Appendix A – Reasonably Foreseeable Development Scenario

Reasonably Foreseeable Development Scenario for Oil and Gas

Dixie National Forest

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SUMMARY

A reasonably foreseeable development scenario for oil and natural gas is developed based on the assumption that all potentially productive areas can be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation or executive order. It covers a time period of 15 years[1] and includes all lands within the boundaries of the Dixie National Forest regardless of ownership and adjacent non forest lands where oil and gas activity may impact Forest lands.

Several oil and gas plays, mostly hypothetical, cover the area of interest but exploration of Forest lands has been minimal and results of activity on surrounding lands have been modest. The discovery of the Upper Valley Oil Field in 1964 in the southern part of the Escalante Ranger District stimulated exploration of other similar structures in the area and oil shows were encountered but no commercial production established. Several wells drilled later encountered carbon dioxide gas in Paleozoic and lower Mesozoic formations leading to the recognition of an area including a large part of the forest where oil and natural gas have been removed by carbon dioxide gas flushing. Uncertainties about source rocks, migration paths and timing have also negatively impacted exploration during the past 15 years.

Oil and gas occurrence potential in the northern half of the Cedar City, Powell and Escalante Ranger Districts is rated as low with a low degree of certainty. The southern part of the three districts is given a high potential rating for oil and gas occurrence with a low degree of certainty. A narrow zone near the center of the districts is given a moderate potential, based mostly on the possibility of natural gas in Cretaceous sandstones and coals, again with a low certainty rating. The entire Pine Valley Ranger District is given a moderate potential for occurrence with a low degree of certainty resulting from the hypothetical Upper Paleozoic Basin and Range Play.

The Pine Valley Ranger District and the northern half of the Cedar City, Powell and Escalante districts are given a low potential for development. The southern parts of the latter three districts have a high degree of potential for development and a thin zone near their centers have moderate development potential.

It is estimated here that 60 exploration wells will be drilled during the next 15 years possibly resulting in the discovery of one new oil field with 20 production wells. Total (gross) surface disturbance associated with the exploration and production drilling is estimated to affect approximately 1,673 acres. It is further estimated that seismic exploration will impact 422 acres resulting in a total disturbance of approximately 2,095 acres.

[1] From the approval date of the FEIS

1.0 INTRODUCTION

The recently signed Memorandum of Understanding (MOU) between the Bureau of Land Management (BLM) and the Forest Service (FS) states that BLM has sole responsibility to provide Reasonably Foreseeable Development Scenarios (RFD) for oil and gas leasing on NFS lands, if requested, and outlines what should be included in the RFD. The MOU further states that the RFD will follow the Interagency Reference Guide "Reasonably Foreseeable Development Scenarios and Cumulative Effects Analysis". Following this, the BLM Utah State Office is preparing a RFD for oil and gas for the Dixie National Forest (DNF).

The RFD will draw heavily from the report "*The Oil, Gas, Coalbed Gas, Carbon Dioxide, and Geothermal Resources of the Dixie National Forest, Southwestern Utah"* prepared by the Utah Geological Survey (UGS, 2003) but will include some additional resource information. It will be consistent with BLM Handbook 1624-1 and BLM Instructional Memorandum (IM) 2004-089 as well as the Interagency Reference Guide. IM 2004-089 requires that the RFD project a baseline scenario of activity assuming all potentially productive areas are open to leasing under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation or executive order. The RFD Scenario presented here is a reasonable, technical, and scientific estimate of anticipated oil and gas activity using the best information and data currently available. The baseline scenario will be adjusted according to each alternative developed in the planning process in order to determine cumulative impacts from oil and gas activity.

The area administered by the DNF consists of four separate Ranger Districts (RDs), Pine Valley, Cedar City, Powell and Escalante from west to east (Map 1). The baseline scenario will be for all lands, regardless of ownership, within each of the four RDs. a reasonable distance outside their boundaries where the cumulative effects of oil and gas activity may impact National Forest System (NFS) lands and for a period of 15 years[2]. The scenario presented later in this discussion (4 exploration wells/year with one new field with 20 production wells) is restricted to the area administered by DNF but it is possible that the new field would extend onto adjacent lands. Earlier estimates of activity on the DNF, BLM Kanab Field Office and counties including the DNF are given so that the reader can get a feel for historical activity levels in this part of Utah. The number of wells projected here is slightly higher than some of the other projections due, in part, to the assumptions stated in the Baseline Scenario section. The Forest Service will use this baseline scenario to develop alternatives so that cumulative effects of oil and gas leasing and subsequent activities may be analyzed on both National Forest and other lands within a reasonable distance from the National Forest.

[2] From the approval date of the FEIS

2.0 DESCRIPTION OF GEOLOGY

The Utah Geological Survey report referenced above gives a detailed description of the general geology of the DNF and surrounding area. A brief summary is given here and the interested reader is referred to the referenced UGS (2003) report, Stokes (1987) and Hintze (1988) for a more detailed discussion of geological relationships.

Most of the DNF lies within the Basin and Range/Colorado Plateau Transition Zone Physiographic Province but the eastern part of the Escalante RD extends into the Colorado Plateau proper. Elevations are generally greater than 6000 feet and include the Pine Valley Mountains and the Kolob-Markagunt, Sevier-Paunsagunt and Aquarius-Kaiparowits Plateaus (UGS, 2003). The intervening valleys separating the RDs consist of BLM, private and State of Utah lands.

2.1 Stratigraphy, Source Rocks and Reservoirs

Figure 1 shows the general stratigraphy in the area of interest. Much of southern Utah is underlain by Early Proterozoic metamorphic rocks which are in turn overlain by Late Proterozoic sedimentary rocks (not shown in figure 1). A typical Cambrian sequence of basal sandstone, shale and carbonate rocks overlie the Late Proterozic rocks. The Late Proterozoic rocks probably underlie the Escalante RD (UGS, 2003) and may contain petroleum source rocks. A major unconformity separates Cambrian and Devonian age rocks with Ordivician and Silurian rocks being absent within the DNF. Middle and Late Devonian rocks present throughout most of the area were deposited in a shallow marine environment near a fluctuating shoreline and consist of carbonate rocks, shales and sandstones.

Marine conditions existed in the DNF area during the Mississippian Period when the Redwall Limestone was deposited. This limestone and dolomitized limestone unit thickens from about 700 feet on the east side of the forest to 1,200 feet at the west side. It has good reservoir characteristics in some areas and has been a major producer of oil and gas at the Lisbon Field in northern San Juan County, Utah. Organic-rich and phosphatic units of Mississippian age in western Utah and eastern Nevada have been recognized as promising petroleum source rocks (Sandberg and Gutschick, 1984). During late Mississippian time, the sea retreated and a regolith of reddish soils formed on the exposed limestone. Early Pennsylvanian seas transgressed the area resulting in a significant unconformity separating the upper Mississippian regolith and lower Pennsylvanian shallow marine sediments. Later, the marine Callville Limestone was deposited in the western part of the DNF area while the eastern half was on the margin of the Paradox Basin where interbedded carbonate and sand deposition produced the Hermosa Formation. Both of these units may contain viable reservoir beds. The

entire DNF area was exposed to erosion during latest Pennsylvanian time. As a result of the repeated transgressions and regressions, rocks of Pennsylvanian age show considerable variations in thickness ranging from 400 to 800 feet. Crustal instability continued throughout the Permian Period producing a series of eastward marine transgressions and subsequent withdrawals across the area of interest resulting in numerous east- west facies changes. The oldest Permian rocks (Pakoon Dolomite and Halgaito Shale) were deposited in a marine and marginal marine environment respectively and are overlain by an alternating sequence of continental and marine sandstones. The marine Kaibab Limestone is the youngest Permian unit in the area and has been a prolific oil producer at the Upper Valley Field in Garfield County.

Figure 1 Stratigraphic columns at SW and NE corners of DNF.

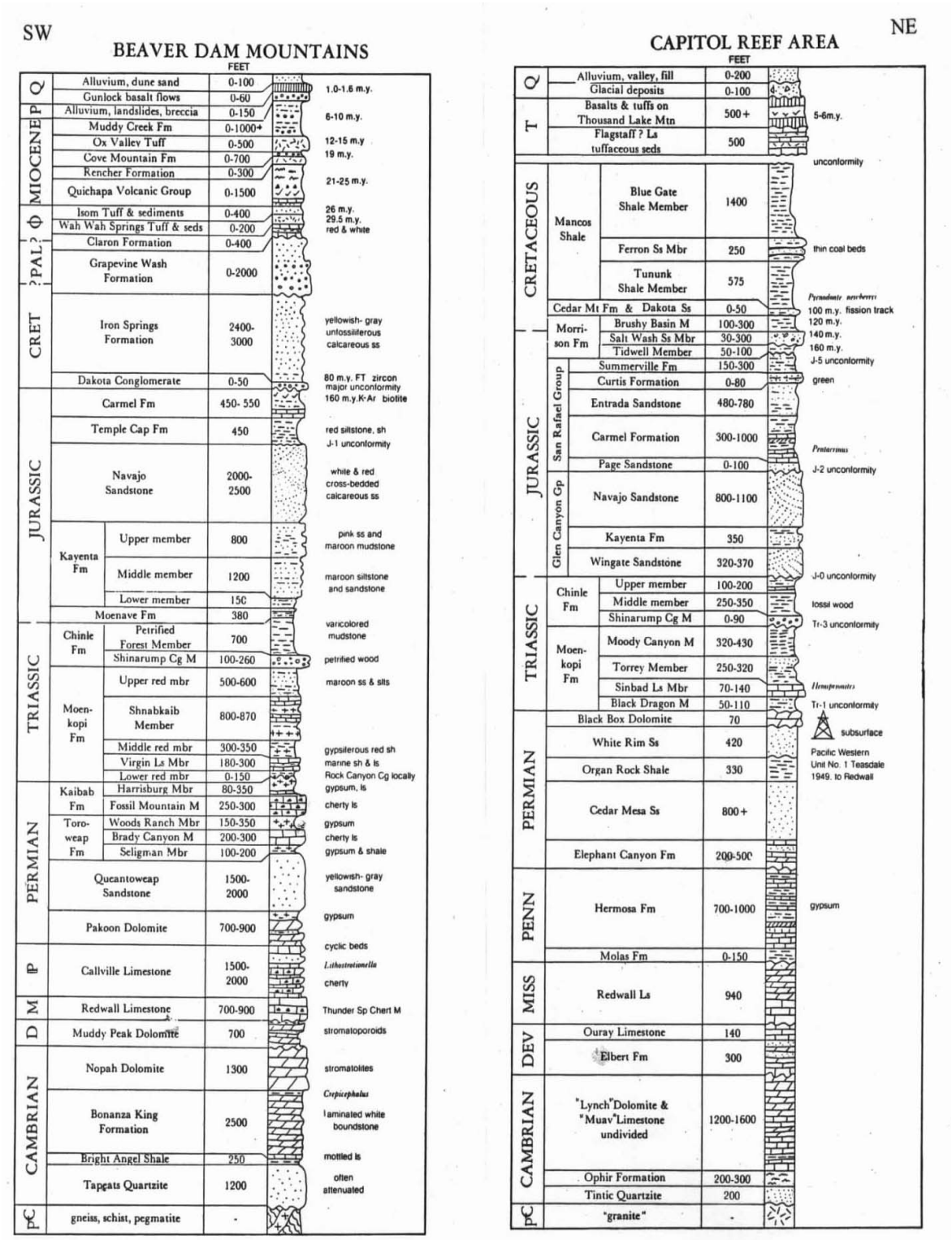


Figure 1. Stratigraphic Columns at SW and NE corners of DNF. Hintze, 1988.

