | 31000128 | Oil production, processing operations: not classified | Total Oil Production |
| WYDEQ Permitted Sources | 31000228 | Dehydrator | Total Gas Production |
| WYDEQ Permitted Sources | 31000402 | Process heaters | Total Gas Production |
| WYDEQ Permitted Sources | 40400150 | Permitted tank losses | Gas Well Condensate Production |
| WYDEQ Permitted Sources | 40400300 | Permitted tank losses | Gas Well Condensate Production |

| Source | SCC | Description | Projection Parameter |
|---|---|---|---|
| WYDEQ Permitted Sources | 40400302 | Permitted tank losses | Gas Well Condensate Production |
| WYDEQ Permitted Sources | 40400312 | Permitted tank losses | Gas Well Condensate Production |
| WYDEQ Permitted Sources | 40400316 | Permitted tank losses | Gas Well Condensate Production |
| WYDEQ Permitted Sources | 40400402 | Permitted tank losses | Gas Well Condensate Production |
| WYDEQ Permitted Sources | 2501000000 | Permitted tank losses | Gas Well Condensate Production |

## PROJECTION METHODOLOGIES FOR THE POWDER RIVER BASIN

For the Powder River Basin, the methodology for obtaining the 2015 value of each projection parameter (total well counts, conventional gas well counts, spud counts, total gas production, CBM gas production, total oil production, oil well oil production, and condensate production) 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.

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).

### Johnson and Sheridan Counties

Conventional Gas Well Counts

Conventional gas well counts in Johnson and Sheridan Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 1, including projections to 2015.

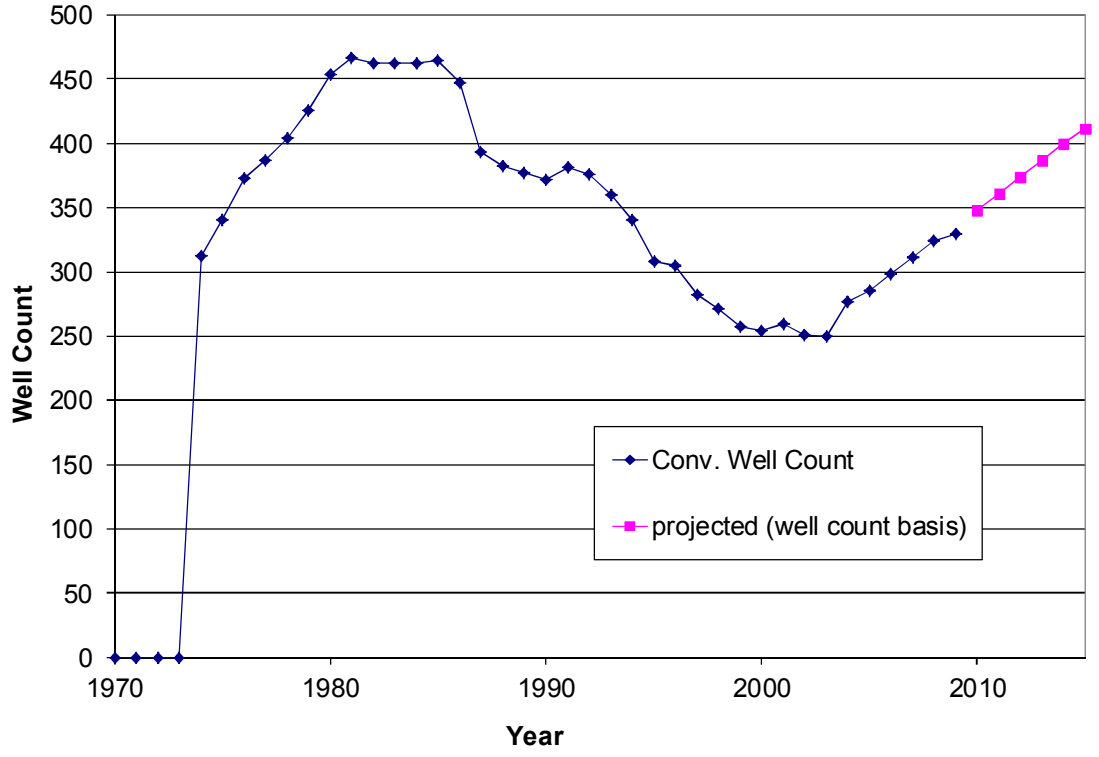


**Figure 1.** Conventional gas well count historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015. [1]

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

Conventional gas well count projections were developed for the period 2010 – 2015 by linear extrapolation of the well counts in the period 2003-2009. This period represented the recent historic increase in gas production in the basin and was considered a reasonable historic period from which to project the remaining data.

CBM Well Counts

CBM well counts in Johnson and Sheridan Counties in the Powder River Basin have been plotted for the years 1970 – 2011 below in Figure 2, including projections to 2015.

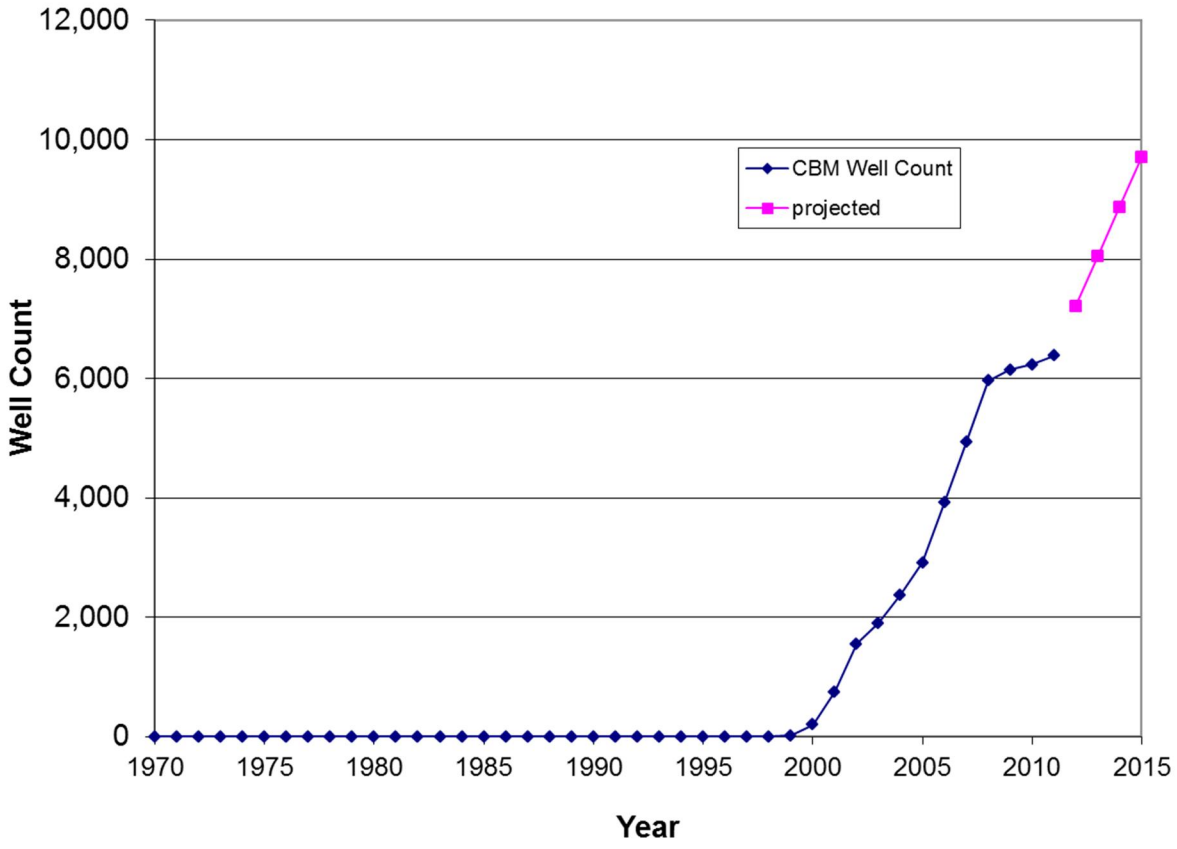


**Figure 2.** CBM well count historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015.[2]

CBM well count in Johnson and Sheridan Counties in the Powder River Basin increased relatively steadily during in the period roughly from 2000-2008, with increases at a lesser rate from 2008-2011. CBM well count projections were developed for the period 2012 – 2015 assuming linear growth from 2011 according to the historic 2004-2009 increase in CBM activity.

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

Total Well Counts

The total well counts for Johnson and Sheridan Counties in the Powder River Basin in 2015 were developed by summing the projected conventional gas and CBM well counts according to Equation 1:

Equation (1) $N_{TOTAL} = N_{CBM} + N_{CONV}$

where:

$N_{TOTAL}$ is the estimated total number of wells in 2015 in Johnson and Sheridan Counties
$N_{CBM}$ is the estimated total number of CBM wells in 2015 in Johnson and Sheridan Counties
$N_{CONV}$ is the estimated total number of conventional wells in 2015 in Johnson and Sheridan Counties

Spud Counts

Spud counts in Johnson and Sheridan Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 3, including projections to 2015.

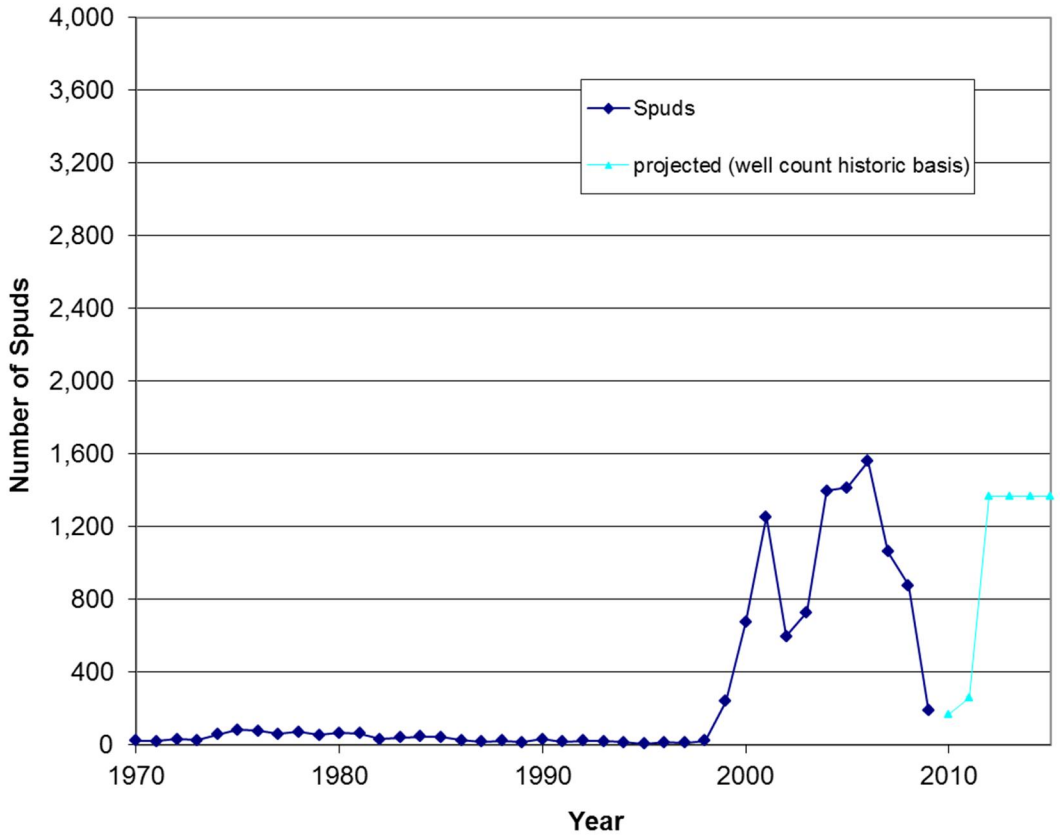


**Figure 3.** Spud count historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015. [3]

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

Historic spud counts in Johnson and Sheridan Counties, as obtained from the IHS database for the period 1970-2009 are erratic, making an extrapolation from historical data infeasible. Rather the change in the number of active wells each year in the period 2004-2009 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 1.62 was then applied to the projected number of wells in Johnson and Sheridan Counties as described in Figures 1 and 2 above to estimate the projected number of spuds.

Conventional Gas Production

Conventional gas production in Johnson and Sheridan Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 4, including projections to 2015.

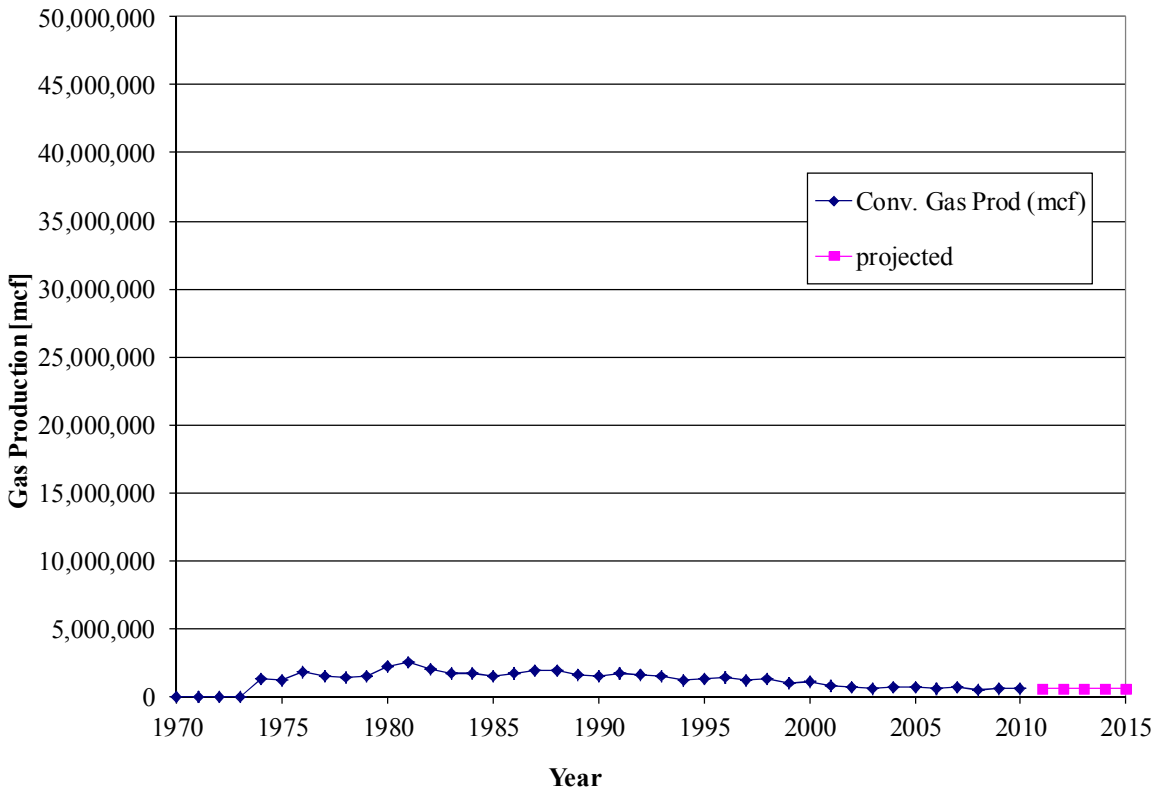


**Figure 4.** Conventional gas production historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015.[4]

As noted above, Johnson and Sheridan Counties represent the core CBM development area in the Powder River Basin. Figure 4 shows minimal conventional gas production in these counties in the past 10 years from 2000-2009. Conventional gas production was therefore conservatively assumed to remain at 2009 levels for the period 2010-2015.

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

CBM Gas Production

CBM gas production in Johnson and Sheridan Counties in the Powder River Basin has been plotted for the years 1970 – 2011 below in Figure 5, including projections to 2015.

