Miles City Field Office

Resource Management Plan (RMP)
and
Environmental Impact Statement (EIS)

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO FOR FLUID MINERALS

Prepared for:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
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Shared Lands ~
Shared Plan

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SUMMARY

Areas within the Miles City Field Office (MCFO) Resource Management Plan (RMP) area that are considered to have high potential for oil and gas occurrence are located within the Powder River Basin (PRB), the Cedar Creek Anticline, and in the northeastern portion of the Montana Williston Basin Area (NE Williston Basin) (Figure 2-2). The PRB area contains Coal Bed Natural Gas (CBNG) reserves within the Lower Tertiary sedimentary rocks, while the Cedar Creek Anticline and the northeastern Williston Basin area contain oil and gas reserves in various formations from the Cambrian Deadwood Formation to the upper Cretaceous Eagle Formation. The NE Williston Basin and Cedar Creek Anticline contain two of the most active oil and gas producing regions in Montana, while CBNG development is making the PRB one of the largest natural gas producing regions in Montana.

Historically, the Cedar Creek Anticline and the NE Montana Williston Basin areas have experienced the majority of drilling and development activity in the RMP area. The number of current producing wells in each sub region of the RMP area is included in Table 4-3. There are currently approximately 4,015 producing wells in the MCFO RMP area according to the MBOGC database as of the end of the year 2004. Of those 4,015 wells, 76% or 2,865 of those wells are located within the Williston Basin Geologic area; this includes 1,555 producing wells from the Cedar Creek Anticline. The Powder River Basin contains 976 producing wells as of the end of the year 2004.

Natural gas and oil prices are currently over $6/mcf and $50/bbl, respectively; both values are considerably higher than they have historically been. The DOE EIA predicts a decrease in both prices over the next 10 years. If this comes to pass, this would likely result in slightly slower development than if current high price trends continue.

Within the Montana portion of the PRB, it was estimated (BLM, 2003) that between 220 and 970 new conventional oil and gas wells could be drilled in the next 20 years, with 53 to 220 of these wells producing from Federal (BLM administered) minerals. In addition, between 5,485 and 15,635 CBNG wells could be drilled in the next 20 years of which 4,895 to 14,072 are estimated to be producing wells, with 2,420 to 6,954 producing wells completed on Federal minerals. Table 6-1 presents a summary of the predicted number of wells drilled by producing area broken down by mineral ownership. Tables 8-1 and 8-2 present the level of development and the associated disturbance on a per well basis for the three stages of well development including exploration, construction, and production.

Within that portion of the Williston Basin located within the MCFO RMP, it is estimated that in Richland County where Bakken Formation production has expanded rapidly in the last three years, there could be 400 to 600 new wells of which 15 to 22 of these wells could be producing from Federal minerals within the next 20 years with much of this activity occurring in the near future. Outside of the Bakken Formation, but within the NE Williston Basin area, an estimated 360 to 920 new conventional oil and gas wells are expected, of which 23 to 46 could be producing from BLM minerals in the next 20 years. On the Cedar Creek Anticline it is estimated that 2,904 to 5,832 new conventional oil and gas wells could be drilled in the next 20 years, with 555 to 1,114 of these wells producing from Federal minerals. On the Poplar Dome, it is estimated that 54 and 105 new conventional oil and gas wells could be drilled in the next 20 years, with one to three of these wells producing from Federal minerals. Outside of these regions but within the Williston Basin, it is estimated that another 15 to 28 new conventional oil and gas wells could be drilled within the next 20 years with two to four of these wells producing from Federal minerals. Table 6-1 is a summary of the predicted number of wells drilled by producing area broken down by mineral ownership.

Outside of the MCFO RMP portions of the PRB and Williston Basin are those parts of the Porcupine Dome and other areas located in the RMP that have the potential for new conventional oil and gas wells. On the Porcupine Dome it is estimated that 37 and 67 new conventional oil and gas wells could be drilled in the next 20 years with five to ten of these wells producing from Federal Minerals. The so-called other areas include all the remaining lands within the MCFO RMP area where it is estimated that 33 to 66 new conventional oil and gas wells could be drilled in the next 20 years with 7 to 14 of these wells producing from Federal Minerals.

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ACRONYMS AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
APLIC	Avian Power Line Interaction Committee
APD	Application for Permit to Drill
AU	Assessment Units
BCF	billion cubic feet
BFO	Buffalo Field Office
BLM	Bureau of Land Management
BOPD	barrels of oil per day
CBNG	Coal Bed Natural Gas
EIS	Environmental Impact Statement
EOR	Enhanced Oil Recovery
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
MBOGC	Montana Board of Oil and Gas Conservation
MCFO	Miles City Field Office
MMBO	million barrels of oil
NDGS	North Dakota Geological Survey
PRB	Powder River Basin
ROD	Record of Decision
RMP	Resource Management Plan
SMA	Surface Management Agency
TCF	trillion cubic feet
TPS	Total Petroleum Systems
USGS	U.S. Geological Survey

1.0 Introduction

1.1 Background on RMP/RFD Revisions

The Bureau of Land Management's Miles City Field Office is located in Miles City, Montana, and manages approximately 2.8 million federal surface acres and 11.8 million acres of federal mineral estate land in the eastern portion of the state. Prior to 1998, the field office operated under two resource areas - Big Dry and Powder River. The lands in each of these resource areas were managed under their own resource management plan (RMP) - the Big Dry RMP and the Powder River RMP. To address new land use issues the BLM Miles City Field Office is revising and combining the Powder River and Big Dry resource management plans into a new resource management plan to be called the *Miles City Field Office RMP (MCFO RMP)*.

An evaluation of the Big Dry RMP Record of Decision (ROD) (completed in 1996) in 2002 recommended writing an oil and gas Reasonably Foreseeable Development Scenario (RFD) for the entire planning area. A Powder River RMP ROD was issued in 2003 which included information related to the RFD scenario for Coal Bed Natural Gas (CBNG) and conventional oil and gas development (the RFD was completed in 2002 as part of the Environmental Impact Statement (EIS) process and included as an appendix to the Final Environmental Impact Statement (FEIS) completed in 2003) within the planning area. The RFD forecasts fluid mineral exploration, development, and production for the planning area for the next 15 to 20 years. RFDs assume a baseline scenario in which no new policies are introduced and all areas not currently closed to leasing and development are opened for oil and gas activity. Projections under the different management situations presented in each alternative of the NEPA document are also made. For this RFD, the data from the 2002 Powder River RMP will be incorporated into the reasonably foreseeable development scenario for the rest of the Miles City Field Office RMP area.

"Interagency Reference Guide - Reasonably Foreseeable Development Scenarios and Cumulative Effects Analysis for Oil and Gas Activities on Federal Lands in the Greater Rocky Mountain Region" (USDI 2002), "Policy for Reasonably Foreseeable Development Scenario (RFD) for Oil and Gas (BLM WO IM No. 2004-089) and Planning for Fluid Minerals Supplemental Program Guidance (BLM Handbook H-1624-1) guided the criteria and analyses methods used in this RFD.

1.2 Discussion of Determining Oil and Gas Resource Potential

Potential accumulations of oil and gas are described in Section 2. Non-BLM land adjacent to the planning area may be included in this section when it provides a better understanding of resource potential on BLM property. These determinations were made using the geologic criteria provided by reference in Section 2. Also contained in Section 2 are descriptions of stratigraphy, structure, historic oil and gas activities, as well as relevant studies done in the area. Potential reservoir rocks, source rocks, and existing stratigraphic and structural traps are discussed in detail.

1.3 Methodology for Predicting Future Oil and Gas Exploration and Development Activity

Section 7 predicts the type and intensity of future oil and gas exploration and development activities. These forecasts are determined by an area's geology, and historical and present activity, as well as factors such as economics, technological advances, access to oil and gas areas, transportation, and access to processing facilities. Economics, technology, and other factors may be hard to predict because of their complex nature and rapid rate of change. Projections of oil and gas activities are based

upon present knowledge. Future changes in global oil and gas markets, infrastructure and transportation, or technological advancements, may affect future oil and gas exploration and development activities within the RMP area.

1.4 Relating the Potential for Resource Occurrence to Potential for Activity

Predicted oil and gas activity does not necessarily correlate with geologic potential for the presence of hydrocarbons. Although the geology of an area may suggest the possibility of oil and gas resources, actual exploration and development may be restricted by high exploration costs, low oil and gas prices, or difficulty accessing the area due to lease stipulations. Thus a small area may have a high resource potential, yet have a low exploration and development potential due to severe restrictions on access. Conversely, technological advancements or an increase in oil and gas prices could result in oil and gas activities in areas regarded as having low potential for occurrence.

2.0 Geology Description

The Miles City RMP area is located along the eastern portion of Montana within the western part of the Great Plains Province (Figure 2-1). The Great Plains Province extends from the Dakotas into the eastern portions of Montana, Colorado, and Wyoming. In the RMP area the Great Plains Province is represented at the surface by broad basinal features. The basins within the Great Plains Province have accumulated sediments several miles in thickness; these sands, shales, and limestones form the source and reservoirs of Montana's fossil energy reserves – crude oil, natural gas, coal, CBNG (ALL 2001). There are two basins of particular interest in the Miles City RMP area - the Williston Basin and Powder River Basin (PRB). Both basins are generally flat lying plains, dissected by the various streams and rivers which drain north and east across eastern Montana. The Williston Basin is bound on the east and southeast by the Canadian Shield and the Sioux Uplift; to the west and southwest by the Black Hills Uplift, Miles City Arch, Porcupine Dome, and Bowdoin Dome (Peterson, 1996). The PRB is bound to the west by the Bighorn Uplift, to the southwest and south by the Casper Arch, Laramie Mountains, and Hartville Uplift; and to the east by the Black Hills Uplift. The Miles City Arch and the Cedar Creek Anticline lie north of the PRB and separate the PRB and Williston Basin (Figure 2-2).

The two areas within the Miles City RMP with high to moderate oil and gas potential are the PRB, especially those areas were coal is present, and the Williston Basin, including the Cedar Creek Anticline.

2.1 Powder River Basin

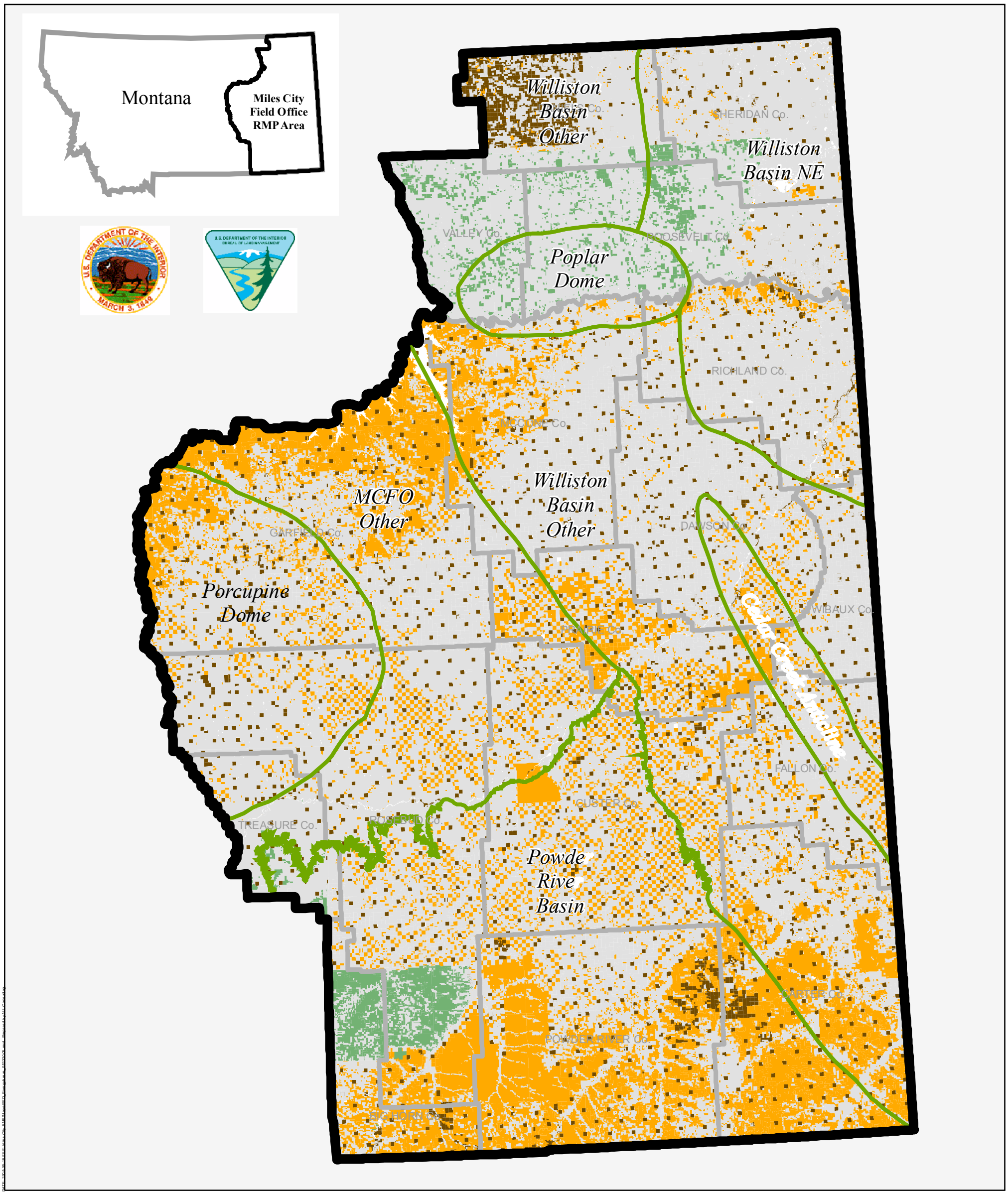
The southern portion of the Miles City RMP area is located within the northern part of the PRB (Figure 2-2). The PRB totals approximately 12,000 square miles and extends northward from Wyoming into the following Montana Counties: Big Horn, Powder River, Custer, Rosebud, Treasure, and Prairie (ALL, 2001). The PRB formed as a result of Laramide tectonics which caused the surrounding area to the west to be uplifted; subsequently these uplifted areas contributed sediments to the basin during the Late Cretaceous and Early Tertiary. As a result of the accumulation of the sediments (Figure 2-3) combined with structural subsidence, the PRB developed into an asymmetric basin predominantly filled with the Tertiary Fort Union Formation (ALL, 2001).

2.1.1 Stratigraphy and Geologic Structure: reservoirs, traps, source rocks and seals

Outcrops within the PRB consist primarily of Tertiary sediments from the Paleocene Fort Union Formation and Eocene Wasatch Formation to the south, and Quaternary alluvium along the various river valleys (Figure 2-2). The Tertiary deposits contain sediments which include the various coal beds that have been developed for CBNG since 1999. Additional details on the coals within the Tertiary sediments of southeastern Montana can be found in the Final Environmental Impact Statement (FEIS) and supporting documents completed in 2003 by the BLM Miles City Field Office and State of Montana (Bureau of Land Management, 2003a). In addition to the Tertiary deposits, scattered conventional oil and gas wells have produced hydrocarbons from deeper formations including the Cretaceous Judith River, Shannon, Eagle, Muddy, and Lakota/Dakota Formations. These formations are present across the PRB at depths ranging from 2,200 and 9,000 feet below ground surface and are overlain by the Cretaceous Colorado and Pierre Formation Shales (Noble et al., 1982). A generalized stratigraphic column for the northern Powder River Basin is presented in Figure 2-3.

2.1.1.1 Geologic Structure

The PRB is an asymmetrical basin with the sedimentary beds dipping toward the basin axis which trends northwest to southeast and is located against the western basin margin (Ellis et



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MilesCity Field Office Draft RMP/EIS

Figure 2-1
Oil and Gas Occurrence Areas

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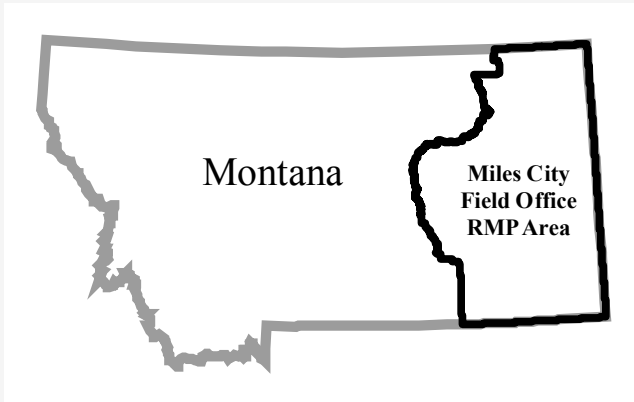

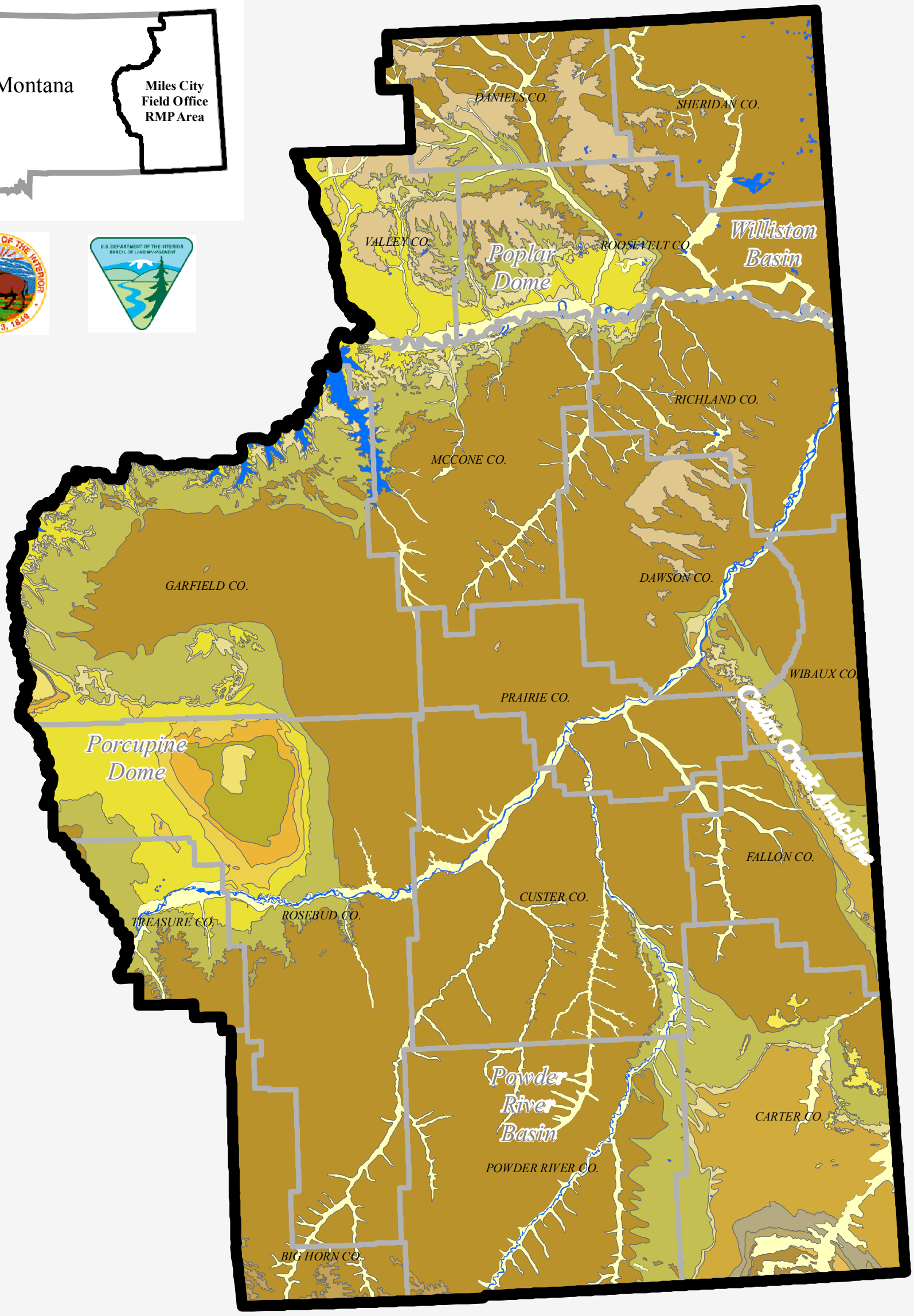

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Figure 2-2
Surficial Geology
by Formation

Legend

RMP Area
County

FORMATION							
Water	Kce	Khc	QTt	Tg
Kb	Kcl	Kjr	Qal	Tw
Kbf	Keu	Kmo	Ta	Twr
Kc	Kfh	Kn	Tf	
	Kg	Kp	Tfu	

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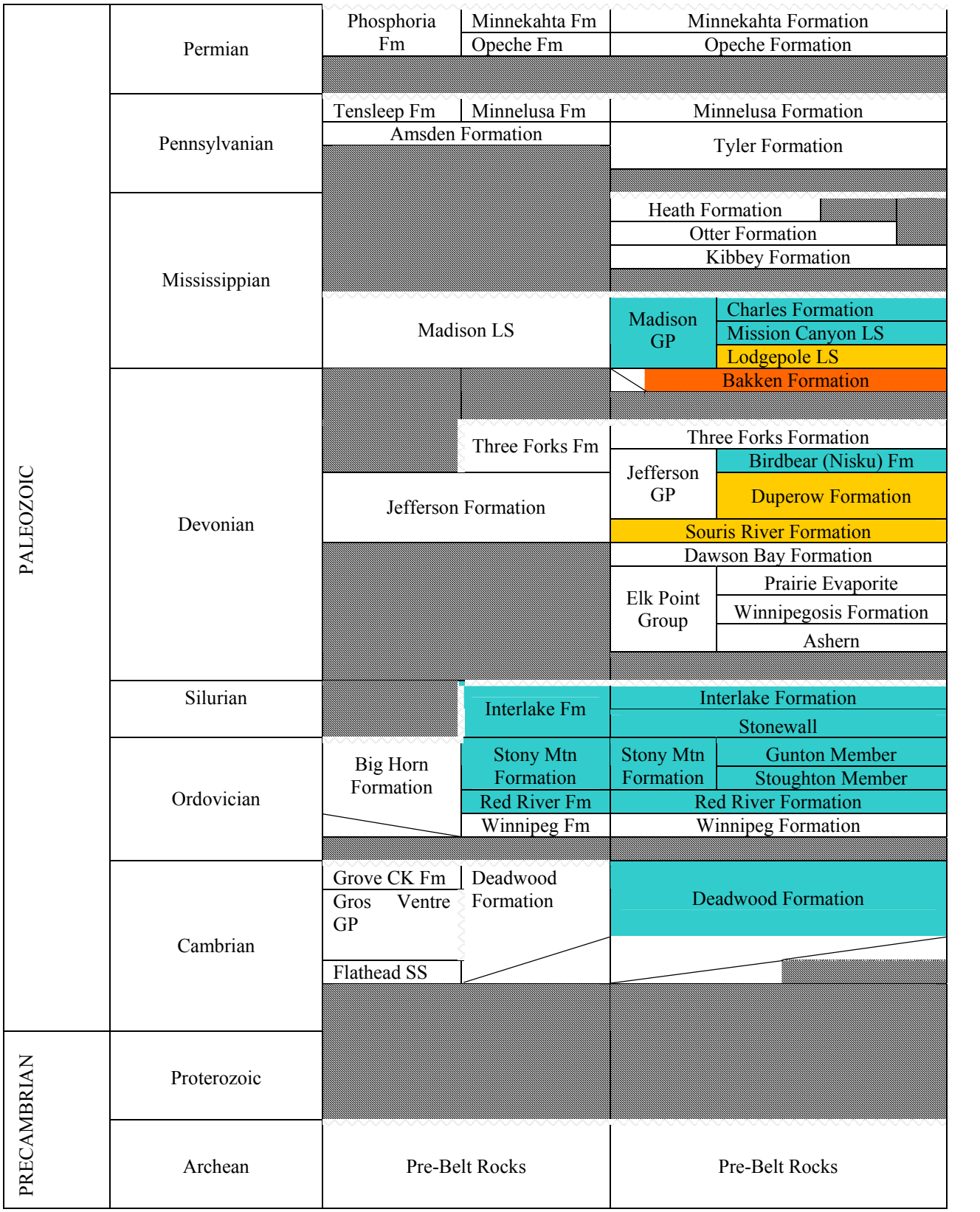
FIGURE 2-3 STRATIGRAPHIC COLUMN OF THE MILES CITY RMP AREA PORTIONS OF THE POWDER RIVER AND WILLISTON BASINS

ERATHEM	SYSTEM, SERIES, AND OTHER DIVISIONS		POWDER RIVER BASIN, MONTANA		WILLISTON BASIN, MONTANA		
CENOZOIC	Quaternary		Alluvium		Alluvium		
	Tertiary	Pliocene			Flaxville Formation		
		Miocene					
		Oligocene					
		Eocene	Wasatch Formation				
		Paleocene	Fort Union Fm	Tongue River Member			
				Lebo Shale Member			
				Tullock Member			
MESOZOIC	Cretaceous	Upper	Hell Creek Formation		Hell Creek Formation		
			Montana Group	Fox Hills Formation	Montana Group	Fox Hills Formation	Pierre Formation
				Bearpaw Shale		Bearpaw Shale	
				Judith River Formation (Parkman SS)		Judith River Formation	
				Clagget Formation		Clagget Formation	
				Eagle Formation (Shannon SS)		Eagle Formation	
				Telegraph Ck. Fm.		Telegraph Ck. Fm.	
			Colorado Group	Niobrara Formation	Colorado Group	Niobrara Formation 1st White SPK	
				Carlile Formation		Carlile Formation	
				Greenhorn Formation		Greenhorn Formation	
				Belle Fouche Fm		Belle Fourche Fm	
		Lower		Mowry Formation		Mowry Formation	
				Muddy SS		Muddy SS	
				Skull Creek SH		Skull Creek SH	
				Dakota Silt		Dakota Silt	
			Dakota Formation		Dakota Formation		
			Fuson Formation		Kootenai Formation (Fuson)		
			Lakota Formation		Lakota Formation		
	Jurassic		Morrison Formation		Morrison Formation		
			Sundance Formation	Upper Mbr	Ellis Group	Swift Formation	
						Rierdon Formation	
				Lower Mbr		Piper Fm	Bowes Mbr
							Firemoon Mbr
							Tampico Mbr
			Gypsum Springs Fm			Nesson Fm	Kline Mbr
							Picard Mbr
							Poe Mbr
	Triassic		Spearfish Formation		Spearfish Formation		
							Pine Salt


PALEOZOIC
PRECAMBRIAN
Permian
Pennsylvanian
Mississippian
Devonian
Silurian
Ordovician
Cambrian
Proterozoic
Archean
Phosphoria Fm
Minnekahta Fm
Opeche Fm
Minnekahta Formation
Opeche Formation
Tensleep Fm
Minnelusa Fm
Amsden Formation
Minnelusa Formation
Tyler Formation
Heath Formation
Otter Formation
Kibbey Formation
Madison LS
Madison GP
Charles Formation
Mission Canyon LS
Lodgepole LS
Bakken Formation
Three Forks Fm
Three Forks Formation
Jefferson GP
Birdbear (Nisku) Fm
Duperow Formation
Jefferson Formation
Souris River Formation
Dawson Bay Formation
Elk Point Group
Prairie Evaporite
Winnipegosis Formation
Ashern
Interlake Fm
Interlake Formation
Stonewall
Big Horn Formation
Stony Mtn Formation
Stony Mtn Formation
Gunton Member
Stoughton Member
Red River Fm
Red River Formation
Winnipeg Fm
Winnipeg Formation
Grove CK Fm
Gros Ventre GP
Flathead SS
Deadwood Formation
Deadwood Formation
Pre-Belt Rocks
Pre-Belt Rocks
Source rocks
Reservoir rocks
Combined source and reservoir

al., 1998). The beds dip away from the surrounding highs of the Bighorn Uplift in the west, the Casper Arch, Laramie Mountains, and the Hartville Uplift to the southwest and south, and the Black Hills Uplift to the east. Along the western side of the basin the beds have steeper dips (averaging 20-25° toward the east), while the beds along the eastern side of the basin have shallower dips (averaging 2-5°) (Ellis et al., 1998).

2.1.1.2 Source Rocks

In the Montana portion of the basin the coals are primarily represented in the Tongue River Member of the Fort Union Formation, which is divided into the upper, middle, and lower units. The Fort Union Formation and other source rocks within the PRB are highlighted in the stratigraphic column presented in Figure 2-3. The coals of the Lower Tongue River unit include the Stag, Terret, Witham, Robinson, Rosebud-McKay, Flowers-Goodale, Nance, Calvert, and Knobloch coals. The coals of the Middle Tongue River unit include the Sawyer, Mackin-Walker, Cache, Odell, Brewster-Arnold, Pawnee, and Wall Coals. The coals of the Upper Tongue River unit include the Otter, Cook, Carney, Canyon, Anderson, Dietz, and Smith coal zones. The Tongue River Member varies in thickness from 750 feet near the outcrop up to 3,000 feet near the axis of the basin, with individual coals in the lower unit reaching thicknesses of 71 feet. In the upper unit thicknesses up to 57 feet are seen near the Decker mine (Roberts et al., 1999a and Roberts et al., 1999b).