The Kaibab Limestone is unconformably overlain by the Moenkopi Formation of Triassic age which consists of as many as six members in south central Utah including limestone and generally red siltstone and fine-grained ripple-marked sandstone. The clastic units represent fluvial material deposited in a flood plain to tidal-flat environment. The Moenkopi thickens to the west and becomes more marine in character. Hydrocarbons have been produced from Moenkopi reservoirs in the Virgin, Upper Valley and Grassy Trail fields. A major unconformity separates the Moenkopi from the Late Triassic Chinle Formation which consists of continental red-bed deposits with channel sandstones. The lower part of the Chinle is named the Shinarump Member and represents discontinuous channel deposits cut into the upper part of the Moenkopi. It possesses good reservoir characteristics in some areas. The upper, Petrified Forest Member contains colorful mudstones and muddy sandstones of continental origin. A period of Late Triassic/Early Jurassic erosion separates Chinle and Jurassic units. The thick (1,200 to 5,500 feet) Jurassic section includes, in ascending order, the Wingate-Moenave, Kayenta, Navajo, Temple Cap, Carmel, Entrada, Summerville-Curtis and Morrison formations but all units may not be present at a given location and they vary considerably in thickness. Several of the units are eolian sandstones (Wingate, Navajo and Entrada) exhibiting spectacular cross-bedding at certain locations and formed in arid coastal environments. The Carmel, Curtis and Summerville formations, where present, represent shallow marine deposition. Wolverine Gas and Oil's discovery of oil in the Navajo Sandstone at the Covenant Field near Sigurd in 2004 sparked a revival of leasing and exploration activity in the surrounding area and discoveries of gas in the Wingate and Entrada formations at Flat Rock and Peter's Point fields have increased interest in the Jurassic eolian sandstones as exploration targets. The late Jurassic Morrison Formation, a producer in northern Grand County, is separated from the underlying Curtis and Summerville formations by an unconformity.

Rocks of Cretaceous age in southern Utah were deposited in a basin separated from the familiar northern basin and generally have a different nomenclature. Sedimentation in the southern basin, as in the northern basin, was strongly affected by transgressions and regressions of the Cretaceous seaway and is characterized be east-west facies changes. The oldest Cretaceous unit is the Cedar Mountain Formation which consists of a basal conglomerate overlain by a series of channel sandstones, overbank mudstones and terrestrial carbonate deposits. The Cedar Mountain Formation is generally uncomformably overlain by the Dakota Sandstone but is missing in some areas so that the Dakota directly overlies Jurassic rocks. The Dakota Sandstone represents sedimentation near the northwestward transgressing shoreline of the Cretaceous sea and contains coal deposits in some areas. The Tropic Shale underlies most of the DNF becoming thicker toward the southeast and represents the full incursion of the Cretaceous Western Interior Seaway into eastern Utah. The Tropic Shale is absent in the western part of the DNF and the Iron Springs Formation directly overlies the Dakota Sandstone. Facies changes toward the east cause the Iron

Springs Formation to be replaced by the Straight Cliffs, Wahweap and Kaiparowits Formations, in ascending order. Coal beds occur in the John Henry Member of the Straight Cliffs Formation.

Upper Cretaceous rocks are unconformably overlain by the Paleocene-Eocene Claron Formation which consists of colorful fluvial and lacustrine deposits. This unit is over 3,000 feet thick near the southern boundary of the DNF and thins toward the north. Oligocene and lower Miocene felsic and intermediate volcanic units cap the Tertiary section in much of the area. The presence of volcanic rocks probably has had little affect on exploration interest in the area as productive reservoirs underneath volcanic rocks are relatively common but if it is discovered that igneous activity also included the formation of large intrusive bodies the accompanying heat may have "cooked" and destroyed any existing hydrocarbons. The physical properties of the volcanic rocks must be known to obtain useful seismic data. Quaternary alluvial deposits and local basalt flows represent the youngest rocks in the forest.

2.2 Structure

The DNF area is generally characterized by gently warped strata cut in places by north-south trending high angle faults resulting in a series of relatively high plateaus: Aquarius-Kaiparowits, Sevier-Paunsagunt and Kolob-Markagunt, from west to east. Structural complexity increases toward the west where Mesozoic thrust faulting and Cenozoic extensional faulting become more significant. Finer structural details are obscured in many areas by Oligocene and Miocene volcanic deposits.

2.3 Summary of Oil and Gas Plays

Several oil and gas plays described by the U. S. Geological Survey (USGS) or the Utah Geological Survey (UGS) extend into the DNF area and are listed below.

USGS 1995 National Assessment Plays:

2106- Permo-Triassic Unconformity Play.
1902- Late Paleozoic Play (hypothetical).
2403- Late Proterozic and Cambrian Play (hypothetical)

UGS 2003 Plays:

2100- Cretaceous Coalbed Gas Plays.
2107- Cretaceous Sandstone Play*
2108- Paleozoic Devonian through Pennsylvanian Play.
* This play is an extension of the USGS (1995) Upper Cretaceous Conventional

Play in the Uinta-Piceance Province.

2.3.1 USGS PLAYS (1995)

The plays defined by USGS (1995) in the DNF and surrounding area are shown in Map 2. The Late Proterozic and Cambrian Play (2403) is a hypothetical play based on the discovery of shales rich in organic carbon in the Late Proterozic Chuar Group in the Grand Canyon. These potential source rocks extend into the subsurface of southern Utah and the play, as defined, covers the Escalante, Powell and extreme southeastern portion of the Cedar City RDs. Potential reservoirs are siltstones within the Chuar group, basal Cambrian sandstones and possibly other Paleozoic units. Tests of these units in the Circle Cliffs and Kaiparowits Basin encountered carbon dioxide gas but no hydrocarbons. The hypothetical Late Paleozoic Play (1902) includes only the Pine Valley RD. It is based on the possibility of reservoirs, traps and seals in upper Paleozoic units in western Utah where sparse exploration drilling has not produced promising results to date.

The Permo-Triassic Unconformity Play (2106) is so named because all known accumulations, shows and oil staining are associated with this unconformity, either above or below. The play covers a large area including the Escalante, Powell and Cedar City RDs. Several potential source rocks of Precambrian and Paleozoic age have been recognized but no single one has been positively identified with this play and reservoirs include the Kaibab Limestone (Permian) and the Timpoweap member of the Triassic Moenkopi Formation. The discovery of the Upper Valley field in Garfield County in 1964 stimulated a period of exploration in the area which yielded numerous oil shows but no other commercial production. Several wells drilled in the 1980s in and near the DNF encountered carbon dioxide gas in reservoirs above and below the unconformity but no hydrocarbons.

2.3.2 UGS PLAYS (2003)

Utah Geological Survey Play 2108 (Paleozoic Devonian-Pennsylvanian Play) is based on oil shows and small amounts of production from mid Paleozoic reservoirs (primarily the Redwall and Callville limestones). The play is subdivided into an oil and a gas portion and a carbon dioxide portion with most of the DNF included in the latter. Only the extreme southern and eastern parts of the forest are within the oil and gas portion of the play (UGS, 2003, figure 1.7).

The Cretaceous Sandstone Play is an extension of USGS Play 2107 in the Uinta-Piceance Province as it relates to similar units deposited in the southern Cretaceous Basin and includes the southern parts of the Cedar City, Powell and Escalante RDs. Potential source rocks are coal and carbonaceous shale that intertongue with the sandstones.

Sandstone reservoirs may be present in the Straight Cliffs, Dakota, Cedar Mountain and Morrison formations. The UGS Cretaceous Coalbed Gas Plays (2100) is based on potential coalbed sources and reservoirs in the Dakota and

Straight Cliffs formations and includes the southern parts of the Cedar City, Powell (Dakota) and Escalante (Straight Cliffs) RDs.

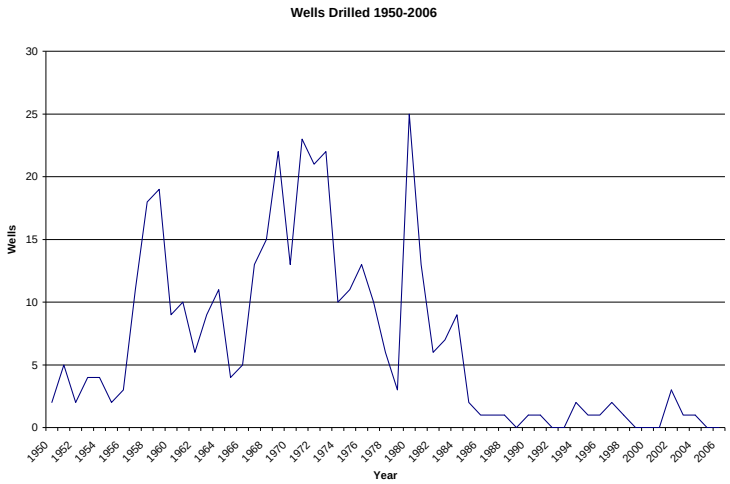
As noted above UGS (2003) subdivided their play 2108 into a hydrocarbon portion and a carbon dioxide portion. They similarly show the same carbon dioxide area, which includes a large part of DNF, within USGS (1995) plays 2106 and 2403. This is based on the existence of several wells in the central and southern part of the state that encountered carbon dioxide gas in Paleozoic and lower Mesozoic reservoirs and is usually attributed to flushing of oil and gas by carbon dioxide gas generated by volcanic heating of carbonate rocks during the Tertiary (anonymous, 1984). At this point, too few wells have been drilled in this large area to definitively show which areas have been flushed and how efficient the flushing process has been.

3.0 PAST AND PRESENT OIL AND GAS EXPLORATION ACTIVITY

BLM file maps indicate that numerous seismic surveys have been conducted on the Cedar City, Powell and Escalante RDs and especially on BLM, private and State of Utah lands that separate the RDs. The maps show fewer surveys in the Pine Valley RD. No data are available as to when the surveys were conducted but it is thought that they were done in the 1970s and 1980s.

