Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and the Extent and Nature of Restrictions or Impediments to Their Development

PHASE II CUMULATIVE INVENTORY:

NORTHERN ALASKA; MONTANA AND WYOMING THRUST BELTS; UINTA-PICEANCE, PARADOX/SAN JUAN, POWDER RIVER, GREATER GREEN RIVER, DENVER, BLACK WARRIOR, AND APPALACHIAN BASINS; AND THE FLORIDA PENINSULA

IN COMPLIANCE WITH THE ENERGY ACT OF 2000, P.L. 106-469 §604 AS AMENDED BY THE ENERGY POLICY ACT OF 2005, P.L. 109-58 §364

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EXECUTIVE SUMMARY

THE MANDATE FROM CONGRESS

In November 2000, Congress passed and President Clinton signed the Energy Act of 2000 (also referred to as the Energy Policy and Conservation Act [EPCA]). The Act directed the Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, to conduct an inventory of oil and natural gas resources beneath onshore Federal lands:[1]

The inventory shall identify:

1) the United States Geological Survey estimates of oil and gas resources underlying these lands;

2) the extent and nature of any restrictions or impediments to the development of the resources, including—

(A) impediments to the timely granting of leases;

(B) post-lease restrictions, impediments, or delays on development for conditions of approval, applications for permits to drill, or processing of environmental permits…

The EPCA marked the first time that Congress asked the Department of the Interior to conduct a study of restrictions.

On October 11, 2001, Congress provided its sense of priority for this study:

> . . . in light of recent attacks on the United States that have underscored the potential for disruptions to America's energy supply, the managers believe this project should be considered a top priority for the Department.

In August 2005, Congress passed and President Bush signed the Energy Policy Act of 2005 (EPAct 2005). Section 364 of this Act amends the inventory requirements of EPCA. [2]

This release presents a large majority of the inventory of public oil and gas resources requested by Congress. The EPCA Phase II inventory is a comprehensive review of Federal oil and gas resources and constraints on their development within 11 geologic provinces across the United States. It is cumulative in that it incorporates the Phase I areas (geologic provinces of the Interior West). Further, it represents an expansion of the inventory to include previously unstudied areas in the Interior West, Northern Alaska and several Eastern basins (Figure ES-1).

The EPCA requires that all onshore Federal lands be inventoried. Areas addressed in the Phase II inventory contain approximately 76 percent of the onshore natural gas and

[1] Federal lands are defined as not including Indian lands.

[2] EPAct 2005 amends the inventory requirements at 42 USC 6217. The updates have been reflected in the text of this document.

oil under Federal ownership. The inventory will be expanded in the future to include all Federal lands and resources.

Figure ES-1. Study Area Locations

For the Federal agencies that manage public land (principally the Department of the Interior's Bureau of Land Management [BLM] and the U.S. Department of Agriculture's Forest Service [USDA-FS]) and the citizens they serve, this inventory will serve primarily as a planning tool. It provides public land managers with additional information to help them develop management plans for the lands under their jurisdiction. It enables them to identify areas of high oil or gas potential and to evaluate the effectiveness of mitigating stipulations and conditions of approval in balancing the responsible development of those resources with the protection of other valuable resources in the area. The inventory also allows resource managers to identify areas of low oil and gas potential, but high potential for other resources (e.g., wildlife habitat) or uses (e.g., recreation). In these situations, resource managers and oil and gas operators can consider applying land management strategies that promote increased protection of other valuable resources or uses that might ordinarily conflict with oil or gas development. This report is a critical step in evaluating whether the documented impediments and restrictions are appropriate, or are unnecessarily interfering with oil and gas development.

THE PRESIDENT'S NATIONAL ENERGY POLICY DIRECTIVES

In May 2001, President Bush's National Energy Policy directed that the EPCA inventory be expedited and that constraints to Federal oil and gas leasing be reassessed and modified "where opportunities exist (consistent with the law, good environmental practice, and balanced use of other resources)." The National Energy Policy further directed that any reassessment of constraints be conducted "with full public consultation, especially with people in the region." This inventory provides information regarding the geographical relationship between oil and gas resources and the constraints that govern their development. It is not a reassessment of any stipulations or conditions of approval on the development of oil and gas resources. The public's opportunity to participate in any change of restrictions on oil and gas activities will occur during the land use planning or legislative process. This inventory provides some basic information for any such process. Additional information may be available from monitoring and scientific studies incorporated into adaptive management processes.

The National Energy Policy provides an overview of the U.S. energy situation and alternatives available to increase energy efficiency and conservation, increase energy supplies, and protect the environment. At the direction of Congress, the present study focuses on the traditional energy resources of oil and natural gas beneath Federal lands.[3]

[3] In recognition of the increased emphasis on the development of alternative energy resources in the National Energy Policy, the Department of Energy, in coordination with the Department of the Interior, has released a report,

This inventory was prepared under the lead of the Bureau of Land Management. Senior professionals from the Department of the Interior's BLM and United States Geological Survey (USGS), the USDA-FS; the Department of Energy (DOE)-Office of Fossil Energy, and the Energy Information Administration (EIA) were the major contributors. The USGS provided the assessment of undiscovered technically recoverable oil and natural gas resources beneath Federal lands based on commercially available data. The EIA contributed the analysis of reserves growth and proved reserves for Federal lands. The DOE provided technical expertise to guide the design and analysis process for the inventory. Field offices of the BLM and the USDA-FS contributed their land use planning information regarding oil and natural gas availability and leasing stipulations for the lands under their respective jurisdictions.

METHODOLOGY

This inventory is based on information that has been previously developed through the scientific and planning processes of the contributing Federal agencies. This information has in large part been provided to the public for its review and use and is the best that is commercially and scientifically available. It has been compiled and analyzed by experts from the contributing agencies. The analytical methods and protocols used in the supporting studies have been subjected to rigorous review. The present study necessarily incorporates the assumptions, conditions, and limitations of the supporting scientific information as discussed in this report. This inventory is significant because it builds upon the process established in the EPCA Phase I inventory. It examines oil and gas (undiscovered technically recoverable resources and reserves growth) in context with information about constraints on their development.

The Phase II inventory examines six geologic provinces in addition to the five areas examined within the Interior West in the Phase I inventory. These six provinces are Northern Alaska (the National Petroleum Reserve in Alaska [NPR-A] and the Arctic National Wildlife Refuge [ANWR] Section 1002 only); the Wyoming Thrust Belt in Wyoming, Utah, and Idaho; the Denver Basin in Colorado, Wyoming, Nebraska, and South Dakota; the Florida Peninsula; the Black Warrior Basin in Mississippi and Alabama; and the Appalachian Basin in Tennessee, Kentucky, West Virginia, Virginia, Maryland, Ohio, Pennsylvania, New Jersey, and New York. These areas were selected for Phase II of the inventory because, as a group, they include Alaska, a state containing important oil and gas resources, and contain a large portion of the inventoried onshore Federal oil and gas resources in the lower-48 states relative to the EPCA Phase I study areas. In addition, especially in the West, the Federal lands within these areas are becoming increasingly important for recreation, livestock grazing, open space, wildlife habitat, cultural resources, and mining, as well as oil and gas and other energy production.

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analogous to the present report, on the potential of Federal lands to support alternative energy technologies such as wind, solar, and biomass. See http://www.nrel.gov/docs/fy03osti/33530.pdf

The Phase II inventory encompasses 295 million acres, of which about 99 million acres are under Federal management. This acreage includes split estate lands where private surface lands are underlain by Federal mineral rights.

This analysis of constraints to development centers on two factors that affect access to oil and gas resources on Federal lands. These factors are (1) whether the lands are "open" or "closed" to leasing, and (2) the degree of access afforded by lease stipulations and other conditions on "open" lands (some leasable lands may in effect be "closed" if no drilling can occur). All oil and gas leases are subject to a baseline level of constraint governed by statutory and regulatory requirements. These stipulations serve many purposes, ranging from the protection of environmental, social, historical, or cultural resources or values to the payment of rentals and royalties.

The Phase II inventory finds that approximately 2,130 individual lease stipulations are being applied by the land managing agencies in the areas analyzed. To focus the analysis of constraints on oil and gas development, the inventory evaluates the onshore Federal lands: (1) where leasing is permitted under standard stipulations; (2) where leasing is permitted with varying limitations on access, principally seasonal occupancy restrictions; and (3) where oil and gas leasing is precluded or prohibited. The inventory also considers exceptions to stipulations that are granted after a review of on-the-ground conditions and the use of modern technologies such as directional drilling. The impact of conditions of approval (COAs) attached to Federal drilling permits is also analyzed, which gives a more complete assessment of access constraints. A total of 175 unique COAs were identified and their effects on development evaluated. The nine categories of constraints analyzed in this report include the complete range of access restrictions associated with oil and gas leasing.

RESULTS

The results of this cumulative Phase II inventory are unique for each of the eleven areas examined. The aggregate results for all of the areas (Table ES-1, Figure ES-2, and Figure ES-3) are summarized below.

- Total Federal lands, including split estate, total 99.2 million acres.
- Undeveloped oil resources under these Federal lands total 21.2 billion barrels, comprising 20.6 billion barrels of undiscovered technically recoverable resources and 593 million barrels of reserves growth.
- Undeveloped gas resources under these Federal lands total 186.9 trillion cubic feet, comprising 181.9 trillion cubic feet of undiscovered technically recoverable resources and 4.98 trillion cubic feet of reserves growth.
- Total proved reserves under these Federal lands total 444 million barrels of oil and 26.3 trillion cubic feet of natural gas.
- Approximately 24 percent of the Federal land in these areas (23.8 million acres) is accessible under standard lease terms. Based on resource estimates, these lands contain 3 percent of the oil (743 million barrels) and 13 percent of the gas (25.2 trillion cubic feet).

- Approximately 30 percent (30.0 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard stipulations. Based on resource estimates, these lands contain 46 percent of the oil (9.7 billion barrels) and 60 percent of the gas (111.5 trillion cubic feet).
- Approximately 46 percent (45.5 million acres) of the Federal land is inaccessible. Based on resource estimates, these lands contain about 51 percent of the oil (10.8 billion barrels) and 27 percent of the natural gas (50.1 trillion cubic feet).

Table ES-1. Summary of All EPCA Inventory Areas—Total Federal Land and Oil and Natural Gas Resources by Access Category
Figure ES-2. Simplified Results; Summary of All Phase II Study Areas—Total Federal Land and Resources by Accessibility
Figure ES-3. Results; Summary of All Phase II Study Areas—Total Federal Land and Oil and Natural Gas Resources by Access Category

Overall the study shows that oil and gas resources are concentrated in Northern Alaska and the Interior West. Figure ES-4 summarizes the accessibility of these resources (on a trillion cubic feet-equivalent basis).

Figure ES-4. Regional Charts

COMPLIANCE WITH THE LAW

All oil and gas leases on Federal land, including those issued with only the standard lease terms, are subject to full compliance with all environmental laws and regulations. These laws include, but are not limited to, the National Environmental Policy Act, Clean Water Act, Clean Air Act, Endangered Species Act, and National Historic Preservation Act. While compliance with these laws may delay, modify, or prohibit oil and gas activities, these laws represent the values and bounds Congress believes appropriate to place on Federal land managers for their stewardship of Federal lands. The present study was conducted at the request of Congress to provide information for forthcoming deliberations on the role of Federal lands in the U.S. energy supply.

It is important to emphasize that this inventory was prepared at the direction of Congress. It is not a decision-making document. The inventory identifies areas of varying oil and gas potential and the nature of constraints to the development of those resources in eleven areas across the U.S. Any reassessment of restrictions on oil and gas activities will occur as part of the public land use planning or legislative processes, both of which are fully open to public participation and debate about the appropriate balance between resource protection and resource development.

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1.0 INTRODUCTION

As the energy needs of the nation continue to grow, the onshore sedimentary basins of the United States become increasingly significant oil and natural gas sources to help meet these needs, especially for natural gas. In 2005, the U.S. consumed about 22 trillion cubic feet (TCF) of natural gas, produced approximately 18 TCF of that consumption domestically, and imported the remaining 4 TCF. Onshore Federal lands produced about 16% of the 2005 domestic consumption. The Energy Information Administration (EIA) in its *Annual Energy Outlook 2006* Reference Case predicts that the demand for natural gas will rise to nearly 27 TCF by 2025, of which over 5 TCF will be imported.[1]

Based on recent U.S. Geological Survey (USGS)[2] and Minerals Management Service (MMS)[3] assessments, the nation's undiscovered natural gas resources[4] total approximately 1,040 TCF. The largest potential source for domestic natural gas production is the Outer Continental Shelf (OCS) with approximately 40 percent of the nation's undiscovered natural gas resources. However, EIA data indicate that OCS natural gas production peaked in 1996 at 4.7 TCF and is forecast to be 4.3 TCF per year in 2025, based largely on production from the Gulf of Mexico.

The nation's second largest natural gas source is the nonfederal onshore lands and state waters, containing about 35 percent of the total.[5] Onshore Federal lands contain the remaining 25 percent. This inventory analyzes onshore Federal natural gas resources in 11 areas, totaling 187 TCF. This 187 TCF would be sufficient to meet the nation's current residential consumption for nearly 39 years.

Similarly, the U.S. consumed about 7.6 billion barrels (Bbbls) of oil in 2005. About 60% of this oil was imported. Onshore Federal lands produced about 5% of the 2005 domestic consumption. The EIA predicts that the nation will consume 9.5 Bbbls in 2025.

The nation's undiscovered oil resources total slightly over 133 Bbbls. Of that total, the MMS estimates that 86 Bbbls are offshore under the OCS, comprising 64 percent of the nation's resources. Federal onshore oil resources are the second largest potential source of production (20 percent) followed by state waters and nonfederal onshore resources (16 percent).

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[1] Available on the EIA website:
http://www.eia.doe.gov/oiaf/aeo/key.html
[2] Available on the USGS website:
http://energy.cr.usgs.gov/oilgas/noga/index.htm
[3] Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf, 2006 Update, available on the MMS website:
http://www.mms.gov/revaldiv/PDFs/2006NationalAssessmentBrochure.pdf
[4] See the "Undiscovered Petroleum Resources" definition in Appendix 2.
[5] Advanced Resources International estimate

This inventory estimates that, in the 11 areas examined, there are 21.2 Bbbls of oil resources on Federal onshore lands. Of that total, 17.1 Bbbls occur within just two areas of Northern Alaska: the National Petroleum Reserve–Alaska (NPR-A) and the Arctic National Wildlife Refuge (ANWR) 1002 area.

It is clear that Federal lands will be an important future energy supply source. According to the EIA, the Rocky Mountain region was poised in 2005 to eclipse the Gulf Coast as the single largest supplier of natural gas to the nation. The sedimentary basins in the Interior West are particularly significant future sources of natural gas, and the Alaska North Slope is similarly noteworthy with respect to both oil and gas. Considerable natural gas supply would become available to the lower 48 states with the building of an Alaskan natural gas pipeline.

Congress directed the Secretary of the Interior to inventory the nation's Federal onshore oil and gas resources in relation to Federal actions that inhibit access to these resources. The purpose of this inventory is to add clarity to the debate and assist energy policymakers and Federal land managers in making decisions concerning oil and gas development.

The Phase II inventory examines areas extending from Alaska to Florida (Figure 1-1). Of the more than 295 million acres within these study areas, over 99 million acres of Federal lands (including split estate) were analyzed.

Figure 1-1. Study Area Locations

A full set of acronyms used in this report, as well as a glossary, can be found in Appendices 1 and 2, respectively.

1.1 BACKGROUND

Access to Federal lands is probably the most oft-cited issue affecting onshore domestic oil and gas exploration and production. The restrictions and impediments that constrain access to Federal lands are frequently a complex patchwork of requirements that can preclude drilling or increase costs and delay activity. They include areas unavailable for leasing and areas where the minerals can be leased, but the surface of the land may not be occupied thereby affecting recovery of those resources. There are also limitations on drilling activities due to a variety of environmental considerations, typically manifested as lease stipulations and drilling permit conditions of approval (COAs).

Recent attempts to understand the impacts of Federal land management decisions on access to oil and gas resources began with a 1999 National Petroleum Council (NPC) study.[6] The NPC is an advisory committee to the Secretary of Energy.

One of the objectives of the NPC study was to collect and analyze data on land use and

[6] Meeting the Challenges of the Nation's Growing Natural Gas Demand, December 1999, available on the NPC website: http://www.npc.org/reports/ng.html

natural gas resources for Federal lands to identify opportunities for increasing natural gas supply from this area. The NPC identified the Interior West as a significant future source of gas supply to help meet the anticipated growing demand. The NPC also estimated that about 40 percent (137 TCF) of the potential supply from this region is currently unavailable for leasing or is subject to surface-use access restrictions because of competing uses or environmental considerations. This analysis was based on a limited sample of Federal lands in the region. The report was developed through a cooperative effort of Federal agencies, including the Department of Energy (DOE), the Bureau of Land Management (BLM), and the U.S. Department of Agriculture's Forest Service (USDA-FS) and the oil and gas industry. Representatives from state and local governments and other stakeholders also participated.

In response to the NPC recommendation, DOE, with the cooperation of the Department of the Interior (DOI) and the U.S. Department of Agriculture (USDA), embarked on an effort to assess the relationship between gas resources and land use restrictions on Federal lands. The first area studied was the Greater Green River Basin (GGRB) of Wyoming and Colorado. DOE released its report in May 2001, which showed that 53 percent of the GGRB's natural gas resources were either closed to development or available with restrictions.[7]

Both the NPC and DOE studies were substantially less comprehensive than the present Phase II inventory. While the DOE study was being conducted, EPCA was signed into law in November of that year. Section 604 of this act required a similar study, to be led by DOI in cooperation with the USDA and DOE, which was to include an analysis of undiscovered oil and natural gas resources and proved oil and gas reserves for all onshore Federal lands in the United States. The text of Section 604 and the related conference report are given below.

1.2 THE EPCA AS AMENDED BY THE EPAct 2005

SEC. 604. SCIENTIFIC INVENTORY OF OIL AND GAS RESOURCES[8]

(a) IN GENERAL—
The Secretary of the Interior, in consultation with the Secretaries of Agriculture and Energy, shall conduct an inventory of all onshore Federal lands. The inventory shall identify—

(1) the United States Geological Survey estimates of the oil and gas resources underlying these lands;

(2) the extent and nature of any restrictions or impediments to the development

[7] "Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, Study Methodology and Results," May 2001, available on the DOE website: http://fossil.energy.gov/programs/oilgas/publications/fla/Federal_Lands_Assessment_Report.html

[8] Section 604 of EPCA was amended by Section 364 of EPAct 2005 (42 USC 6217).

of the resources, including—

(A) impediments to the timely granting of leases;
(B) post-lease restrictions, impediments, or delays on development for conditions of approval, applications for permits to drill, or processing of environmental permits; and
(C) permits or restrictions associated with transporting the resources for entry into commerce; and

(3) the quantity of resources not produced or introduced into commerce because of the restrictions.';

(b) REGULAR UPDATE—Once completed, the USGS resource estimates and the surface availability data as provided in subsection (a)(2) shall be regularly updated and made publicly available.

(c) INVENTORY—The inventory shall be provided to the Committee on Resources of the House of Representatives and to the Committee on Energy and Natural Resources of the Senate within two years after the date of enactment of this section.

(d) ASSESSMENTS—Using the inventory, the Secretary of Energy shall make periodic assessments of economically recoverable resources accounting for a range of parameters such as current costs, commodity prices, technology, and regulations.

Congress further emphasized the importance of this inventory during the appropriation process:

CONFERENCE REPORT ON H.R. 2217, DEPARTMENT OF INTERIOR AND RELATED AGENCIES APPROPRIATIONS ACT, 2002

JOINT EXPLANATORY STATEMENT OF THE COMMITTEE OF CONFERENCE

The managers agree to the following:

… In light of recent attacks on the United States that have underscored the potential for disruptions to America's energy supply, the managers believe this project should be considered a top priority for the Department. [9]

1.3 THE NATIONAL ENERGY POLICY, MAY 2001

The President's comprehensive National Energy Policy, issued in May 2001, outlines more than 100 recommendations to diversify and increase energy supplies, encourage conservation, and improve energy distribution. The policy recommends a balanced approach that emphasizes renewable energy production, conservation, and traditional fossil fuel production. Oil and natural gas is a major component of the President's policy; in particular, examining ways to increase access to these resources. The Policy

[9] Congressional Record, October 11, 2001, House, p. H6526.

notes that some Federal lands otherwise available for leasing, have been legislatively or administratively withdrawn from leasing. The Vice-President's National Energy Policy Development Group recommended:

> …that the President direct the Secretary of the Interior to examine land status and lease stipulation impediments to Federal oil and gas leasing, and review and modify those where opportunities exist (consistent with the law, good environmental practice, and balanced use of other resources).
>
> Expedite the ongoing Energy Policy and Conservation Act study of impediments to Federal oil and gas exploration and development, and
>
> Review public lands withdrawals and lease stipulations, with full public consultation, especially with the people in the region, to consider modifications where appropriate.[10]

1.4 THE EPCA PHASE I INVENTORY, 2003

Completed in January 2003, the Phase I inventory focused on basins of the Interior West, where most Federal onshore oil and gas resources in the lower 48 states are located.[11] The Phase I inventory covered the Uinta-Piceance, Paradox/San Juan, Powder River, and Greater Green River Basins and the Montana Thrust Belt. The methodologies used in the EPCA Phase I inventory and this inventory are similar and modified data from Phase I are incorporated into this study (see Section 2).

1.5 THE NATIONAL PETROLEUM COUNCIL REPORT, 2003

Also completed in 2003, the NPC provided an update to its 1999 natural gas study.[12] The revised study shows a fundamental shift in the natural gas supply-and-demand balance resulting in higher prices and greater price volatility. Further, the study finds that despite increasing energy efficiency and greater conservation efforts, the traditional North American producing areas can only meet 75 percent of long-term U.S. natural gas needs, leaving the balance to be supplied by imports. To solve some of these problems, the NPC made four recommendations, of which the second was:

Recommendation 2: Increase supply diversity

- Increase Access and Reduce Permitting Impediments to Development of Lower-48 Natural Gas Resources
- Enact Enabling Legislation … for an Alaska Gas Pipeline

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[10] National Energy Policy, Report of the National Energy Policy Development Group, May 2001, available on the White House website: http://www.whitehouse.gov/energy/.
[11] Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and Reserves and the Extent and Nature of Restrictions or Impediments to Their Development, January 2003, available on the BLM website: http://www.blm.gov/energy/epca.htm
[12] Balancing Natural Gas Policy: Fueling the Demands of a Growing Economy, National Petroleum Council, September 2003, available on the NPC website: http://www.npc.org/reports/ng.html

With respect to Federal land access, the NPC examined Conditions of Approval (COAs) in addition to lease stipulations. The study found that the COAs are more of an impediment to development than leasing stipulations. For example, in the Green River Basin, the 2003 NPC study determined that 9 percent of the resource was unavailable for leasing with an additional 31 percent "effectively" off-limits to development due to prohibitive COAs. The NPC study noted that, in addition to making leasable areas unavailable, the COAs added significant costs and delays to development. Further, it estimated that of the 238 TCF undiscovered, technically recoverable natural gas resources in the Rocky Mountain region, 69 TCF are unavailable for development while the remaining 56 TCF are impacted by access-related regulatory requirements.

1.6 APPROACH

Similar to the Phase I inventory, the Steering Committee, composed of representatives from the participating agencies, was responsible for overseeing the completion of the Phase II inventory. Subsequent to the Phase I inventory, the Steering Committee identified the next six major oil and gas geologic provinces:

- Northern Alaska (NA; NPR-A and ANWR 1002)
- Wyoming Thrust Belt (WTB)
- Denver Basin (DEN)
- Florida Peninsula (FLP)
- Black Warrior Basin (BWB)
- Appalachian Basin (APB).

As with the Phase I inventory, each of these study areas is defined by the aggregation of the USGS oil and gas resource plays for each area. The energy resource, Federal land status, and oil and gas constraints data for these areas have been incorporated into a Geographic Information System (GIS) that allows derivative mapping and statistical analysis. The results presented in this report are cumulative as the Phase II inventory incorporates and supersedes Phase I.

1.7 ROLES OF THE AGENCIES

Section 604 of EPCA designated responsibility for preparing the inventory to the Department of the Interior, in consultation with the Departments of Agriculture and Energy. The Interagency Steering Committee is responsible for providing guidance for conducting the studies, recommending direction to the contractor,[13] making decisions concerning critical parameters, reviewing the methodologies and results, and publishing the report.

The Secretary of the Interior designated the BLM as the lead agency for the inventory. The BLM maintains the oil and gas lease stipulation information and well files containing COAs for lands under its jurisdiction, and land status data for all Federally owned lands

[13] The contractor is Advanced Resources International of Arlington, VA. They have engaged Premier Data Services of Englewood, CO as a subcontractor.

within the United States.

The USGS, also a bureau of the DOI, conducts assessments of undiscovered technically recoverable oil and natural gas. The primary source of the oil and gas resource information used in this study is the USGS National Assessment of United States Oil and Gas Resources.