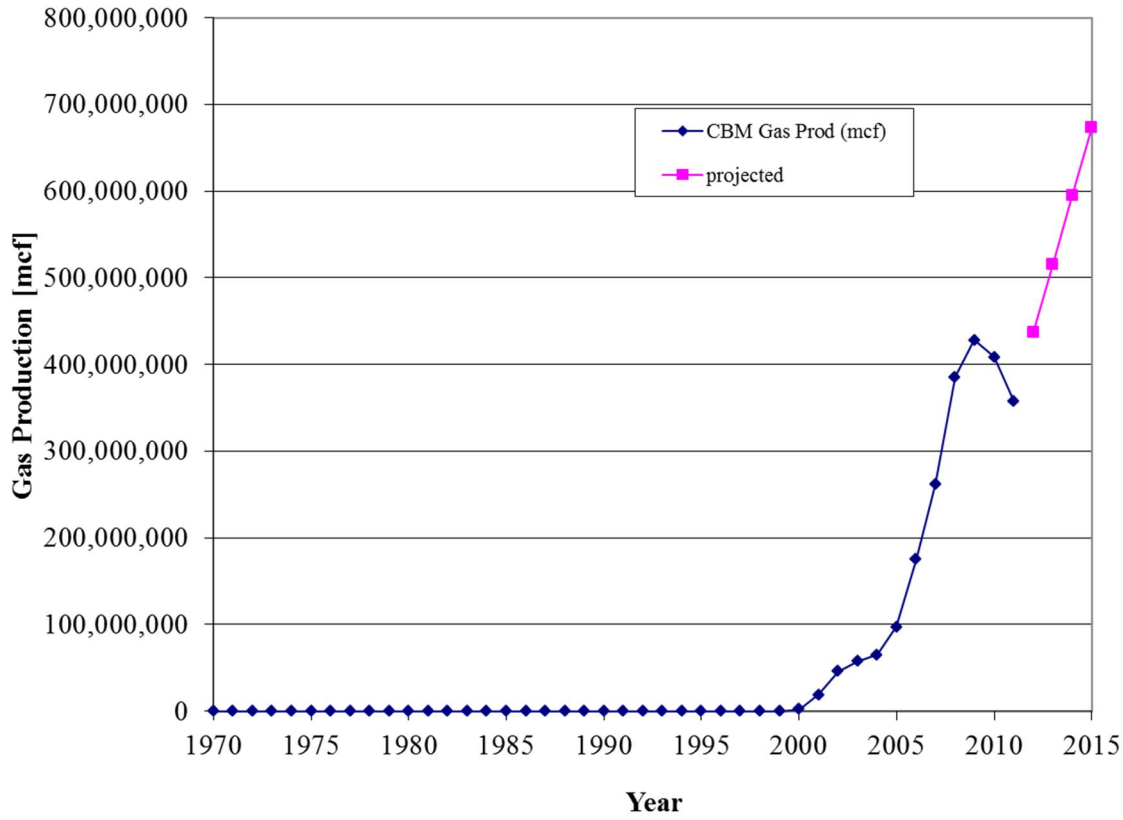


**Figure 5.** CBM gas production historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015.[5]

CBM gas production in Johnson and Sheridan Counties in the Powder River Basin increased during the period roughly from 2000-2009, with decreases from 2009-2011. These two counties represent the core CBM development area in the Powder River Basin. CBM gas production was linearly projected to 2012 - 2015 from the 2011 gas production estimate according to the rate of increase based on historic data from the period 2004-2009 in order to account for future growth in CBM gas production.

Total Gas Production

The total gas production for Johnson and Sheridan Counties in the Powder River Basin in 2015 was developed by summing the projected conventional gas and CBM production according to Equation 2:

Equation (2) $P_{TOTAL} = P_{CBM} + P_{CONV}$

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

where:

$P_{TOTAL}$ is the estimated total gas production in 2015 in Johnson and Sheridan Counties
$P_{CBM}$ is the estimated total CBM gas production in 2015 in Johnson and Sheridan Counties
$P_{CONV}$ is the estimated total conventional gas production in 2015 in Johnson and Sheridan Counties

Oil Well Oil Production

Oil well oil production in Johnson and Sheridan Counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 6, including projections to 2015.

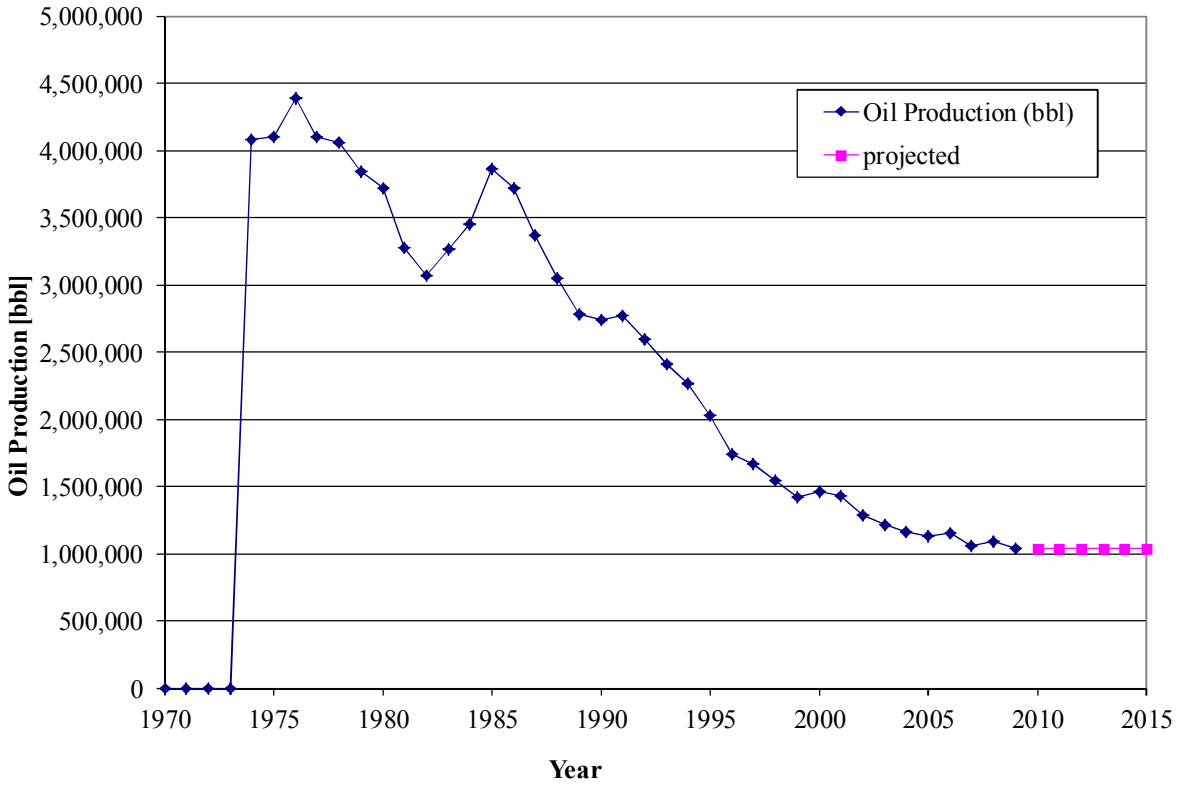


**Figure 6.** Oil production historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015.[6]

Oil production has been in significant decline in Johnson and Sheridan Counties in the Powder River Basin since approximately the mid-1980's and is expected to continue to decline. This analysis conservatively projected that oil production would remain at 2009 levels in the period through 2015.

Condensate Production

Condensate production in Johnson and Sheridan Counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 7, including projections to 2015.

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

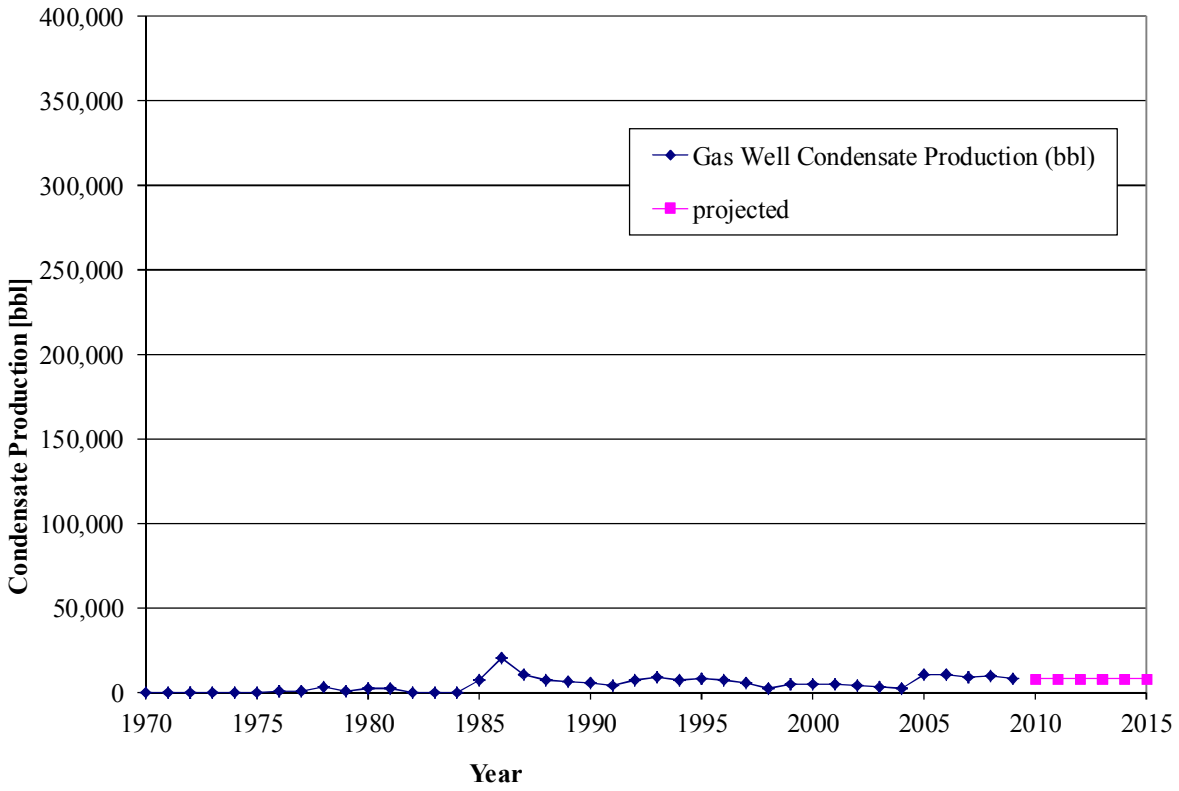


**Figure 7.** Condensate production historical data (from the IHS database) for Johnson and Sheridan Counties in the Powder River Basin and projections to 2015. [7]

Consistent with the observations above in Figure 4 for conventional gas production, there is minimal condensate production in Johnson and Sheridan Counties in the Powder River Basin. Similar to oil production, this analysis conservatively projected that condensate production would remain at 2009 levels in the period through 2015.

Total Oil Production

The total oil production for Johnson and Sheridan Counties in the Powder River Basin in 2015 was developed by summing the projected oil well oil and condensate production according to Equation 3:

Equation (3) $W_{TOTAL} = W_{OIL} + W_{COND}$

where:

$W_{TOTAL}$ is the estimated total oil production in 2015 in Johnson and Sheridan Counties
$W_{OIL}$ is the estimated total oil well oil production in 2015 in Johnson and Sheridan Counties
$W_{COND}$ is the estimated total condensate production in 2015 in Johnson and Sheridan Counties

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

**Converse and Natrona Counties**

Conventional Well Counts

Conventional well counts in Converse and Natrona Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 8, including projections to 2015.

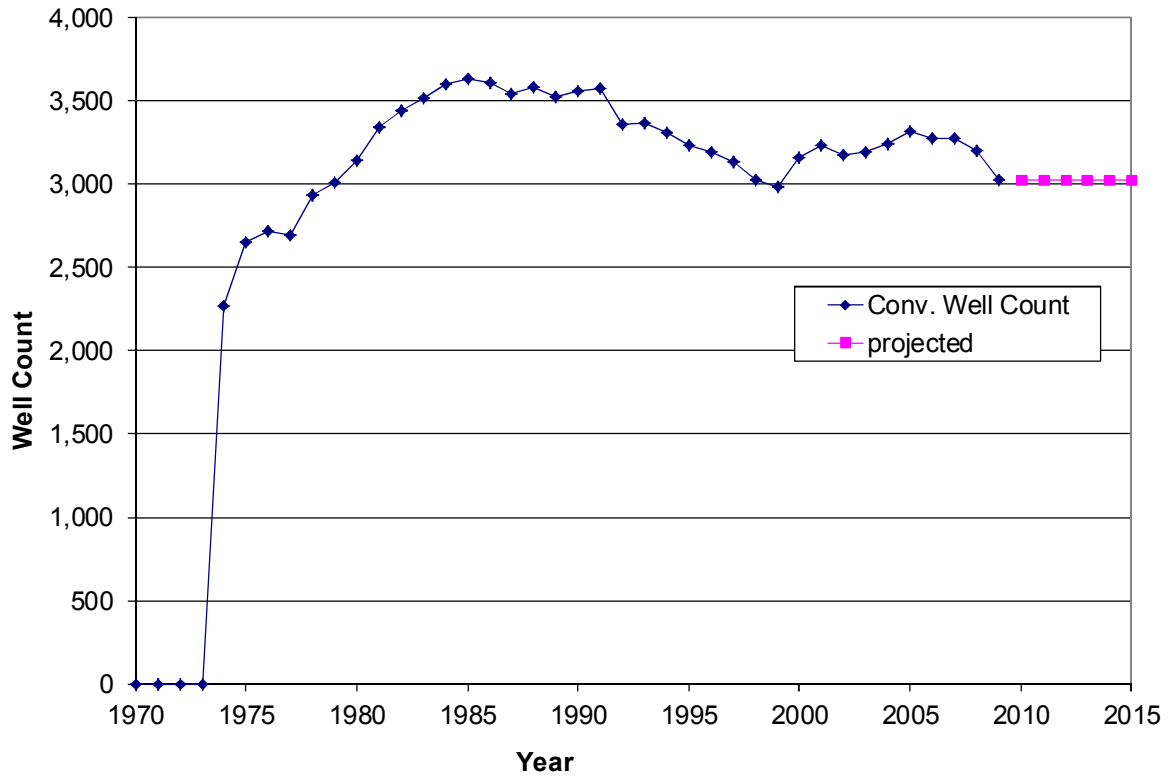


**Figure 8.** Conventional well count historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [8]

Conventional well count projections (including gas and oil wells) have decline from a peak in the mid-1980's to approximately 3,000 active wells in 2000. In the period 2000-2009, there was growth in the number of active wells followed by decline to approximately the same number of active wells in 2009 as in 2000. Given the difficulty in projecting growth or decline in the number of conventional gas and oil wells in these counties, this analysis assumed that conventional well counts remained at 2009 levels through 2015.

CBM Well Counts

CBM well counts in Converse and Natrona Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 9, including projections to 2015.