UGS (2003) reported that 62 wells were drilled in the DNF between 1947 and 1986 with one field (Upper Valley) discovered in 1964. A search of BLM oil and gas lease records produced the result that 14 leases containing 18,116.3 acres currently exist in the DNF however several of the leases near the forest boundary also include adjacent BLM lands so the actual forest acreage is 12871.43 These are old leases that were issued before 1987 after which single leases were not issued with mixed Federal ownership. No leases have been issued in the forest in the last 20 years which has probably reduced the number of exploratory wells that would have otherwise been drilled. Topography, absence of infrastructure and distance to markets have also negatively impacted exploration activity.
Drilling data for the counties where DNF lands are located (Iron, Washington, Garfield, Wayne and Kane) indicates that 385 wells were drilled between 1950 and 2006 (IHS Energy, 2006) but this number includes 47 development wells in the Virgin Field and 50 development wells in the Upper Valley Field. This indicates that approximately 288 exploration wells were drilled between 1950 and 2006 resulting in two field discoveries (Upper Valley and Anderson Junction) for a success rate of 0.7 percent. Figure 2 shows drilling activity in the 5 counties during the period 1950-2006. When all 385 wells are considered a drilling rate of 6.9wells/year is derived. If 97 development wells at Upper Valley and Virgin fields are excluded the number of exploration wells/year equals five.

Figure 2 Wells drilled each year between 1950 and 2006. IHS Energy data.



Phillips Petroleum Company drilled two wells on the Escalante Anticline in 1960 and 1961which reportedly encountered carbon dioxide gas. In 1975 the Shell Oil Company Harvey-Federal (10-32S-1E), approximately 12 miles to the northwest, encountered carbon dioxide gas in the Shinarump Member of the Chinle Formation. Midcontinent Oil and Gas Company drilled the Charger 1, 2 and 4 wells near the Phillips wells on the Escalante Anticline and reported large volumes of carbon dioxide gas in several Permian and Triassic age formations. No hydrocarbons were found in any of these wells.

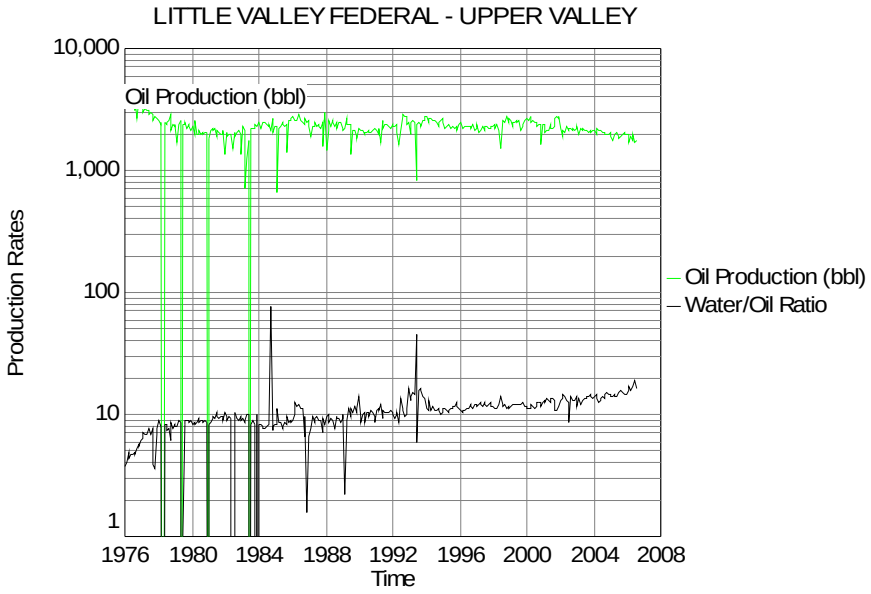
The Upper Valley Oil Field, located along the southeastern boundary of the Escalante RD, was discovered in 1964 with the Tenneco Oil Company Unit No. 2 well in section 13, T. 36 S., R. 1 E. (Allin,1993). Most of the subsequent production has been from the Kaibab Limestone but the Timpoweap Member of the Moenkopi has also contributed oil. The field is unusual in that the oil column is offset onto the western flank of the Upper Valley Anticline by a strong hydrodynamic drive. According to Utah Division of Oil, Gas and Mining Production data (June, 2006) the field had produced 27,219,013 barrels of oil (BO), 61,623 thousand cubic feet of gas (MCFG) and 451,757,376 barrels of water (BW) and is still producing.

More recently in 2002, Legend Energy of Utah drilled 3 wells on private lands near the southern tip of the Cedar City and Powell RDs to test coals in the Dakota Sandstone. All three wells encountered coal at depths ranging from 1200 feet to 4640 feet and gas shows were reported in cores from one of the wells (IHS Energy Well Data) but all three wells were plugged.

4.0 PAST AND PRESENT OIL AND GAS DEVELOPMENT ACTIVITY

The Upper Valley Oil Field, in the southeastern corner of the Escalante RD, represents the only development activity in the DNF. The field was discovered by Tenneco Oil Company in 1964 when the Unit No. 2 well was completed with an initial production rate of 300 barrels of oil per day (BOPD) with no water. IHS Energy's well histories database lists 52 wells for the field including producing oil wells, plugged and abandoned wells and secondary recovery injection wells. The north-northwest trending elongate elliptical productive area is approximately 8 miles by 3 miles and the average distance between wells is about 0.3 miles. A peripheral, updip water injection pressure maintenance program was initiated in 1969 and was later replaced by a tertiary polymer flood (Allin, 1993). The field has produced very little gas and, according to Allin (1993), oil API gravity ranges from 18.5 to 27 degrees. Figure 3 shows the production history for the Little Valley Number 1 well (SWSE of section 18, T. 37 S., R. 2 E.) as representative of the field. The long term stable production rate and water/oil ratio should be noted. After oil is separated from produced water a ten-mile long pipeline carries oil off-lease to a transfer site adjacent to Highway 12 about eight miles east of Henrieville. From there the oil is trucked to markets in Salt Lake City. Water is reinjected and surface impacts related to these activities are discussed in the section considering surface disturbance.

Figure 3. Little Valley No. 1 well production history (IHS Energy, September, 2006).



Two abandoned oil fields, the Virgin Field and Anderson Junction Field, were located in Washington County a short distance southeast of the Pine Valley RD. The Virgin Field was discovered in 1907 and was the first discovery in the state. Production was from the Timpoweap Member of the Moenkopi Formation (USGS Permo-Triassic Unconformity Play; 2106) which was encountered at depths of less than 1000 feet in the field. According to Heylmun (1993) the oil collected in synclinal pockets and structural terraces on the east flank of a broad northeast plunging structural nose, under the influence of gravity. Several hundred wells were drilled in the field and Heylmun (1993) stated that reported cumulative production exceeded 200,000 barrels of oil but noted that the figure is suspect. The abandoned Anderson Junction Field was located 6 miles northwest of the Virgin Field and was discovered in 1968. Harris (1993) reported that 2 producing wells and 3 dry holes were drilled in the field. Production was from the Callville Limestone of Pennsylvanian age (UGS Paleozoic Devonian through Pennsylvanian Play; 2108) was reported as 2,733 BO, 16,388 MCFG and 3,744 BW (Harris, 1993).

5.0 OIL AND GAS OCCURRENCE POTENTIAL

An oil and gas RFD prepared by the Utah Geological Survey (UGS, 2006) for the BLM Kanab Field Office included the Escalante, Powell and the southeastern half of the Cedar City RDs. These areas were rated as having moderate or high potential for oil and gas occurrence for all of the identified plays although the northern parts of the RDs are shown as carbon dioxide gas areas. This is based on several wells in the area that tested carbon dioxide and the theory that carbon dioxide gas was generated by Tertiary age igneous activity and flushed oil from the area (anonymous, 1984). USGS plays 2403 and 2106 cover the Powell, Cedar City, and Escalante RDs as does UGS play 2108. UGS (2006) maps indicated that the northern two thirds of the four RDs had oil removed by flushing and pore fluids in these areas are likely to be carbon dioxide gas. Potential gas-bearing reservoirs exist in the Cretaceous sandstones and coal beds that underlie the southern parts of the Escalante, Powell and Cedar City RDs (UGS play 2100 and extension of USGS play 2107). Only one identified play covers the Pine Valley RD; the hypothetical USGS Basin and Range Play 1902 (Late Paleozoic).

BLM Handbook 1624-1 recommended that all areas within USGS or other defined plays should be given a high potential rating for oil and gas occurrence. The only play among those considered here with significant production is USGS Play 2106, Permo-Triassic Unconformity Play and the production has all been from the Upper Valley Field. Minor production has been reported from UGS Play 2108 (Paleozoic Devonian-Pennsylvanian Play) at the Upper Valley Field (UGS, 2003, p.23) and at the abandoned Anderson Junction Field (Harris, 1993). All of the Paleozoic and lower Mesozoic plays have been affected by carbon dioxide gas flushing in the area of the DNF (Anonymous, 1984; UGS, 2003 and 2006) but the extent and paths of flushing are poorly constrained. The Cretaceous Sandstone Play (UGS 2107) was defined in the northern Cretaceous Basin and is hypothetical in the DNF area as no production has occurred in the southern basin. Similar reasoning can be applied to the Cretaceous Coalbed Gas Plays (UGS 2100) even though coal is known to occur in the Straight Cliffs and Dakota formations.

When the above factors are considered along with the small number of existing leases, few recent seismic surveys, and limited exploratory drilling it becomes difficult to define meaningful occurrence potential for the various RDs. Map 3 is an attempt. The Pine Valley RD is included in only the hypothetical USGS Late Paleozoic Play (1902) which covers western Utah and eastern Nevada. The geology in the play is complex and the area lightly explored. Consequently the oil and gas occurrence potential is rated as only moderate with a low degree of certainty (M/B). The northern portions of all the other RDs are given low oil and gas occurrence potential rating with a low degree of certainty (L/B) based on evidence that oil and natural gas have been flushed from potential Paleozoic and lower Mesozoic reservoirs in this area by carbon dioxide gas. Several wells

within this area have encountered significant amounts of the gas but no hydocarbons. The configuration of the flushed area is poorly constrained because of the small amount of drilling that has occurred and the outline in map 3 is adapted from maps in UGS (2003 and 2006). A narrow strip crossing the Cedar City, Powell and Escalante RDs is given a moderate rating with low degree of certainty (M/B) based on the potential for gas in Cretaceous sandstones and coal in this area. The remainder of the DNF is rated as having high potential for oil and gas occurrence with a moderate certainty (H/C) based on the existence of overlapping Paleozoic and Mesozoic plays in these areas.