The Secretary of Agriculture designated the USDA-FS, its primary land management agency, to contribute its information regarding oil and gas lease availability and leasing stipulations for lands within the National Forest System.

The DOE, as author of the above-mentioned GGRB report, contributes its expertise and experience in guiding the design and analysis process for the inventory. DOE's EIA contributes its analysis of proved reserves estimates and reserves growth for Federal lands.

During the course of this study, members of the Steering Committee and contract personnel visited field offices within the various basins. BLM and USDA-FS personnel from more than 80 offices (Table 1-1) participated in these visits. The purpose of these visits was to inform BLM and USDA-FS officials about the studies and to solicit input concerning lease stipulations, COAs, and other issues of concern regarding oil and gas development. As described in Section 2, parameter input from these officials was critical to the study. Data were collected during and following the field visits.

Table 1-1. BLM and Forest Service Offices Participating in the Inventory

1.8 INTENDED USE

This inventory is designed to be useful to a wide range of interests. In a broad sense, it gives a picture of where oil and natural gas is estimated to occur and a quantification of what statutory and administrative constraints limit exploration and development. Agencies can use this inventory data to identify areas of high resource potential and to examine Federal land management decisions affecting access to energy resources. This inventory provides both the public and Federal land managers with information about the potential magnitude of oil and natural gas resources unavailable for development due to access limitations. This information can be used in conjunction with information about other resource values and the environment.

The highly detailed Federal land access data along with the oil and gas resource data is available for additional analyses by Congress, industry, environmental organizations, and other interested parties. Land withdrawals, oil and gas lease stipulations, and COAs protect or mitigate adverse impacts to other valuable land resources. Land management agencies can analyze this information together with existing policies and procedures to identify opportunities for improving and enhancing decisions in their land use planning, leasing, and permitting processes. Agencies can use this information to prioritize the need for additional data and analyses, and to identify opportunities for improving access to oil and gas resources. Overall, this inventory provides fundamental

information to help resolve development issues.

A fundamental product of this inventory is the GIS database containing numerous layers of geographic data referenced by longitude and latitude. While the surface data used in the inventory is accurate, an important caution applies to the use and interpretation of the undiscovered energy resources data: the *precise* locations of recoverable accumulations of undiscovered oil and natural gas resources on Federal lands are unknown. For the purpose of this inventory, it was assumed that there is a uniform distribution of the resources within a given play or assessment unit.

Over the last several decades, the USGS methodology has been the government's standard for oil and gas resource estimation. The USGS assessment process estimates the volume of undiscovered oil, natural gas, and natural gas liquids that have the potential to be added to reserves during a thirty-year forecast period. Assessment results are based on known or estimated geologic input parameters provided by knowledgeable geologists--parameters such as trapping mechanism, source rock, reservoir quality and size of known accumulations. Because of the uncertainty about the input parameters, the assessment result is expressed as a probability distribution of potential resources in the assessment unit or geologic play. For these reasons this inventory does not imply that the locations of accumulations of undiscovered oil and gas resources are known to occur under specific land parcels.

1.9 PRODUCTS/FUTURE DIRECTION

The tables, data, maps (GIS products), and this summary report, describing the methodology, applied standards, results, and land access issues, are available on DVD and on the BLM (http://www.blm.gov/) website.

Section 604 of EPCA requires that all Federal lands of the onshore United States be inventoried. With the completion of this Phase II report, an estimated 76 percent of the onshore Federal oil and gas resources have been inventoried. For the Phase III/IV release, the inventory has been redesigned by the Steering Committee to cumulatively analyze 18 geologic provinces comprehensively, and to extrapolate the access constraints for the small portion of remaining resources (estimated to be about 10 percent) in the rest of the U.S. For subsequent releases, the information and analysis for previously studied areas will be updated as the availability of new data and developments in technology warrant.

In addition, the recently passed Energy Policy Act of 2005 (EPAct 2005) Section 364, modifies the scope of this inventory to require the evaluation of additional Federal constraints associated with granting permits, post-lease restrictions, and barriers to transportation. The EPAct 2005 also requires the DOE, using this inventory, to make periodic assessments of economically recoverable resources. The inclusion of the impact of COAs on Federal oil and gas accessibility in this Phase II release represents a partial fulfillment of these additional requirements.

2.0 METHODOLOGY

The Phase II inventory examines the following geologic provinces:[1]

- Northern Alaska (NA; NPR-A and ANWR 1002 only)
- Uinta-Piceance Basin (UP)
- Paradox/San Juan Basins (PDX/SJ)
- Montana Thrust Belt (MTB)
- Powder River Basin (PRB)
- Wyoming Thrust Belt (WTB)
- Greater Green River Basin (GGRB)
- Denver Basin (DEN)
- Florida Peninsula (FLP)
- Black Warrior Basin (BWB)
- Appalachian Basin (APB).

The study areas were delineated by aggregating oil and/or natural gas resource plays[2] within the provinces as defined by the USGS National Assessment of Oil and Gas Resources. Resource play boundaries and oil and gas resource estimates within the plays were obtained in GIS format from the USGS. These plays were then aggregated in a GIS to create a resource density map layer for each study area.

Where play boundaries span more than a single geologic province, one province was selected over the other in order to preserve geographic uniqueness. For example, at the boundary of the PDX/SJ and UP study areas, the UP was defined by the outline of Uinta plays even though these plays overlap plays from the Paradox Basin. The Uinta/Piceance study area thus contains some Paradox Basin resources and reserves. Likewise, the WTB and GGRB study areas were defined by the GGRB USGS boundaries and the DEN and PRB study areas by the PRB USGS province boundaries.

Federal land status was generated using the “Status” dataset from the BLM’s Legacy Rehost 2000 (LR-2000) system to create GIS maps. Oil and gas leasing stipulation and COA data were obtained for each jurisdiction from BLM field offices and USDA-FS offices in the study areas. Most of the stipulation data were available in GIS format; some existed only as hardcopy and had to be digitized to create GIS digital map files.

Stipulations and COAs are additional requirements that are attached to Federal oil and gas leases and drilling permits for environmental protection and other reasons and are subject to change over time. This inventory represents a "snapshot" of the conditions within the study areas at the time of data collection. The stipulations used in the inventory are those applied when new oil and gas leases are issued and are those

[1] The study areas in this document are referenced in USGS Oil and Gas province order.
[2] “Plays,” more recently referred to as “assessment units,” are a set of known or postulated oil and gas accumulations having similar geologic origins. The term plays is used generically in this document (see section 2.2.1 for further explanation).

contained primarily in National Forest Plans (FPs) and BLM Resource Management Plans (RMPs) in effect as of August 2002 (for the UP, PDX/SJ, MTB, PRB, and GGRB study areas), March 2005 (for the WTB, DEN, FLP, BWB, and APB study areas) and January 2006 (NA study area). Some stipulations are not maintained in an automated system and may not have been available for use in this inventory (see Section 2.1.2 for further discussion).

The analyses entailed the spatial intersection (in a GIS) of oil and gas resource information with data on Federal land status and access constraints. The inventory also takes into account how leasing stipulations are implemented in practice by Federal land managers by considering the effect of directional drilling and the general frequency with which exceptions to the stipulations are granted.

To the extent that current leases were issued under and are stipulated according to an existing land use plan, the inventory accurately reflects the access situation. Older leases issued before the effective date of the relevant plans may not be stipulated accordingly. It is reasonably accurate, however, to consider the plan stipulations as a proxy because the environmental conditions that necessitate stipulations often are the driver for COAs that are attached to drilling permits on the older unstipulated leases to achieve the needed environmental protection.

Additional factors exist that affect oil and gas exploration and development on Federal lands and cannot be quantified geographically prior to the receipt of a specific drilling application. The factors include:

- Protection for threatened, endangered, and sensitive species. Surveys are sometimes required to determine whether a lease contains habitat for such species.
- Archaeological surveys required by the National Historic Preservation Act, along with related issues involving cultural resources, including consultation with Native American tribes.
- Air quality impacts and resulting restrictions on activities that may affect air quality.
- Visual impacts of oil and gas operations.
- Noise from oil and gas operations.
- Suburban encroachment on oil and gas fields and county government restrictions.

Section 4 of this report presents these issues in greater detail. Many of these requirements manifest themselves as COAs attached to drilling permits following a specific analysis under the National Environmental Policy Act (NEPA). These requirements can delay or modify a planned oil and gas development activity at the permit stage and in some cases preclude it altogether. Site-specific COAs have been incorporated into the inventory.

The rest of this section provides a more detailed description of the inventory methodology.

2.1 PROCEDURES FOR COLLECTING AND PREPARING LAND

STATUS AND OIL AND GAS ACCESS CONSTRAINTS

2.1.1 Federal Land Status

This section briefly presents the process for determination of land status. See Appendix 3 for a more detailed description.

2.1.1.1 Sources of Land Status Data

In contrast to the Phase I inventory, which exclusively examined basins in the Interior West, Federal lands status determination was much more complex for the Eastern study areas included in the Phase II inventory (FLP, BWB, and APB). For the Eastern study areas the mapping of Federal lands was completed based upon detailed research of multiple sources of information that describe the nature and extent of Federal surface and mineral interests. The primary source of Federal land status data outside of the Eastern areas was the BLM's LR-2000 Status Dataset, which was supplemented by other records from Federal, state, and county governments.

2.1.1.2 Land Status Data Preparation

These data, which are often stored in alphanumeric format, were converted as necessary for this inventory into a GIS layer by using commercially available software. The software interpolated the legal descriptions contained in the Status Dataset against a public land survey GIS layer derived from either the BLM's Geographic Coordinate Database (GCDB) or other sources such as digitized USGS 7-1/2 minute quadrangle maps.

Maps of the Federal land status for the study areas are presented in Figures 2-1 through 2-11.

Figure 2-1. Federal Land Status Map, Northern Alaska Study Area

Figure 2-2. Federal Land Status Map, Uinta-Piceance Basin Study Area

Figure 2-3. Federal Land Status Map, Paradox/San Juan Basins Study Area

Figure 2-4. Federal Land Status Map, Montana Thrust Belt Study Area

Figure 2-5. Federal Land Status Map, Powder River Basin Study Area

Figure 2-6. Federal Land Status Map, Wyoming Thrust Belt Study Area

Figure 2-7. Federal Land Status Map, Greater Green River Basin Study Area

Figure 2-8. Federal Land Status Map, Denver Basin Study Area

Figure 2-9. Federal Land Status Map, Florida Peninsula Study Area

Figure 2-10. Federal Land Status Map, Black Warrior Basin Study Area

Figure 2-11. Federal Land Status Map, Appalachian Basin Study Area

2.1.1.3 Land Status Data-Related Caveats

The following precautions are advised when reviewing this inventory:

- The land status data are generally spatially accurate down to 40 acres. The data vintage is August 2002 for the Phase I basins and March 2005 for the Phase II basins.
- The GIS files, created using the processes described in detail in Appendix 3, were interpolated from the legal land descriptions contained in the BLM's LR-2000 database. If a legal description referenced a small survey lot or tract by number, a nominal location was mapped through a process that referenced the Legal Land Description dataset. This dataset is limited to a 40-acre description and therefore carries a minor degree of generalization in complex areas. Isolated parcels of less than 40 acres, particularly in the Eastern study areas, were not included in the inventory.
- This mapping process uses public land survey data derived from various sources. The spatial location of the land status parcels so derived matches the accuracy of the survey data.
- Some land status GIS data are restricted from the public domain by agency request. Such data were used in the analyses presented in this report, but are not contained in the public datasets.

For purposes of this inventory, Federal lands include split estate. In cases of split estate where the Federal government holds a partial interest in the oil and gas mineral estate, the Federal government was assumed to hold total mineral interest.

Table 2-1. Federal Land Acreage by Surface Management Agency

2.1.2 Federal Oil and Gas Availability for Leasing and Lease Stipulations

All onshore Federal oil and gas leases contain terms and conditions as specified on the standard lease form (BLM Form 3100-11).[3] Some of these terms and conditions govern land use and resource development to a certain extent. Environmental and other considerations, which are identified during the land use planning process, determine the need for additional terms and conditions, also known as lease stipulations. For example, a lease may contain a stipulation that prohibits surface disturbance during certain time periods for wildlife. Such stipulations on land use and timing may constrain exploration and development of oil and natural gas on Federal lands.

Some Federal lands are unavailable for leasing. See Table A9-2 in Appendix 9 for a listing of agencies and Federal designations that generally prohibit oil and gas leasing.

The Federal government does not issue oil and gas leases for areas where it has surface ownership but no mineral rights. In such instances, the Federal government, while allowing access to the subsurface resources owned by another party, typically uses surface occupancy restrictions (SORs) to protect surface resources. From the

[3] The form is available at https://www.blm.gov/FormsCentral/show-form.do?nodeId=687#

standpoint of the EPCA inventory, SORs and lease stipulations have similar impacts. Thus, for the purposes of this study, the term "stipulations" is used generically to include SORs.

2.1.2.1 Sources of Lease Stipulation Data

Oil and gas lease stipulations are derived from the Federal surface management agency's land use plans, e.g., Resource Management Plans (RMPs) for the BLM and Forest Plans (FPs) for the Forest Service. These plans are produced and maintained by their respective agencies on a field office jurisdictional basis (in the case of the BLM), or on a National Forest/Grassland basis (in the case of the USDA-FS). Land use planning documents are revised every ten to fifteen years, or on an as-needed basis, but may be amended to address specific land use issues. Table 2-2 lists the land use planning documents used for this inventory.

Table 2-2. Land Use Plans by Study Area

Hardcopy and digital data showing the mapped lease stipulation areas were collected from BLM and Forest Service offices within the study areas (see Table 1-1). During office visits, copies of guidance documents, such as RMPs and FPs, were also obtained.

Most of the lease stipulation data are maintained by the agencies as GIS data layers (digital map files). Some offices, particularly where the planning effort pre-dated the widespread availability of GIS technology, maintain this information in the form of hardcopy maps. For this inventory, these maps were digitized, stored, and analyzed as GIS layers. The digitized maps were then returned to the originating field offices for review and future use.

For some BLM and USDA-FS plans, maps are not available for some stipulations either in GIS or hardcopy form. Stipulations for which GIS data are not available or could not be generated from other data sources are annotated on the stipulations lists accompanying this report.[4]

Data for this study were collected during the two phases of the inventory. For the UP, PDX/SJ, PRB, and MTB study areas, data were collected in the winter of 2001-2002. For the GGRB study area, data were used from the DOE's Federal lands analysis[5] collected during the fall and winter of 2000-2001; these data were verified with the local BLM and USDA-FS offices and were current as of August 2002. The data for NA were collected in the fall of 2003. Data for the WTB, DEN, BWB, FLP and APB were collected during 2004. These data were verified with the local BLM and USDA-FS offices and were current as of March 2005.

[4] The stipulation list for each Study Area exists as a Microsoft Access Table within its respective ESRI geodatabase on the DVD. It can either be imported into an ArcMap project or viewed directly in Access.
[5] Federal Lands Analysis, Natural Gas Assessment, Southern Wyoming and Northwestern Colorado, Study Methodology and Results, June 2001, available on the DOE website: http://fossil.energy.gov/programs/oilgas/publications/fla/Federal_Lands_Assessment_Report.html.

2.1.2.2 Lease Stipulation Data Preparation

Most of the lease stipulation data preparation consisted of the gathering, digitizing, and compiling of the gathered data in multi-layered digital map files. Federal Geographic Data Committee Standards (FGDC)-compliant supporting documentation (metadata) for the resulting GIS layers was also created.[6]

This inventory concerns only Federal lands within the aggregate resource play boundaries of the study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. Consequently, the land status and stipulation digital map files, which correspond to Federal land management agency jurisdiction boundaries, were clipped using GIS to fit within each of the study area boundaries. Data contained within the compiled digital map files were then queried for unique leasing stipulation values. The results were saved as separate map files. Each digital map file represents a unique stipulation value.

For a description of the specific data preparation steps, see Appendix 4.

2.1.2.3 Lease Stipulation Data-Related Caveats

The following precautions are advised when reviewing this study:

- All stipulations for which GIS data were available from the Federal land management agencies were used in the analysis. Most of the stipulations within the study areas were available in GIS data formats; however, supporting documentation was not generally provided with GIS files. Although this can lead to inaccuracies due to undocumented differences in technical parameters, such errors are minor in terms of the scope of the inventory.
- Many stipulations not available in GIS format were digitized. Any resulting inaccuracies due to this process are likely to have insignificant impacts upon the analysis.
- Neither hardcopy nor digital maps were available for some stipulations (see Section 2.3.1.1 for further discussion).
- The lease stipulation data are generally accurate to a minimum of 40 acres.
- Some lease stipulation GIS data are restricted from the public domain by agency request. Such data were used in the Phase II analysis but are not contained in the public datasets.

2.1.3 Federal Drilling Permit Conditions of Approval

As described in section 2.1.2, a Federal oil and gas lease conveys only the right to develop such resources on the leased land subject to reasonable regulations as determined by the land managing agency. After lease issuance, and prior to approval of any drilling activities, the operator must submit an Application for Permit to Drill (APD). An APD provides operational and geologic information as well as the applicant's

[6] GIS layers for surface management agency land status, stipulations, and the analyses, as well as the associated metadata, are available on the DVD and the web site.

proposal for use of the surface. COAs are post-lease requirements that are attached to an approved APD for environmental protection, safety, conservation of resource. COAs have been developed over a number of years as mitigation for surface disturbing activities and are based upon lease notices and/or administrative policy actions.

The Phase I inventory evaluated the impact of lease stipulations on access to oil and gas resources on Federal lands, but did not explicitly address the effects of COAs, assuming that they were implicitly covered by lease stipulations that would be issued for future leases. Subsequent to the Phase I inventory, the 2003 NPC study examined COAs as a complement to lease stipulations and concluded that COAs are a greater impediment to development than leasing stipulations.

Partially in response to the 2003 NPC study, and in anticipation of the inventory amendments contained in EPAct 2005, the effects of COAs on oil and gas accessibility have been incorporated into the Phase II analysis. The purpose of the inclusion of COAs is to enhance the land access constraints analysis and thus provide a more complete assessment of the onshore Federal lands' availability for oil and gas exploration and development.

COAs arise from a variety of controlling authorities, but the most significant and wide-ranging are those governed by four Federal laws; specifically, the Federal Land Policy and Management Act (FLPMA), the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA). The COAs attached to each APD can be general in nature or site-specific, and thus vary from one BLM Field Office (FO) to another.

Some COAs can be identified as "best management practices" while others are included as a standard set by the approving office. In the Phase II study areas, approximately 175 types of COAs provide mitigation for surface-disturbing activities. For example, COAs can address:

- Big game winter range
- Protection of wildlife habitat
- Protection of archeological and paleontological sites
- Noise reduction
- Road construction and maintenance tanks and pits for fluid storage
- Pipeline and power line construction
- Wildfire suppression
- Management of noxious weeds
- Reclamation
- Erosion control
- Fertilizer application

COAs and stipulations beyond the standard lease terms often occur together. Prior to this inventory, there has not been a comprehensive method to characterize their impact on Federal land access. The National Petroleum Council, in its 2003 report (see

Section 1.5) crafted an ingenious method to estimate the effect that COAs have on Federal land accessibility. However, the NPC did not have access to the actual well files containing COAs, but instead used publicly available wildlife data as a proxy to estimate their impact. In examining COAs and their effects upon land access for this inventory, it was necessary for the BLM to review extensively the APD well records in its Field Offices. The methodology for the assessment of COAs is described in Appendix 5.

2.1.3.1 Sources of Conditions of Approval Data

For the Phase II inventory, a number of APDs for all study areas were sampled. The APDs were selected by applying a stratified random sampling protocol to a list of all APDs approved during fiscal years 1999-2004. The sample represents approximately 10 percent of the total population of APDs. BLM Field Offices were visited and information on site-specific COAs was abstracted from the hardcopy well files. A summarized version of the COAs and stipulations that affected oil and gas access in each selected APD was noted.

In addition, information was obtained from BLM Field Office personnel to qualitatively assess the extent of negotiations that occur prior to the submission of an APD, including adjustments at the time of well staking and are presented in Appendix 5.

2.1.3.2 Conditions of Approval Data Preparation

The COAs data preparation consisted of compiling the collected information into spreadsheets and spatial GIS displays. The abstracted information was grouped into general classes that were assigned unique codes. Table 2-3 presents a list by BLM office. Appendix 5 contains details on the data preparation task.

Table 2-3. COAs by BLM Field Office

2.1.3.3 Conditions of Approval Data-Related Caveats

The APDs examined were randomly sampled. To the extent that the sample is not representative of the population, extrapolation of sample results could introduce error.

Because of the large number of approved Federal APDs, the sample for the inventory was restricted to represent a portion of the total number of APDs, but has been improved by means of a stratified sampling protocol explained in Appendix 5. This method reduces the impact of potential inaccuracies introduced due to extrapolation of results to general areas. Some field offices had small populations of wells (<30), which can lead to relatively poor samples. In such cases, all wells in an office were sampled.

2.2 PROCEDURES FOR COLLECTING AND PREPARING OIL AND GAS RESOURCE, RESERVES GROWTH, AND RESERVES DATA

2.2.1 Undiscovered Oil and Gas Resources

2.2.1.1 Sources of Oil and Gas Resources Data

In conformance with 42 USC §6217, the volumes of undiscovered technically recoverable oil and gas resources in each oil and gas play are supplied exclusively by the USGS.

Editor's note–insert sidebar ("Oil and gas resources occur in four categories:") at this point

Undiscovered technically recoverable resources are those hydrocarbon resources that, on the basis of geologic information and theory, are estimated to exist outside of known producing fields. These resources can be produced using current technology without regard to economic profitability. Technically recoverable resources are a subset of the total resource-in-place that could be expected to be recovered over an exploration and development life cycle measured in decades.

The USGS assesses oil and gas resources in geologic "plays" or "assessment units." A play is a set of known or postulated oil and gas accumulations defined by common geological conditions (source rock, migration, timing, charge, traps, seals, etc.) that characterize a group of hydrocarbon accumulations in the subsurface. An assessment unit is defined as a mappable volume of rock within a total petroleum system that encompasses accumulations (discovered and undiscovered) that share similar geologic traits and socio-economic factors. Accumulations within an assessment unit should constitute a sufficiently homogeneous population such that the chosen methodology of resource assessment is applicable. A total petroleum system might equate to a single assessment unit. If necessary, a total petroleum system can be subdivided into two or more assessment units so that each unit is sufficiently homogeneous to assess individually.

The USGS assesses two resource play types: conventional and continuous. Conventional plays contain discrete hydrocarbon accumulations often associated with hydrocarbon/water contacts. Continuous plays are pervasive hydrocarbon accumulations that can cross rock unit boundaries, lack discrete structural boundaries, and exhibit other atypical reservoir properties (Figure 2-12). They include tight gas sands, gas shales, and coalbed natural gas (also referred to as coal gas, coalbed gas or coalbed methane). Compared to conventional plays, continuous accumulations typically are more geographically extensive. Most of the resources in the study areas in the lower-48 states are of the continuous type.

Figure 2-12. Conventional vs. Continuous Accumulations

The USGS has identified 150 discrete oil and natural gas resource plays in the Phase II study areas. The probabilistic mean estimate of hydrocarbon resource volumes for each USGS-defined play was utilized for this inventory (Table 2-4) The assessed resources include oil, natural gas liquids (NGLs), associated dissolved (AD) natural gas, non-associated natural gas (NAG) and liquids in gas reservoirs. Oil is a natural liquid of mostly hydrocarbon molecules. NGLs are liquid when produced to the surface but exist in the gas phase in the subsurface. Natural gas is a mixture of hydrocarbon gases consisting primarily of methane. Associated dissolved natural gas is that produced from oil fields, whereas non-associated natural gas is that produced from gas fields. The USGS assesses technically recoverable resources for each of these resource types, and these volumes were provided for the inventory. While modeled discretely in this analysis, for purposes of presentation in this inventory, undiscovered oil, NGLs, and liquids associated with natural gas reservoirs were subsequently aggregated into a single “Total Oil” resource category. Similarly, AD and non-associated natural gases were combined as “Total Natural Gas.”

Table 2-4. Undiscovered Technically Recoverable Resources by Play

Table 2-4. Undiscovered Technically Recoverable Resources by Play (concluded)

2.2.1.2 Oil and Gas Resource Data Preparation

The geometry of an oil and gas play is defined by its geology and extends horizontally and vertically in the subsurface. Figure 2-13 is an idealized block diagram showing how three different plays can occur in a single area. Plays are commonly "stacked" in the subsurface so that a given surface land parcel can overlie numerous plays.

For this inventory, a homogeneous distribution of resource within a play boundary is assumed because of the lack of more geographically specific information. In fact, the USGS indicates that resources are generally not homogeneously distributed within a play. This is particularly true for conventional accumulations, and less so for continuous accumulations. Despite the assumption of homogeneous distribution of resources in the plays, various oil and gas densities can be mapped as a result of play stacking.