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

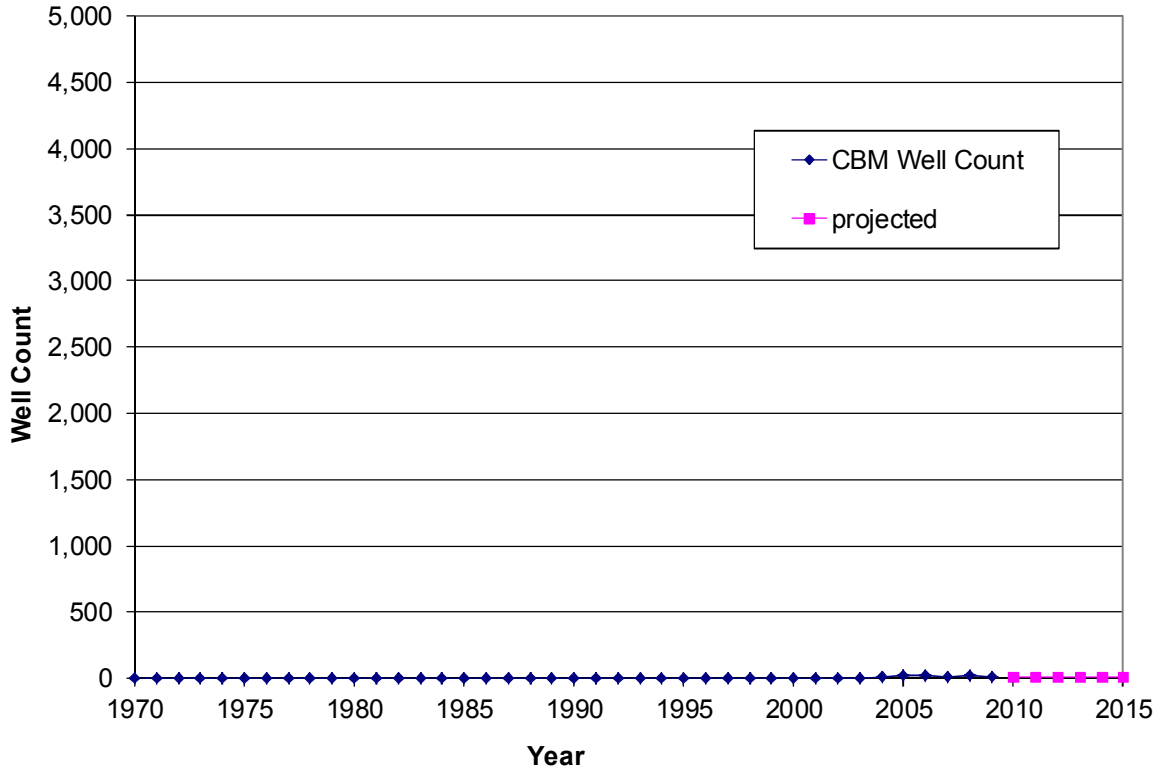


**Figure 9.** CBM well count historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [9]

There is minimal CBM gas development activity in Converse and Natrona Counties in the Powder River Basin. This analysis assumed that the number of active CBM wells in 2009 remained constant through 2015.

Total Well Counts

The total well counts for Converse and Natrona Counties in the Powder River Basin in 2015 were developed by summing the projected conventional and CBM well counts, similar to the approach described above for Johnson and Sheridan Counties in Equation 1.

Spud Counts

Spud counts in Converse and Natrona Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 10, including projections to 2015.

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

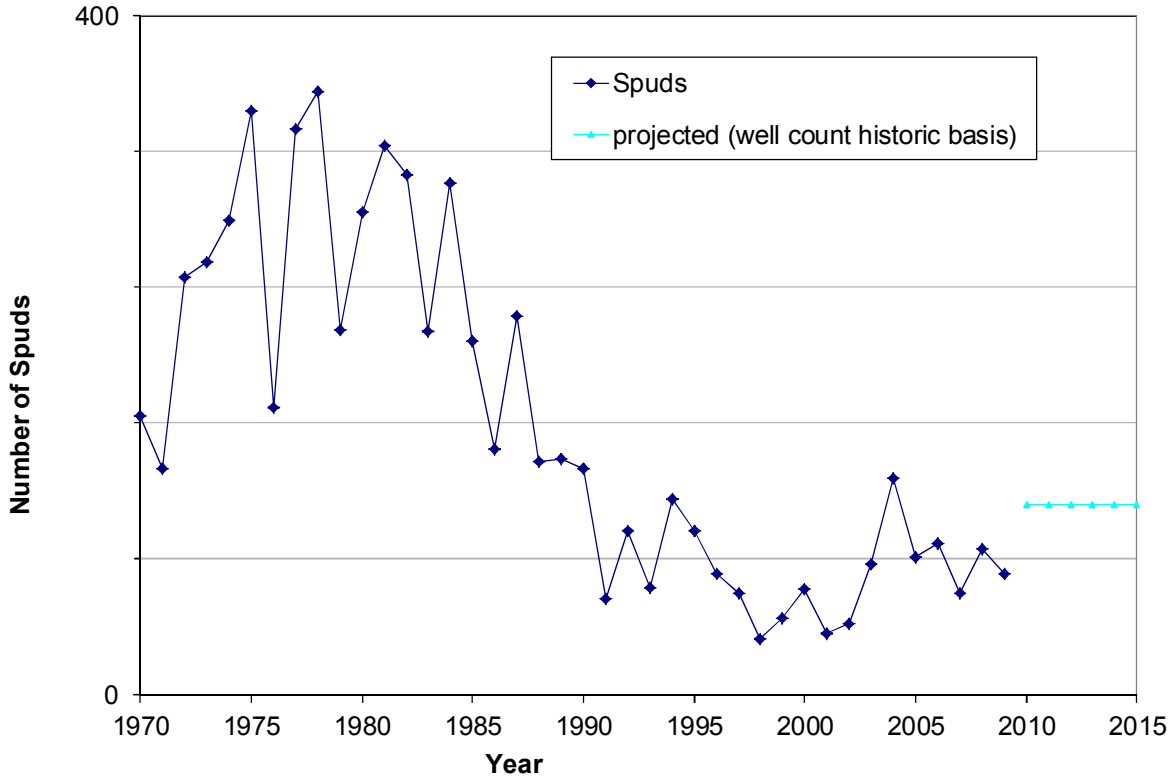


**Figure 10.** Spud count historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [10]

Historic spud counts in Converse and Natrona Counties, as obtained from the IHS database for the period 1970-2009 are erratic, making an extrapolation from historical data infeasible. The change in the number of active wells each year in the period 2004-2009 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 2004-2009 was developed, with a value of 112 spuds per year. The annual number of spuds estimated using this methodology was held constant for the period 2010-2015.

Conventional Gas Production

Conventional gas production in Converse and Natrona Counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 11, including projections to 2015.

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

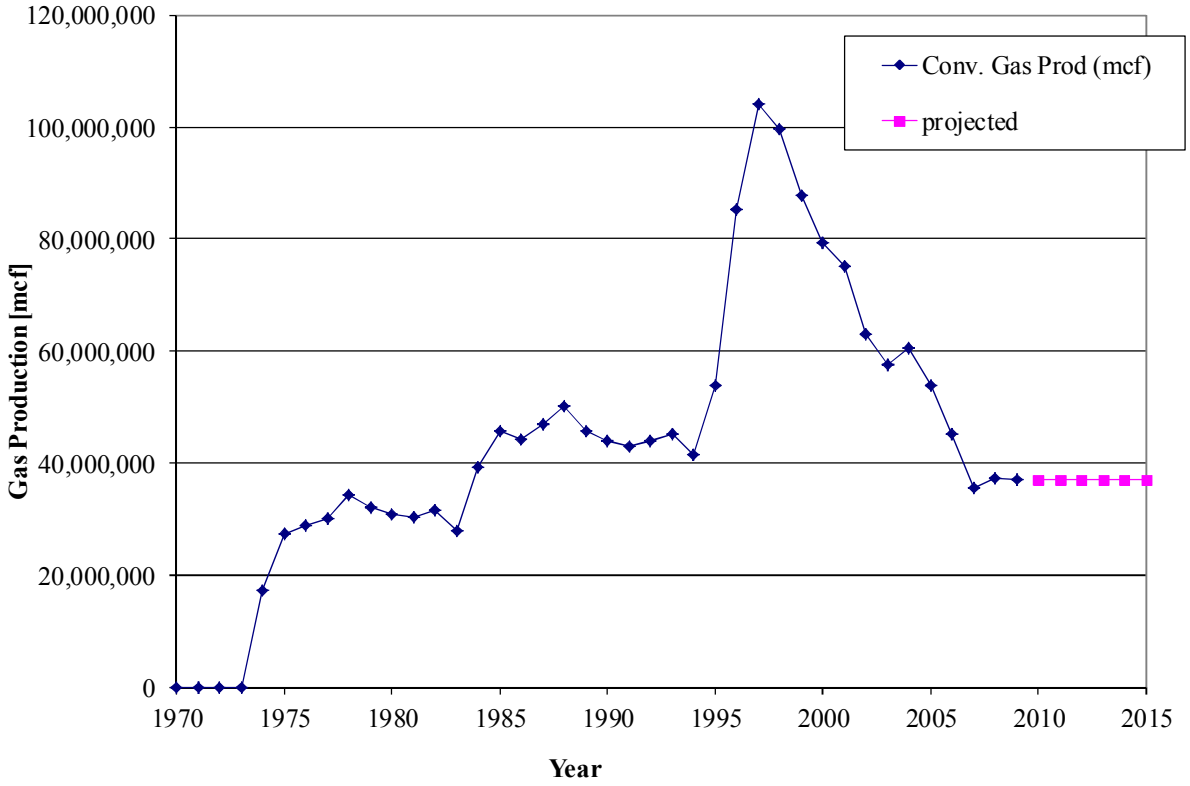


**Figure 11.** Conventional gas production historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [11]

Conventional gas production in Converse and Natrona Counties has been generally in decline from a peak in 1997. Data from 2008 and 2009 show that conventional gas production levels have remained constant during these past two years, and therefore this analysis conservatively assumed that conventional gas production would remain at 2009 levels through the period 2010-2015.

<u>CBM Gas Production</u>

CBM gas production in Converse and Natrona Counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 12, including projections to 2015.

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

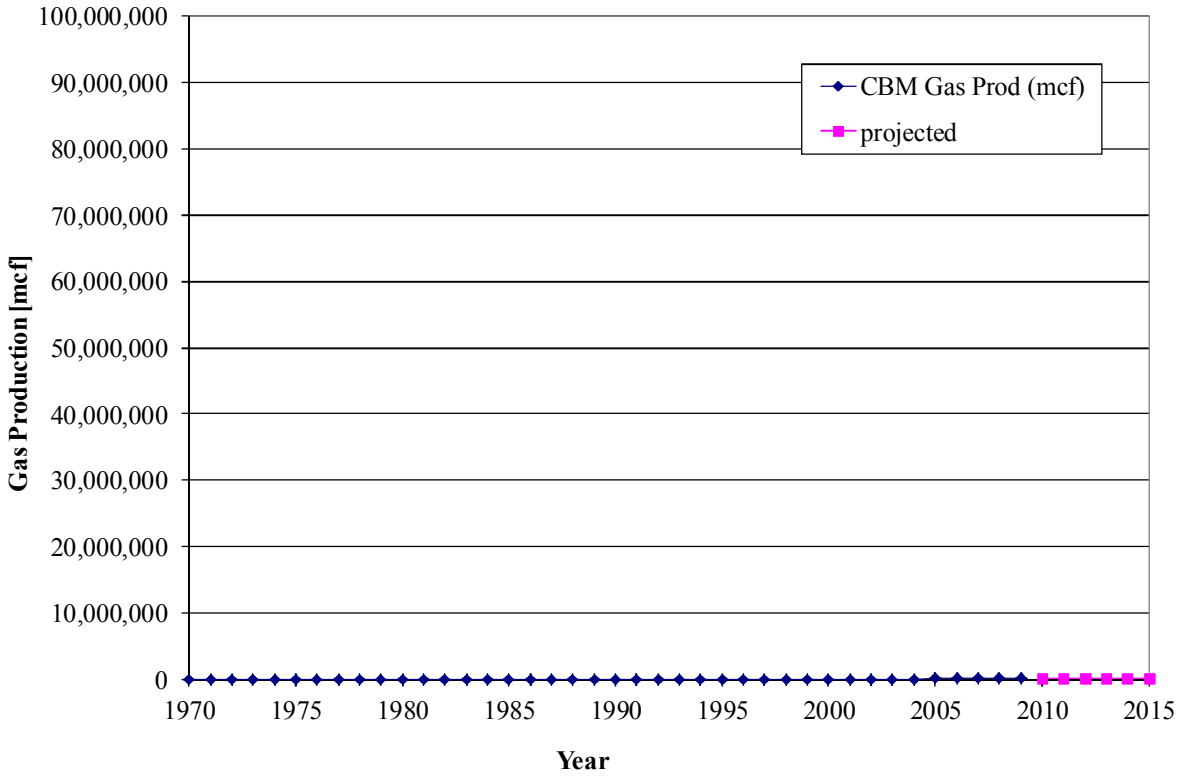


**Figure 12.** CBM gas production historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [12]

There is minimal CBM gas production in Converse County and no CBM gas production in Natrona County in the period 2000-2009. This analysis conservatively assumed that CBM gas production would remain at 2009 levels through the period 2010-2015.

Total Gas Production

The total gas production for Converse and Natrona Counties in the Powder River Basin in 2015 was developed by summing the projected conventional and CBM gas production, similar to the approach described above for Johnson and Sheridan Counties in Equation 2.

Oil Well Oil Production

Oil well oil production in Converse and Natrona Counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 13, including projections to 2015.

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

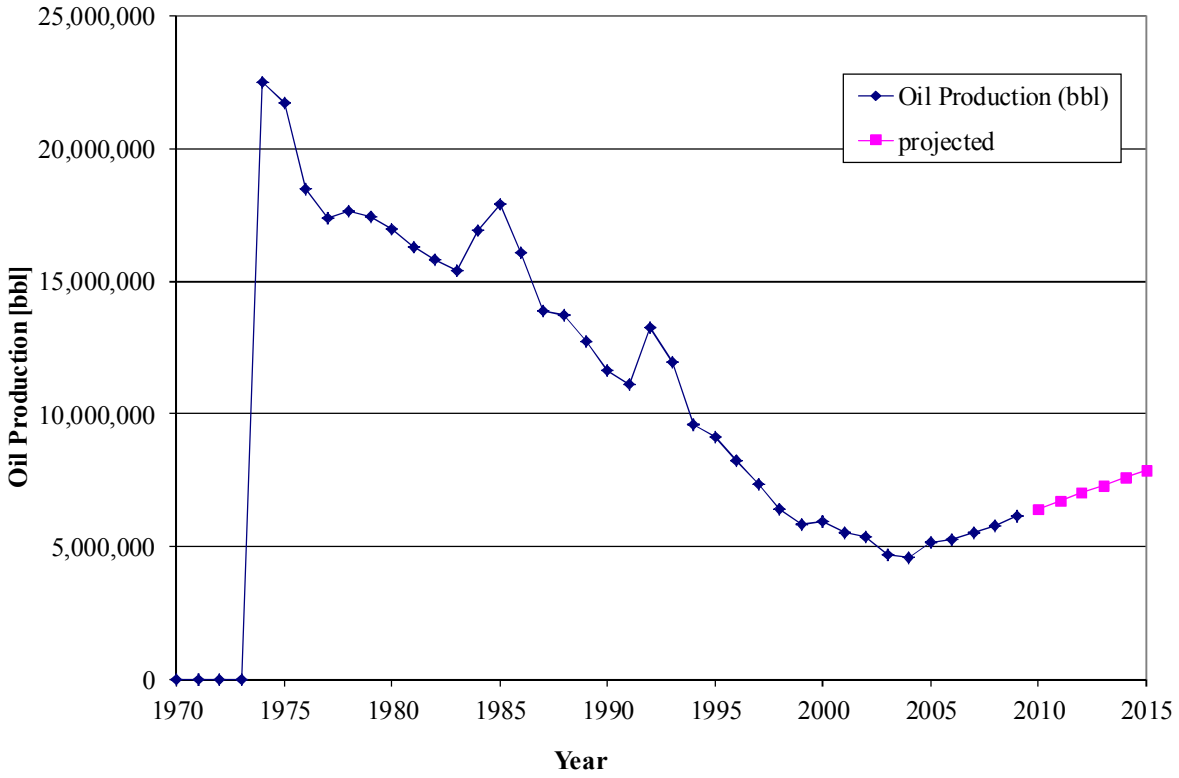


**Figure 13.** Oil production historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [13]

Oil production has been increasing in Converse and Natrona Counties in the Powder River Basin since 2004 after decades of steady decline since the 1970's. The moderate increase in oil production in these counties was linearly projected to continue in the period 2010-2015.