6.0 OIL AND GAS DEVELOPMENT POTENTIAL

Two recent studies have addressed potential oil and gas development within the Dixie National Forest and some surrounding areas (UGS, 2003 and 2006). Several factors have combined to discourage past development activity in this part of the state. The area's remoteness, rugged topography and lack of infrastructure have made oil and gas exploration both difficult and expensive so that detailed geological information is generally lacking. No oil and gas leases have been issued in the past 20 years in the DNF, although leases covered about 75 percent of the forest in 1986. Currently only 12,871.43 acres are under lease after most leases terminated when no activity occurred on them during their 10 year term. Map 4 shows the locations of existing oil and gas leases on BLM lands near the DNF. The large group of leases northwest of the Cedar City RD probably results from the discovery of the Covenant Field to the northeast and may have only minor significance relative to leasing interest within the DNF itself. Lands in the Cedar City, Powell and western Escalante RDs have been nominated for inclusion in BLM competitive lease sales during 2005 and 2006 (Map 5) and indicate industry interest in these areas.

Proven oil reserves are known only at the Upper Valley Field where no additional development is anticipated although production from existing wells will continue in the near future. Any other oil and gas development will depend, in large part, on the results of whatever exploration activity the DNF permits in the future. Map 6 shows the estimated development potential of the DNF and surrounding area based on occurrence potential estimates and consideration of topography, infrastructure, potential markets, past activity, industry interest and other relevant factors.

7.0 RFD BASELINE SCERARIO ASSUMPTIONS AND DISCUSSION

BLM Interim Memorandum 2004-089 provided guidance relative to what a RFD scenario for oil and gas should be. The initial assumption is that **all potentially productive areas can be open under standard lease terms and conditions except those areas designated as closed to leasing by law, regulation or executive order.** Following this assumption several large areas within the DNF would be excluded from the RFD: Pine Valley Mountain, Ashdown Gorge and Box-Death Hollow wilderness areas, and Cedar Breaks National Monument. Significant areas contiguous to the DNF that are designated closed to oil and leasing are Bryce Canyon National Park and the Escalante-Grand Staircase National Monument. Other factors that may negatively impact future drilling such as remoteness, topography, etc. have been discussed in above sections.

UGS (2003) estimated that 30 new wells will be drilled in the DNF during the next 15 years (equal to 2 wells/year) with the Permo-Triassic Unconformity Play (2106) representing the favored target. UGS (2006) later projected 55 new exploration wells (3.7/year) would be drilled within the BLM Kanab Field Office which includes much of the eastern DNF and other lands to the south. They also project one small field with 20 production wells resulting in a total of 75 wells (5/year). The same plays cover much of the two areas and Play 2106 is again projected to be the major target although a single well can test reservoirs associated with multiple overlapping plays. Historical drilling rates for the five county area that includes the DNF were discussed in the sections on past and present exploration and production activity. Table 1 summarizes these data.

Table 1. Past and projected future drilling rates for DNF and surrounding area. Data areFrom IHS Energy and UGS 2003 and 2006.

Five county 1950-2006 drilling rate (exploration wells):	5/year
Five county 1950-2006 drilling rate (all wells):	7/year
Dixie N F 1947-2003 drilling rate (all wells)	1/year
Dixie N F projected rate (exploration wells):	2/year
BLM Kanab F O projected rate (exploration wells):	3.7/year
BLM Kanab F O projected rate (all wells):	5/year

No leases have been issued in the DNF in recent years, which accounts in part for the low drilling rate (1/year). When surrounding non-forest areas are considered along with the DNF rates are considerably higher but still low relative to other areas of the state. Several factors have contributed to the low rate including remoteness of the area, lack of infrastructure, distance to markets and rugged topography in some areas. Geological factors, such as low drilling success rate, complex geology, poorly defined plays and uncertainties about source rocks, migration paths and carbon dioxide flushing have also contributed.

It is projected here that an average of 4 exploration wells/year will be drilled in the National Forest and adjacent areas, or 60 total wells during the 15 years covered by this RFD. It should be stressed that this is a hypothetical forecast based on the assumption that all potentially productive areas would be open to leasing under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation or executive order. The 60 wells projected here are similar in number to the 55 projected for the BLM Kanab Field Office (UGS, 2005), which includes the southeastern portion of the DNF and other lands to the south and east, during the same time period. It is possible that this exploration will lead to the discovery of one new oil field with 20 development wells. The field would most likely be discovered within the area of high development potential (Map 6), but it is also possible for the discovery to be made in areas of moderate or low development potential.

The following section will estimate surface disturbance resulting from the exploration and production activity based on reasonable assumptions as to how the seismic exploration, exploratory drilling, development drilling and construction of production facilities will proceed.

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

8.1 SEISMIC EXPLORATION

Any future major exploration activity in the DNF and surrounding area will likely begin with seismic surveys of some type. The purpose in conducting these surveys is to determine the configuration of subsurface rock layers as an aid in locating structures that can trap hydrocarbons. This is accomplished by generating seismic waves at or near the earth's surface which then penetrate the subsurface rocks. Some of the seismic energy is reflected back to the surface by "reflector" beds and returned to the surface where it is recorded by instruments called geophones. The time required for seismic energy to travel downward to a given reflector bed, and then back to the surface (two way travel time) combined with physical properties of subsurface rocks permits calculation of the depth of the reflector beds. Mapping the determined depths over the area of interest depicts the configuration of the subsurface beds.

Seismic energy used in seismic surveys is usually generated in one of two ways: high frequency vibrations (Vibroseis method) or explosions. Vibroseis utilizes large trucks with vibrator pads which can be lowered to the ground and thus induce energy into the subsurface. The Vibroseis method is usually only used along existing roads on National Forest System lands.

The explosion method involves drilling shallow small-diameter shot holes, placing an explosive charge in the hole and covering it. The charge is detonated to generate seismic energy for the survey. Drill rigs mounted on trucks are used to drill the holes in areas with roads or trails but portable rigs may be transported by helicopter in rugged terrains or areas of environmental concern. Off-road buggies mounted with drill rigs are being increasingly used where possible as they are less expensive than helicopters.

UGS (2003) estimated that 700 line miles of seismic data will be acquired during the next 15 years and that half the data would be obtained using buggy-mounted drill rigs and half by using helicopter-portable equipment. Based on other recent surveys in the state UGS estimated that buggy mounted acquisition usually disturbs 1.2 acres/mile whereas helicopter surveys disturb 0.007 acres/mile. **Total surface disturbance** from seismic surveys is then equal to **422.5** acres (350 x 1.2+ 350 x 0.007). If the ratio of buggy/helicopter is greater than 1:1, the number of acres disturbed obviously will increase.

8.2 EXPLORATION DRILLING

This RFD projected that 60 exploration wells will be drilled during the next 15 years (assuming that all potentially productive areas are open under standard

lease terms and conditions except those areas designated as closed to leasing by law, regulation or executive order). The two major sources of surface disturbance resulting from exploratory drilling are drill pad construction and access road construction.

Drill Pads

Drill pads vary in size depending on topography, depth of well (rig size), duration of drilling and possibly other factors and are usually between 2.5 and 5 acres in area. Drilling pads in the Uinta Basin are usually between 3.7 and 5 acres, including roads which would be a small part of the disturbance there (McKee, 2006). Pads constructed on National Forests would probably tend to be larger than those in the Uinta Basin because the factors listed above would all tend toward larger pads. Another factor is the recent trend of using larger drill rigs and employing directional drilling to minimize new road construction in rugged topography or sensitive areas. A drill pad disturbance area of 5.9 acres is assumed here (Dixie NF O&G Engineering Report, 2007). This estimate assumes the high-end pad dimensions of 425 feet by 350 feet with additional disturbance for topsoil storage, drainage diversions, and vegetation clearing.

Pad Access Roads

New roads would be necessary to access the pads from existing National Forest System roads and other highways. It is likely that access roads would be longer on forest lands than on BLM lands because National Forests are often more remote, have more rugged topography and drill sites may be occupied for greater lengths of time requiring more supply storage space. The following parameters were used to calculate the amount of surface disturbance resulting from road construction for each well (Dixie NF O&G Engineering Report, 2007). A GIS-based analysis was used to determine the average straight line distance of all potential pad locations on the Forest from an existing National Forest System road or other highway. This average distance was adjusted to account for topography and road grade.

Average adjusted road length	0.66 miles
Width of area disturbed for road	39 feet
Curve widening etc., factor	1.25
Topsoil storage	0.25 acres/mile

Calculations using these figures yield an average disturbance of 4.1 acres per well from road construction.

Reconstruction of Existing National Forest System Roads

Additional disturbance would result from reconstruction of National Forest System roads to a standard needed to safely accommodate existing traffic, rig

mobilization, and other project traffic. The GIS-based analysis determined an average distance of 3.41 miles/well for reconstruction. This number was increased by 15% to 3.92 miles to meet Forest Service road maintenance objectives for the higher road level.

Average adjusted length	3.92 miles
Width of new disturbance	13 feet
Subtotal Disturbance	6.18 acres
Additional disturbance for turnouts	0.28 acre
Additional disturbance for curve widening	0.16 acre

Calculations yield an average disturbance of 6.6 acres per well for road reconstruction.

Total Disturbance

The total estimated disturbance per exploration well, including the pad (5.9 acres), new road (4.1 acres), and road reconstruction (6.6 acres) would be **16.6 acres.**

The total gross disturbance for exploration drilling for the 15- year period would be **996.0 acres** (60 wells x 16.6 acres/well).

Once a well is plugged and abandoned the site would be reclaimed. Reclamation includes returning the disturbed drill pad and access road to approximate original contour, replacing topsoil, and seeding the area to accomplish required standards for revegetation.

If it is assumed that wells are drilled at a constant rate of 4/year and that reclamation requires 5 years, total acres disturbed by drilling will remain constant at **332.0 acres** after the fifth year as reclamation balances new disturbance. Stated differently, the **net** disturbance from exploration wells at the end of 15 years will be **332.0 acres**.

8.3 PRODUCTION WELLS AND FACILITIES

The baseline RFD outlined above projects the possible discovery of one oil field within the DNF during the next 15 years. This field might resemble the existing Upper Valley Oil Field (figure 4) but is here estimated to be somewhat smaller considering current industry and environmental standards and available technology with a total of about 20 production wells. The discovery well would become one of the production wells and 19 more wells would be drilled for production with each pad estimated at 5.9 acres. Nineteen pads would result in a disturbance of 112.1 acres. Assuming that an access road for the discovery well drill site remains available new road construction would consist only of spur roads between the wells. Assuming that the production well spacing would be

similar to Upper Valley, a maximum road length for each well is estimated at 0.5 miles. Road construction would disturb 6.15 acres per mile (Dixie NF O&G Engineering Report, 2007) resulting in an average disturbance per well of 3.1 acres. A topsoil storage area of 0.4 acres per well is estimated. This would produce a total disturbance of 9.3 acres/well (5.9 + 3.1 + 0.25). It is possible that more than one well would be drilled from some of the pads thereby reducing surface disturbance but it would serve no useful purpose to speculate without more site specific information, so the analogy with Upper Valley seems appropriate.