Figure 2-13. Conceptual Block Diagram of Oil and Gas Plays

2.2.1.3 Oil and Gas Resource Data-Related Caveats

The estimation of undiscovered technically recoverable resources is inherently uncertain, as reflected by the fact that the USGS develops cumulative probability distributions of the estimated resources for each play. These distributions are used to derive 95 percent probable resource (a 19-in-20 chance of that volume or more), 5 percent probable resource (a 1-in-20 chance of that much or more), and mean resource volumes. The mean volume, used in this inventory, represents the arithmetic average of all possible resource outcomes weighted by their probability of occurrence. The analytical results in the inventory use the mean and therefore do not explicitly

reflect the range of uncertainty in the resource assessments.

Not all of the resource plays recognized by the USGS within the boundaries of this inventory have been evaluated. The USGS has identified hypothetical plays that lack sufficient data to estimate undiscovered resources. To the extent that hypothetical plays contain significant resources, the results presented here would be an underestimate.

It should be understood that all resource assessments change over time. Not only is it difficult to assess accurately the resource at any one point in time, but the recoverable portion of the resource changes in response to advances in technology, and changes in other conditions under which extraction occurs. Nonetheless, accurate and up-to-date assessments of the potential resources must be continually provided to ensure that public policy decisions are conducted with the best information possible.

For this inventory, the assumption is made that the estimated oil and gas volumes are evenly distributed under the surface area of each play. A resource density map for each basin was created in the GIS by using a spatial summation of the oil and gas volumes contributed by each play. The densities are expressed as millions of cubic feet (MMCF) of gas per square mile and thousands of barrels (Mbbls) of oil per square mile.

2.2.2 Proved Ultimate Recovery Growth (Reserves Growth)

The EIA's role in this inventory is to provide data and analysis relevant to proved reserves and reserves growth of crude oil, natural gas, and natural gas liquids that are associated with already discovered fields underlying Federal onshore lands. This responsibility involves:

- Providing estimates of proved reserves for these fields at the highest possible level of detail consistent with a legal requirement to protect the confidentiality of field operators' proprietary data.
- Estimating future ultimate recovery appreciation for currently producing fields.
- Providing inputs to estimate additional land access constraints that may result from expected ultimate recovery appreciation.

The estimation of proved reserves is necessary for developing reserves growth estimates.

The proved ultimate recovery (PUR) of an oil or gas field is the estimated volume of oil or gas that will ultimately be produced from the field. At any point in time, the PUR is the sum of a field's estimated proved reserves and its cumulative production. The estimated PUR for a new oil or gas field generally increases with time, as a result of new geologic and engineering knowledge gained during operation of the field.

This phenomenon is variously termed "reserves growth," "reserves appreciation," "ultimate recovery appreciation" or "proved ultimate recovery growth." Proved ultimate

recovery growth (PURG), the term preferred by the EIA, has been recognized since 1960 and currently accounts for the majority of annual additions to domestic proved reserves. Owing to its importance to present and future domestic oil and gas supply, EIA has been highlighting PURG in the overview section of its annual reserves reports since 1992. Since 1976 PURG has grown in all but one year for both oil plus lease condensate and natural gas. From 1976 through 1994 only 12 percent of proved reserves additions of crude oil and lease condensate and 11 percent of proved reserve additions of wet natural gas were booked as new field discoveries. The rest came from the proved reserves categories related to the proved ultimate recovery appreciation process.[7]

The proved ultimate recovery for an individual field or group of fields in a basin "grows" with time due to such factors as:

- Delineation and development drilling that extends the area of known reservoirs
- Discovery of new producing zones (deeper or shallower)
- Application of improved reservoir management and well completion practices and technologies
- Economic factors that increase wellhead prices or reduce operating costs thus extending the economic life of producing fields.

Initial estimates of PUR are usually conservative owing to the small knowledge base available at that time regarding a field's performance. Annual estimates of a field's PUR normally increase significantly in the early post-discovery years as the field is delineated. In later years, PUR continues to grow due to such factors as installation of improved recovery technology, increased knowledge of field performance, and infill drilling, although generally the annual rate of growth slows. Consequently, the growth factors are large during the early years of field development and then often decline as PUR asymptotically approaches a maximum value, i.e., reserves growth usually slows as field development matures.

For the Phase II study areas, the EIA estimated remaining proved ultimate recovery growth (RPURG), the future reserves growth resource. The resources attributed to future reserves growth are 973 million barrels of oil and 10.55 TCF of gas. See Appendix 7 for a detailed explanation of the estimation methodology.

Table 2-5. Remaining Proved Ultimate Recovery Growth (Reserves Growth) by Study Area (Federal and nonfederal)

The EIA's selected RPURG estimates covering Federal and nonfederal lands are provided in Table 2-5. Not all of the Phase II study areas could be evaluated owing to insufficient data.

[7] Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2004 Annual Report, November 2005, available online at http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html.

2.2.2.1 Sources of Remaining Proved Ultimate Recovery Data

The EIA compiled the historical increase in estimates of PUR for oil and gas fields in each study area and extrapolated these data to estimate the PUR of the fields at abandonment. RPURG is the estimated future portion of the growth in PUR from 2003 to the time of field abandonment.

For each study area, the EIA created a database containing field names, field discovery dates, annual oil and gas production for each field, estimated cumulative production, and annual estimates of oil and gas proved reserves for each field.[8] Each field in a study area was assigned to a vintage year according to its date of first production or its date of discovery. The annual proved reserves estimates were usually available only from 1977 to present. The resulting files contained vintage year, number of fields in each vintage (in barrels of oil equivalent), PUR for each field vintage, annual natural gas PUR for each vintage, and annual liquid PUR for each vintage.

Many field names and codes had to be altered, corrected, and matched across the multiple data sources in order to accumulate properly the field data. Obvious major errors were corrected, but many apparent data discontinuities and variations within vintages were mostly accepted "as-is." Reserves data were used as reported by the field operators unless very obvious errors were found. Specific vintages that did not fit the trend of most of the data for a basin were excluded from the extrapolation. Attempts to divide the data within a basin into conventional reservoirs, tight formation, and coal gas resources were largely unsuccessful because of the limited number of vintages, the short histories available for some of the fields, and frequent inability to separate the data by reservoir type within a field.

The EIA used two models to estimate RPURG for each study area and resource type, an exponential cumulative growth factor model and a hyperbolic incremental growth factor model. The exponential model depends on annual average cumulative growth factors for a basin. The hyperbolic model depends on incremental growth factors by vintage, or age of the fields in the basin. Both are asymptotic functions that use time as the sole driver. Although other potential drivers such as drilling rates or wellhead prices are not directly used, these factors have affected the historical data that feed into the models. The application of both models for estimating PURG for a basin over time is described in Appendix 7.

Results of the two models were compared for each study area and hydrocarbon type and a preferred model result was selected based on the EIA modeling team’s best judgment. The exponential model results were selected most of the time. Appendix 7 provides a detailed report of EIA’s methodology and results.

[8] Data sources included the EIA Reserves and Production Division's Oil and Gas Integrated Field File (RPD OGIFF), the EIA Field Code Master List (FCML), the EIA-23 Reserves Survey, various state web sites, and commercial sources (mainly IHS Energy Group).

There were insufficient data from the Appalachian Basin and Montana Thrust Belt for a PURG analysis. Separate estimates for tight reservoirs were not made for the Denver Basin, Black Warrior Basin and the Wyoming Thrust Belt owing to a combination of data anomalies and data interpretation concerns. In all study areas, the available coalbed natural gas data were deemed not to be dependable for establishing PURG and are therefore not separately reported. Tight formation results using the exponential model were reported for the Uinta-Piceance and Paradox/San Juan Basins, but were not carried forward into the analysis for the sake of consistency.

2.2.2.2 Remaining Proved Ultimate Recovery Data Preparation

The estimated remaining proved ultimate recovery or "reserves growth" resources for each study area were incorporated into the inventory by adding a "reserves growth resource" layer to the USGS undiscovered technically recoverable resources. As with the undiscovered resource layer, the inventory assumes that the reserves growth resources are homogeneously distributed within the geographic boundaries of the reserves growth resource layer. This is a simplifying assumption, which may be modified in the future as new reserves growth methodologies and findings become available.

The geographic boundary of the reserves growth resource layer was created for each study area from a union of the field boundaries of all the producing oil and gas fields identified by the EIA within the study area. The individual field boundaries were extended an additional mile in all directions prior to the union, so the geographic boundary of the reserves growth resource layer extends a mile beyond the 2003 boundaries of the actual fields incorporated into the layer. This was done to approximate future extensions to the proved area of producing fields, which contributes to reserves growth. Next, the total reserves growth resource estimated for each study area was homogenously distributed within the geographic boundary of the reserves growth resource layer for the study area. Lastly, the two resource layers, the USGS undiscovered technically recoverable resource layer and the EIA RPURG resource layer, were combined to create the oil and natural gas resource maps shown in Section 2.2.3.

2.2.2.3 Remaining Proved Ultimate Recovery Estimate Data-Related Caveats

The estimated reserves growth resources for the Phase II study areas are lower than generally would be expected, especially compared to previously published reserves growth estimates including the USGS 1995 National Assessment[9], the NPC[10], the Potential Gas Committee (PGC),[11] as well as some operators' not necessarily

[9] Root, D.H. and others, 1995, Estimates of inferred reserves for the 1995 USGS national oil and gas resource assessment, U.S. Geological Survey Open-File Report 95-75L.
[10] National Petroleum Council, 2003, *Balancing Natural Gas Policy-Fueling Demands of a Growing Economy*, September 2003. The Supply Task Group estimated reserves growth for natural gas.
[11] Potential Gas Committee, 2005, *Potential Supply of Natural Gas in the United States as of December 31, 2004*, September 2005. The PGC estimates "Probable Resources" for natural gas. PGC defines Probable Resources as

representative anecdotal reports of estimated reserves growth for fields in some study areas.[12] Appendix 7 (Table A7-2) contains a side-by-side comparison of this inventory's reserves growth estimates to other relevant estimates. Reserves growth in most of the study areas ranged from 3 percent to 25 percent of current proved reserves. However, the Black Warrior Basin reserves growth was estimated to be 110 percent of proved reserves.

It is unlikely that there is a single cause of the differences with other studies. Certainly there are some significant differences in methodology and input data. For example, the PGC uses a non-statistical, reservoir-specific approach that relies on expert judgment to estimate the probable resources associated with the additional development of an already discovered reservoir. Historically, the most successful estimates of reserves growth have relied on the use of reservoir level data, rather than the more aggregate field level data on which this inventory's estimates are based. This is not particularly surprising since most factors that affect the reserves growth phenomenon are reservoir-specific and will not necessarily apply to an entire field when it consists of multiple reservoirs as many fields do.[13] Unfortunately, reservoir level proved reserves data are only rarely available for onshore United States fields and the RPURG estimation must therefore be done using the field level data that are available. It should also be noted that this is, insofar as we know, the first time that field level RPURG analysis has been attempted on a scale comparable to that of this inventory.

The Energy Information Administration methodology used for the Phase II study areas and the methodology used by the U.S. Geological Survey to estimate reserves growth for the most recent National Assessment are both statistical extrapolations of historical reserves growth and are subject to the same inherent limitations,[14] although the methodologies differ in detail. These limitations introduce substantial uncertainty into the final results, which the USGS is currently addressing in an ongoing review of their reserves growth estimation methodology (see below). In a recent test, the USGS found that two different statistical extrapolation methodologies produce reserves growth estimates that differed by approximately 25 percent and were as much as 60 percent higher than actual volumetric data.[15] The results shown in Table A7-1 should be interpreted with these limitations in mind:

- Inherent uncertainty in the underlying data (for example, 'reserves' are defined differently by different operators and different commercial/private databases; fields and reservoirs are inconsistently defined).
- Current statistical methodologies rely on field age (since field discovery) as a surrogate for field development effort. Other factors such as reserves recognition

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resources associated with known fields including supply from future extensions of existing pools in known productive reservoirs, infill drilling, and future new pool discoveries within existing fields.

[12] For example, EnCana reports significant reserves growth in Jonah and Mamm Creek fields.

[13] *The Intricate Puzzle of Oil and Gas "Reserves Growth,"* available online at http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/1997/intricate_puzzle_reserves_growth/m07fa.pdf

[14] From Klett, Timothy, *One-Year Reserve-Growth Scoping Project, Fiscal Year 2006*, presentation to American Association of Petroleum Geologists, Committee on Resource Evaluation, February 9, 2006.

[15] Ibid; slide titled "Test of Modified Arrington and USGS Least Squares/Monotonic Methods"

practices, differential application of new technology and production monitoring practices, different operating environments, and access to markets may not be adequately represented by field age alone.

- Large fields have more weight in the analysis, which may bias the results toward the development histories of the largest fields in a basin or study area. Large fields may be more likely than smaller fields to receive consistently applied development efforts and new technology applications, and be less sensitive to economic factors.
- Uncertainties are not addressed directly, such as variance of the input data and uncertainties in the underlying assumed field development scenarios.

Table 2-6. Range of EIA Estimated Remaining Proved Ultimate Recovery Growth ("Reserves Growth") for Selected Study Areas

Table 2-6, which shows the range of RPURG results using the two different models, exponential and hyperbolic, illustrates the uncertainty surrounding the reserves growth estimates. The model fits of the field growth factors (provided as figures in Appendix 7) appear to be very conservative in some cases and inconclusive in others, so that the resulting extrapolation of proved ultimate recovery may be too low. The datasets for some of the study areas may simply be too small to support adequately the extrapolation of remaining proved ultimate recovery. There are many apparent anomalies and errors in the available field-level proved reserves data series that doubtless affect the estimates and that, at present, would require a very labor-intensive effort to isolate, characterize, and correct.

A phenomenon observed in the 1995 USGS National Assessment may also be operating, in which the estimated reserves growth based on a dataset for the lower-48 states as a whole produced greater reserves growth estimates than the sum of reserves growth estimated independently for individual regions. In October 2005, the USGS commenced a one-year scoping project to evaluate possible improvements to existing reserves growth methodology, identify alternative methodologies, and recommend a robust reserves growth methodology that can be universally applied.[16] The EIA is investigating whether it might be possible to develop improved, less labor-intensive means of cleansing the field level data of its apparent anomalies and errors and whether the estimates can be improved by moving to a multi-parameter estimation methodology. The findings and recommendations of the USGS reserves growth scoping project will be incorporated into the reserves growth assessment for subsequent phases of this inventory. Consequently, the reserves growth volumes estimated for this report are likely to be re-evaluated and are subject to change.

2.2.3 Oil and Natural Gas Resource Maps

The products of the oil and gas resource data preparation work are maps of hydrocarbon volumes, projected to the surface. These maps depict areas of varying potential resource richness based on often overlapping play resource volumes. The distributions of undiscovered technically recoverable resources and reserves growth are

[16] Brenda S. Pierce, USGS, personal communication to Jeffrey Eppink, Advanced Resources International, regarding USGS Energy Resources Team Reserves Growth Scoping Project, project number 8930C1K.

shown by study area for oil in Figures 2-14 through 2-24 and for natural gas in Figures 2-25 through 2-35.

2.2.4 Proved Reserves

Proved reserves are defined as quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as greater than 90 percent probability) to be recoverable from *known* reservoirs *under existing economic and operating conditions*. Proved reserves are, in effect, the current "inventory on-the-shelf" portion of total resource endowment.[17]

2.2.4.1 Sources of Proved Oil and Gas Reserves Data

[17] The full technical definition of proved reserves is at the Society of Petroleum Engineers website at http://www.spe.org/spe/jsp/basic/0,,1104_12169,00.html

Comprehensive estimates of the domestic proved reserves of crude oil, natural gas, and natural gas liquids are prepared annually by the EIA. These estimates are a combination of reported and statistically imputed volumes based on:

- Thousands of individual proved reserves and production estimates reported to EIA annually,[18] either at the field level or at the state level by a representative sample of the operators of domestic oil and gas wells. Of the 22,519 operators in the 2001 survey, 1,867 were included in the sample.
- All operators of active domestic natural gas processing plants who annually report their operations on Form EIA-64A "Annual Report of the Origin of Natural Gas Liquids Production." For the 2001 survey, 525 active gas processing plants responded to the survey.

Only the largest oil and gas well operators (those producing 1.5 million barrels or more of crude oil, or 15 billion cubic feet or more of natural gas per year) are required to submit to EIA proved reserves and production estimates by field for all of their operated properties. There were 172 large operators in the 2001 survey, all of which were included in the sample. The response rate was 100 percent.

Intermediate size operators (those producing less than the largest operators but at least 400,000 barrels of crude oil, or at least 2 billion cubic feet of natural gas per year) are required to submit production estimates by field for all of their operated properties, but are only required to submit proved reserves estimates by field when they maintain them in their records. There were 439 mid-sized operators in the 2001 survey. All were included in the sample and their response rate was also 100 percent.

Small operators are those with production less than 400,000 barrels of crude oil or 2 billion cubic feet of natural gas per year. There were 21,908 small operators in the 2001 survey. Of these, 1,175 were sampled with certainty at an associated response rate of 98 percent and an additional 622 were randomly sampled at an associated response rate of 95 percent.

2.2.4.2 Proved Oil and Gas Reserves Data Preparation

The procedures used to prepare the proved oil and gas reserves data are described in Appendix 8**.**

2.2.4.3 Proved Reserves Data-Related Caveats

Because the EIA's proved reserves survey is expressly designed to minimize the respondents' reporting burden and yet provide reliable estimates at the state and national level of data aggregation, the EIA does not have operator-submitted, field-specific proved reserves information covering every oil or gas field in the country. However, the EIA has data reported for about 90 percent of all estimated domestic

[18] Form EIA-23 "Annual Survey of Domestic Oil and Gas Reserves."

proved reserves. The EIA may have only partial reported estimates for a field that has two or more operators if one is not required to report proved reserves by field.

These deficiencies in EIA's field-specific proved reserves information were remedied for this inventory by use of additional procedures based on either publicly-available production data or reserve-to-production ratio analogs.

In addition to gaps and omissions in operator-reported estimates of proved reserves, the proved reserves data are subject to two further caveats:

1. For the EIA survey, field location is reported at the county level. The precise field locations needed for this inventory's GIS-based methodology required correlation of the EIA's reserves data files with commercial sources of field and/or well information that provide more precise location data. This process involved detailed, often well-by-well, work owing to the existence of non-standard field names and codes, or the occasional lack of a field name, in the commercial or State data sources.
2. EIA is obliged by law to ensure the confidentiality of the data submitted by each reserves survey respondent. Within the Phase II study areas, there are situations where a field is operated by a single operator, or where a single operator is dominant. In such cases, EIA cannot disclose the proved reserves estimates for the field without a written agreement from the operator waiving the right to confidentiality. Such agreements are rare and time-consuming to obtain. To avoid the release of confidential information while still adequately supporting this inventory, EIA elected not to present field-specific proved reserves estimates even where doing so would not have compromised a respondent's identity. Instead, the fields have been grouped into a range of proved reserves categories that are broad enough to prevent extraction of the estimates for any specific field.

Table 2-7 provides a summary of proved reserves on Federal and nonfederal lands. Note that proved oil and gas reserves are not presented on Figures 2-14 through 2-35. See Appendix 8 for a more detailed explanation of proved reserves estimation and field boundary construction.

Table 2-7. Proved Reserves Summary Statistics

This inventory is designed to portray the constraints on future access to the potential oil and gas resource base. Consequently, undiscovered technically recoverable resources and reserves growth resources are included in the categorization, but not proved reserves.[19] Table 2-8 summarizes the oil and gas resource types on Federal lands for each study area.

Table 2-8. Summary of All Federal Oil and Gas Resources

[19] Proved reserves were incorporated into the EPCA Phase I inventory. Due to the revision of inventory requirements by the Energy Policy Act of 2005, proved reserves volumes are reported in this Phase II inventory but are excluded from the access categorization.

by Study Area and Resource Type

2.3 DATA INTEGRATION AND SPATIAL ANALYSIS

2.3.1 Categorization of Oil and Gas Access Constraints

The main factors that affect access to oil and gas resources on Federal lands are land availability (Section 2.1.1) and leasing and drilling restrictions (Sections 2.1.2 and 2.1.3). To simplify the analysis and present meaningful results, these factors were categorized into a hierarchy that represents varying levels of access as shown in Table 2-8. This categorization was necessary to enable a reasonable quantitative analysis, given the fact that approximately 2,130 individual stipulations from 65 Federal land use plans (LUPs) exist for the study areas within the Phase II inventory.

Table 2-9. Federal Land Access Categorization Hierarchy

The hierarchy of categories was formulated to ensure that the constraints on oil and gas development could be appropriately assessed (especially for areas of multiple, overlapping stipulations), and to ensure that the cumulative impacts on access would be examined. In addition, the hierarchy was formulated based upon the accessibility of the lands for leasing, and for areas where leasing is permitted, the impacts relative to the difficulty for conducting drilling operations.

The Federal lands categorization hierarchy is ordered from "No Leasing" (most constrained) to "Leasing with Standard Lease Terms" (least constrained) as follows:

1. **No Leasing (Statutory/Executive Order) (NLS)** are lands that cannot be leased due to Congressional or Presidential action. Examples include national parks, national monuments, and wilderness areas.
2. **No Leasing (Administrative) (NLA)** are lands that are withheld from leasing based on discretionary decisions made by the Federal land management agency. NLA areas can include endangered species habitat and historical sites.
3. **No Leasing (Administrative), Pending Land Use Planning or NEPA Compliance (NLA/LUP)** are lands that have not yet undergone or are currently undergoing land use planning or NEPA analysis, and that are generally not available for leasing. In the cases where there is no land use plan in effect, non-Federal mineral estate underlying Federal land is categorized as NLA/LUP to reflect the fact that access to mineral estate can be allowed through the NEPA process.
4. **Leasing, No Surface Occupancy (NSO) (Net NSO for Oil & Gas Resources)** are lands that can be leased but ground-disturbing oil and natural gas exploration and development activities are prohibited. These stipulations protect identified resources such as special status plant species habitat. Their surface areas are mapped as described by the land use plans. However, at least some of the resources can be accessed by directional drilling from nearby lands where surface occupancy is allowed. This is accounted for by creating an extended drilling zone (EDZ, as described in Appendix 9) that reduces the size of the NSO

area. The area removed is then placed in the next most restrictive resource access category (5 through 9, below) that would otherwise apply in the absence of the NSO stipulation. Within the EDZ area the underlying resource is considered accessible even though the surface above it cannot be occupied by drilling equipment. After the EDZ is removed, the NSO area that remains is referred to as "Net NSO" (NNSO) and the resources under it are therefore considered inaccessible.

5. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >9 Months**
6. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >6 to ≤9 Months**
7. **Leasing, Cumulative Timing Limitations (TLs) on drilling of >3 to ≤6 Months** are lands that can be leased, but stipulations and/or COAs limit the time of the year when oil and gas exploration and drilling can take place. Timing limitation stipulations prohibit surface use during specified time intervals to protect identified resources such as sage grouse habitat or elk calving areas.
8. **Leasing, Controlled Surface Use (CSU)** are lands where stipulations and/or COAs control the surface location of natural gas and oil exploration and development activities by excluding them from portions of the lease. For example, a CSU stipulation could require an operator to develop a specialized mitigation plan based on the presence of moderately steep slopes. This category also includes the minimal areas that have timing limitations of less than three months.
9. **Leasing, Standard Lease Terms (SLTs)** areas are lands that can be leased and where no additional stipulations are added to the standard lease form. Standard lease terms, however, still dictate that the lessee must comply with many environmental standards and other requirements (see 2.1.2, above).

Categorizations were made on the basis of LUPs and discussions with Federal land management agencies. In most cases categorization is relatively straightforward; in other cases judgments were made based upon experience with stipulation datasets. For USDA-FS, FPs standards and guidelines are both included in the definition of "Management Direction" at 36 CFR 219.3 (Forest Planning), and were used synonymously without distinction in evaluating USDA-FS stipulations.

All categorizations were made available to field offices for review and comment.

2.3.1.1 Data Integration And Spatial Analysis-Related Caveats

The following precautions are advised when reviewing this study:

- A total of 2,132 stipulations in 65 LUPs were analyzed in the Phase II inventory. Substantial efforts were made to assess stipulations where no GIS data were available, either by digitizing or obtaining data from other sources. Despite these efforts, not all stipulations have corresponding GIS data. While it is impossible to assess the absolute magnitude of this issue, it is nevertheless believed to be significant. By item count, approximately 39 percent of total stipulations in the Phase II inventory do not have GIS associated with them. To the extent that this issue exists, the inventory overestimates access to lands and resources. The induced error is likely to be less than 39 percent as many of the missing stipulations are not

likely to have large geographic coverage or may be outside a given study area. This issue points to a data gap to be addressed by Federal agencies.

- In NSO areas that abut non-Federal lands, no assumption was made about the availability of adjacent non-Federal lands as a base from which to drill under Federal lands. It is estimated that this situation has a minimal effect, impacting less than one half of one percent of resources in the study areas. Therefore, an Extended Drilling Zone (EDZ) was not applied to NSO lands adjacent to non-Federal lands.

