Tennessee

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO FOR FLUID MINERALS

Prepared for:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
EASTERN STATES
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The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times. Management is based on the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include air, fish and wildlife, minerals, paleontological relics, recreation, rangelands, scenic scientific and cultural values, timber; water, and wilderness.

BLM/ES/PL-08/XXX

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ACRONYMS

ACEC	Area of Critical Environmental Concern
APD	Application for Permit to Drill
AU	Assessment Units
BCF	billion cubic feet
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
EIS	Environmental Impact Statement
JFO	Jackson Field Office
MMBO	million barrels of oil
ROD	Record of Decision
RMP	Resource Management Plan
SMA	Surface Management Agency
TCF	trillion cubic feet
TPS	Total Petroleum Systems
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey

Summary

1.0 INTRODUCTION

The Bureau of Land Management's Jackson Field Office is located in Jackson, Mississippi, and is responsible for 11 southern states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The Jackson Field Office manages approximately 34.25 million acres of federal mineral estate in the eastern portion of the United State. Of this approximately 1.9 million mineral estate acres are located in Tennessee.

The Reasonable Foreseeable Development Scenario (RFDS) forecasts fluid mineral exploration, development, and production for the planning area for the next 10 years. The RFDS assumes 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.

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.

1.1 Discussion of Determining Oil and Gas Resource Potential

Potential accumulations of oil and gas are described in Section 2. Non-BLM land within the state 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.

1.2 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 state.

1.3 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 DESCRIPTION OF THE GEOLOGY OF TENNESSEE

The surface geology of the State of Tennessee is dominated by exposures of Paleozoic rocks that range in age from Ordovician to Pennsylvanian. Exposures of younger Mesozoic and Tertiary aged units are confined to the western part of the state. Quaternary aged sediments in the state are generally confined to areas associated with rivers and tributaries in the western parts of the state (See Figure 1 Geologic map of Tennessee).

The distribution of these exposures and the general topography and physiography of the region are largely controlled by the parts of three major structural features that are present within the state. These include part of the Appalachian basin including the associated Appalachian fold-and-thrust province, the southern most extent of the Cincinnati Arch, and a part of the Mississippi Embayment which is located in the western part of the state. These regionally scaled structural features include smaller localized features that include folded geologic structures and individual faults or fault trends. Figure 2 shows the location of these regional structural features and indicates individual counties in which oil and gas resources have been identified.

2.1 Subsurface Stratigraphy and Structure

The subsurface stratigraphy and structure related to the occurrence of oil and gas resources in Tennessee is largely dominated by the Nashville Dome and associated “Cumberland Saddle” which is located on the southern most extension of the north – south trending Cincinnati arch. The furthermost eastern flank of this feature forms parts of the adjacent Appalachian Basin area. Oil and gas production in Tennessee is generally consistent with an extension of similar production identified in central and south central Kentucky. The Appalachian fold-and-thrust province, located to the east of the Appalachian Basin forms the valley and ridge physiographic region of eastern Tennessee. These regional structural features which effect the distribution of the geologic surface exposures and the general physiography of the state also largely control the distribution of subsurface rock units and in turn effect the distribution of oil and gas occurrences.

2.1.1 North Central Tennessee Region

The North Central Tennessee productive region is located in north-central Tennessee and is coincident with the crestal and flank areas of the Cincinnati arch and parts of the Appalachian Basin which extends from southern Kentucky into north-central Tennessee.

The Cincinnati arch is a positive geologic structural feature that represents an extension of the Kankakee and Findley arches which extend southward from northern Illinois and western Ohio into Kentucky and then further on into Tennessee where it terminates in central and south central part of the state. The structural features of this arch in Tennessee are the Nashville Dome, and the “Cumberland Saddle”. The Cumberland Saddle consists of the structural sag located north of the Nashville Dome of Tennessee and south of Jessamine Dome of Kentucky. The eastern flank of the Cincinnati Arch forms the western flank of the Appalachian Basin and is included in this portion of Tennessee that is productive of oil and gas. While some production has been established in direct association with the southeastern flank of the Nashville Dome the majority of the production in Tennessee is from those counties in the area of the “Cumberland Saddle” or portions of the Appalachian Basin and adjacent Appalachian Thrust.

Figure 1: Geologic Map of Tennessee

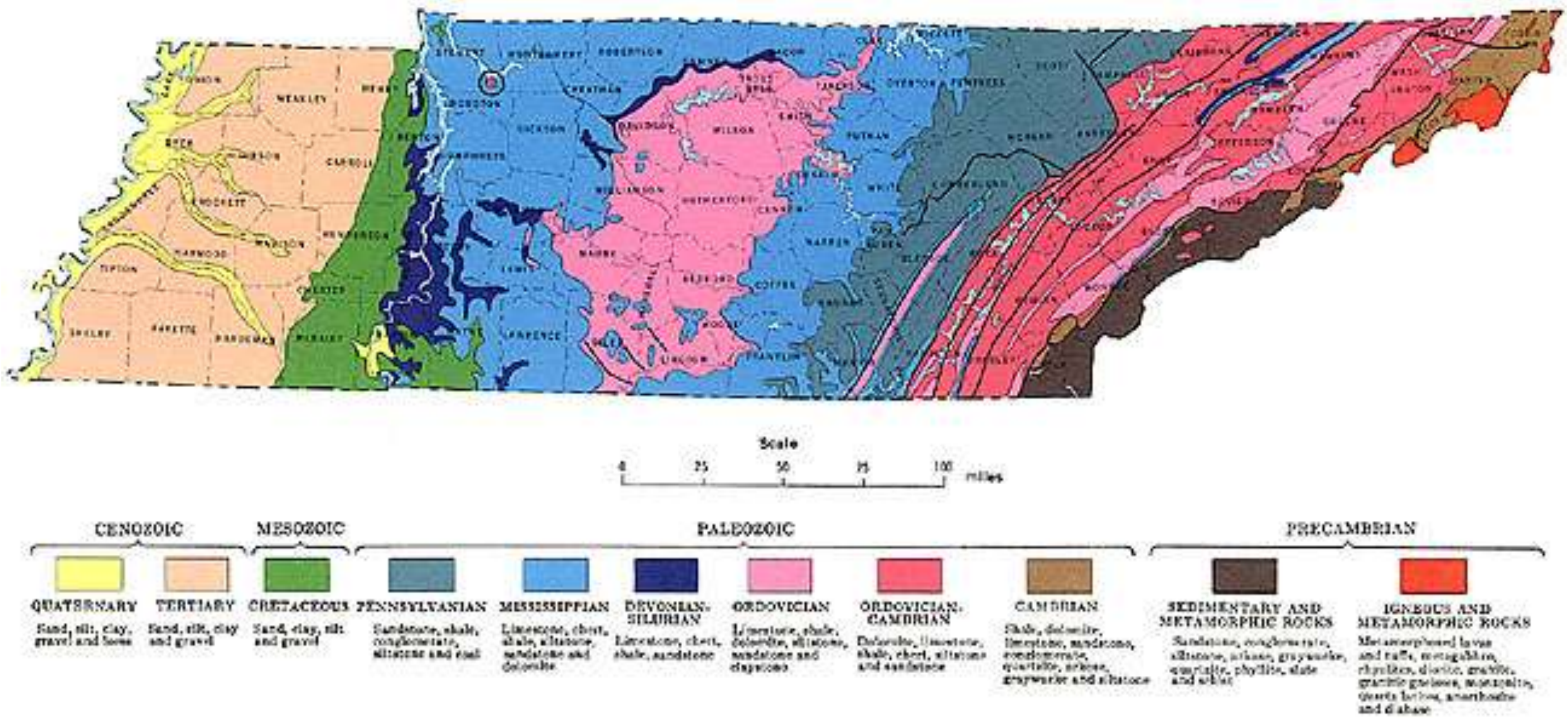
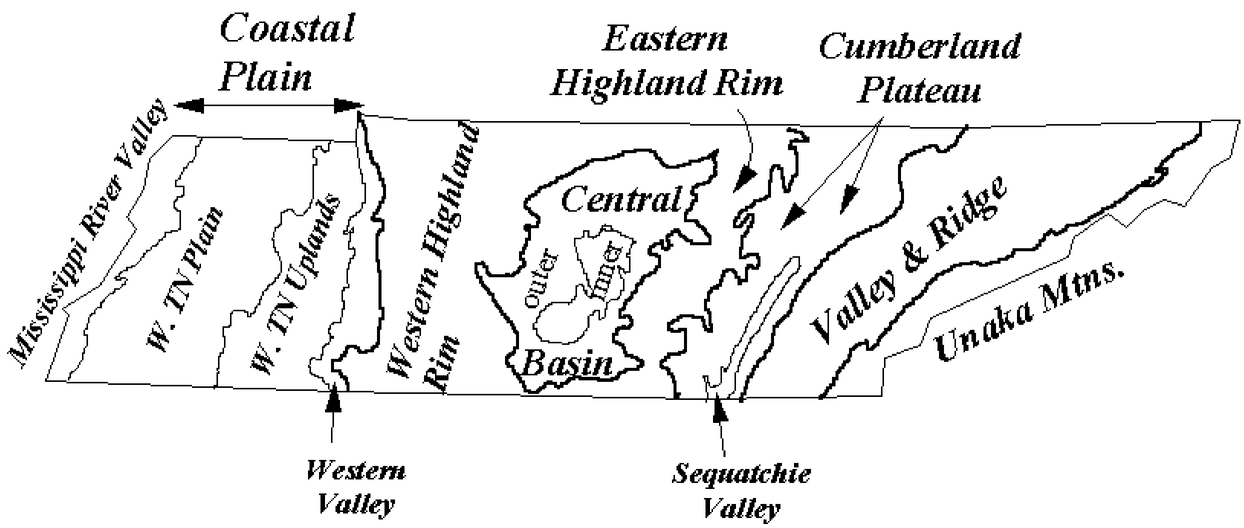


Figure 2: Physiographic Map of Tennessee



This region contains reservoirs that are productive of both oil and natural gas and that range in age from the Cambrian-Ordovician System through Mississippian System. The individual reservoir units include both carbonate and clastic lithologic units. Table 1 shows a generalized stratigraphic column for reservoir units in the North Central Tennessee region.

Table 2 provides data relative to active and inactive oil and gas fields located in northern–central Tennessee and includes fields located in the area of the Cumberland Saddle of the Cincinnati Arch and the Appalachian Basin as well some production established in association with the area included in the Appalachian Thrust. The fields in this part of Tennessee are classified a mix of fields with non-associated gas with oil and oil and associated-dissolved gas present.