Using the Upper Valley oil field as a model, it is assumed that a new overhead powerline of approximately 5 miles and occupying 25 acres, and a substation of approximately 0.4 acres, would be necessary to provide electric power for the operation. Pipelines and power lines within the new oil field would mostly be buried under access roads and the produced oil would be trucked to market. However, it might be necessary to locate some portions of the lines in other areas or adjacent to existing roads to avoid sharp bends and other features. In order to accommodate this possibility, it is assumed that an additional 50-foot wide corridor could be disturbed for a distance of 5 miles for a total of **30.3 acres**.

A central production facility would be constructed which would receive the oil and water from individual wells after which the two liquids would be separated. The oil will be stored in tanks until removed by truck or possibly moved by pipeline to a nearby loading station. The separated water would be temporarily stored in a holding facility and then piped to a water injection well. The size of central production facilities varies depending on the volumes of produced liquids, shop and office facilities required and other factors. The most recently constructed central production facility in the area is at the Covenant Field and occupies approximately 29 acres. This facility is on land owned by the operator and the facility is considerably larger than one located on National Forest lands would be. A reasonable size for the postulated facility on the DNF would be **12 acres**. One water disposal well is projected with 0.5 miles of road construction resulting in **9.0 acres** (5.9 acres + 3.1 acres). In addition, oil would most likely be piped from the central production facility to a truck-loading facility adjacent to a major highway. Construction of a truck-loading facility would involve disturbance of another **0.5 acres**.

Figure 4 Upper Valley Oil Field.

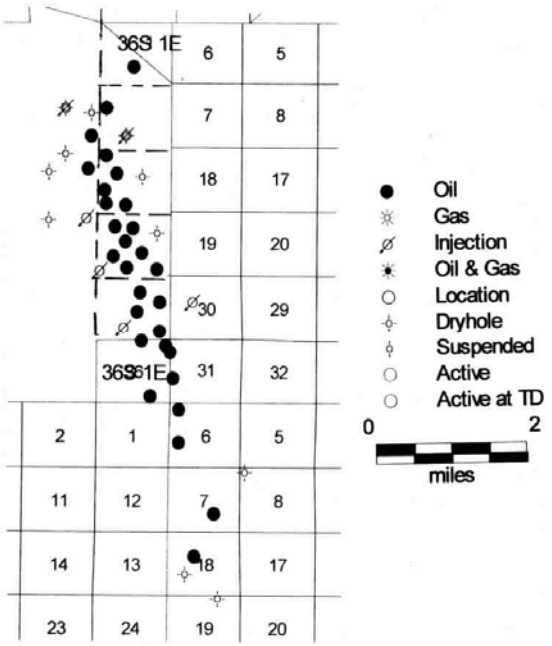


Figure 4. Upper Valley Oil Field. Modified from IHS Energy (2006).

Surface disturbance for the oil field is displayed below:

Discovery Pad and Road (Included under Exploration)	---
Production Wells and Roads and topsoil storage areas	176.7 acres
Central Production Facility	12.0 acres
Water Disposal Well and Road	9.0 acres
Overhead powerline and substation	25.4 acres
Additional Pipeline/Powerline Corridor	30.3 acres
Truck Loading Area	0.5 acres
Total Disturbance	**253.9 acres**

Based on the Upper Valley Field, oil production from the new field is estimated to be 2,000 barrels per day. The field is estimated to be productive at this level or reduced levels due to draw-down for approximately 30 years.

Water produced from the wells is assumed to be of poor quality; very high in total

dissolved solids. Reported water production at Upper Valley Field has averaged around 30,000 barrels per day (Utah Division of Oil, Gas and Mining) including reinjected water and similar rates are to be expected at the projected new field. It is assumed that water would be temporarily held in storage/evaporation ponds or tanks, then injected back into the ground; most likely to the aquifer from where it came. Water injection may also be used to enhance oil recovery by increasing reservoir pressures. Water injection/disposal is subject to regulation and permitting by the State of Utah to assure that no ground waters or surface waters are contaminated by industrial waters. Salt accumulations in the storage/evaporation ponds would be disposed of at facilities licensed to accept such wastes by the State of Utah.

Hydrogen sulfide (H2S), a toxic heavier-than-air gas, is produced with the oil at the Upper Valley Field. Releases into the air are regulated and managed using required monitoring, containment, and disposal methods. It is possible that similar concentrations of H2S could be encountered in the new field and that release into the adjacent environment would be controlled using current required and proven methods.

8.4 TOTAL ESTIMATED SURFACE DISTURBANCE

Gross Disturbance

Gross disturbance is the total of all disturbance regardless of the duration. The total estimated gross surface disturbance is displayed below by facility:

Seismic Exploration	422.5 acres
Exploration Wells	996.0 acres
Production Wells	176.7 acres
Central Production Facility	12.0 acres
Water Disposal Well	9.0 acres
Buried Pipeline and Powerline Corridors	30.3 acres
Overhead Powerline and Substation	25.4 acres
Truck Loading Facility	0.5 acres
Total Disturbance	**1,672.4 acres**

Net Disturbance

The total net or long-term surface disturbance after reclamation would be less than the total gross surface disturbance.

Surface disturbance for seismic lines is temporary, usually lasting only during the field season that operations occur. Operations are conducted by overland travel by rubber-tired vehicles or by helicopter and no road construction occurs.

Exploration well pads and roads (inherently non-productive) would be plugged,

abandoned, and reclaimed soon after drilling and revegetated, usually within 5 years.

Production pads and the water disposal well pad would be partially reclaimed to a smaller area needed for production and workover (periodic cleaning of the bore with drill rigs) operations. Approximately 1/3 of the original pad area needed for drilling would be reclaimed and cut and fill slopes would be reduced to facilitate long-term erosion control and revegetation (5.9 acres/well x 0.67 = 3.75 acres/well).

The total estimated net surface disturbance is displayed below:

Production Wells and Access Roads	144.6 acres
Central Production Facility	12.0 acres
Water Disposal Well	7.0 acres
Overhead Powerline and Substation	25.4 acres
Buried Pipeline and Powerline Corridors	30.3 acres
Truck Loading Facility	0.5 acres
Total Net Disturbance-Production facilities	**219.8 acres**

At the end of the 15-year analysis period it is assumed that the total area of surface disturbance would be 219.8 acres associated with production facilities plus the residual disturbance remaining to be reclaimed for exploration wells drilled during the final five years (332.0 acres), for a total of 551.8 acres.

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APPENDIX A

Mineral Occurrence Potential Classification System

This report uses the mineral occurrence potential classification system found in BLM Manual 3031, *Energy and Mineral Resource Assessment.* The dual system uses a potential rating and a level of certainty rating as defined below.

Level of Potential:

0. The geologic environment, the inferred geologic processes and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.

L. The geologic environment and inferred geologic processes indicate low potential for accumulation of mineral resources.

M. The geologic environment, the inferred geologic processes and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

H. The geologic environment, the inferred geologic processes, the reported mineral occurrences and/or valid geochemical/geophysical anomaly and the known mines or deposits indicate high potential for accumulation of mineral resources. The “known mines and deposits” do not have to be within the area being classified, but have to be within the same type of geologic environment.

ND. Mineral(s) potential not determined due to lack of useful data. This notation does not require a level of certainty qualifier.

Level of Certainty:

A. The available data are insufficient insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources in the respective area.

B. The available data provide indirect evidence to support or refute the

possible existence of mineral resources.

C. The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidence to support
or refute the possible existence of mineral resources.

APPENDIX B

Maps

Map 1. Land Ownership

Map 2. U. S. Geological Survey Plays (1995)

Map 3. Oil and Gas Occurrence Potential

Map 4. Authorized Oil and Gas Leases

Map 5. DNF Lands Nominated for Oil and Gas Lease Sales 2005 – 2006

Map 6. Oil and Gas Development Potential

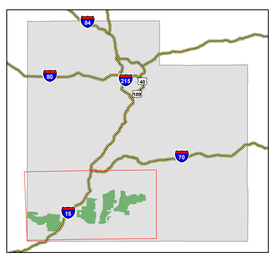
Oil & Gas Leasing EIS on Lands Administered by the Dixie National Forest

Dixie National Forest Location Map

Prepared by JBR Environmental Consultants
5 January 2007

1:240,000

Horizontal Datum = NAD 83
Coordinate System = Zone 12N



Legend

- Cities
- Minor Roads*
- Highways
- Interstates
- Water Bodies
- State Boundaries