2.3.2 Analytical Modeling of Federal Lands and Resources

See Appendix 9 for a detailed description of the GIS methodology used to categorize the Federal lands and resources for the inventory.

3.0 RESULTS

The results of the inventory are presented below, summarized by access category for land area and resources and grouped by study area. Table 3-1 shows the combined results for all 11 study areas, while Tables 3-2 through 3-12 show the results for individual study areas. Also depicted on the bottom of each table is a simplified summary showing accessibility of oil and gas resources. The tables show the results for Federal land access categorization by land area, total oil (used generically to include oil, NGLs, and liquids associated with gas reservoirs), and total natural gas (associated and non-associated with oil reservoirs). Oil and natural gas totals include undiscovered technically recoverable and reserves growth resources. Figures 3-1 through 3-57 show the corresponding pie charts depicting the simplified and the nine-category access hierarchy, the Federal land access categorization maps for each study area, and the corresponding maps showing undiscovered oil and natural gas resources on Federal lands.

Table 3-1. Summary of All Phase II Study Areas—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-1. Simplified Chart of Results, Summary of All Phase II Study Areas—Federal Land and Oil and Natural Gas Resources

Figure 3-2. Chart of Results, Summary of All Phase II Study Areas—Federal Land and Oil and Natural Gas Resources by Access Category

3.1 STUDY AREA FEATURES

Each of the study areas is unique in terms of its Federal land and resources accessibility. Noteworthy features are presented below.

3.1.1 Northern Alaska (NPR-A and ANWR 1002 only)

- None of the Federal land in this study area is accessible under standard lease terms (Figures 3-3 and 3-4, Category 9).
- Approximately 43 percent (10.4 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-3 and 3-4, Categories 5 through 8). Based on resource estimates, these lands contain 41 percent (6.9 Bbbls) of the technically recoverable Federal oil and 51 percent (33.3 TCF) of the technically recoverable Federal natural gas.
- Approximately 57 percent (13.9 million acres) of the Federal land is not accessible (Figures 3-3 and 3-4, Categories 1 through 4). Based on resource estimates, these lands contain about 59 percent (10.2 Bbbls) of the technically recoverable Federal oil and 49 percent (32.2 TCF) of the technically recoverable Federal natural gas.
- Only conventional resources have been assessed for Northern Alaska. Continuous resources (See Section 2.2.1.1) will be included in a future USGS assessment.

Reserves growth has not been estimated for this study area.

- Although the Federal portion of NPR-A (22.5 million acres) is about 15 times larger in surface area than the Federal portion of ANWR 1002 (1.5 million acres), it is estimated to contain only about 1.2 times as much oil (9.3 Bbbls versus 7.7 Bbbls).

Table 3-2. Northern Alaska Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-3. Simplified Chart of Results, Northern Alaska Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-4. Chart of Results, Northern Alaska Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-5. Federal Land Access Categorization Map, Northern Alaska Study Area

Figure 3-6. Map of Total Federal Oil, Northern Alaska Study Area

Figure 3-7. Map of Total Federal Natural Gas, Northern Alaska Study Area

3.1.2 Uinta-Piceance Basin

- Approximately 38 percent (4.9 million acres) of the Federal land is accessible under standard lease terms (Figures 3-8 and 3-9, Category 9). Based on resource estimates, these lands contain 28 percent (36 MMbbls) of the Federal oil and 24 percent (3.1 TCF) of the Federal natural gas.
- Approximately 27 percent (3.6 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-8 and 3-9, Categories 5 through 8). Based on resource estimates, these lands contain 56 percent (72 MMbbls) of the Federal oil and 61 percent (7.8 TCF) of the Federal natural gas in the basin.
- Approximately 35 percent (4.6 million acres) of the Federal land is not accessible (Figures 3-8 and 3-9, Categories 1 through 4). Based on resource estimates, these lands contain about 17 percent (22 MMbbls) of the Federal oil and 15 percent (1.9 TCF) of the Federal natural gas.
- Most of the undiscovered natural gas (greater than 95 percent) is expected to occur as continuous resources.

Table 3-3. Uinta-Piceance Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-8. Simplified Chart of Results, Uinta-Piceance Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-9. Chart of Results, Uinta-Piceance Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-10. Federal Land Access Categorization Map, Uinta-Piceance Basin Study Area

Figure 3-11. Map of Total Federal Oil, Uinta-Piceance Basin Study Area

Figure 3-12. Map of Total Federal Natural Gas, Uinta-Piceance Basin Study Area

3.1.3 Paradox/San Juan Basins

- Approximately 40 percent (7.0 million acres) of the Federal land is accessible under standard lease terms (Figures 3-13 and 3-14, Category 9). Based on resource estimates, these lands contain 38 percent (156 MMbbls) of the Federal oil and 39 percent (10.5 TCF) of the Federal natural gas.
- Approximately 11 percent (1.9 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-13 and 3-14, Categories 5 through 8). Based on resource estimates, these lands contain 39 percent (159 MMbbls) of the Federal oil and 54 percent (14.7 TCF) of the Federal natural gas.
- Approximately 49 percent (8.7 million acres) of the Federal land is not accessible (Figures 3-13 and 3-14, Categories 1 through 4). Based on resource estimates, these lands contain about 23 percent (96 MMbbls) of the Federal oil and 7 percent (2.0 TCF) of the Federal natural gas.
- Most of the undiscovered natural gas (approximately 95 percent) is expected to occur as continuous resources.

Table 3-4. Paradox/San Juan Basins Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-13. Simplified Chart of Results, Paradox/San Juan Basins Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-14. Chart of Results, Paradox/San Juan Basins Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-15. Federal Land Access Categorization Map, Paradox/San Juan Basins Study Area

Figure 3-16. Map of Total Federal Oil, Paradox/San Juan Basins Study Area

Figure 3-17. Map of Total Federal Natural Gas, Paradox/San Juan Basins Study Area

3.1.4 Montana Thrust Belt

- Approximately 3 percent (0.2 million acres) of the Federal land is accessible under standard lease terms (Figures 3-18 and 3-19, Category 9). Based on resource

estimates, these lands contain 2 percent (3 MMbbls) of the Federal oil and 1 percent (0.07 TCF) of the Federal natural gas.

- Approximately 5 percent (0.3 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-18 and 3-19, Categories 5 through 8). Based on resource estimates, these lands contain 6 percent (10 MMbbls) of the Federal oil and 4 percent (0.27 TCF) of the Federal natural gas.
- Approximately 92 percent (5.2 million acres) of the Federal land is not accessible (Figures 3-18 and 3-19, Categories 1 through 4). Based on resource estimates, these lands contain about 92 percent (158 MMbbls) of the Federal oil and 95 percent (6.0 TCF) of the Federal natural gas.
- The USDA-Forest Service is the primary land management agency in the Montana Thrust Belt, with 71 percent of the Federal lands. Almost half is currently not being leased while undergoing new land use planning.

Table 3-5. Montana Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-18. Simplified Chart of Results, Montana Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-19. Chart of Results, Montana Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-20. Federal Land Access Categorization Map, Montana Thrust Belt Study Area

Figure 3-21. Map of Total Federal Oil, Montana Thrust Belt Study Area

Figure 3-22. Map of Total Federal Natural Gas, Montana Thrust Belt Study Area

3.1.5 Powder River Basin

- Approximately 49 percent (5.8 million acres) of the Federal land is accessible under standard lease terms (Figures 3-23 and 3-24, Category 9). Based on resource estimates, these lands contain 22 percent (198 MMbbls) of the Federal oil and 19 percent (1.7 TCF) of the Federal natural gas.
- Approximately 32 percent (3.9 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-23 and 3-24, Categories 5 through 8). Based on resource estimates, these lands contain 74 percent (668 MMbbls) of the Federal oil and 71 percent (6.2 TCF) of the Federal natural gas in the basin.
- Approximately 19 percent (2.3 million acres) of the Federal land is not accessible (Figures 3-23 and 3-24, Categories 1 through 4). Based on resource estimates, these lands contain about 4 percent (32 MMbbls) of the Federal oil and 10 percent (0.87 TCF) of the Federal natural gas.

- Almost all of the undiscovered natural gas is expected to be found in coalbeds (98 percent).
- Among the study areas, this area has the highest proportion of split estate lands (59 percent of the Federal oil and gas ownership is split estate).

Table 3-6. Powder River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-23. Simplified Chart of Results, Powder River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-24. Chart of Results, Powder River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-25. Federal Land Access Categorization Map, Powder River Basin Study Area

Figure 3-26. Map of Total Federal Oil, Powder River Basin Study Area

Figure 3-27. Map of Total Federal Natural Gas, Powder River Basin Study Area

3.1.6 Wyoming Thrust Belt

- Approximately 13 percent (0.6 million acres) of the Federal land is accessible under standard lease terms (Figures 3-28 and 3-29, Category 9). Based on resource estimates, these lands contain 16 percent (7 MMbbls) of the Federal oil and 14 percent (0.05 TCF) of the Federal natural gas.
- Approximately 17 percent (0.7 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-28 and 3-29, Categories 5 through 8). Based on resource estimates, these lands contain 31 percent (14 MMbbls) of the Federal oil and 46 percent (0.17 TCF) of the Federal natural gas.
- Approximately 69 percent (2.9 million acres) of the Federal land is not accessible (Figures 3-28 and 3-29, Categories 1 through 4). Based on resource estimates, these lands contain about 53 percent (24 MMbbls) of the Federal oil and 40 percent (0.15 TCF) of the Federal natural gas.

Table 3-7. Wyoming Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources Affected by Access Category

Figure 3-28. Simplified Chart of Results, Wyoming Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-29. Chart of Results, Wyoming Thrust Belt Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-30. Federal Land Access Categorization Map, Wyoming Thrust Belt Study Area

Figure 3-31. Map of Total Federal Oil, Wyoming Thrust Belt Study Area

Figure 3-32. Map of Total Federal Natural Gas, Wyoming Thrust Belt Study Area

3.1.7 Greater Green River Basin (Southwestern Wyoming)

- Approximately 30 percent (3.5 million acres) of the Federal land is accessible under standard lease terms (Figures 3-33 and 3-34, Category 9). Based on resource estimates, these lands contain 14 percent (335 MMbbls) of the Federal oil and 15 percent (9.4 TCF) of the Federal natural gas.
- Approximately 50 percent (5.7 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-33 and 3-34, Categories 5 through 8). Based on resource estimates, these lands contain 77 percent (1,828 MMbbls) of the Federal oil and 76 percent (47.8 TCF) of the Federal natural gas.
- Approximately 20 percent (2.2 million acres) of the Federal land in the basin is not accessible (Figures 3-33 and 3-34, Categories 1 through 4). Based on resource estimates, these lands contain about 9 percent (213 MMbbls) of the Federal oil and 9 percent (5.6 TCF) of the Federal natural gas.
- Almost all of the undiscovered natural gas (97 percent) is expected to occur as continuous deposits.
- A relatively large portion of the Federal land (43 percent of the surface area,) along with 44 percent of the oil and 43 percent of the natural gas, are under timing limitations of 3 to 9 months.
- The land ownership pattern is highly complex due a checkerboard pattern of ownership resulting from railroad land grants.

Table 3-8. Greater Green River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-33. Simplified Chart of Results, Greater Green River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-34. Chart of Results, Greater Green River Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-35. Federal Land Access Categorization Map, Greater Green River Basin Study Area

Figure 3-36. Map of Total Federal Oil, Greater Green River Basin Study Area
Figure 3-37. Map of Total Federal Natural Gas, Greater Green River Basin Study Area

3.1.8 Denver Basin

- Approximately 32 percent (0.9 million acres) of the Federal land is accessible under standard lease terms (Figures 3-38 and 3-39, Category 9). Based on resource estimates, these lands contain 16 percent (2 MMbbls) of the Federal oil and 11 percent (0.01 TCF) of the Federal natural gas.
- Approximately 42 percent (1.18 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-38 and 3-39, Categories 5 through 8). Based on resource estimates, these lands contain 68 percent (9 MMbbls) of the Federal oil and 58 percent (0.03 TCF) of the Federal natural gas.
- Approximately 25 percent (0.7 million acres) of the Federal land is not accessible (Figures 3-38 and 3-39, Categories 1 through 4). Based on resource estimates, these lands contain about 16 percent (2 MMbbls) of the Federal oil and 31 percent (0.02 TCF) of the Federal natural gas.

Table 3-9. Denver Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-38. Simplified Chart of Results, Denver Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-39. Chart of Results, Denver Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-40. Federal Land Access Categorization Map, Denver Basin Study Area

Figure 3-41. Map of Total Federal Oil, Denver Basin Study Area

Figure 3-42. Map of Total Federal Natural Gas, Denver Basin Study Area

3.1.9 Florida Peninsula

- None of the Federal land in the study area is accessible under standard lease terms (Figures 3-43 and 3-44, Category 9).
- Approximately 6 percent (0.1 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-43 and 3-44, Categories 5 through 8). Based on resource estimates, these lands contain 14 percent (11 MMbbls) of the Federal oil and 15 percent (0.05 TCF) of the Federal natural gas.
- Approximately 94 percent (1.88 million acres) of the Federal land is not accessible (Figures 3-43 and 3-44, Categories 1 through 4). Based on resource estimates, these lands contain about 86 percent (64 MMbbls) of the Federal oil and 85 percent (0.28 TCF) of the Federal natural gas.
- The Department of the Interior has agreed in principle to acquire the mineral rights under Big Cypress National Preserve, Florida Panther National Wildlife Refuge, and

Ten Thousand Islands National Wildlife Refuge from Collier Resources Company, virtually ensuring no new oil and gas development in the three areas.[1]

Table 3-10. Florida Peninsula Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-43. Simplified Chart of Results, Florida Peninsula Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-44. Chart of Results, Florida Peninsula Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-45. Federal Land Access Categorization Map, Florida Peninsula Study Area

Figure 3-46. Map of Total Federal Oil, Florida Peninsula Study Area

Figure 3-47. Map of Total Federal Natural Gas, Florida Peninsula Study Area

3.1.10 Black Warrior Basin

- The Federal lands in this study area contain only about 1 MMbbls of oil out of a total of 13 MMbbls for all lands.
- Approximately 3 percent (0.02 million acres) of the Federal land is accessible under standard lease terms (Figures 3-48 and 3-49, Category 9). Based on resource estimates, these lands contain 11 percent of the Federal oil (0.08 MMBbls) and 18 percent (0.07 TCF) of the Federal natural gas.
- Approximately 15 percent (0.10 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-48 and 3-49, Categories 5 through 8). Based on resource estimates, these lands contain 32 percent of the Federal oil (0.24 MMBbls) and 35 percent (0.14 TCF) of the Federal natural gas.
- Approximately 82 percent (0.57 million acres) of the Federal land is not accessible (Figures 3-48 and 3-49, Categories 1 through 4). Based on resource estimates, these lands contain 57 percent of the Federal oil (0.43 MMBbls) and 47 percent (0.19 TCF) of the Federal natural gas.

Table 3-11. Black Warrior Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-48. Simplified Chart of Results, Black Warrior Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-49. Chart of Results, Black Warrior Basin Study Area—Federal Land and

[1] *Interior Reaches Agreement to Acquire Mineral Rights in Everglades, Settles Litigation on Offshore Oil and Gas Leases in Destin Dome..* See the website: http://www.fws.gov/southeast/news/2002/n02-002.html

Field Code Changed

Oil and Natural Gas Resources by Access Category

Figure 3-50. Federal Land Access Categorization Map, Black Warrior Basin Study Area

Figure 3-51. Map of Total Federal Oil, Black Warrior Basin Study Area

Figure 3-52. Map of Total Federal Natural Gas, Black Warrior Basin Study Area

3.1.11 Appalachian Basin

- Approximately 16 percent (0.9 million acres) of the Federal land is accessible under standard lease terms (Figures 3-53 and 3-54, Category 9). Based on resource estimates, these lands contain 15 percent (5 MMbbls) of the Federal oil and 17 percent (0.4 TCF) of the Federal natural gas.
- Approximately 39 percent (2.1 million acres) of the Federal land is accessible with restrictions on oil and gas operations beyond standard lease terms (Figures 3-53 and 3-54, Categories 5 through 8). Based on resource estimates, these lands contain 43 percent (14 MMbbls) of the Federal oil and 41 percent (1 TCF) of the Federal natural gas.
- Approximately 45 percent (2.4 million acres) of the Federal land is not accessible (Figures 3-53 and 3-54, Categories 1 through 4). Based on resource estimates, these lands contain about 41 percent (14 MMbbls) of the Federal oil and 42 percent (1.01 TCF) of the Federal natural gas.
- Most of the undiscovered gas resource (94 percent) is expected to occur in continuous deposits.
- Coalbed natural gas accounts for about 13 percent of the total undiscovered continuous gas.

Table 3-12. Appalachian Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-53. Simplified Chart of Results, Appalachian Basin Study Area—Federal Land and Oil and Natural Gas Resources by Accessibility

Figure 3-54. Chart of Results, Appalachian Basin Study Area—Federal Land and Oil and Natural Gas Resources by Access Category

Figure 3-55. Federal Land Access Categorization Map, Appalachian Basin Study Area

Figure 3-56. Map of Total Federal Oil, Appalachian Basin Study Area

Figure 3-57. Map of Total Federal Natural Gas, Appalachian Basin Study Area

3.2 REGIONAL FEATURES

Figure 3-58 shows a comparison of the access charts for the top five basins in the following categories: total Federal land, total Federal oil, and total Federal natural gas. The pie charts are scaled proportionately to one another. Northern Alaska dominates both the land and the resource categories, followed by the Rocky Mountain basins.

Figure 3-58. Charts of the Top Five Areas

Figure 3-59 is a map showing the Phase II study areas with the access category charts compiled by region, relatively sized, by total resources.[2] The largest amount of oil and gas resources are found in Northern Alaska (165 TCFe), followed closely by the Rocky Mountain region (142 TCFe), with the Eastern basins a distant third in rank (4 TCFe).

None of the resources in the two Northern Alaska study areas are accessible under standard lease terms, 45% are accessible with additional restrictions (in NPRA only, due primarily to drilling being restricted to the winter), and 55% are inaccessible.

About 20% of the resources in the seven Rocky Mountain study areas are accessible under standard lease terms, 66% are accessible with additional restrictions (primarily because of timing limitations and the impact of conditions of approval), and 14% are inaccessible.

About 13% of the resources in the three Eastern study areas are accessible under standard lease terms, 35% are accessible with additional restrictions, and 52% are inaccessible.

Figure 3-59. Regional Charts

[2] On a TCF-equivalent (TCFe) basis

4.0 ADDITIONAL FEDERAL LAND ACCESS ISSUES

Additional statutory and discretionary requirements beyond lease stipulations impact Federal land access for oil and gas development. Many of these impacts were not quantified because GIS data do not exist, or they are issues that are not amenable to quantitative analysis. Many of these requirements can be considered restrictions on drilling because they have effects similar to stipulations on oil and gas development activities.

These issues can directly or indirectly impact Federal land accessibility for oil and gas development. Tables 4-1 through 4-11 present office-specific issues that were recorded from discussions with BLM and USDA-FS staff during field visits. Average APD processing time was calculated for each office using input from the offices supplemented by an analysis of BLM's Automated Fluid Minerals Support System (AFMSS).[1]

4.1 ISSUES DIRECTLY IMPACTING ACCESS

The National Environmental Policy Act of 1969. NEPA is the nation's central environmental statute. It requires Federal agencies to consider environmental impacts before an action is taken. The NEPA process is intended to help public officials make better decisions based on an understanding of their environmental consequences.

NEPA is embedded into the fabric of Federal land management decision-making and has become the most important procedural public land management statute because it requires agencies to comply with its processes in all situations where major actions are

[1] These tables include only offices that were visited or specifically contacted during EPCA Phase I and Phase II data collection. Not all offices responded.

contemplated. When an activity or action is proposed on Federal lands, an interdisciplinary review of the environmental effects of the proposal is conducted and made available to citizens and public officials. The review can take one of four forms:

- a categorical exclusion (CX)
- documentation of NEPA adequacy (DNA)
- an environmental assessment (EA)
- an environmental impact statement (EIS).

In its 2003 report to the Council on Environmental Quality, the NEPA Task Force published an assessment of NEPA,[2] stating that "The term 'analysis paralysis' is used to address a broad range of concerns about inefficiencies such as agency specific procedural requirements, project priority setting, project management, and Federal consultation and coordination requirements. Many respondents are concerned that the development of these analyses and documents takes too long and results in documentation that is excessive in light of the significance of the actions evaluated."

The NEPA process impacts oil and gas development in terms of cost and time delays. Typically an EIS or EA is drafted in consultation with the cooperating agencies, presented for public comment, and reviewed by multiple agencies. A simple EIS can take 24 to 36 months to complete, while those with more complex issues may require three to six years to complete. The land use planning process as a whole takes well in excess of 36 months, particularly if there is oil and gas involved. NEPA documents analyze alternatives to the proposed action and must include a "no action" alternative. Impacts are classified as direct, indirect, and cumulative, and include the evaluation of economic impacts to counties and states to be considered, as well as impacts on resources.

When considering oil and gas leasing, the BLM has identified the need to obtain additional data on such issues as air quality and clean water as a part of the cumulative impact analysis required by NEPA and land use planning processes. This has been cited as an overarching issue that affects oil and gas lease parcel nominations. This lack of data can result in leasing delays when existing documents are deemed inadequate. The net result is that potential applicants are often aware of the problem and make decisions not to develop in areas that will be or could be held up by the NEPA process.

With respect to the NEPA process itself, concern was expressed by some government officials that individual documents provide "piecemeal" information and that better environmental decisions could be made based on larger scale studies that look at the "bigger picture." For example, wildlife habitat fragmentation is better characterized when it is examined in the context of larger rather than smaller areas.

[2] See the website http://ceq.eh.doe.gov/ntf/report/finalreport.pdf for the "Modernizing NEPA Implementation" report.

Delays can increase costs for oil and gas operations because, rather than waiting for the Federal agency to complete the work, operators frequently pay a third-party contractor to perform the necessary work.

Based on the NPC 2003 natural gas study, to conduct wildlife, cultural, and other surveys related to Federal oil and gas permitting costs between $21,000 and $330,000 and causes a delay of 3 to 26 months per exploration well. Per-well survey costs and delays for development wells range from $18,000 to $21,000 and 2 to 32 months respectively.

Section 366 of EPAct 2005 sets a deadline for the consideration of applications for permits. The permit must be issued within 30 days (if NEPA and other legal requirements have been met), or defer the decision and provide to the applicant a notice.

The Endangered Species Act of 1973. The ESA requires Federal agencies to conserve listed species. Under the ESA, species are treated as either listed, proposed, or candidate species. In BLM and USDA-FS jurisdictions, listed and proposed species are treated similarly. Candidate species are generally handled in a discretionary manner. All BLM administrative offices treat sensitive species as defined by BLM and state governments the same as endangered species.

Federal agencies are responsible for managing wildlife habitat, while state governments manage the wildlife itself. In many areas, some habitat has not yet been mapped. This can become an added delay for oil and gas development, if habitat information is required before leasing and permitting can proceed. Habitat for candidate species has been generally withheld from oil and gas leasing by Federal agencies during a consideration period of up to 2½ years.

Inventoried Roadless Areas. A total of 8.4 million acres of National Forest Inventoried Roadless Areas (IRAs) exists within the boundaries of the Phase II study areas. Forest Service representatives recognize the complexity surrounding the issue of IRAs. In July 2004, the Forest Service published a proposed rule to revise the Roadless Area Conservation Rule published in January 2001, which had been struck down in July 2003 by the Federal District Court for the District of Wyoming.

The final roadless rule was published in May 2005. The rule allows governors to petition the Secretary of Agriculture to develop regulations to manage roadless areas in order to meet specific needs within each state. USDA-FS will accept state petitions from governors for 18 months after the effective date of the final rule. During the state-petitioning process, the Forest Service will continue to maintain interim measures to conserve inventoried roadless areas.

In spite of the controversy surrounding the issue, leasing is occurring in some roadless areas. Leases in various forests within IRAs are issued with the caveat to industry that

the disposition of roadless areas is unresolved and that the areas under lease may have to remain roadless.

Visual Impacts. Concern over visual impacts is affecting oil and gas development in some areas. For example, field developments can be delayed until impacts and other issues are assessed. Visual impacts were raised as a potential issue by many BLM and USDA-FS offices.

Suburban Encroachment. Opposition to oil and gas activities is increasing as residential construction spreads into previously undeveloped areas. This has not been a significant issue until recently and has not generally been incorporated into oil and gas planning activities. NSO stipulations to maintain open space near housing developments are being considered by some offices.

Seasonal Restrictions in Alaska. The primary constraint to access in the NPRA is the restriction that limits exploratory drilling activities to the winter season, which lasts approximately five months. During that time, ice roads need to be built, a task that can take one or two months and may be limited to 25-30 miles. Coupled with timing limitations for threatened and endangered species, the cumulative effects of these limitations make drilling operations difficult and significantly impact project economics.