Condensate Production

Condensate production in Converse and Natrona Counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 14, including projections to 2015.

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

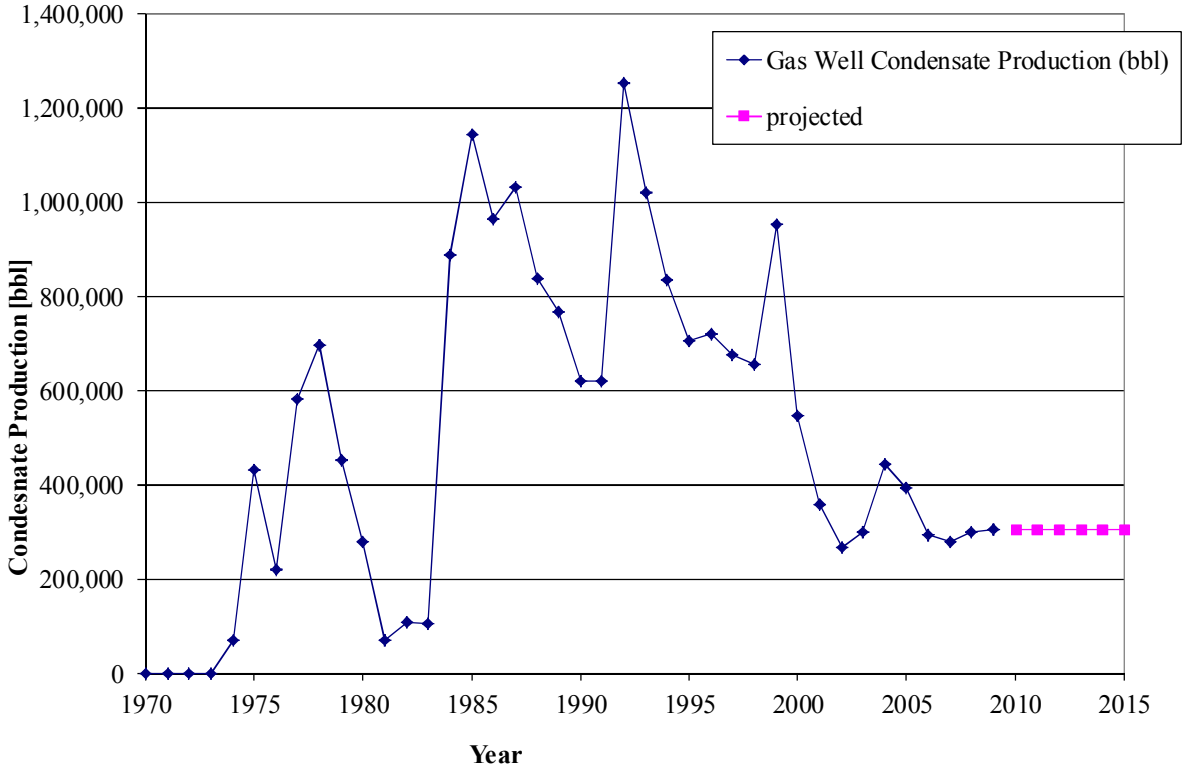


**Figure 14.** Condensate production historical data (from the IHS database) for Converse and Natrona Counties in the Powder River Basin and projections to 2015. [14]

Historic condensate production levels are erratic, but condensate production in the period 2000-2009 has declined significantly from peaks in the mid-1980's through mid-1990's. Consistent with the projections for conventional gas production in Converse and Natrona Counties, condensate production was projected to remain at 2009 levels through the period 2010-2015.

Total Oil Production

The total oil production for Converse and Natrona Counties in the Powder River Basin in 2015 was developed by summing the projected oil well oil and condensate production, similar to the approach described above for Johnson and Sheridan Counties in Equation 3.

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

**Campbell County**

Conventional Well Counts

Conventional well counts in Campbell County in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 15, including projections to 2015.

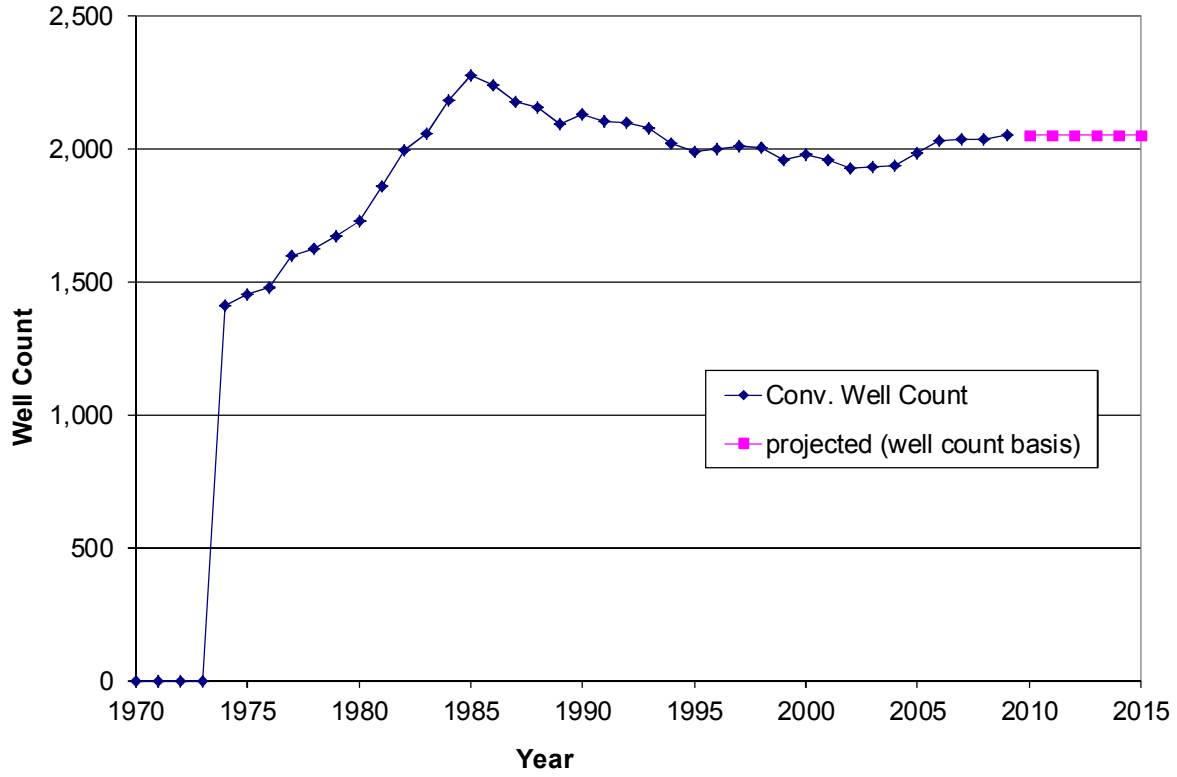


**Figure 15.** Conventional well count historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [15]

Conventional well counts in Campbell County have been more or less static in the period 2000-2009, with both some decline and some growth. In general, active conventional well counts have decreased since a peak in the early 1980's. This analysis conservatively assumed that conventional well counts would remain at 2009 levels through the period 2010-2015.

CBM Well Counts

CBM well counts in Campbell County in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 16, including projections to 2015.

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

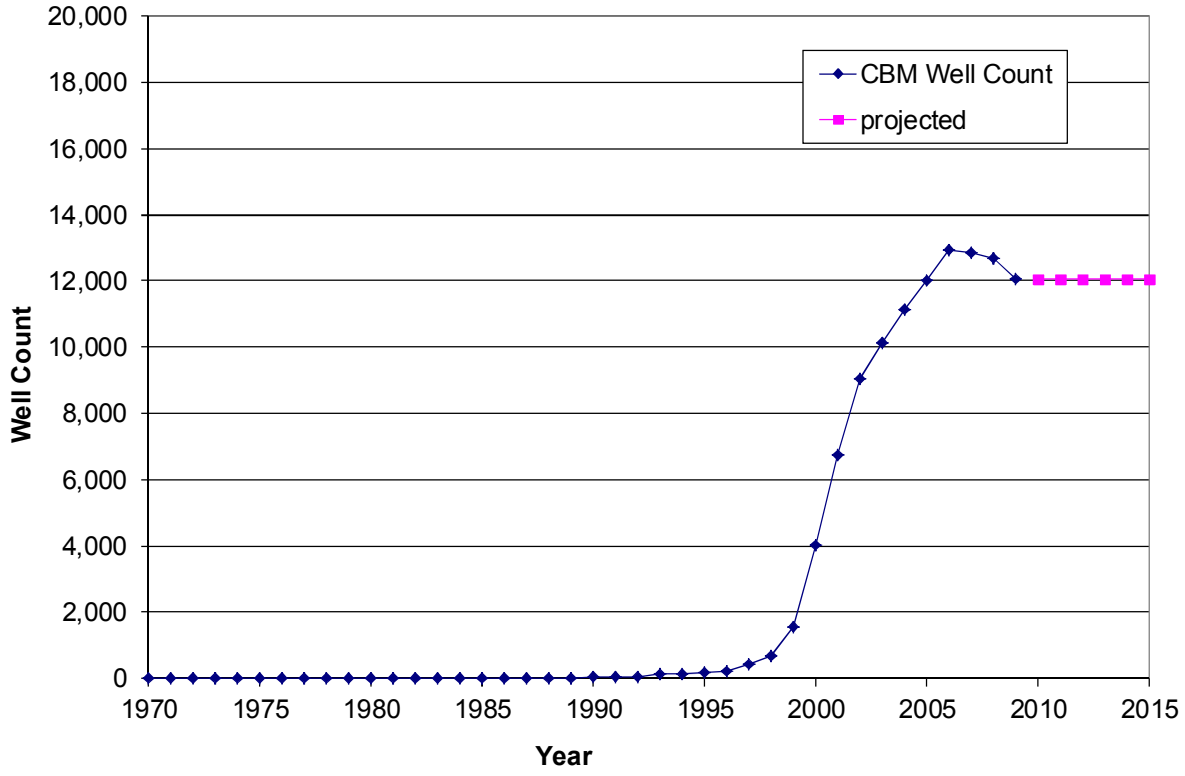


**Figure 16.** CBM well count historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [16]

There has been a significant increase in CBM wells in Campbell County in the period approximately from 1995-2006. After 2006 active CBM well counts begin to decline from a peak value of approximately 13,000 wells, however this analysis conservatively assumed that CBM well counts would remain at 2009 levels through the period 2010-2015.

Total Well Counts

The total well counts for Campbell County in the Powder River Basin in 2015 were developed by summing the projected conventional and CBM well counts, similar to the approach described above for Johnson and Sheridan Counties in Equation 1.

Spud Counts

Spud counts in Campbell County in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 17, including projections to 2015.

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

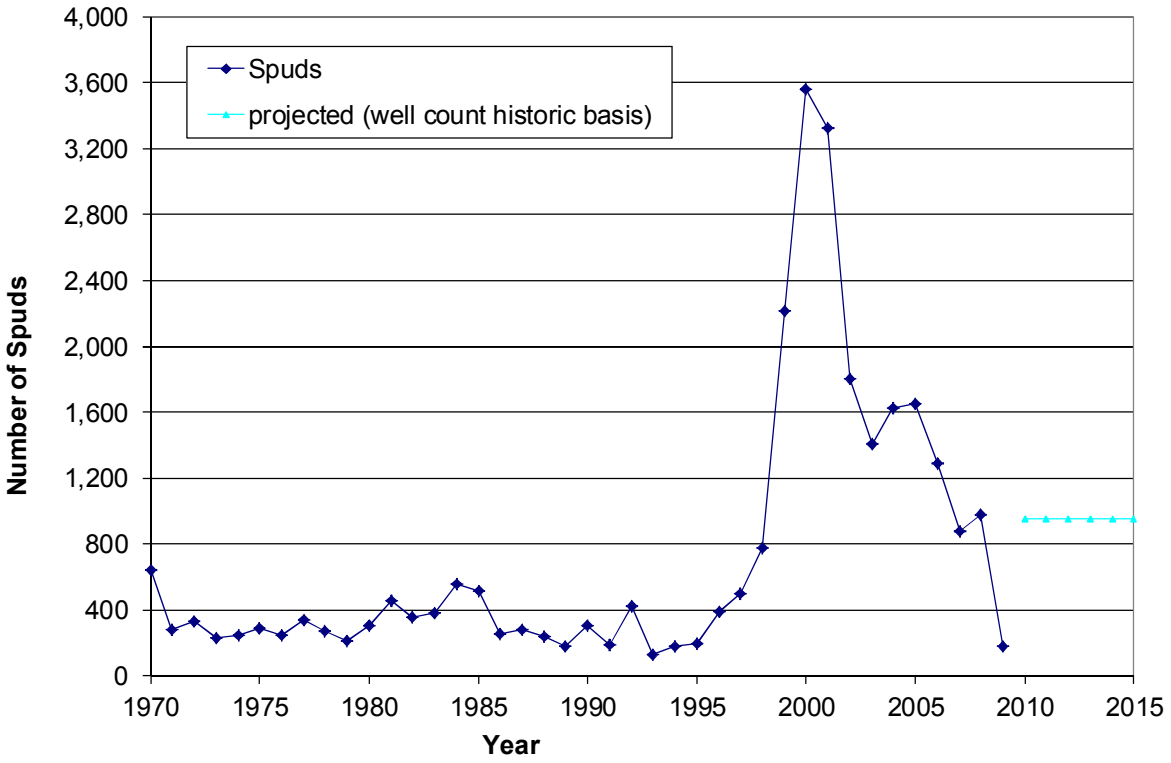


**Figure 17.** Spud count historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [17]

Historic spud counts in Campbell County, as obtained from the IHS database for the period 2000-2009 show a significant decline in the number of spuds from a peak of approximately 3,600 spuds in 2000 to 182 spuds in 2010. However, given the conservative projections of well counts in Campbell County as shown in Figures 15 and 16, a projection of continued decline in spuds would be inconsistent with the well count projections. Therefore the average ratio of spuds to number of active wells added per year (1.36) in the period 2002-2006 was derived. This ratio was then used to estimate the number of spuds in the period 2010-2015 by multiplying the projected total number of wells added in each year in that period by the factor 1.36 to obtain the number of spuds in each year.

Conventional Gas Production

Conventional gas production in Campbell County in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 18, including projections to 2015.