2.1.2 Other Regions in Tennessee

The eastern part of the state is located in the valley and ridge province of the Appalachian area. The sedimentary sequence in this area is highly faulted and in some areas affected by regional metamorphism. Northeast southwest trending faults predominate with over thrusting and sharp folding common to the area.

The western part of the state lies within the northern reaches of the Mississippi Embayment which is marked by exposures of Mesozoic (Cretaceous) and Tertiary rock units. These units are generally composed of clastic strata including gravels, sands and sandstone, silts, and mud. To date there has been no oil and gas production established in this part of the state.

Figure 3 indicates the general federal surface in the state of Tennessee.

Table 1: Stratigraphic Column - North Central Tennessee

SYSTEM	GROUP	FORMATION / RESERVOIR
Pennsylvanian	Pottsville Group	
Mississippian	Chester	Pennington Formation * Bangor Limestone (Big Lime) * Monteagle Limestone
	Meramec	* Monteagle Limestone St Louis limestone Warsaw Limestone
	Osage	* Fort Payne
	Kinderhook	
Devonian	Onongdaga Grp.	* Chattanooga Shale
Silurian	Albion - Lockport	Lego Limestone Laurel Limestone Osgood Formation Brassfield Limestone
Ordovician	Richmond Grp.	
	Maysville Grp.	Leipers Formation
	Nashville Grp (Trenton)	Catheys Formation *Bigby-Cannon Limestone *Hermitage Formation
	Stones River Grp	Carters Limestone * Lebanon Limestone Ridley Limestone Pierce Limestone * Murfreesboro Limestone Wells Creek Dolomite
Cambrian - Ordovician	Knox	* Knox Dolomite

* Indicates horizon or stratigraphic equivalent is a productive or prospective reservoir(s).

Table 2: Active and Inactive Oil and Gas Fields – North Central Tennessee

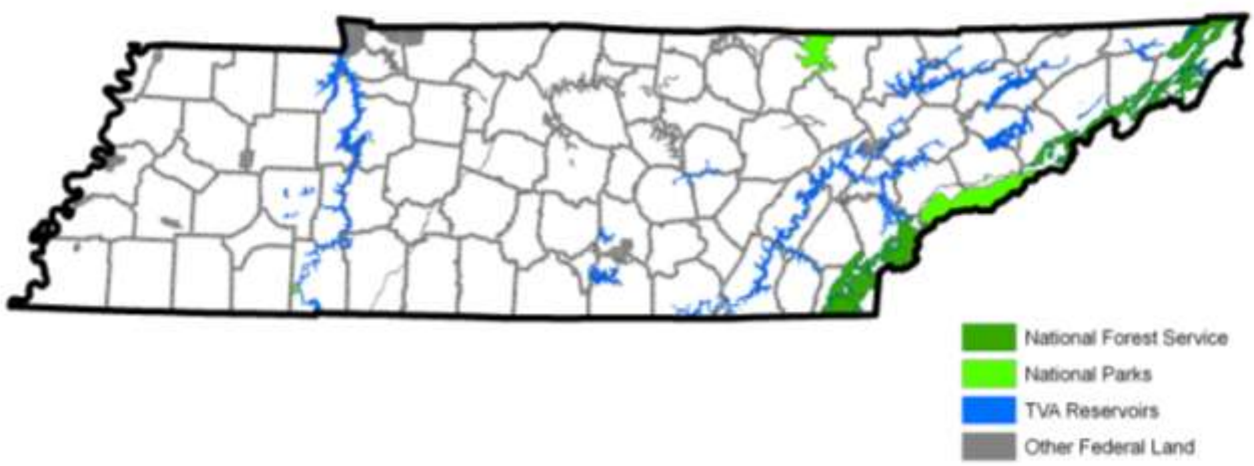
FIELD NAME	COUNTY NAME	TYPES	FIELD NAME	COUNTY NAME	TYPES
ALGOOD	*PUTNAM*	O	DEER LODGE NORTH	*MORGAN*	N
ALLRED	*OVERTON*	O	DIFFICULT	*SMITH*	N
ALTAMONT	*GRUNDY*	N	DODSON CHAPEL	*OVERTON*	N
ARCOTT SCHOOL	*CLAY*	O	DOUGLAS BRANCH	*MORGAN*	ON
ASHBURN CREEK	*CLAY*	O	DOUGLAS BRANCH EAST	*MORGAN*	O
ASHBURN CREEK SOUTH	*OVERTON*	ON	DREW BRANCH	*CAMPBELL*	O
BARREN PLAINS	*ROBERTSON*	ON	DRY CREEK	*CLAY*	O
BEATY	*FENTRESS*	O	EAGLE CREEK	*OVERTON*	O
BENDIX SPUR	*SCOTT*	ON	FAULKNER SPRINGS	*WARREN*	N
BIG BRANCH	*FENTRESS*	N	FAYETTEVILLE	*LINCOLN*	N
BIG EAGLE CREEK	*OVERTON*	ON	FINDLEY NE	*WHITE*	N
BLACK HOLLOW	*OVERTON*	O	FLAT CREEK NE	*OVERTON*	O
BOATLAND	*FENTRESS*	O	FLATT CREEK	*OVERTON*	ON
BOATLAND NE	*FENTRESS*	N	FORBUS	*FENTRESS & PICKET*	O
BOONE CAMP	*MORGAN*	ON	FOX SPRINGS	*CLAY*	O
BRICEVILLE	*ANDERSON*	O	FRANKFORT NE	*MORGAN*	ON
BROKEN LEG	*OVERTON*	O	FROG POND	*MACON*	N
BROWN POND	*SCOTT*	ON	GATEWOOD SW	*MORGAN*	ON
BUCKLICK	*MORGAN*	O	GATEWOOD-STOWERS	*MORGAN*	ON
BUFFALO COVE	*FENTRESS*	O	GEORGE WEST BRANCH	*SCOTT*	N
BURCHETT HOLLOW	*CLAY & OVERTON*	O	GLADES EAST	*MORGAN*	ON
BURRVILLE	*MORGAN*	ONA	GLENMARY	*SCOTT*	ON
BURRVILLE EAST	*MORGAN*	O	GLENMARY SE	*SCOTT*	O
CAPITOL HILL	*SCOTT*	ON	GLENOBEY	*FENTRESS*	ON
CARVER BRANCH	*SMITH*	O	GOOD HOPE	*OVERTON*	ON
CARYVILLE	*CAMPBELL*	OA	GOOD PASTURE BEND	*CLAY*	O
CECIL HOLLOW	*SCOTT*	ON	GRAVE HILL	*SCOTT*	O
CELINA	*CLAY*	O	GRAVE HILL NORTH	*SCOTT*	O
CELINA NORTH	*MORGAN*	O	GREEN POND	*OVERTON*	N
CHANEY GAP	*MORGAN*	O	GREENWOOD SOUTH	*JACKSON*	O
CLARKRANGE	*FENTRESS*	O	GRIMSLEY NORTH	*FENTRESS*	O
CLIFTY DOME	*MACON*	N	GROCE	*PICKETT*	O
COAL HILL	*SCOTT*	ON	GRUETLI	*GRUNDY*	N
COALMONT	*GRUNDY*	N	GUM BRANCH	*MORGAN & SCOTT*	ONA
COLLINS RIVER	*WARREN*	ON	HANGING LIMB	*OVERTON*	N
COOKEVILLE	*PUTNAM*	N	HARPETH VALLEY	*DICKSON*	N
COON HOLLOW	*MORGAN*	ON	HELENWOOD WEST	*SCOTT*	ON
COON HOLLOW NE	*MORGAN*	N	HENEGER	*WARREN*	N
CROOKED BRANCH	*FENTRESS*	N	HICKORY CREEK	*COFFEE*	N
DAYS CHAPEL	*CLAIBORNE*	OA	HIGGENBOTTOM BEND	*WARREN*	N
DEER LODGE	*MORGAN*	O	HIGH POINT	*SCOTT*	O

FIELD NAME	COUNTY NAME	TYPES	FIELD NAME	COUNTY NAME	TYPES
HONEY CREEK SOUTH	*FENTRESS & SCOTT*	ONA	MILL CREEK	*CLAY*	O
HUNTSVILLE	*SCOTT*	ON	MILLER MOUNTAIN	*OVERTON*	ON
HURRICANE CREEK	*FENTRESS*	ON	MITCHELL	*SUMNER*	O
HIGH POINT SOUTH	*SCOTT*	O	MITCHELL CREEK	*CLAY*	O
HILHAM	*OVERTON*	N	MITCHELL CREEK SE	*OVERTON*	O
HIWASSEE	*FENTRESS*	N	MOODYVILLE EAST	*PICKETT*	O
INDEPENDENCE SCHOOL	*OVERTON*	ON	NEELEY CREEK	*CLAY*	O
INDIAN CREEK	*MORGAN*	OA	NEW HAVEN	*SCOTT*	N
INDIAN CREEK SE	*MORGAN*	O	NEWCOMB	*CAMPBELL*	N
IRONS CREEK	*CLAY*	O	NIGGS CREEK	*SCOTT*	N
JACK BRANCH	*OVERTON*	O	NOAH FORK	*COFFEE*	O
JAMESTOWN NE	*FENTRESS*	N	NORTH CREEK	*CUMBERLAND*	ON
JAMESTOWN SE	*FENTRESS*	O	OAK GROVE	*OVERTON*	OA
JOHN HALL FLATS	*SCOTT*	ON	PALL MALL NORTH	*FENTRESS*	O
JONES CREEK	*DICKSON*	O	PARKER-ETTER	*PICKETT*	ON
JOUETTE CREEK	*PICKETT*	O	PERKINS HOLLOW	*CAMPBELL*	O
JOUETTE CREEK EAST	*PICKETT*	O	PETERMAN BEND	*CLAY*	O
KETTLE CREEK	*CLAY*	O	PETERS BRIDGE	*FENTRESS*	O
KHOTAN	*ANDERSON*	OA	PILOT MOUNTAIN	*MORGAN*	ON
LEWALLEN C	*SCOTT*	N	PINE BRANCH SW	*CLAY*	O
LIBERTY	*MACON*	N	PINE GROVE	*MORGAN*	N
LIBERTY CHURCH	*OVERTON*	N	PLEASANT RIDGE	*MORGAN*	ON
LICK BRANCH	*SCOTT*	ON	PLEASANT SHADE	*SMITH*	N
LILLYDALE	*CLAY & PICKETT*	O	POPLAR COVE	*FENTRESS*	O
LITTLE CLEAR CREEK	*MORGAN*	ON	PREVIT BRANCH	*SCOTT*	O
LITTLE CRAB	*FENTRESS*	O	PUNCHEONCAMP	*SCOTT*	O
LITTLE PROCTOR	*CLAY*	O	RED HILL	*FENTRESS*	O
LIVINGSTON EAST	*OVERTON*	O	RIVER JUNCTION	*SCOTT*	N
LOCK BRANCH	*JACKSON*	O	RIVERTON	*FENTRESS*	O
LONG FORK	*SCOTT*	N	ROBBINS	*SCOTT*	ON
LONG RIDGE	*JACKSON*	O	ROSLIN SOUTH	*FENTRESS & MORGAN*	N
LOVE LADY NW	*PICKETT*	O	RUGBY	*FENTRESS, MORGAN, & SCOTT*	ON
LOW GAP SOUTH	*SCOTT*	ON	RUSSELL FORK	*CAMPBELL*	O
LOW GAP-REUBEN HOLLOW	*SCOTT*	OA	RUSSELL RIDGE	*PICKETT*	O
MANSON SCHOOL	*FENTRESS*	ON	SHIRLEY	*FENTRESS & MORGAN*	N
MARTIN BRANCH	*CANNON*	O	SHEPHERD BRANCH	*FENTRESS*	ON
MCKINNEY	*CAMPBELL*	O	SHILOH	*OVERTON*	ON
MILE ONE	*SCOTT*	O	SHUG MOUNTAIN	*SCOTT*	O