4.2 ISSUES INDIRECTLY IMPACTING ACCESS

Clean Water. In the Uinta-Piceance Basin, the issue of clean water has been raised in the context of the need for examining entire watersheds. It is increasingly recognized that an entire watershed (rather than administrative jurisdictions) must be examined in instances where activity within one jurisdiction may affect another downstream. States and counties increasingly object to drilling in municipal watersheds, often resulting in added stipulations and/or conditions of approval for protection. In addition, localized clean water issues include mitigating selenium concentrations, salinity, and sedimentation.

Air Quality. Air quality can be a contentious issue in Rocky Mountain basins such as the Greater Green River Basin. Increasingly, air quality issues are being raised, especially in Utah.

Staffing. Workload requirements are increasing and the BLM is facing challenges with respect to the timely processing of APDs, energy-related rights of ways, and monitoring compliance. The number of APDs received increased from nearly 4000 in FY 2000 to over 8000 in FY 2005. Recruitment and retention of professional oil and gas staff is challenging.

Section 365 of EPAct 2005 requires the Secretary of the Interior to establish a Federal Permit Streamlining Pilot Project to improve Federal oil and gas permit coordination. A Memorandum of Understanding establishing staffing needs and funding protocols for the pilot offices was signed on October 25, 2005, by the Department of Interior, Department of Agriculture, Environmental Protection Agency, and the Army Corps of

Engineers. The seven pilot offices (Rawlins and Buffalo, Wyoming; Miles City, Montana; Farmington and Carlsbad, New Mexico; Grand Junction/Glenwood Springs, Colorado; and Vernal, Utah) have been created.

Native American Consultation. The large number of APDs and leases impacts the timeliness of completing the consultation requirements of the National Historic Preservation Act. Consultation with Tribes is increasing and can extend the time required to obtain leases and drilling permits.

Conflicts between Mineral and CBNG Developers. In the Powder River Basin, conflicts can occur between coal mining operators and coalbed natural gas producers. It is the policy of the BLM to encourage oil and gas and coal companies to resolve conflicts between themselves; when requested, the BLM will assist in facilitating agreements between the companies. The BLM will also exercise authority provided in the leases, applicable statutes, and regulations to manage federal mineral development in the public's best interest.

Infrastructure. The physical infrastructure to support oil and gas development and production is often strained. Existing pipelines may be at capacity and new pipeline construction is often a lengthy process. County roads are typically not designed for the volume of truck traffic that they can experience during oil and gas field development. Infrastructure issues can act to constrain future marketing capacity, especially for natural gas in the Piceance Basin, although new pipeline construction can relieve this bottleneck.

BLM's energy-related rights-of-way processing workload has increased along with the increase in APDs. These authorizations are required for such infrastructure as pipelines, roads, and power lines that are located outside of a lease or unit boundary.

Snow Delays. In the higher elevation areas of the Rocky Mountains, snow depths can be so great as to preclude drilling even if there are no winter drilling stipulations. This situation potentially makes for a short drilling window, especially if there are timing limitations during non-snow months.

Industry Understanding of the Leasing and Permitting Process. There is often less-than-optimal understanding and planning within some companies with respect to these processes. The BLM encourages oil and gas operators to inform and work with the permitting agencies as early in the planned development process as possible. The issuance of the recently updated *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development* (the "Gold Book," 4th edition, 2006, available at http://www.blm.gov/bmp/goldbook.htm) should enhance operators' understanding and expectations.

APPENDIX 1

ACRONYMS AND ABBREVIATIONS

AAGF	Average Annual Growth Factor
AAPG	American Association of Petroleum Geologists
ACEC	Area of Critical Environmental Concern
AD	Associated Dissolved (natural gas)
AFMSS	Automated Fluid Minerals Support System
AGF	Annual Growth Factor
AK	Alaska
ANWR	Arctic National Wildlife Refuge
APB	Appalachian Basin
APD	Application for Permit to Drill
API	American Petroleum Institute
AL	Alabama
ARMP	Approved Resource Management Plan
Bbbls	Billion Barrels
BCF	Billion cubic feet (of natural gas)
BHL	Bottom-Hole Location
BLM	Bureau of Land Management
BOE	Barrels of Oil Equivalent
BOEULT	Barrels of Oil Equivalent Ultimate
BOR	Bureau of Reclamation
BWB	Black Warrior Basin
CBNG	Coalbed Natural Gas
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CGF	Cumulative Growth Factor
CO	Colorado
COA	Conditions of Approval
COE	Corps of Engineers
CPA	Citizens' Proposal Area
CSU	Controlled Surface Use
CWP	Citizens' Wilderness Proposals
CWR	Critical Winter Range
DEM	Digital Elevation Model
DEN	Denver Basin
DFC	Desired Future Condition
DHS	Department of Homeland Security
DNR	Department of Natural Resources
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor

DR	Decision Record
DVA	Department of Veterans Affairs
EA	Environmental Assessment
EDZ	Extended Drilling Zone
EF	Exception Factor
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCA	Energy Policy and Conservation Act
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
EUR	Estimated Ultimate Recovery
EV	Exceptional Value
FAA	Federal Aviation Administration
FCML	Field Code Master List
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FGDC	Federal Geographic Data Committee
FL	Florida
FlorRs	Federal Lands or Resources
FLP	Florida Peninsula
FLS	Federal Land Status
FO	Field Office
FOOGLRA	Federal Onshore Oil and Gas Leasing and Reform Act
FP	Forest Plan
Ft	Feet
GCDB	Geographic Coordinate Database
GGRB	Greater Green River Basin
GIS	Geographic Information System
GNIS	Geographic Names Information System
GOR	Gas to Oil Ratio
GSA	General Services Administration
HCP	Habitat Conservation Plan
HUD	Department of Housing and Urban Development
IRAs	Inventoried Roadless Areas
ITCs	Incorporated Towns and Cities
LAC	Land Access Categorization
LGR	Liquids to Gas Ratio
LLD	Legal Land Description
LR	Legacy Rehost
LUEA	Land Use Emphasis Area
LUP	Land Use Plan
MA	Management Area
Mbbls	Thousands of Barrels
MBOE	Thousands of Barrels of Oil Equivalent

MCF	Thousand Cubic Feet
MD	Maryland
MFP	Management Framework Plan
MMbbls	Million Barrels
MMCF	Millions of Cubic Feet
MMS	Minerals Management Service
MS	Mississippi
MTB	Montana Thrust Belt
NA	Northern Alaska
NAG	Non-Associated (natural gas)
NASA	National Aeronautics and Space Administration
NE	Nebraska
NEPA	National Environmental Policy Act
NF	National Forest
NGL	National Grasslands
NGLs	Natural Gas Liquids
NHPA	National Historic Preservation Act
NIMBY	Not In My Back Yard
NLA	No Leasing, Administrative
NLA/LUP	No Leasing, Administrative/Land Use Planning
NLS	No Leasing, Statutory or Executive Order
NM	National Monument
NNSO	Net No Surface Occupancy
NPC	National Petroleum Council
NPRA	National Petroleum Reserve-Alaska
NPS	National Park Service
NRHP	National Register of Historic Places
NSF	National Science Foundation
NSO	No Surface Occupancy
O&G	Oil and Gas
OCS	Outer Continental Shelf
OGIFF	Oil and Gas Integrated Field File
OHV	Off-Highway Vehicle
P75	75^{th} percentile
PDS	PetroDataSource
PDX/SJ	Paradox/San Juan Basins
PGC	Potential Gas Committee
PL	Public Law
PLSS	Public Land Survey System
PRB	Powder River Basin
PUR	Proved Ultimate Recovery
PURG	Proved Ultimate Recovery Growth
QC	Quality Control
RMA	Resource Management Area
RMP	Resource Management Plan
RMU	Resource Management Unit

RNA	Research Natural Area
ROD	Record of Decision
ROW	Right-of-Way
RPD	Reserves and Production Division of the EIA
RPURG	Remaining Proved Ultimate Recovery Growth
SA	Study Area
SC	Steering Committee
SHPO	State Historical Preservation Office
SLT	Standard Lease Terms
SMA	Special Management Area
SMZ	Streamside Management Zone
SOPs	Standard Operating Practices
SORs	Surface Occupancy Restrictions
SPL	Split
SPR	Semi Primitive Recreation
SRMA	Special Recreation Management Area
STIPID	Stipulation Identification
SUPO	Surface Use Plan of Operations
T&E	Threatened and endangered (species)
TCF	Trillion cubic feet (of natural gas)
TCFe	Trillion cubic feet (of natural gas) equivalent
TIN	Triangular Irregular Network
TL	Timing Limitation
TN	Tennessee
TPS	Total Petroleum System
UP	Uinta Piceance Basin
URA	Ultimate recovery appreciation
USC	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USDA-FS	United States Department of Agriculture-Forest Service
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
UT	Utah
VA	Virginia
VBA	Visual Basic for Application
VQO	Visual Quality Objective
VRM	Visual Resource Management
WRAs	Wilderness Reinventory Areas
WSA	Wilderness Study Area
WTB	Wyoming Thrust Belt
WV	West Virginia
WY	Wyoming

APPENDIX 2

GLOSSARY OF TERMS

-A-

Access Probability: The probability, expressed as a decimal fraction, of sufficient access (political and physical) to a particular assessment unit within a given time frame for the activities necessary to find an accumulation of minimum size and to add its volume to proved reserves. The time frame for this assessment is 30 years.

Accumulation: Consists of two types: conventional and continuous. A conventional accumulation is an individual producing unit consisting of a single pool or multiple pools of petroleum grouped on, or related to, a single structural or stratigraphic feature. A continuous accumulation is also an individual producing formation of regional extent that has among other features diffuse boundaries, no obvious oil water contact and no obvious relation to a structural or stratigraphic trap (see continuous-type accumulation).

Affected Environment: Surface or subsurface resources (including social and economic elements) within or adjacent to a geographic area that could potentially be affected by oil and gas activities; the environment of the area to be affected or created by the alternatives under consideration (40 CFR 1502.15).

Alternative: A combination of management prescriptions applied in specific amounts and locations to achieve a desired management emphasis as expressed in goals and objectives. One of several policies, plans, or projects proposed for decision-making. An alternative need not substitute for another in all respects.

Alternative, No Action: An alternative that maintains established trends or management direction and implements those actions previously analyzed and/or approved.

Application: A written request, petition, or offer to lease lands for the purpose of oil and gas exploration and/or the right of extraction.

Application for Permit to Drill (APD): An application to drill a well submitted by a lessee or operator to the BLM. The APD consists of a Drilling Plan that discusses downhole specifications and procedures (reviewed by the BLM) and a Surface Use Plan of Operations (SUPO) that examines surface uses, including access roads, well site layout, cut and fill diagrams, reclamation procedures, production facility locations, etc. (reviewed by the surface-managing agency). The approved APD is a contract between the operator and the Federal government and cannot be changed or modified unless authorized by the BLM and the surface-managing agency.

Aquifer: (1) A sand, gravel, or rock formation capable of storing or conveying water below the surface of the land (USDA, Natural Resources Conservation Services). (2)

The down-dip portion of a water-drive hydrocarbon reservoir that contains predominantly water.

Archeological/historic site: A site that contains either objects of antiquity or cultural value relating to history and/or prehistory that warrant special attention.

Area of Critical Environmental Concern (ACEC): Places that receive special management attention because of potential hazards and/or to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes.

Assessment Unit: A mappable volume of rock within a total petroleum system that encompasses accumulations (discovered and undiscovered) that share similar geologic traits and socio-economic factors. Accumulations within an assessment unit should constitute a sufficiently homogeneous population such that the chosen methodology of resource assessment is applicable. A total petroleum system might equate to a single assessment unit. If necessary, a total petroleum system can be subdivided into two or more assessment units in order that each unit is sufficiently homogeneous to assess individually. An assessment unit may be identified as conventional, if it contains conventional accumulations, or as continuous, if it contains continuous accumulations.

Assessment Unit Probability: Represents the likelihood, expressed as a decimal fraction, that, in a given assessment unit, at least one undiscovered accumulation of a selected minimum size exists that has the potential for its volume to be added to proved reserves in a given time frame. The assessment unit probability is the product of the probabilities of the three geologic attributes (charge, rocks, and timing) and the probability of access.

Associated/Dissolved Gas: Natural gas that occurs in an oil accumulation, either as a free gas cap or in solution; synonymous with gas in oil accumulations.

-B-

Barrels of Oil Equivalent (BOE): A unit of petroleum volume in which the gas portion is expressed in terms of its energy equivalent in barrels of oil. For this assessment, 6,000 cubic feet of gas equals 1 BOE.

Basin: (1) An area largely enclosed by higher lands. (2) A low in the Earth's crust of tectonic origin in which sediments have accumulated.

Big Game: Larger species of wildlife that are hunted, such as elk, deer, bighorn sheep, and pronghorn antelope.

Big Game Winter Range: An area available to and used by big game (large mammals normally managed for sport hunting) through the winter season.

Buffer Zone: (1) An area between two different land uses that is intended to resist, absorb, or otherwise preclude developments or intrusions between the two use areas. (2) A strip of undisturbed vegetation that retards the flow of runoff water, causing deposition of transported sediment.

Bureau of Land Management: An agency within the U.S. Department of the Interior that administers 261 million surface acres of America's public lands, located primarily in 12 Western States. The BLM sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations. The BLM also manages 699 million subsurface acres for mineral leasing and development.

-C-

Candidate Species: (1) A species for which substantial biological information exists on file to support a proposal to list it as endangered or threatened, but for which no proposal has yet been published in the Federal Register. The list of candidate species is revised approximately every two years in the Notice of Review. (2) Any species not yet officially listed, but undergoing a status review or proposed for listing according to Federal Register notices published by the Secretary of the Interior or the Secretary of Commerce.

Casing: Steel pipe placed in an oil or gas well to prevent the hole from caving and to anchor well control equipment.

Cell: A subdivision or area within an assessment unit having dimensions related to the drainage areas of wells (not to be confused with finite-element cells). Three categories of cells are recognized: cells tested by drilling, untested cells, and untested cells having potential to provide additions to reserves within the forecast span of the assessment. A continuous-type assessment unit is a collection of petroleum-containing cells.

Coalbed Natural Gas: Natural gas found in coalbeds. Also termed “coalbed methane” or “coalbed gas”.

Completion: The activities and methods to prepare a well for production. Includes installation of equipment for production from an oil or gas well.

Composite Total Petroleum System: A mappable entity encompassing all or a portion of two or more total petroleum systems. Composite total petroleum systems are used when accumulations within an assessment unit are assumed to be charged by more than one source rock.

Continuous-Type Accumulation: A petroleum accumulation that is pervasive throughout a large area, that is not significantly affected by hydrodynamic influences, and has no obvious seal or trap. Continuous-type accumulations lack well-defined down-dip water contacts. The terms “continuous-type accumulation” and “continuous accumulation” are used interchangeably. Example of continuous-type accumulations include basin-centered gas, coalbed methane and shale gas.

Controlled Surface Use (CSU): Allowed use and occupancy (unless restricted by another stipulation) with identified resource values requiring special operational constraints that may modify the lease rights. CSU is used as an operating guideline, not as a substitute for NSO or Timing Limitations (TLs) stipulations.

Conventional Accumulation: A discrete petroleum accumulation, commonly bounded by a down-dip water contact that is significantly affected by the buoyancy of petroleum in water. Conventional accumulations occur as the result of discrete stratigraphic or structural traps.

Council on Environmental Quality (CEQ): An advisory council to the President established by the National Environmental Policy Act of 1969. It reviews Federal programs for their effect on the environment, conducts environmental studies, and advises the President on environmental matters.

Crucial Winter Range (CWR): Winter habitat on which a wildlife species depends for survival. Because of severe weather conditions or other limiting factors, no alternative habitat would be available.

Cultural Resources: Those fragile and nonrenewable physical remains of human activity, occupation, or endeavor reflected in districts, sites, structures, buildings, objects, artifacts, ruins, works of art, architecture, burial mounds, petroglyphs, and natural features that were of importance in past human events. These resources consist of (1) physical remains; (2) areas where significant human events occurred, even though evidence of the event no longer remains; and (3) the environment immediately surrounding the resource. Cultural resources are commonly discussed in terms of prehistoric and historic values; however, each period represents a part of the full continuum of cultural values from the earliest to the most recent.

Cumulative Petroleum Production: Reported cumulative volume of petroleum that has been produced. Cumulative oil, cumulative gas, and cumulative production are sometimes used as abbreviated forms of this term.

-D-

Directional Drilling: The intentional deviation of a wellbore from vertical to reach subsurface targets that are not located directly below the drilling site.

-E-

Endangered Species: As defined in the Federal Endangered Species Act, any species that is in danger of extinction throughout all or a significant portion of its range. For terrestrial species, the U.S. Fish and Wildlife Service determines endangered status.

Environmental Assessment (EA): A public document for which a Federal agency is responsible that serves to: (1) briefly provide sufficient evidence and analysis for

determining whether to prepare an Environmental Impact Statement (EIS) or a finding of no significant impact; (2) help an agency comply with the NEPA when no EIS is necessary; and (3) facilitate the preparation of an EIS when one is necessary. An EA includes brief discussions of the need for the proposal and of the environmental impacts of the proposed action and other alternatives.

Environmental Impact Statement (EIS): A written analysis of the impacts on the natural, social, and economic environment of a proposed project or resource management plan.

Estimated Ultimate Recovery (EUR): The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with total recovery.

Extended Drilling Zone (EDZ): A buffer zone along the perimeter of NSO areas into which directional drilling can occur in a generalized (as opposed to specific) sense. An EDZ relates NSO to NNSO areas (see below).

-F-

Federal Land: For the purpose of this inventory, land owned by the United States, without reference to how the land was acquired or which Federal agency administers the surface; includes mineral estates underlying private surface.

Field: A production unit consisting of a collection of oil and gas pools that, when projected to the surface, form an approximately contiguous area that can be circumscribed.

Field Growth: The increases in known petroleum volume that commonly occur as oil and gas fields are developed and produced; synonymous with reserve growth.

Forecast Span: A specified future time span in which petroleum accumulations have the potential to provide additions to reserves. A 30-year forecast span is used in the USGS assessments, which affects (1) the minimum undiscovered accumulation size, (2) the number of years in the future that reserve growth is estimated, (3) economic assessments, (4) the accumulations that are chosen to be considered, and (5) the risking structure as represented by access risk.

Forest Plan (FP): A land use plan for a unit of the National Forest system.

Forest Service (USDA-FS): An agency of the U.S. Department of Agriculture that manages 193 million acres of public lands in national forests and grasslands.

-G-

Gas Accumulation: An accumulation with a gas to oil ratio of 20,000 cubic feet/barrel or greater.

Gas in Gas Accumulations: Gas volumes in gas accumulations.

Gas in Oil Accumulations: Gas volumes in oil accumulations.

Gas to Oil Ratio (GOR): The ratio of gas to oil (in cubic feet/barrel) in an accumulation. GOR is calculated using known gas and oil volumes at surface conditions.

Geographic Information System (GIS): A computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e., data identified according to their locations.

Geologic Province: A USGS-defined area having characteristic dimensions of perhaps hundreds to thousands of kilometers encompassing a natural geologic entity (for example, a sedimentary basin, thrust belt, or delta) or some combination of contiguous geologic entities.

Geospatial: Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from remote sensing, mapping, and surveying technologies, or from other sources.

Grown Petroleum Volume: Known petroleum volume adjusted upward to account for future reserve growth. Thirty years of reserve growth is considered for the USGS assessments.

-H-

Habitat: A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.

Hibernacula (Indiana bat): The caves and mines in which the Indiana Bat hibernates.

-I-

-J-

-K-

Known Petroleum Volume: The sum of cumulative production and remaining reserves as reported in the databases used in support of an assessment. Also called estimated total recoverable volume (sometimes called "ultimate recoverable reserves" or "estimated ultimate recovery").

-L-

Landscape: A relatively large area of land with common climate, geology, and soils containing predictably occurring terrain features such as slopes, drainage channels, rock outcrops, etc.

Lease (Oil and Gas): An authorization to use Federal lands and minerals issued under the Act of February 25, 1920, as amended (30 U.S.C. 181, et seq.); the Act of May 21, 1930 (30 U.S.C. 351-359); the Act of August 7, 1947 (30 U.S.C. 351, et seq.); or the Act of November 16, 1981 (PL 97-98, 95 Stat. 1070).

Lease Stipulations: See Stipulations.

Liquids to Gas Ratio (LGR): Ratio of total petroleum liquids (including oil, condensate, and natural gas liquids) to gas (in barrels/million cubic feet) in a gas accumulation. The LGR is calculated using known petroleum liquids and gas volumes at surface conditions. This ratio is used to assess the liquid co-products associated with undiscovered gas in gas accumulations.

-M-

Mineral: Organic and inorganic substances occurring naturally, with characteristics and economic uses that bring them within the purview of mineral laws; a substance that may be obtained under applicable laws from public lands by purchase, lease, or pre-emptive entry.

Minimum Accumulation Size: The smallest accumulation size (volume of oil in oil accumulations or volume of gas in gas accumulations) that is considered in the USGS assessment process for conventional accumulations.

Minimum Petroleum System: The mappable part of a total petroleum system for which the presence of essential elements has been proved by discoveries of petroleum shows, seeps, and accumulations.

Minimum Total Recovery Per Cell: The smallest total recovery per cell (volume of oil or gas) that is considered in the USGS assessment process for continuous-type accumulations.

Mitigation: Includes the following:
(1) Avoiding an impact altogether by not taking a certain action or parts of an action.
(2) Minimizing impacts by limiting the degree of magnitude of the action and its implementation.
(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(5) Compensating for the impact by replacing or providing substitute resources or environments.

Monitoring: The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting resource management objectives.

-N-

National Environmental Policy Act (NEPA): An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes. The law requires the assessment and documentation of the environmental and social impacts of Federal actions. (PL 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by PL 94-52, July 3, 1975, PL 94-83, August 9, 1975, and PL 97-258, § 4(b), Sept. 13, 1982)

National Forest (NF): Created by an act of Congress in 1892, National Forests are Federal land reservations that are administered by the United States Department of Agriculture-Forest Service for multiple uses, including grazing, logging, minerals, and recreation.

National Register of Historic Places (NRHP): A Federal Government list of ". . .districts, sites, buildings, structures, and other objects significant in American history, architecture, archeology, and culture." The National Register is maintained by the National Park Service, U.S. Department of the Interior, and is published in its entirety in the Federal Register each year in February.

Natural Gas Liquids (NGL): Petroleum that occurs naturally as a gas in the reservoir, but that is a liquid under surface conditions. Natural gas liquids are typically reported separately from crude oil.

Natural Gas Liquids to Gas Ratio (for oil accumulations): Ratio of natural gas liquids to gas (in barrels/million cubic feet) in an oil accumulation, calculated using known natural gas liquids and gas volumes at surface conditions. This ratio is used to assess the natural gas liquids associated with undiscovered gas in oil accumulations.

Net No Surface Occupancy (NNSO): NSO areas are areas that can be leased but stipulations prohibit surface occupancy for natural gas and oil drilling activities to protect identified resources. To access O&G resources under NSO areas in the inventory, use of directional drilling technology is taken into consideration resulting in NNSO resources. The impacts of NNSO are similar to NLA areas. See also No Surface Occupancy.

Non-Associated Gas: Natural gas that occurs in a gas accumulation; synonymous with gas in gas accumulations.

No Surface Occupancy (NSO): An area where no surface-disturbing activities of any nature or for any purpose are allowed. For example, construction or the permanent or long-term placement of structures or other facilities would be prohibited. It is also used as a stipulation or mitigation requirement for controlling or prohibiting selected land uses or activities that would conflict with other activities, uses, or values in a given area.

When used in this way, the NSO stipulation or mitigation requirement is applied to prohibit one or more specific types of land and resource development activities or surface uses in an area, while other—perhaps even similar— types of activities or uses (for other purposes) would be allowed. For example, protecting important rock art relics from destruction may require closing the area to the staking of mining claims and surface mining, off-road vehicle travel, construction or long-term placement of structures or pipelines, power lines, general purpose roads, and livestock grazing. Conversely, the construction of fences (to protect rock art from vandalism or from trampling or breakage by livestock), an access road or trail, and other visitor facilities to provide interpretation and opportunity for public enjoyment of the rock art would be allowed. Additionally, if there were potential and interest for leasing and consequent mineral development in the area, then leases for gas and oil, coal, etc., could be issued with a NSO stipulation or mitigation requirement for the rock art site, which would still allow access to the minerals from adjacent lands and underground. The term "no surface occupancy" has no relationship or relevance to the presence of people in an area.

In the NPRA, NSO stipulations generally apply only to permanent facilities but provide for wintertime exploration.

Notice: The communication of a pending Federal action; the notification to parties of Federal actions about to the taken. This is a part of due process.

-O-

Occupancy: Actual possession and use of land in something more than a slight or sporadic manner. As defined as a multiple use component, it is the management of public lands for occupancy involving the protection, regulated use, and development of lands as sites for economically and socially useful structures, either publicly or privately owned.

