

A Look Back and Forward at USGS Bakken-Three Forks Assessments

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INTRODUCTION

United States Geological Survey (USGS) assessments serve an important role in providing unbiased projections of the future remaining undiscovered, technically recoverable oil and gas resource potential of various regions throughout the United States and beyond. The assessments help guide both the oil and gas industry in making investment decisions as well as supporting infrastructure planning and development.

The first USGS Bakken assessment was completed in 1995 (Gautier et al., 1995), which was several years prior to the discovery of the Elm Coulee Field of eastern Montana during 2000. The first major assessment of the prolific Bakken unconventional play was completed by the USGS in 2008, shortly after the discovery and initial development of the Parshall Field in western North Dakota. The 2008 USGS Bakken assessment yielded a mean of 3.65 billion barrels of undiscovered, technically recoverable oil and 1.8 TCF (trillion cubic feet) of gas (figs. 1 and 2) (Pollastro et al., 2008; 2012), which will be discussed in more detail below. At

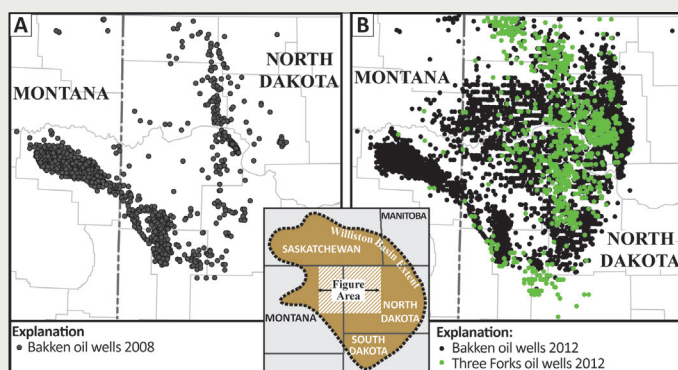
the time, this was the largest continuous oil assessment in the history of USGS assessments. This early assessment provided confidence in the size of the Bakken play not only for the oil and gas industry, but also to local and regional government officials making infrastructure plans as well as secondary businesses such as housing developers, hotels, restaurants, hospitals, etc. Due to limited production data and geologic information, the Three Forks Formation was not included in the 2008 assessment.

In 2013, the USGS completed a new assessment of the Bakken Formation, as well as the underlying Three Forks Formation, which developed into a prominent drilling target and resource following the 2008 assessment (Gaswirth and Marra, 2015). The addition of the Three Forks more than doubled the mean undiscovered, technically recoverable oil to 7.4 billion barrels from the 2008 to the 2013 assessment while gas more than tripled to 6.7 TCF (figs. 1 and 2) (Gaswirth and Marra, 2015). Presently there is a third pending continuous oil assessment by the USGS for the Bakken and Three Forks Formations. This article will provide insight into USGS assessment methodology and implications for the third pending assessment.

USGS ASSESSMENT METHODOLOGY

USGS assessments combine available geological data and information with historical oil and gas well production results to estimate future technically recoverable, undiscovered resources. The USGS has developed two separate assessment methodologies, one for conventional petroleum (oil and gas) resources (Schmoker and Klett, 2005) and a second for continuous (unconventional) petroleum resources (Charpentier and Cook, 2010). The Bakken and Three Forks Formations have been primarily assessed as continuous petroleum resources because both units lack a downdip oil-water contact which is characteristic of conventional oil and gas accumulations.

The USGS begins each continuous resource assessment by subdividing the resource play area into one or more assessment units



based upon the regional geology. Next, five factors are combined to calculate an approximate remaining undiscovered, technically recoverable resource for each assessment unit: 1) potential area of production, 2) average drainage area per well, 3) percent of area untested (undrilled), 4) success ratio (%), and 5) average well EUR (estimated ultimate recovery) (Eq. 1). The first four factors from the equation calculation combine to yield the number of future potential wells. The fifth factor, average well EUR, is the approximate total volume of oil and gas that a well could cumulatively produce. Distributions of values are created for each of the five factors (minimum, mode, and maximum) and a mean of each distribution is calculated. A Monte Carlo simulation is then utilized to create a distribution of resource amounts for each assessment unit, which includes: an F95 value (95 percent chance of producing at least the amount tabulated), a mean value (approximate average value), and an F5 value (5 percent chance of producing at least the amount tabulated). The mean calculated volumes of undiscovered, technically recoverable oil and/or gas are generally headlined within each assessment.