The Cretaceous Mowry Shale, Skull Creek Shale, and Fall River sequence are organic-rich rocks which are the likely source rocks for much of the oil and gas present in the deeper reservoirs of the PRB (Dolton and Fox, 1996). The Mowry and Skull Creek Shale both contain type II and type III kerogens, with the Mowry having a higher proportion of type II and is considered the better source for petroleum of the two. Both shales exhibit thermal maturation deeper in the basin. The Carlile, Niobrara, and Frontier Formations are also organic-rich rocks which are the likely source rocks for the oil and gas in the Upper Cretaceous reservoirs (the Shannon Sandstone and Mesa Verde Formations). The Carlile and Niobrara are likely to be the major sources of oil with secondary amounts from the Frontier Formations. Although these three formations are believed to be source rocks for oil within the PRB they do not have the areal extent of the Mowry Shale (Dolton and Fox, 1996).

2.1.1.3 Reservoir Rocks

The potential and active producing reservoirs within the PRB include the coalbeds within the Tertiary-age Fort Union Formation, and various sandstones and carbonates ranging in age from Pennsylvanian to Upper Cretaceous. Unconventional reservoirs which have potential include the Cretaceous-aged, fractured Mowry Shale. These reservoirs and others present in the PRB have been highlighted in the stratigraphic column presented in Figure 2-3. The sandstones and carbonates include the eolian dune sandstones complexed with sequences of marine and non-marine sandstones and carbonates of the Minnelusa Formation, and fine to coarse-grained sandstones of the Muddy, Fall River, and Lakota Sandstones. The Minnelusa reservoirs are typically orthoquartzitic sandstones with average porosities between 12 and 24 percent. The porosities of the other sandstone reservoirs vary across the PRB, but general averages for these reservoirs are 5 to 20 percent and locally may be as low as 8 to 9 percent. Reservoir thicknesses and permeabilities also vary within these sandstone reservoirs, with the Muddy averaging between 10 and 25 feet in thickness and permeability ranging from 1 to >1,000 mDarcies. The Lakota sandstone is typically thinner than the Muddy, ranging between 6 to 13 feet thick, but may be thicker locally. The Shannon reservoir is a marine shelf sandstone which is narrow and sinuous within the known fields, thicknesses range from 5 to 32 feet, porosity from 10 to 15 percent, and permeability between 1 and 20 mDarcies (Dolton and Fox, 1996).

The Fort Union coals act as both source rock and reservoir for coal bed natural gas resources in the PRB and are the result of developments

within the PRB during the early to late Paleocene when the PRB was a partially enclosed basin and drained by fluvial processes. The partially enclosed nature of the PRB allowed for the development of swamps which resulted in the accumulation of thick peat sequences near the fluvial drainage ways which dissected the PRB during the Paleocene. These coal beds vary in thickness, are interbedded with other clastic sediments, split and pinch out across the basin. All of these attributes are caused by the cyclical changes associated with the fluvial depositional environment (Ellis et al., 1998).

2.1.1.4 Traps

Oil and natural gas accumulations can be discussed as conventional and continuous resource traps. Conventional traps include both structural and stratigraphic examples. Continuous resource reservoirs are complex facies related units that are unaffected by the included water column and are therefore not classical traps. Continuous resource reservoirs are often geographically extensive and require the drilling of large numbers of wells. Several of these reservoirs may be present in the MCFO RMP.

The coals of the PRB contain continuous resource natural gas accumulations that are trapped by hydrostatic pressure from groundwater inflows in addition to being confined by shales. Elsewhere in the basin, conventional reservoirs are confined by a variety of structural and stratigraphic traps. Oil in the Upper Minnelusa is trapped by the overlying Opeche Shale where paleo-topographic highs and erosional surfaces are present; other traps include depositional and diagenetic pinchouts and low-relief structural closures (Dolton and Fox, 1996). The traps within the Lakota, Fall River, Muddy, and Shannon Sandstones are primarily stratigraphic in nature resulting from pinchouts of the sandstones and erosional surfaces being sealed updip by finer-grained sediments, usually shales. Depths to traps in these formations range from 2,000 to 14,000 feet, with depths of the Lakota and Muddy Sandstones having the broader range and the Fall River and Shannon Sandstones being in the 6,000 to 12,000 feet range. Additional natural gas traps may occur as a result of stratigraphy, small structural closures, and combination traps in the Upper Cretaceous and Tertiary sequences at depths between 700 and 3,000 feet (Dolton and Fox, 1996).

2.1.2 Summary of USGS Oil and Gas Assessments

The U.S. Geological Survey (USGS) oil and gas assessment for the entire Powder River Basin was performed in 1995 for conventional resources and continuous oil and gas resources. The continuous oil and gas resource assessment was added and an updated version of the Powder River Basin Province assessment is available on the National Oil and Gas assessment website (USGS, 2003) with a summary factsheet of the 2003 assessment. The data from the updated assessment and information from the factsheet will be here after referred to as the 2003 USGS assessment. The USGS assessments evaluate the potential of oil and gas resources using a geology-based assessment methodology to calculate estimated undiscovered resources using a variety of geologic elements (USGS, 2002). The combined assessments for the entire PRB estimated a mean undiscovered natural gas resource of 16.5 trillion cubic feet, a mean undiscovered oil resource of 1.5 billion barrels, and a mean undiscovered natural gas liquids of 86.5 million barrels (USGS, 2002). The PRB is divided into the Wyoming portion (approximately 57.3% of the surface) and the Montana portion (approximately 42.7% of the surface); sediment volume is probably approximately the same division. The 1995 PRB assessment identified 11 conventional oil and gas plays with estimated undiscovered resources (Dolton and Fox, 1996). The 2003 version considered assessments as part of Total Petroleum Systems (TPS). A TPS is the USGS's integrated approach for geologic and geochemical studies that matches source rocks with reservoirs and migration paths, timing, reservoirs, sequence stratigraphy, traps, and structural elements, allowing greater precision in assessing reservoir rock quality, source rock potency, and migration efficiency.

The USGS defines a TPS as:

> "The total petroleum system constitutes the basic geologic unit of the oil and gas assessment. The total petroleum system includes all genetically related petroleum that occurs in shows and accumulations (discovered and undiscovered) that (1) has been generated by a pod or by closely related pods of mature source rock; and, (2) exists within a limited mappable geologic space, along with the other essential mappable geologic elements (reservoir, seal, and overburden rocks) that control the fundamental processes of generation, expulsion, migration, entrapment, and preservation of petroleum. The minimum petroleum system is that part of a total petroleum system encompassing discovered shows and accumulations along with the geologic space in which the various essential elements have been proved by these discoveries. "

The 2003 USGS assessment of the PRB identified four TPS that embrace six continuous assessment units (AU's) and one conventional AU (USGS 2002 and USGS 2003). The USGS defines an AU as follows:

> "An assessment unit (AU) is a mappable part of a total petroleum system in which discovered and undiscovered fields constitute a single, relatively homogeneous population such that the chosen methodology of resource assessment based on estimation of the number and sizes of undiscovered fields is applicable. A total petroleum system may equate to a single assessment unit, or it may be subdivided into two or more assessment units if each unit is sufficiently homogeneous in terms of geology, exploration considerations, and risk to assess individually. "

Of the 11 conventional oil and gas plays identified in the 1995 assessment, six plays (Upper Minnelusa, Lakota Sandstone, Fall River Sandstone, Muddy Sandstone, Sussex-Shannon Sandstone, and the Mesaverde-Lewis) extend into the Montana portion of the PRB. Of the four TPS identified in the 2003 assessment, three TPS and four assessment units (the Upper Fort Union Formation AU and Lower Fort Union-Lance Formation AU in the Tertiary-Upper Cretaceous Coal-Bed Methane TPS, the Mowry TPS and Cretaceous Biogenic Gas TPS) extend into the Montana portion of the PRB. Potential resources from each play are considered separately below; reserves for the Montana portion of the PRB are summarized in Table 2-1.

2.1.2.1 Tertiary-Upper Cretaceous Coal-Bed Methane TPS

There are two assessment units from the Tertiary-Upper Cretaceous Coal Bed Methane TPS that fall within the Miles City RMP area, the Upper Fort Union Formation AU and the Lower Fort Union-Lance Formation AU. These assessment units are located in the Southwestern portion of the MCFO RMP area, in eastern Bighorn, southern Rosebud, Powder River, eastern Treasure and northern Carter County in Montana (Figure 2-4). The two assessment units represent coal bed natural gas plays in which the coals act as both the source rock and the reservoir. The natural gas contained in the coals is methane which is generated by thermogenic (heat-driven) and biogenic (microbial-driven) conditions and trapped within the coal seam by the pressure of groundwater. Within the Montana portion of the PRB the methane is believed to be predominately of biogenic origin. The amount of the CBNG contained in the coal beds is determined by the gas adsorptive capacity of the coal, coal composition, depth of burial and related pressure, and the coal volume.

USGS estimates of the total resources contained within the Tertiary-Upper Cretaceous Coal Bed Methane TPS within the PRB vary from 8.2 TCF to more than 22.4 TCF; the 2003 USGS assessment estimated a mean of 14.3 TCF. Of the 14.3 TCF of CBNG resources estimated by the USGS in 2002, 12.1 TCF are estimated to be in the Upper Fort Union Formation AU of which approximately 32.7% of the area is located in Montana within the MCFO RMP area, while the Lower Fort Union-Lance Formation AU is estimated to contain 200 BCF of which approximately 49.9% is located in Montana within the MCFO RMP area. The remaining 2 TCF of CBNG resources is estimated for the Wasatch Formation AU of which approximately

1.57% of the assessment unit area falls within the Montana portion of the PRB (USGS 2002).

The Tongue River member of the Fort Union Formation is the primary coal and CBNG producing unit in the Upper Fort Union Formation AU. The Tongue River varies in thickness across the AU but can be more than 1,700 feet in thickness, with as many as eight to ten coal beds. Individual coal bed thicknesses also vary with ranges from 5 feet to as much as 190 feet, with laterally continuous beds commonly occurring in the 20 to 90 feet thick range (Dolton and Fox, 1996).

In the Montana portion of the PRB at the end of 2004, there were approximately 500 CBNG producing wells with total natural gas production for the year of approximately 12.5 MMcf (MBOGC, 2005). In 2004 Montana CBNG production was occurring in two areas, the CX Ranch Field and from Wildcat Wells in Big Horn County; the CX Ranch Field is also located in Big Horn County, Montana near the Wyoming state line.

2.1.2.2 Mowry TPS

The Mowry TPS consists of the Mowry Continuous Oil AU, an unconventional oil play in which the Mowry fractured shale is both the source rock and reservoir (USGS, 1995). The 2003 USGS assessment of the Mowry TPS estimated mean undiscovered resource volumes of 198 million barrels of oil (MMBO), 198 billion cubic feet of gas (BCF), and 12 million barrels of natural gas liquids within the PRB. The majority of the Mowry Continuous Oil AU is predominantly located in the Wyoming portion of the PRB (>99%), with only a small piece (approximately 0.23% see Figure 2-5 and Table 2-1) of the AU extending into the southern portion of Big Horn County, Montana in the area of the Decker Mine (USGS, 2003). The USGS assessment of this play identifies the Mowry TPS as a hypothetical play with only limited production from the Mowry Shale typically associated with production from the Muddy Sandstone. Although there has been production from the fractured Mowry Shale, the USGS identified no known purposeful exploration into the Mowry Shale exclusively; generally, exploration of the Mowry is coupled with activity in another formation.

TABLE 2-1
SUMMARY OF 2003 USGS RESOURCE ASSESSMENT OF THE POWDER RIVER BASIN, MONTANA PORTION ONLY

Montana Portion - PRB		
Play	**Mean Oil Resources**	**Mean Gas Resources**
Continuous Resource Reservoirs		
Upper Fort Union (Tertiary) CBNG	0.0	3.96
Lower Fort Union - Lance (CBNG)	0.0	0.1
Wasatch CBNG	0.0	0.03
Mowry TPS	0.48	0.0
Cretaceous Biogenic Gas	0	0.18
Conventional Reservoirs		
Fall River Sand	51.8	0.03
Upper Minnelusa	89.8	0.005
Muddy Sand	23.5	0.12
Sussex-Shannon Sand	1.1	0.005
Mesa Verde-Lewis	3.48	0.003
Lakota Sand	15.26	0.006
TOTAL	**185.42**	**4.439**

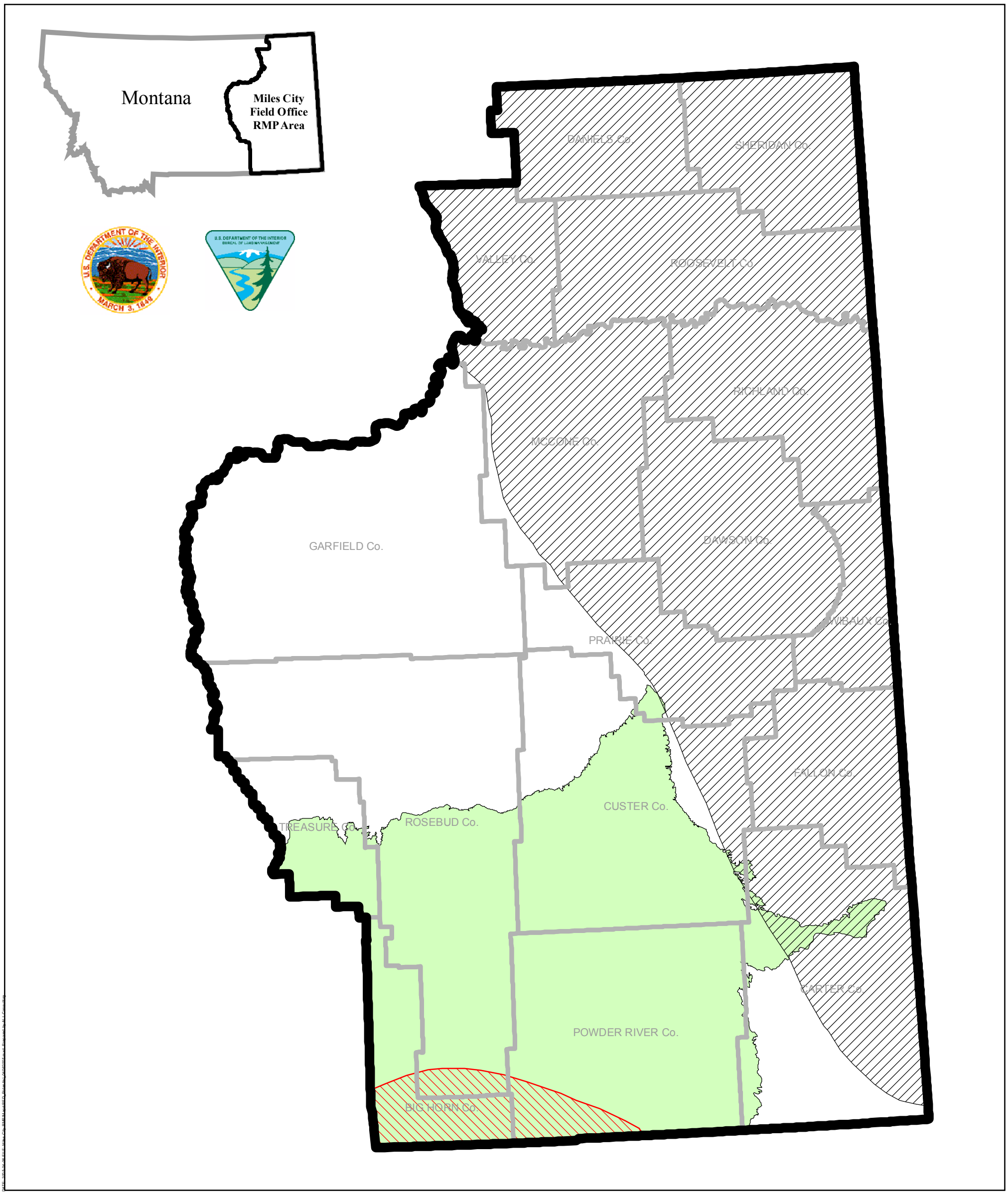


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Figure 2-4
Oil and Gas Assessment Units

Legend

- RMP Area
- County
- Madison (Mississippian)
- Sussex-Shannon Sandstone
- Tertiary-Upper Cretaceous Coalbed Methane

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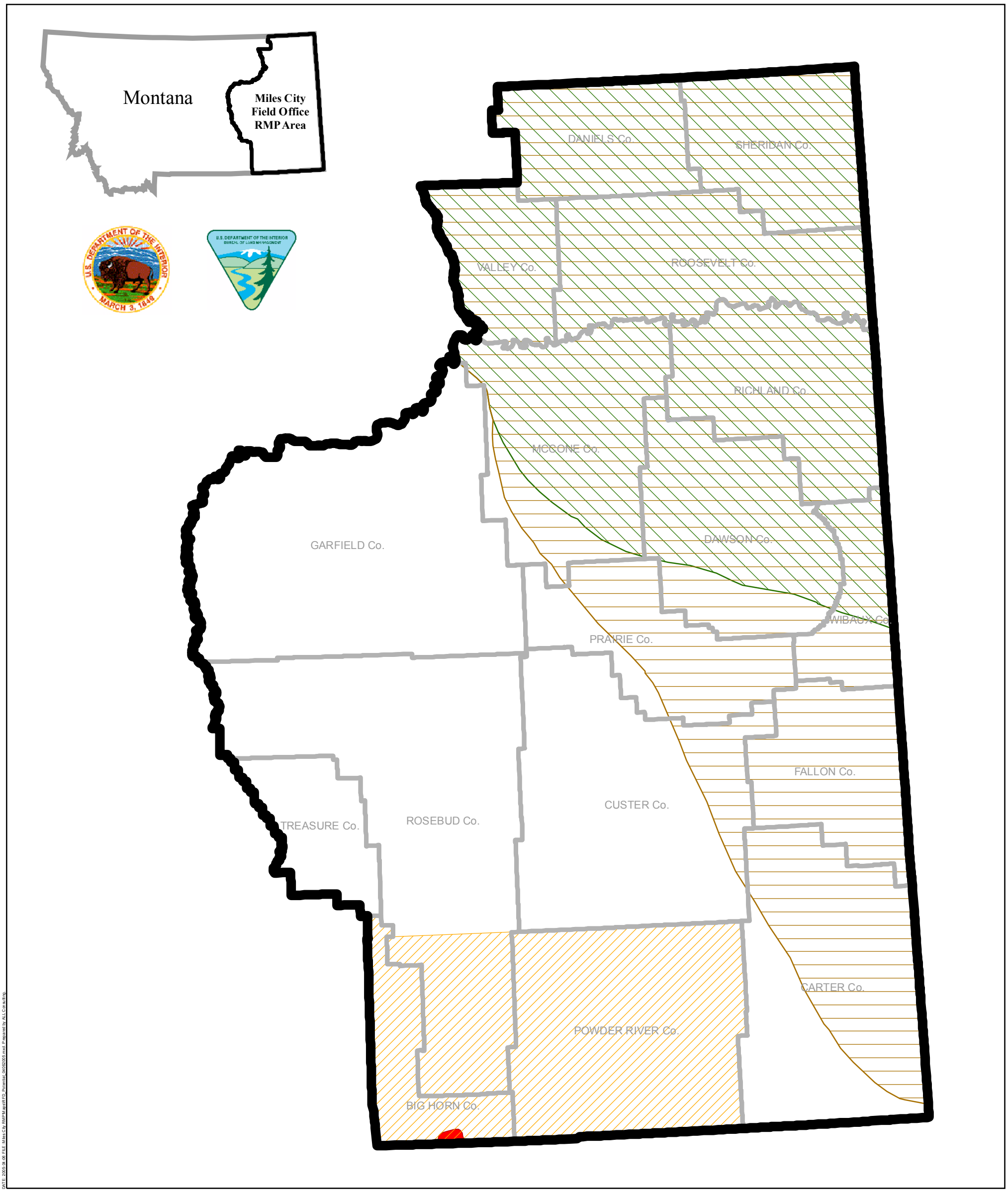

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Figure 2-5
Oil and Gas Assessment Units

Legend

- RMP Area
- County
- Mowry
- Biogenic Gas
- Middle and Upper Devonian (Pre-Bakken - Post-Prairie Salt)
- Post-Madison through Triassic Clastics

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2.1.2.3 Cretaceous Biogenic Gas TPS

The Cretaceous Biogenic Gas TPS consists of the Shallow Continuous Biogenic Gas Assessment Unit, and is a natural gas play in which biogenically generated gas has been trapped by conventional structural and stratigraphic traps in the Tertiary and Cretaceous sediments. The 2003 USGS assessment of the Shallow Continuous Biogenic Gas AU estimated average natural gas resources of 787 BCF, of which approximately 23.53% of the assessment unit (Table 2-1) is located in Montana within the MCFO RMP area (Figure 2-6). The AU is believed to include nearly all of the Cretaceous and Fort Union sequence in Montana; the play rises to higher stratigraphic formations toward the south into the uppermost Cretaceous and Tertiary beds. Reservoirs include the sandstones from the Early Cretaceous to the Eocene, specifically the sandstones from the Frontier, Sussex, Mesaverde, Bearpaw, Lance, and Fort Union Formations (Dolton and Fox, 1996). The natural gas from this play is sourced from the coal beds and fine-grained humic-rich rocks of the Tertiary and Cretaceous time. This gas is contained by stratigraphic traps, combination traps, and small structural closures. The play has been developed from the East Bell Creek, Hammond, Pumpkin Creek, Hardin, and Toluca fields, but none of these accumulations are believed to contain more than 6 BCF of natural gas (Dolton and Fox, 1996).

2.1.3 Conventional Oil and Gas Assessments

The 1995 USGS Powder River Basin assessment identified six conventional oil and gas plays which have occurrences within the Miles City RMP area including: the Upper Minnelusa Sandstone, Lakota Sandstone, Fall River Sandstone, Muddy Sandstone, Sussex-Shannon Sandstone, and the Mesaverde-Lewis Play. Of these six plays, all but the Lakota Sandstone have been explored and developed in the PRB; the Minnelusa, Fall River, and Muddy Sandstones have well established histories of over 30 years (Dolton and Fox, 1996).

2.1.3.1 Fall River Sandstone Play

This conventional oil and gas play is the result of resources trapped within a regressive clastic wedge stratigraphic trap in the Fall River Formation. The play extends into Montana through western Carter County, across most of Powder River County, and into the southern portion of Rosebud County (Figure 2-6). The source rocks are most likely the overlying Mowry Shale, but other possible sources include the Skull Creek and Fall River Shales. The reservoir rocks are the fine grained sandstones of the Fall River Dakota Sandstone, which is overlain by the Fall River Shale and underlain by the Skull Creek Formation, which provide stratigraphic traps for the resources (Dolton and Fox, 1996). The depth to these traps range from 4,000 to 14,500 feet. As of the 1995 USGS assessment, there were approximately 30 fields or pools identified in the Wyoming portion of the PRB estimated to contain 170 MMB of oil and 110 BCF of natural gas; there are no fields in Montana reporting production from the Fall River Sandstone Play. The 2002 USGS assessment estimates the mean undiscovered resources to be 192 MMB of oil, 115 BCF of natural gas and 8 MMB of natural gas liquid of which approximately 25.9% (Table 2-1) of the assessment unit is located within the MCFO RMP area (USGS, 2002).

2.1.3.2 Upper Minnelusa Sandstone Play

This conventional oil play is the result of oil stratigraphically trapped by paleotopography, reservoir truncations, and pinchouts at the top of the Minnelusa Formation. The play extends northward from Wyoming into Montana through western Carter County into eastern and southern Powder River County (Figure 2-7). The oil is believed to be sourced from the Pennsylvanian-age (Desmoinesian stage) marine shales that underlie the Upper Minnelusa sandstone, trapped in a complex of cyclic sequences of carbonates and sandstones that are overlain by the Opeche Shale (Dolton and Fox, 1996). The depth to these traps ranges from 5,000 to 15,000 feet. As of 1990, there were approximately 160

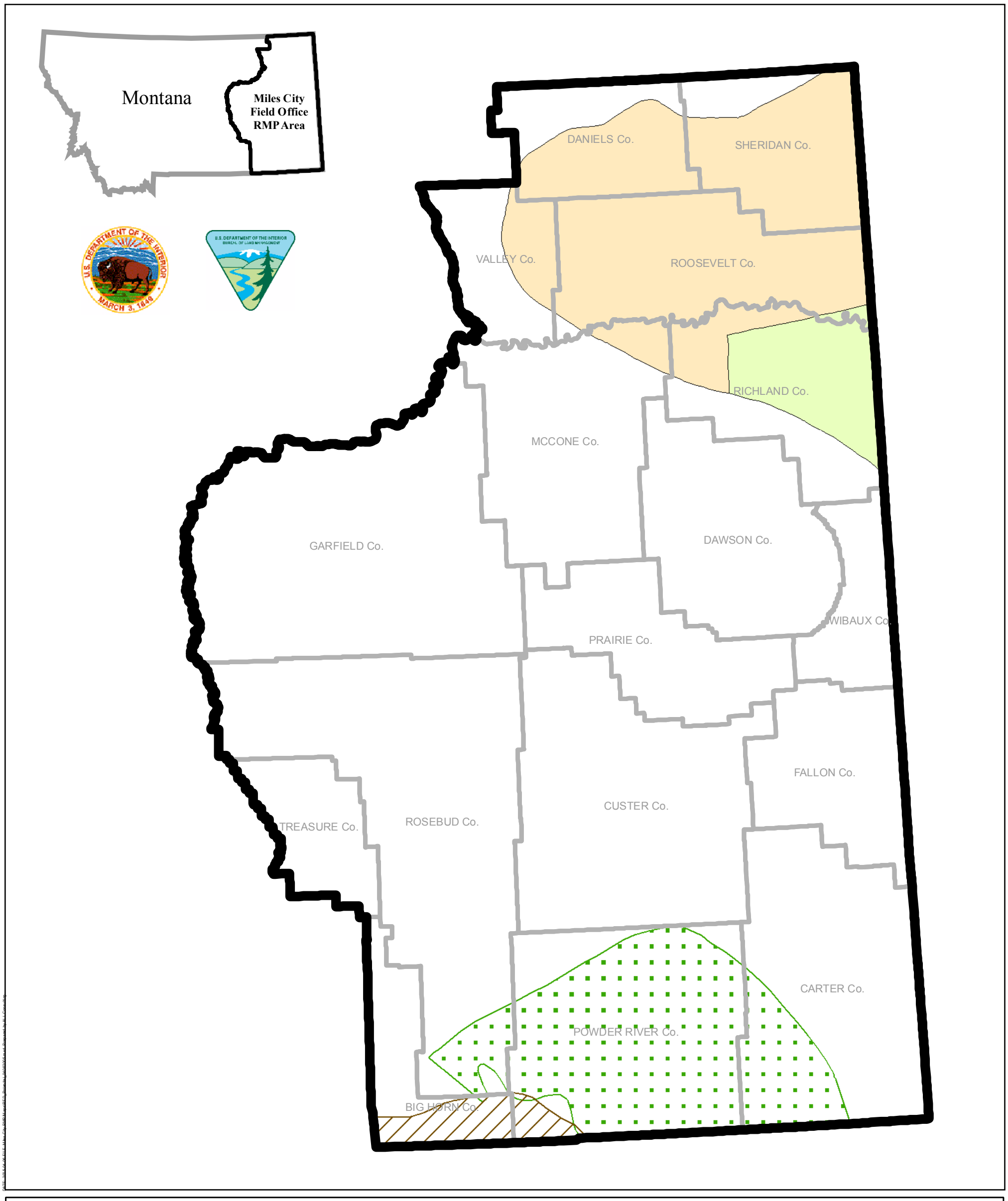

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Figure 2-6
Oil and Gas Assessment Units

Legend

- Mesaverde-Lewis
- Fall River Sandstone
- Bakken Intermediate
- Bakken Outlying
- RMP Area
- County

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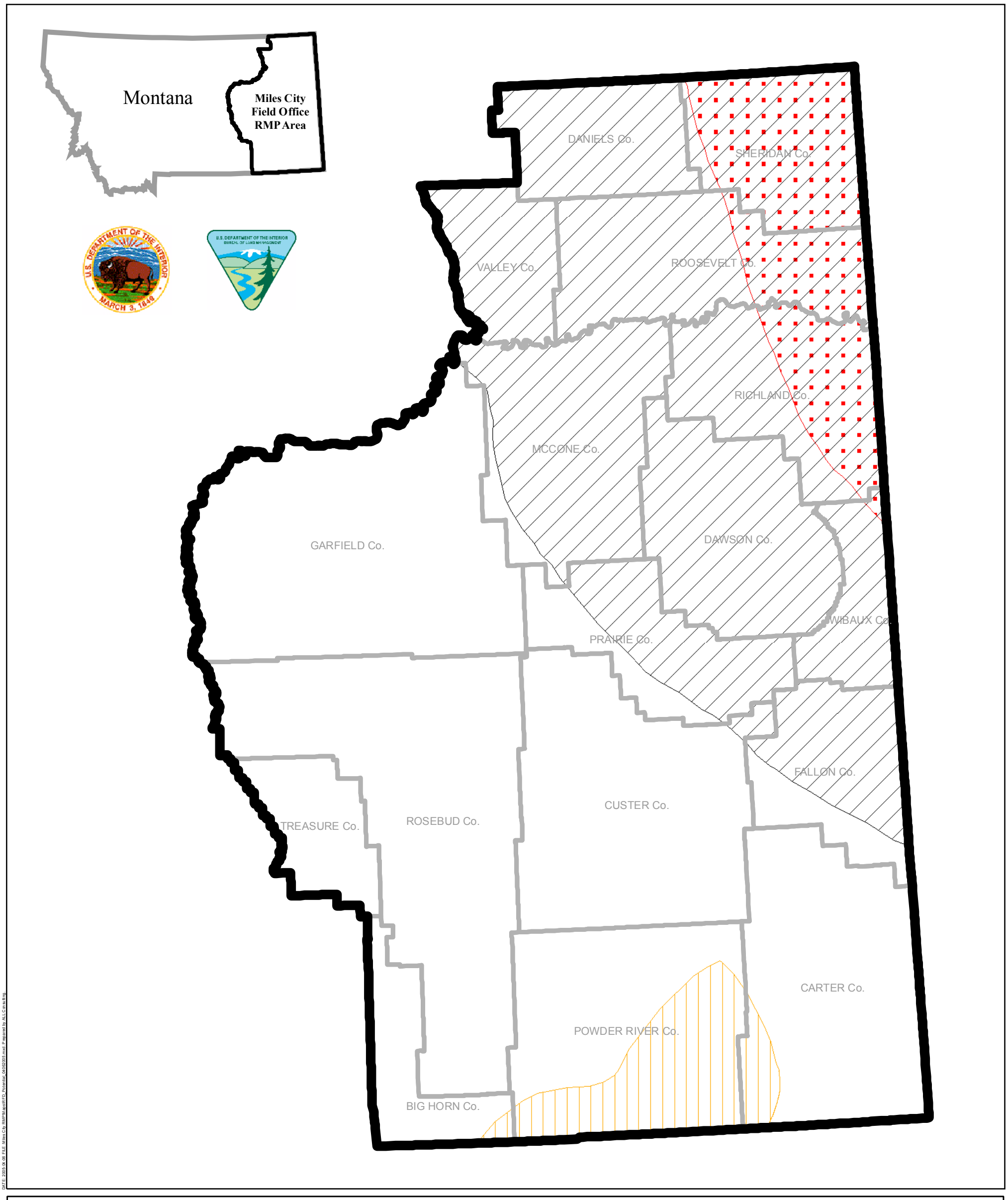

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Figure 2-7
Oil and Gas Assessment Units

Legend

- RMP Area
- County
- Upper Minnelusa Sandstone
- Pre-Prairie Middle Devonian and Silurian
- Pre-Red River Gas

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fields in the PRB within only one Montana field (outside of the MCFO RMP area) reporting production from the Minnelusa, with total discoveries for the PRB estimated to contain 500 MMB of oil. The 2003 USGS assessment estimates the mean undiscovered resources to be 522 MMB of oil and 31.3 BCF of natural gas of which approximately 17.2% (Table 2-1) of the assessment unit area is located within the MCFO RMP area (USGS, 2002).