FIELD NAME	COUNTY NAME	TYPES	FIELD NAME	COUNTY NAME	TYPES
SILVER PINE	*FENTRESS*	ON	TACKETT CREEK	*CLAIBORNE*	O
SMITHLAND	*LINCOLN*	N	TALLMAN FORD	*MACON*	
SPARTA	*WHITE*	N	TINSLEYS BOTTOM	*CLAY & JACKSON*	O
SPRING CREEK	*OVERTON*	O	TOWN CREEK	*WARREN*	O
SPURRIER	*PICKETT*	O	TRAVISVILLE	*PICKETT*	O
ST JOHN	*CLAY*	O	TURKEY CREEK	*CLAY*	O
STANLEY JUNCTION	*SCOTT*	ON	UNION HILL	*MORGAN*	ON
STAR POINT	*PICKETT*	N	UNION HILL SW	*MORGAN*	ON
STATIC	*PICKETT*	O	VANS BRANCH	*PICKETT*	O
STILLHOUSE CREEK	*CLAY*	O	VERDUN	*SCOTT*	N
STOCKTON	*FENTRESS*	O	WALNUT GROVE	*WHITE*	N
STOCKTON SW	*FENTRESS*	ON	WILLIAMS CREEK	*SCOTT*	O
SUGAR GROVE	*SUMNER*	O	WILLOW GROVE	*CLAY*	O
SUNBRIGHT	*MORGAN*	ON	WINONA	*SCOTT*	ON
SUNBRIGHT CENTRAL	*MORGAN*	ON	WIRMINGHAM	*OVERTON*	O
SWAN CREEK	*HANCOCK*	ON	WOLF RIVER EAST	*FENTRESS*	O
SYCAMORE VALLEY	*MACON*	N	YELLOWCLIFF	*SCOTT*	N

ONA = Oil, non-associated gas, and associated dissolved gas are present.
ON = Oil and non-associated gas present; associated-dissolved gas absent.
N = Non-associated gas present; oil and associated-dissolved gas absent.
O = Oil present; non-associated gas and associated-dissolved gas absent.
OA = Oil and associated-dissolved gas present; non-associated gas absent.
Source: Tennessee State Oil and Gas Board 2007

Figure 3: Federal Surface in Tennessee



3.0 SUMMARY OF USGS PLAY DESCRIPTIONS FOR THE STATE OF TENNESSEE

The most recent oil and gas assessment for the Cincinnati Arch (last updated in 1995), the Illinois Basin (updated in 2007) and the Appalachian Basin (updated in 2002) provinces updates were completed by the USGS. In each of those assessments for these provinces a number of conventional and unconventional oil and gas plays were assessed which might have an impact on oil and gas exploration and production activity in Tennessee.

The following is a summary of those province assessments and includes only very general information relative to the play. The primary source materials for this summary presentation are the geologic reports for each of the province assessments as published by the USGS and are available at the USGS National Oil and Gas Assessment website (http://energy.cr.usgs.gov/oilgas/noga/).

3.1 Illinois Basin in Tennessee

The assessment of the Illinois Basin province by the USGS recognized three total petroleum systems (TPS) that included parts of north-western Tennessee (USGS, 2007). The total petroleum systems included: a Precambrian to Cambrian TPS, Ordovician Ancell/Maquoketa TPS, and a Devonian to Mississippian New Albany TPS.

3.1.1 Precambrian to Cambrian TPS

The Precambrian to Cambrian TPS is comprised of three assessment units: the Precambrian to Cambrian Rift-Fill AU, the Cambrian Mount Simon to Eau Claire AU, and the Cambrian to Ordovician Knox Group AU (USGS, 2007). The assessment units of the Precambrian to Cambrian TPS were not assessed quantitatively by the USGS and therefore the USGS did not provide numerical values for Total Undiscovered Resources. The USGS fact sheet for the Illinois Basin is provided in Appendix B.

3.1.2 Ordovician Ancell/Maquoketa TPS

The Ordovician Ancell/Maquoketa TPS is comprised of two assessments units; Ordovician Dutchtown to Galena AU, and Ordovician St. Peter/Everton AU. The USGS did not quantitatively assess the Ordovician St. Peter/Everton AU therefore the USGS did not provide numerical values for Total Undiscovered Resources. The USGS fact sheet for the Illinois Basin is provided in Appendix B.

3.1.3 Devonian to Mississippian TPS

The Devonian to Mississippian TPS is comprised of eleven assessment units: Pennsylvanian Sandstones AU, Upper Mississippian Sandstones AU, Lower Mississippian Carbonates AU, Lower Mississippian Borden AU, Middle Devonian Carbonates AU, Middle Devonian Dutch Creek Sandstone AU, Lover Devonian Carbonates AU, Upper Silurian Carbonates (Reef) AU, Upper Silurian Calcareous Siltstones AU, Lower Silurian Carbonates AU, and Cambrian to Ordovician Carbonates Cumberland Saddle AU. The quantitative assessment values developed by the USGS are provided in Appendix B.

3.2 Cincinnati Arch Province in Tennessee

The assessment of the Cincinnati Arch province by the USGS recognized four conventional plays and one unconventional play that included parts of central and north-central Tennessee located on the Cincinnati Arch (Ryder, 1996a). Those conventional plays included: a Cambrian and Lower Ordovician Carbonate Play, Middle and Upper Ordovician Carbonate Play, a Silurian and Devonian Carbonate play, and a Mississippian Carbonate Play. The unconventional play recognized was a Devonian Black Shale Gas Play.

3.2.1 Cambrian and Lower Ordovician Carbonate Play

The Cambrian and Lower Ordovician Carbonate Play is an oil play with associated gas trapped in a karstic dolomite by Knox unconformities and small anticlines (Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.2.2 Middle and Upper Ordovician Carbonate Play

The Middle and Upper Ordovician Carbonate Play is an oil play with associated gas trapped in dolomite and bioclastic limestones by stratigraphic traps, fracture zones and small anticlines (Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.2.3 Silurian and Devonian Carbonate Play

The Silurian and Devonian Carbonate Play is an oil and gas play trapped in Silurian and Devonian carbonates by truncations, facies-change, and combination traps (Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas, as previous development has exhausted larger fields in the play area. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.2.4 Mississippian Carbonate Play

The Mississippian Carbonate Play is an oil and gas play trapped in Mississippian bioherms by facies-change, and combination traps (Ryder, 1996a). The Cincinnati Arch area is predicted to have no potential for production around 1 MMBO and 6 BCF of gas, as previous development has exhausted larger fields in the play area. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.2.5 Devonian Black Shale Gas Play (Chattanooga Shale)

The Devonian Black Shale Gas Play is an unconventional continuous-Type Play in which gas has been generated and trapped in fractured shales of the Upper Devonian Chattanooga and New Albany Shales (Ryder and Hatch, 1996). The Cincinnati Arch area is predicted in the 1995 assessment to have the potential for small amounts of undiscovered gas, this data may be out of date as test wells have been developed in the shale and technology has advanced to facilitate production of this gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3 Appalachian Basin Province in Tennessee

The assessment of the Appalachian Basin province by the USGS recognized four conventional plays and one unconventional play that included parts of eastern and east –central Tennessee located in the Appalachian Basin. The conventional plays included: a Upper Cambrian, Ordovician and Lower / Middle Silurian Thrust Belt Play, Beekmantown/Knox Carbonate Oil/Gas Play, a Trenton/Black River Carbonate Oil/Gas, and a Mississippian and Pennsylvanian Sandstone/Carbonate Play. The unconventional play listed as being included in a very small part of the Tennessee portion of the Appalachian Basin Province is a Devonian Black Shale Gas Play.

3.3.1 Upper Cambrian, Ordovician and Lower/Middle Silurian Thrust Belt Play

The Upper Cambrian, Ordovician and Lower/Middle Silurian Thrust Belt Play is a conventional gas trap play reservoired in Dolomites, limestones, and sandstones by large anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for several undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.2 Beekmantown/Knox Carbonate Oil/Gas Play

The Beekmantown/Knox Carbonate Oil and Gas Play is a conventional play with oil and gas in dolomite reservoirs trapped by truncations, paleotopographic highs, and low amplitude anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number l undiscovered oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.3 Trenton/Black River Carbonate Oil/Gas Play

The Trenton/Black River Carbonate Oil and Gas Play is a conventional play with the oil and gas in platform limestone reservoirs trapped by low amplitude anticlines, dolomitized fracture zones, and natural fractures (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number l undiscovered oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.4 Mississippian and Pennsylvanian Sandstone/Carbonate Play

The Mississippian and Pennsylvanian Sandstone/Carbonate Play is an ol and gas play reservoired in shallow-marine sandstone and shelf limestone trapped by facies-change stratigraphic, combination, unconformity and local anticlinal traps (Ryder, 1996b). The Appalachian Basin area has the potential for a small number oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.5 Devonian Black Shale Gas Play (Chattanooga Shale)

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4.0 PAST AND PRESENT OIL AND GAS EXPLORATION ACTIVITY

4.1 Geophysical and Geochemical Surveys

No extensive geophysical or geochemical surveys have been undertaken in Tennessee in recent years other than individual seismic operations targeted at specific exploration targets generated off of surface or subsurface geologic studies (Hoyal, M.L., 2008).