National Forest System Lands

- Dixie National Forest
- Fishlake National Forest
- NFS Wilderness Areas

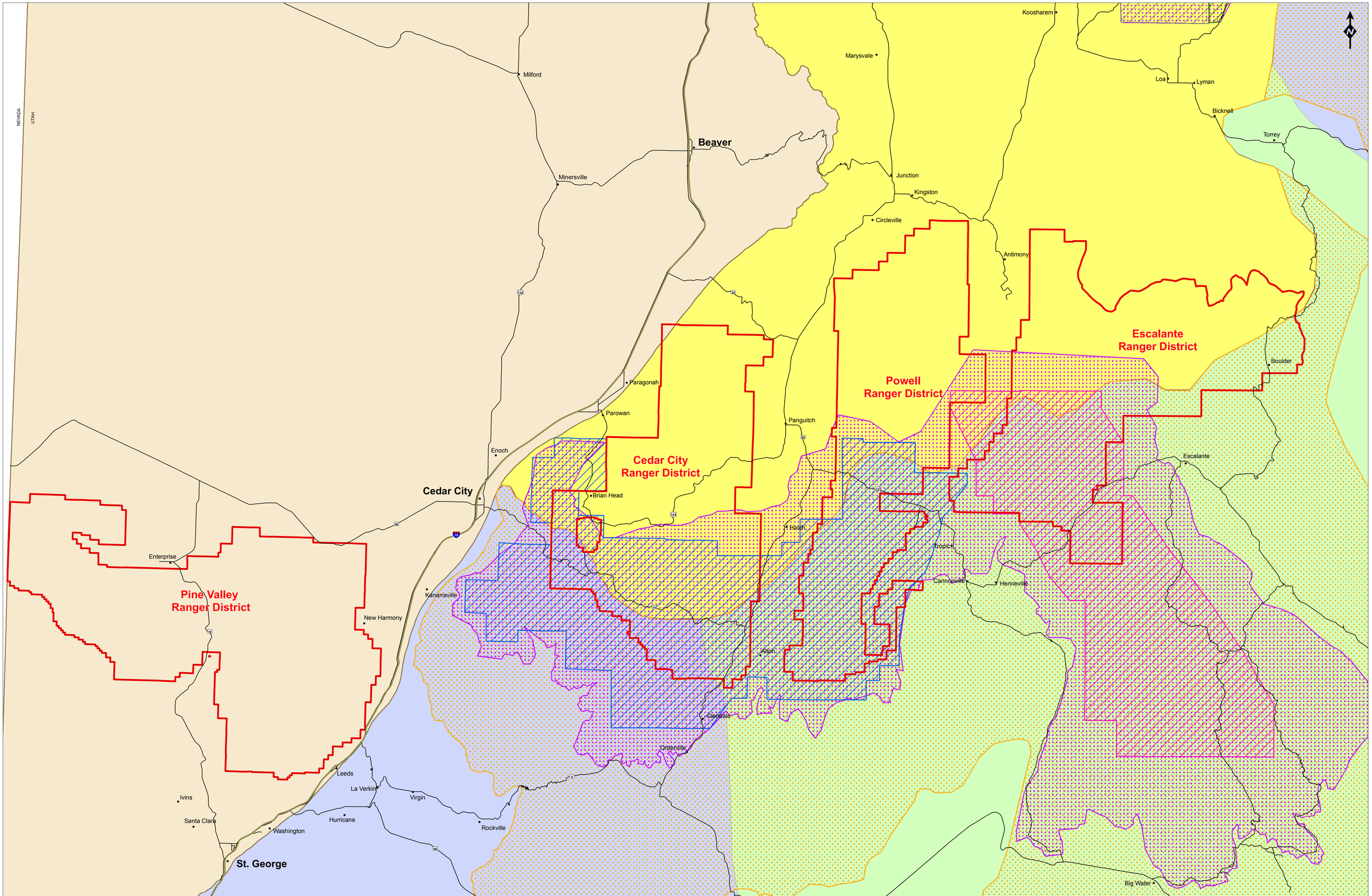
Other Land Administration

- Private
- Bureau of Land Management
- National Park Service
- State of Utah
- Tribal
- Grand Staircase-Escalante National Monument**

*Not all roads are shown. Only some roads are depicted for orientation purposes.
**Managed by the Bureau of Land Management.

Original data was compiled from multiple source data and may not meet the U.S. National Mapping Accuracy Standard of the Office of Management and Budget. For specific dates and/or additional digital information, contact the Forest Supervisor, Dixie National Forest, Cedar City, Utah. This map has no warranties to its contents or accuracy. THIS MAP IS A PRELIMINARY DRAFT FOR SCOPING PURPOSES ONLY.

Miles
0 4 8 12 16



DIXIE OIL & GAS EIS

Oil & Gas Plays and Carbon Dioxide Plays

Dixie National Forest

Prepared by JBR Environmental Consultants

4 December 2006

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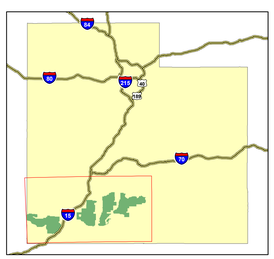
Coordinate System = Zone 12N



Legend

- Cities
- Major Roads
- Freeways
- State Boundaries
- Dixie National Forest (1)

Plays on Dixie National Forest (2)

- Cretaceous conventional play
- Permo-Triassic oil and gas play
- Proterozoic/Cambrian oil & gas play
- Carbon dioxide play (3)

Devonian-Pennsylvanian plays

- Basin and Range Dev.-Penn. oil and gas play
- Paradox Basin Dev.-Penn. oil & gas play

Coalbed Gas Plays

- Emery Sandstone Member play
- Dakota Formation play
- John Henry Member play
- Ferron Sandstone Member play

Miles: 0, 7.5, 15, 22.5, 30

(1) Excludes Fremont Ranger District (administered by Fishlake National Forest).
(2) From Utah Geological Survey Report: The Oil, Gas, Coalbed Gas, Carbon Dioxide, and Geothermal Resources of the Dixie National Forest, Southwestern Utah. April 2004.
(3) Includes Devonian-Pennsylvanian, Proterozoic/Cambrian, and Permo-Triassic carbon dioxide plays.

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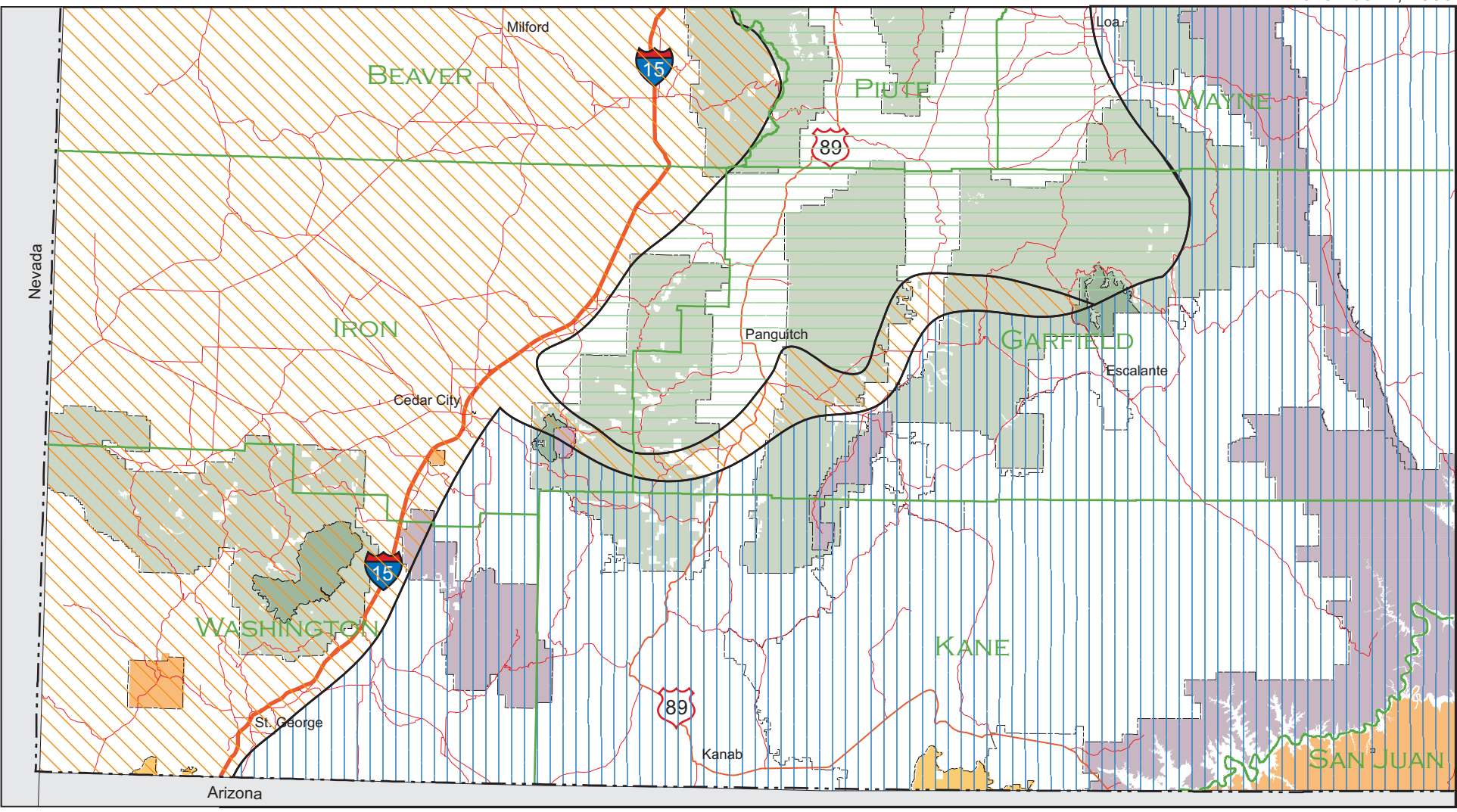
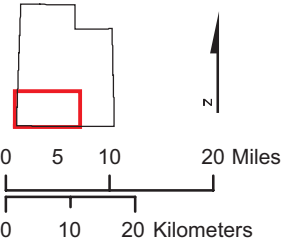
Oil and Gas Occurrence Potential

November 1, 2006





Low Potential / Low Certainty

High Potential / Low Certainty

Moderate Potential / Low Certainty

BLM Wilderness

Indian Reservation

National Forest Wilderness

National Forest

National Park

Map - 3

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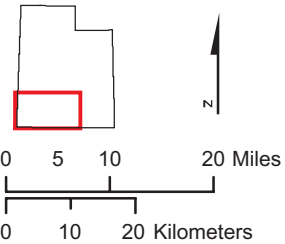
Authorized Oil and Gas Leases

November 1, 2006

Milford
Loa
BEAVER
PIUTE
WAYNE
15
89
Nevada
IRON
Panguitch
GARFIELD
Escalante
Cedar City
15
WASHINGTON
KANE
89
St. George
Kanab
SAN JUAN
Arizona

Map - 4



Authorized Oil and Gas Leases

National Park
BLM Wilderness
Indian Reservation
National Forest Wilderness
National Forest