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

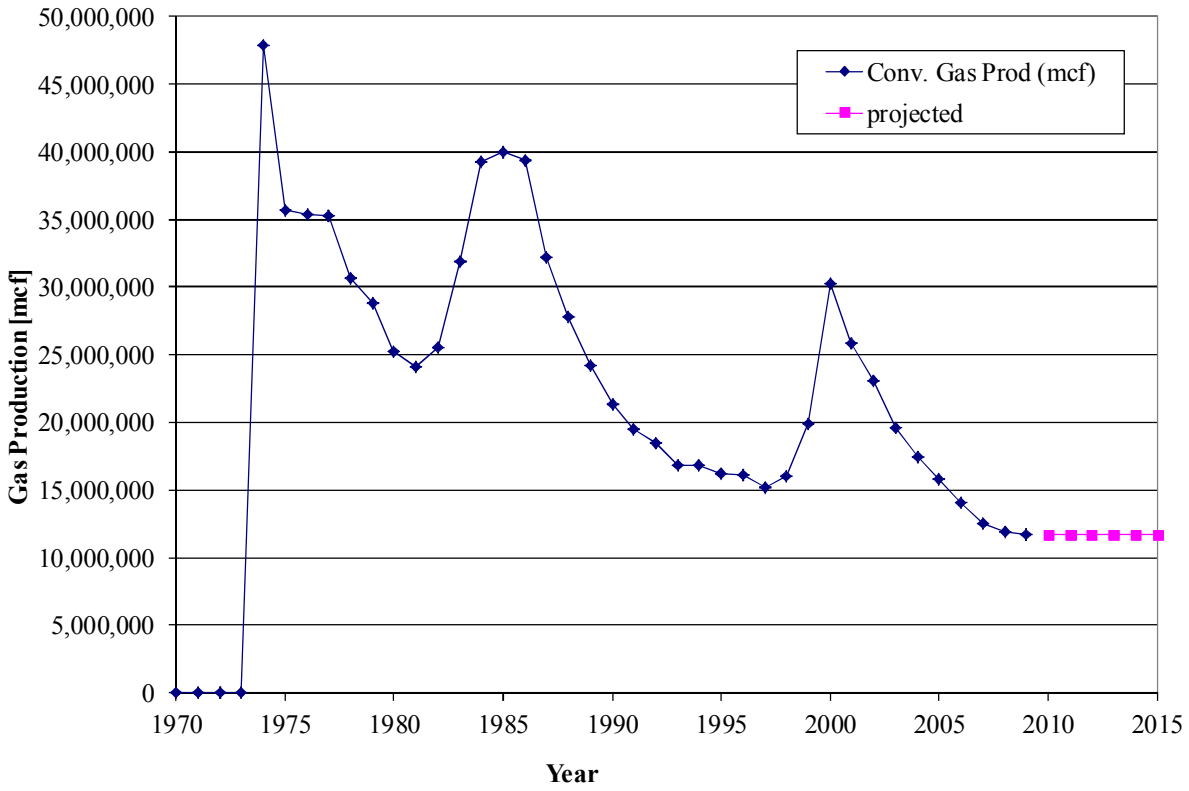


**Figure 18.** Conventional gas production historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [18]

Conventional gas production in Campbell County has been in a steady decline from a peak in 2000. Data from 2008 and 2009 suggest that the decline conventional gas production may be leveling off, and therefore this analysis conservatively assumed that conventional gas production would remain at 2009 levels through the period 2010-2015.

CBM Gas Production

CBM gas production in Campbell County in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 19, including projections to 2015.

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

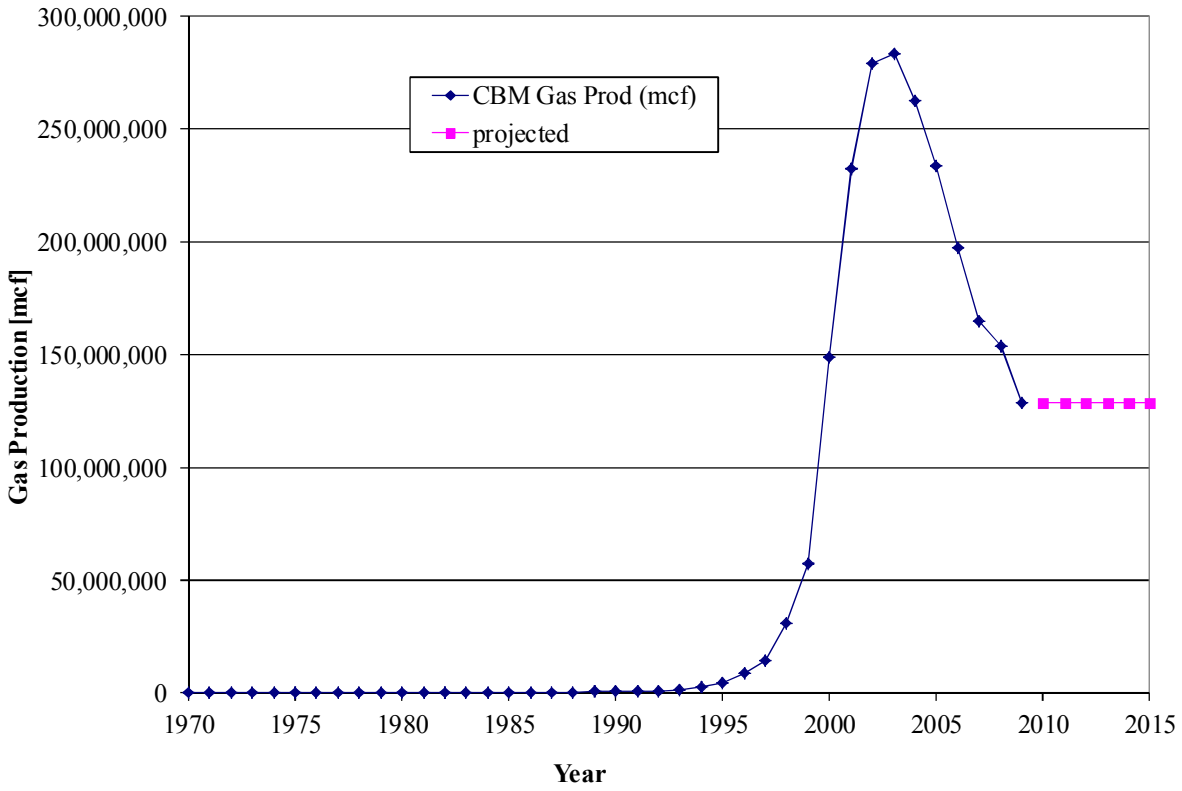


**Figure 19.** CBM gas production historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [19]

Similar to conventional gas production, CBM gas production in Campell County has been declining steadily from a peak in 2003. This analysis conservatively assumed that CBM gas production would remain at 2009 levels through the period 2010-2015.

Total Gas Production

The total gas production for Campbell County in the Powder River Basin in 2015 was developed by summing the projected conventional and CBM gas production, similar to the approach described above for Johnson and Sheridan Counties in Equation 2.

Oil Well Oil Production

Oil well oil production in Campbell County in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 20, including projections to 2015.

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

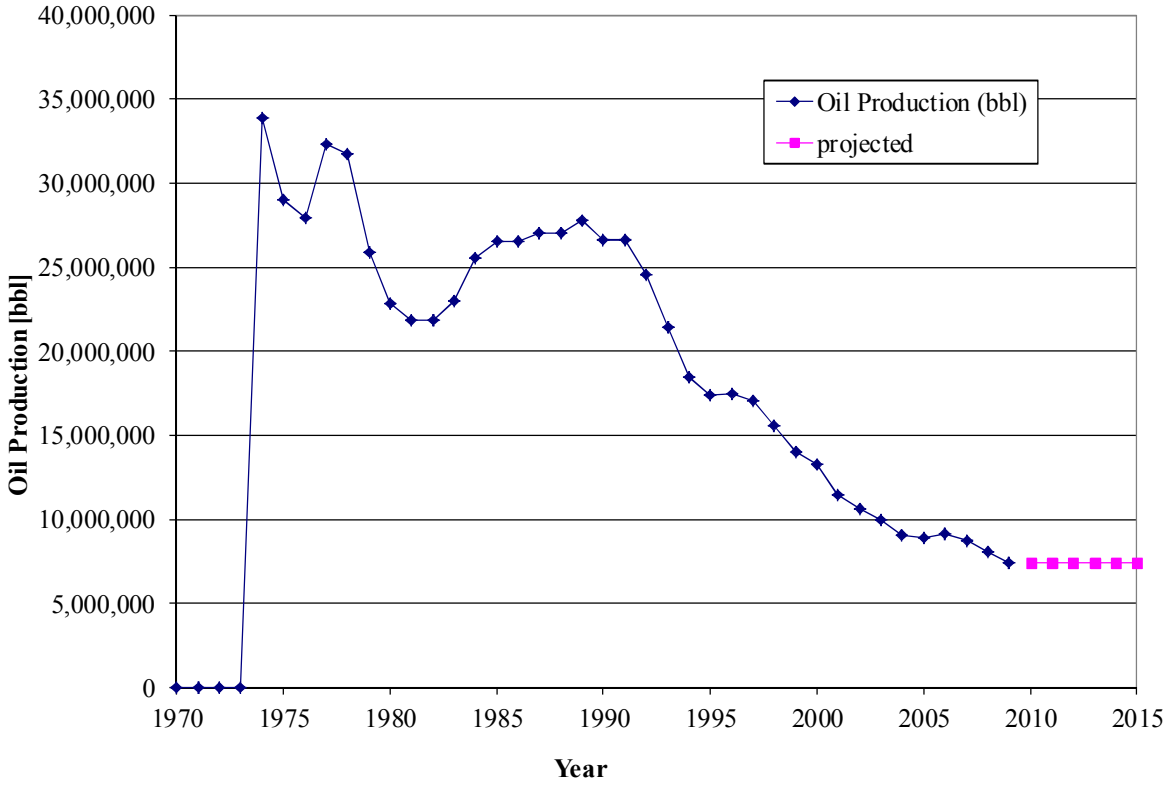


**Figure 20.** Oil production historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [20]

Oil production in Campbell County has been steadily decreasing since a peak in 1989. This analysis conservatively assumed that oil production would remain at 2009 levels through the period 2010-2015.

Condensate Production

Condensate production in Campbell County in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 21, including projections to 2015.

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

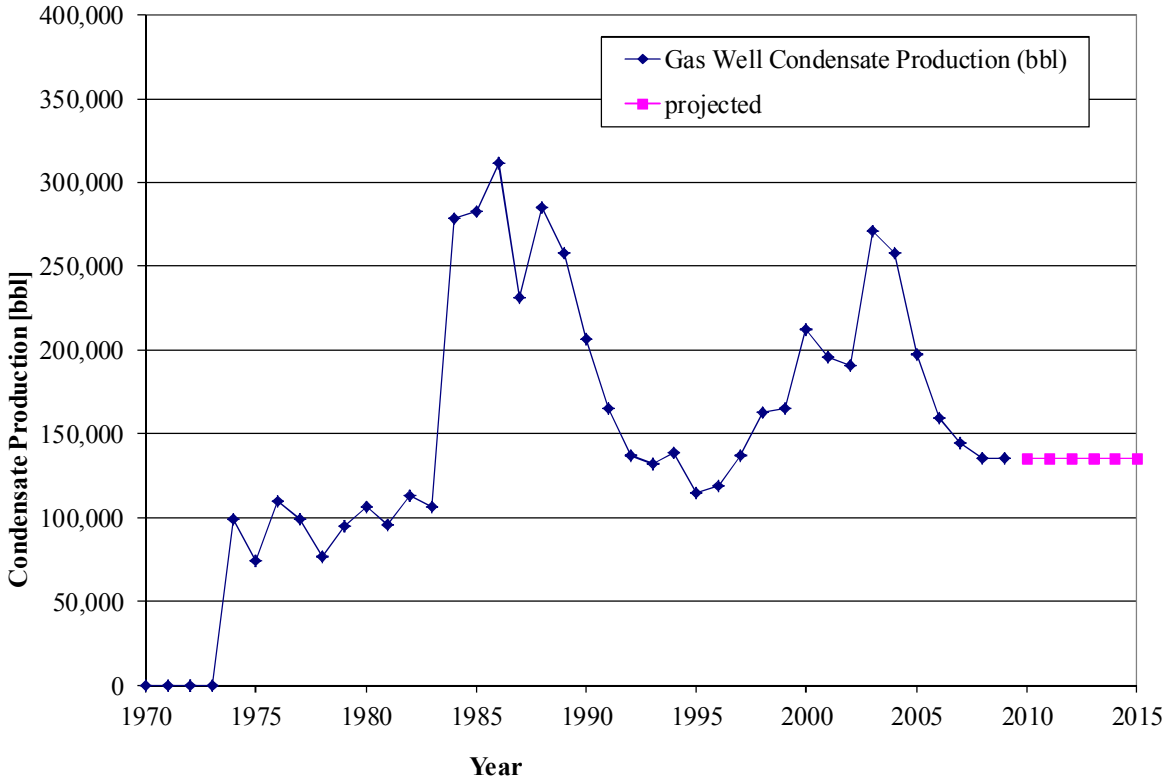


**Figure 21.** Condensate production historical data (from the IHS database) for Campbell County in the Powder River Basin and projections to 2015. [21]

Condensate production in Campbell County generally increased from the mid-1990's to a peak in 2003, and has since been steadily declining. This analysis conservatively assumed that condensate production remains at 2009 levels through the period 2010-2015.

Total Oil Production

The total oil production for Campbell County in the Powder River Basin in 2015 was developed by summing the projected oil well oil and condensate production, similar to the approach described above for Johnson and Sheridan Counties in Equation 3.

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

**Minor Counties**

The remaining counties in the Powder River Basin, including Crook, Niobrara and Weston in Wyoming and Big Horn and Powder River in Montana, were projected as a group since they collectively represent only a small fraction of oil and gas activity in the basin.

Conventional Well Counts

Conventional well counts in the minor counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 22, including projections to 2015.

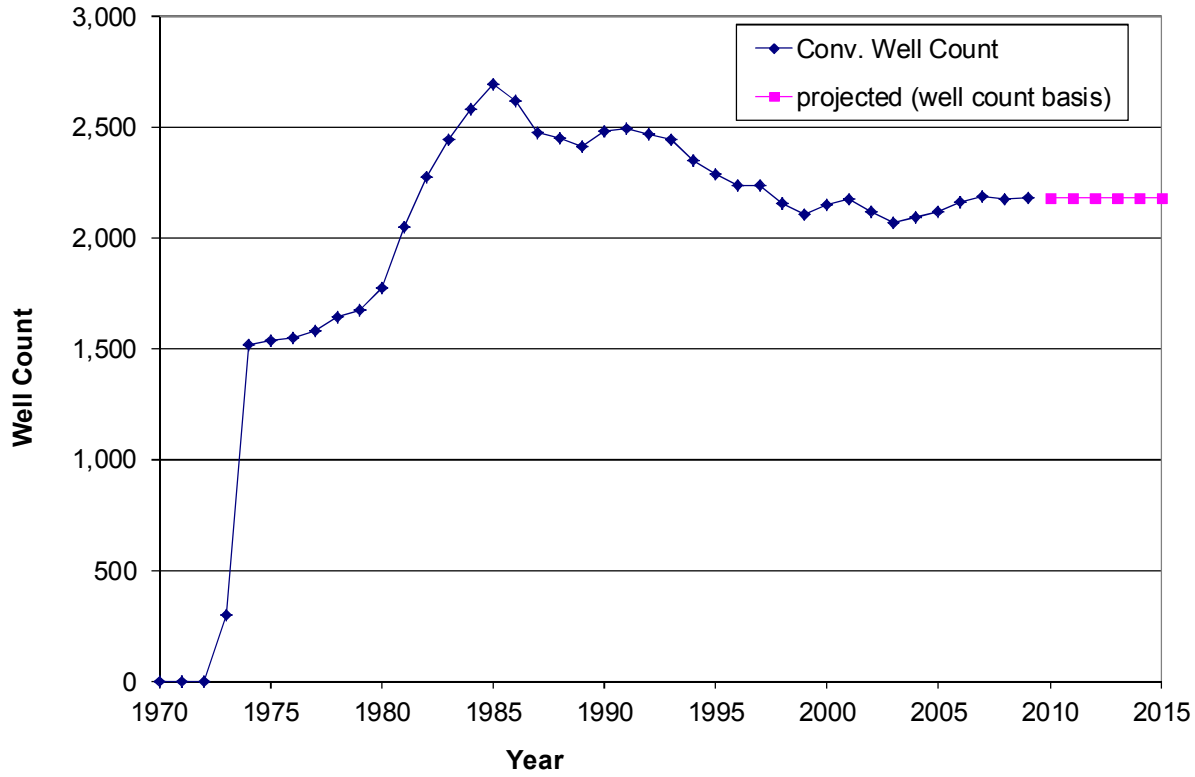


**Figure 22.** Conventional well count historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015. [22]

Conventional well counts in the minor counties in the Powder River Basin have been in a general decline since the mid-1980's. In the period 2000-2009, conventional well counts have been generally constant, with minor fluctuations. This analysis conservatively assumed that conventional well counts would remain at 2009 levels through the period 2010-2015.