2.1.3.3 Muddy Sandstone Play

This conventional oil and gas play is the result of stratigraphic traps of the Cretaceous Muddy Sandstone. The play extends into the southeastern portion of Montana through western Carbon County, Powder River County, southern Rosebud County, and eastern Big Horn County (Figure 2-8). The oil is likely sourced from the overlying Mowry Shale, but other possible sources include the underlying Skull Creek Shale. The reservoirs are generally fined-grained sandstone, with thicknesses that vary because of the unconformity that exists on the top of the Skull Creek Shale. Average reservoir thicknesses are between 10 and 25 feet (Dolton and Fox, 1996).

The reservoirs are stratigraphically bounded by finer grained sediments from the Skull Creek, Muddy, and Mowry shales, which act as traps for the hydrocarbons. These traps range in depth from 3,000 to 14,000 feet (Dolton and Fox, 1996). The 1995 USGS assessment noted that more than 170 individual accumulations had been discovered with estimates of at least 500 MMB of oil and 940 BCF of natural gas; within MCFO RMP area there are five fields (three oil and two gas) with reported production from the Muddy Formation.

The 2003 assessment estimates the Muddy Sandstone in two separate plays, an Oil play and a Gas play. The Muddy Sandstone Oil play is estimated to contain mean undiscovered resources of 59 MMB of oil, 177 BCF of natural gas, and 12.4 MMB of natural gas liquid. The Gas play is estimated to contain mean total undiscovered resources of 272 BCF of natural gas and 16.3 MMB of natural gas liquid (USGS 2002). Approximately 26.8% (Table 2-1) of the assessment unit is located within the MCFO RMP area.

2.1.3.4 Sussex-Shannon Sandstone Play

This conventional oil and gas play is the result of stratigraphic traps of the Sussex and Shannon Sandstone Members of the Eagle Formation. The play extends into the southeastern portion of Montana through southwestern Powder River County, southern Rosebud County, and southeastern Big Horn County (Figure 2-4). The oil is attributed to the underlying Niobrara and Carlisle Formations, with secondary accumulations from Upper Cretaceous shales from the Frontier and Steele Formations. The reservoirs are marine shelf sandstones, which are relatively narrow and sinuous; thicknesses range from 5 to 32 feet. The traps are stratigraphic in nature where the narrow and sinuous shelf sandstones have updip pinchouts overlain by shales. Depths to the traps range from 7,000 to 11,000 feet (Dolton and Fox, 1996).

The 1995 USGS assessment of the play identified 22 existing fields with one field located in the MCFO RMP area with reported production, with estimated discoveries for all of the PRB of 180 MMBO and 90 BCFG. The 2003 USGS assessment estimated mean undiscovered resources of 68 MMB of oil, 54 BCF of natural gas and 4.3 MMB of natural gas liquid of which approximately 10% (Table 2-1) of the assessment unit is located within the MCFO RMP area (USGS, 2003).

2.1.3.5 Mesaverde-Lewis Play

This conventional oil and gas play is the result of stratigraphic traps of marine sandstones in the Cretaceous Mesaverde Formation and Lewis Shale. The play extends into the southeastern portion of Montana through southwestern Powder River County and into southeastern Big Horn County (Figure 2-6). The oil and gas present in the play are attributed to the source rocks of the Niobrara Formation and the Carlile Shale, with secondary oil amounts from the Frontier Formation and Steele Shale. The reservoirs are porous, feldspathic sandstones in

the Teapot and Parkman Sandstone Members of the Mesaverde Formation, and the Teckla Sandstone of the Lewis Shale. Average thicknesses of the reservoirs are between 10 and 150 feet. The traps are stratigraphic in nature, a result of updip pinchouts from erosional surfaces and facies changes from shallow-marine sandstones to offshore siltstone and shale. The depth to these traps range from 5,000 to 9,500 feet near the basin axis (Dolton and Fox, 1996).

The 1995 USGS assessment of the play identified 60 existing fields, none of which are located within the MCFO RMP area, with estimated discoveries of 110 MMB of oil and 180 BCF of natural gas. The 2003 USGS assessment estimated mean undiscovered resources of 58 MMB of oil, 58 BCF of natural gas, and 4.1 MMB of natural gas liquid of which approximately 5.6% (Table 2-1) of the assessment unit is located within the MCFO RMP area.

2.1.3.6 Lakota Sandstone Play

This conventional oil and gas play is the result of stratigraphic traps of the Cretaceous-aged basal Lakota Sandstone. The play extends into the southeastern portion of Montana through southwestern Carbon County, southern Powder River County, southern Rosebud County, and southeastern Big Horn County (Figure 2-8). The oil and gas present in the play are attributed to the overlying Mowry Shale, with other possible source rocks including the marine Skull Creek Shale and the shales of the Fall River sequence. The reservoirs are fine- to coarse-grained sandstones, with average thicknesses between 6 and 13 feet. The traps are stratigraphic in nature, with some associated with local structure elements. The stratigraphic the traps are the result of sandstone pinchouts of alluvial channels. Overlying seals include the Fall River and Skull Creek Shales (Dolton and Fox, 1996). The depths of the traps range from 2,000 to 13,000 feet.

The 1995 USGS assessment of the play notes only light exploration due to the size, unpredictability and difficulty in finding accumulations of oil or gas. The 2003 USGS assessment estimated mean undiscovered resources of 54 MMB of oil, 21.5 BCF of natural gas, and 1.5 MMB of natural gas liquid, of which approximately 27.5% (Table 2-1) of the assessment unit is located within the MCFO RMP area.

2.2 Williston Basin

Most of the remaining portion of the Miles City RMP area located outside of the PRB is located within the northwestern portion of the Williston Basin (Figure 2-2). The Williston Basin totals approximately 95,000 square miles including parts of eastern Montana, North and South Dakota, Manitoba, and Saskatchewan, Canada. The Williston Basin is the result of subsidence which is believed to have started as early as the Ordovician Period and continues today. The Williston Basin contains a nearly complete rock record (Figure 2-3) reflecting the numerous transgressive/regressive sequences which have occurred in the basin (Heck et al., 2002). Within the Montana Portion of the Williston Basin there are two dominant structural features, the Cedar Creek Anticline and the Poplar Dome (Heck et al., 2002).

2.2.1 Stratigraphy and Geologic Structure: reservoirs, traps, source rocks and seals

Outcrops within the Williston Basin consist primarily of the Tertiary sediments from the Fort Union Formation, Cretaceous sediments from the Hell Creek Formation, and Quaternary Alluvium along the various river valleys. A generalized stratigraphic column of the Montana portion of the Williston Basin is presented in Figure 2-3. The Tertiary deposits contain sediments which include various lignites and sub-bituminous coals which to date have only been sporadically tested for coal bed natural gas in North Dakota. The sedimentary rocks within the Williston Basin (see Figure 2-3) are unique because the basin contains one of the most complete rock records preserved, with sedimentary rocks from the Cambrian through the Holocene present (Schmoker, 1996, and Heck et al., 2002). Oil and gas has been developed

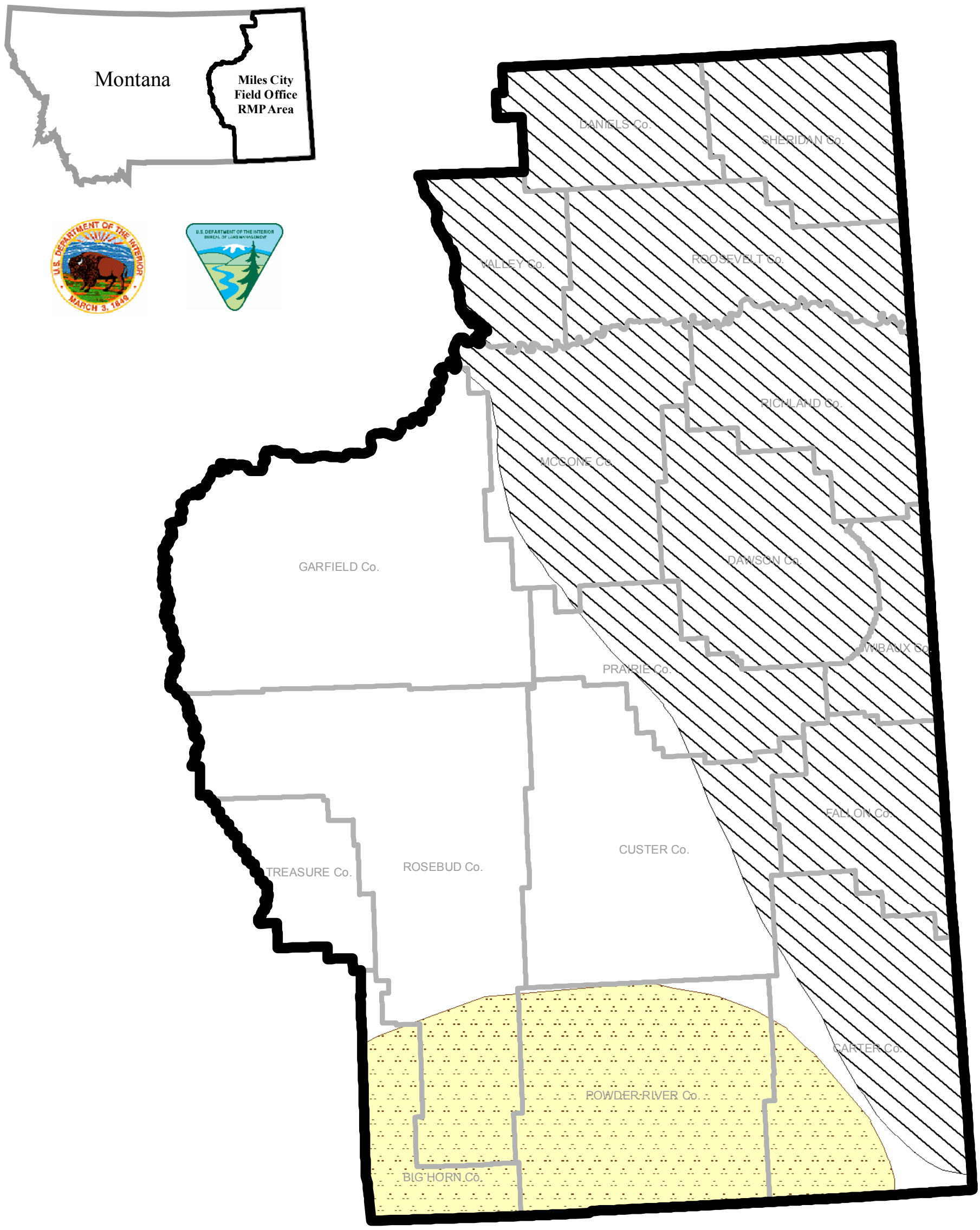

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Figure 2-8
Oil and Gas Assessment Units

Legend

- RMP Area
- County
- Red River (Ordovician)
- Muddy Sandstone
- Lakota Sandstone

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from Cretaceous, Mississippian, Devonian, Silurian, and Ordovician reservoirs within the basin (MBOGC, 2005).

2.2.1.1 Geologic Structure

The Williston Basin is a nearly circular basin with the center located in western North Dakota. The basin covers nearly 300,000 square miles extending into South Dakota, Montana, and into the Canadian provinces of Saskatchewan and Manitoba. At the basin's deepest point, sediments are believed to be as much as 16,000 feet thick with the strata becoming shallower and thinner toward the basin margins. Structural deformation within the Williston Basin is attributed to basin subsidence which is believed to have started in the Late Cambrian to Early Ordovician and continues to the present; the results of the structural deformation can be seen in the folds and faults of the regional structures. Major structures include the Nesson, Cedar Creek, Little Knife, and Billings anticlines located in eastern Montana and western North Dakota, all of which have reported oil production (Heck et al., 2002).

2.2.1.2 Source Rocks

The source rocks for much of the oil and gas in the Williston Basin are organic-rich, dark marine shales and shaly carbonates. The lower Lodgepole and Bakken Formations are interpreted to be the source rocks for Madison oil and gas. The upper shales and shaly carbonates of the Red River Formation and the overlying Upper Ordovician Stony Mountain Formation are interpreted to be the source rocks for the Red River. The source rocks for the Middle to Upper Devonian play are likely the interbedded marine shales and shaly carbonates within the Duperow and Nisku. The Devonian/Silurian play is likely sourced from organic shales in the Devonian Souris River and Upper Ordovician Stony Mountain Formations. The marine shales of the Tyler and upper Deadwood Formations are the likely source rocks for the post-Madison Triassic play and the Red River play, respectively (Peterson, 1996). The Bakken Formation is also a self-sourced reservoir with considerable volumes of oil reserves.

The lower Lodgepole and Bakken Formations are situated at the base of the Mississippian Madison Group. As source rocks, these formations are thermally mature in the basin center (vitrinite reflectance up to 1.1 percent) and become immature toward the basin boundaries (vitrinite reflectance of 0.4 percent), where the organic carbon content tends to be lower. Within the Bakken Formation, there are two shale members (the upper and lower) which are high in organic matter (Type II kerogen). The upper member contains up to 12.1 weight-percent organic carbon and the lower member up to 11.5 weight-percent organic carbon. The total mass of organic carbon within the thermally mature area is approximately 10^{14} kg. Oil generation is believed to have been initiated in the Late Cretaceous and continues today (Peterson, 1996).

The organic-rich marine shales and shaly carbonates are present in the upper part of the Ordovician Red River, overlying Ordovician Stony Mountain and Devonian Souris River Formations. These source rocks are thermally mature to overmature in the main part of the Williston Basin and pinch out on the basin margins. The marine shales and shaly carbonates of the Devonian Duperow and Nisku are also thermally mature in the center of the basin and immature or absent on the basin margins. Oil generation in the Red River Formation is estimated to have started in the Late Paleozoic, while the other formations probably initiated oil generation in the early Cretaceous, with all formations likely having subsequent migration as a result of later structural movements including those associated with the Laramide orogeny (Peterson, 1996).

The organic-rich marine shales of the Pennsylvania Tyler Formation and organic-rich beds of the Mississippian Heath Formation are mature in the central and western parts of the basin respectively, where present, but become immature toward the basin margins. Oil generation is estimated to have occurred during the late Mesozoic to early Tertiary. The marine

shales interbedded in the Ordovician Winnipeg Sandstone and present in the Deadwood Formation are thermally mature to overmature deeper in the basin. Gas generation is believed to have commenced in the late Cretaceous to early Tertiary, with enhancement of migration and accumulation from fracture development during the late Cretaceous and into the Tertiary (Peterson, 1996).

2.2.1.3 Reservoirs

The potential and active reservoirs in the Williston Basin include the Madison Mission Canyon and Charles Formations; the dolomites and dolomitic limestones of the Red River, Duperow, Birdbear (Nisku), Winnipegosis, Souris River, and Dawson Bay Formations; and the sandstone beds of the Tyler, Big Snowy, Winnipeg, and Deadwood Formations. The Madison Mission Canyon and Charles Formation are dolomitized bank carbonates of algal-oolitic, crinoidal, or bioclastic origin, while the Ordovician Red River dolomites are the result of bioclastic buildups and tidal-flat dolomites (Peterson, 1996). The middle and upper Devonian carbonates (Duperow and Birdbear/Nisku) are the result of carbonate - evaporate cycles, while the earlier Devonian carbonates (Winnipegosis, Souris River, and Dawson Bay) and Silurian Interlake Formation carbonates are reef and tidal carbonates (Peterson, 1996). The clastic reservoirs of the late Mississippian to Triassic are discontinuous mix of marine, deltaic, and fluvial sandstones along with dolomites and dolomitic limestones, especially in the late Mississippian formations.

The Bakken Formation is a continuous type, unconventional, self-sourced oil reservoir in which reservoir quality, as traditionally measured in terms of matrix porosity and permeability, is consider poor. Oil production is a result of fracture development within the formation, thus production success and recovery volumes are both tied to the degree of development and connection within the fracture system, but low recovery rates are more common than true dry holes (Peterson, 1996).

2.2.1.4 Traps and Seals

The reservoirs of the Williston Basin are generally exposed to structural traps from large scale structural features such as the Cedar Creek and Nesson Anticlines and the Billings Nose. The major traps for the Mississippian Madison, Ordovician Red River, and the Devonian, Silurian, and Pre-Red River Plays are associated with the folds and fault closures that are present around the two anticlines and the Billings Nose. The Madison Formation seals are related to carbonate buildups overlain by salts or shales, updip stratigraphic traps, and truncations associated with Mesozoic clastics, with some hydrodynamic-assisted traps also reported. The Ordovician Red River and Middle to Upper Devonian seals include carbonate buildups overlain by anhydrite beds within the formations. Shaly beds of the Silurian, Devonian, and lower Mississippian are important for the Red River Formation along the Cedar Creek Anticline. Secondary seals from argillaceous carbonates and shales are associated with the Devonian Formations, with the shales of the Three Forks Formation providing regional seals for the Nisku (Peterson, 1996).

The Dawson Bay and Souris River seals include the folds and fault closures of the Cedar Creek and Nesson Anticlines, carbonate reef and mound buildups, and potentially some updip porosity and pinchout traps with the main regional seal being the Devonian Prairie salt and anhydrite beds. Post Madison Formation traps are dominantly stratigraphic in nature while Pre-Red River seals are associated with Ordovician and Upper Cambrian Shales (Peterson, 1996).

2.2.2 Summary of USGS Oil and Gas Assessments for the Williston Basin

The USGS oil and gas assessment for the entire Williston Basin was performed in 1995 for conventional resources (Peterson, 1996) and continuous oil and gas resources (Schmoker, 1996). The USGS assessments estimate the potential of undiscovered oil and gas resources using a geologic based assessment methodology. The USGS assessment for the entire Williston

Basin estimated a mean undiscovered natural gas resource of 970 BCF of gas, a mean undiscovered oil resource of 344.3 MMB and a mean undiscovered natural gas liquids of 102 million barrels (Peterson, 1996). The 1995 Williston Basin assessment identified six conventional oil and gas plays and their estimated undiscovered resources (Peterson, 1996). The 1995 assessment also identified four unconventional continuous resource plays including the Bakken Fairway Play, Bakken Intermediate and Bakken Outlying Plays, and the Southern Williston Basin Margin-Niobrara Shallow Biogenic Play (Schmoker, 1996). Of the six conventional oil and gas plays identified in the 1995 assessment, all six plays (Madison, Red River, Middle and Upper Devonian, Pre-Prairie Middle Devonian and Silurian, Post-Madison to Triassic Clastics, and the Pre-Red River Gas Play) extend into the Montana portion of the Williston Basin. Of the four continuous plays identified in the 1995 assessment, the Bakken Play extends into the Montana portion of the Williston Basin.

2.2.2.1 Madison Play

The conventional Mississippian-aged Madison play is a structural-stratigraphic play in which the traps are associated with structural folds and closures on anticlines with updip stratigraphic traps. The play extends eastward from the southeastern most corner of Montana in Carter County along a northwestward trend to the northwestern edge of Valley County (Figure 2-4). The oil and associated natural gas are sourced from organic-rich shales and shaly carbonates of the Madison Group, Lodgepole and Bakken Formations. The reservoirs are dolomitized carbonate banks of the Mission Canyon and Charles Formations at average depths of 5,000 to 13,000 feet. As of the 1995 assessment, there had been nearly 400 accumulations identified in the play within the MBOGC database; there are 45 fields reporting production within the MCFO RMP area. Mean estimated resources for the Williston Basin include 168.5 MMB of oil, 168.5 BCF of natural gas, and 14.3 MMB of natural gas liquid (Peterson, 1996). Approximately 28.1% (Table 2-2) of the assessment unit is located within the MCFO RMP area.

2.2.2.2 Red River Play

The conventional Ordovician-aged Red River play is a structural-stratigraphic play in which the traps are associated with the major structural anticlines (Nesson and Cedar Creek) of the basin. The play extends along the eastern side of Montana from the southeastern corner in Carter County along a northwest trend to the northwestern edge of Valley County (Figure 2-8). The oil and natural gas present are sourced from marine shales and shaly carbonates of the upper Red River Formation, with secondary accumulations from the Upper Ordovician Stony Mountain Formation. The reservoirs are the dolomites and dolomitic limestones of the Red River Formation, present at depths ranging from 7,000 to 15,000 feet, and sealed by the evaporates and shales of the Silurian, Devonian, and Lower Mississippian. As of the 1995 assessment, there were approximately 350 known accumulations with mean estimated resources of 53.5 MMB of oil, 371.5 BCF of natural gas, and 52.2 MMB of natural gas liquid (Peterson, 1996). Approximately 28.1% (Table 2-2) of the assessment unit is located within the MCFO RMP area.

2.2.2.3 Middle and Upper Devonian (Pre-Bakken – Post-Prairie Salt) Play

The conventional Middle/Upper Devonian play is a stratigraphic play in which carbonate-evaporite and shale sequences are associated with fold trends on the major structural features in the basin. The play extends along the same trend as the Red River and Madison plays (Figure 2-5). The oil and gas present are sourced in the shales and shaly carbonates of the Nisku and Duperow cycles. The reservoirs are the interbedded dolomites and dolomitic limestones within the Duperow and Nisku cycles in addition to the sandstone and carbonates of

TABLE 2-2
SUMMARY OF 1995 USGS RESOURCE ASSESSMENT OF THE WILLISTON BASIN, MONTANA PORTION ONLY

Montana Portion - WB		
Play	**Mean Oil Resources (million bls)**	**Mean Gas Resources (TCF)**
Continuous Resource Reservoirs		
Bakken Fairway	NA	NA
Bakken Intermediate	NA	NA
Bakken Outlying	NA	NA
Conventional Reservoirs		
Madison Play	47.3	0.05
Red River Play	15.0	0.10
Middle and Upper Devonian (Pre-Bakken – Post-Prairie Salt) Play	15.5	0.04
Pre-Prairie Middle Devonian and Silurian	13.9	35.4
Post-Madison through Triassic Clastics	7.6	0.002
Pre-Red River Gas	NA	NA
TOTAL	**99.3**	**35.592**

NA = Mean resource values were not available in the 1995 USGS assessment.

the Three Forks Formation, depths average between 6,000 and 14,000 feet. The traps are folds and closures of carbonate banks sealed by evaporites and shales associated with structural elements such as the Nesson Anticline and Billings Nose. As of the 1995 assessment, there were approximately 150 existing accumulations with mean estimated reserves of 55.3 MMB of oil, 126 BCF of natural gas, and 4.4 MMB of natural gas liquid (Peterson, 1996). Approximately 28.1% (Table 2-2) of the assessment unit is located within the MCFO RMP area.

2.2.2.4 Pre-Prairie Middle Devonian and Silurian Play

The Middle Devonian/Silurian play is a stratigraphic play in which carbonate reservoirs are overlain by a regional evaporate (Middle Devonian Prairie). In Montana, the play extends eastward from southeastern Fallon County along a northwest trend toward northwestern Valley

County (Figure 2-7). The oil and gas present are sourced in the shaly beds of the Upper Ordovician Stony Mountain and Middle Devonian Souris River Formations. The reservoirs are the carbonate beds of the Middle Devonian Winnipegosis, Souris River and Dawson Bay and the Silurian Interlake Formation, depths range from 7,000 to 15,000 feet. The traps are folds and fault closures accessory to the major structural features of the Nesson and Cedar Creek Anticline, with secondary traps associated with updip pinchout and porosity traps (Peterson, 1996). As of the 1995 assessment, there were approximately 50 existing accumulations with mean estimated resources of 49.3 MMB of oil, 212 BCF of natural gas, and 28.7 MMB of natural gas liquid (Peterson, 1996). Approximately 28.1% (Table 2-2) of the assessment unit is located within the MCFO RMP area.

2.2.2.5 Post-Madison to Triassic Clastics Play

The Pennsylvanian to Triassic aged play is a stratigraphic play in which fluvial-deltaic and nearshore marine sandstones and carbonates are sealed by overlying shales and evaporites. In Montana, the play extends to the east of a line that trends from central Wibaux County westward through Dawson County, then trends northwestward to northwestern Valley County (Figure 2-5). The oil and gas present are sourced in the marine shales of the Tyler Formation and organic-rich beds of the Big Snowy (Heath) Formation. The reservoirs are the sandstones of the Tyler and Big Snowy Formations with secondary reservoirs of the carbonates of the upper Big Snowy and Amsden Formation, depths range from 4,000 to 8,000 feet. The traps are generally associated with anticline structures with stratigraphic components. As of the 1995 assessment, there were approximately 25 accumulations with mean estimated reserves of 17.7 MMB of oil and 5.7 BCF of natural gas (Peterson, 1996). Approximately 42.9% (Table 2-2) of the assessment unit is located within the MCFO RMP area.