Equation 1.

USGS Continuous Resource Assessment Calculation:										
(Potential area of production)	÷	Average drainage area per well	×	Percent of area untested	×	Success ratio (%)	×	Average Well EUR*	=	Undiscovered technically recoverable resource

Monthly production volumes from existing wells are extrapolated to upwards of 60 years (720 months) of production, combined with a few probabilistic components, and used as analogs to estimate the production results from future, undrilled/uncompleted wells (Cook, 2013). The USGS assessments do not factor in the price of oil and/or gas when calculating average well production volumes, and therefore do not translate to oil and gas reserves. However, the assessments do apply a minimum well EUR cutoff of 2,000 barrels of oil, which means the average well within a given continuous oil assessment needs to be able to cumulatively produce at least 2,000 barrels of oil over the course of 60 years to be assessed.

REVIEW OF PREVIOUS USGS BAKKEN-THREE FORKS ASSESSMENTS

At the time of the 2008 Bakken assessment, approximately 1,200 wells had been drilled and completed in North Dakota and Montana (Pollastro et al., 2008; 2012) (fig. 1). The 2008 assessment yielded mean volumes of 3.65 billion barrels of oil (F95 and F5 values of 3.1 and 4.3 billion barrels) and 1.8 TCF of gas (F95 and F5 values of 1.0 and 3.0 TCF) for undiscovered, technically recoverable resource. Combining the mean values of assessment unit areas, cell sizes (well density/spacing), future success ratios, and % of untested areas, approximately 21,000* successful Bakken wells remained to be drilled and completed at the time of the first assessment (Pollastro et al., 2008; 2012). Subdividing the mean volumes of undiscovered, technically recoverable oil (3.65 billion barrels) and gas (1.8 TCF) by the 21,000* future projected wells, the average future Bakken well at the time of the first assessment was expected to ultimately produce approximately 174,000* barrels of oil and 86,000* MCF (thousand cubic feet) of gas.

The 2013 assessment used well and production data through the end of 2012, which included more than 6,600 Bakken (~5,000) and Three Forks (~1,600) wells that had been drilled and completed within the US portion of the Williston Basin, North Dakota and Montana (Gaswirth and Marra, 2015) (fig. 1). Approximately 5,000 of those Bakken-Three Forks wells were located in western North Dakota (NDOGD, 2019). Based upon combining mean values from the USGS assessment tables, there were approximately 38,000* successful Bakken (~18,000*) and Three Forks (~20,000*) horizontal wells remaining to be drilled and completed at the time of the second assessment. Subdividing the mean volumes of undiscovered, technically recoverable oil (7.4 billion barrels) and gas (6.7 TCF) by the 38,000* future projected wells, the average future Bakken-Three Forks well at the time of the second assessment was expected to ultimately produce approximately 195,000* barrels of oil and 176,000* MCF of gas.

DISCUSSION

One common misconception about USGS assessments is that their reported, published numbers include historical and future production from both existing and future wells. However, the term “undiscovered, technically recoverable resources” includes only the future production from either undrilled and/or uncompleted wells within a given play. The reported resource values do not include any production (historical or future) from the existing well inventory (active as well as inactive/plugged and abandoned). As soon as a well produces the first barrel of oil from a given formation being assessed, that well is considered a “discovered” resource for all its eventual cumulative production. The historical production data from the existing well inventory is only used to calculate estimated values for the future production from undrilled and/or uncompleted wells.