4.2 Exploratory Drilling and Success Rates

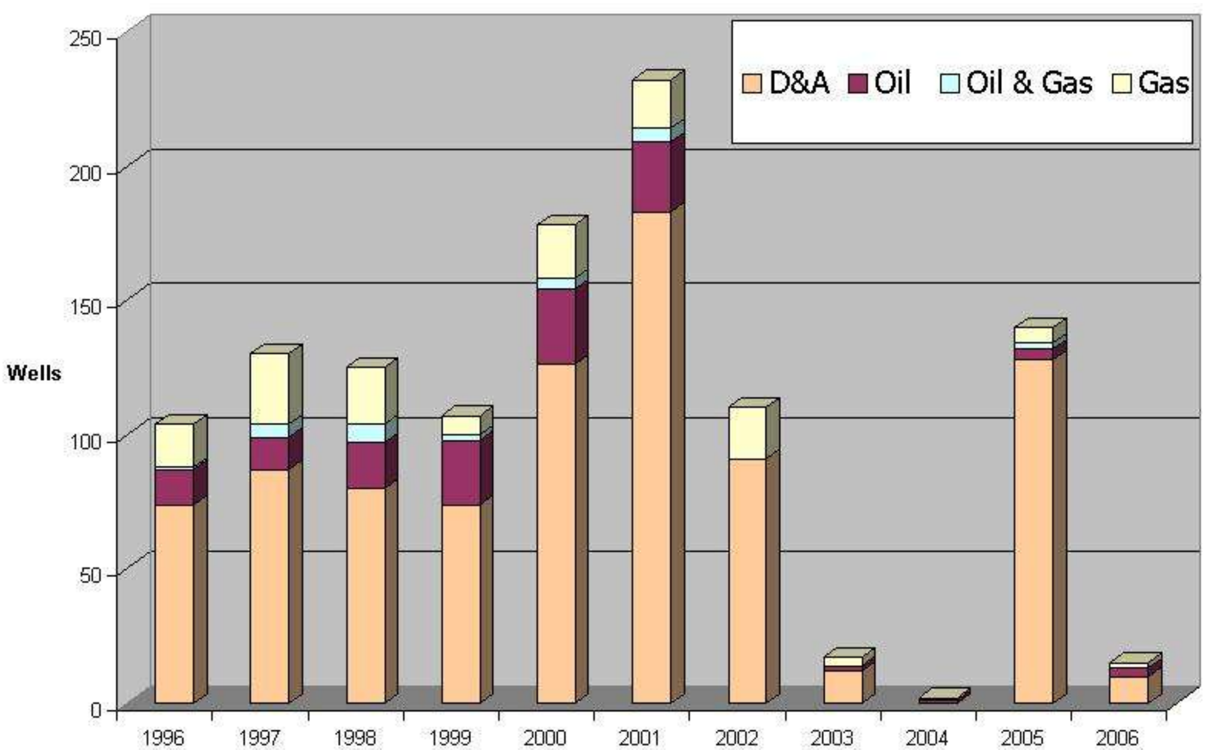
The success rates are reported from Tennessee Oil and Gas Association annual report. The average success rate over the last ten years for new field wildcat and outpost wells is approximately 33%. Annual success rates have varied from a 100% success rate in 2004 when two wells were drilled to 9% in 2005 when 140 wells were drilled. Figure 4 presents the total number of wells drilled per year by type, including dry wells (D&A), Oil, Oil & Gas, and Gas wells as reported by the Tennessee Department of Environment and Conservation's Division of Geology. Figure 5 shows where recent permits have been issued by county and figure 6 show past production by county.

4.3 New Field and Reservoirs

4.3.1 Chattanooga Shale Play (Devonian):

The Chattanooga Shale is a Devonian aged shale of the Onondgaga Group. Drilling has been focused in the following five counties in north central Tennessee; Anderson, Campbell, Claiborne, Morgan and Scott Counties. Drilling of wells in this play have increased in recent years as the economics of this gas play have become more profitable.

Figure 4: Tennessee Well Completion Records by Well Type



Source: TDEC, 2006

Figure 5: Permits Issued from 2001 - 2005

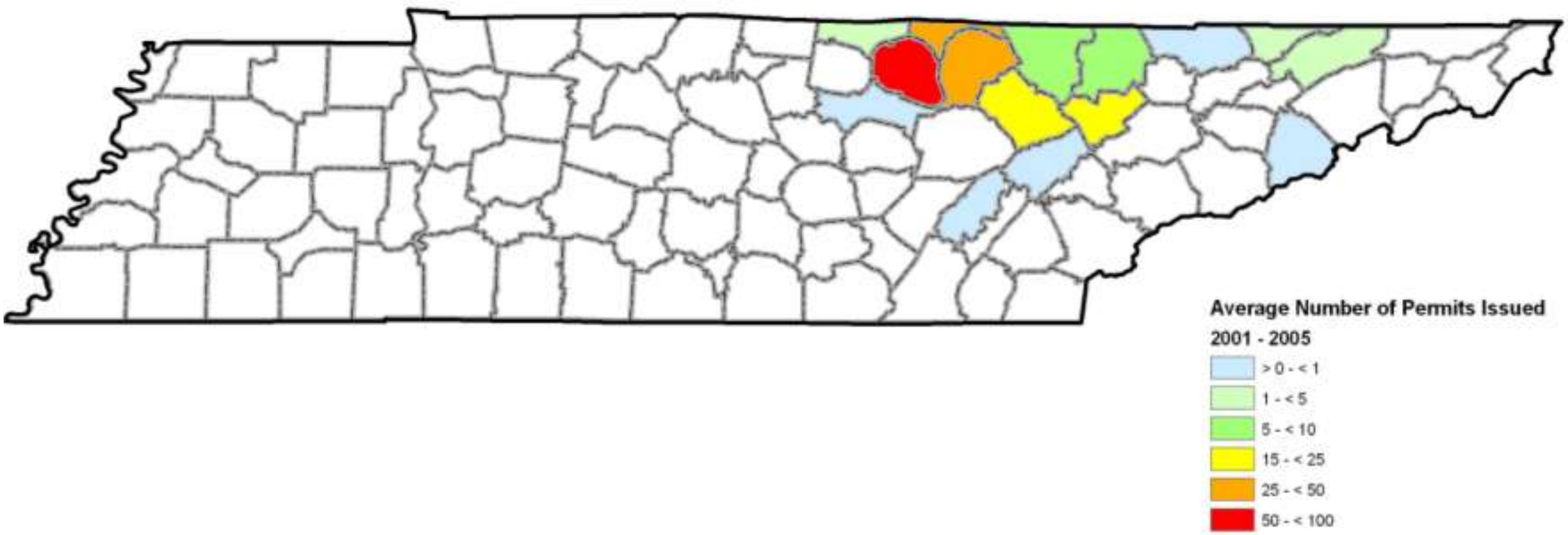
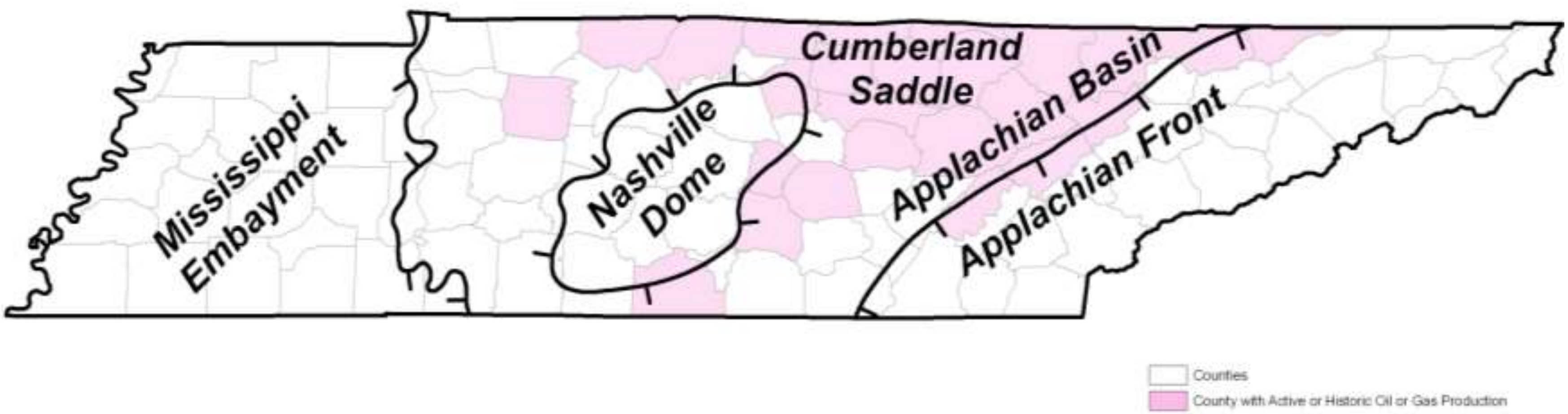


Figure 6: Counties with Active or Historic Production



5.0 OIL AND GAS ACTIVITY IN TENNESSEE

This section deals with the current status of oil and gas activity in Tennessee based on information provided by both public and private sources. Information includes; leasing activity, well spacing requirements, drilling permits by county, Drilling practices, production statistics, oil and gas characteristics, oil and gas prices, operational costs (drilling and completion), conflicts with other mineral development, and gas storage fields.

5.1 Leasing Activity

Leasing activity in Tennessee is on-going in the primary area of oil and gas operations which is located generally in north-central Tennessee.

While leasing costs vary across this area they tend to range from $10.00 to $20.00 per acre, although lease prices in the order of $1,000 per acre have been reported for acreage offsetting established production with good production rates (Goodwin, W., 2008).

5.2 Well Spacing Requirements

Well spacing requirements for oil and gas wells drilled in Tennessee are subject to the rules and regulations of the Tennessee Oil and Gas Board (TOGB). Spacing requirements fall under those set by specific field rules issued by the Board upon notice and hearing and those covered under the general rules and regulations of TOGB.

The specific TOGB regulation which deals with spacing requirements not covered under established field rules is Rule 1040-2-4. The complete text of this rule is attached in Appendix B. While there are certain exceptions available under specific conditions Table 3 shown below summarizes the standard requirements for unit size, spacing and setbacks as outlined in Rule 1040-2-4.