2.2.2.6 Pre-Red River Gas

The Ordovician and Cambrian play is a structural play in which sandstone reservoirs are buried beneath marine shales associated with major structural features in the basin. In Montana, the play extends along the northeastern edge of the state from northern Wibaux County to northwestern Sheridan County (Figure 2-7). The oil and gas present are sourced from the marine shales of the Upper Deadwood Formation and the marine shales within the Middle Ordovician Winnipeg Sandstone. The reservoirs are the sandstones of the Ordovician Winnipeg and Upper Deadwood, and Cambrian Deadwood Formations at depths from 12,000 to 16,000 feet. The traps are generally associated with folds and trends adjacent to the Nesson Anticline sealed by the Ordovician and Upper Cambrian shales. As of the 1995 assessment, there were few known accumulations and resource estimates are not well known due to lack of exploration because of the depth of the reservoirs. Approximately 18.4% of the assessment unit is located within the MCFO RMP area.

2.2.2.7 Bakken Play

The Mississippian and Devonian Bakken Play is an unconventional continuous type play in which the source rock also serves as the reservoir. In Montana, the play extends along the northeastern edge of the state from Richland County to eastern Valley County and northward into central Daniels County back eastward into Sheridan County (Figure 2-6). The source rocks are the upper and lower shale members of the formation which are rich in organic matter and thermally mature enough to generate considerable oil resources (Schmoker, 1996). Production from the Bakken play is controlled by fracturing of the shales, with zones of recoverable resources limited by thermal maturity and not the result of stratigraphic or structural traps. The USGS divided the Bakken play into three sub classifications based on similarities in the exploration and production results, the Bakken Fairway, Intermediate, and Outlying plays. However, there are several geologic factors that were identified that may

support the division of the plays that are related to the fracture development and spacing within the shales and thermal maturity (Schmoker, 1996). Exploration activities within the Bakken play were initiated in the early 1950's with various degrees of success into the 1970's when additional exploration on the Nesson Anticline became relevant. The evolution of horizontal drilling practices has resulted in the rapid expansion of Bakken exploration and development in recent years in eastern Montana and western North Dakota. There are approximately 0.04% of the Bakken Fairway play, 13.3% of the Bakken Intermediate play and 62.3% of the Bakken Outlying play located within the MCFO RMP area.

2.2.3 Non-USGS Oil and Gas Resource Assessments

2.2.3.1 Williston Basin Coal Bed Natural Gas Play

The 1995 USGS assessment of plays in the Williston Basin does not include an assessment of CBNG. However, coal research has been performed by the USGS, North Dakota Geological Survey, and the Montana Bureau of Mines and Geology to assess the coal deposits present in the Williston Basin. The USGS has assessed the coals of the Fort Union Formation in the Williston Basin of North Dakota (Ellis et al., 1999, and Flores and Keighin, 1999). The North Dakota Geological Survey (NDGS) assessed the potential for CBNG development from lignites in the North Dakota portion of the Williston Basin (Murphy and Goven, 1998). Additional analysis of the CBNG potential of the Williston Basin in North Dakota has been reported in the series of papers and presentation by Ralph Specht (Specht, 2002 and 2003).

The coals of the Williston Basin are sub-bituminous to lignite in grade and are present in the Paleocene Fort Union Formation (Specht, 2002). The North Dakota side of the Williston Basin has more published research relative to the presence and differentiation of the coal units and the potential for CBNG development than is currently available on the Montana portion of the basin. The deposition of the coal bearing strata across the Williston Basin coincided with deposition of the PRB coal bearing strata although environmental differences resulted in thinner and less-widespread accumulations in the Williston Basin (Specht, 2003). Similar to the coals of the PRB, the Williston Basin coals act both as source rock and reservoir with much of the gas being derived from biogenic generation. The coals of the Williston Basin tend to be shallower than the PRB with depths ranging from outcrop to 750 feet, with the crop out zones located along the western boundaries in eastern Montana (Specht, 2003). The NDGS surveyed coal and other drilling related industry personnel regarding instances of gas shows when drilling wells in lignites across North Dakota. Although there were several reports of gas blowing out the well bores in various parts of North Dakota, (including northwestern part near the Montana state line) there has not been sufficient analysis to indicate the gas present was methane (Murphy and Goven, 1998). In summary, the NDGS concludes that the potential for CBNG in the Williston Basin has not been sufficiently explored to truly determine the presence of profitable methane shows from lignites, as most wells drilled in the lignites have either been at sufficiently "mudded up" or at such shallow depths (<400 feet) that the gas may have migrated into other formations (Murphy and Goven, 1998). Specht (2002) proposes the presence of up to 13 TCF of methane gas reserves the Williston Basin of North Dakota, a value based on the estimated volume of sub-bituminous and lignite coal, and gas-sorption values from biogenic methane producing basins nearby.

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3.0 Past and Present Oil and Gas Exploration Activity

Oil and gas have been developed in the Powder River Basin after the discovery of the Salt Creek field in 1908 (Dolton and Fox, 1996). Since this initial discovery, recoverable resources have been estimated at 2.7 billion barrels of oil and 2.3 TCF of natural gas within the basin (Dolton and Fox, 1996). Conventional oil and gas exploration has been declining in the Montana portion of PRB, with considerable decreases in oil production since 1986; natural gas production had averaged less than 0.3 BCF/year in the Montana portion of the PRB until the start of CBNG production in 1999. Since 1999, the PRB has increasingly become a larger source of natural gas revenues for Montana, with production rising above 10 BCF in 2002 and 2004.

Oil and gas has been developed within the Williston Basin since shallow gas was discovered on the Cedar Creek Anticline in southeastern Montana in 1916. Major oil companies moved into the area after World War II, where Shell Oil Company produced oil and gas from the Siluro-Ordovician carbonate reservoirs (Peterson, 1996). Early Montana fields on the Cedar Creek Anticline include the Glendive (Silurian and Ordovician Red River), Pine (Ordovician Red River and Mississippian Madison), Pennel (Silurian, Red River, Madison), Cabin Creek (Silurian, Red River, Madison), Poplar East (Red River, Bakken, Devonian), and Little Beaver (Red River). Current major exploration and production has been from the Siluro-Ordovician with recent horizontal water-floods getting the most attention in the basin. Vertical wells are being replaced with long-reach horizontals used as both injectors and producers. Exploration activities are moving to formations where long-reach horizontals can be used to take advantage of producing formations (Mississippian Formations) which have been previously difficult to develop with vertical wells.

- Two Mississippian formations – the Madison Group and the Bakken – are getting serious interest in Montana and North Dakota for oil produced in stratigraphic traps. The Bakken is the target for most of the wildcats drilled in the basin. The Madison Group includes the Madison, Lodgepole, and Ratcliffe among other formations; these carbonates receive a great deal of interest every year in the Williston Basin.

- A Devonian carbonate – the Nisku or Birdbear – is the target for several wildcats each year in Montana and North Dakota.

- The Eagle and Judith River are shallow sands that produce small amounts of natural gas in scattered areas of the Williston Basin. These shallow sands contain stratigraphic traps that are the target for several wildcat wells every year in each state.

- The Tertiary coals in the Fort Union have been pursued in only a very few wells across the Williston Basin, mostly in North Dakota (Specht, 2003). The coals rank from lignite to sub-bituminous and can be present as thick as 105 feet. The depths of these coals range from the surface to approximately 750 feet. Three operators have drilled 12 CBNG tests in the Williston Basin in North Dakota. Several wells have had shows of CBNG, but no production has occurred. The methane content was evaluated in only a few wells and has been in the 5 to 10 mcf/ton range – approximately 1/5 to 1/10 the range of PRB methane content. CBNG could be a future development in the Williston Basin, although it is not believed to be widespread across the basin.

Recent exploration trends in the Miles City RMP area have been identified by drilling activity and the identification of areas which have recently undergone geophysical or seismic exploration lines. The Montana Board of Oil and Gas Conservation (MBOGC) tracks seismic survey permits (issued by either the county clerk or the BLM) for all seismic surveys conducted within in the state including the Miles City RMP

area. The number of seismic permit notices MBOGC has received for the Miles City RMP area have been decreasing since 1994 when 34 permits were issued. The lowest permit count (five) occurred in 1999 and 2000, while in 2001 and 2002 the number of seismic permit notices increased to 12 and 11, respectively. Over the last two years the number of permit notices received by MBOGC has again decreased to six for 2003 and four for 2004 (MBOGC, 2005). There have been ten seismic permit notices received by MBOGC during 2003 and 2004, only one of these permits was issued for a survey outside of the Williston Basin area (Big Horn County in the PRB); six of the permits were issued for Richland County inside the Williston Basin area (MBGOC, 2005). Richland County within the Williston Basin is currently one of the most active oil and gas areas in Montana and the most active area for new development in the Miles City RMP area due to the Bakken Play. Presently, the MBOGC reports the Bakken Play is receiving much of the attention in the Williston Basin due to soon to expire leases, high oil prices, and the technologic advances in horizontal well drilling (Halvorson, personal communication, 2005).

4.0 Past and Present Oil and Gas Development Activity

The Miles City RMP area consists of approximately 2.8 million surface acres and 11.8 million acres of federally managed mineral estates. Within the Miles City RMP area is the most active producing area for oil in the state of Montana (Williston Basin), while the Williston and Powder River Basins are both becoming larger pieces of the state's total natural gas production. The analysis included in this section evaluates oil and gas development activity as it relates to past and present activities.

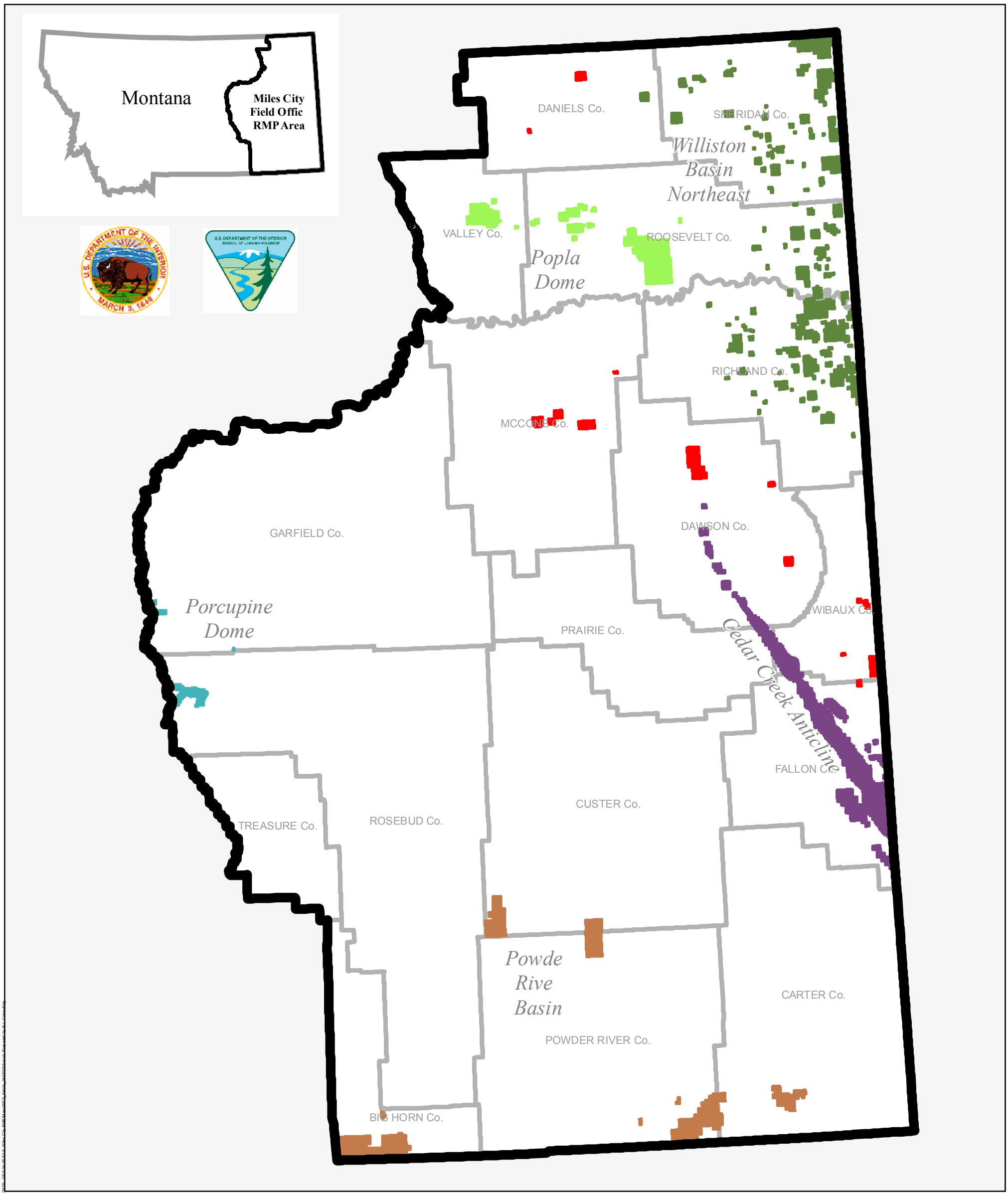
The BLM offers multiple oil and gas lease sales per year. The results of lease sales from 2000 through the first lease sale of 2005 are summarized in Table 4-1 (BLM 2005). Since 2001, the total number of lease parcels offered by the Miles City FO has shown a decrease between 5% and 15% per year, while the number of parcels sold has fluctuated (Table 4-1). The acreage offered for lease has shown a similar decrease to lease parcels since 2001, while the number of lease acres sold has fluctuated but increased in 2004 (Table 4-1). Total bonus dollars and average bonus dollars per acre received on leased acres decreased from 2001 to 2003, but have increased for 2004 and appear to be decreasing again in 2005 (Table 4-1).

The Montana Board of Oil Gas Conservation collects statistics and completion data for all wells with Applications for Permit to Drill (APDs) in the state of Montana and this database is available online on the MBOGC website. Well record data for the Miles City Field Office RMP area was extracted from the database to define the number of registered APDs and producing wells. The well and field data was categorized by the following geologic boundaries to define three active areas: the Powder River Basin, Williston Basin (includes the Cedar Creek Anticline, Poplar Dome, Williston Basin Northeast, and Williston Basin other areas), and Porcupine Dome (Figure 4-1). The Williston Basin represents the largest percentage of the oil and gas development within the RMP because there are several key

TABLE 4-1
OIL AND GAS LEASE SALES FOR THE MILES CITY FIELD OFFICE 2000-2005

Sale Date	Parcels Offered	Parcels Sold	Acreage Offered	Acreage Sold	Total Bonus Dollars ($)	Avg. Bonus Dollars per acre ($)
2000	427	231	421,741	218,763	$1,462,889.50	$6.69
2001	481	178	648,808	235,855	$2,354,800.00	$9.98
2002	406	212	392,198	101,674	$626,315.00	$6.16
2003	387	68	328,968	48,166	$229,183.00	$4.76
2004	329	104	306,846	72,518	$1,003,530.00	$13.84
2005a	93	57	75,230	42,844	$455,832.70	$10.64
Total	2,123	850	2,173,791	719,820	$6,132,550.20	$8.52

a. Fiscal Year 2005 includes values for the competitive lease sale on January 25, 2005 and March 29, 2005 only.



US Department of the Interior

Bureau of Land Management

MilesCity Field Office Draft RMP/EIS

N W E S

0 5 10 20 Miles

Figure 4-1
Oil and Gas Producing Fields Grouped by Geographic Area

Legend

- RMP Area
- County
- Cedar Creek Anticline
- Poplar Dome
- Porcupine Dome
- Powder River Basin
- Williston Basin NE
- Williston Basin Other

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features related to oil and gas development. Because of these features, the data for the Williston Basin was subdivided into four geographically and geologically related areas, the Cedar Creek Anticline, Poplar Dome, Williston Basin Northeast, and Williston Basin other areas (Figure 4-1). When available, the data for each sub-area of the Williston Basin is presented separately and combined for a Williston Basin total area. Table 4-2 and 4-3 were generated from the well data extracted from the MBOGC database. Table 4-2 shows the number and type of wells with an active APD in the RMP area by geologic boundary while Table 4-3 shows the number and type of producing wells in the RMP area.

As of March 2005, there are 7,267 registered APDs in the MBOGC database for the Miles City RMP Area. Of these 4,015 producing oil and gas and CBNG wells are located in 171 producing fields (Tables 4-2, Table 4-3, Figure 4-1 and Figure 4-2).

The Williston Basin contains the most producing wells with 2,865, or 72%, (Figure 4-2) and the most producing fields with 159 (Table 4-3). Within the Williston Basin, the Cedar Creek Anticline area contains 1,555 producing wells (Figure 4-2) which equates to 39% of the MCFO RMP area total, and 54% of the Williston Basin area total. The Williston Basin northeast area contains 1,030 producing wells. Outside of the Williston Basin, the Powder River Basin has the next largest number of producing wells at 976, 25% of the MCFO RMP area total. The remaining 4% of the producing wells in the RMP area are located on the Porcupine Dome (174 producing wells or 4% of the total).

MBOGC data for well permits and completions for the MCFO RMP area from 2000 through March of 2005 are provided in Table 4-4 and Table 4-5. Over the five-year period shown, the total number of well permits issued by MBOGC has increased from 602 permits per year in 2000 to 841 permits per year through the end of 2004. While the number of well completions has been rather steady with an average of 500 wells completed per year, one exception to this average occurred in 2003 when there were 676 well completions (Table 4-5). The increase in well completions for 2003 is due to the large increase in the number of CBNG wells (190) completed during that year compared to previous years (Table 4-5).

Table 4-4 and 4-5 include the data for the number of horizontal well permits and completions MBOGC reported for those years, the horizontal completions are included in the yearly data by well type and the yearly totals thus the horizontal completion data are presented after the totals in the tables. Horizontal well completion data presented include both new horizontal wells and horizontal recompletions of vertical wells. The number of horizontal wells and the ratio of horizontal to verticals wells has been increasing in Montana since 2000 with the highest number of horizontal completions and highest horizontal to vertical ratio occurring in 2004 (Table 4-5). Figure 4-3 shows the growth in the number of producing horizontal wells in Montana from 1986 through 2004, including the growth of horizontal wells since tax incentives were first initiated for horizontal drilling in 1994.

TABLE 4-2
MBOGC CURRENT WELL COUNTS FOR THE MILES CITY RMP AREA

Area / *Field*	WELL TYPE *																
Porcupine Dome	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	ST	SWD	UN	WS	WW	Total Wells
Sumatra			128	2	56	1					130		2				324
Stensvad			20		10						22		1		1		54
Ivanhoe			19		3						18		2	5	1		43
Cat Creek			4								4						8
Beanblossom			1								2		1				4
AREA TOTALS *5*	0	0	172	2	69	1	0	0	0	0	176	0	6	0	7	0	433
Powder River Basin	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	ST	SWD	UN	WS	WW	Total Wells
Bell Creek			121		109		4			2	420				4		660
CX	4	637	12														653
Wildcat Big Horn	2	56	250				13				4	6		3	2	2	338
Hammond			8				20				2	1					31
Liscom Creek			14				11										25
Pumpkin Creek			10				13										23
Leary																	20
Coal Creek		16	1														17
Bell Creek, Southeast		15	3				6			5					1		10
Wright Creek											7						9
AREA TOTALS *10*	6	709	434	0	109	0	67	0	0	2	438	7	2	3	7	2	1,786
WB - Cedar Creek Anticline	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	2 ST	SWD	UN	WS	WW	Total Wells
Cedar Creek			27		2		721	176		1	5						932
Pennel			13		118	1	1	9			255				4		407
Pine			17		68	1	12			2	190		4		10		304
Cabin Creek			8		55		2	3			173	6	5		1		247
Lookout Butte			7		23		2	8		1	80		2		3		126
Little Beaver			8		19		5				54				1		87
Gas City			10		3		8				34		11		1		67
Monarch			7		3			7			44		2				63
Pine Gas							55										55
Little Beaver, East			5		11						30		3		5		54
Glendive			17								23						49
Plevna			18				29										47
Cupton			12			1					17	9	2				33
Lookout Butte, East											27						27
Sand Creek			3	1			1				13						18
Waterhole Creek											18						18
Windy Ridge											17	1					17
Deer Creek			2								11		2				15
Gas Light			3				11										14
Woodrow			3								7		1				11
Wills Creek, South											6						6
Plevna, South							5										5
Fertile Prairie											4						4
AREA TOTALS *23*	0	0	160	1	302	3	851	204	0	4	1,008	0	48	0	25	0	2,606
WB - Poplar Dome	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	ST	SWD	UN	WS	WW	Total Wells
Poplar, East			27		2		1		10	4	116		5		5		170
Lustre			20			1			3		88			1			113
Poplar, Northwest			12						4		48						65
Tule Creek									2				3				23
Benrud, East						1			2			1	2				18
Volt		12	4						2	6	6		1				13
Midfork		10	2						1	3	9						12
Benrud			4			1			1		2		1				9
Long Creek, West			3						1		4						8
Benrud, Northeast			5								1		1				7
Tule Creek, East			4						1		1		1				7
Tule Creek, South			1						2		3		1				7
Lustre, North			1						1		1						3
Lone Rider											1						1
Red Fox											1						1
AREA TOTALS *15*	0	0	105	0	2	3	1	0	30	4	290	0	16	1	5	0	457
WB - Northeast	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	ST	SWD	UN	WS	WW	Total Wells
Wildcat Richland			140			1					397						540
Flat Lake			19		32						97		1		4		153
Goose Lake			17	1	10						43	2					77
Dwyer			15		6						46		2		2		71
Mon Dak, West			1								47	6	2				50
Sioux Pass, North			13								32						46
Ridgelawn			2		3						35				1		41
												1					

Area / *Field*	WELL TYPE *																
Brorson			4								31		2				37
Fairview			3			1					30		1				35
Vaux			2								31		1				34
Sidney			2								27		1				30
Anvil			8								16		2				26
Bainville, North			2								24						26
Reserve			11								13						25
Outlook			7								15		2				24
Raymond			1		1						17	1	3				22
Divide			3	1							16						21
Nohly			2								19						21
Putnam			1								18	1	1				20
Sioux Pass			7								12		1				20
Fort Gilbert											19						19
Medicine Lake			7								10		2				19
Brush Lake			4								13		1				18
Clear Lake			1								16		1				18
Katy Lake, North			3								13		2				18
Lonetree Creek			3								14		1				18
Comertown			1								13		1				15
Target											14						15
Crane			1								10		1				12
Flat Lake, South			1		1						9	1	1				12
Fox Creek, North			3								9						12
Mustang			3								9						12
Big Muddy Creek			5		1						5						11
Colored Canyon			2								9						11
Enid, North			3								8						11
Hay Creek			4								6		1				11
Sioux Pass, Middle			4								7						11
Salt Lake			2								6		2				10
Spring Lake			1								8		1				10
Sunny Hill			4								5		1				10
Charlie Creek, East			5								4						9
Oxbow			5			1					2		1				9
Bainville			1								7						8
Brorson, South			1								7						8
Charlie Creek			4								3		1				8
Second Creek			2								5		1				8
Three Buttes											8						8
Wakea											8						8
Bainville, West			1								6						7
Cattails											7						7
Lone Butte											7						7
Canal											6						6
Flaxville			3								2		1				6
Girard											6						6
Outlook, West			1								3		2				6
Redstone			4								2						6
Riprap Coulee			1								5						6
Bainville II			1								4						5
Cattails, South											5						5
Goose Lake Red River			1								4						5
Lambert			1								4						5
Otis Creek, South											4						5
Pronghorn											5						5
Raymond, North			1								4	1					5
Dagmar, North			2								1		1				4
Diamond Point			1								2		1				4
Intake II											3						4
Lowell											4						4
McCabe			1								3	1					4
Outlook, South											2						4
Singletree			1								2		1				4
Alkali Coulee			1								2	2					3
Burget			1								2						3
Charlie Creek, North							1				2						3
Comertown, South											3						3
Cottonwood											3						3
Dugout Creek			1								2						3
Fairview, East											2						3
Goose Lake, East			2								1						3
Green Coulee			2								1	1					3
Honker			2								1						3
Lambert, South											3						3

Area / *Field*	WELL TYPE *																
Oxbow II			1								2						3
Shotgun Creek, North			1								2						3
Frog Coulee			1								1						2
Green Coulee, East			1								1						2
Hawk Haven											2						2
Lonetree Creek, West											2						2
Medicine Lake, South											2						2
Midby			1								1						2
Missouri Breaks											1						2
Neiser Creek											2						2
Olje											2	1					2
Otter Creek			1								1						2
Raymond, Northeast			1								1						2
Reserve II											2						2
Reserve, South											2						2
Ridgelawn, North											2						2
Rocky Point											2						2
Sioux Pass, West											2						2
Spring Lake, South											2						2
Stampede											2						2
Wagon Trail			1								1						2
Wrangler											2						2
Ator Creek											1						1
Bainville (Ratcliffe/ Mission Canyon)											1						1
Flat Lake, East											1						1
Four Mile Creek											1						1
Lariat											1						1
Lowell, South											1						1
McCabe, South											1						1
McCabe, West											1						1
Nohly, South											1						1
Outlook, Southwest											1						1
Rainbow											1						1
Red Water, East											1						1
Salt Lake, West											1						1
Snake Creek											1						1
Spring Lake, West											1						1
Stampede, North			1														1
Sundown											1						1
AREA TOTALS *121*	0	0	367	2	54	3	1	0	0	0	1,379	0	61	0	7	0	1,874
Williston Basin Other	C5	CBNG	DH	DMY	EOR	EX	GAS	GST	ILW	MON	OIL	ST	SWD	UN	WS	WW	Total Wells
Weldon			4		3						14		4				25
Cow Creek, East			9								9		3				21
Richey, Southwest			6		3						8						17
Bloomfield			4								7						11
Cow Creek			6								2						8
Carlyle			2								2		1				5
Yates			1								4						5
Black Diamond			1								1		1				3
Den											3						3
Ollie											2						3
Vida											3						3
Burns Creek, South											2	1					2
Krug Creek			1								1						2
Lamesteer Creek											2						2
Outlet											1						1
AREA TOTALS *15*	0	0	34	0	6	0	0	0	0	0	61	0	10	0	0	0	111
WILLISTON BASIN TOTALS 174	0	0	666	3	364	9	853	204	30	8	2,738	0	135	1	37	0	5,048
RMP AREA Totals 189	6	709	1,272	5	542	10	920	204	30	10	3,352	7	143	4	51	2	7,267

C5	Class V Injection	ILW	Injection, Indian Lands
CBNG	Coal Bed Natural Gas	MON	Monitor/Observation
DH	Dry Hole	OIL	Oil
DMY	Dummy Well	ST	Stratigraphic Test
EOR	Injection, EOR	SWD	Injection - Disposal
EX	Expired Location	UN	Unknown
GAS	Gas	WS	Water Source
GST	Gas Storage	WW	Domestic Water

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TABLE 4-3
MBOGC PRODUCING WELL COUNTS FOR THE MILES CITY RMP AREA

Area/ *Field*	Producing Well Types											
Porcupine Dome	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
Sumatra		3	29						105	1	3	141
Stensvad			1						18			19
Ivanhoe			1						10			11
Beanblossom									2	1		3
Area Totals 4	0	3	31	0	0	0	0	0	135	2	3	174
Powder River Basin	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
CX	475											475
Bell Creek		3	42		1			1	399			446
Hammond					20							20
Wildcat Big Horn	14				1							15
Liscom Creek					8							8
Wright Creek									6	1		7
Leary									3			3
Bell Creek, Southeast					2							2
Area Totals 8	489	3	42	0	32	0	0	1	408	1	0	976
Cedar Creek Anticline	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
Cedar Creek					551	5						556
Pennel			62	1					218	2	3	286
Pine		2	21					1	149	3	2	178
Cabin Creek			29						143	3		175
Lookout Butte		1	11						60	1	2	75
Pine Gas					53							53
Little Beaver			4						43			47
Monarch			1						40			41
Gas City									23	1		24
Little Beaver, East			3						19	1		23
Glendive		1							17	3		21
Lookout Butte, East									12			12
Gas Light					10							10
Cupton									9			9
Windy Ridge									9			9
Deer Creek									8			8
Waterhole Creek									7			7
Wills Creek, South									6			6
Plevna, South					5							5
Sand Creek									4			4
Woodrow		1							3			4
Plevna					2							2
Area Totals 22	0	5	131	1	621	5	0	1	770	14	7	1,555
Area/ *Field*	Producing Well Types											
Poplar Dome	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
Poplar, East							2		87	1		90
Lustre									75			75
Poplar, Northwest							1		37			38
Midfork							1		9			10
Volt		2							6			8