CBM Well Counts

CBM well counts in the minor counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 23, including projections to 2015.

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

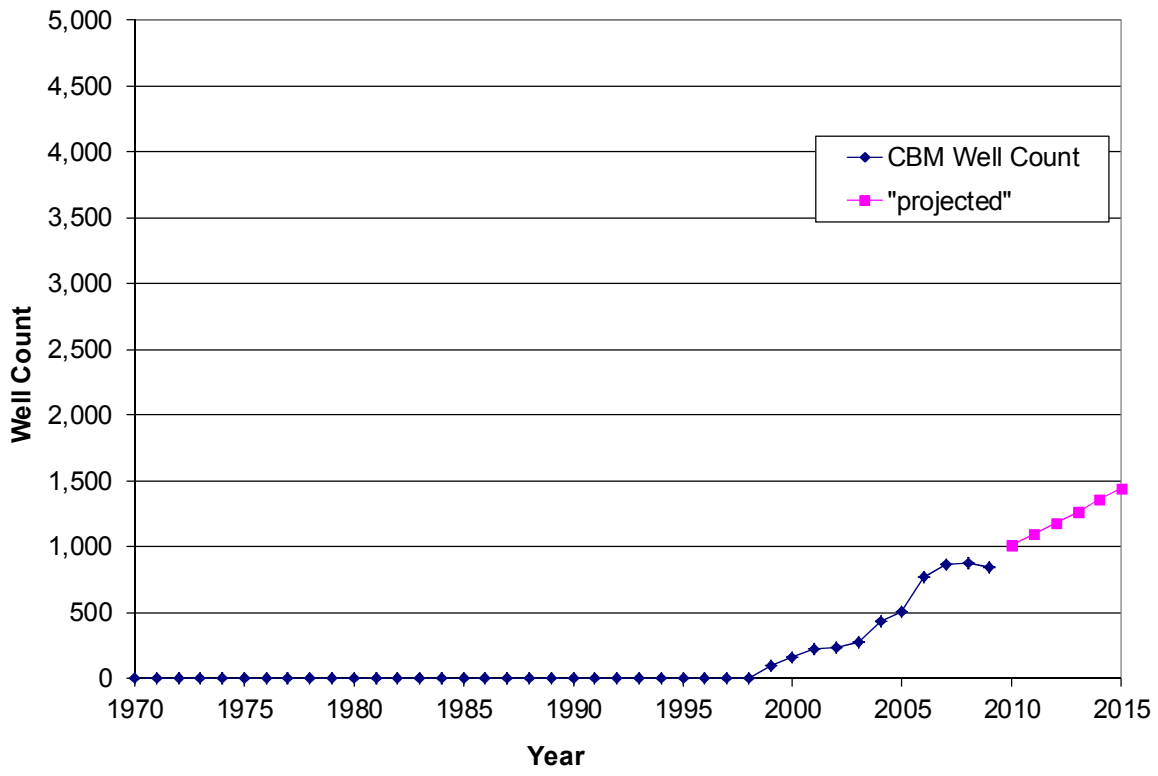


**Figure 23.** CBM well count historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015.[23]

CBM well counts in the minor counties in the Powder River Basin have been generally increasing in the period approximately from 1998-2009. CBM well counts were linearly projected based on the 1998-2009 data set for the period 2010-2015

Total Well Counts

The total well counts for the minor counties in the Powder River Basin in 2015 were developed by summing the projected conventional and CBM well counts, similar to the approach described above for Johnson and Sheridan Counties in Equation 1.

Spud Counts

Spud counts in the minor counties in the Powder River Basin have been plotted for the years 1970 – 2009 below in Figure 24, including projections to 2015.

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

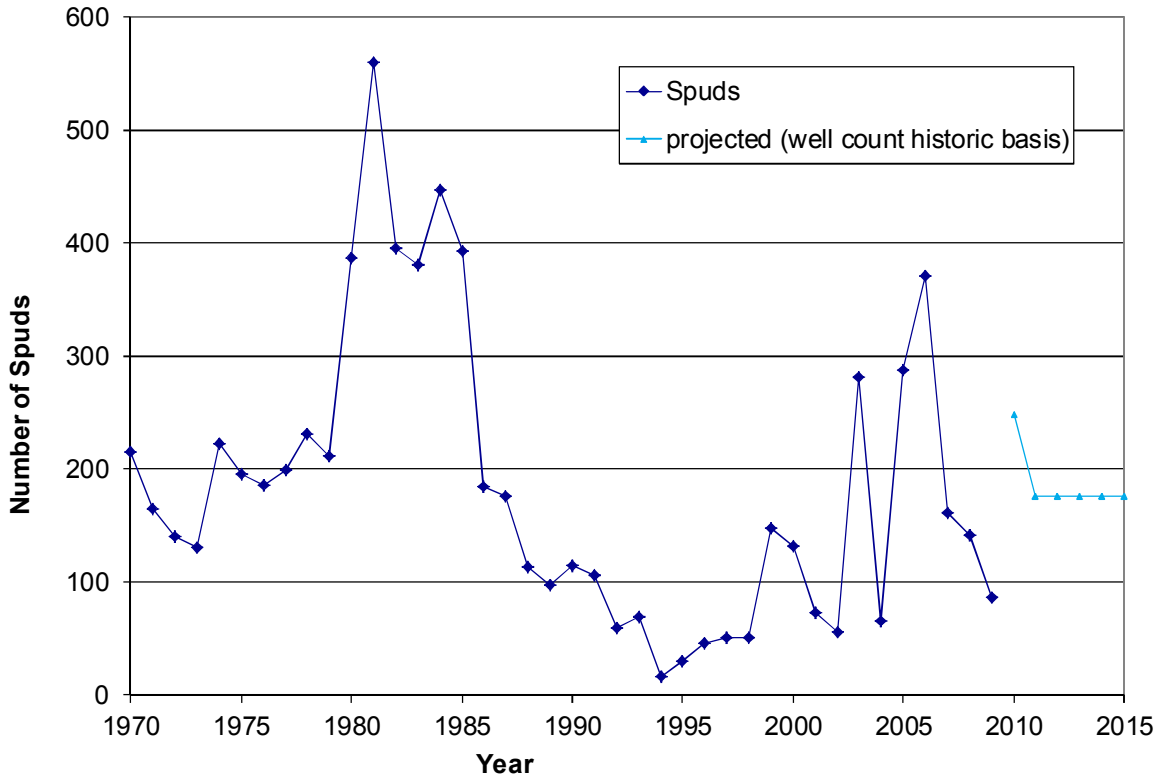


**Figure 24.** Spud count historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn and Powder River) in the Powder River Basin and projections to 2015. [24]

Historic spud counts in the minor counties in the Powder River Basin, as obtained from the IHS database for the period 1995-2009 are highly erratic and do not permit projections based on historic trends. For the period 1998-2009, the annual change in total well counts was determined, from which the annual number of spuds needed to meet a constant well count was determined. This annual spud count to meet constant well counts was added to the projected increase in total well counts to arrive at a value of total projected annual spuds (176 spuds/year).

Conventional Gas Production

Conventional gas production in the minor counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 25, including projections to 2015.

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

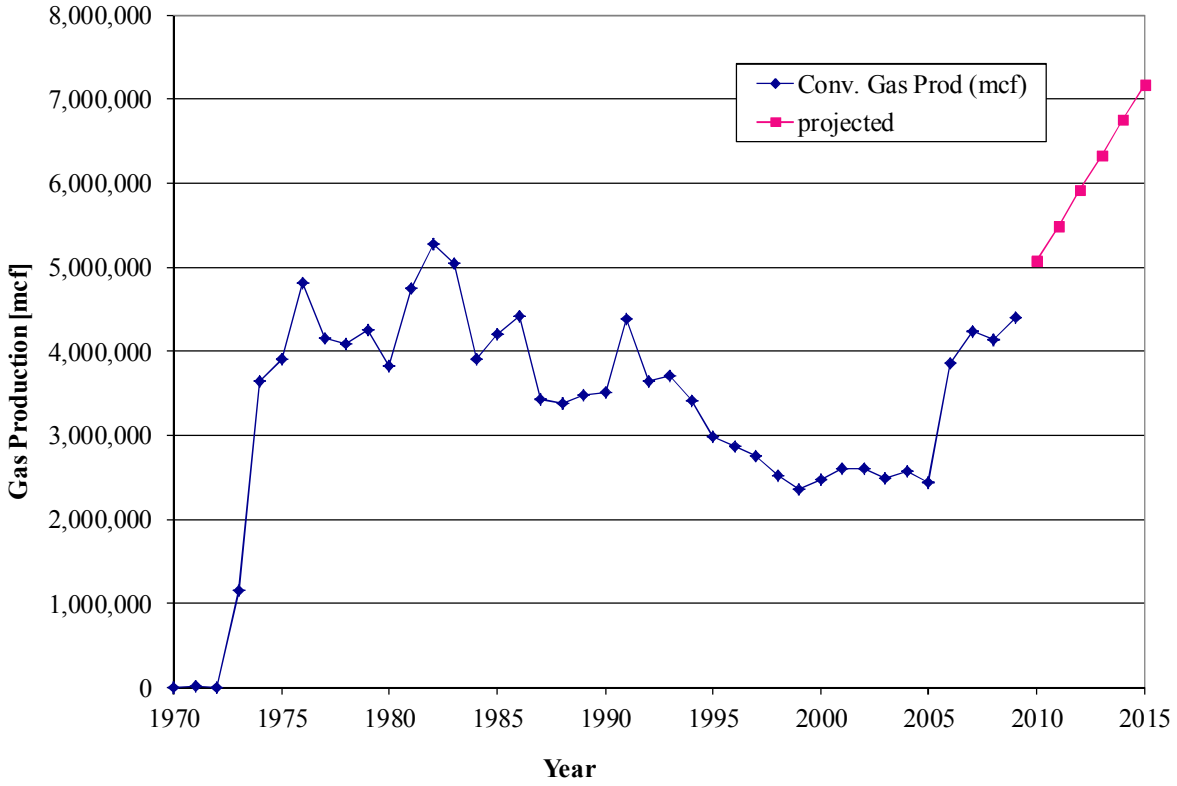


**Figure 25.** Conventional gas production historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015. [25]

Conventional gas production in minor counties has experienced some growth between 2005-2009, after a period of decline from the early 1990's to 2000. This analysis conservatively assumed that conventional gas production would continue to increase with a linear projection from 2009 levels through the period 2010-2015.

CBM Gas Production

CBM gas production in the minor counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 26, including projections to 2015.

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

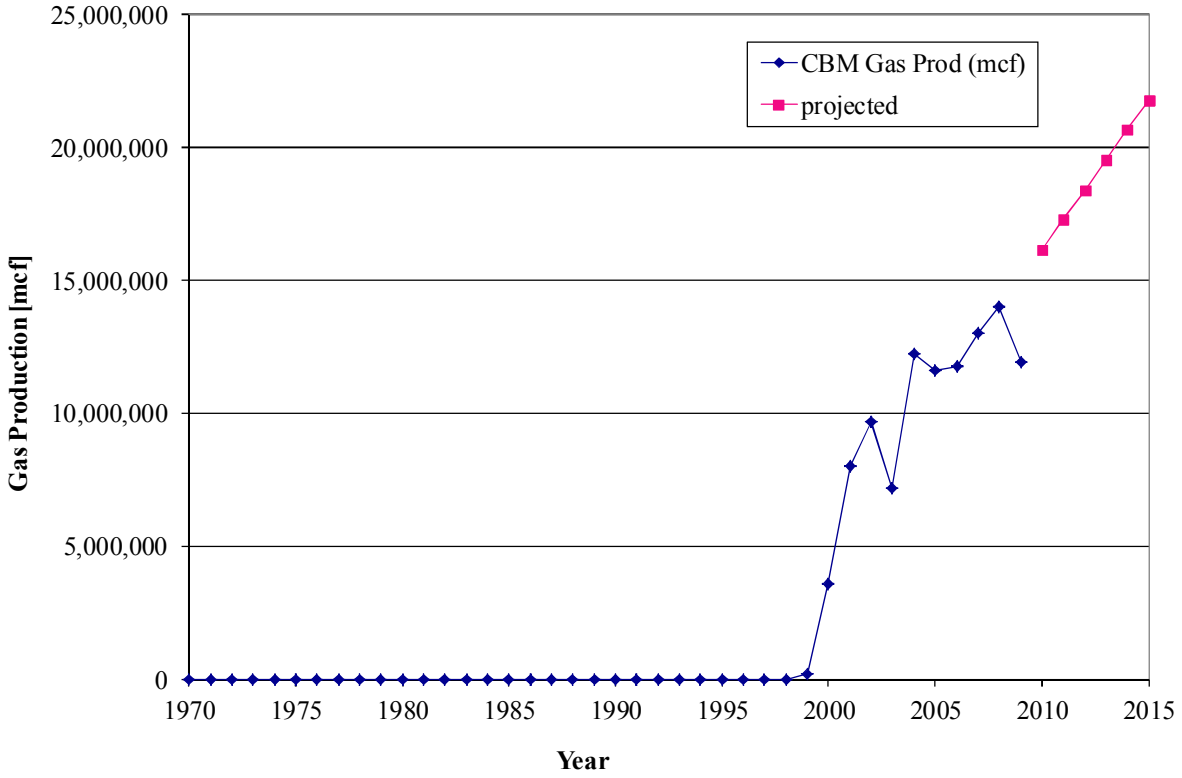


**Figure 26.** CBM gas production historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015. [26]

Similar to conventional gas production, CBM gas production in the minor counties in the Powder River Basin has experienced increases in the period 2000-2009. This analysis conservatively assumed that CBM gas production would continue to increase with a linear projection from 2009 levels through the period 2010-2015.

Total Gas Production

The total gas production for the minor counties in the Powder River Basin in 2015 was developed by summing the projected conventional and CBM gas production, similar to the approach described above for Johnson and Sheridan Counties in Equation 2.

Oil Well Oil Production

Oil well oil production in the minor counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 27, including projections to 2015.

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

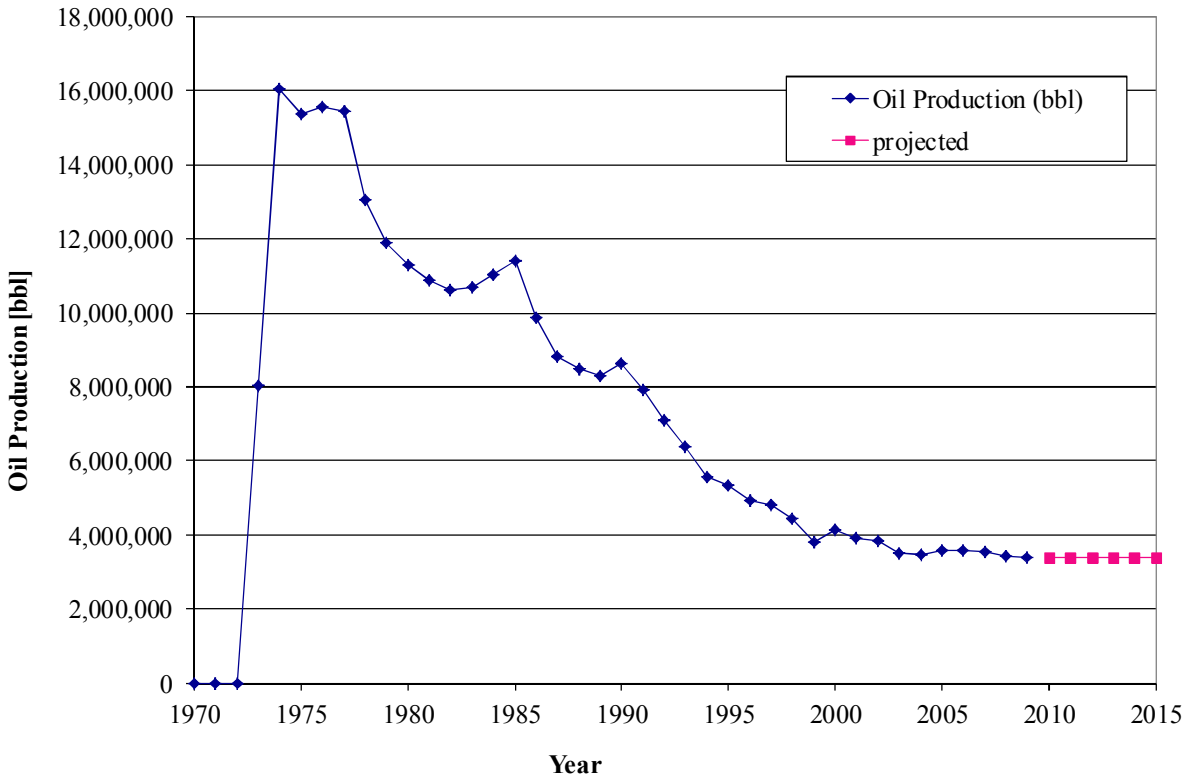


**Figure 27.** Oil production historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015.[27]

Oil production in the minor counties in the Powder River Basin has been generally decreasing since a peak in the mid-1970's. This analysis conservatively assumed that oil production would remain at 2009 levels through the period 2010-2015.