As noted, one set of values not directly reported in the USGS assessments is the past and future production from the existing well inventory, which could be referred to as the discovered, technically recoverable resource. Although the USGS does not directly report the discovered, technically recoverable (and

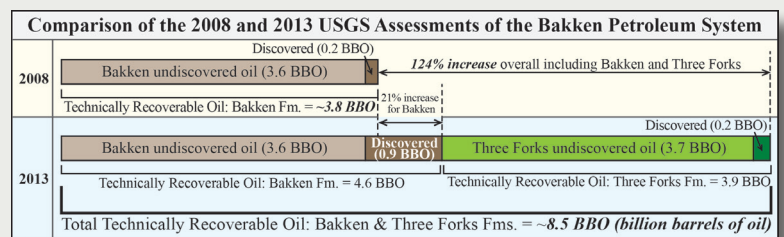


Figure 2. Comparison of the mean calculated oil volumes from the 2008 USGS Continuous Bakken Assessment and the 2013 USGS Continuous Bakken-Three Forks Assessment. The “undiscovered oil” volumes were directly reported by the USGS using their mean input values. The “Discovered” oil volumes were not directly reported in the USGS assessments but were back calculated by the author utilizing mean input volumes published in the USGS assessment tables. Discovered, Technically Recoverable Oil = historical and future production from the existing inventory of drilled and completed wells at the time of a given assessment; Undiscovered, Technically Recoverable Oil = future production from undrilled and/or uncompleted wells at the time of the a given assessment.

*Noted values above are not directly reported in the USGS Bakken-Three Forks assessments. Instead, the noted values above were calculated by the author using various mean values extracted from the published assessment tables.

recovered) resource, the volumes can be back calculated from their assessment summary tables. At the time of the first Bakken assessment, only ~1,200 wells had been drilled and completed, which amounted to approximately 200 million barrels of discovered, technically recoverable and recovered oil (fig. 2). Combining that with the undiscovered, technically recoverable oil, the first USGS continuous assessment indicated that the Bakken Formation would eventually cumulatively produce approximately 3.8 billion barrels of oil using the mean assessment values (fig. 2). At the time of the 2013 assessment, the mean undiscovered, technically recoverable volume of oil for the Bakken was approximately the same at 3.65 billion barrels. However, the discovered, technically recoverable oil had increased to approximately 0.9 billion barrels owing to the addition of more than 4,000 horizontal Bakken wells being drilled and completed (fig. 2). Therefore, the combined total of mean discovered and undiscovered, technically recoverable oil for the Bakken increased from approximately 3.8 to 4.6 billion barrels of oil between the first two assessments. Additionally, the upper Three Forks was added in for the second assessment, which added mean volumes of 3.7 (undiscovered) and 0.2 (discovered) billion barrels of technically recoverable oil.

As a result of continuing development in the play, the number of remaining undrilled Bakken and Three Forks wells has likely decreased since the time of the last assessment. Through the end of 2019, more than 15,000 Bakken and Three Forks wells had been drilled and completed in North Dakota alone (NDOG, 2019). This represents an increase of approximately 10,000 Bakken-Three Forks wells that have been drilled and completed since the time of the last assessment. Both the past and future production of those ~10,000 wells counted as undiscovered, technically recoverable resource in the 2013 Bakken-Three Forks assessment, but will not be considered undiscovered in the present assessment as the USGS removes the tested area from each assessment. Therefore, a decrease in the remaining undrilled well inventories may cause the volume of **undiscovered**, technically recoverable oil to decrease in the Bakken and Three Forks Formations.

While the number of drilled and completed Three Forks wells has substantially increased since the 2013 assessment, additional resource may be present in the unit that was not fully realized at the time of the last assessment. The Three Forks Formation has three distinct stacked reservoir targets that are informally referred to as the upper, middle, and lower members, or alternatively as the 1st, 2nd, and 3rd benches by some operating companies (Nesheim, 2019a). The upper Three Forks (1st bench) developed into a prominent exploration and development target following the 2008 USGS Bakken assessment, and therefore was focused on in the 2013 assessment. Meanwhile, operating companies did not start drilling and testing the middle and lower Three Forks (2nd and 3rd benches) until late 2012 to early 2013 (Nesheim, 2020a; Nesheim 2021). Consequently, there was minimal production data and limited geological information publicly available at the time of the last assessment for the middle and lower Three Forks. The 2013 USGS Bakken-Three Forks assessment did note activity in those units but primarily focused on examining and evaluating the upper Three Forks (Gaswirth and Marra, 2015).