Table 3: Summary of Well Spacing Requirements Tennessee Oil and Gas Board Rule 1040-2-4

Well Type	Well Depth (Formation)	Unit Size	Minimum Distance to Nearest Well in Same Pool	Setback to Nearest Property or Unit Line
Oil & Gas	< 1,000 Ft.	10 Acres	No closer than 660 Ft	330 Ft.
Oil & Gas	>1,000 <2,000 Ft. (or B/ Chattanooga)	20 Acres	No closer than 660 Ft	330 Ft.
Oil	> 2,000 Ft.	40 Acres	No closer than 660 Ft	330 Ft.
Gas	2,000 – 5,000 Ft.	40 Acres	No closer than 660 Ft	330 Ft.
Gas	> 5,000 Ft.	160 Acres	No closer than 660 Ft	330 Ft.

5.3 Drilling and Completion Statistics

5.3.1 Drilling Practices

The vast majority of drilling operations in Tennessee are standard vertical tests drilled with air rotary equipment that vary in depth from 2000 feet to 6,000 feet. This range of is based on the drill site's elevation and general position on regional structural features (Cumberland Saddle, Appalachian Basin or Appalachian Thrust) with the average well depth in the order of 2,000 feet (Burton , M., 2008, Goodwin, W., 2008 and Hoyal, M.L., 2008). The deepest vertical test drilled to date reached a depth of approximately 9,500 feet and as of late 2007 only one horizontal drilling operation for oil and gas has been conducted in Tennessee (Burton, M., 2008).

5.3.2 Drilling and Completion Costs

Drilling costs and well completion costs vary by depth, reservoir, and completion practice for the specific reservoir to be produced. Very generalized costs associated with gas production areas in the state suggest that well costs are in the order of approximately $70,000 for drilling costs and $30,000 to $100,000 for completion costs (Goodwin, W. 2008).

5.4 Production Statistics

5.4.1 Crude Oil

Annual crude oil production data for Tennessee for the period 1996 through 2006 is graphically displayed with pricing information in Figure 7. As can be seen from a review of this graph the annual crude oil production rate at the beginning of this period stood at 380,750 barrels of oil per year. That rate has subsequently declined to 261,575 barrels / year in 2006. This production decline trend is not expected to be significantly altered as most of the oil production located in the north-central part of the state is categorized as very mature production that is dependent on infill and trend development drilling as well as secondary recovery operations for generally sustaining this rate (Burton , M., 2008 and Hoyal, M.L., 2008).

5.4.2 Natural Gas

Annual natural gas production in Tennessee for the years 1996 through 2006 is graphically displayed with pricing information in Figure 8. Unlike oil production, natural gas production has generally been on the rise since 2000 when annual production stood at 1,154,197 Mcf of gas for the year. Since that year annual production has generally risen each year through which there is data available with 2006 annual production reaching 2,662,584 Mcf or a 130.6% increase in production over that which was reported in 2000. This increase in production is undoubtedly because of the increase in wellhead gas prices over that period coupled with the increase in drilling operations and discoveries in Monteagle Limestone, Fort Payne, Stones River, and Knox reservoirs as well as the Chattanooga Shale gas interval.

5.5 Oil and Natural Gas Characteristics

5.5.1 Natural Gas

Natural gas produced from oil and gas fields in north-central Tennessee although limited in volume can be either a wet or dry gas depending on the individual reservoir.

The natural gas from the fields has as a general average a heating value of 1600 Btu per cubic foot with little or no problems with CO2 or nitrogen content being reported (Goodwin, W. 2008).

5.5.2 Crude Oil

Crude oil produced in Tennessee varies in color and in odor by area and by individual reservoir; however the overall quality of the oil does not appreciably vary across geographic regions or reservoirs and is considered to be consistent with

Figure 7: Tennessee Crude Oil Production 1996-2006

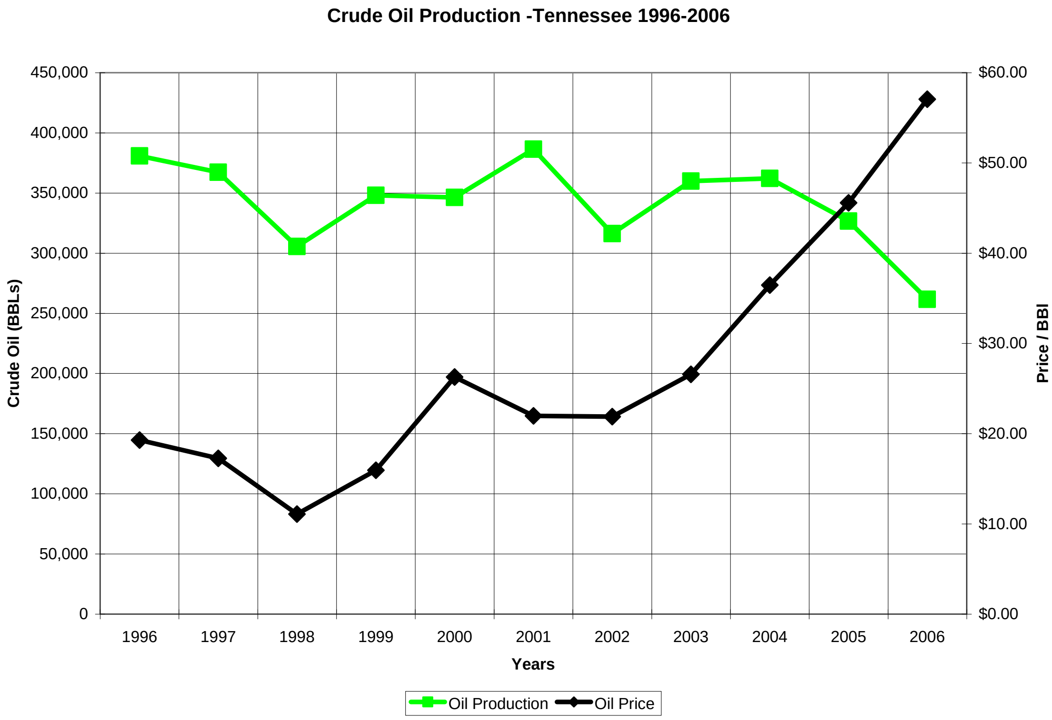
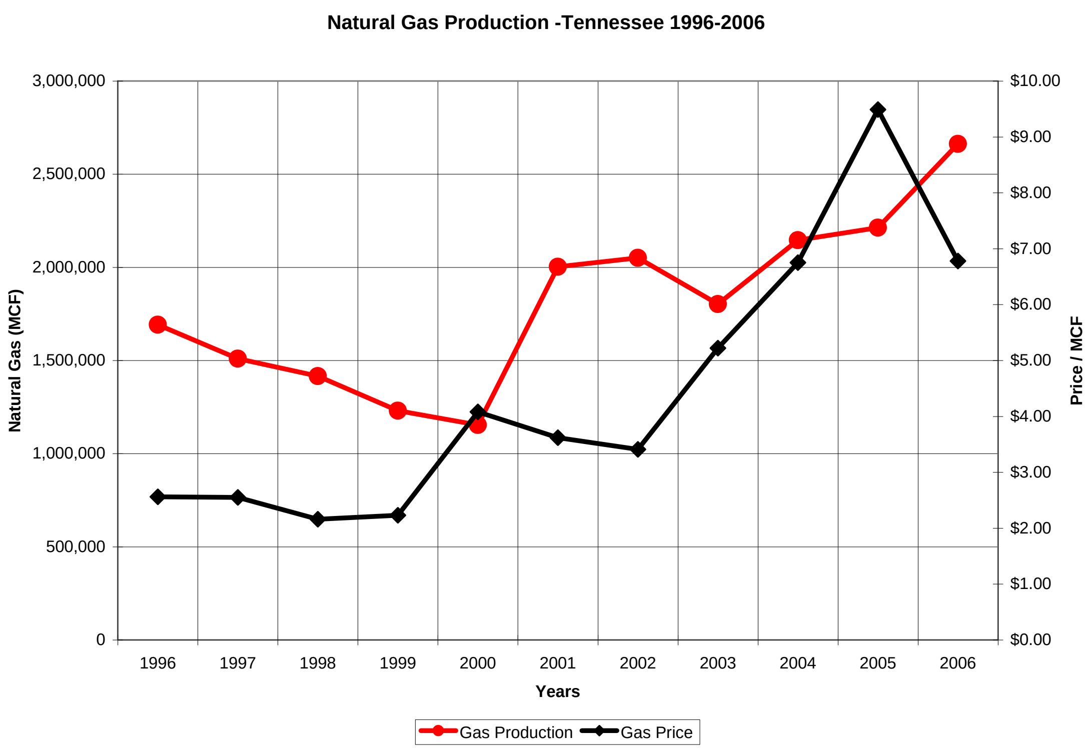


Figure 8: Tennessee Natural Gas Production 1996-2006



2008). Crude oils consistent with "Pennsylvania grade crude" oil are thermally stable and generally have a high viscosity index. Only very limited specific information as to the gravity of crude oil by reservoir and area is available. That data is included in Table 4 shown below.

5.6 Oil and Gas Prices

Average annual crude oil prices for Tennessee based on data provided by the Tennessee Division of Geology (TDOG) during the period from 1996 through 2006, as seen in Figure 7 referenced above in the section concerning production trends, show that crude oil prices have risen from 19.28 $/ bbl to 57.06 $/bbl during that timeframe (Zurawski, Ronald P., 2007). The September 2007 posting of the average crude oil purchase price reported to EIA shows wellhead crude prices at 73.62 $/bbl for the PADD II area (Petroleum Administration Defense District) of which Tennessee is a part (EIA, website). Pricing for crude oil in Tennessee in early 2008 was approximately $14.00 below that being posted on the NYMEX exchange.

As can be seen from a review of the graph in Figure 8 the annual average wellhead price for Tennessee natural gas reported by the TDOG has steadily risen from 4.08 $/Mcf in 2000 to 6.78 $/Mcf in 2006 (Zurawski, Ronald P., 2007). While annualized data for 2007 is not as of yet available, current wellhead prices for local utility use including transportation and compression costs are estimated to be in the order of 6.54 $/Mcf based on the current (2/2008) NYMEX posting of 7.25 $/mmBtu (Goodwin, W., 2008).

Both crude oil and natural gas prices are generally expected to remain strong for the foreseeable future.