Condensate Production

Condensate production in the minor counties in the Powder River Basin has been plotted for the years 1970 – 2009 below in Figure 28, including projections to 2015.

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

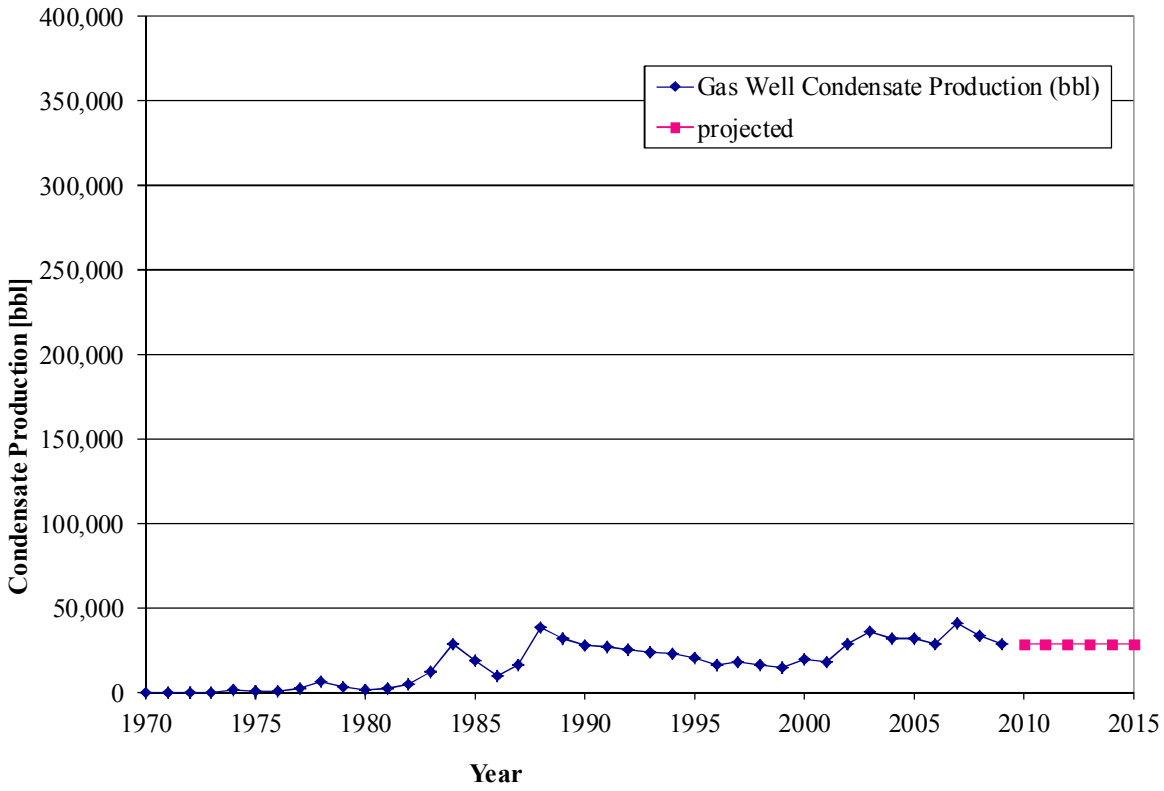


**Figure 28.** Condensate production historical data (from the IHS database) for minor counties (Crook, Niobrara, Weston, Big Horn, Powder River) in the Powder River Basin and projections to 2015. [28]

Condensate production in the minor counties in the Powder River Basin has been generally constant at below 50,000 bbl/year since the mid-1980's. This analysis conservatively assumed that condensate production remains at 2009 levels through the period 2010-2015.

Total Oil Production

The total oil production for minor counties in the Powder River Basin in 2015 was developed by summing the projected oil well oil and condensate production, similar to the approach described above for Johnson and Sheridan Counties in Equation 3.

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

## SCALING FACTOR DEVELOPMENT AND UNCONTROLLED 2012 EMISSIONS

Scaling factors were generated for the Powder River Basin geographic groupings described above, for each parameter considered here: total well counts, conventional gas well counts, spud count, total gas production, CBM gas production, condensate production, oil well oil production and total oil production. These are presented for each county below, and it is noted for geographic groupings comprised of more than one county 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 2006 is the scaling factor for that parameter for purposes of this projection. This is shown in Equation 4 below:

Equation (4) $$f_{i,j} = W_{i,j,2015} / W_{i,j,2006}$$

where:

$f_{i,j}$ is the scaling factor for geographic grouping $j$ in the Powder River Basin for parameter $i$ (total well count, conventional gas well count, spud count, total gas production, CBM gas production, total oil production, condensate production, oil well oil production)

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

$W_{i,j,2012}$ 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 Powder River Basin are presented in Table 2 below.

**Table 2.** Scaling factors for the eight parameters used in the projection analysis for all counties in the Powder River Basin.

| County | Total Well Count | Conv. Well Count | Spud Count | Total Gas Production | CBM Gas Production | Total Oil Production | Condensate Production | Oil Well Oil Production |
|---|---|---|---|---|---|---|---|---|
| Campbell (WY) | 0.94 | 1.01 | 0.74 | 0.66 | 0.65 | 0.81 | 0.84 | 0.81 |
| Converse (WY) | 0.92 | 0.92 | 1.26 | 0.82 | 0.37 | 1.47 | 1.04 | 1.50 |
| Crook (WY) | 1.24 | 1.01 | 0.48 | 1.86 | 1.85 | 0.95 | 0.98 | 0.95 |
| Johnson (WY) | 2.40 | 1.38 | 0.88 | 3.84 | 3.85 | 0.91 | 0.79 | 0.91 |
| Natrona (WY) | 0.92 | 0.92 | 1.26 | 0.82 | 0.37 | 1.47 | 1.04 | 1.50 |
| Niobrara (WY) | 1.24 | 1.01 | 0.48 | 1.86 | 1.85 | 0.95 | 0.98 | 0.95 |
| Sheridan (WY) | 2.40 | 1.38 | 0.88 | 3.84 | 3.85 | 0.91 | 0.79 | 0.91 |
| Weston (WY) | 1.24 | 1.01 | 0.48 | 1.86 | 1.85 | 0.95 | 0.98 | 0.95 |
| Big Horn (MT) | 1.24 | 1.01 | 0.48 | 1.86 | 1.85 | 0.95 | 0.98 | 0.95 |
| Powder River (MT) | 1.24 | 1.01 | 0.48 | 1.86 | 1.85 | 0.95 | 0.98 | 0.95 |

## CONTROLLED 2012 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 Powder River 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) | US EPA | Phase in from 2008 - 2011 | Control factors developed considering the specific composition of engines in the inventory (described in more detail below). |
| New or Relocated Stationary Engines | WYDEQ BACT Requirements for New or Relocated Stationary Engines | WYDEQ | 2012 | Control factors developed considering the specific composition of engines in the inventory (described in more detail below). |
| Pneumatic Devices | WYDEQ BACT Requirements for Pneumatic Devices | WYDEQ | 2010 | New or added pneumatic devices assumed to be low- or no-bleed |
| Pneumatic Pumps | WYDEQ BACT Requirements for NG-Operated Pumps | WYDEQ | 2010 | 98% control of all emissions or pump vent streams must be routed into a closed loop system. Conventional gas production projected to decline therefore no control factor assumed. |
| Dehydrators | WYDEQ BACT Requirements for Dehydrators | WYDEQ | 2010 | 98% control of dehydrator emissions if uncontrolled emissions > 8TPY. Conventional gas production projected to decline and negligible VOC emissions from CBM wells therefore no control factor assumed. |
| Tank Flashing | WYDEQ BACT Requirements for Condensate and Oil Tanks | WYDEQ | 2010 | 98% control of tank flashing emissions if uncontrolled emissions > 8TPY. Minimal condensate production in Powder River Basin and oil tank emissions unlikely to trigger control requirement, therefore no control factor assumed. |

| Source Category | Regulation | Enforcing Agency | Effective Date | Implementation in the 2012 Powder River Basin Emissions Projections |
|---|---|---|---|---|
| Blowdowns | Emissions shall be minimized to the extent practicable (WYDEQ, 2010). | WY DEQ | 2010 | Conservatively assumed no changes in emissions due to control in future years. Blowdowns that were controlled in the baseline 2006 inventory as captured in operator survey data are incorporated into 2015 emissions, but any decreases beyond those captured in the 2006 survey are difficult to quantify and are therefore not incorporated. |
| Well Completions | Green completion permits must be obtained (WYDEQ, 2010). | WY DEQ | 2010 | Conservatively assumed no changes in emissions due to control in future years. Completions that were controlled in the baseline 2006 inventory as captured in operator survey data are incorporated into 2015 emissions, but any decreases beyond those captured in the 2006 survey are difficult to quantify and are therefore not incorporated. |
| Produced Water Tanks | 98% control of produced water tank emissions when emissions ≥ 8 TPY VOC (WYDEQ, 2010). | WY DEQ | 2010 | Conservatively assumed no changes in emissions due to control in future years. |

**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 and Wyoming NOx BACT Requirements for Engines**

A combined analysis was undertaken to implement both the US EPA NSPS and the NOx BACT requirements for engines from the Wyoming DEQ, since both of these rules affect the same source category and had overlapping requirements in some cases. 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 for purposes of developing the 2015 emissions inventory. It is noted that in the Powder River Basin for some geographic groupings gas production is projected to increase and in other geographic groupings it is projected to decrease. Where gas production is projected to increase, NSPS and Wyoming BACT requirements were applied, similar to the assumptions made in developing projected emissions for other basins.

<u>NSPS Regulations</u>

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 engine fleet in the Powder River Basin. Engines were sorted into bins representing horsepower ranges based on the detailed compressor engine data gathered as part of the baseline 2006 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 2006-2012. For each year, the additional compression horsepower was sorted into the horsepower range bins, and NSPS was applied to these engines. Because of the Wyoming

BACT requirements for engines (described below), consideration was made of whether the Wyoming BACT requirement or the NSPS was more stringent for a given year and horsepower range, and the more stringent of these two requirements was applied.

Wyoming BACT Requirement for Engines

The Wyoming DEQ provided assumptions for modeling the NOx BACT requirements for engines in the Powder River Basin 2015 projected inventory. These assumptions indicated that new or modified engines would be required to meet a 2 g/bhp-hr NOx emission standard in 2007, and a 1 g/bhp-hr NOx emission standard in 2008 and beyond. Similar to the NSPS regulation, described above, the Wyoming BACT requirement for engines was assumed to apply only to the grown portion of compression emissions. Existing engines were assumed to not turn over during the period of this projection. As noted above, the more stringent of the NSPS and Wyoming BACT requirement for engines was applied.

## SUMMARY RESULTS

The scaling factors were applied to the baseline 2006 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.

Figure 29 and Table 7 show that NOx emissions are primarily concentrated in Campbell and Johnson Counties representing approximately 62% of total basin-wide NOx emissions. Additional significant NOx emissions occur in Converse, Natrona and Sheridan Counties. Figure 30 and Table 7 show that VOC emissions are primarily concentrated in Campbell County alone, representing approximately 46% of total basin-wide VOC emissions Additional VOC emissions are observed in Johnson and Natrona Counties. Given the high fraction of produced gas in the Powder River Basin that is CBM gas with a low VOC content, VOC emissions in the Powder River Basin are driven by compressor exhaust emissions and by the presence of conventional gas or oil production.

Consistent with the 2006 baseline emissions analysis, compressor engines remain the dominant NOx source category in the Powder River Basin, representing approximately 58% of total basin-wide NOx emissions as shown in Table 8. It is noted that drilling is projected to be lower in 2015 than in 2006 for most geographic groupings in the basin, therefore NOx emissions from compression are expected to become a more significant portion of the total basin-wide NOx emissions.

VOC emissions are divided among a number of source categories, similar to the 2006 baseline inventory for the basin as shown in Table 9. However compressor engine exhaust VOC emissions are still projected to be the dominant source category, representing a greater fraction of the total basin-wide VOC emissions in 2015 than in 2006. This is driven by the projected growth in gas production. Venting from pneumatic devices is observed to decrease as a percentage of total basin-wide VOC emissions in 2015 relative to 2006, from a combination of the increasing percentage of compressor VOC emissions and from controls requirements for pneumatic devices.