Area/ *Field*	Producing Well Types											
Tule Creek									5			5
Benrud, East									3	1		4
Long Creek, West									2			2
Tule Creek, South							1		1			2
Benrud, Northeast									1			1
Lustre, North									1			1
Red Fox									1			1
Tule Creek, East									1			1
Area Totals 13	0	2	0	0	0	0	5	0	229	2	0	238
Williston Basin NE	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
Wildcat Richland		1							163			164
Flat Lake		1	3						91		4	99
Mon Dak, West									45			45
Goose Lake			3						36	2		41
Ridgelawn			3						34		1	38
Vaux									29	1		30
Dwyer			1						24	1		26
Sidney		1							25			26
Sioux Pass, North									26			26
Bainville, North									24			24
Fairview									23			23
Brorson									19			19
Fort Gilbert									17			17
Nohly									17			17
Putnam									17			17
Raymond			1						16			17
Clear Lake									14	1		15
Anvil									14			14
Target									14			14
Lonetree Creek									12	1		13
Outlook		1							12			13
Comertown									12			12
Sioux Pass									12			12
Crane									10	1		11
Divide									11			11
Katy Lake, North									11			11
Brush Lake									10			10
Medicine Lake									9			9
Mustang									9			9
Reserve		1							7			8
Wakea									8			8
Brorson, South									7			7
Cattails									7			7
Colored Canyon									7			7
Lone Butte									7			7
Salt Lake									5	2		7
Spring Lake									7			7
Bainville									6			6
Big Muddy Creek		1							5			6

Area/ *Field*	Producing Well Types											
Canal									6			6
Enid, North									6			6
Sioux Pass, Middle									6			6
Bainville, West									5			5
Flat Lake, South			1						4			5
Hay Creek									5			5
Pronghorn									5			5
Riprap Coulee									5			5
Second Creek									5			5
Three Buttes									5			5
Cattails, South									4			4
Charlie Creek									3	1		4
Lambert									4			4
Lowell									4			4
Otis Creek, South									3	1		4
Oxbow		1							2	1		4
Raymond, North									4			4
Bainville II									3			3
Charlie Creek, East									3			3
Charlie Creek, North					1				2			3
Comertown, South									3			3
Cottonwood									3			3
Fairview, East									2	1		3
Fox Creek, North									3			3
Girard									3			3
Intake II									3			3
Lambert, South									3			3
McCabe									3			3
Outlook, West									3			3
Sunny Hill									3			3
Diamond Point									2			2
Flaxville									2			2
Medicine Lake, South									2			2
Neiser Creek									2			2
Olje									2			2
Oxbow II									2			2
Reserve II									2			2
Reserve, South									2			2
Ridgelawn, North									2			2
Rocky Point									2			2
Singletree									2			2
Sioux Pass, West									2			2
Spring Lake, South									2			2
Stampede									2			2
Wrangler									2			2
Alkali Coulee									1			1
Ator Creek									1			1
Bainville (Ratcliffe/ Mission Canyon)									1			1

Area/ *Field*	Producing Well Types											
Dagmar, North									1			1
Dugout Creek									1			1
Flat Lake, East									1			1
Four Mile Creek									1			1
Frog Coulee									1			1
Goose Lake Red River									1			1
Green Coulee, East									1			1
Hawk Haven									1			1
Honker									1			1
Lonetree Creek, West									1			1
Lowell, South									1			1
McCabe, West									1			1
Missouri Breaks									1			1
Nohly, South									1			1
Outlook, South										1		1
Outlook, Southwest									1			1
Rainbow									1			1
Red Water, East									1			1
Redstone									1			1
Salt Lake, West									1			1
Shotgun Creek, North									1			1
Snake Creek									1			1
Spring Lake, West									1			1
Sundown									1			1
Area Totals 111	0	7	12	0	1	0	0	0	991	14	5	1,030
Williston Basin Other	CBNG	DH	EOR	EX	GAS	GST	ILW	MON	OIL	SWD	WS	Total Wells
Cow Creek, East									8	2		10
Richey, Southwest			2						7			9
Bloomfield		1							6			7
Black Diamond									1	1		2
Burns Creek, South									2			2
Carlyle									2			2
Den									2			2
Ollie									2			2
Yates									2			2
Cow Creek									1			1
Lamesteer Creek									1			1
Outlet									1			1
Vida									1			1
Area Totals 13	0	1	2	0	0	0	0	0	36	3	0	42
Williston Basin Total 159	0	15	145	1	622	5	5	1	2.026	33	12	2,865
RMP Area Totals 171	489	21	218	1	654	5	5	2	2,569	36	15	4,015

CBNG	Coal Bed Natural Gas	ILW	Injection, Indian Lands	EX	Expired Location
DH	Dry Hole	MON	Monitor/Observation	GAS	Gas
EOR	Injection, EOR	OIL	Oil	GST	Gas Storage
WS	Water Source	SWD	Injection - Disposal		

TABLE 4-4
MBOGC ANNUAL WELL PERMITS ISSUED FOR 2000 TO MARCH 2005

Year	Oil	Gas	CBNG	Gas Storage	EOR Injection	Disposal	Other	Total[1]	Horizontal[2] Permits
2000	131	344	113	6	2	2	4	602	56
2001	127	468	81	7	3	0	6	692	116
2002	143	453	13	2	0	0	0	611	138
2003	213	399	218	3	0	1	0	834	235
2004	241	528	66	0	0	1	5	841	253

1. Total includes both horizontal and vertical permits.
2. Horizontal permits include both new horizontal permits and permits for horizontal recompletions.

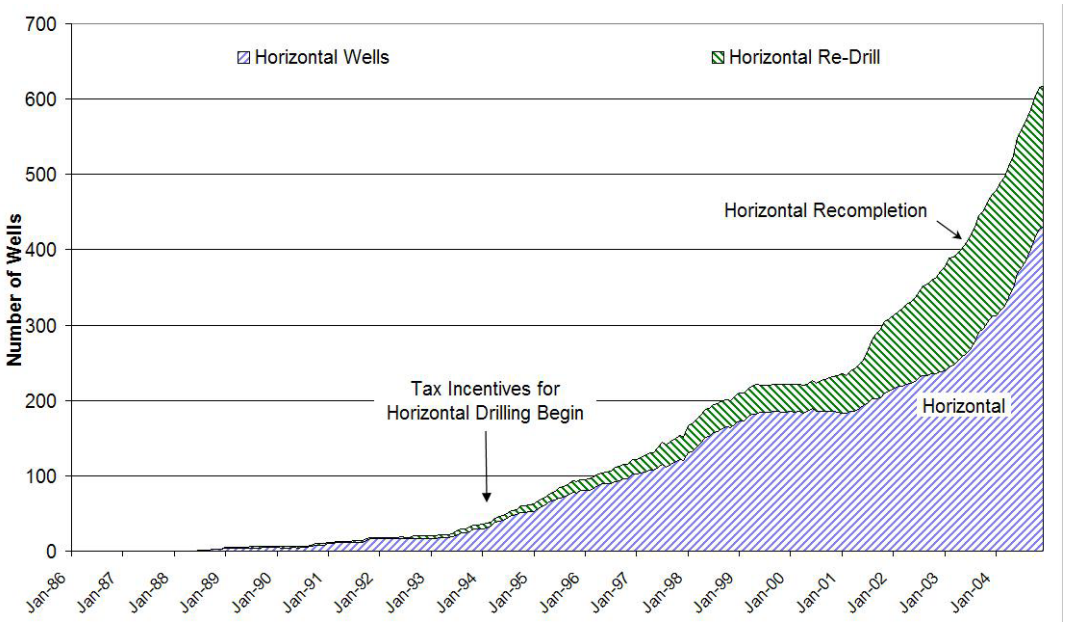
TABLE 4-5
MBOGC ANNUAL WELL COMPLETIONS FOR 2000 TO MARCH 2005

Year	Oil	Gas	CBNG	Gas Storage	EOR Injection	Disposal	Other	Dry	Total[1]	Horizontal Completions[2]
2000	58	287	77	6	5	0	0	57	490	33
2001	94	298	48	1	13	2	4	82	542	93
2002	57	313	8	6	7	0	1	71	463	92
2003	97	303	193	0	12	3	0	68	676	122
2004	102	346	40	0	1	1	5	39	534	140

1. Total includes both horizontal and vertical completions.
2. Horizontal completions include both new horizontal completions and horizontal recompletions of vertical wells.

FIGURE 4-2 PRODUCING OIL, GAS, AND CBNG WELLS

FIGURE 4-3 TOTAL HORIZONTAL PRODUCING WELLS AND HORIZONTAL RECOMPLETIONS



Trends in well drilling activity for the geologic division areas of the MCFO RMP Area from the MBOGC database for 1986 to 2004 are presented in Figure 4-4 through 4-9. Figures 4-4 through 4-7 present the number of wells drilled in the four Williston Basin areas: Cedar Creek Anticline, Poplar Dome, Williston Basin Northeast, and Williston Basin Other. Figure 4-4 presents the number of wells drilled in the Cedar Creek Anticline over the record presented from 1986 to 2004; the number of oil wells drilled has fluctuated with a general increase over the five-year period. The number of gas wells drilled has steadily risen on the Cedar Creek Anticline since 1994 with the majority of new wells drilled in the last five years being gas wells (Figure 4-4). The Cedar Creek Anticline has also had more enhanced oil recovery (EOR) wells drilled over the last five years than previous years. In general, there has been an increase in drilling activity on the Cedar Creek Anticline since 1993, while in the last five years the rate of drilling has more than doubled from 2000 to 2004 (Figure 4-4).

Figure 4-5 presents the drilling activity from the Williston Basin Northeast area, the second most active oil and gas region in the Montana portion of the Williston Basin. Since 1986 the Williston Basin Northeast region has underground fluctuations in the number of wells drilled within the area, with a more than four-fold increase in the number of wells drilled occurring from 2000 to 2004 (Figure 4-5). All of the drilling activity within this region of the Williston Basin has been oil wells with a few EOR wells having been drilled each year since 2001.

Figure 4-6 presents the drilling activity from the Poplar Dome area where only oil wells have been drilled since 1986. The number of oil wells drilled in this area has been relatively steady with an average of approximately two wells drilled per year since 1986. The number of wells drilled in the Poplar Dome area appears to be relatively steady over the record show (Figure 4-6). Figure 4-7 presents the drilling activity in the rest of the Williston Basin area of the MCFO RMP area, where there has been little

FIGURE 4-4 WELLS DRILLED PER YEAR WITHIN THE CEDAR CREEK ANTICLINE 1986 TO 2004

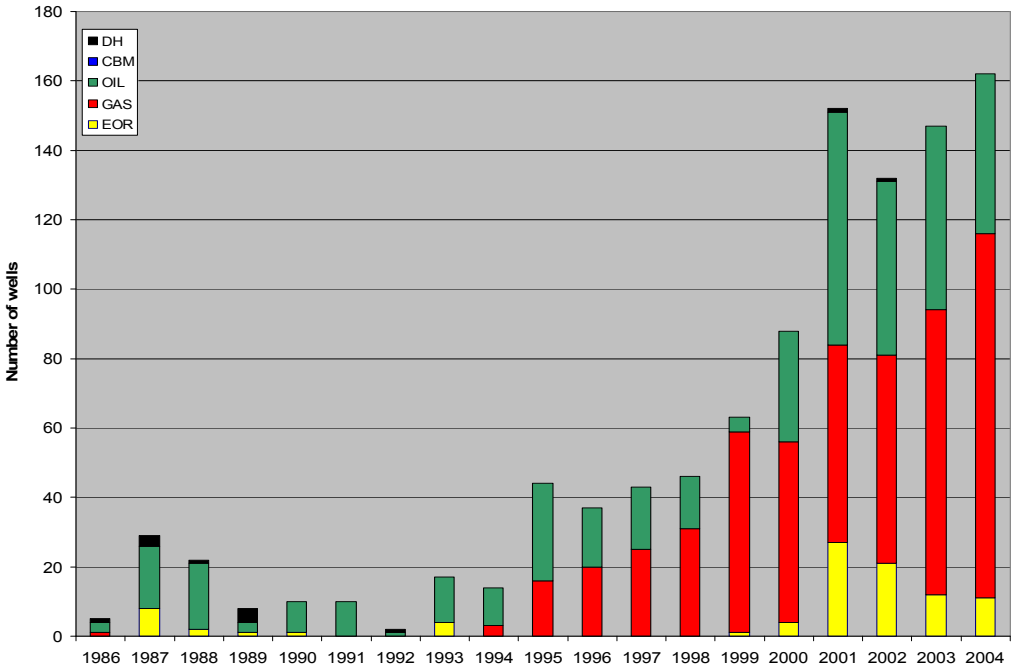


FIGURE 4-5 WELLS DRILLED PER YEAR WITHIN THE WILLISTON BASIN NORTHEAST AREA 1986 TO 2004

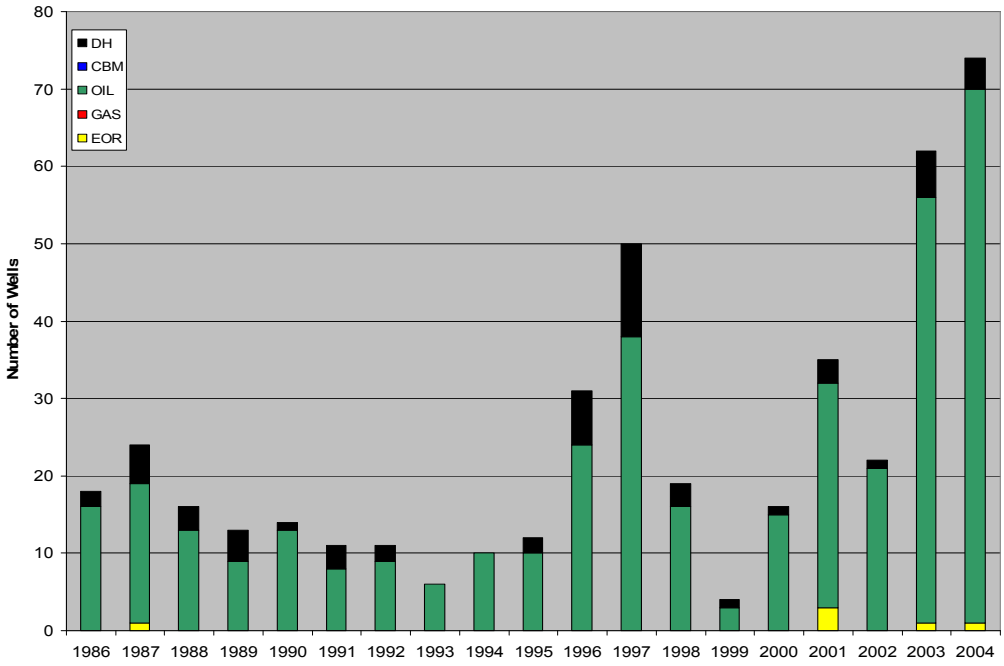


FIGURE 4-6 WELLS DRILLED PER YEAR WITHIN THE POPLAR DOME 1986 TO 2004

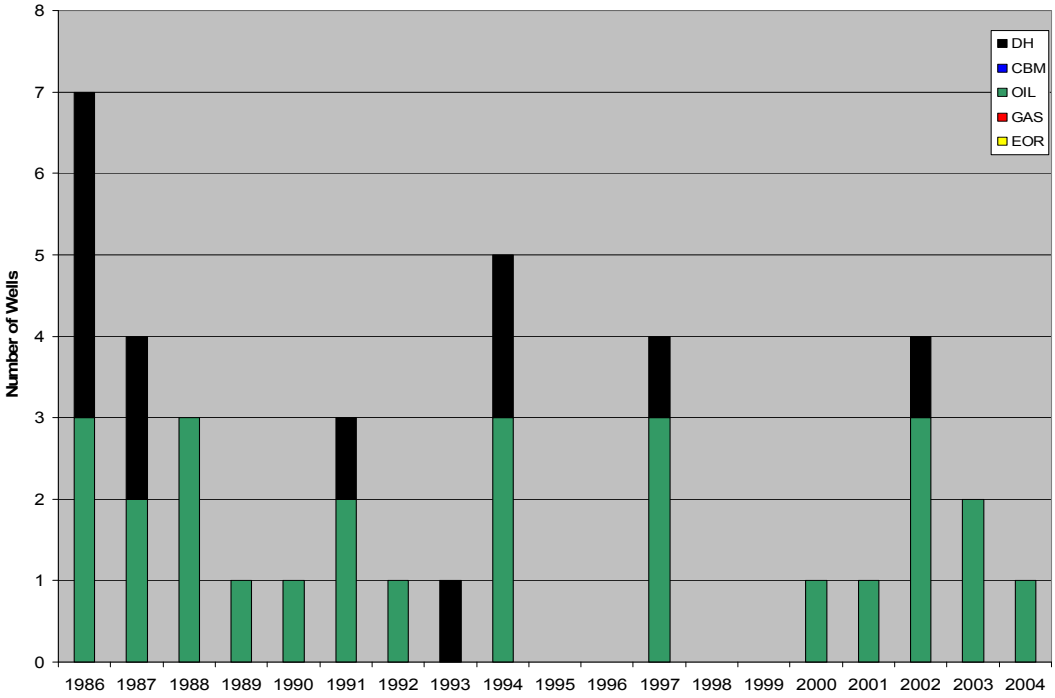


FIGURE 4-7 WELLS DRILLED PER YEAR WITHIN THE OTHER WILLISTON BASIN AREAS 1986 TO 2004

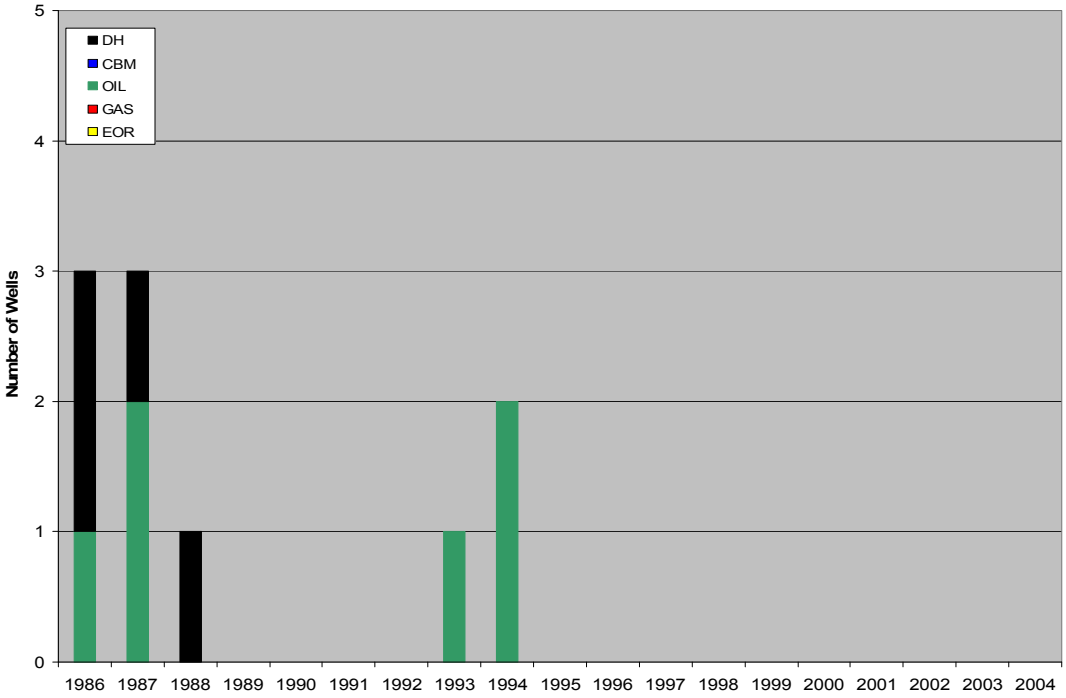


FIGURE 4-8 WELLS DRILLED PER YEAR WITHIN THE PORCUPINE DOME AREA 1986 TO 2004

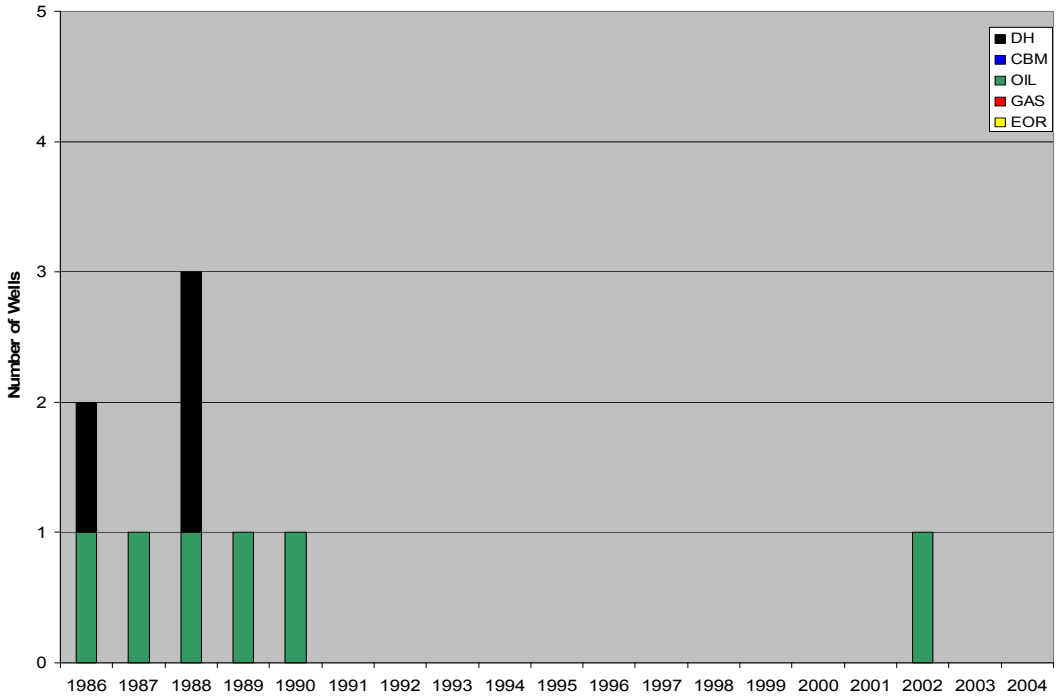
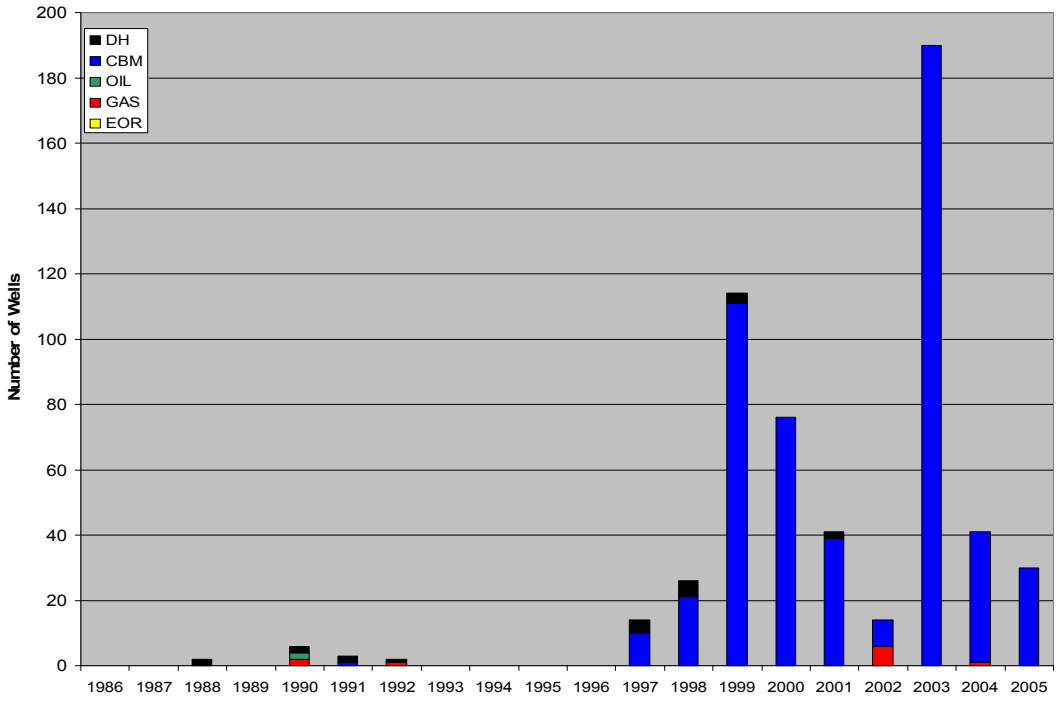


FIGURE 4-9 WELLS DRILLED PER YEAR WITHIN THE POWDER RIVER BASIN 1986 TO 2004



activity since 1986 and the last wells drilled were during 1994. Drilling activity in these other regions has been limited to oil wells since 1986 with only six wells having been drilled during this time.

Figure 4-8 presents the drilling activity on the Porcupine Dome within the MCFO RMP Area. Drilling activity has slowed considerably in this region with only one well having been drilled since 1990 and only six oil wells total drilled since 1986 (Figure 4-8). Figure 4-9 presents the drilling activity within the Powder River Basin within the MCFO RMP area since 1986. From 1986 to 1997 there had been only a few (5) oil and gas wells drilled in the PRB area, with that activity occurring in 1990 through 1992. Since 1997, CBNG well drilling has occurred in the area, and the number of wells drilled is climbing towards 200 CBNG wells per year (Figure 4-9). Conventional natural gas well drilling has also restarted in the PRB with seven new gas wells having been drilled in the basin since 2002 (Figure 4-9).

The MBOGC also tracks the depths to which wells are drilled within the state of Montana. Figures 4-10 through 4-15 present the number of wells drilled at four depth intervals (<2,000 feet, between 2,000 and 5,000 feet, between 5,000 and 10,000 feet, and >10,000 feet) for the each of the geologic division areas within the MCFO RMP area from 1986 to 2004. Figure 4-10 presents the drilled well depth data for the Cedar Creek Anticline area within the Williston Basin. The depth of drilled wells within the Cedar Creek Anticline are dominated by two depth ranges (<2,000 feet and >10,000 feet) from 1994 to present. Wells drilled to both of these depth ranges have shown an increase over the last 5 years while the number of wells less than 2,000 feet in depth has been increasing since 1994 (Figure 4-10).

FIGURE 4-10 WELLS DRILLED PER YEAR BY DEPTH WITHIN THE CEDAR CREEK ANTICLINE

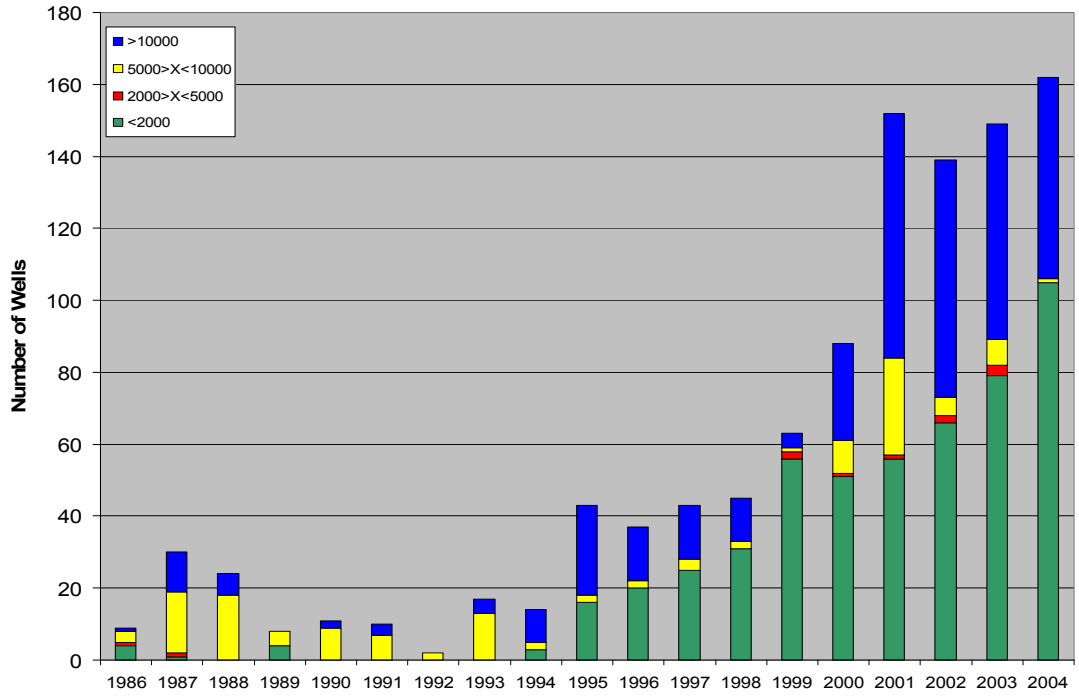


Figure 4-11 presents the number of wells drilled by depth within the Williston Basin Northeast from 1986 to 2004. The wells drilled in this region of the RMP area are dominated by the two deeper well groups (5,000 feet to 10,000 feet, and >10,000 feet), with most of the wells being drilled to depths greater than 10,000 feet. The number of deep wells within this region has been increasing over the last five years with number of drilled wells deeper than 10,000 feet in 2003 and 2004 being two and three times, respectively, greater than the number in 2001.