5.7 Conflicts with Other Mineral Development

Mineral development in Tennessee is extensive and involves in addition to oil and gas a number of different mineral resources. Mineral resources produced in Tennessee fall into six broad categories and include: Mineral fuels, Clay, Stone, Sand and Gravel, Shale, and Metals. Information contain in this mineral summary is from the USGS 2004 Mineral Yearbook and from the Tennessee Division of Geology.

Mineral Fuels

The Mineral fuels produced in Tennessee include oil and natural gas and coal,

Tennessee's coal production is small by comparison to other producing states but generally of high quality. Coal production is a bituminous grade coal from the Cumberland Plateau and Cumberland Mountains areas.

Clay

Clay mineral production includes "Ball clay", kaolin, and fuller's earth (montmorillonite).

Crushed Stone and Dimension Stone

The most recent data for the State (2004) indicates that the crushed stone industry operated 157 quarries in Tennessee. Production of crushed stone is widespread through out the state with production located in 66 counties. Dimension stone production includes both dimension marble and sandstone.

Sand and Gravel

Sand and gravel for construction and industrial purposes was produced at 94 sites in 30 counties across the State.

Shale

A total of 9 shale mining operations were active in Tennessee in 2004 with the material from these operations going to the production of construction bricks.

Metals

Zinc production has in the past been an important metal mining sector in Tennessee. The most recent mineral industry data however indicates that zinc mining and processing operations have been suspended in all of Tennessee's zinc mines.

Table 4: Crude Oil Data for Reservoirs in Tennessee

Reservoir	County	Crude Oil Gravity (API)
Pennsylvanian	unknown	32.0
Mounteagle	Morgan	34.4
Mounteagle	Scott	35.2
Mounteagle	Cumberland	36.7
Fort Payne	Morgan	30.9
Fort Payne	Scott	31.8 – 36.0
Trenton	Fentress	35.6
Trenton	Overton	39.1
Stones River	Overton	39.4

Source: (Hoyal, M.L., 2008)

Based on interviews with personnel from the TDOG there appears to be little or no conflicts between oil and gas operations and on-going mineral development (Burton , M., 2008, Goodwin, W., 2008) and Hoyal, M.L., 2008).

5.8 Gas Storage Fields

EIA gas storage data for 2006 indicates that there is one active gas storage field operating in the State of Tennessee (EIA website, Natural Gas Storage, Form EIA-191 Data, 2007). That field, the Lick Branch Unit (LBU) is a depleted gas field located in Morgan and Scott counties that has been converted to gas storage operations. The EIA data indicates that the operator of the field is Cambridge Resources Inc. The reservoir is in the Fort Payne section. The reported total field capacity and authorized maximum daily delivery is 1,200,000 Mcf and 20,000 Mcf respectively. The LBU includes 14 wells used for injection and withdrawal, 3 wells for observation and 10 wells for oil production (Forexco Inc., website, LBU Operations, 2008).

6.0 OIL AND GAS OCCURRENCE POTENTIAL

6.1 Existing oil and gas production

Oil and gas has been produced in Tennessee for many years. Twenty-five counties have active or historic production of oil or natural gas. There are nine counties with active natural gas production in 2006. There are twelve counties with active oil production in 2006. Natural gas is distributed very differently from oil and the occurrence of two will be discussed separately. Between 2001 and 2005 there were 15 counties in which drilling permits for oil or natural gas wells were issued.

Drilling activity records are maintained by the state of Tennessee Division of Geology. Drilling activity as presented in Figure 4 is composed of active producing wells and dry and abandoned wells; undrilled permits and shut-in wells are not considered since their actual disposition is as yet unknown. There has only been one horizontal well attempted in Tennessee.

Oil and Natural gas production statistics for the year 2005 by county are presented in Table 5. Eight counties have combined oil and gas production.

Table 5: Crude Oil and Natural Gas Production by County in Tennessee for 2005

County	Oil (bbls)	County	Gas (mcf)
Overton	154,507	Anderson	813,297
Morgan	51,814	Morgan	401,522
Scott	35,191	Hancock	291,477
Fentress	25,669	Claiborne	231,678
Pickett	21,786	Scott	219,858
Claiborne	13,917	Campbell	201,895
Campbell	9,044	Fentress	42,899
Anderson	8,427	Overton	9,865
Hancock	4,946	Roane	1,027
Clay	785		
Cumberland	224		
Franklin	168		

7.0 OIL AND GAS DEVELOPMENT POTENTIAL

7.1 Relative Oil and Gas Development Potential

Counties are ranked in the previous section according to current production and drilling activity. Most of these counties have seen decreased oil and gas activity since approximately 2001, for the last two years there has been a resurgence which may result from increases in crude oil and natural gas prices. It is expected that the current historical high price for oil (between $90 and $100 per bbl) will continue into the future or increase to some extent. If, on the other hand, crude oil and natural gas prices were to slip downward, drilling rates would likely be reduced.

The increase in drilling is also the result of increased interest in the shallow gas plays of the Devonian Chattanooga Shale. Successful development of this play in neighboring states has resulted in an increased interest in Tennessee.

7.2 Drilling Development

Drilling rate fluctuations have been seen over the last ten years with the number of wells drilled over the last 5 years declining in comparison to the previous five years. The average number of oil wells completed has declined from 12 per year to 2 per year, the average number of natural gas wells has declined from 13 per year to 6 per year. The percentage of dry holes has remained relatively constant with the 10 year average at 67% and the 5 year average at 65%.

Drilling activity forecast is shown in Table 6 and Table 7; the forecast value for annual wells during the next ten years is taken from drilling activity in 2006 or the average from 1996 to 2006. The number of wells shown in Table 6 and Table 7 is split between general federal ownership, US Forest Service, and state plus fee land on the basis of the percentage of ownership in the county. Since we do not know where in each county future drilling will happen, we can assume a random distribution. Figures 9 and 10 depict the gas and oil rankings per county respectively.

Table 6: Ten-Year Forecast of Gas Wells in Tennessee

COUNTY	Gas Rank	Federal acres	Total Acres	2006 Wells	2001-2006 wells	10-year Forecast Gas Wells[1]	Forecast Federal Gas Wells		% Fed Acreage
							BLM	USFS	
ANDERSON	High	14,137	342,719	ND	ND	15	1	0	6.46%
MORGAN	High	6,183	331,371	ND	ND	15	0	0	1.87%
HANCOCK	Medium	0	139,170	ND	ND	10	0	0	0.00%
CLAIBORNE	Medium	8,149	291,252	ND	ND	10	0	0	2.80%
SCOTT	Medium	58,901	218,724	ND	ND	10	2	0	17.20%
CAMPBELL	Medium	18,238	317,330	ND	ND	10	1	0	5.75%
FENTRESS	Low	28,031	316,357	ND	ND	5	1	0	8.86%
OVERTON	Low	156	278,524	ND	ND	5	0	0	0.06%
ROANE	Low	53,364	250,649	ND	ND	5	1	0	21.30%
Total				**2**	**49**	**85**	**6**	**0**	

1 - Forecasted gas wells represent all mineral owners, state, fee, and federal.
ND – Indicates no data was available for the individual counties only annual total data for the state was presented.

Table 7: Ten-Year Forecast of Oil Wells in Tennessee

COUNTY	Oil Rank	Federal acres	Total Acres	2006 Wells	2001-2006 wells	10-year Forecast Oil Wells[1]	Forecast Federal Oil Wells		% Fed Acreage
							BLM	USFS	
Overton	High	156	278,524	ND	ND	10	0	0	0.06%
Morgan	High	6,183	331,371	ND	ND	10	2	0	1.87%
Scott	Medium	58,901	218,724	ND	ND	5	1	0	17.20%
Fentress	Medium	28,031	316,357	ND	ND	5	0	0	8.86%
Pickett	Medium	15,076	114,796	ND	ND	5	1	0	13.1%
Claiborne	Medium	8,149	291,252	ND	ND	5	0	0	2.80%
Campbell	Low	18,238	317,330	ND	ND	3	0	0	5.75%
Anderson	Low	14,137	342,719	ND	ND	2	0	0	6.46%
Hancock	Low	0	139,170	ND	ND	3	0	0	0.00%
Clay	Low	19.477	164,971	ND	ND	2	0	0	11.8%
Cumberland	Low	0	437,521	ND	ND	3	0	0	0.00%
Franklin	Low	0	363,724	ND	ND	2	0	0	0.00%
Roane	Low	53,364	250,649	ND	ND	3	1	0	21.30%
Total				**3**	**43**	**58**	**5**	**0**	

1 - Forecasted gas wells represent all mineral owners, state, fee, and federal.
ND – Indicates no data was available for the individual counties only annual total data for the state was presented.