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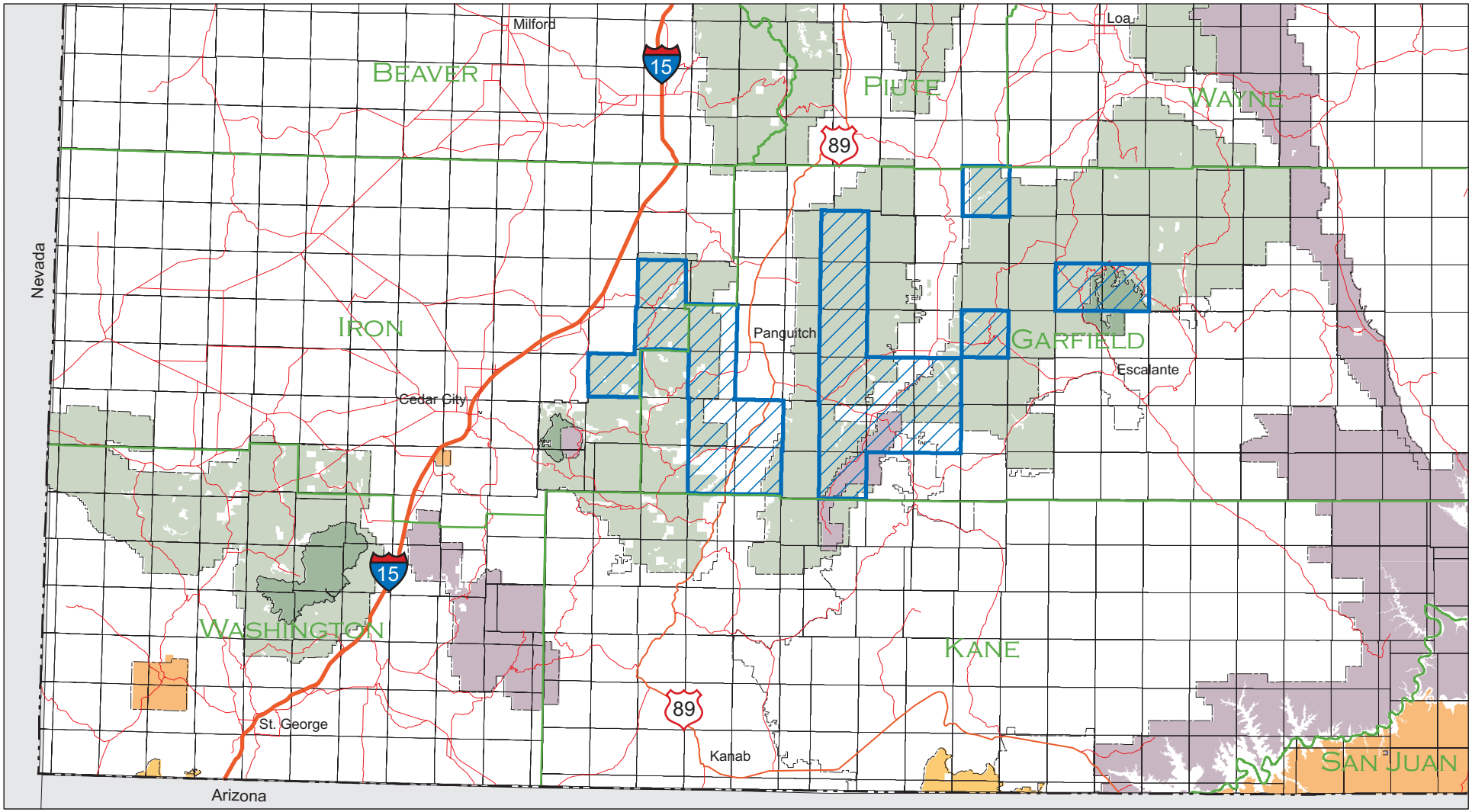
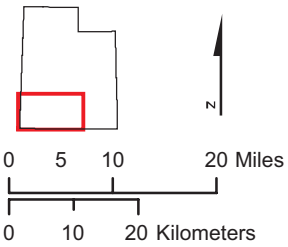
DNF Lands Nominated for Oil & Gas Lease Sales 2005 - 2006

November 1, 2006





- BLM Wilderness
- Indian Reservation
- National Forest Wilderness
- National Forest
- National Park
- Townships Where Lands Were Nominated

Map - 5

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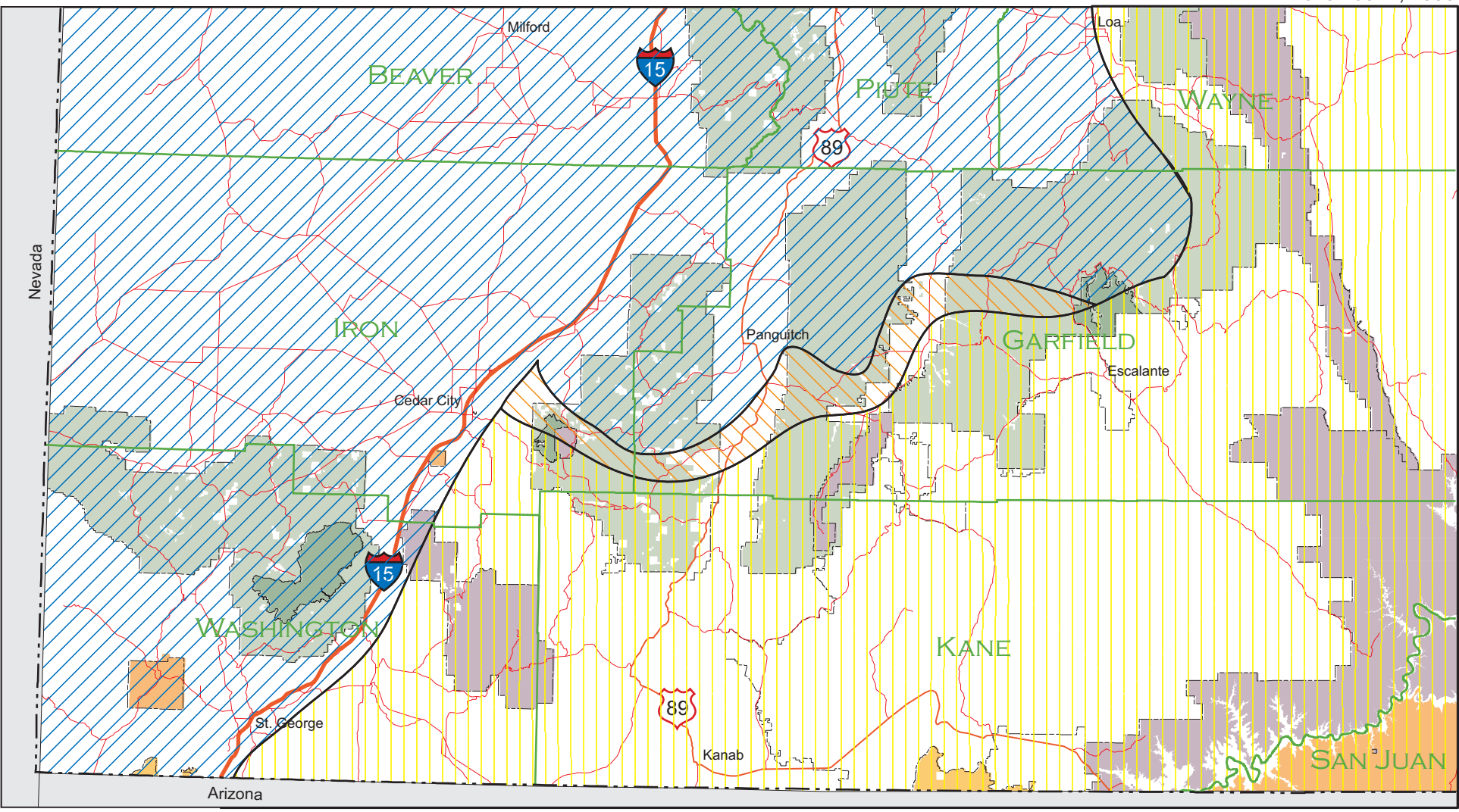
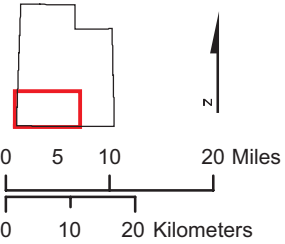
Oil and Gas Development Potential

November 1, 2006





High Potential

Moderate Potential

Low Potential

BLM Wilderness

Indian Reservation

National Forest Wilderness

National Forest

National Park

Map - 6

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Oil and Gas Engineering Report
Dixie National Forest Oil and Gas Leasing Analysis

This report provides engineering estimates of surface disturbance associated with oil and gas facilities that could be constructed following leasing on the Dixie National Forest. Assumptions and calculations are described.

Exploration Wells

Summary of Surface Disturbance:

Exploration well pads	= 5.9 acres per well
Road Construction (including topsoil storage)	= 4.1 acres per well
Road Reconstruction	= 6.6 acres per well
Total surface disturbance	= **16.6 acres per well**

Assumptions and calculations:

- *Well pad dimensions*. The well pad would be 425 feet x 350 feet with a 1 foot vertical x 3 foot horizontal ditch on the cut slope side and an 18-inch high berm 1 foot wide at the top with 1.5 horizontal to 1 foot vertical slope ratio. Clearing widths are 5 feet beyond the toe of slope and 5 feet beyond the top of cut.
- *Well pad disturbance.* Surface disturbance for well pads: On a 5% cross section slope and a 5 foot clearing width beyond top of cut and toe of fill = 4.6 acres (491 feet x 406 feet/43,560 sq feet per acre). On a 20% cross section slope with 5-feet clearing beyond the top of cut and toe of fill = 7.2 acres (616 feet x 506 feet/43,560 sq feet per acre). An average disturbance of 5.9 acres [(4.6 + 7.2) / 2] is projected for a typical well pad.
- *Topsoil storage for well pads.* Approximately 5,600 cubic yards of top soil will be stored for reclamation based on salvaging top soil on an average of 6 inch depth. The top soil storage area would represent an area approximately 85 feet x 125 feet = 0.25 acre per well pad.
- *Average road construction distance*. The Dixie used a GIS-based analysis to determine the average straight-line distance of new road construction required to reach a typical well pad is 0.52 miles (See GIS Methodology Report in Project File). The straight-line distance was plotted and laid out on a contour map at a 6% average road grade. (This analysis was conducted by the Fishlake National Forest Road Engineer and the following adjustment factor was used for both the Fishlake and Dixie). This resulted in an increase in projected new road length by a factor of 1.27. The adjusted distance of new construction necessary for a typical exploration well on the Dixie National Forest is 0.66 miles (0.52 miles x 1.27).
- *Exploration road dimensions.* The road template is 18 feet wide. This provides adequate width for a 16 foot subgrade to accommodate a road base of 6 inch depth, and a 0.5 foot deep ditch for erosion control. Road cut slope ratio is 1:1 and road fill slope ratio 1.5 horizontal to 1 foot vertical. Road side clearing is 5 feet beyond the top of cut and 10 feet below toe of fill. Ten feet below the toe of fill provides sufficient area to treat road construction slash.

- *Road construction disturbance area.* Using an average cross section slope of 20%, the surface disturbance for each mile of new road construction is 6.15 acres. An average road width of 39 feet is used (24 feet + 15 feet clearing distance). This yields an average disturbed area of 4.72 acres (39 feet x 5,280 feet per mile /43,560 square feet per acre = 4.72 acres, which is increased by a 1.25 adjustment factor to 5.9 acres for curve widening, turnouts, and adequate road widths to provide for hauling by transport equipment. To account for topsoil storage, an additional 0.25 acres per mile is added to yield an average disturbance of 6.15 acres per mile of new road.
- *Road reconstruction distance.* From the Dixie's GIS-based distance analysis (GIS Methodology Report), the average straight-line distance from a well pad to an improved road (Maintenance Level 3, 4, or 5) is 3.20 miles. The terrain adjustment factor (1.27) applied to new road construction is also applied to road reconstruction, resulting in an adjusted average distance from a typical pad to an improved road of 4.07 miles. To estimate the average length of road reconstruction needed for access to an exploration well pad, the adjusted road construction distance is subtracted from the adjusted distance to an improved road, yielding 4.07 – 0.66 = 3.41 miles. This distance is increased by 15% to meet road maintenance objectives for an improved road including larger curve radii, producing an average reconstructed road length of 3.92 miles.