Figure 4-12 presents the number of wells drilled by depth within the Poplar Dome area from 1986 to 2004. The majority of the wells drilled in this region are in the 5,000 to 10,000 feet depth range over the period of record (Figure 4-12). The number of wells drilled in this region at other depths has been sporadic with only four wells having been drilled in at other depths in two separate years (1998 and 2001).

Figure 4-13 presents the number of wells drilled by depth within the other regions of the Williston Basin from 1986 to 2004. The figure shows that the wells drilled in the other Williston Basin area during the 1986 and 1987 were deep wells with depths greater than 10,000 feet (Figure 4-13). The wells drilled since 1988 have been in the middle two depth classifications with most of the wells being drilled in the 5,000 to 10,000 feet of depth range.

FIGURE 4-11 WELLS DRILLED PER YEAR BY DEPTH WITHIN WILLISTON BASIN NORTHEAST

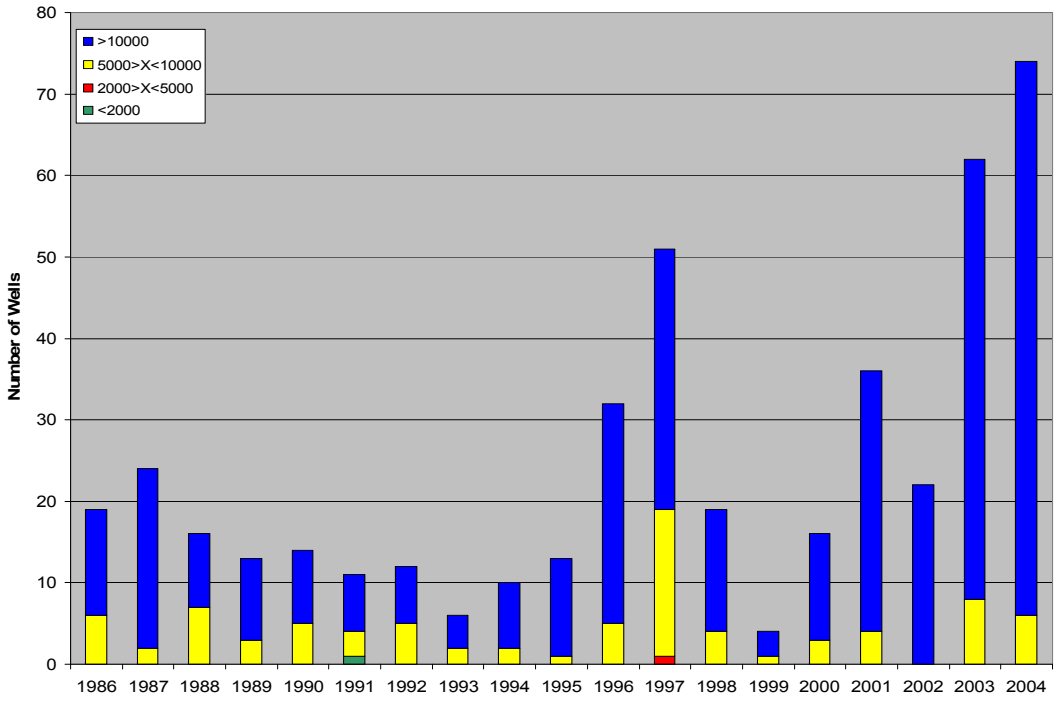


FIGURE 4-12 WELLS DRILLED PER YEAR BY DEPTH NEAR THE POPLAR DOME 1986 TO 2004

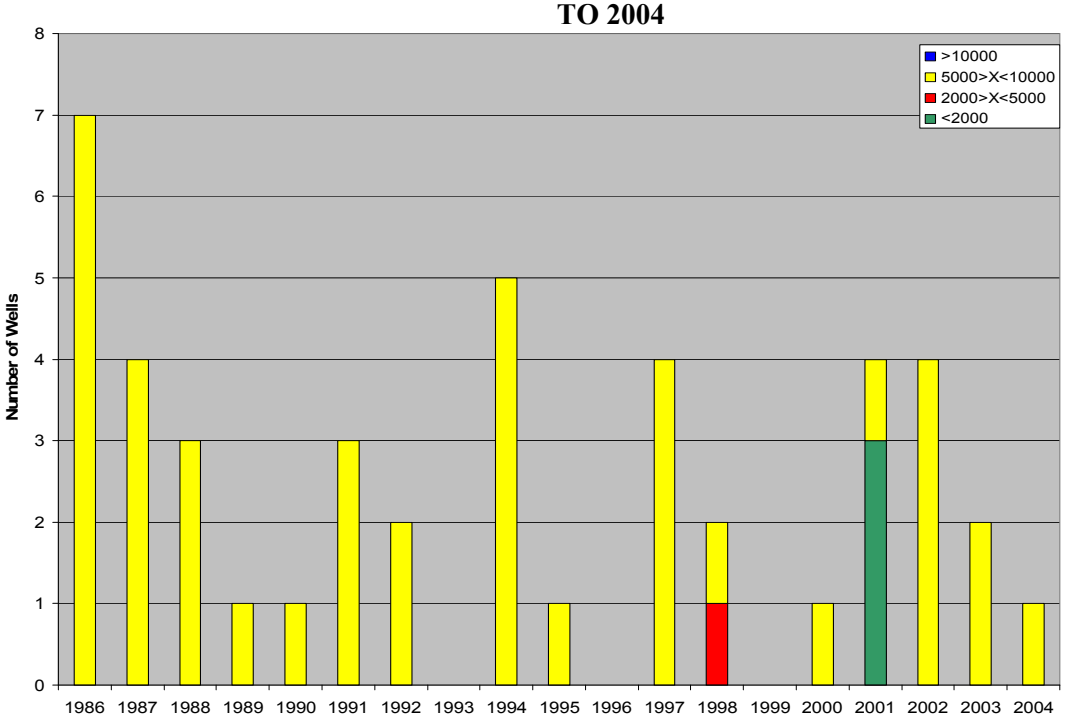


FIGURE 4-13 WELLS DRILLED PER YEAR BY DEPTH WITHIN THE OTHER WILLISTON BASIN AREAS 1986 TO 2004

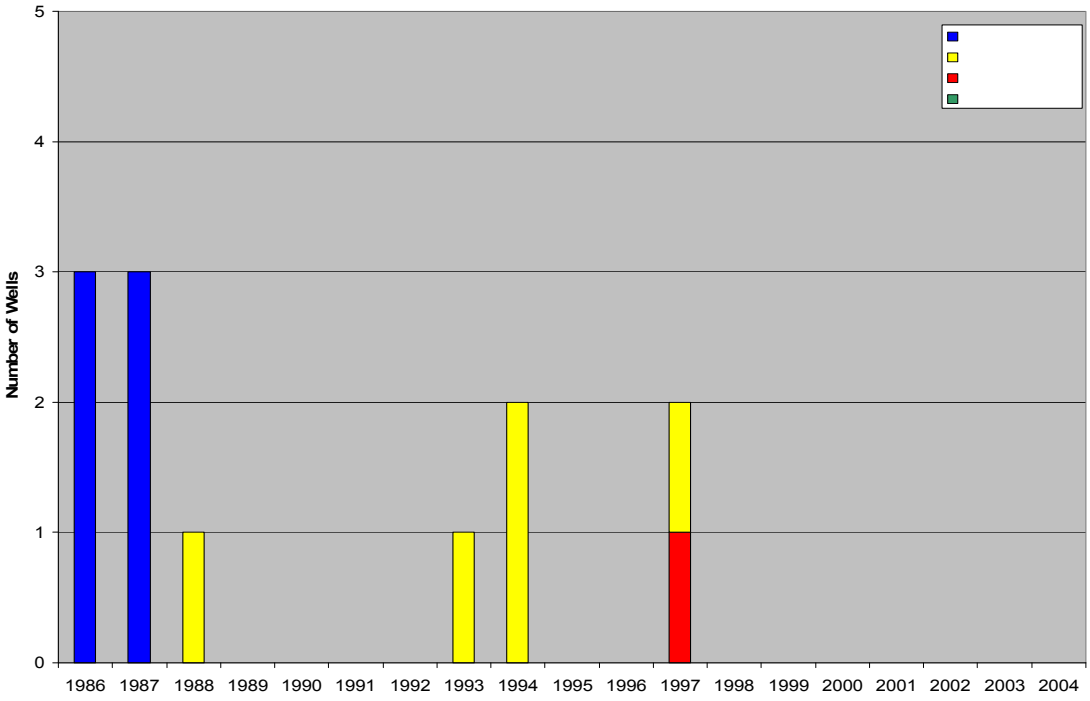


Figure 4-14 presents the number of wells drilled by depth within the Porcupine Dome area from 1986 to 2004. The majority of the wells drilled in this area have been less than 5,000 feet deep, with only two wells drilled in 1988 having depths between 5,000 and 10,000 feet (Figure 4-14). There has only been one well drilled in this area since 1990, which was drilled to a depth between 2,000 and 5,000 feet in 2002.

Figure 4-15 presents the number of wells drilled by depth within the Powder River Basin from 1986 to 2004. Since the start of CBNG drilling in 1997 nearly all of the wells drilled in the PRB have been less than 2,000 feet (Figure 4-15).

Prior to the start of CBNG development, the wells in the PRB varied, but all wells were drilled to depths less than 10,000 feet.

The MBOGC sets the spacing requirements for oil and gas wells in the state of Montana. Current well spacing for wildcat gas wells is set at 640 acres per well for each producing formation. For oil wells spacing is set based on the well depth. Currently, for oil wells set at a depth between 0 and 6,000 feet the spacing is one well per 40 or 80 acres, for 6,001 to 11,000 feet the spacing is one well per 160 acres, and for wells greater than 11,001 feet in depth the spacing is one well per 320 acres.

FIGURE 4-14 WELLS DRILLED PER YEAR BY DEPTH NEAR THE PORCUPINE DOME AREA

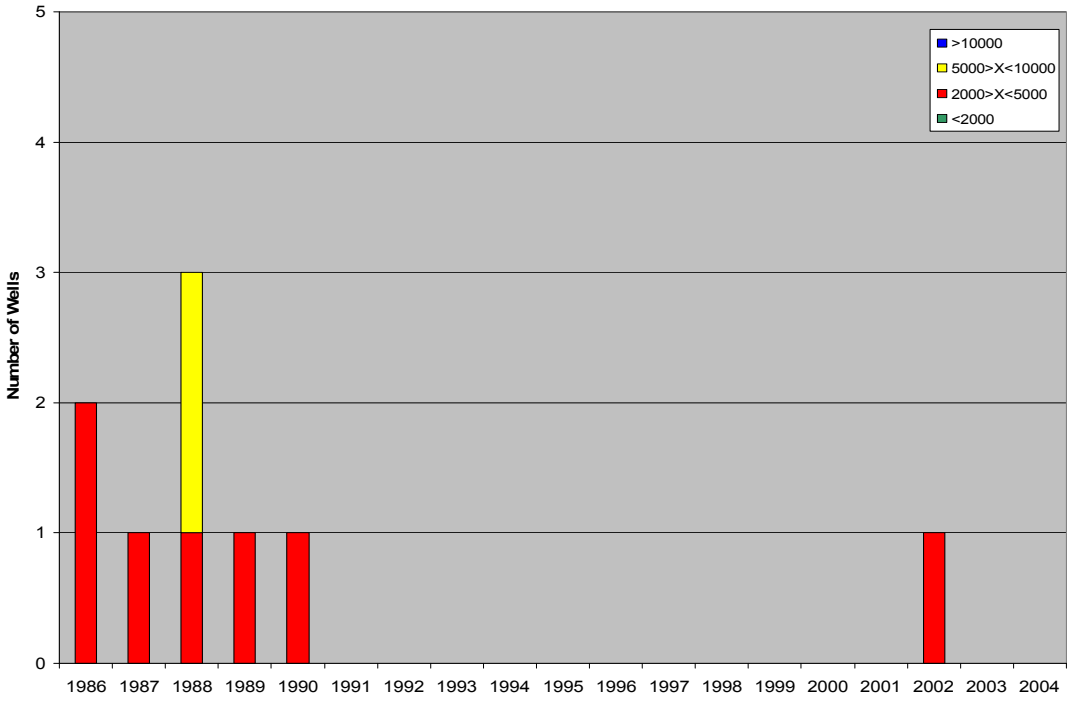
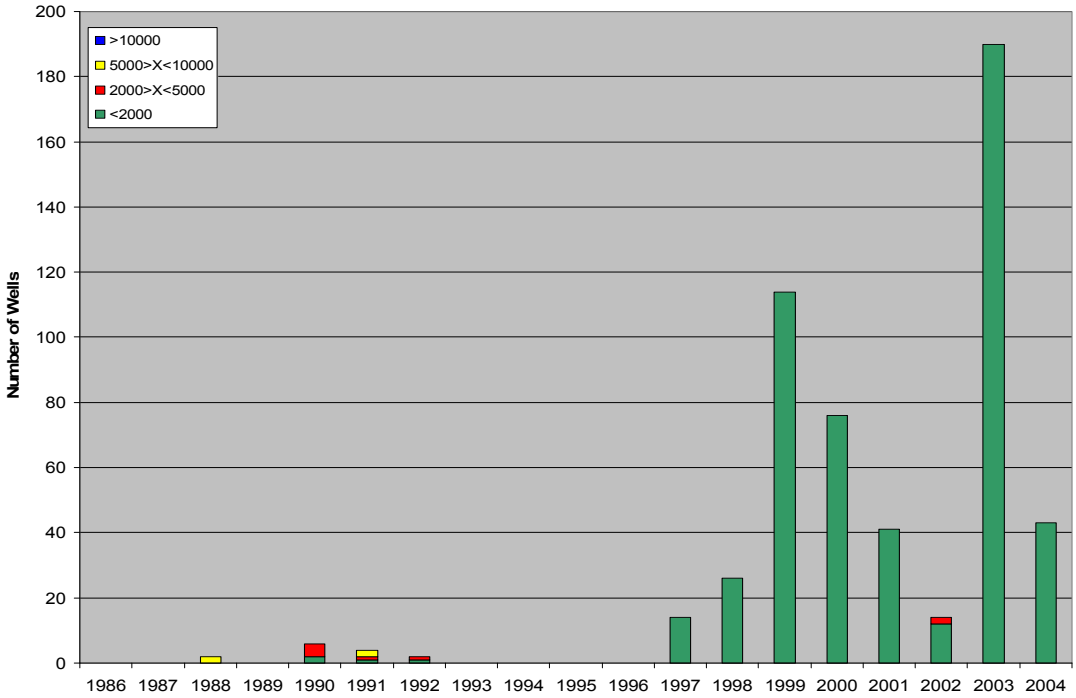


FIGURE 4-15 WELLS DRILLED PER YEAR BY DEPTH WITHIN THE POWDER RIVER BASIN



MBOGC also sets the spacing for CBNG wells, which is currently one well per 640 acres. In the case of CBNG, multiple wells within the standard 640-acre spacing unit are typically required to efficiently produce CNBG. The MBOGC will review spacing when a new field is discovered and the exploration company requests the establishment of permanent spacing unit that is different from the standard statewide spacing. Well spacing can be changed by the MBOGC after lease operators provide geologic, engineering, and economic data to the Board for review. A decision is generally rendered at a Board hearing and a Board Order is issued establishing the new spacing requirements. Board orders for existing fields are available on the MBOGC website.

Projected decline rates and estimated production figures for the Miles City Field Office RMP area have been arranged in three groups to facilitate analysis for this RFD – deep oil, Bakken oil and shallow natural gas. This grouping allows a sound generic discussion of production trends in the planning area. These three groups can be considered to be typical of other reservoirs that are likely to be discovered in the MCFO RMP Area. Historic and estimated future production and reserves are discussed below.

Deep oil reserves can be represented by Encore's Pennel field, a Red River Formation field on the Cedar Creek Anticline of the Williston Basin. The field was discovered in 1955 and has produced approximately 109 million bbls as of the end of 2004 from approximately 200 producing wells for an average of approximately 500,000 bbls per well. Detailed production data is only available from 1986 to the present; the average per-well production from established, pre-1995 is shown in Figure 4-16. Production declined at a

discontinuous though increasing rate until approximately March of 1999. At that point the operator began re-drilling and re-completing the wells as horizontal completions (Figure 4-16). The introduction of horizontal wells increased production until approximately May of 2001 when per-well production from established wells peaked. Horizontal drilling has continued since that time and new wells have been added, but these wells were not considered in the computation of per-well averages. Established wells (pre-1995) are declining at the rate of approximately 7.44% per year and are producing approximately 21 bpd. Continued production to an abandonment point of 2.0 bpd will add approximately 100,000 bbls in the next 30 years (Figure 4-16). Ultimate economic reserves are expected to average approximately 600,000 bbls of oil per well. The Pennel field can be considered a reference for the Red River and other Lower Paleozoic carbonate and sandstone reservoirs that prove to be oil-productive in the Planning Area.

In total, the Pennel field includes 69 surface facilities with tanks, 879 wells (including, producing and injection wells) with an estimated 1.0 miles of pipeline/flowline on average per well (Encore, personal communication, 2005). As an average this would breakdown to 12.7 wells per facility which is split between tank batteries, water plants, injection sites, etc. The current rate of production is near capacity for this field; additional wells added would result in the need for additional facilities if the rate of addition exceeds the rate of decline.

Natural gas fields within the MCFO RMP area are represented by the Cedar Creek Gas Field, the largest in the Planning area. This field currently consists of 522 wells producing from the Eagle and Judith River Formations. This field was discovered in 1914 and has produced approximately 81 BCF since discovery. Average decline rates are illustrated in the decline curve below calculated for those wells completed prior to 1995 (Figure 4-17). Prior to 1992, the field was curtailed by high line pressures; beginning in 1992 the line pressure was brought down with the use of compressors and more gas was produced. High rates of production were maintained until approximately 1998 when the existing wells began to show a general decline of approximately 10.68% per year (Figure 4-17). The average well among those completed before 1995 is expected to continue to produce for another ten years and have total ultimate economically recoverable reserves of approximately 1,029 mmcf (1.029 BCF) of gas. The performance of the established wells (completed prior to 1995) can be considered typical for Eagle and other shallow sands in the Planning Area.

The Bakken Formation has been exploited for many years in the Williston Basin. Through the end of the year 2000, there were a total of 53 reported wells completed in the Bakken Formation. Between 2001 and 2004 there were an additional 153 producing wells completed in the Bakken bringing the total to over 200 completed wells with another 100 approved well permits. Most recently the Middle Bakken play has become the most active play in the Williston Basin. The Middle Bakken is best suited to exploitation via long-reach horizontal wells that can be completed at initial rates up to 1,000 bopd. The Middle Bakken Fairway in Richland County contains approximately 185 wells; the decline curve for a typical well is shown below (Figure 4-18), documenting a decline of 51.1% annually. The decline presented is based on normalized (to month zero) production data for all currently producing wells as reported to the MBOGC, and includes data for wells which have been reworked (second fracture treatments, horizontal recompletions, etc.) as well as some infill wells. The production profile is based on data for the first 55 months of reported Bakken production. Because there is a limited number of wells with production records beyond 30 months, the reported data begins to fluctuate above the theoretical decline beyond this time frame. After 50 months, there are only several wells with reported production and this, coupled with secondary fracture treatments and other well work, has resulted in an increase in production during the late months as shown in Figure 4-18.

FIGURE 4-16 TYPICAL WELL DECLINE IN PENNEL OIL FIELD DATA COMPILED FROM WELLS WITH PRE-1995 PRODUCTION

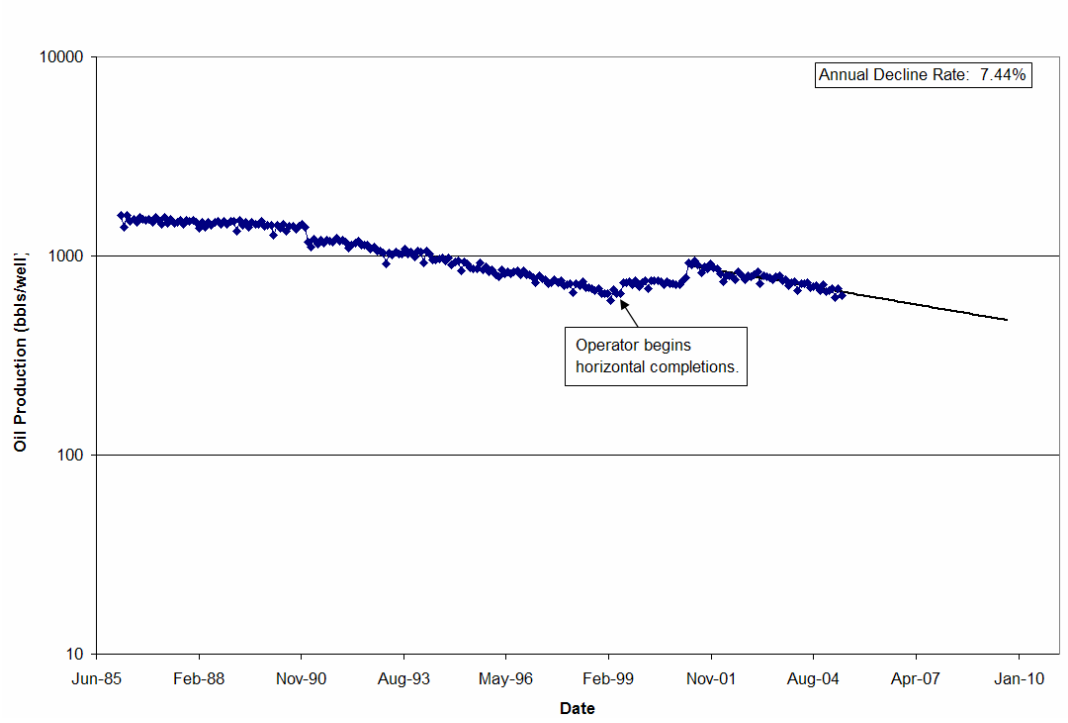


FIGURE 4-17 TYPICAL WELL DECLINE IN CEDAR CREEK GAS FIELD DATA COMPILED FROM WELLS WITH PRE-1995 PRODUCTION

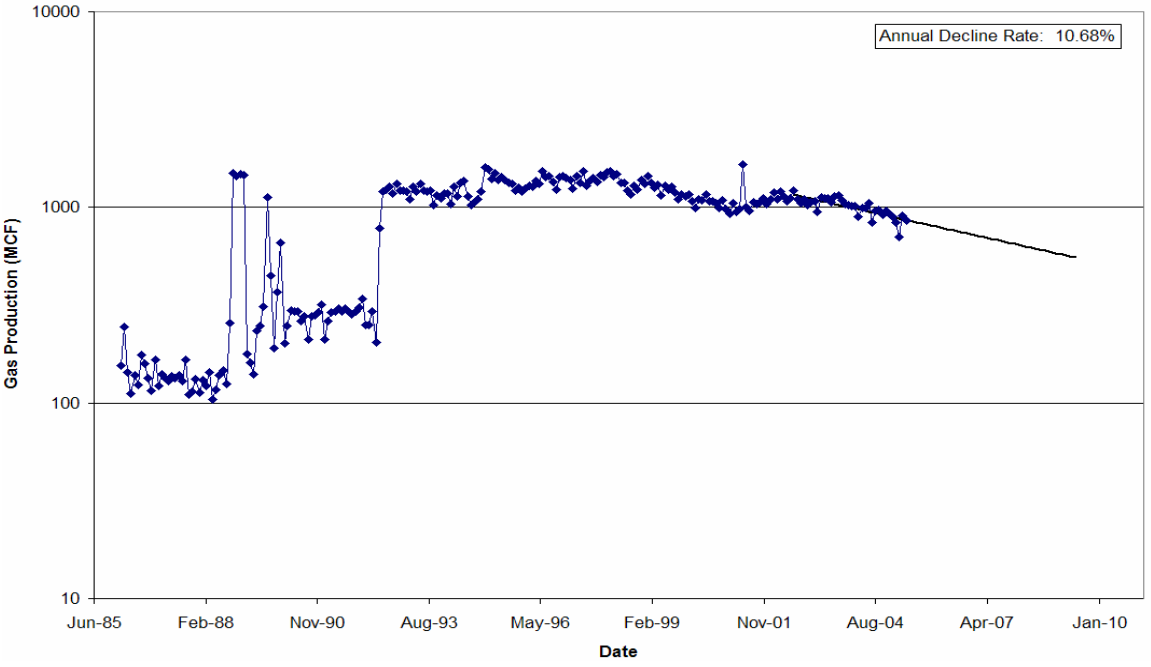
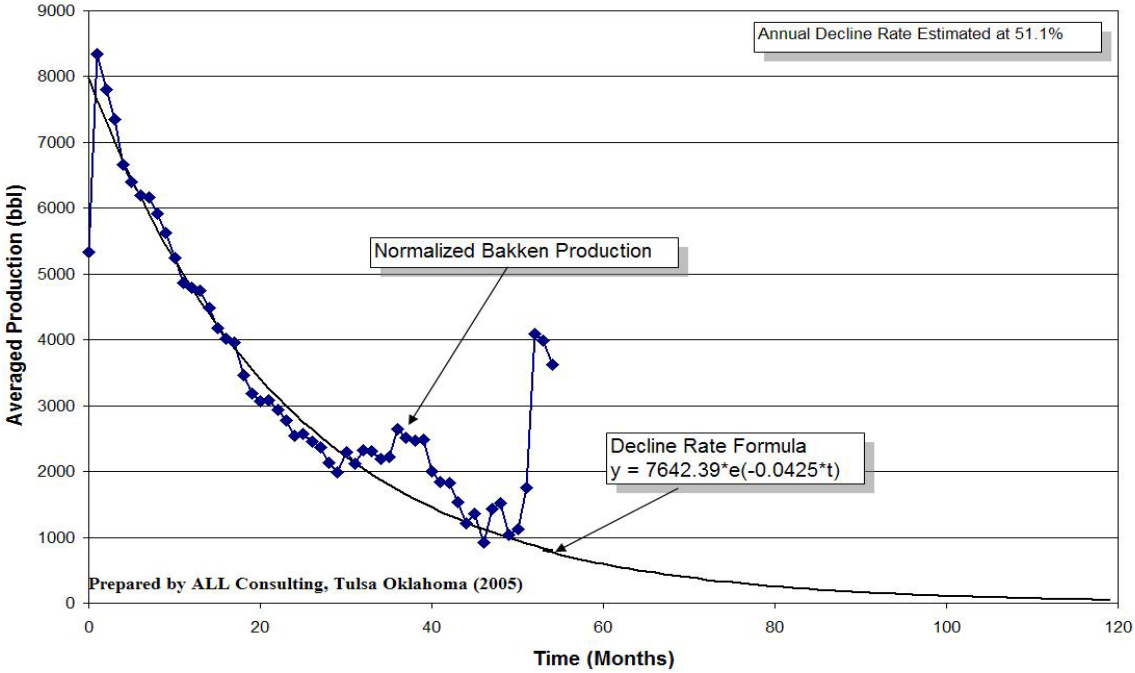


FIGURE 4-18 TYPICAL BAKKEN WELL DECLINE ANALYSIS DATA COMPILED FOR ALL REPORTED PRODUCING WELLS.



Ultimate economically recoverable reserves are expected to average approximately 174,313 bbls for these wells. The Fairway can be expected to serve as a reference for other Bakken discoveries in the MCFO RMP Area.

Figures 4-19 through 4-21 present the annual oil and gas production data from the MBOGC database for the years 1986 through 2004 for the Williston Basin, Powder River Basin, and other MCFO RMP areas, respectively. The Williston Basin has shown increases in oil and gas production during recent years, with annual natural gas production in the Williston Basin for 2004 more than 2.5 times greater than the level of production in 1996 (Figure 4-19). Oil production had been declining between 1986 to 1999 in the Williston Basin, but since 2000 oil production has risen steadily, with 2004 oil production exceeding that of 1986 (Figure 4-19). In the Powder River Basin, oil production decreased sharply from 1986 to a low in 1994, since 1995 oil production has shown a slight increase (Figure 4-20). Natural gas production was relatively low and stable in the PRB prior from 1986 to 1999. Since 1999 however, natural gas production has increased sharply (Figure 4-20). Figure 4-21 shows similar trends for both oil and natural gas production for the other areas within the MCFO RMP area, since 1986 both oil and gas have been on a steady decline.