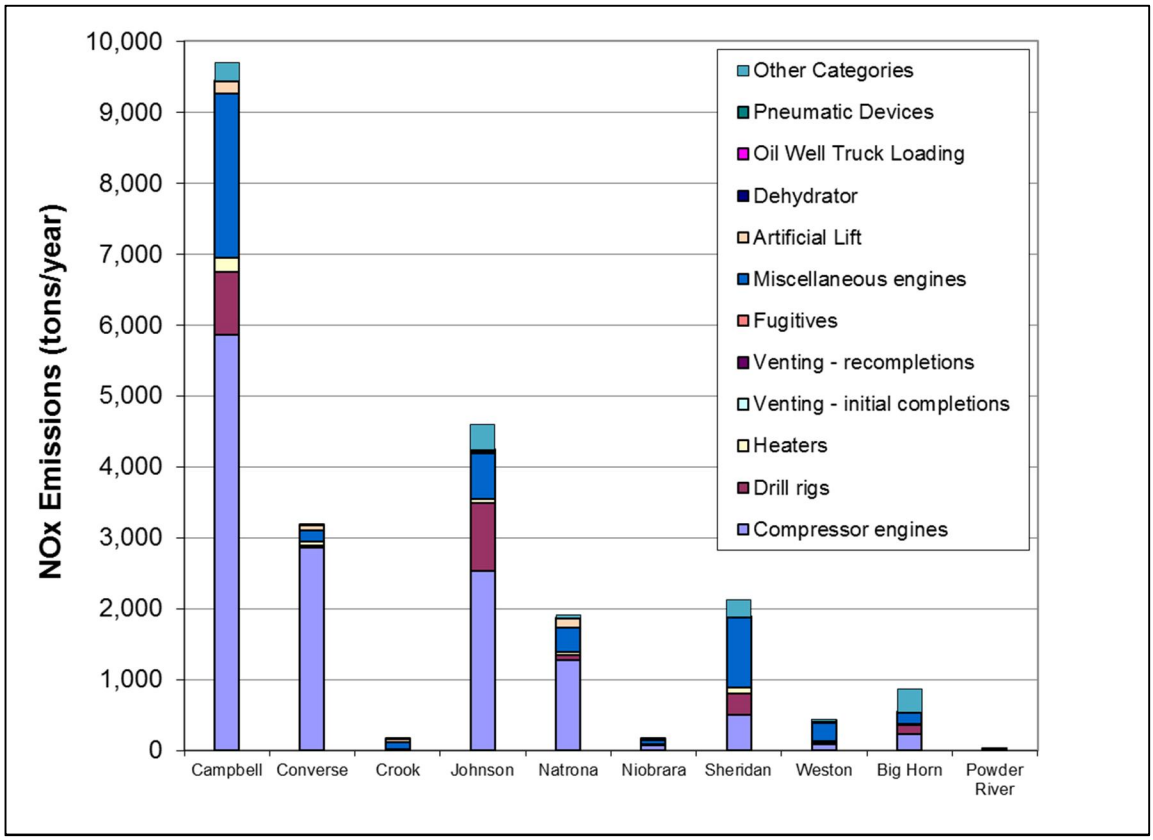


**Figure 29**. 2015 NOx emissions by source category and by county in the Powder River Basin.

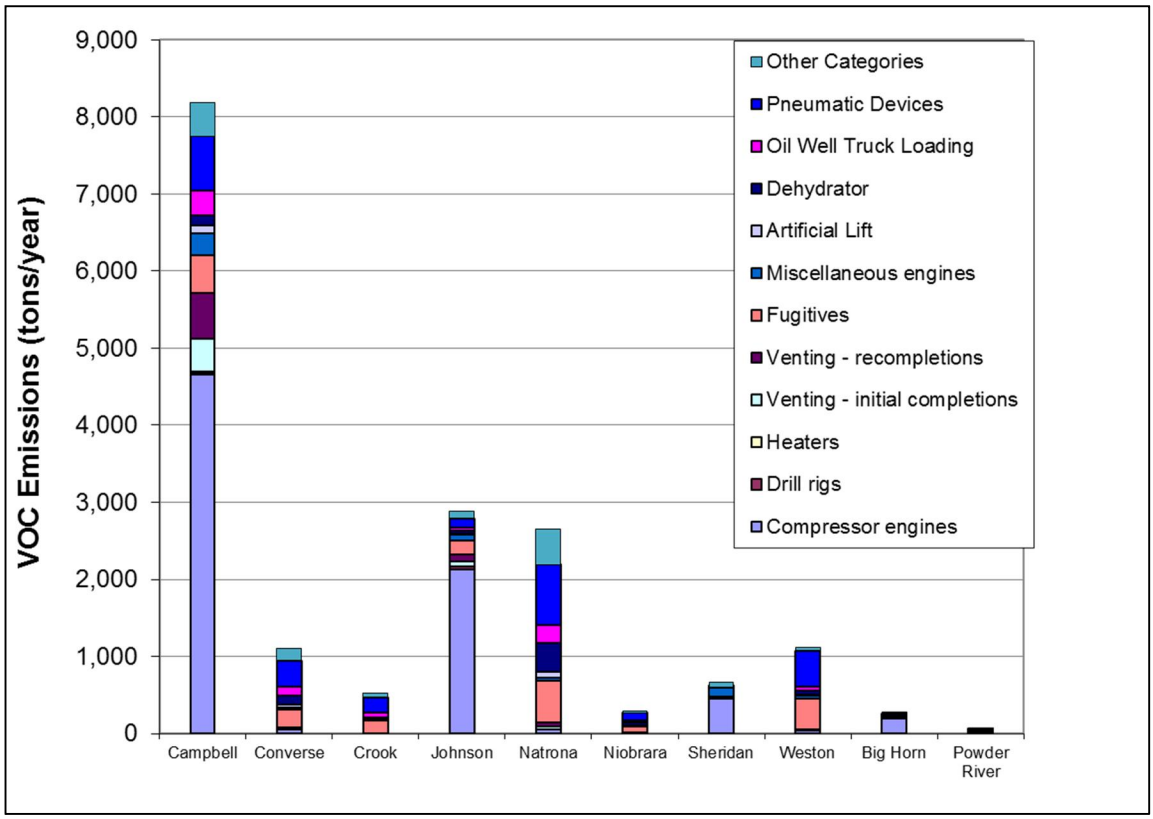


**Figure 30.** 2015 VOC emissions by source category and by county in the Powder River Basin.

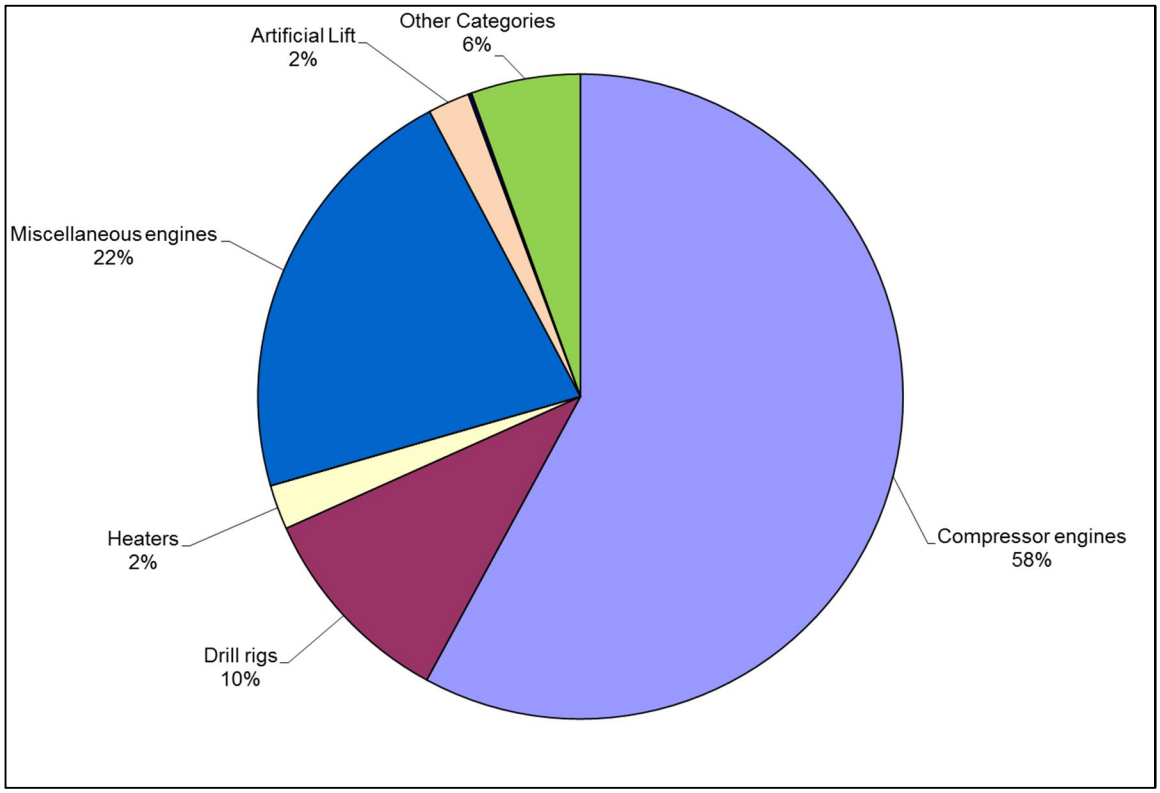


**Figure 31.** 2015 NOx emissions contributions by source category in the Powder River Basin.

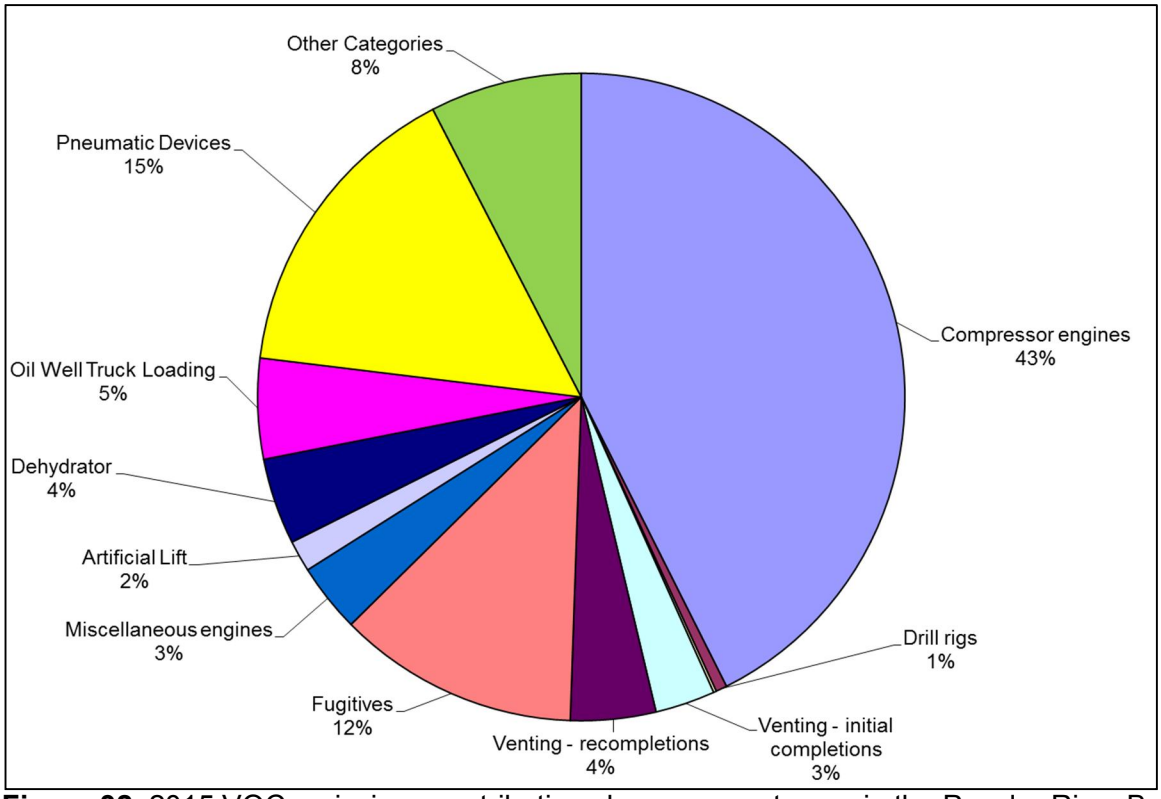


**Figure 32.** 2015 VOC emissions contributions by source category in the Powder River Basin.

**Table 7.** 2015 emissions of all criteria pollutants by county for the Powder River Basin.

| County | NOx [tons/yr] | VOC [tons/yr] | CO [tons/yr] | SOx [tons/yr] | PM [tons/yr] |
|---|---|---|---|---|---|
| Campbell (WY) | 9,701 | 8,189 | 10,641 | 236 | 284 |
| Converse (WY) | 3,184 | 1,108 | 1,044 | 15 | 20 |
| Crook (WY) | 163 | 523 | 151 | 10 | 13 |
| Johnson (WY) | 4,594 | 2,886 | 3,323 | 99 | 129 |
| Natrona (WY) | 1,903 | 2,648 | 1,066 | 33 | 45 |
| Niobrara (WY) | 162 | 295 | 236 | 5 | 7 |
| Sheridan (WY) | 2,118 | 666 | 2,278 | 113 | 127 |
| Weston (WY) | 432 | 1,119 | 493 | 25 | 28 |
| Big Horn (MT) | 869 | 276 | 2,376 | 20 | 32 |
| Big Horn (Nontribal) | 548 | 227 | 2,201 | 19 | 31 |
| Big Horn (Tribal) | 321 | 49 | 176 | 1 | 2 |
| Powder River (MT) | 22 | 69 | 23 | 1 | 2 |
| **Totals** | **23,149** | **17,779** | **21,630** | **558** | **686** |
| **Total Nontribal** | 22,828 | 17,730 | 21,455 | 557 | 684 |
| **Total Tribal** | 321 | 49 | 176 | 1 | 2 |

**Table 8.** 2015 NOx emissions by county and by source category for the Powder River Basin.

| County | Compressor Engines | Drill Rigs | Heaters | Miscellaneous Engines | Artificial Lift | Other Categories | Total |
|---|---|---|---|---|---|---|---|
| Campbell (WY) | 5,854 | 888 | 207 | 2,308 | 180 | 264 | 9,701 |
| Converse (WY) | 2,852 | 31 | 68 | 152 | 66 | 14 | 3,184 |
| Crook (WY) | 1 | 3 | 9 | 105 | 38 | 8 | 163 |
| Johnson (WY) | 2,536 | 949 | 55 | 654 | 25 | 375 | 4,594 |
| Natrona (WY) | 1,271 | 69 | 50 | 340 | 128 | 43 | 1,903 |
| Niobrara (WY) | 75 | 13 | 4 | 52 | 13 | 4 | 162 |
| Sheridan (WY) | 498 | 304 | 84 | 986 | 0 | 246 | 2,118 |
| Weston (WY) | 87 | 22 | 25 | 253 | 27 | 19 | 432 |
| Big Horn (MT) | 230 | 126 | 15 | 161 | 2 | 335 | 869 |
| Big Horn (Nontribal) | 230 | 125 | 14 | 153 | 0 | 25 | 548 |
| Big Horn (Tribal) | 0 | 0 | 1 | 8 | 2 | 310 | 321 |
| Powder River (MT) | 1 | 0 | 1 | 14 | 4 | 1 | 22 |
| **Totals** | **13,405** | **2,405** | **519** | **5,025** | **484** | **1,310** | **23,149** |
| **Total Nontribal** | **13,405** | **2,405** | **518** | **5,017** | **482** | **1,000** | **22,828** |
| **Total Tribal** | 0 | 0 | 1 | 8 | 2 | 310 | 321 |

**Table 9.** 2015 VOC emissions by county and by source category for the Powder River Basin.

| County | Compressor engines | Drill rigs | Venting - initial completions | Venting - recompletions | Fugitives | Miscellaneous engines | Artificial Lift | Dehydrator | Oil Well Truck Loading | Pneumatic Devices | Other Categories | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Campbell (WY) | 4,653 | 37 | 416 | 592 | 493 | 280 | 104 | 129 | 332 | 703 | 451 | 8,189 |
| Converse (WY) | 57 | 1 | 7 | 10 | 236 | 18 | 38 | 120 | 122 | 338 | 159 | 1,108 |
| Crook (WY) | 0 | 0 | 0 | 1 | 167 | 13 | 22 | 1 | 69 | 197 | 53 | 523 |
| Johnson (WY) | 2,129 | 39 | 63 | 89 | 176 | 79 | 14 | 36 | 46 | 117 | 96 | 2,886 |
| Natrona (WY) | 48 | 3 | 37 | 52 | 542 | 41 | 74 | 378 | 237 | 775 | 462 | 2,648 |
| Niobrara (WY) | 7 | 1 | 1 | 1 | 83 | 6 | 8 | 43 | 24 | 98 | 25 | 295 |
| Sheridan (WY) | 451 | 13 | 1 | 1 | 7 | 120 | 0 | 4 | 1 | 5 | 63 | 666 |
| Weston (WY) | 38 | 1 | 6 | 9 | 402 | 31 | 16 | 49 | 50 | 474 | 44 | 1,119 |
| Big Horn (MT) | 189 | 5 | 1 | 2 | 15 | 20 | 1 | 5 | 3 | 20 | 16 | 276 |
| Big Horn (Nontribal) | 189 | 5 | 1 | 2 | 1 | 19 | 0 | 5 | 0 | 1 | 5 | 227 |
| Big Horn (Tribal) | 0 | 0 | 0 | 0 | 14 | 1 | 1 | 0 | 3 | 19 | 11 | 49 |
| Powder River (MT) | 0 | 0 | 0 | 0 | 23 | 2 | 2 | 2 | 8 | 27 | 5 | 69 |
| **Totals** | **7,573** | **99** | **532** | **757** | **2,144** | **610** | **279** | **767** | **892** | **2,753** | **1,373** | **17,779** |
| **Total Nontribal** | **7,573** | **99** | **532** | **757** | **2,131** | **609** | **278** | **767** | **889** | **2,734** | **1,362** | **17,730** |
| **Total Tribal** | **0** | **0** | **0** | **0** | **14** | **1** | **1** | **0** | **3** | **19** | **11** | **49** |

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