Since the time of the 2013 USGS assessment, more than 270 spatially dispersed, horizontal wells have been drilled and completed in the middle Three Forks and another 40+ in the lower Three Forks (Nesheim, 2020b). Several sets of geological data indicate viable oil resource in both units, such as elevated oil saturation trends from core-plug analyses which correlate with water-cut variations from productive wells (Nesheim, 2018; 2019b). In addition, most of the middle and lower Three Forks wells drilled and completed now have several years of production with cumulative produced oil volumes on the order of 10,000's to 100,000's of barrels of oil (Nesheim, 2020c), which exceeds the 2,000 barrels of oil per well minimum cutoff. Future assessments of the middle and lower Three Forks, as well as a significant increase in average well EUR, could offset a potential decrease in the undrilled/uncompleted well inventories of the Middle Bakken and upper Three Forks.

REFERENCES

- Charpentier, R.R., and Cook, T.A., 2010, Improved USGS methodology for assessing continuous petroleum resources: U.S. Geological Survey Data Series 547, 22 p. and program: <http://pubs.usgs.gov/ds/547/>
- Cook, T.A., 2013, Procedure for calculating estimated ultimate recoveries of Bakken and Three Forks Formations horizontal wells in the Williston Basin: U.S. Geological Survey Open-File Report 2013-1109, 14 p., <http://pubs.usgs.gov/of/2013/1109/>.
- Gaswirth, S.B., and Marra, K.R., 2015, U.S. Geological Survey 2013 assessment of undiscovered resources in the Bakken and Three Forks Formations of the U.S. Williston Basin Province: AAPG Bulletin, v. 99, no. 4, pp. 639-660.
- Gautier, D. L., G. L. Dolton, K. I. Takahashi, and K. L. Varnes, eds., 1995 National assessment of United States oil and gas resources: Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series 30.
- Nesheim, T.O., 2018, Examination of Oil Saturations and Horizontal Well Production for the Middle and Lower Three Forks Formation: North Dakota Geological Survey, Geological Investigations no. 205, 23 pp.
- Nesheim, T.O., 2019a, Revisiting Stratigraphic Nomenclature for the Three Forks Formation in western North Dakota: North Dakota Geological Survey, Geological Investigations no. 225, 6 pp, 1 plate.
- Nesheim, T.O., 2019b, Examination of downward hydrocarbon charge within the Bakken-Three Forks petroleum system – Williston Basin, North America: Marine and Petroleum Geology, v. 104, p. 346-360.
- Nesheim, T.O., 2020a, History of Exploration and Development in the Middle Three Forks (2nd Bench): North Dakota Department of Mineral Resources, Geo News, v. 47, no. 2, p. 18-20.
- Nesheim, T.O., 2020b, Preliminary Middle and Lower Three Forks (2nd bench) Horizontal Well Identification: North Dakota Geological Survey, Geological Investigations no. 244, 8 pp.
- Nesheim, T.O., 2020c, Evaluation of Water-Cut from Middle and Lower Three Forks Production (2nd and 3rd benches), Western North Dakota: North Dakota Geological Survey, Geological Investigations no. 245, 18 pp.
- Nesheim, T.O., 2021, Overview of Development History and Future Potential for the lower Three Forks Formation (3rd bench): Bakken-Three Forks Petroleum System: North Dakota Department of Mineral Resources, Geo News, v. 48, no. 1, p. 24 - 28
- North Dakota Oil and Gas Division (NDOG), 2019, North Dakota Cumulative Oil Production by Formation through December 2019: <https://www.dmr.nd.gov/oilgas/stats/2019CumulativeFormation.pdf> (retrieved June 1st, 2021).
- Pollastro, R.M., Roberts, L.N.R., Cook, T.A., and Lewan, M.D., 2008, Assessment of undiscovered technically recoverable oil and gas resources of the Bakken Formation, Williston Basin, Montana and North Dakota, 2008: U.S. Geological Survey Open-File Report 2008-1353, 3 sheets.
- Pollastro, R. M., L. N. R. Roberts, and T. A. Cook, 2012, Geologic model for the assessment of technically recoverable oil in the Devonian – Mississippian Bakken Formation, Williston Basin, in J. A. Breyer, ed., Shale reservoirs—Giant resources for the 21st century: AAPG Memoir 97, p. 205 – 257.
- Schmoker, J.W., and Klett, T.R., 2005, U.S. Geological Survey Assessment Concepts for Conventional Petroleum Accumulations: in Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah - U.S. Geological Survey Digital Data Series DDS-69-D, 6 p.