Figure 9: Forecasted Rank for Gas Exploration

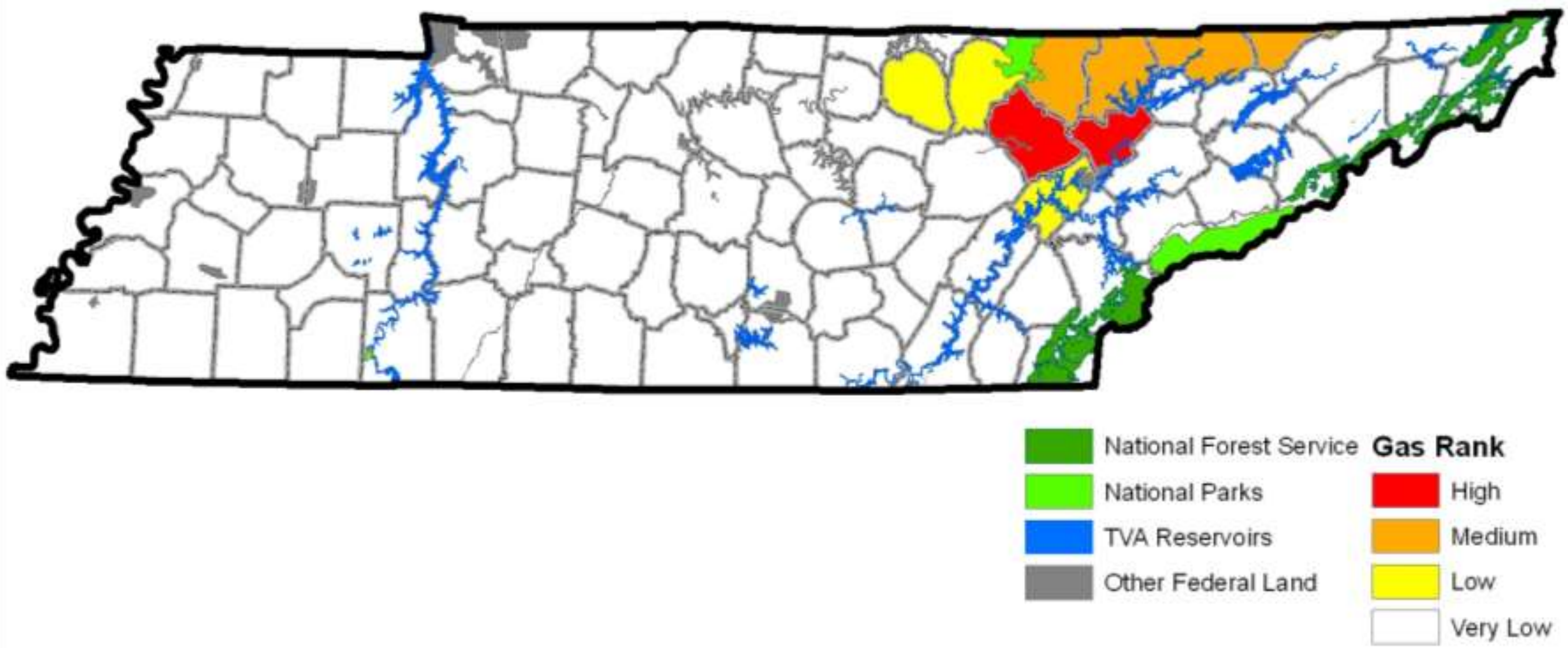
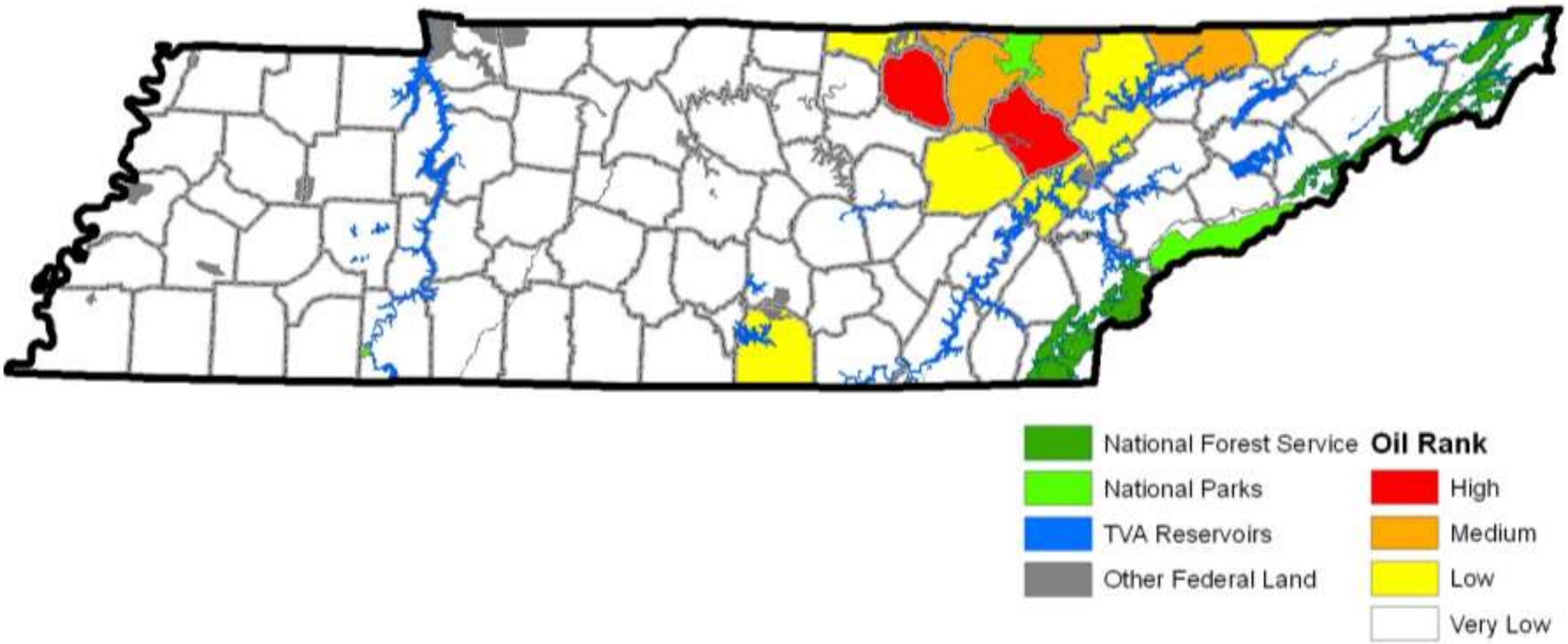


Figure 10: Forecasted Rank for Oil Exploration



8.0 REASONABLE FORESEEABLE DEVELOPMENT 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 (ACECs), Wilderness Study Areas (WSAs) and USFWS Wildlife Refuges. The RFD scenario contains projections for the number or wells and acres disturbed for these counties. This in no way is intended to imply that the BLM are making decisions about the Forest Service lands or the USFWS 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:

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

- Wells drilled to date were taken from the Tennessee Division of Geology annual reports.
- The number of wells drilled to date was statistically analyzed to calculate a median per year wells drilled per county.
- The data trends associated with the last 6 years (2001-2006) represents a more accurate estimate of future development trends than historical data, thus, it is weighted more heavily.
- The data trends from 1996 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 data trends for the complete historical record represent the least accurate estimate of future development trends and, thus, it was weighted the lightest.
- For each geographic/geologic boundary region and sub region, the calculated estimates for future development were summed to obtain a per year well count.
- Wellhead oil and gas prices are a driving force for well drilling and completion; current prices are historically high and have resulted in increased activity throughout the state. An estimate of activity for the future well development to into consideration this influence. The forecast assumes wellhead oil and gas prices will remain high and development over the next 10 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 county times the total number of producing wells anticipated to be developed in that boundary area.
- The average acreage figure (acres per well) for the resource area was used to estimate federal disturbed acres.
- The RFD projections have a 10-year life.
- The number of dry holes was determined based on historic analysis of dry holes in the geologic boundary areas.

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.

9.0 SURFACE DISTURBANCE DUE TO OIL AND GAS ACTIVITY ON ALL LANDS

9.1 Surface Disturbances

Estimates of the surface disturbances associated with the development of oil and gas on federal minerals within the State of Tennessee were determined from a variety of resources, including previous oil and gas environmental assessments, discussions with BLM and state oil and gas personnel, discussions with various operators, and document review.

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 oil and gas well (<2,000 feet deep) typically includes a well pad of 2.0 acres, 0.10 miles of gravel road and 0.55 miles of utility lines for a total construction disturbance area of approximately 4.8 acres. Deeper oil and gas wells (5,000 to 12,000 feet below surface) require a greater disturbance area to accommodate the larger amount of equipment necessary to complete drilling. Usually a 3.25 acre well pad, 0.075 miles of gravel road, and 0.475 miles of utility lines for a total of 6.7 disturbed acres during the construction phase. Horizontal wells are typically drilled using a larger well pad estimated at 3.5 acres. However, the total construction disturbance for a horizontal oil and gas well is estimated to be 6.9 acres. This estimate is greater than the disturbance from deep oil and gas wells because the surface disturbance required for construction of both utility and transportation lines will be somewhat more for horizontal wells. Tables 8, 9, and 10 present surface disturbance estimates for conventional shallow and deep oil and gas wells and horizontal wells along with their associated support facilities.

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 county 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, 9, and 10.

9.2 Site Construction

The shortest feasible route is chosen to minimize haulage distances and construction costs while considering environmental factors and the surface owner's wishes. The access roads are typically constructed using bulldozers and graders to connect the existing road or trail and the drill site. In some cases improvements such as cattle guards and culvert crossings are installed because of the terrain.

In the planning area the kind of drill rig and drilling depth varies and is determined by the geologic province and expected product from the well. The extent of surface disturbance necessary for construction depends on the terrain, depth of the well, drill rig size, circulating system, and safety standards. The depth of the drill test determines the size of the work area necessary, the need for all-weather roads, water requirements, and other needs. The terrain influences the construction problems and the amount of surface area to be disturbed. Reserve pit size may vary because of well depth, drill rig size, or circulating system.

Access roads to well sites usually consist of running surfaces 14 to 18 feet wide that are ditched on one or both sides. Many of the roads constructed will follow existing roads or trails. New roads might be necessary because existing roads are not at an acceptable standard. For example, a road may be too steep so that realignment is necessary.

TABLE 8
LEVEL OF DISTURBANCE FOR CONVENTIONAL SHALLOW 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 (300-foot by 300-foot pad during drilling and construction, 175-foot by 175-foot pad during operation)		2.07	2.07	0.70
Access Roads to Well Sites	Two-track (12-foot wide by 0.25 miles long)	0.36	N/A	N/A
	Graveled (20-foot wide by 0.10 miles long for construction and operation)	N/A	N/A	0.24
	Bladed (20-foot wide by 0.10 miles for construction and operation)	N/A	0.24	0.0
Utility Lines	Water lines (15-foot by 0.20 miles)	N/A	0.18	0.0
	Overhead Elec. (10-foot by 0.15 miles)	N/A	0.12	0.03
	Underground Elec. (15-foot by 0.20 miles)	N/A	0.36	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.1 miles)	N/A	0.18	0.045
	High Press. Gas or Crude Oil Gathering Line (20-foot by 0.25 miles)	NA	0.61	0.15
Processing Areas	Tank Battery (one 0.50-ac tank battery per 20 wells)	N/A	0.025	0.025
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 20 wells)	N/A	0.025	0.025
	Sales Compressor (2-ac pad for 150 wells)	N/A	0.01	0.01
	Sales Line (20-foot by 5 miles per 200 wells)	N/A	0.061	0.015
Produced Water Management	Produced Water pipeline (15-foot by 0.25 miles)	N/A	0.45	0.11
	Water plant/ Inj well (6 ac site per 20 wells)	N/A	0.3	0.3
Total Disturbance per Conventional Oil or Gas Well (acres)		**2.43**	**4.79**	**1.81**

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.