Oil Accumulation: An accumulation with a gas to oil ratio of less than 20,000 (in cubic feet/barrel).

Oil in Gas Accumulations: Oil volumes in gas accumulations. For the EPCA inventory, oil in gas accumulations was calculated with other liquids rather than separately.

Oil in Oil Accumulations: Oil volumes in oil accumulations.

Operator: An individual, group, association, or corporation authorized to conduct, for example, livestock grazing or oil and gas drilling on public lands.

-P-

Petroleum: A collective term for oil, gas, natural gas liquids, and tar.

Play: A set of known or postulated oil and gas accumulations sharing similar geologic, geographic, and temporal properties, such as source rock, migration pathway, timing, trapping mechanism, and hydrocarbon type. A play may or may not differ from an assessment unit; an assessment unit can include one or more plays.

Proposed Species: A species of plant or animal formally proposed by the U.S. Fish and Wildlife Service (USFWS) to be listed as threatened or endangered under the Endangered Species Act.

Proved Reserves: Quantities of crude oil, natural gas, or natural gas liquids that geological and engineering data demonstrate with reasonable certainty (defined as 90 percent or more probable) to be recoverable in future years from known reservoirs under existing economic and operating conditions.

Public Lands: Any land and interest in land owned by the United States that are administered by the Secretary of the Interior through the BLM, without regard to how the United States acquired ownership, except for (1) lands located on the Outer Continental Shelf and (2) lands held for the benefit of Indians, Aleuts, and Eskimos; includes public domain and acquired lands (see definitions). Vacant, unappropriated, and unreserved public lands, or public lands withdrawn by Executive Order 6910 of November 26, 1934, as amended, or by Executive Order 6964 of February 5, 1935, as amended, and not otherwise withdrawn or reserved, or public lands within grazing district established under Section 1 of the Act of June 28, 1934 (48 Stat. 1269), as amended, and not otherwise withdrawn or reserved.

-Q-

-R-

Remaining Petroleum Reserves: Volume of petroleum in discovered accumulations that has not yet been produced. Remaining reserves is sometimes used as an abbreviated form of this term.

Reserve Growth: The increases in known petroleum volume that commonly occur as oil and gas accumulations are developed and produced; synonymous with field growth.

Resource Management Plan (RMP): A land use plan that provides the basic, general direction and guidance for BLM-administered public lands, usually within a specific administrative area.

Right-of-Way (ROW): A permit or easement which authorizes the use of public land for certain specified purposes, commonly for pipelines, roads, telephone lines, etc.; also, the lands covered by such an easement or permit. It does not grant an estate of any kind, only the right of use. May also include a site.

Riparian Areas: The vegetation along the banks of rivers and streams and around springs, bogs, wet meadows, lakes, and ponds.

Roadless: Refers to an absence of roads that have been constructed and maintained by mechanical means to ensure regular and continuous use.

Roads: Vehicle routes that have been improved and maintained by mechanical means to ensure relatively regular and continuous use. (A way maintained strictly by the passage of vehicles does not constitute a road).

-S-

Shapefile: GIS file format usable with ESRI (such as ArcView) and other commercial GIS software. It is a nontopological data structure that does not explicitly store topological relationships. However, unlike other simple graphic data structures, one or more rings represent shapefile polygons. A ring is a closed, non-self-intersecting loop. This structure can represent complex structures, such as polygons, that contain "islands." The vertices of a ring maintain a consistent, clockwise order so that the area to the right, as one "walks" along the ring boundary, is inside the polygon, while the area to the left is outside the polygon.

Split Estate: Federal mineral estate administered by the BLM, which is under either private lands, state lands, or lands administered by another Federal agency. On split estate lands, the surface owner or managing agency controls the surface uses but the mineral estate is the dominant estate. The BLM coordinates with surface owners on mineral leasing and development. In a few cases, the BLM administers the surface, but the minerals are owned by the state or a private entity.

Stipulations: Conditions, promises, or demands added to a lease when the environmental and planning record demonstrates the necessity for the stipulations. Stipulations, as such, are neither "standard" nor "special"; they are a necessary modification of the terms of the lease. In order to accommodate the variety of resources encountered on Federal lands, stipulations are categorized as to how the stipulation modifies the lease rights, not by the resource(s) to be protected. What, why, and how this mitigation/protection is to be accomplished is determined by the land management agency through land use planning and NEPA analysis. If, upon weighing the relative resource values, uses, and/or users, conflict with oil and gas operations is identified that cannot be adequately managed and/or accommodated on other lands, then a lease stipulation is necessary. Land use plans serve as the primary vehicle for determining the necessity for lease stipulations. Documentation of the necessity for a stipulation is disclosed in planning documents or through site-specific analysis. Land use plans and/or NEPA documents also establish the guidelines under which future waivers, exceptions, or modifications may be granted. Substantial modification or waiver of stipulations subsequent to lease issuance is subject to public review for at least a 30-day period in accordance with Section 5102.f of the Federal Onshore Oil and Gas Leasing Reform Act of 1987. Stipulations may be necessary if the authority to control the activity on the lease does not already exist under laws, regulations, or orders. An authorized Federal officer has the authority to modify the site location and design of facilities, control the rate of development and timing of activities, and require other

mitigation under standard lease terms. The necessity for individual lease stipulations is documented in the lease-file record with reference to the appropriate land use plan or other leasing analysis document. The necessity for exceptions, waivers, or modifications is documented in the lease-file record through reference to the appropriate plan or other analysis.[1]

Study Areas: Northern Alaska, Uinta-Piceance Basin, Paradox/San Juan Basins, Montana Thrust Belt, Powder River Basin, Wyoming Thrust Belt, Greater Green River Basin, Denver Basin, Florida Peninsula, Black Warrior Basin and the Appalachian Basin, which were selected as the geologic provinces for this inventory. They comprise the areas underlain by known or postulated oil and/or natural gas resources based upon USGS assessments.

Subsurface Allocation: An allocation of potential additions to reserves to land entities based on subsurface ownership of mineral rights.

Surface Allocation: An allocation of potential additions to reserves to land entities based on surface ownership.

Sweet Spot: An area within a continuous-type deposit where production characteristics are relatively more favorable.

-T-

Technically Recoverable Resources: In-place resources that are producible using current recovery technology but without reference to economic profitability. These resources are generally conceived as existing in accumulations of sufficient size to be amenable to the application of existing recovery technology.

Timing Limitations (TLs): Prohibit surface use during specified (usually seasonal) time periods to protect identified resource values. They do not apply to the operation and maintenance of production facilities unless there is a continued need for such mitigation and less stringent, project-specific mitigation measures would be insufficient. Also called a Seasonal Restriction.

Total Petroleum System (TPS): A mappable entity encompassing genetically related petroleum that occurs in seeps, shows, and accumulations (discovered or undiscovered) that have been generated by a pod or by closely related pods of mature source rock, together with the essential mappable geologic elements (source, reservoir, seal, and overburden rocks) that controlled fundamental processes of generation, migration, entrapment, and preservation of petroleum.

[1] Taken from the booklet, “Uniform Format for Oil and Gas Lease Stipulations,” prepared by the Rocky Mountain Regional Coordinating Committee in March 1989. These guidelines were developed by the BLM and USDA-FS.

Total Recovery: The total expected recoverable volume of oil, gas, and natural gas liquids production from a well, lease, or field under present economic and engineering conditions; synonymous with estimated ultimate recovery.

-U-

Ultimate Recovery Appreciation (URA): The generally observed increase of Estimated Ultimate Recovery over time.

Undiscovered Petroleum Resources: Resources postulated from geologic information and theory to exist outside of known oil and gas accumulations.

USGS-Assessed Petroleum Volumes: The quantities of oil, gas, and natural gas liquids that have the potential to be added to reserves within some future time frame, which for this assessment is 30 years. The USGS assessed petroleum volumes include both those from undiscovered accumulations, whose sizes are greater than or equal to the selected minimum accumulation size, and those from the reserve growth of fields already discovered.

-V-

-W-

Wetlands: Permanently wet or intermittently flooded areas where the water table (fresh, saline, or brackish) is at, near, or above the soil surface for extended intervals; where hydric wet soil conditions are normally exhibited; and where water depths generally do not exceed two meters. Marshes, shallows, swamps, muskegs, lake bogs, and wet meadows are examples of wetlands.

Wilderness: A Congressionally designated area of undeveloped Federal land retaining its primeval character and influence, without permanent improvement or human habitation, that is protected and managed so as to preserve its natural conditions and that (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and, (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Wildlife: Animals that are neither human nor domesticated.

Withdrawal: An action that restricts the disposition of public lands and that holds them for specific public purposes; also, public lands that have been dedicated to public purposes (for example, recreation sites, office or warehouse sites, etc.).

-X-

-Y-

-Z-

APPENDIX 3

FEDERAL LAND STATUS PREPARATION

A3.1 SOURCES OF DATA

Federal lands mapping for Phases I and II of the inventory was completed based upon detailed research of multiple sources of information that describe the nature and extent of Federal surface and mineral interests. Spatial data themes were created that define various ownership characteristics and categories for lands within the study area boundaries. The final data sets were rendered to delineate both surface and subsurface U.S. rights. Ownership cases were extracted from the BLM's LR-2000 Database, processed, and used to create polygon themes for the project. The primary digital datasets processed and mapped include LR-2000 Status, Case Recordation, Legal Land Description, and various competitive oil and gas lease sales. In the Appalachian Basin study area, data from the "Site Log" were obtained from the BLM's Milwaukee Field Office and supplemented by other records from Federal, state and county governments. Digital land title records were supplemented with paper maps, land ownership ledgers, resource management plans and other miscellaneous real property records. The primary BLM land record databases are shown on the following schematic in Figure A3-1.[1]

In the Public Land Survey System (PLSS) states, the BLM's Geographic Coordinate Data Base (GCDB), where available, was utilized as the survey framework to create Federal land ownership and parcel boundaries. In areas where GCDB was not available, alternate sources were used to establish the positions of PLSS corners and subdivisions. In the Eastern states where only non-rectangular surveys exist, the best data available from Federal, state and county sources were used. Geographic coordinates were not available in all cases and therefore may be somewhat generalized.

Figure A3-1. Schematic of BLM's Primary Land Records Databases

A3.2 DATA PREPARATION

Polygon themes were created for over 180,000 individual ownership cases within the study areas that were extracted from the BLM's LR-2000 Database.

The Surface Management Agency (SMA) and ownership polygon boundaries reflect parcel geometry as described by the legal land description maintained in the electronic records. All land descriptions were processed, including minor subdivisions where available down to and including 2.5 acres or lower. Lands described by lot, tract or

[1] Information is available at http://www.geocommunicator.gov which provides searching, accessing and dynamic mapping of data for Federal land stewardship, land and mineral use records, and land survey information. It also provides spatial display for land and mineral cases from BLM's LR2000 system.

special surveys where GCDB was not available were processed against the BLM Legal Land Description (LLD) file to convert the lot references to nominal aliquot descriptions. Depending on the actual survey type and special survey geometry, the resulting polygon may contain a degree of generalization. Additionally, the BLM record systems do not contain individual records for public domain lands. The location of these lands was determined through various subtractive polygon-processing steps.

The primary information that defines U.S. ownership are data elements associated with various title transactions and business events recorded and maintained within the LR-2000 Database. Case records that fall within the following four general categories were extracted and mapped.

1. **Land Disposals,** including patents, grants, deeds, land sales and all other transactions that conveyed ownership rights in lands from the Federal government.
2. **Acquired Lands,** including lands that were re-acquired by the United States under various legal authorities.
3. **Land Exchanges,** including lands exchanged between the Federal government and other parties.
4. **Quiet Title Cases,** including all records established to cure title and quiet adverse claims.

These four major categories formed the basis to extract the desired records from the BLM's databases. The four queries were processed against both the Status and Case Recordation datasets. Due to formatting differences between the two databases, the resulting polygon attributes contained in the GIS shape files varied slightly. Additionally, in some records extracted from the Case Recordation system, U.S. Rights were not readily available but were determined as accurately as possible through interpretation from land records obtained at BLM state and field offices.

The following attribute fields shown in Table A3-1 lists the data elements contained in the shape files produced from each of the LR-2000 datasets:

Table A3-1. Polygon Attributes from the LR-2000 Datasets

In the Western study areas, the data simplification process was completed through numerous steps that combined data associated with each of the four broad record categories described above.

A general discussion of the processing steps is described below:

1. The GCDB or alternate source PLSS data was used as the cadastral reference framework. The PLSS grid contains data elements and coordinates that define both townships, sections, and 1/16 subdivisions. Where legal descriptions described parcels less than 40 acres, CartéView software was used to map the minor aliquot parts down to 2.5 acres or smaller.[2]

[2] CartéView is the proprietary software of Premier Data Services, Englewood, CO.

2. After the PLSS base was loaded, a master polygon (Figure A3-2) was created to represent the original U.S. land purchases and annexations. For example, lands that fall within the geographic extent of the Denver Basin study area were acquired in 1803 through the Louisiana Purchase. All surface and subsurface rights were claimed by the United States of America.

Figure A3-2. Master Polygon

3. The next step involved processing textual legal land descriptions against the PLSS framework file by subdividing according to the survey rules embedded in the CartéView software. The data shown in Table A3-2 shows a typical input file.

Table A3-2. Typical CarteView Input File

4. After the records from the Status and Case Recordation datasets were processed, the resulting polygon themes were re-attributed to facilitate merging them together. These polygons were then overlaid on the Master Polygon to establish the location of lands where ownership left the Federal government by virtue of patent, grant or other title transfer authority. The resulting coverages are represented in the following graphic, Figure A3-3.

Figure A3-3. Public Domain Lands

The yellow polygons shown on the above map represent lands in the public domain where surface and subsurface rights are managed by the BLM.

5. The next step involved constructing a series of queries of the U.S. rights data associated with lands that were disposed through various title transfers. This query process, (Figure A3-4) involved a very complex analysis against the attribute tables in the spatial datasets. The results of these processes delineate all lands where subsurface oil and gas mineral rights are owned by the United States.

Figure A3-4. Query of U.S. Rights Data

Figure A3-5 illustrates the distribution of split estate mineral ownership within a four township area. The parcels shaded gray represent patented lands where the United States retained rights to the oil and gas mineral estate.

Figure A3-5. Federal Split Estate Oil and Gas Ownership

6. The last step in the spatial query and overlay process was to define any other Federal management agencies or state surface ownership. These determinations were made by completing a series of queries against the ownership fields in the parcel base. The results of this query are shown in Figure A3-6.

Figure A3-6. Defining Ownership

The parcels shaded blue represent lands that were granted to the State of South Dakota.

7. The final processing step was to dissolve the individual parcels into ownership categories that define the surface and mineral estates. The view in Figure A3-7 shows the surface management agencies and how land ownership is distributed within an area of the Denver Basin in South Dakota.

Figure A3-7. Surface Management View

In contrast to the surface management view, the mineral estate in the view shown in Figure A3-8 covers the same area and yields a much different picture. The yellow areas represent lands where the Federal government manages oil and gas rights.

Figure A3-8. Subsurface Oil and Gas Ownership View

Eastern Study Areas Data Collection Summary

Ownership data for Eastern basins was collected by researching a range of sources that include the BLM's LR-2000 Database, Site Log, the USGS National Atlas, state and local governments and other land title records. All data sources are referenced in the metadata associated with each map theme. The data obtained from the numerous agencies varied dependant upon the knowledge base of local office personnel, technological capabilities and ability to release data. Therefore, county and state datasets were obtained when possible to support known missing Federal properties.

[Sidebar]

After the BLM records (LR-2000 and Site Log) were processed, USGS 1:24,000 quadrangle maps and the Geographic Names Information System (GNIS) provided the next level of detail for research and initial data collection. Various recreation atlases were also used to identify Federally owned lands for follow-up verification.

A3.3 DATA LIMITATIONS

The data sets created from the processes described above reflect the legal land descriptions contained in the BLM databases. There was no attempt to analyze and review all of the error logs that were generated from the parcel generation process. If legal land descriptions were not properly entered and formatted according to BLM's published LR-2000 standards, an error log was generated.

Other limitations:

- The BLM Case Recordation System is not consistently populated with U.S. Rights data. The split estate ownership generated from LR-2000 was verified by contacting BLM State and Field Offices. These data may carry a minor degree of generalization.

- The Interagency Steering Committee advised against processing certain withdrawal cases from the BLM's Status and Case Recordation datasets. This decision made it necessary to integrate Surface Management Agency information from GIS coverages obtained from multiple sources. During the spatial processing and merging of this data, sliver polygons were created. These sliver polygons were not edited and may be present in certain ownership themes.
- The PLSS data were not edge matched across state boundaries.

A3.4 DATA SOURCE BY AGENCY

Data were provided by agencies as described below:

- **Bureau of Land Management:** Digital land records, hard copy maps and GIS shapefiles of Federal mineral ownership
- **United States Forest Service:** Hard copy maps and digital polygon files showing surface and subsurface ownership. Verbal confirmation for individual polygons overlapping other agency datasets
- **Fish and Wildlife Service:** Hard copy maps and digital shapefiles
- **National Park Service:** Digital shapefiles
- **United States Army Corps of Engineers (COE):** Hard copy maps, aerial photos, digital shapefiles of ownership polygons, county and municipal parcel datasets
- **Department of Defense:** Hard copy maps and digital shapefiles of ownership polygons. State, county and local datasets provided boundaries, verbally confirmed by direct contact with installation. BLM and COE also provided ownership boundaries by hard copy maps
- **Department of Energy:** Hard copy maps from the BLM and digital data provided by county and municipal datasets
- **Department of Homeland Security:** Digital shapefiles of ownership polygons, local county and municipal parcel datasets
- **Department of Justice:** Local tax GIS datasets. Federal prisons were verified by phone and digitized from hard copy maps
- **Department of Labor:** Local tax GIS datasets
- **Department of Veterans Affairs:** Hard copy maps from the BLM and digital polygons provided by county and municipality datasets
- **Federal Aviation Administration:** County and municipal parcel datasets
- **General Services Administration:** Local tax GIS datasets
- **National Aeronautics and Space Administration:** Hard copy maps from the BLM
- **Tennessee Valley Authority:** Digital shapefiles provided by the primary administrative and local agency offices
- **United States Department of Agriculture (other):** Local tax GIS datasets

Merging of datasets for Federal surface and subsurface ownership followed three basic rules in order of priority:

- Data extrapolated from deed records were considered have the highest confidence level
- Newer data and map publication dates were used over older sources

- Verbal verification by agency was obtained

APPENDIX 4

FEDERAL OIL AND GAS LEASE STIPULATION DATA PREPARATION

The bulk of the data preparation for lease stipulations consisted of data gathering, digitization, and compilation in a multi-layered GIS format (ESRI shapefiles). FGDC-compliant metadata for the resulting GIS layers were also created. GIS coverages from SMA land status, stipulations, and the analyses, as well as the associated metadata, are presented on the DVD-ROM accompanying this report.

Where necessary, the shapefiles obtained from the Federal land management agencies were processed using ArcGIS software by matching specific leasing stipulations found in the guidance documents.

This inventory is limited to those Federal lands within the aggregate resource play boundaries of the eleven study areas, which are based on geology as defined in the USGS National Assessment of Oil and Gas Resources. The land status and stipulation shapefiles, which correspond to Federal land management agency jurisdiction boundaries, were "clipped" using the GIS to the appropriate study boundary. Some of the shapefiles fell into multiple study areas, in which case the clipping process was repeated for each area. The attribute tables of the compiled shapefiles were then queried for unique leasing stipulation values. The query results were then saved as separate polygon shapefiles. Each shapefile represents a unique stipulation value.

The following discussion of the specific data preparation steps uses the Wyoming Thrust Belt study area as an example:

1. The first step entails loading the study area (union of resource plays) boundary shapefile and the compiled stipulation shapefile into ArcGIS (Figure A4-1)

Figure A4-1. Stipulation Polygons and Study Area Boundary

   The next step in this process is to "clip" or cut the compiled stipulation shapefile to the study boundary. Figure A4-2 shows the GIS coverage after it has been clipped.

Figure A4-2. Example of Polygons after Clipping to Study Area Boundary

2. The compiled stipulation shapefile is then queried for unique stipulation attributes values as shown in the ArcGIS Query Builder (Figure A4-3). For this example, all polygons covered by the leasing stipulation "Critical Big Game Habitat" were selected. The highlighted rows in the attribute table (Figure A4-5) show which records are selected.

Figure A4-3. Query in ArcGIS for all "Critical Big Game Habitat" Stipulations

Figure A4-4. Attribute Table Showing all "Critical Big Game Habitat" Polygons

3. Using the ArcGIS function "Create layer from Selected Features," a new shapefile is

created that contains only polygons labeled with the attribute "Critical Big Game Habitat". Figure A4-5 shows the new shapefile that is created.

Figure A4-5. New Polygons Representing Land with Leasing Stipulation for "Critical Big Game Habitat"

For certain stipulations, such as steep slopes, for which GIS data were not available from the BLM or Forest Service offices, shapefiles were created from available data in conformance with stipulation requirements. For example, a typical steep slope stipulation impacts leasing in areas where slopes exceed 25 percent. Polygon themes were created from slope data derived from USGS 1:24,000 Digital Elevation Models (DEMs). These raster data sets contain elevation information on a 100-meter grid spacing. The original for the Phase I inventory was a 30-meter grid spacing, which was resampled to 100 meters.

The USGS DEMs were first clipped to the BLM or Forest Service jurisdictional area. In situations where more than one agency had the same stipulations, the DEM was clipped to the agencies' combined jurisdictional area. A raster coverage was then created containing slope percentage data as calculated by ArcGIS. This coverage was then queried to isolate the areas covered by the stipulation (e.g., all areas steeper than 25 percent). The selected raster data was then converted to a vector polygon coverage, and the coverage was coded and attributed as described above. Figure A4-6 shows the creation of steep slope polygons. The 100-meter USGS DEM for this portion of the Denver Basin is shown in shades of grey. The red theme represents the polygon shapefile showing areas with a greater than 25 percent slope.

Figure A4-6. Creation of Steep Slope Restriction Polygons

Following the above procedures, the GIS shapefiles of the stipulations were coded with their respective descriptions from the various land use plans. These stipulations can be found in Appendix 11.

A4.1 DIFFERENCES BETWEEN THE PHASE II AND PHASE I INVENTORIES

The Phase II inventory is a cumulative effort and incorporates data from the Phase I inventory. There are a number of differences between the two studies, some minor and some significant. These differences are divided into changes, omissions and errors as detailed below.

Some offices inventoried in Phase I had revised their LUPs since that time. The Medicine Bow-Routt NF is an example. The Phase II inventory does not incorporate these updates. A subsequent release of this inventory will include the updated LUPs.

A4.1.1 Methodological Changes

Categorization Hierarchy. In order to better capture the scope of the limitations on access to Federal lands, changes were made to the categorization hierarchy for the

land status and the stipulations in the Phase II inventory:

- Because the purpose of the study is to identify limitations to exploration and development, proved reserves are not included in the resource categorization in the results tables (Section 3). In Phase I, proved reserves had been categorized as accessible under standard lease terms. This change was made for the Phase II inventory due to amendments to Section 604 of EPCA found in Section 364 of EPAct 2005, which strikes the term "reserves". All categories (where leasing can occur) are defined as requiring drilling for discovery and conversion into reserves. The proved reserves are listed in Section 2, Table 2-6 but are not included elsewhere in this inventory.
- The NLA/LUP and NLA categories are switched (NLA acceding to the second level in the categorization) to present a more logical progression to the hierarchy. The rationale for this decision is that the NLA category is based on a decision within the land use plan or made by the office not to lease an area. In contrast the NLA/LUP category is an area where a decision has not yet occurred and consequently the categorization may be less restrictive when the final land use plan is completed.
- Because their impacts on operators' capacities to drill are similar, stipulations for TLs ≤ 3 months and CSU were combined at level 8 as a simplification. Note that due to this change, some areas on the Phase I land access categorization maps which were pink in color will be gold on the Phase II maps. Lands stipulated with TLs ≤ 3 months cover a very small area.
- A clarification change was made to labeling for the NSO category, where the term "net" was added in reference to the oil and gas resources. Because the analytical model adjusts for directional drilling capabilities (see Appendix 7), Net NSO resource areas are effectively inaccessible.

Citizens' Proposal Areas (CPAs). CPAs, CWPs, and Wilderness Reinventory Areas (WRAs) were considered NLA in Phase I. As a result of *Utah vs Norton*[1], CPAs and WRAs are now considered leasable and subject to stipulations.

Blackleaf Study Area. The Blackleaf area in the Montana Thrust Belt study area was explicitly added due to an indefinite postponement of its EIS in 2004[2].