Table 4-6 presents the annual cumulative oil, gas, and water production for the Miles City RMP area separated into the geologic boundary areas of the Williston Basin, Powder River Basin, and Porcupine Dome areas for the years 2000 through 2004. The Miles City RMP area as a whole has experienced growth in oil and gas production from 2000 to 2004, with growth in oil production of approximately 67%, while natural gas production has grown by approximately 133%. The data for the Williston Basin is presented as a total as well as in the four divisions, the Cedar Creek Anticline, Williston Basin Northeast, Poplar Dome, and other Williston Basin areas. Table 4-6 shows that the Williston Basin is the area within the Miles City RMP with the largest oil production increases (between 6% and 26% annually) over the last five years. While within the Williston Basin, oil production has been increasing on the Cedar

FIGURE 4-19 OIL AND GAS PRODUCTION TRENDS WILLISTON BASIN, MT

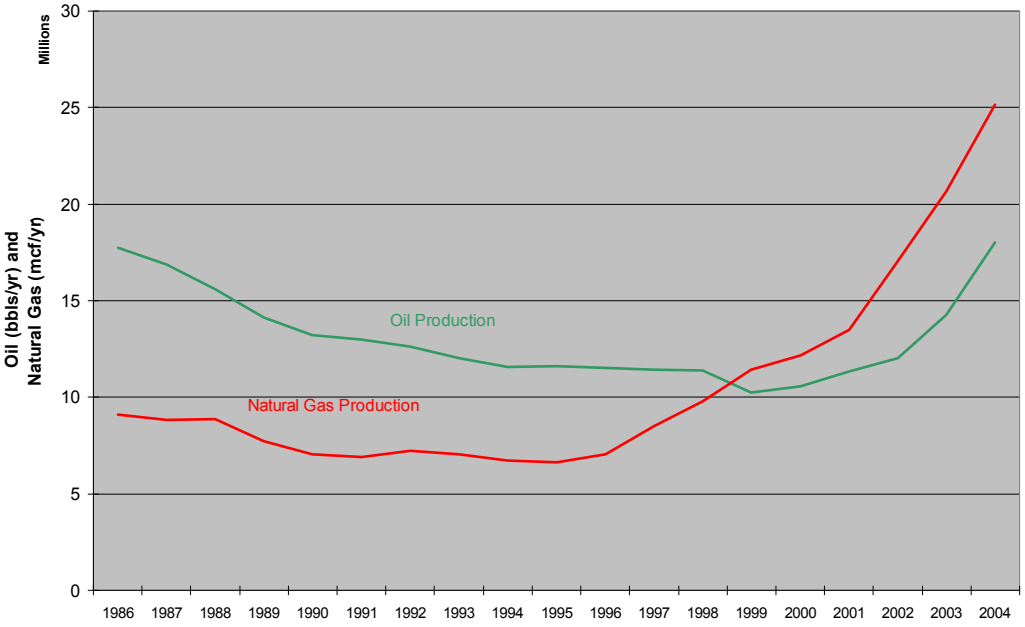


FIGURE 4-20 OIL AND GAS PRODUCTION TRENDS POWDER RIVER BASIN, MT

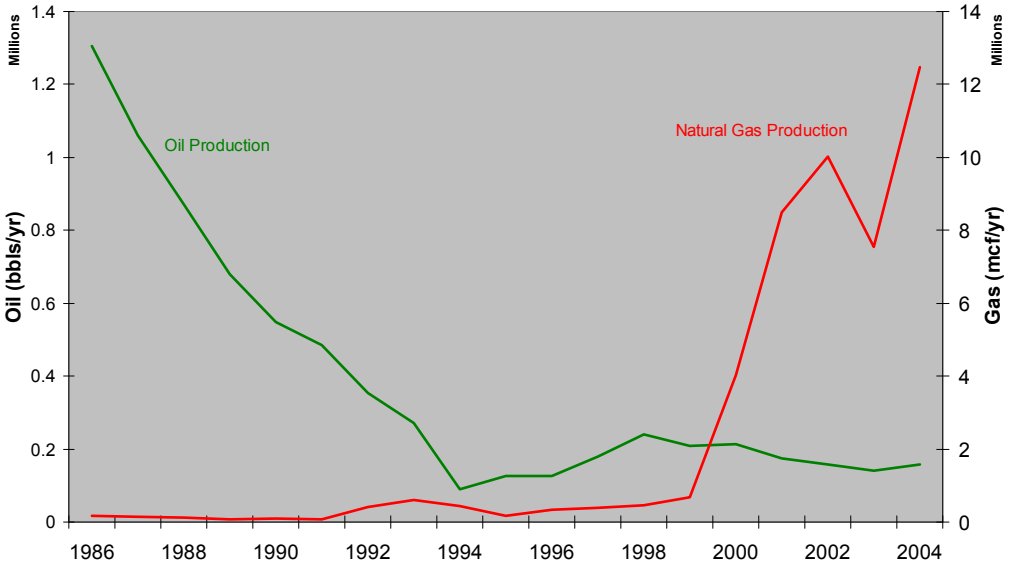
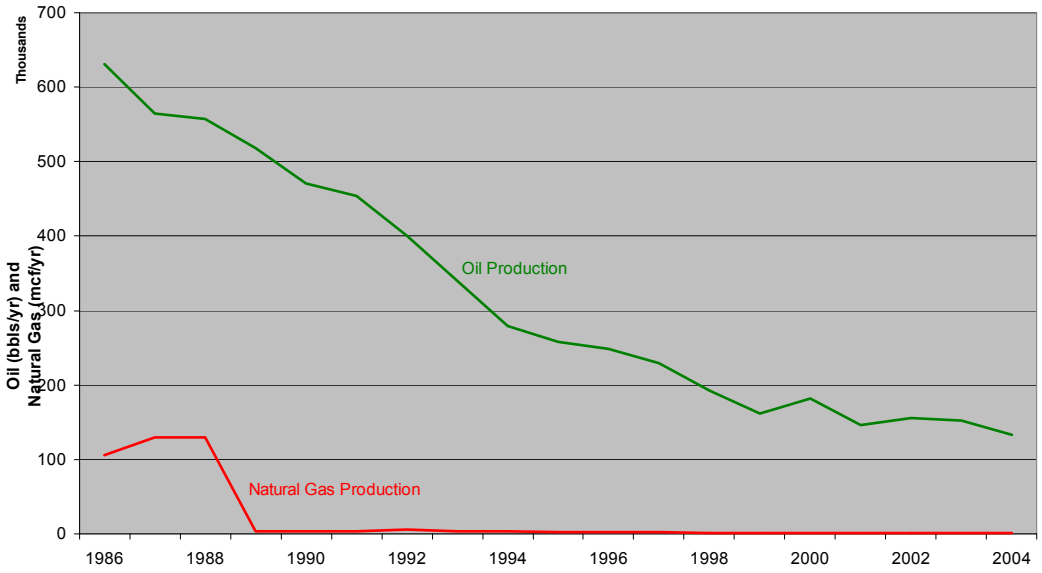


FIGURE 4-21 OIL AND GAS PRODUCTION TRENDS OTHER MILES CITY RMP AREAS



Creek Anticline (31% total increase over the five years show), the production from the Williston Basin Northeast area has grown at a more rapid pace (125% increase over the last five years) and has surpassed the Cedar Creek Anticline for the area with the greatest percentage of the total Williston Basin production.

Natural gas production has more than doubled in the Williston Basin area over the last five years with a large increase in natural gas production on the Cedar Creek Anticline, 123% increase over the 5-year period (Table 4-6). Much of the increase in the Cedar Creek Anticline has been attributed to EOR projects which have been expanding in recent years. The Powder River Basin area has also experienced a large increase in natural gas production during the last five years with more than triple the production of the year 2000 in the year 2004 (Table 4-6). Oil production within the PRB has decreased by 26% from 2000 to 2004. The increase in natural gas production is attributable to the development of CBNG resources in the PRB area.

The other areas within the Williston Basin (the Poplar Dome, and Williston Basin other) and the Porcupine Dome have seen decreases in oil production from 19% to as much as 48%. In addition, natural gas production has also decreased for the Poplar Dome and Williston Basin other areas (49% and 17%, respectively), while the Porcupine Dome area has seen an increase in natural gas production of 28%. However, because total oil and gas production for these areas are such a small percentage of the total production, these decreases have been countered by the greater increases in other areas of the MCFO RMP area.

The increase in oil and gas production within the Williston Basin is in part attributable to the expansion of enhanced recovery (EOR) projects. According to the MBOGC records and the summary of secondary recovery projects from the MBOGC 1999 annual report, the earliest EOR project in the Miles City RMP area started in 1959 (Cabin Creek). The MBOGC online database lists 18 fields within the Miles City RMP area that have enhanced recovery wells. These include from the Williston Basin area the fields: Cabin Creek, Little Beaver, Little Beaver East, Lookout Butte, Monarch, Pennel, and Pine on the Cedar Creek Anticline; Dwyer, Flat Lake, Flat Lake South, Goose Lake, Raymond and

TABLE 4-6
MILES CITY RMP GEOLOGIC BOUNDARY AREAS CUMULATIVE ANNUAL PRODUCTION 2000 – 2004.

Year	2000	2001	2002	2003	2004
Geologic Area	**Annual Cumulative Oil Production (bbls)**				
Williston Basin Total	10,556,562	11,356,070	12,019,269	14,259,869	18,032,971
Cedar Creek Anticline	*5,309,581*	*5,685,354*	*5,946,829*	*6,494,444*	*6,950,027*
Poplar Dome	*444,434*	*439,319*	*466,615*	*443,192*	*361,038*
Williston Basin Northeast	*4,746,607*	*5,188,451*	*5,576,623*	*7,294,520*	*10,692,810*
Williston Basin Other	55,940	42,946	29,202	27,713	29,096
Powder River Basin	213,671	173,567	157,118	141,033	157,929
Porcupine Dome	181,966	145,823	155,710	152,156	133,232
RMP AREA TOTAL	**10,952,199**	**11,675,460**	**12,332,097**	**14,553,058**	**18,324,132**
	Annual Cumulative Gas Production (mcf)				
Williston Basin Total	12,165,422	13,512,775	17,076,183	20,674,868	25,168,657
Cedar Creek Anticline	*8,532,070*	*9,775,377*	*12,829,658*	*15,636,611*	*19,029,099*
Poplar Dome	*85,592*	*74,163*	*71,405*	*68,541*	*43,953*
Williston Basin Northeast	*3,540,754*	*3,655,837*	*4,167,666*	*4,962,633*	*6,089,765*
Williston Basin Other	7,006	7,398	7,454	7,083	5,840
Powder River Basin	4,021,594	8,499,017	10,012,752	7,542,770	12,478,990
Porcupine Dome	1,283	1,263	1,316	1,402	1,638
RMP AREA TOTAL	**16,188,299**	**22,013,055**	**27,090,251**	**28,219,040**	**37,649,285**
	Annual Cumulative Water Production (bbls)				
Williston Basin Total	49,695,716	54,084,462	57,053,862	62,575,084	63,671,792
Cedar Creek Anticline	*28,688,329*	*32,218,728*	*34,608,755*	*39,291,968*	*42,039,200*
Poplar Dome	*8,898,870*	*8,717,933*	*9,124,824*	*8,501,565*	*7,443,907*
Williston Basin Northeast	*11,466,092*	*12,597,165*	*13,001,478*	*14,525,309*	*13,862,970*
Williston Basin Other	642,425	550,636	318,805	256,242	325,715
Powder River Basin	23,827,422	24,101,121	19,634,017	14,392,761	19,577,779
Porcupine Dome	8,569,680	7,444,857	8,199,196	8,421,881	7,376,836
RMP AREA TOTAL	**82,092,818**	**85,630,440**	**84,887,075**	**85,389,726**	**90,626,407**

Ridgelawn in the Williston Basin Northeast and Richey – Southwest in other Williston Basin areas; Bell Creek Consolidated in the Powder River Basin; and Ivanhoe, Stensvad, and Sumatra in the Porcupine Dome area. A review of the MOBGC online board orders shows three fields in the Miles City RMP area have entered into tertiary recovery: Little Beaver, Little Beaver-East, and Pennel Unit, all three fields are located on the Cedar Creek Anticline and are currently operated by the Encore Operating, LP.

In addition to EOR projects, the increase in oil and gas production in the Williston Basin is also the result of recent development within the Bakken Formation Play. The Bakken Formation is currently experiencing the most activity in the Williston Basin of Montana and is the focus of the majority of drilling activity within the basin. Bakken wells are being horizontally completed in a variety of different styles.

The increase in natural gas production in the Powder River Basin is a result of the development of CBNG resources which began in 1999. Current production of CBNG is still limited to two producing areas (CX Ranch Field and Wildcat wells in Big Horn County) in southern Montana, and a couple of test wells in central and northern Powder River County. The decline rate of producing CBNG wells was assessed as part of the 2003 FEIS from the state of Montana and BLM and is included in the Minerals Appendix of the FEIS (BLM 2003a).

Oil and Gas Prices

Annual oil and gas price changes affect the level of development that occurs in an area; when prices are low, production, exploration, and development tend to slow. The DOE Energy Information Administration produces Annual Energy Outlook reports which contain projected oil and gas prices for the next 20 years. The 2005 Outlook projected lower 48 state wellhead oil prices to decrease through 2010, then increase to $30 per barrel by 2025 (Figure 4-22). For natural gas prices, the EIA predicts a decrease through 2011, and then prices to increase to near $5.00 mcf by 2025 (Figure 4-23). Recently, increases in oil and natural gas prices have exceeded the previously predicted wellhead prices for both oil and natural gas. If this trend continues with oil and gas prices exceeding predictions, development of resources may occur at an increased rate.

FIGURE 4-22 HISTORIC WELLHEAD OIL PRICES FOR MONTANA AND UNITED STATES AVERAGE (SOURCE EIA, 2005).

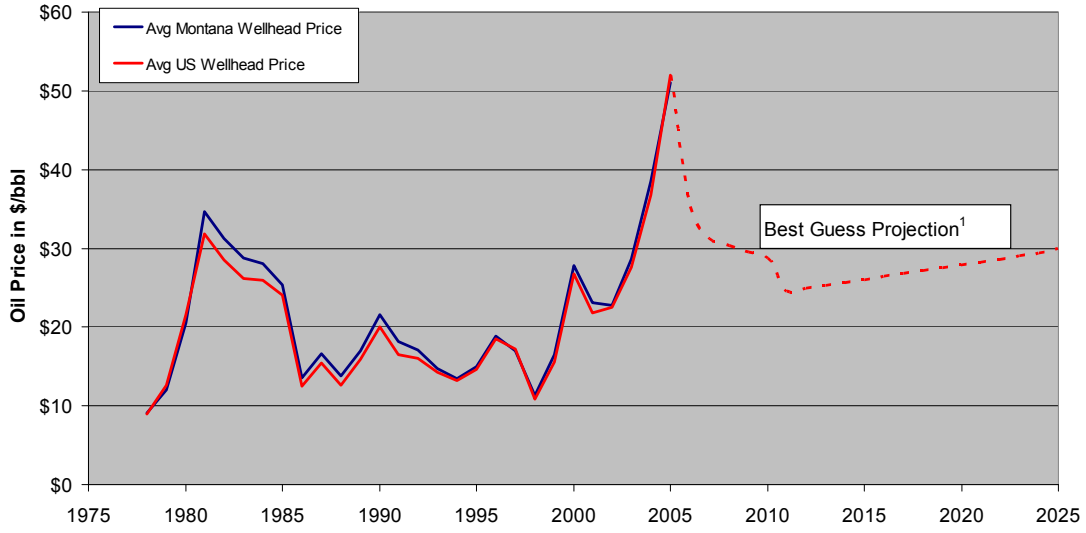
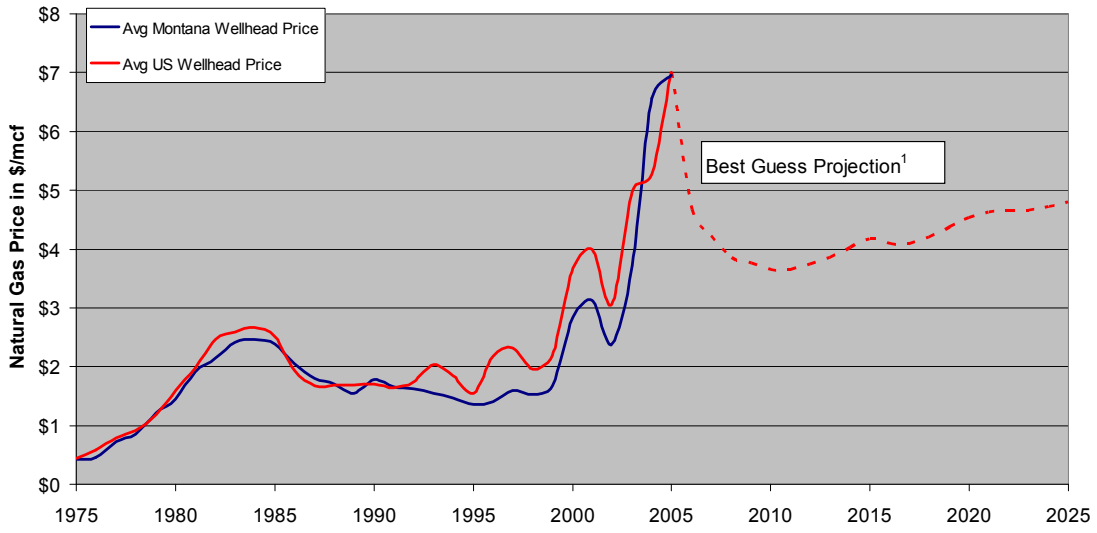


FIGURE 4-23 HISTORIC WELLHEAD NATURAL GAS PRICES FOR MONTANA AND UNITED STATES AVERAGE (SOURCE EIA, 2005).



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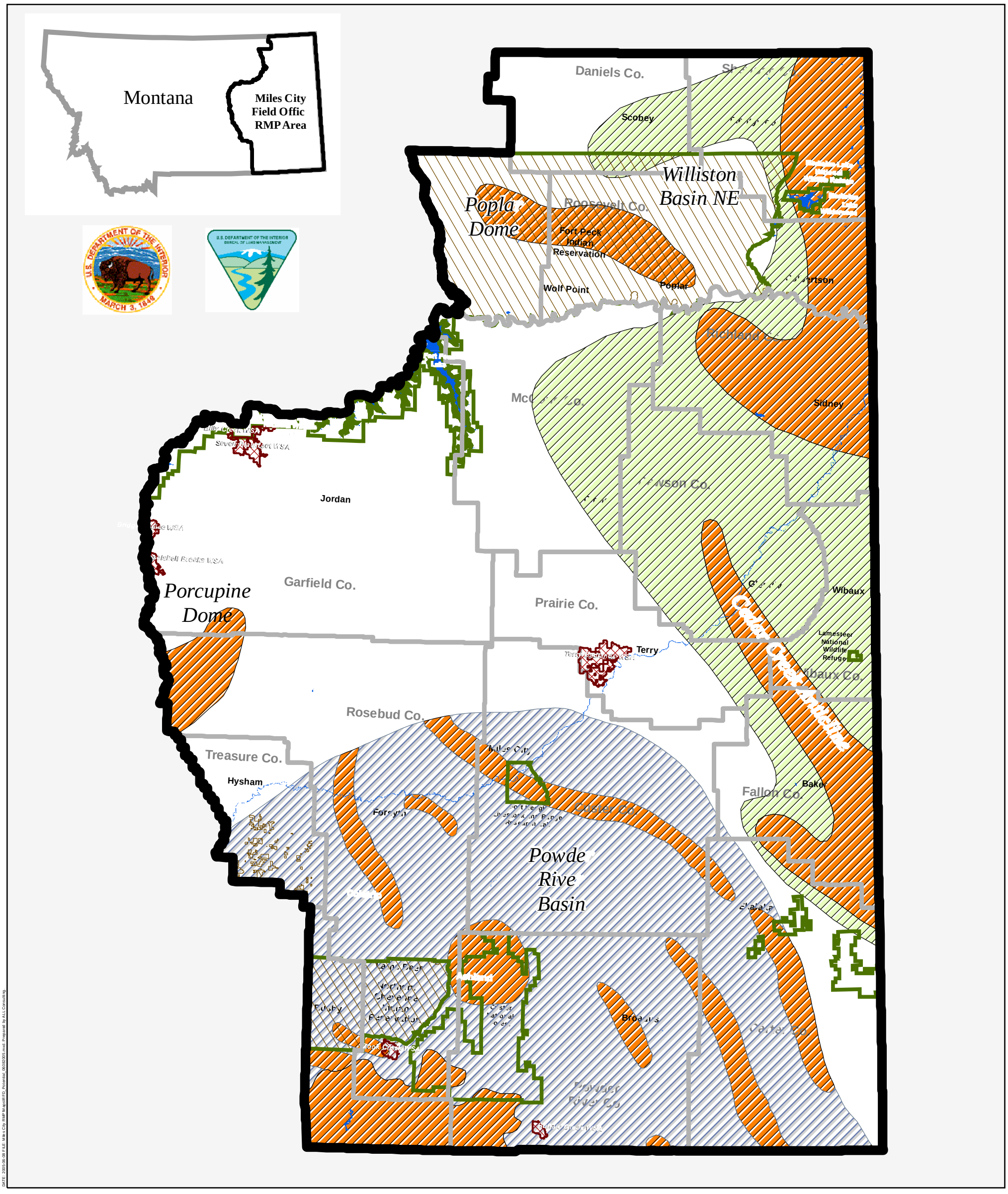
5.0 Oil and Gas Occurrence Potential

Figure 5-1 presents the oil and gas occurrence potential for the MCFO RMP area. The areas with high oil and gas occurrence potential in the Miles City Field Office RMP area are primarily located within the Williston Basin and the Powder River Basin. Within the Williston Basin, the high potential areas are focused along the Cedar Creek Anticline, along the eastern boundary, along the Poplar Dome, and across Richland County. These areas have high oil and gas occurrence potential associated with plays identified by the USGS assessments, most of which are currently being developed. The medium potential areas within the Williston Basin extend across most of the eastern side of the basin and are associated with USGS potential occurrence assessments and limited existing production. The low potential oil and gas occurrence areas within the Williston Basin extend across the remaining area, with some potential identified in the USGS assessments; these accumulations are likely to be confined to small-scale structural or stratigraphic traps.

Within the Powder River Basin (Figure 5-1), the high potential areas are associated with the CBNG locations assessed to have thick and relatively mature coal resources and in areas within the USGS assessed oil and gas plays with identified structural elements. In medium potential areas, the coal beds are generally shallower and have lower potential to still have natural gas trapped within the coal cleat. The low potential areas are where the producing coal beds crop out at the surface or where no structural features have been identified to act as traps for oil and gas resources.

The resource occurrence potential for the PRB was based on the 2002 USGS assessment and modified based on existing oil and gas development and known structural elements. The Williston Basin resource occurrence potential was based on the 1995 USGS assessment and modified to include elements associated with existing production and reserve estimates as well as known structural elements.



0 5 10 20 30 Miles

US Department of the Interior

Bureau of Land Management

MilesCity Field Office Draft RMP/EIS

Figure 5-1
Oil and Gas Occurrenc
and Development Potential

Legend

- RMP Area
- County
- Water
- Wilderness Study Area (WSA)
- Reservation Boundaries
- Federal Land

Occurrence Potential

- High
- Medium
- Low

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DATE: 2005-06-08 FILE: Miles City RMP Maps\RFD_Potential_06082005.mxd Prepared by ALL Consulting

6.0 Oil and Gas Development Potential

The Oil and Gas Development Potential Map for the MCFO RMP area is presented in Figure 5-1. The features mapped in this figure would be virtually the same as an Oil and Gas Occurrence Potential Map for the RMP with the exclusion of certain Areas of Critical Environmental Concern (ACECs). Oil and gas development within the ACECs will be curtailed or prohibited. While not appearing on Figure 5-1, ACECs embrace 506.7 acres ranked as having low potential, 99.5 acres as having medium potential, and 1,640.9 acres as having high potential. In addition, the three national wildlife refuge areas shown on Figure 5-1 may curtail or prohibit oil and gas development. These wildlife refuges represent approximately 7,227.5 acres of medium potential and 29,513.0 acres of high potential. Other areas within the Custer National Forest and the two tribal reservations may restrict oil and gas development within all or parts of their boundaries.

6.1 Reasonably Foreseeable Level of Development for the MCFO RMP

Reasonable estimates are described in the following section for oil, natural gas, and CBNG in several development areas; the data are cast into Table 6-1. The oil and gas development potential for the Powder River Basin area within the MCFO RMP was recently defined for the 2003 FEIS and there have been no changes to CBNG resource assessments. The level of CBNG development in the Montana portion of the PRB since the 2003 FEIS has increased at CX Field from 258 wells on March 30th, 2003 to 555 wells as of September 15th, 2005. The 2003 FEIS predicted that by year two (2005) there would be 11% of the anticipated CBNG wells drilled, which would be approximately 490 to 1,400 new CBNG wells. The development of CBNG in Montana has been slowed by several lawsuits against state, and federal agencies as well as operators which have resulted in delays in approving Plans of Development and Applications for Permits to Drill. The following is a summary from the 2003 FEIS for the RFD scenario for the areas that fall within the current MCFO RMP area. The Montana PRB RFD predicted the level of development that would occur over the next 20 years; this included a separate analysis for the level of development of CBNG wells and conventional oil and gas wells. The conventional oil and gas well assessment was based on historic drilling activity and oil and gas price projections and resulted in an estimate of 221 to 970 new conventional wells in the PRB within the MCFO area over the next 20 years, with 53 to 220 of these wells on Federal minerals (Table 6-1). Other mineral ownership include Indian trust mineral interest which may include 10 to 44 of these wells and state trust land mineral ownership that is estimated to include 12 to 54 of these wells.

CBNG development within the PRB of Montana was predicted based on a series of assumptions provided in the minerals appendix of the 2003 FEIS (BLM, 2003a). The results of the analysis predicted an estimated 5,485 to 19,835 wells could be drilled in the PRB area of Montana. The drilling would occur in phases with 200 to 1,100 wells being drilled each year, resulting in a total of 4,895 to 17,852 CBNG producing wells. Estimates of the number of CBNG producing wells that would be developed on federal minerals range from 2,420 to 6,954 (Table 6-1). Other mineral ownership included the Northern Cheyenne Tribe 500-3600 producing wells and the U.S, Forest Service with 25-180 producing wells.

In addition to the CBNG wells, the following additional infrastructure was estimated: 100 to 275 field compressors, 15 to 28 sales compressors, 1,600 to 4,450 miles of plastic gathering lines, 200 to 550 miles of steel lines, and 250 miles of sales lines would be needed. Details of the rate of development and abandonment are provided in the 2003 FEIS RFD and can be found in the Minerals Appendix (BLM, 2003a).

Within the Williston Basin, much of the current drilling activity has been focused on the Bakken Play in Richland County, on the Cedar Creek Anticline - shallow gas development, and

TABLE 6-1
MILES CITY FIELD OFFICE RMP AREA PREDICTED NEW WELL DEVELOPMENT.

Develop Area	Well Type	Total Wells Drilled		Producing Wells Total		Producing Wells Federal Minerals		Producing Wells Tribal Minerals		Producing Wells State Minerals		Dry Holes	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Williston NE	OIL	1,520	761	1,246	624	46	23	18	9	68	34	274	137
	Gas	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	1,520	761	1,246	624	46	23	18	9	68	34	274	137
Cedar Creek Anticline	OIL	3,149	1,568	2,581	1,285	602	300	0	0	165	82	568	283
	Gas	2,683	1,336	2,199	1,095	512	255	0	0	141	70	484	241
	TOTAL	5,832	2,904	4,780	2,380	1,114	555	0	0	306	152	1,052	524
Poplar Dome	OIL	105	54	86	44	3	1	37	19	1	0	19	10
	Gas	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	105	54	86	44	3	1	37	19	1	0	19	10
Williston Basin Other	OIL	28	15	23	12	4	2	1	1	2	1	5	3
	Gas	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	28	15	23	12	4	2	1	1	2	1	5	3
Powder River Basin	OIL	844	192	805	183	191	46	44	10	54	12	39	9
	Gas	126	29	120	28	29	7	7	1	8	2	6	1
	CBNG	15,635	5,485	14,072	4,895	6,954	2,420	3,600	1,253	900	313	1,564	791
	TOTAL	16,605	5,706	14,997	5,106	7,174	2,473	3,650	1,264	962	327	1,609	801
Porcupine Dome	OIL	67	37	55	30	10	5	0	0	4	2	12	7
	Gas	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	67	37	55	30	10	5	0	0	4	2	12	7
MCFO Other	OIL	66	33	54	27	14	7	0	0	3	2	12	6
	Gas	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	66	33	54	27	14	7	0	0	3	2	12	6
MFCO RMP TOTAL	OIL	5,779	2,660	4,850	2,206	870	384	100	39	297	133	929	455
	Gas	2,809	1,364	2,319	1,123	541	262	7	1	149	72	490	242
	CBNG	15,635	5,485	14,072	4,895	6,954	2,420	3,600	1,253	900	313	1,564	791
	TOTAL	**24,223**	**9,509**	**21,241**	**8,223**	**8,365**	**3,066**	**3,706**	**1,293**	**1,346**	**518**	**2,983**	**1,487**

enhanced recovery projects with horizontal wells. The Bakken Play is expected to continue to be developed at the current elevated rate until the limits of the play are defined in the next two to three years (Halverson, personal communication, 2005). Estimates of the total recoverable resources in the Bakken Play are difficult to predict as the boundary of the play is currently not well defined, and the unconventional nature of the reservoir makes assessment of recoverable oil quantities difficult. However, an assessment of future well development can be made based on recent drilling activity and the assumption that the number of drilling rigs in the region is not going to suddenly be increased in the near future. As of March 2005, Rigdata reported that 18 of the 28, or 64%, drilling rigs active in the state of Montana were drilling in Richland County, Montana. Based on previous drilling activity, it takes 30 to 35 days to drill a Bakken horizontal well. Assuming that 18 rigs will be available for drilling throughout the remainder of the year, approximately 200 wells could be drilled in the coming year. Assuming the play is currently only half-way defined and that infill drilling will result in two wells per section, during the next two to three years a total of 400 to 600 new Bakken wells could be drilled of which 15 to 22 wells would be on Federal minerals (Table 6-1).