TABLE 9
LEVEL OF DISTURBANCE FOR CONVENTIONAL DEEP 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 (375-foot by 375-foot pad during drilling and construction, 200-foot by 200-foot pad during operation)		3.23	3.23	0.92
Access Roads to Well Sites	Two-track (12-foot wide by 0.5 miles long)	0.73	N/A	N/A
	Graveled (20-foot wide by 0.075 miles long for construction and operation)	N/A	N/A	0.18
	Bladed (20-foot wide by 0.075 miles for construction and operation)	N/A	0.18	N/A
Utility Lines	Water lines (12-foot by 0.20 miles)	N/A	0.29	0.0
	Overhead Elec. (10-foot by 0.075 miles)	N/A	0.09	0.023
	Underground Elec. (15-foot by 0.20 miles)	N/A	0.36	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.075 miles)	N/A	0.14	0.034
	High Press. Gas or Crude Oil Gathering Line (25-foot by 0.5 miles)	NA	1.21	0.30
Processing Areas	Tank Battery (one 0.50-ac tank battery per 15 wells)	N/A	0.03	0.03
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 15 wells)	N/A	0.03	0.03
	Sales Compressor (2-ac pad for 150 wells)	N/A	0.01	0.01
	Sales Line (25-foot by 6 miles per 150 wells)	N/A	0.12	0.12
Produced Water Management	Produced Water pipeline (15-foot by 0.25 miles)	N/A	0.45	0.11
	Water plant/ Inj well (6 ac site per 15 wells)	N/A	0.40	0.40
Total Disturbance per Conventional Oil or Gas Well (acres)		**3.96**	**6.71**	**2.24**

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.

TABLE 10
LEVEL OF DISTURBANCE FOR HORIZONTAL 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)		2.98	2.98	0.92
Access Roads to Well Sites	Two-track (15-foot wide by 0.25 miles long)	0.45	N/A	N/A
	Graveled (15-foot wide by 0.15 miles long for construction and operation)	N/A	0.0	0.27
	Bladed (15-foot wide by 0.15 miles for construction and operation)	N/A	0.27	0.0
Utility Lines	Water lines (15-foot by 0.5 miles)	N/A	0.90	0.0
	Overhead Elec. (10-foot by 0.15 miles)	N/A	0.18	0.045
	Underground Elec. (15-foot by 0.15 miles)	N/A	0.27	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.25 miles)	N/A	0.45	0.11
	High Press. Gas or Crude Oil Gathering Line (20-foot by 0.5 miles)	NA	1.21	0.30
Processing Areas	Tank Battery (one 0.50-ac tank battery per 16 wells)	N/A	0.031	0.031
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 16 wells)	N/A	0.031	0.031
	Sales Compressor (2-ac pad for 128 wells)	N/A	0.016	0.016
	Sales Line (20-foot by 4 miles per 128 wells)	N/A	0.075	0.019
Produced Water Management	Discharge Point	N/A	N/A	N/A
	Storage Impoundment (20 acres each serving 64 wells)	N/A	0.31	0.31
Total Disturbance per Conventional Oil or Gas Well (acres)		**3.43**	**6.90**	**2.21**

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.

Roads can be permanent or temporary, depending on the success of the well. The initial construction can be for a temporary road; however, it is designed so that it can become permanent if the well produces. Not all temporary roads constructed are rehabilitated when the drilling stops. A temporary road is often used as access to other drill sites. The main roads and temporary roads, require graveling to be maintained as all-weather roads. This is especially important in the spring. Access roads may be required to cross public lands to a well site located on private or state lands. The portion of the access road on public land would require a BLM right-of-way.

Most conventional wells are drilled from a fixed platform while the majority of CBNG wells are drilled using a truck-mounted rig. Site preparation generally takes about a week before the drill rig is assembled. For moderate depth oil wells drilling generally takes 2 to 4 weeks, although deeper wells may require longer drilling time because of the geologic formations encountered. Wells drilled from a platform require more surface preparation and cause disturbance to a larger area for the ancillary facilities. CBNG wells are usually drilled in under a week and site preparation is typically less than for conventional wells.

Approximately 1 to 4 acres are impacted by well site construction. The area is cleared of large vegetation, boulders, or debris. Then the topsoil is removed and saved for reclamation. A level area from 1 to 4 acres is then constructed for the well site, which includes the reserve pit.

The well pad is constructed by bulldozers and motor scrapers. The well pad is flat (to accommodate the drill rig and support equipment) and large enough to store all the equipment and supplies without restricting safe work areas. The drill rig must be placed on "cut" material rather than on "fill" material to provide a stable foundation for the rig. The degree of cutting and filling depends on terrain; that is, the flatter the site, the less dirt work is required.

Hillside locations are common, and the amount of dirt work varies with the steepness. A typical well pad will require a cut 10 feet deep against the hill and a fill 8 feet high on the outside. It is normal to have more cut than fill to allow for compaction, and any excess material is then stockpiled. Eventually, when the well is plugged and abandoned, excavated material is put back in its original place.

Reserve pits are normally constructed on the well pad. Usually the reserve pit is excavated in "cut" material on the well pad. The reserve pit is designed to hold drill cuttings and used drilling fluids. The size and number of pits depends on the depth of the well, circulating system and anticipated down hole problems, such as excess water flows.

Reserve pits are generally square or oblong, but may be irregular in shape to conform to terrain. The size of reserve pits for deeper wells can be reduced by the use of steel mud tanks. For truck-mounted drill rigs used in shallow gas fields, a small pit (called the blooie pit) is used. Most or all of the reserve pit is located in the cut location of the drillsite for stability. When the drillsite is completed, the rig and ancillary equipment are moved on location and drilling begins.

The reserve pit can be lined with a synthetic liner to contain pit contents and reduce pit seepage. Not all reserve pits are lined; however, BLM often requires a synthetic liner depending upon factors such as soils, pit locations, ground water and drilling mud constituents. The operator can elect to line the reserve pit without that requirement.

An adequate supply of water is required for drilling operations and other uses. The sources of water can be a well at the drill site or remote sources such as streams, ponds, or wells. The water is transported to the site by truck or pipeline. Pipelines are normally small diameter surface lines. The operator must file for and obtain all necessary permits for water from the state. On public lands an operator must have the BLM's permission before surface water can be used.

9.3 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 would be applied to permits, leases or approvals granted by the land management agency. Mitigation measures would be included as appropriate to address site-specific concerns during all phases of oil, gas and CBNG development.

9.4 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 Operating Standards for Oil and Gas Exploration and Development" (USDI, BLM 1989) and BLM Manual 9113 entitled "Roads".

9.5 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.

9.6 Total Disturbances

The disturbances for the RFD scenario over the next 10 years have been calculated and are displayed in Tables 11 and 12. Table 11 address the disturbances from exploration and construction activities for types of gas and oil wells anticipated to be developed. Estimates for horizontal gas and deep gas, and multiple horizontal wells from single pads as well as deep oil wells have been extrapolated. The total disturbances for all predicted wells are estimated at 760 acres. Disturbance from federal mineral development would be 53 acres of which zero acres would be on USFS lands. The remaining federal disturbance (53 acres) would be on military sites, national park lands, and TVA lands. The disturbance to state and fee lands would be 707 acres.

Table 12 depicts the residual disturbance by well type remaining after appropriate mitigation measures and site restoration or rehabilitation activities have taken place. The total residual disturbance from anticipated development activities is 154 acres of which 13 would be from federal mineral development. The federal disturbances would affect zero USFS acres and 13 acres of various surface agencies. State and fee residual disturbance would be 141 acres.

The mitigation of initial exploration and construction disturbances would equal nearly 606 acres. Mitigation measures would account for remediation of 28 federal acres, and 287 state and fee acres.

TABLE 11
PREDICTED DEVELOPMENT AND SURFACE DISTURBANCE (EXPLORATION AND CONSTRUCTION) FOR GAS AND OIL WELLS

Well Type	Total Wells Drilled	Dry Holes	Disturbance per Dry Hole	Total Dry Hole Disturbance	Federal Producing Wells	Disturbance per Federal Well	Total Federal Disturbance	State/Fee Producing Wells	Disturbance per State/Fee Well	Total State/Fee Disturbance	USFS Producing Wells	Disturbance per USFS Well	Total USFS Disturbance	Total Producing wells	Total Disturbance
Gas – horizontal	30	0	3.43	0	4	6.90	27.60	26	6.90	179.40	0	6.90	0	30	217.00
Gas – horizontal (2 from single pad)	0	0	4.25	0	0	7.72	0	0	7.72	0	0	7.72	0	0	0
Gas – deep	55	36	3.96	141.57	0	6.71	0	19	6.71	127.49	0	6.71	0	19	269.06
Gas – shallow	0	0	2.43	0	0	4.79	0	0	4.79	0	0	4.79	0	0	0
Oil - Deep	58	38	3.96	149.29	2	6.71	13.42	18	6.71	120.78	0	6.71	0	20	283.49
CBNG – horizontal	0	0	3.43	0	0	6.9	0	0	6.9	0	0	6.9	0	0	0
Total	143	74		290.86	6		41.02	63		427.67	0		0	69	759.55

Assumptions:

Disturbance per well includes the well pad plus incremental roads, utility lines, transportation lines, processing equipment areas, and produced water management as outlined in Tables 8, 9, 10,& 11 for exploration.

TABLE 12
PREDICTED DEVELOPMENT AND RESIDUAL SURFACE DISTURBANCE (PRODUCTION) FOR GAS AND OIL WELLS

Well Type	Total Wells Drilled	Federal Producing Wells	Disturbance per Federal Well	Total Federal Disturbance	State/Fee Producing Wells	Disturbance per State/Fee Well	Total State/Fee Disturbance	USFS Producing Wells	Disturbance per USFS Well	Total USFS Disturbance	Total Producing wells	Total Disturbance
Gas – horizontal	30	4	2.21	8.84	26	2.21	57.46	0	2.21	0	30	66.30
Gas – horizontal (2 from single pad)	0	0	2.5	0	0	2.5	0	0	2.5	0	0	0.00
Gas – deep	55	0	2.24	0	19	2.24	42.56	0	2.24	0	19	42.56
Gas – shallow	0	0	1.81	0	0	1.81	0	0	1.81	0	0	0.00
CBNG	58	2	2.24	4.48	18	2.24	40.32	0	2.24	0	20	44.80
CBNG – horizontal	0	0	2.21	0	0	2.21	0	0	2.21	0	0	0.00
Total	143	6		13.32	63		140.34	0		0	69	153.66

Assumptions:

Disturbance per well is the residual disturbance remaining after the mitigation measures have been implemented.

10.0 References

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Appendix A

Tennessee GENERAL RULES

Appendix B

USGS Play Descriptions