Additional Resources in the Phase I Study Areas. Study areas for this inventory are defined by the USGS play boundaries. Further, plays from distinct USGS oil and gas provinces can overlap, as is the case in the WTB relative to the GGRB. However, because the inventory is focused on the land surface, study areas must, by definition, be geographically unique. In the case of the WTB and the GGRB, the overlapping resources have been allocated to the GGRB, resulting in a change in the resource numbers in comparison to the originally published Phase I results. While this does not affect the land access categorization, it does affect resource access categorization to the extent that resource densities in the GGRB for the Phase II inventory are different where associated with specific stipulations. This situation also occurs at the intersection

[1] See http://www.blm.gov/nhp/efoia/wo/fy03/im2003-274.htm
[2] See http://www.doi.gov/news/041005a

of the Powder River and Denver basins and in the Paradox and Uinta basins in Phase I inventory.

Inventoried Roadless Areas. The Phase I inventory included the IRAs as a Federal Land Use Designation and categorized them as subject to stipulations. In the Phase II inventory, the guidance from the USDA-FS was modified slightly—specifically, the accessibility of roadless areas is determined by the local Forest Plan. Roadless area stipulations exist for Ashley, Grand Mesa/Uncompahgre/Gunnison, Uinta, White River and Lewis and Clark NFs. The GIS data were not available for many of these stipulations. Instead, the national IRA GIS layer was used.

NSO Areas. In the EPCA II inventory, the geoprocessing of NSO areas was made stricter to provide greater accuracy. Specifically, if an NSO area abutted an area that cannot be leased, an "extended drilling zone" (EDZ, see Appendix 7 for a full description) was not calculated from that area based upon the fact that a drilling rig could not legally be set up. Further, within a Federal jurisdiction that contained NSO lands, buffering from non-Federal lands onto Federal lands was not performed, as it could not be assumed that the non-Federal lands are leasable.

Further, in the GGRB study area, a generalized EDZ for the basin was used in the Phase I inventory (based on a prior DOE analysis).[3] During the course of Phase II data collection, individual offices (that are also in the Phase I Study Area) were interviewed to determine specific EDZs, and those EDZ values were used in the Phase II analysis. These offices were: Kemmerer, WY, BLM FO; Rawlins, WY, BLM FO; Casper, WY, BLM FO; Wasatch-Cache NF; Bridger-Teton NF.

Stipulations for Which No GIS Data Are Available. As noted in Section 2.1.2.3., specific efforts were made to assess stipulations where no GIS data were available. By count, approximately 39 percent of the 2132 stipulations in the Phase II inventory do not have GIS associated with them. To the extent that this exists, the Inventory overestimates access to lands and resources. This quantification had not been made in the Phase I inventory.

A4.1.2 Omissions in Phase I

Additional Data Received from Offices. For some Phase I offices, especially those that are also in the Phase II study areas, some additional data was received. Offices where significant new GIS data were obtained are the Black Hills NF; Bridger-Teton NF; Casper, WY, BLM FO; Kemmerer, WY, BLM FO; Nebraska NF; Newcastle, WY, BLM FO; Rawlins, WY, BLM FO; Rock Springs, WY, BLM FO; and the Wasatch Cache NF.

In addition, an updated national GIS layer for Wilderness Areas, Inventoried Roadless Areas, Special Designated Areas, National Conservation Areas, Wilderness Reinventory Areas, Incorporated Towns and Cities, Wilderness Study Areas, Research

[3] The Greater Green River Basin Study. See website http://www.fossil.energy.gov/news/techlines/2001/tl_ggrb_gas.html

Natural Areas, National Monuments Areas, National Wildlife Refuges, Wild and Scenic Rivers, and National Scenic and Historic Trails was provided by the BLM's National Landscape Conservation System.

Incorporated Towns and Cities (ITCs). After the Phase I inventory was published, it was determined that ITCs were not considered. These were added in Phase II because, by regulation, incorporated areas are not available for Federal mineral leasing as established in 43 CFR 3100-3(a)(2)(iii) and 3100-3(b)(2)(ii).

A4.1.3 Errors in Phase I

Analytical Errors. There were about 980 stipulations having GIS data In the Phase I inventory. Miscellaneous analytical errors were made that impacted the results presented in published version of that inventory. Without running the analytical model specifically for the stipulations in question, the absolute magnitude of these errors cannot be assessed; however their impacts are believed to be modest to minor for any individual study area. The errors are:

- In the Vernal, UT, BLM FO, Phase I results indicate larger areas of NSO than is the case. Comparison of the Phase I and Phase II model runs shows this error to make a 4 percent difference in NNSO areas in the UP study area.
- In the Rock Springs, WY, BLM FO, some sage grouse leks[4] were absent from the model runs. Based upon a comparison of the model runs for this FO, the impact of this is believed to be significant. Differences in TLs between the two runs are 13 percent, although a noteworthy portion of these differences also come from additional sage grouse stipulation data received from the Kemmerer, WY, BLM FO during Phase II. Another error in the Rock Springs FO is one stipulation that was miscategorized as NLA. It has been corrected to CSU.
- In the Lander, WY, BLM FO, a stipulation had an incorrect listing of its timing limitation resulting in a one-level higher categorization than is the case. In addition, another CSU stipulation was improperly depicted to partially cover the FO when it should have covered the portion of the FO within in the GGRB study area. The stipulation geography was corrected.
- In the Craig, CO, FO, one stipulation had been categorized as NLS and was corrected to NSO.
- In the St. George, UT, BLM FO, missing NLA and CSU stipulations were added.
- In the Richfield, UT, BLM FO some stipulations were missing from the Phase I model runs. During EPCA II a complete copy of the stipulation data was obtained and the error was corrected.
- For the Navajo Reservoir, NM, BOR, the reservoir should have been classified as NSO.
- In the Thunder Basin NG, a NSO stipulation has been deleted as it is not a USDA-FS stipulation (but does occur in the BLM RMP covering this portion of the study area).

[4] Sage grouse have a lek mating system in which males defend display territories but provide no resources such as nesting or forage to females.

- In the Buffalo, WY, BLM FO, a wildlife stipulation had an incorrect listing of its timing limitation resulting in a one-level higher categorization than is the case.
- In the PDX/SJ and UP study areas, an error was made in the allocation of overlapping resources resulting in changes to the results. The oil resource assessment was shown as incorrect by 30 percent (however the total amount of oil resource is modest). The gas assessment was shown as incorrect by 15 percent.
- In the PRB, an error in the land status layer resulted in a 10 percent understatement of Federal lands. At the resource level the error is ≤ 1.5 percent.

Rendering Errors. In the presentation of some Federal land status and land access categorization (LAC) in the Phase I inventory publication, errors were made in rendering in figures within the report. These items have been checked specifically and they do not impact the analytical results presented, but are an erroneous display of the land status and categorization on maps. Table A4-1 presents listing of offices where such rendering errors occurred relative to the Phase I report figures.

Table A4-1. Rendering Errors in Phase I Offices

To alleviate this problem, the Phase II geospatial model has been modified to explicitly produce Federal land status and LAC map presentations.

APPENDIX 5

APD CONDITIONS OF APPROVAL DATA PREPARATION

In contrast to the EPCA Phase I inventory, Phase II incorporated a large-scale statistical sampling and categorization of COAs and related data for APDs.

The data preparation consisted primarily of the creation of a Federal oil and gas permit/well GIS point data theme. This task was performed by processing legal description data from the BLM's AFMSS against the PLSS dataset collected as described in Appendix 3. Data gathering, compiling, categorizing, digitizing and analysis followed as described below.

1. The initial task consisted of a pilot study to determine more fully the nature of COAs by abstracting information from well files located in BLM's Vernal and Price FOs. The purpose of this initial task was to provide information for the subsequent design and execution of the full-scale statistical sampling in the study areas as shown on Table A5-1. The Montana Thrust Belt study area was not included because it is approximately 97 percent closed to access and has little drilling history. The Florida Peninsula was also excluded given the relative lack of drilling history.

Table A5-1. Study Areas Sampled for COAs

2. Excel spreadsheets were used to collect the COA data during visits to BLM FOs. They included attributes from the AFMSS database identifying lease number, surface location legal description (including footage calls, if available), surface managing agency, operator name, well name, well number, well type, received date, approval date, spud date, and completion date.

3. All APDs approved between and including the dates of October 1, 1999 and September 30, 2004 were included. Wells on non-Federal minerals within Federal agreements and on Indian lands were excluded. The COAs and related data were collected from approved APDs issued by the BLM FOs (Table A5-2) within the Phase I and II study areas. This well/permit data theme was then spatially intersected with the study area polygons to eliminate points outside of the inventory. The distribution of the resultant APDs was then geographically mapped.

Table A5-2. BLM Field Offices for which COAs Data was Abstracted

4. The above data theme was then randomly sampled to generate a new GIS point data theme. A stratified random sampling method was used with two data strata: BLM Field Office and surface managing agency. The samples from each stratum were weighted by total APDs approved for each Field Office. The resultant total sample was approximately 10 percent of the total population of permits/wells and

followed the guidance presented on Table A5-3, as determined during the pilot study.

Table A5-3. Stratified Random Sampling Guidance

5. Contractor personnel, accompanied by BLM personnel, visited BLM FOs and abstracted COA and other related information from the hardcopy well files identified by the sampling process. Those offices whose sample count within the study areas fell below six were generally not visited. Instead, the FO was requested to transmit the COAs to the BLM Washington Office where they were examined.

   The abstracted information contained site-specific restrictions or impediments that affect the ability of the permittee and/or lessee to access the underlying lease for the purpose of exploring for and developing oil and gas resources. All abstracted information was restricted to Federal lands and limited to the 13-point surface use plan of the APD and related documents.

6. Other relevant information for the study was obtained through interviews held with FO personnel. This information was essential to determine the extent, through a qualitative analysis, of negotiations that occur prior to the submission of an APD, including adjustments at the time of well staking. This included the determination of:

- Whether applicant-funded surveys (e.g., wildlife or archeological) are a prerequisite to acceptance of an APD as administratively complete (Table A5-4a)
- The number of APDs not actually applied for because the cumulative effects of lease stipulations and probable COAs were prohibitive (Table A5-4b).

Table A5-4a. Findings from Interviews with BLM Field Personnel – Applicant Funded Surveys

Table A5-4b. Findings from Interviews with BLM Field Personnel – Prohibitive Lease Stipulations/COAs

7. COA data were compiled into spreadsheets and spatial displays (GIS, etc.) that can used to assist BLM management in decisions regarding APD approvals. The compilation process consisted of grouping of COAs by class (e.g., wildlife, soils, archeological, construction, sage grouse, etc.), and subsequent assignment of a unique identifier for each type of COA within a class. Only COAs that were more restrictive than (and not merely a restatement of) the stipulations on the underlying lease were considered. A total of 175 unique COAs were identified.

8. These unique COAs were categorized as to their effect on access by the Interagency Steering Committee. The result was that COAs fell either into controlled surface use (CSU) or cumulative timing limitation (TL) categories that correspond with the leasing hierarchy described in Table 2-8. Changes in land access categorization arising from COAs were integrated into the spatial model. This recategorization methodology consisted of first computing for each unique COA the percentage of wells having that COA (% unique-COA) with respect to the total

number of wells sampled within a given FO and also within the non-NSO leasable areas as represented by the equation:

$$\%uniqueCOA = \frac{(\#Wells)_{uniqueCOA}}{(\#Wells)_{Acc.Area}} = 10\%$$

Where:

$\%uniqueCOA$: Percentage of wells with a unique COA

$(\#Wells)_{uniqueCOA}$: Number of wells with a unique COA

$(\#Wells)_{Acc.Area}$: Total number of wells in the accessible area.

Table A5-5 is a breakdown of the COAs by BLM FO and includes the categorization, number of occurrences, and percentage of the wells in the sample that have that COA.

Table A5-5. COA Statistics by Field Office
Table A5-5 (concluded). COA Statistics by Field Office

9. Subsequently this percentage value was extrapolated to the overall leasable area to estimate the change in accessibility. A grid composed of 400 by 400 meter grid (approximately 40 acres) was created for each FO or NF containing a study area. Cells were then randomly selected at the previously calculated percentage rate to create a potential access constraint theme. Figure A5-1 illustrates the process to extrapolate the effects of COAs on accessibility. This is an example for a case where 10 percent of the leasable area is potentially subject to a particular COA type.

Figure A5-1. Example of Extrapolating the Effects of COAs on Accessibility

10. Once the recategorization was accomplished, the resulting areas and volumes of the undiscovered technically recoverable oil and gas resources and reserve growth affected by the cumulative impact of COAs was computed. The land access categorization was then performed using the method for lease stipulations described in Section 2 and Appendix 9.

APPENDIX 6

U.S. GEOLOGICAL SURVEY METHODOLOGY FOR THE ASSESSMENT OF UNDISCOVERED OIL AND GAS RESOURCES

By U.S. Geological Survey National Assessment Review Team[1]

A6.1 INTRODUCTION

The USGS conducts assessments of technically recoverable undiscovered oil and gas resources of the onshore and state waters of the United States. The last comprehensive USGS oil and gas assessment was completed in 1995, and comprises the onshore and state waters portion of 71 geologic provinces (Gautier and others, 1996). In 1999, the USGS launched a new initiative to produce incremental assessments of the most significant U.S. oil and gas provinces.

To meet the requirements of Section 604 of EPCA, the USGS reorganized the priority list for the new assessments. For the Phase I inventory (released 2003), new assessments were conducted for the Uinta-Piceance Basin, San Juan Basin, Montana Thrust Belt, Powder River Basin, and Greater Green River Basin. The 1995 assessment results were used for the Paradox Basin. For the Phase II inventory, new assessments were conducted for Northern Alaska (NPRA and ANWR-1002), Wyoming Thrust Belt, Denver Basin, Florida Peninsula, Black Warrior Basin, and Appalachian Basin.

The general assessment methodology has not changed from the 1995 assessments; however, some refinements have been made to accommodate increased geologic understanding of the occurrence of resources and more sophisticated means of capturing the range of uncertainty inherent in these variables. For example, the assessment model for continuous resources in the 1995 assessment assumed a homogenous distribution of oil and gas resources in a play. For the new assessments, that model has been replaced with an analysis of geologically controlled sweet spots of production, which demonstrate the geologic heterogeneity common to continuous oil or gas accumulations. The recognition of production sweet spots is a major advancement in the assessment of continuous resources.

A6.2 TERMINOLOGY

Terminology used in this report reflects standard definitions and usage of the oil and natural gas industry and the petroleum resource assessment community. Several terms have been developed by the USGS for oil and gas assessment purposes (see Glossary

[1] EPCA Geology and Assessment Review Team: Schenk, Christopher J., Charpentier, Ronald R., Klett, Timothy R., Pollastro, Richard M., Cook, Troy A., and Crovelli, Robert A.

in Appendix 2). The 1995 USGS assessment focused on the definition and assessment of geologic *plays.* In the latest USGS assessments, the focus is on understanding total petroleum systems and defining *assessment units* within total petroleum systems. The total petroleum system approach is designed to focus the geologic studies on the hydrocarbon source rocks, processes that create hydrocarbons, migration pathways, reservoirs, and trapping mechanisms. For discussion purposes in this report, the term *play* will be used throughout to represent both *assessment units* and *plays*.

The USGS assesses two main categories of hydrocarbon occurrence: conventional and continuous (Figure A6-1). Conventional oil and gas accumulations are defined as discrete fields with well-defined hydrocarbon-water contacts, where the hydrocarbons are buoyant on a column of water. Conventional accumulations commonly have relatively high matrix permeabilities, have obvious seals and traps, and have high recovery factors. In contrast, continuous accumulations (also called unconventional accumulations) commonly are regional in extent, have diffuse boundaries, and are not buoyant on a column of water. Continuous accumulations have very low matrix permeabilities, do not have obvious seals and traps, are in close proximity to source rocks, are abnormally pressured, and have low recovery factors. The USGS assessment focused on understanding the geology and occurrence of continuous hydrocarbon accumulations, as the resource potential of these accumulations may be greater than that for conventional accumulations in the U.S. Included in the category of continuous accumulations are hydrocarbons that occur in tight reservoirs, shale reservoirs, unconventional reservoirs, basin-centered reservoirs, fractured reservoirs, coal beds, and oil shales.

Figure A6-1. Conventional vs. Continuous Accumulations

A6.3 OVERVIEW OF THE OIL AND GAS ASSESSMENT PROCEDURE

The assessment process is based on the characterization of the petroleum geology of each province. The geologists define the geologic elements of the total petroleum systems, and, in conjunction with an analysis of historic oil and gas production and exploration/discovery data, define the oil and gas plays within the provinces. The geologists then develop probability distributions for sizes and numbers of undiscovered conventional accumulations, or numbers of cells and EUR for continuous accumulations, using all available geologic information and historic oil and gas data. These distributions are then used to generate probability distributions for undiscovered oil and gas resources.

A6.4 ROLE OF GEOLOGIC INFORMATION IN THE ASSESSMENT

The strength of the USGS oil and gas resource assessments is the province geologists' understanding of the petroleum geology of the provinces being assessed. These fundamental geologic studies allow new concepts and hypothetical plays to be incorporated into the assessment of undiscovered resources. A purely statistical approach to an assessment such as discovery process modeling that uses only historical data will overlook any new geologic concepts, models, or hypothetical plays.

The team of geologists develops an understanding of the province petroleum geology using published, proprietary, and original research and data. Studying the total petroleum systems within a province includes: (1) identification and mapping the extent of the major hydrocarbon source rocks; (2) understanding the thermal evolution of each source rock, the extent of mature source rock, and the timing of hydrocarbon generation, expulsion, and migration; (3) estimating migration pathways and all forms of hydrocarbon trapping; (4) modeling the timing of structural development and the timing of trap formation relative to hydrocarbon migration; (5) determining the sequence stratigraphic evolution of reservoirs, and the presence of conventional or continuous reservoirs, or both; and (6) modeling the burial history of the basin and the effect burial and uplift has had on the preservation of conventional and continuous hydrocarbons.

Once the total petroleum systems of the province are known in satisfactory detail, the team of geologists defines oil and gas plays, which represent a synthesis of all geologic information, including production and exploration data. The key component of this analysis is a geologic model for the assessment of each play. The geologic model encompasses all elements of the total petroleum system, and is commonly summarized by a total petroleum system events chart.

A6.5 SOURCES OF OIL AND GAS DATA

Data for domestic oil and gas fields, reservoirs, and wells are derived from commercial databases purchased annually by the USGS. With more than 2.5 million domestic oil and gas wells and 40,000 oil and gas fields, the USGS has opted to purchase the data from commercial vendors rather than attempt to generate a comprehensive database. The oil and gas wells and production databases are now purchased from the IHS Energy Group (IHS) (2000 a, b). Previous assessments used the predecessors to IHS: PetroROM Production Data (Petroleum Information/Dwights LLC, 1999a) and the Well History Control System (Petroleum Information/Dwights LLC, 1999b). The USGS also relies on the NRG Associates, Inc. Significant Oil and Gas Fields of the United States (NRG Associates, 2001). Data from these commercial databases are subject to proprietary constraints, and the USGS cannot publish, share, or serve any data from these databases. However, derivative representations in the form of graphs and summary statistics can be prepared and presented for each play. The USGS, however, cannot verify the accuracy, completeness, or currency of data reported in commercial databases.

The IHS production database provides oil and gas production data for wells, leases, or producing units (collectively called “entities” in these databases). The IHS oil and gas wells database provides individual well data (including data for dry holes) that include well identification, locations, and information on penetrated and producing formations. Oil and gas field databases provide location, geologic characterization, and oil and gas production data for domestic oil and gas fields and reservoirs.

Additional oil and gas data are obtained, where available, from operators, state agencies, and other government sources, such as the U.S. Department of Energy’s

Energy Information Administration proprietary files, publications from the former Bureau of Mines, and other sources.

A6.6 ASSIGNING ACCUMULATIONS AND WELLS TO PLAYS

Digital maps of plays are created using a GIS.[2] Digital play maps are used to assign oil and gas wells and accumulations to their respective plays, and these assignments are entered into the databases. Oil and gas accumulations are assigned to only one play. Wells, however, can be assigned to more than one play if they penetrate vertically stacked plays. Oil and gas accumulations and well assignments are reviewed to ensure proper assignments, identify inconsistent data, and examine the need for minor revisions of play boundaries.

Historic production and exploration/discovery data are collected for each play using oil and gas accumulations or well assignments. Types of data retrieved include: (1) known volumes (sum of cumulative production and remaining reserves) of recoverable oil, gas, and natural gas liquids (NGLs) of accumulations; (2) discovery dates of accumulations (the year the first reservoir in the accumulation was discovered); (3) monthly production and cumulative production of wells; (4) initial classification and final classification of wells (for example, new-field wildcat, development, producing, abandoned, etc.) of wells; and (5) completion dates of wells.

A6.7 OIL AND GAS PRODUCTION DATA

The historic oil and gas production data are compiled for each play so that the data from discovered accumulations can be used as a guide for potential undiscovered accumulations. For conventional plays, these data include (1) field name, (2) field discovery year or date of completion of the discovery well, (3) known volumes of oil, gas (non-associated and associated-dissolved), and NGLs, and (4) depth to the top of each reservoir. All of the production data for conventional assessment units are arranged in terms of oil accumulations and gas accumulations and sorted by size and discovery date for statistical calculations and plotting. A list of new-field wildcat wells and their completion dates is compiled and organized into the number of wells drilled per year for conventional plays. (A new-field wildcat well is an exploratory well drilled at least two miles from a producing field to test a separate trap). Once organized, the number of wells drilled in a given year is used as a measure of exploration effort. These data are then combined with the production data using the discovery dates of the accumulations and the completion dates of the wells.

Oil and gas production data compiled for each producing well in continuous-type plays include past monthly production of liquids (oil and NGL) and gas (non-associated and associated-dissolved), from which EURs are estimated using well decline-curve analysis, the date of first production, and depth to the topmost perforation. A list of all wells and completion dates are compiled and organized. However, the number of wells drilled in a given year is not combined with production data, but analyzed separately.

[2] The oil and gas play boundaries are available at http://energy.cr.usgs.gov/oilgas/noga

Co-product ratios (GOR; NGLs to gas ratio; and LGR) are calculated and major commodities (oil or gas) are identified for each conventional accumulation. Co-product ratios are based on accumulation-level oil, gas, and NGL volumes. Oil and gas accumulations are treated separately; an oil accumulation is defined as one having a GOR less than 20,000 cubic feet/barrel whereas a gas accumulation has a GOR equal to or greater than 20,000 cubic feet/barrel.

Supplemental data from individual reservoirs within the accumulations include thickness (net and gross), average porosity, average permeability, temperature, pressure, fluid properties (for example, sulfur content of oil, API gravity of oil, non-hydrocarbon gas contents), trap type, drive type, and well spacing. These data are combined with the data from the commercial databases to help refine the geologic interpretations and assessment process.

A6.8 GRAPHS AND STATISTICS FOR CONVENTIONAL PLAYS

Two sets of graphs and statistics are generated for conventional plays–one set using known accumulation sizes as of the effective date of the assessment and one set using accumulation sizes that are corrected for anticipated reserve growth (grown accumulation size) within the forecast span of the assessment.

The set of graphs and statistics generated for conventional plays includes sizes and number of accumulations with respect to discovery date and exploration effort, exploration effort through time, size distributions of accumulations, reservoir depth versus discovery date and exploration effort, co-product ratios versus reservoir depth, and a histogram of the API gravity. Accumulations containing less than a specified minimum volume of oil or gas (that is, the smallest accumulation size that is considered in the assessment process) are not included in these graphs or statistics. Counts of new-field wildcat wells are used as a measure of exploration effort for finding new accumulations.

A6.9 ASSESSMENT INPUT FOR CONVENTIONAL PLAYS

Critical input data for conventional plays are probability distributions for sizes and numbers of undiscovered oil and gas accumulations and co-product ratios. The geologists develop these distributions by synthesizing all petroleum systems information and historic oil and gas data. For hypothetical plays, the geologist may utilize an analog data set for sizes and numbers of discovered fields as a guide to the distributions of sizes and numbers of undiscovered fields in the play or assessment unit being assessed. Geologists provide information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

A6.10 GRAPHS AND STATISTICS FOR CONTINUOUS-TYPE PLAYS

A set of graphs and statistics comparable to that for conventional plays is generated for continuous-type plays, but the EUR per cell and numbers of tested cells are used rather

than accumulation sizes and number of discovered accumulations. Tested cells of less than the specified minimum EUR per cell are not included in these graphs or statistics, and reserve-growth adjustments for cells are not incorporated.

The set of graphs and statistics generated for continuous-type plays includes number of wells drilled through time (all wells as opposed to new-field wildcat wells), probability distributions of EUR, EUR versus production-start year and number of all wells drilled, cumulative EUR versus production-start year and number of wells drilled, cumulative EUR versus depth of the topmost perforation, and GOR versus ranked EUR. All of this information is provided to the assessor as a guide to generating distributions for the assessment of undiscovered resources.

A6.11 ASSESSMENT INPUT FOR CONTINUOUS PLAYS

Critical input data for the continuous play assessment model include numbers of cells that have potential to be added to reserves, the EUR distribution for these cells, and the co-product ratios. For hypothetical plays, the geologist may utilize an analog data set for distribution of cell size and for the EUR distribution as guides to the distributions of cell sizes and EUR's of undiscovered area in the play being assessed. The geologist provides information on oil and gas quality, range of drilling depths, and range of water depths for future economic analyses.