Williston Basin development will continue in plays other than the Bakken. The number of expected permits and completions for the non-Bakken wells in Montana were calculated for a high and low estimate of permits and completed wells. For the Poplar Dome area within the Williston Basin, it is estimated that between 54 and 105 wells could be drilled over the next 20 years, of which 19 to 37 will be completed on BIA/Tribal minerals and one to three will be completed on BLM minerals (Table 6-1). For the Williston Basin Northeast area excluding Bakken well development, 360 to 920 wells could be drilled over the next 20 years, of which 23 to 46 well completions are expected to be on BLM managed mineral resources. For the Cedar Creek Anticline, it is estimated that between 2,904 and 5,832 wells could be drilled over the next 20 years with 555 to 1,114 well completions expected to occur on BLM managed minerals (Table 6-1). For the Williston Basin other field areas, it is estimated that between 15 and 28 wells could be drilled over the next 20 years, with two to four of these wells being completed on BLM managed mineral estates (Table 6-1). Outside of the Williston and Powder River Basins are the Porcupine Dome and Miles City Field Office other areas. On the Porcupine Dome an estimated 37 to 67 wells could be drilled over the next 20 years with five to ten of these wells being completed on BLM managed minerals. The Miles City Field Office other area is estimated to have 33 to 66 new wells drilled with 7 to 14 of these wells being completed on BLM managed minerals (Table 6-1).

Williston Basin CBNG development is still in the assessment stage with development over the next 20 years expected to include only limited drilling for testing purposes. The number of test wells to be drilled is expected to be between one and five per year, thus over the next 20 years between 20 and 100 test borings could be expected of which none are expected to be producing wells.

Estimates for the total number of wells to be completed over the next 20 years for the MCFO RMP area were based on historical completion data, current and predicted gas prices, and recent completion trends. The statistical data analysis performed here was based on trend analysis for historical and recent data sets; the recent data was weighted more heavily in the predictions for number of wells over the next 20 years. The low calculations assume that price predictions will maintain the level of development, while the high predictions are based on the assumption that oil and gas prices will be maintained at their current price or increase in the next 20 years resulting in the expansion of development.

A review of federally managed areas adjacent to the Miles City RFD revealed the predicted oil and gas development in the Wyoming portion of the PRB. Prior to the 2003 Buffalo Field Office (BFO) Area EIS for CBNG development in Wyoming, an RFD for oil and gas development activity through the year 2010 was developed (BLM, 2001). Estimates of seismic activity on

BLM surface acreage is expected to average 15 surveys per year, while non-CBNG wells on federal lands are expected to be drilled at an average of 30 to 150 per year, but, estimates as high as 200 per year are possible with 5 to 10 new field discoveries per year (BLM, 2001). CBNG wells in Wyoming are expected to continue to increase with estimates of 50,000 (moderate development) to 80,000 wells (high development) being drilled by 2010, with total CBNG well numbers in Wyoming estimated at 81,000 (moderate) to 139,000 (high). The rate and number of potential CBNG wells for the Wyoming portion of the PRB is higher than Montana because the amount of CBNG resources estimated to be present in the coal beds of the PRB occur over a larger area in Wyoming.

7.0 RFD Baseline Scenario Assumptions and Discussion

This RFD scenario assumes that all potentially productive areas are open under the standard lease terms and conditions except those areas designated as closed to leasing by law, regulation, or executive order. The areas closed to leasing typically include Areas of Critical Environmental Concern (ACEC) and wilderness study areas (WSAs). Within the MCFO, there are 16 designative ACECs and 5 WSAs. The RFD scenario for the MCFO RMP amendment contains projections for the number or wells and acres disturbed for the producing regions identified; this includes areas within the Northern Cheyenne and Fort Peck Reservations, the Ashland Ranger District of the U.S. Forest Service, and Montana State Trust mineral estates. This in no way is intended to imply that the BLM are making decisions about the reservations, the Forest Service lands or the Montana State Trust lands. The predictions are intended to provide the information necessary so that all potential cumulative impacts can be analyzed. The disturbance for each well is based on the typical depth of wells for an area; generally, shallow gas wells disturb fewer acres than deeper oil wells. The assumptions for conventional oil and gas are as follows:

A. The number of wells was calculated based on historical statistics and data trends as follows:

- Wells drilled to date were taken from the MBOGC Public Database.

- The number of wells drilled to date was statistically analyzed to calculate a median per year wells drilled, for three time trends: first the complete historical record dating back as far as 1901, second the data back to 1986, and third recent data from 2000 to 2004.

- The data trends associated with the last five years represents a more accurate estimate of future development trends than historical data, thus, it is weighted more heavily (the median value was multiplied by 0.75).

- The data trends from 1986 to present data set are a more accurate estimate of future trends than the complete historical record and were weighted more heavily than the historical record (the median value was multiplied by 0.15).

- The data trends for the complete historical record represent the least acturate estimate of future development trends and, thus, it was weighted the lightest in the calculations (the median values was multiplied by 0.10)

- For each geographic/geologic boundary region and sub region, the calculated estimates for future development for the three time trends were summed to obtain a low per year well count. This low per year well count was then multiplied by 20 to calculate the forecasted low estimate of wells.

- Wellhead oil and gas prices are a driving force for well drilling and completion; current prices are resulting in an estimated doubling of activity, thus, for the high forecast of future well development the influence from each of the three time trends was doubled. The high forecast assumes wellhead oil and gas prices will remain high and development over the next 20 years will continue at an elevated rate.

- Estimates of well counts for the different mineral ownership entities are based on spatial analysis of the percent of mineral ownership within each geologic boundary area times the total number of producing wells anticipated to be developed in that boundary area.

B. The average acreage figure (acres per well) for the resource area was used to estimate federal disturbed acres.

C. The RFD projections have a 20-year life.

D. The number of dry holes was determined based on historic analysis of dry holes in the geologic boundary areas.

The assumptions for CBNG in the PRB were taken from the 2002 RFD which can be found in the Minerals Appendix of the FEIS for statewide development of CBNG in Montana (BLM, 2003a). The assumptions were used to calculate the number of wells to be drilled, the number of in-field compressors, and the number of sales compressors required from the 2003 FEIS, and are being incorporated here by reference.

The assumptions for CBNG wells in the PRB are the same as the 2002 RFD as presented in Appendix A (pgs. Min-16 and 17) of the BLM FEIS for CBNG development (BLM, 2003a).

8.0 Surface Disturbance Due to Oil and Gas Activity on All Lands

8.1 Surface Disturbances

Estimates of the surface disturbances associated with the development of oil and gas within the MCFO RMP area for CBNG development are based on the data from the 2003 CBNG FEIS for Montana. The data for surface disturbances was determined from a variety of resources, including previous CBNG Environmental Assessments, discussions with BLM and state oil and gas personnel, discussions with various CBNG operators, and document review. The data for surface disturbances for CBNG wells are presented in Table 8-1 below. The surface disturbances are scaled to a per well disturbance level so that calculation of the total disturbance can be generated at the project, field, or RMP area level by multiplying the number of wells for analysis by the numbers provided in the table. Existing surface disturbances are commensurate with the estimates provided in Table 8-1.

The level of disturbance associated with conventional oil and gas development varies depending on the depth of the well and type of well drilled (horizontal vs. vertical). A shallow gas well (<2,000 feet deep) typically includes a well pad of 0.5 acres and 2 miles of bladed road for a total drilling disturbance area of 1 acre. Shallow oil well (<5,000 feet) surface disturbances include 2-acre well pads and 1.5 acres of bladed road for a total of 3.5 disturbed acres. Deeper oil wells (5,000 to 12,000 feet) have greater disturbance area, usually a 3-acre well pad and 1.5 acres of bladed road for a total of 4.5 disturbed acres. Horizontal wells such as those being drilled in the Bakken Play are currently being drilled using a larger well pad estimated at 5 acres, however because well spacing is currently one to two wells per section, drilling locations are usually closer to existing roadways and total disturbance is similar to the 5.5 disturbed acres for deep oil wells. Table 8-2 presents surface disturbance data for conventional oil and gas wells and associated facilities. Existing surface disturbances are similar to those presented in Tables 8-1 and 8-2.

TABLE 8-1
LEVEL OF DISTURBANCE FOR CBNG WELLS AND ASSOCIATED PRODUCTION FACILITIES

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Sites		0.25	0.25	0.05
Access Roads/ Routes to Well Sites	Two-track	N/A	0.30	0.30
	Graveled	N/A	0.10	0.10
	Bladed	0.75	0.075	0.10
Utility Lines	Water	N/A	0.35	----[1]
	Overhead Elec.	N/A	0.20	0.20
	Underground Elec.	N/A	0.35	----
Transportation Lines	Low Pressure Gas	N/A	0.90	----
	Intermediate Pres. Gas	N/A	0.25	----
Processing Area	Battery Site	N/A	0.020	0.020
	Access Roads	N/A	0.15	0.15
	Field Compressor	N/A	----	0.02 (0.5 acres / 24 producing wells)
	Sales Compressor	N/A	----	0.005 (1.0 acres / 240 producing wells)
	Plastic Line	N/A	----	0.5[2]
	Gathering Line	N/A	----	0.25
	Sales Line	N/A	----	0.075
Produced Water Management	Discharge Point	N/A	0.01	0.002
	Storage Impoundment	N/A	0.3	0.25
Total Disturbance		1.0	3.25	2.0

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.

2. Plastic lines within the processing area are assumed to disturb an average corridor with of 25 feet.

TABLE 8-2
LEVEL OF DISTURBANCE FOR OIL AND GAS WELLS AND ASSOCIATED PRODUCTION FACILITIES

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Pad (360-foot by 360-foot pad during drilling and construction, 200-foot by 200-foot pad during operation)		3	3	1
Access Roads to Well Sites	Two-track (12-foot wide by 0.21 miles long)	N/A	0.3	0.3
	Graveled (12-foot wide by 0.075 miles long)	0.5	0.1	0.1
	Bladed (12-foot wide by 0.05 miles)	0.5	0.075	0.075
Utility Lines	Water lines (15-foot by 0.20 miles)	N/A	0.35	1
	Overhead Elec. (10-foot by 0.15 miles)	N/A	0.2	0.2
	Underground Elec. (15-foot by 0.20 miles)	N/A	0.35	0
Transport-ation Lines	Intermediate Press. Gas line to and from field compressor (25-foot by 0.08 miles)	N/A	0.25	0.001
	High Press. Gas or Crude Oil Gathering Line (25-foot by 0.3 miles)	NA	0.9	0.2
Processing Areas	Tank Battery (one 0.50-ac tank battery per 12.5 wells)	N/A	0.02	0.04
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 12.5 wells)	N/A	0.2	0.04
	Sales Compressor (2-ac pad for 240 wells)	N/A	0.01	0.01
	Sales Line (25-foot by 6 miles per 240 wells)	N/A	0.075	0.075
Produced Water	Produced Water pipeline (25-foot by 0.3 miles)	N/A	0.9	0.2

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Management	Water plant/ Inj well (6 ac site per 12.5 wells)	N/A	0.25	0.5
Total Disturbance per Conventional Oil or Gas Well (acres)		**4**	**7.1**	**3**

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.

2. It is assumed that each conventional oil and gas well will need product pipeline and produced water line from the well. In addition, some wells will need intermediate pipeline run from the field compressor to sales line.

8.2 Mitigation Measures

Mitigation measures are restrictions on lease operations, which are intended to minimize or avoid adverse impacts to resources or land uses from oil and gas activities. The mitigation measures listed in Table 8-3 would be applied to permits, leases or approvals granted by the land management agency. The list is not all inclusive, but presents the mitigation measures most often used in the Miles City Field Office RMP area. The wording of the mitigation measure may be modified or additional measures may be developed to address specific conditions. Mitigation measures would be included as appropriate to address site-specific concerns during all phases of oil, gas and CBNG development.

8.3 Conditions of Approval

An approved application for permit to drill (APD) includes conditions of approval (COA), and Informational Notices which cite the regulatory requirements from the Code of Federal Regulations, Onshore Operating Orders and other guidance. Conditions of approval are mitigation measures which implement lease restrictions to site specific conditions. General guidance for COA are found in the BLM and U.S. Forest Service brochure entitled "Surface Opereating Standards for Oil and Gas Exploration and Development" (USDI, BLM 1989) and BLM Manual 9113 entitled "Roads".

The Final Big Dry RMP/EIS contains a list of COA that is similar to the mitigation measures presented in Table 8-3. These COAs may be modified or additional COAs may be developed to address specific conditions found throughout the MCFO RMP area.

8.4 Lease Stipulations

Certain Resources in the planning area require protection from impacts associated with oil and gas development. The specific resources and methods of protection are contained in lease stipulations. Lease stipulations usually consist of no surface occupancy, controlled surface use, or timing limitations. A notice may be included with a leased to provide guidance regarding resources or land use. While actual wording of stipulations may be adjusted at the time of leasing, the protection standard described will be maintained.

The Final Big Dry RMP/EIS contains descriptions of lease stipulations which have been applied and maybe retained for use under the revised MCFO RMP.

TABLE 8-3
MITIGATION MEASURES THAT WOULD BE APPLIED AS APPROPRIATE TO MINIMIZE IMPACTS

Mitigation Measure	BLM
Disturbed areas resulting from any construction will be seeded following the BLM seeding policy, state guidance or surface owner's requirements. Depending on surface ownership seeding is usually required during the fall or late spring.	X
To the extent practicable, vegetation will be preserved and protected from construction operations and equipment except where clearing operations are required to conduct oil and gas operations, such as for roads, well pads, pipelines, power lines, utility lines, and structures. Clearing of vegetation will be restricted to the minimum area needed for construction and equipment.	X
Temporary and permanent access roads will be avoided on south-facing slopes within big game winter range, where practicable.	X
To the maximum extent practicable, all maintenance yards, field offices, and staging areas will be arranged to minimize disturbance to trees, shrubs, and other native vegetation.	X
Topsoil removed by construction activities will be stockpiled for reclamation. Sensitive habitat areas will not be used for topsoil storage.	X
The planting of grasses, forbs, trees, or shrubs beneficial to wildlife will follow the BLM seeding policy. When needed, BLM will require installation of erosion and sedimentation control measures, such as riprap, erosion mats, mulch, bales, dikes, or water bars. Riprap material and placement must be approved by the appropriate agency.	X
Erosion control and site restoration measures will be initiated as soon as a particular area is no longer needed for exploration, production, staging, or access. Disturbed areas will be recontoured to provide proper drainage.	X
Topsoil piles may be required to be seeded following the BLM seeding policy.	X
All above-ground electrical poles and lines will be raptor-proofed to avoid electrocution following the criteria and outlined in the Avian Power Line Interaction Committee (APLIC) (1994) and APLIC (1996). (APLIC 1994. Mitigating Bird Collisions with Power Lines: The State of the Art in 1994. Edison Electric Institute, Washington D.C. 78 pp.; APLIC 1996. Suggested Practices for Raptor Protection on Power Lines. Edison Electric Institute. Washington, D.C. 128 pp.).	X
Conduct three nesting habitat surveys for mountain plover in suitable habitat between May 1 and June 15. Surface use may be deleted in accordance with 43 CFR 3101.1-2.	X
The Surface Management Agency is responsible for assuring that the leased lands are examined to determine if cultural resources are present and to specify mitigation measures. Guidance for application of this requirement can be found in NTL-MSO-85-1.	X
Cuts and fills for new roads will be sloped to prevent erosion and to facilitate revegetation.	X

Mitigation Measure	BLM
It is the responsibility of the operator to control noxious weeds on lands disturbed in association with oil and gas lease operations. Lease-associated weed control strategies, when required by BLM, are to be coordinated with any involved surface owners and local weed control boards. A pesticide-use proposal must be prepared, and reviewed and approved by BLM prior to any herbicide application on lands disturbed by federal oil and gas lease operations. A pesticide application record must be within 24 hours after completion of application of herbicides. Additional measures may be required to prevent the spread of noxious weeds.	X
Activities such as stream crossings that could directly impact sensitive or protected fish species will be undertaken during non-spawning periods for these species. In the unlikely event that multiple, sensitive, or protected fish species with back-to-back spawning periods are present in the same stream reach, one of the following options will be exercised. These options include selecting a nearby, alternative stream crossing site that does not provide suitable spawning habitat for the fish species of concern; using a nearby, existing stream crossing over the channel to avoid instream disturbances; or using shore-based equipment to position and extend the pipeline or other item (e.g., temporary bridge) across the stream, thereby avoiding in-channel activities.	X
Operators must develop a Spill Prevention Control and Countermeasures plan to deal with accidental spills, the plan would include the strategic placement of berms and dikes.	X
The road ditches would be flat bottomed and "V" ditches would not be allowed. Place water turn outs where appropriate to lessen the water impacts upon the ditches.	X
Prior to surface disturbance on slopes over 30 percent, an engineering/reclamation plan must be approved by the authorized officer. Such plan must demonstrate how the following will be accomplished: • Site productivity will be restored. • Surface runoff will be adequately controlled. • Off-site areas will be protected from accelerated erosion, such as rilling, gullying, piping, and mass wasting. • Water quality and quantity will be in conformance with state and Federal water quality laws. • Surface-disturbing activities will not be conducted during extended wet periods. • Construction will not be allowed when soils are frozen.	X
Surface occupancy and use is prohibited within existing coal leases with approved mining plans.	X
Surface occupancy and use is prohibited within riparian areas, 100-year flood plains of major rivers, and on water bodies and streams.	X
Surface use is prohibited from December 1 to March 31 within crucial winter range for wildlife. This stipulation does not apply to the operation and maintenance of production facilities.	X
Surface use is prohibited from April 1 to June 15 within established spring calving range for elk. This stipulation does not apply to the operation and maintenance of production facilities.	X
Surface occupancy is prohibited in the designated Bighorn Sheep Range.	X

Mitigation Measure	BLM
Surface occupancy and use is prohibited within ¼ mile of grouse leks.	X
Surface use is prohibited from March 1 to June 15 in grouse nesting habitat within 2 miles of a lek. This stipulation does not apply to the operation and maintenance of production facilities.	X
Surface use is prohibited from March 1 – August 1, within ½ mile of raptor nest sites which have been active within the past 2 years. This stipulation does not apply to the operation and maintenance of production facilities.	X
Surface occupancy and use is prohibited within ¼ mile of designated reservoirs and fisheries.	X
The "Draft Guidelines for Oil and Gas Activities in Prairie Dog Ecosystems Managed for Black-footed ferret Recovery" (FWS, 1990) will be used as appropriate to develop site-specific conditions of approval to protect black-footed ferret reintroduction and recovery. Specific conditions of approval will depend on type and duration of proposed activity, proximity to occupied ferret habitat, and other site-specific conditions.	X
Prior to surface disturbance, prairie dog colonies and complexes 80 acres or more in size will be examined to determine the absence or presence of black-footed ferrets. The findings of this examination may result in some restrictions to the operator's plans or may even preclude use and occupancy that would be in violation of the Endangered Species Act (ESA) of 1973. The lessee or operator may, at their own option, conduct an examination on the leased lands to determine if black-footed ferrets are present, or if the proposed activity would have an adverse effect, or if the area can be cleared. This examination must be done by or under the supervision of a qualified resource specialist approved by the Surface Management Agency (SMA). An acceptable report must be provided to the SMA documenting the presence or absence of black-footed ferrets and identifying the anticipated effects of the proposed action on the black-footed ferret and its habitat. This stipulation does not apply to the operation and maintenance of production facilities.	X
Surface occupancy and use is prohibited within ½ mile of known bald eagle nest sites which have been active within the past 7 years and within bald eagle nesting habitat in riparian areas.	X
Surface occupancy and use is prohibited within 1 mile of identified peregrine falcon nesting sites.	X
Surface occupancy and use is prohibited within ½ mile of known ferruginous hawk nest sites which have been active within the past 2 years.	X
Surface occupancy and use is prohibited within ¼ mile of wetlands identified as piping plover habitat.	X
Surface occupancy and use is prohibited within ¼ mile of wetlands identified as interior least tern habitat.	X
Surface occupancy and use is prohibited within sites or areas designated for conservation use, public use, or sociocultural use.	X
Surface occupancy and use is prohibited within designated paleontological sites.	X
Surface occupancy and use is prohibited within developed recreation areas and undeveloped recreation areas receiving concentrated public use.	X

Mitigation Measure	BLM
All surface-disturbing activities, semi permanent and permanent facilities in VRM Class II, areas may require special design, including location, painting, and camouflage, to bend with the natural surroundings and meet the visual quality objectives for the area.	X
Geophysical exploration for oil and gas will be allowed on designated roads and trails with restrictions in the Battle Butte, Finger Buttes, and Reynolds Battlefield areas of the Miles City Field Office RMP area.	X

9.0 References

ALL 2001. Water Resources Technical Report, Montana statewide oil and gas environmental impact statement and amendment of the Powder River and Billings resource management plans. Prepared for the U.S. Department of the Interior, Bureau of Land Management, Miles City Field Office. ALL Consulting, Tulsa, OK.

ALL 2004. Coal Bed Methane Primer New Source of Natural Gas—Environmental Implications, Background and Development in the Rocky Mountain West, Prepared for the U.S. Department of Energy, NETL, ALL Consulting, Tulsa, OK.

Bureau of Land Management 2001, Reasonable Foreseeable Development Scenario for Oil and Gas Development in the Buffalo Field Office Area, Campbell, Johnson, and Sheridan Counties, WY. Wyoming State BLM Office.

Bureau of Land Management 2003a, Final Statewide Oil and Gas Project Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans. U.S. Department of Interior, Bureau of Land Management, Miles City and Billings Field Offices.

Bureau of Land Management 2003b, Record of Decision and Resource Management Plan Amendments for the Powder River and Billings RMPs. U.S. Department of Interior Bureau of Land Management, Miles City and Billings Field Offices.

Bureau of Land Management 2003c, Final Environmental Impact Statement and Planning Amendment for the Powder River Basin Oil and Gas Project. U.S. Department of Interior Bureau of Land Management, Buffalo Field Office.

Bureau of Land Management 2003d, Record of Decision and Resource Management Plan Amendments for the Powder River Basin Oil and Gas Project. U.S. Department of Interior Bureau of Land Management, Buffalo Field Office.

Dolton, Gordon L. and J.E. Fox. 1996, Powder River Basin Province (033), in Gautier, D.L., Dolton, G.L., Vernes, K.L., and Takahashi, K.I., eds. 1995 National Assessment of United States Oil and Gas Resources – Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDA-30.

Ellis, M.S., G.D. Stricker, R.M.Flores, and L.R. Bader. 1998, Sulfur and ash in Paleocene Wyodak-Anderson coal in the Powder River Basin, Wyoming and Montana, Proc. 23rd International Tech. Conference on Coal Utilization, March 1998.

Ellis, M.S., G.L. Gunther, A.M. Ochs, C.W. Keighin, G.E. Goven, J.H. Schuenemeye, H.C. Power, G.D. Stricker, and D. Blake, 1999, Coal Resources, Williston Basin, in U.S. Geological Survey Professional Paper 1625-A, 1999 Resource Assessment of Selected Tertiary Coal Beds and Zones in the Northern Rocky Mountains and Great Plains Region. Online version at http://greenwood.cr.usgs.gov/energy/coal/PP1625A/pp1625A.html

Encore Personal Communication, 2005, Personal conversation between Dale Hinton at Encore Operating, L.P. and Bruce Langhus, May 18, 2005.

Flores, R.M. and C.W. Keighin, 1999, Fort Union Coal in the Williston Basin, North Dakota: A Synthesis, in U.S. Geological Survey Professional Paper 1625-A, 1999 Resource Assessment of Selected Tertiary Coal Beds and Zones in the Northern Rocky Mountains and Great Plains Region. Online version at http://greenwood.cr.usgs.gov/energy/coal/PP1625A/pp1625A.html

Halvorson, Jim, 2005, Geologist for the Montana Board of Oil and Gas Conservation, Billings, MT, personal communication, March 2005.

Heck, T.J., R.D. LeFever, D.W. Fischer, and J. LeFever, 2002. Overview of the Petroleum Geology of the North Dakota Williston Basin, North Dakota Geological Services.

Montana Board of Oil and Gas Conservation, 2005. MBOGC online database, http://bogc.dnrc.state.mt.us/OnlineData.htm

Murphy, E.C. and G.E. Goven, 1998, The Coalbed Methane Potential of North Dakota Lignites: North Dakota Geological Survey Open File Report 98-1, 38p.

Noble, R.A., R.N. Bergantino, T.W. Patton, B.Sholes, F.Daniel, and J.Schofield. 1982, Occurrence and characteristics of groundwater in Montana, MBMG 99.

Peterson, James A. 1996, Williston Basin Province (031), in Gautier, D.L., Dolton, G.L., Vernes, K.L., and Takahashi, K.I., eds. 1995 National Assessment of United States Oil and Gas Resources – Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDA-30.

Rice, D.D. and T.M. Finn. 1996, Unconventional Plays – Coalbed Gas Plays in the Powder River Basin (033), in Gautier, D.L., Dolton, G.L., Vernes, K.L., and Takahashi, K.I., eds. 1995 National Assessment of United States Oil and Gas Resources – Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDA-30.

Roberts, S.B., G.L. Gunther, T.T. Taber, A.M. Ochs, D. Blake, M.S. Ellis, G.D. Stricker, E.M. Wilde, J.H. Schuenemeyer, and H.C. Power. 1999a Decker Coalfield, Powder River Basin, Montana: geology, coal quality, and coal resources, in USGS Prof. Paper 1625-A.

Roberts, S.B., E.M. Wilde, G.S. Rossi, D. Blake, M.S. Ellis, G.D. Stricker, A.M. Ochs, G.L. Gunther, J.H. Schuenemeyer, and H.C. Power. 1999b. Ashland Coalfield, Powder River Basin, Montana: geology, coal quality, and coal resources, in USGS Prof. Paper 1625-A.

Schmoker, James W. 1996, Unconventional Plays – Continuous Type Williston Basin Province, in Williston Basin Province (031) by James Peterson, in Gautier, D.L., Dolton, G.L., Vernes, K.L., and Takahashi, K.I., eds. 1995 National Assessment of United States Oil and Gas Resources – Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDA-30.

Specht, R.W., 2002, The Williston Basin: the Premier "Next Generation" Coalbed Methane Play in the Rocky Mountain/Great Plains: extend abstract, in 10th Williston Basin Horizontal Well and Petroleum Conference, May 7, 2002, Bismarck, N.D.

Specht, R.W., 2003. Coalbed Methane Potential of the Williston Basin, North Dakota, in Emerging Coalbed Methane Plays of North America, HOS, Inc.

Thomas J. Heck, Richard D. LeFever, David W. Fischer, and Julie LeFever. 2002. Overview of the Petroleum Geology of the North Dakota Williston Basin, N.D. Geological Survey

USDI, 2002. Interagency Reference Guide, Reasonably Foreseeable Development Scenario and Cumulative Effects Analysis For Oil and Gas Activities on Federal Lands in the Greater Rocky Mountain Region. Draft Final. Rocky Mountain Federal Leadership Forum on NEPA, Oil and Gas, and Air Quality. August 30, 2002.

USDI, BLM 1989. Surface Operating Standards for Oil and Gas Exploration and Development. Third Edition. Rocky Mountain Regional Coordinating Committee, Miles City District Office, Miles city, Montana.

USGS, 1995. Gautier, D. L., Dolton, G.I., Takahashi, K.T., and Varnes, K.L., eds., 1995 National assessment of United States oil and gas resources--Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30.

USGS, 2002. Assessment of Undiscovered Oil and Gas Resources of the Powder River Basin Province of Wyoming and Montana, 2002. USGS Fact Sheet FS-146-02.

USGS 2003. Powder River Basin, Province 5033, National Oil and Gas Assessment Online Assessment Results, http://certmapper.cr.usgs.gov/noga/servlet/NogaNewMainResultsServ?provnum=33&page=basin