  Road reconstruction disturbance area. Many of the Forest Roads are not currently constructed to the objective road maintenance level. Most lack gravel road base, turnouts, ditches, and curve widening to accommodate heavy and long loads on transport vehicles. It may be necessary to relocate portions of existing roads where the road grades exceed 8%. The surface disturbance for road reconstruction would generally be limited to excavation and clearing to widen roads for gravel, turnouts, curve widening, ditches, and in few areas modifying the road template to accommodate heavy equipment access.

  The following improvements would be made during reconstruction (assuming a cross section slope of 20%):

  - Construct 3 additional turnouts per mile of road (10 ft width 100 ft length/43,560 sq ft per acre) = 0.07 acres per mile;
  - Construct 3 additional curve widening areas per mile of road (6 ft width 100 ft length/43,560 sq ft per mile) = 0.04 acres per mile;
  - Widen the existing road subgrade to accommodate gravel road base (6" to 12" depth dependent on subgrade viability);
  - Ditch construction (1 foot depth, 3:1 slope);
  - Modify cut and fill slopes to accommodate heavy equipment access.

  The dimensions used to estimate road widening and other improvements:

  - Width of an existing primitive road of 25 feet (generally a 12 foot road without ditches + cut and fill slopes with minimal clearing beyond the road subgrade). The width of a reconstructed road is 38 feet (18 foot subgrade + 3 foot ditch + 7 foot cut and fill slope modification + 10 foot clearing for site distance). After reconstruction this would yield 13 feet

additional disturbance width (38 foot width for reconstruction – 25 foot width previously disturbed for the existing road).

This results in an average disturbed area for road widening of 6.18 acres per exploration well (13 feet x 5,280 feet per mile/43,560 sq feet per acre x 3.92 miles average reconstruction distance per well).

The total disturbance per exploration well associated with road reconstruction would be:

Road widening:	6.18 acres
Turnouts:	0.28 acres
Curve widening:	0.16 acres
Total =	6.62 acres per well

Production Wells and Facilities

Summary of Surface Disturbance:

Production Well Pads	= 5.9 acres per well
Road Construction	= 3.1 acres per well
Topsoil storage	= 0.25 acres per well
Road Reconstruction	= 0.0 acres per well
Surface disturbance from wells and roads	= **9.3 acres per well**
Central Production Facility	= 12.0 acres per field
Overhead powerline and substations	= 25.4 acres per field
Additional buried powerline/pipeline corridor	= 30.3 acres per field
Water injection well and road	= 9.0 acres per field
Truck loading area	= 0.5 acres per field

Assumptions and calculations:

- *Well pads, access roads, and topsoil storage areas*. Dimensions and disturbance areas for these facilities would be the same as those determined for exploration facilities.
- *Discovery well to production well.* One production well will have been converted from an exploratory (discovery) well.
- *Miles of new road project road construction and surface disturbance*. The access road to the discovery well will have been constructed by the exploratory well development. Based on the well spacing and distance between pads, approximately 0.5 mile of new access road would be constructed as spur roads for each of the multi-well production pads, each road represents 3.1 acres of surface disturbance (6.15 acres per mile x 0.5 mile).
- *Miles of reconstruction of forest roads and surface disturbance.* Road reconstruction would be completed during the exploration pad development for the well that led to the discovery of the field. No additional surface disturbance is anticipated when production begins.

- *Central Production Facility.* The size of central production facilities will vary depending on the volumes of produced liquids, shop and office facilities required and other factors. The most recently constructed central production facility in the area is at the Covenant Field and occupies approximately 29 acres. This facility is on land owned by the operator and the facility is considerably larger than one located on National Forest lands would be. A reasonable size for the postulated facility on the Dixie National Forest would be 12 acres.
- *Pipelines and Powerlines.* Using the Upper Valley oil field as a model, it is assumed that a new overhead powerline of approximately 5 miles and occupying 25 acres, and a substation of approximately 0.4 acres, would be necessary to provide electric power for the operation. Distance and areas were taken from special use files for those facilities at the Upper Valley field. Pipelines and power lines within the new oil field would mostly be buried under access roads and the produced oil would be trucked to market. However, it might be necessary to locate some portions of the lines in other areas or adjacent to existing roads to avoid sharp bends and other features. It is assumed that an additional 50-foot wide corridor could be disturbed for a distance of 5 miles for a total of 30.3 acres (5 miles x 50 feet/43,560 square feet per acre).
- *Water Injection Well.* A water injection well would likely be constructed with similar dimensions as an exploratory well pad (5.9 acres) and require approximately 0.5 mile of new road construction (3.1 acres) resulting in 9.0 acres of surface disturbance.
- *Truck Loading Area.* Oil would most likely be piped from the central production facility to a truck-loading facility adjacent to a major highway. Construction of a truck-loading facility would involve disturbance of another 0.5 acres.

GIS Methodology Used to Estimate Road Construction and Reconstruction Distances for the Reasonably Foreseeable Development Scenario Dixie National Forest Oil and Gas Leasing Analysis

Created grid of the forest with 5-acre parcels using the Fishnet command. Placed point at the center of each cell.

Used only roads that are "classified" or State/Federal/County on National Forest System Land.

Utilized the "near" command to determine nearest road to each point.

Selected for level 3, 4, or 5 roads, added the State, Fed, County and checked data. The exterior Forest boundary was not included in the dataset. Then started the "Near" process again (near point_cov route_cov line 202300 new_cov) and let it run.

The results are shown in Table 1.

Supplemental GIS specifics:

Generating using fishnet command:

1) Determine the coordinates for the physical extent of the area of interest.
Arc: Generate <filename>
Generate: fishnet
Fishnet Origin Coordinate (x, y): 360416.964, 4198075.246 (xmin, ymin)
Y-Axis Coordinate (x, y): 360416.964, 4380566.761 (xmin, ymax)
Cell Size (width, height): 100.584, 100.584 (distance on side, in meters)
Number of Rows, Columns: 0
Opposite corner of fishnet (x, y): 483623.386, 4380566.761 (xmax, ymax)
Generate: q

The fishnet is created as lines and as points that are placed at the center of each grid. The points are what were used for the analysis. If another (larger) base size is desired, another fishnet is created with different specifications. The larger the base size, the faster the process will run.

2) Next an identity of the fishnet was run with Forest Service ownership and reselected for the specified criteria. The final process included points on private land; but all points that were not within the Forest boundary were deleted. Also, all points in Forest Service Wilderness and Cedar Break National Monument were deleted.

3) Appropriate roads were then selected. The analysis was run twice—once with all Level 2, 3, 4 and 5 roads plus the State, Federal, County routes; and another with just the level 3, 4, and 5 routes plus State/Federal/County.

4) Finally, the "Near" command was run between the selected fishnet points and the selected travel route layer and then the output was analyzed.

The result was a point coverage with a column for the straight-line distance in meters to the nearest route.

Meters were converted to miles in the following table. The average distance was adjusted (increased) to account for the additional road length that would be necessary to maintain a 6% road grade on typical terrain over that distance. The average length of road re-construction was estimated by subtracting the average distance to Forest Maintenance Level 2, 3, 4 and 5 roads from the average distance to Level 3, 4 and 5 roads (considered *improved* roads), which was then increased by 15% to meet higher road maintenance level objectives.

Table 1.

District	Acres	Wilderness /Other	Acres	Net Acres		Average Distance to Level 2,3,4,5 Roads	Average Distance to Level 3, 4, 5 Roads
PINE VALLEY	481,212	PINE VALLEY	50,232	430,979		0.58	2.62
CEDAR CITY	404,260	ASHDOWN GORGE and CEDAR BREAKS	13,177	391,083		0.36	1.23
POWELL	388,598			388,598		0.58	7.28
ESCALANTE	436,575	BOX DEATH HOLLOW	25,564	411,011		0.54	1.87
Totals	1,710,645		88,973	1,621,672	**Area-Weighted Average Straight-line Distance**	0.52	3.20
					Adjusted Road Construction Distance (for 6% road grade)	0.66	4.07
				Average length of road re-construction		3.41	
				Average length of road re-construction (increased by 15% to meet road maintenance objectives)		3.92	

Spatially Adjusting the Dixie National Forest Reasonably Foreseeable Development Scenario for Environmental Impact Analysis

Following are the assumptions and criteria used to estimate the spatial and timing distribution of oil and gas exploration and development activities and facilities on the Dixie National Forest over the 15-year Reasonably Foreseeable Development Scenario (RFDS) analysis period.

The RFDS report projects 60 exploration wells over 15 years following leasing, or a forest-wide average of 4 wells per year. It estimates that exploration drilling during this period would result in a discovery of one oil and gas field with 20 production wells. During the same period, it is expected that 700 line miles of seismic data will be acquired on the Forest.

Exploration Drilling. The maps of the oil and gas development potential and of the lands nominated for oil and gas leases sales between 2005 and 2006 shown in the RFDS report were used to estimate the proportion of the exploration drilling that would occur on each of the four Ranger Districts (Pine Valley, Cedar City, Powell, and Escalante):

- Roughly the southern one-third to one-half of the Cedar City, Powell, and Escalante Ranger Districts have high or moderate potential for oil and gas development. The northern two-thirds to one-half of those Ranger Districts have low development potential. The entire Pine Valley Ranger District is rated as having low development potential.
- Current oil and gas industry interest, which would be reflected in the lands nominated for lease sales between 2005 and 2006, is somewhat evenly distributed among the Cedar City, Powell, and Escalante Ranger Districts. No interest was expressed for leasing lands on the Pine Valley Ranger District during that period.

Using these criteria results in the following estimates of the number of exploration wells that would occur on each Ranger District over the 15-year period:

Pine Valley:	5 wells; an average of one well every three years
Cedar City:	15 wells; an average of one well per year
Powell:	20 wells; an average of four wells every three years
Escalante:	20 wells; an average of four wells every three years

In order to fully evaluate the environmental effects of concurrent exploration activity for the analysis, it can reasonably be assumed that three exploration drilling operations could occur at one time on each of the Ranger Districts.

Oil and Gas Field. Exploration drilling is expected to result in one oil and gas field on the Forest in 15 years. For full impact analysis, the environmental consequences will be evaluated as if it were to occur on each of the Ranger Districts.

Geophysical Operations. Considering development potential and current industry interest for each of the Ranger Districts, the following prorated distances of seismic lines can be reasonably expected to occur over 15 years:

Pine Valley:	100 miles
Cedar City:	200 miles
Powell:	200 miles
Escalante:	200 miles

It is assumed based on project processing timeframes that 50 to 100 miles of geophysical surveys could occur on each of the Ranger Districts in any year.