A6.12 USGS ASSESSMENT REVIEW

The province geologist must present the geology of the play and the input data to a team of USGS personnel for a formal review. The team consists of geologists, geophysicists, and assessment methodologists with broad expertise in petroleum geology, which together promotes a consistent geological and methodological approach to the assessment. Every aspect of the geology and input data are reviewed, and any changes are incorporated into the input data at this time. Once the input data have been finalized, the input data are ready for quantitative analysis.

A6.13 CALCULATION OF UNDISCOVERED CONVENTIONAL AND CONTINUOUS RESOURCES

The final reviewed assessment input forms are the basis of the quantitative calculations of undiscovered oil and gas resources. For conventional plays, the probability distributions for sizes and numbers of undiscovered accumulations and the co-product ratios provided by the assessor are entered into a Monte Carlo simulator and run for a specified number of iterations to provide distributions of undiscovered oil, gas, and NGL resources. In the 1995 assessment, a Truncated Shifted Pareto Distribution (Gautier and Dolton, 1996) was used for the shape of the curve for the distribution of sizes of oil and gas fields. For the present assessment, a Truncated Shifted Lognormal Distribution is used for this purpose (Charpentier and Klett, 2000).

For continuous plays, the distributions for assessment-unit area, untested percentage of

assessment unit area, potential percentage of untested area, and area per cell of untested cells are combined analytically to determine the distribution for number of potential untested cells. The distribution for numbers of potential untested cells EUR per cell, and the co-product ratios are combined using an Analytic Probability Method (Crovelli, 2000) to directly calculate the probability distribution of undiscovered oil and gas resources.

A6.14 ASSESSMENT RESULTS

The results and maps of the resource assessment of the oil and gas plays for Northern Alaska (NPRA and ANWR-1002), Uinta-Piceance Basin, Paradox/San Juan Basins, Montana Thrust Belt, Powder River Basin, Wyoming Thrust Belt, Greater Green River Basin, Denver Basin, Florida Peninsula, Black Warrior Basin, and Appalachian Basin provinces are presented on the internet.[3]

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APPENDIX 7

INITIAL ESTIMATES OF REMAINING PROVED ULTIMATE RECOVERY GROWTH

This appendix documents the methodology used by the Energy Information Administration to estimate future reserves growth, also called 'remaining proved ultimate recovery growth,' that will be associated with existing oil and gas fields in the Phase II study areas. A more complete discussion of this phenomenon and its many causes is presented in *The Intricate Puzzle of Oil and Gas "Reserves Growth."*[1] This paper is highly recommended to readers who want to fully understand the development of and rationale for current statistical approaches to estimating the future growth of existing oil and gas fields, as well as the key uncertainties and data limitations of current methods.

The Proved Ultimate Recovery (PUR) of an oil or gas field at a particular point in time is defined as the sum of its estimated proved reserves and its recorded cumulative production at that time.

Proved Ultimate Recovery Growth (PURG) is the increase in proved ultimate recovery over time that is observed for most oil and gas fields. A field's PUR estimate normally increases significantly in the early post-discovery years as a field is developed for production and its areal limits are better discerned. PUR estimates may also be conservative early in a field's life owing to the smaller knowledge base then available regarding its productive performance. A field's later years are usually characterized by slower growth arising from a variety of possible causes including the installation of improved recovery techniques, increased knowledge of the field's performance, the addition of new reservoirs to the field, and infill drilling. Growth factors calculated from most fields' ultimate recovery histories thus usually increase rapidly as initial field development occurs and then asymptotically approach a maximum value as growth slows in later years.

PURG, or *reserves growth*, and the remaining (future) portion thereof, RPURG, can be estimated from the observed historical proved ultimate recovery growth. In a given year for a group of fields of the same vintage (age) the Annual Growth Factor (AGF) is the sum of the estimated proved ultimate recovery of the fields in that year divided by the sum of estimated proved ultimate recovery of the same fields for the prior year. Going one step further, for a basin the average AGF for its multiple fields in multiple vintages is the sum of the estimated proved ultimate recoveries of all fields in all vintages at the same point in time, i.e., the same year after first production (or after field discovery), divided by the sum of estimated proved ultimate recoveries of the same fields for the prior year.

[1] Available online at http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/1997/intricate_puzzle_reserves_growth/m07fa.pdf .

$$AAGF_n = \frac{\sum_{v=1}^{t}\sum_{f=1}^{i} PUR_n}{\sum_{v=1}^{t}\sum_{f=1}^{i} PUR_{n-1}}$$

where: AAGF = Average Annual Growth Factor
PUR = Proved Ultimate Recovery
n = Years after first production (or discovery)
t = Number of vintages at *n*
i = Number of fields in a vintage at *n*
v = Vintage
f = Field

The Cumulative Growth Factor (CGF) in a particular year is the product of the Average AGF for all fields in all vintages through that year beginning with the first production or discovery year of the first vintage.

$$CGF_n = AAGF_1 * AAGF_2 * ... AAGF_n$$

where: CGF = Cumulative Growth Factor
AAGF = Average Annual Growth Factor
n = Years since first production (or discovery)

The RPURG can be calculated as the product of the ratio of the future CGF to the current CGF and the current PUR.

$$RPURG_{t-n} = \frac{CGF_t}{CGF_n} * PUR_n$$

where: RPURG = Remaining Proved Ultimate Recovery Growth volume at time n
CGF = Cumulative Growth Factor
PUR = Proved Ultimate Recovery volume at current time (n)
n = Current time expressed as years since first production (or discovery)
t = Final time expressed as years since first production (or discovery),
i.e., infinity

Equivalently, the estimate of additional ultimate recovery that may be realized in the future based on reserves growth during the future can be stated as:

$$RPURG_{t-n} = PUR_t - PUR_n$$

where: RPURG = Remaining Proved Ultimate Recovery Growth volume at time n

PUR = Proved Ultimate Recovery
n = Current time expressed as years since first production (or discovery)
t = Final time expressed as years since first production (or discovery)

A7.1 DATABASE PREPARATION

A database was created containing annual oil and gas production, estimates of cumulative production for that production which occurred prior to the keeping of annual production records, annual oil and gas proved reserves, field name, and field discovery date for fields located in selected Phase II study areas (Uinta-Piceance Basin, Paradox/San Juan Basins, Montana Thrust Belt, Powder River Basin, Wyoming Thrust Belt, Greater Green River Basin, Denver Basin and Black Warrior Basin). The available data for the Appalachian Basin were insufficient for PURG analysis. Data sources included the EIA Reserves and Production Division's Oil and Gas Integrated Field File (RPD OGIFF), the EIA Field Code Master List (FCML), the EIA-23 Reserves Survey, various state web sites, and commercial sources (mainly IHS Energy Group).

Each field in a basin was assigned to a vintage year according to its date of first production or its date of discovery depending on which date was available, or which date was deemed the most reliable indicator of initial production. While the earliest field vintage was 1901, the annual proved reserves estimates and therefore the proved ultimate recovery estimates were usually available only from 1977 to present. The resulting files contained vintage year, number of fields in each vintage, annual proved ultimate recovery for each vintage (expressed in barrels of oil equivalent, BOEULT), annual natural gas proved ultimate recovery for each vintage, and annual liquid proved ultimate recovery for each vintage.

Significant effort went into quality control of the data. Many field names and codes had to be altered, corrected, and matched across the multiple data sources and time in order to properly accumulate the field data. *Quality control beyond that point was, however, deliberately conservative.* While obvious major errors had to be corrected, the desire to seek "correction" of things that were merely suspicious had to be resisted for two reasons: first they might well be correct, and second the available task resources and time frames were limited. Therefore, the reserves data were used as reported by the field operators unless very obvious errors were found. Data discontinuities and variations within vintages were for the most part accepted "as-is." Specific vintages that did not fit the trend of most of the data of a basin were excluded from the history matching and forecasting. Attempts to divide the data within a basin into conventional reservoirs, tight formation gas, and coalbed natural gas sources were largely unsuccessful because of the limited number of vintages, the short histories available for some of the fields, and frequent inability to separate the data by reservoir type within a field.

A7.2 ESTIMATION OF REMAINING PROVED ULTIMATE RECOVERY GROWTH

The remainder of this appendix describes two models that were independently used to estimate RPURG by basin and hydrocarbon type within a basin and then details the modeling results. The first model implements an exponential function having two fit parameters while the second model implements a hyperbolic function having four fit parameters. The exponential model is dependent on the annual average cumulative growth factors for the basin, whereas the hyperbolic model is dependent on incremental growth factors by vintage. Both are asymptotic functions that use time as the sole driver. Even though other potential drivers such as drilling rates or wellhead prices of oil and gas are not directly used, they have affected the historical data that feed into the models.

A7.3 EXPONENTIAL CUMULATIVE GROWTH FACTOR MODEL

To estimate a CGF at some time in the future a least squares fit of the historical data can be made using an exponential function. Knowing that the CGF is equal to 1.0 at discovery and that the growth rate should decrease to an asymptote of the CGF, an exponential function beginning at 1.0 at time equals zero (the time of discovery) and thereafter remaining positive as time since discovery increases was found to provide an adequate fit of the historical data, i.e.:

$$CGF = a\left(1 - e^{-bn}\right) + c$$

where: CGF = Cumulative Growth Factor
b = exponent
n = time since first production (or discovery)
c = 1.0 (constant)
a = fit parameter equal to the asymptotic CGF minus 1

Data from the Uinta/Piceance, Paradox/San Juan, Powder River, Wyoming Thrust Belt, Greater Green River, Denver, and Black Warrior basins were evaluated. Sufficient data were not available to evaluate the Montana Thrust Belt and the available coal bed natural gas data were deemed not to be analytically dependable for separate analysis.

A7.4 HYPERBOLIC INCREMENTAL GROWTH FACTOR MODEL

The RPURG for each basin can also be estimated by sorting the data by vintage within that basin and predicting the achievable PURG for the basin over time using a hyperbolic incremental model. The solely time-based model function excludes direct consideration of other factors such as drilling levels, prices, and costs. The historical estimated data were, however, subject to these factors and more. The initial dataset was limited to PUR estimates from 1977 to 2003 and there were significant data gaps in the some of the data series.

The methodology for fitting and using the hyperbolic model involves the following sequential steps:

A. Sort the field-level PUR estimates by hydrocarbon type and vintage year
B. Calculate the relative field growth factor by dividing successive PUR estimates by the "starting" 1977 estimate
C. Determine the incremental percentage increase from year to year for all vintages
D. Create a time-based hyperbolic model curve using the following formula:

$$CGF_{TBHM} = \left[1 + Tbeta1 \times \left(1 - \frac{1}{1 + Tbeta2 \times (n)}\right)\right] \times \left[1 + Tbeta4 \times \left(1 - e^{Tbeta3 \times \frac{n}{10}}\right)\right]$$

where: CGF_{TBHM} = Cumulative Growth Factor of the time-based hyperbolic model.

n = Years after first production (or discovery), a time difference factor that is the number of years between the current year and the vintage year (i.e., 1995-1901).

E. Perform a least squares fit of the incremental percentage increase per vintage year of the model with the actual incremental data, solving for Tbeta1 through Tbeta4, using the following constraints on the variables:

$$1 \leq Tbeta1 \leq 10$$
$$0.1 \leq Tbeta2 \leq 1$$
$$-1 \leq Tbeta3 \leq -0.5$$
$$0 \leq Tbeta4 \leq 5$$

F. Obtain the asymptotic limit of the model by multiplying (1+Tbeta1) x (1+Tbeta4) (note that as the time difference approaches infinity the Tbeta2 and Tbeta3 factors cancel out of the model)
G. Plot the results by basin and fuel using 50 years and 300 years as x-axis lengths to allow for quality control inspection of the results on both short and long time scales
H. Using the known PUR estimate for the basin, and the actual years after first production (or discovery) time difference, use the performance of the model curve fit to predict the RPURG volume

The results obtained using this model are presented by basin and hydrocarbon type in the "Details of Each Methodology" section of this appendix. The Montana Thrust Belt study area had just three vintages, insufficient for modeling purposes.

A7.5 RESULTS

While at first inspection the concepts and implementations of RPURG estimation may appear to be fairly straight-forward, that's rarely the case when the mathematics meet real-world data. Each of the models described above was independently used to estimate the remaining proved ultimate recovery growth volumes for each basin and hydrocarbon type. The available data were sometimes culled differently for the two model fits, i.e., for a given basin and hydrocarbon type the exact same data may or may not have been used for both models. This was because one of the models gave

reasonable results with a specific data set, whereas the other model yielded reasonable results only after certain data or vintages were eliminated. Results of the two model fits were compared for each basin and hydrocarbon type and a preferred model result was selected based on the modeling team's expert judgment and experience. The exponential model was selected the majority of the time. When selection of the preferred model fit was a toss up the exponential model was the default selection. Table A7-1 shows the results of the selection process. The preferred model associated with it is listed along with the PUR volumes by basin and hydrocarbon type for the preferred model results.

Table A7-1. Phase II Selected Models and Results

The Energy Information Administration methodology used for the Phase II study areas and the methodology used by the U.S. Geological Survey to estimate reserves growth for the most recent National Assessment are both statistical extrapolations of historical reserves growth and are subject to the same inherent limitations,[2] although the methodologies differ in detail. These limitations introduce substantial uncertainty into the final results, which the USGS is currently addressing in an on-going review of their reserves growth estimation methodology (see below). In a recent test, the USGS found that two different statistical extrapolation methodologies produce reserves growth estimates that differed by approximately 25 percent and were as much as 60 percent higher than actual volumetric data.[3] The results shown in Table A7-1 should be interpreted with these limitations in mind:

- Inherent uncertainty in the underlying data (for example, 'reserves' are defined differently by different operators and different commercial/ private databases; fields and reservoirs are inconsistently defined)
- Current statistical methodologies rely on field age (since field discovery) as a surrogate for field development effort. Other factors such as reserves recognition practices, differential application of new technology and production monitoring practices, different operating environments and access to markets may not be adequately represented by field age alone.
- Large fields have more weight in the analysis, which may bias the results towards the development histories of the largest fields in a basin or study area. Large fields may be more likely than smaller fields to receive consistently applied development efforts and new technology applications, and be less sensitive to economic factors.
- Uncertainties are not addressed directly such as variance of the input data and uncertainties in the underlying assumed field development scenarios.

Table A7-2 compares the EIA proved ultimate recovery growth estimates shown in Table A7-1 with recent estimates of reserves growth published by the National Petroleum Council[4] and the Potential Gas Committee (PGC).[5] Table A7-2 shows that

[2] From Klett, Timothy, *One-Year Reserve-Growth Scoping Project, Fiscal Year 2006*, presentation to American Association of Petroleum Geologists, Committee on Resource Evaluation, February 9, 2006.
[3] Ibid; slide titled "Test of Modified Arrington and USGS Least Squares/Monotonic Methods"
[4] National Petroleum Council, 2003, *Balancing Natural Gas Policy*, Supply Task Group Report.

for most study areas, the reserves growth volumes estimated are significantly lower than reserves growth estimates published by other organizations. It is unlikely that there's a single cause of these differences. Most certainly there are some significant differences in methodology and input data. For example, the PGC uses a non-statistical, reservoir-specific approach that relies on expert judgment to estimate the probable resources associated with the additional development of an already discovered reservoir. Historically, in fact, the most successful estimates of reserves growth have relied on the use of reservoir level data rather than the more aggregate field level data on which the EPCA estimates are based. That is not particularly surprising since most factors that affect the reserves growth phenomenon are reservoir-specific and will not necessarily apply to an entire field when it consists of multiple reservoirs as many fields do.[6] Unfortunately, reservoir level proved reserves data are only rarely available for onshore United States fields and the EPCA RPURG estimation must therefore be done using the field level data that are available. It should also be noted that this is, insofar as we know, the first time that field level RPURG analysis has been attempted on a scale comparable to that of the EPCA project.

Table A7-2. Comparison of Estimates of Reserves Growth-Natural Gas

Recognizing that the oil and gas constraints analysis is cumulative and ongoing, subsequent phases in the inventory may provide opportunities to use new input data or an improved methodology to investigate and adjust the estimates of proved ultimate recovery growth.

Recognizing the inherent uncertainties and limitations of recent USGS reserves growth estimation methods, the USGS has undertaken a scoping project to review current extrapolation methods and develop feasible improvements to the existing reserve growth methodologies..[6] The USGS “FY 2006 Reserves Growth Scoping Project” will result in various products which could potentially inform and improve the estimates of remaining proved ultimate recovery growth for future inventory releases. These include USGS recommendations for reserves growth estimation methodologies, updates to the USGS database, an evaluation of the use of field “age” or field development effort to estimate reserves growth, and evaluation of “cell-based” estimation approaches.

EIA is investigating whether it will be possible to develop improved, less labor-intensive means of cleansing the field level data of its apparent anomalies and errors. Another EIA goal is improvement of the RPURG estimation methodology via multi-parameter modeling.

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[5] Potential Gas Committee, 2005, *Potential Supply of Natural Gas in the United States as of December 31, 2004*, September 2005

[6] U.S. Geological Survey, Energy Resources Team, *Reserves Growth Scoping Project*, Project No. 8930C1K, October 1, 2005 to September 30, 2006, Timothy Klett, project chief. Also, Klett, Timothy, *One-Year Reserve-Growth Scoping Project, Fiscal Year 2006*, presentation to American Association of Petroleum Geologists, Committee on Resource Evaluation, February 9, 2006.

A7.6 DETAILED RESULTS BY MODEL TYPE

The detailed results of each model are presented in this section. The preferred results previously shown in Table A7-1 were selected after comparing the model results described in this section.

A7.6.1 Exponential Cumulative Growth Factor Model Runs

The exponential cumulative growth factor estimation results for Phase II are reported in Table A7-3. Charts of the exponential model curve fit of the oil equivalent, total liquids, and natural gas are included as Figures A7-1 through A7-26. Separate estimates for gas in tight reservoirs and coal bed methane could not be relied on for most basins owing to a combination of data anomalies and data interpretation concerns. For purposes of consistency, the results for the three instances in which such estimates could be made were not carried forward.

For each type of production any obviously anomalous vintages may not have been used in the analysis and forecast but are nevertheless shown in Figures A7-1 through A7-26. Because some forecasts did not show the expected asymptotic behavior, a CGF calculated for the distant, arbitrarily selected year 2303 was used (t-n = 300) for the CGF in lieu of a model-derived asymptote (as listed in Table A7-3).

A7.6.2 Hyperbolic Incremental Growth Factor Model Runs

The following Table A7-4 and Figures A7-27 through A7-40 show the detailed results of the hyperbolic incremental growth factor model as applied to the Phase II basins.

APPENDIX 8

PROVED RESERVES ESTIMATION AND FIELD BOUNDARY CONSTRUCTION

A8.1 SUMMARY

The Reserves and Production Division (RPD), Office of Oil and Gas, of the Energy Information Administration, estimated proved reserves of crude oil, natural gas and natural gas liquids on Federal lands located in selected geologic basins of the Rocky Mountain, Appalachian, Alaska, and Southeastern United States regions. This task involved attributing reported and imputed proved reserves to individual fields, developing field boundaries, and allocating these to Federal lands. The primary results are presented in a multi-layered GIS format accompanied by metadata compliant with the Federal Geographic Data Committee Metadata Standard. Most of the methods used were modified from those developed for the Phase I inventory in 2002. Some modifications were made to accommodate geological differences between the Phase I and Phase II basins, whereas other modifications represent the implementation of planned improvements.

To provide a fully consistent set of estimates the Phase I study areas were reprocessed using the modified methods. The updated Phase I results, which slightly differ from those previously published, are provided at the end of this appendix.

Four types of data obtained from a variety of sources were used for the project:

- Federal agencies
  - The 2001 Form EIA-23 Reserves Survey was the source for the bulk of the proved reserves estimates
  - The USGS was the source of well data for the state of Virginia (VA)
  - The Federal lands boundary data were provided by the Bureau of Land Management, Department of the Interior.
- State agencies (oil and gas regulatory agencies and geological surveys) provided well and production data either directly or via their websites.
- Commercial vendors
  - The IHS Energy Group Production Data set was a source of field names, reservoir names and 2001 production data for the states of Wyoming (WY), Utah (UT), Colorado (CO), Nebraska (NE), Mississippi (MS), Alabama (AL), Florida (FL) and Alaska (AK)
  - The IHS Well History Data set was a source of well locations for the states of WY, UT, NE and CO
  - PetroDataSource (PDS) was a source of well data for the states of FL, MS and Tennessee (TN)
  - HPDI was a source of well data for the states of West Virginia (WV) and Maryland (MD).

Several steps were involved in the collection and preparation phase:

- Identification of all wells, reservoirs and fields in the study areas
- Standardization of reservoir and field names to make them consistent from source to source
- Assigning field names to wells where they were missing
- Identification and standardization of well types
- Merging of the state, vendor, and Form EIA-23 survey data
- Identification and name editing of those fields that had wells located both inside and outside of the defined Phase II study areas and fields that crossed state boundaries.

To compare the fields and their proved reserves to Federal lands it was necessary to construct a boundary or outline for each field. Field boundaries were determined by placing reasonable and appropriate buffers around individual wells, followed by their union. Buffer size was based on well spacing as determined by measuring the distances between wells in a reservoir or field using the latitude and longitude of each well's spud point or surface location relative to those of neighboring wells (with the exception of Northern AK, where bottom-hole locations were used). For the Eastern states, wells within the same field were used to determine the appropriate buffer size because reservoir information was frequently absent or incomplete. Rules were developed on the basis of these measurements to determine which standard well spacing (buffer) should be used for each reservoir or field. After assigning the appropriate standard well spacing-based buffers to each field or reservoir, field boundary polygons were then generated using ESRI's ArcGIS Version 8.3 software. A Visual Basic application was written to automate this process. The GIS mapping software performed these main steps:

- Selection of all wells with a specific field name
- Creation of a buffer around each well in the field using the assigned "buffer distance" (standard well spacing)
- Unioning of the buffers in each field to dissolve the inner boundaries of overlapping buffers
- Outputting of a boundary polygon (sometimes more than one polygon if one or more wells are located far from the other field wells) for each field.

Portions of field boundaries that extended outside of the defined Phase II study areas were clipped at the basin boundary and removed. For each field the fraction of total field area that was within the study area boundary was then calculated. This fraction was used to reduce the proved reserves for the field portion inside the study area boundary.

The outer margins of resultant multi-well field polygons often have a scalloped appearance. The polygons also often have small internal non-field "islands." Numerous alternative methods were tested to identify and develop an algorithm which would adequately automate smoothing of scalloped-appearing field boundaries and fill in the small "islands" while acceptably limiting the polygon area increase. The resultant

smoothing algorithm, automated by a Visual Basic application in ArcGIS, was applied to all field boundary polygons. Ninety-nine percent of the resultant smoothed outlines have areas that are less than 108 percent of the unsmoothed polygon areas.

Geographic comparison of the smoothed field boundary polygons to the Federal lands polygons was then performed, resulting in output of a Federal lands fraction for each field.

Proved reserves estimates submitted on the 2001 Form EIA-23 survey were used in the estimation process. For those fields in which only some of the operators reported on Form EIA-23, the minimum reserves-to-production ratio of those that had reported was multiplied by the production of non-reporting operators to impute the latter's proved reserves. For those fields (which were usually small) in which no operator had reported on Form EIA-23, regression equations were developed from other reported observations in the basin that were used to estimate proved reserves. The portion associated with Federal lands within the field was then computed using the Federal lands fraction. Each field was then assigned to a proved reserves size class sufficiently narrow to be useful for this inventory's purposes while at the same time broad enough to ensure confidentiality of each Form EIA-23 respondent's proprietary estimates.

For the combined study areas proved Federal lands liquid reserves (crude oil plus condensate) were estimated to be 23.0 percent of total proved reserves with the individual percentages for ranging from 0.0 to 85.9 percent. Similarly, the proved Federal lands gas reserves were estimated to be 22.1 percent of total proved reserves with the individual percentages ranging from 0.0 to 96.1 percent. Also for the combined basins, Federal lands proved barrel-of-oil equivalent (BOE) reserves were estimated to be 22.3 percent of total proved reserves with the percentage for individual basins ranging from 0.0 to 93.6 percent.

A8.2 STUDY AREAS

The Phase II study areas and the states and counties pertinent to them are listed in Table A8-1. Their boundaries were provided by the USGS. All wells in the listed states and counties for which location information (in the form of latitude and longitude coordinates or projected coordinates) were available were selected if within the study area boundaries. Wells not located within the study area boundaries were discarded unless they were in a field that had wells located both inside and outside of the boundaries.

Table A8-1. Phase II Study Areas and Their State and County Affiliations

A8.3 DATA SOURCES

Three principal sources of data were used for this study:

- Federal Agency Data

  - The 2001 Form EIA-23 Survey files which contain field-by-field proved reserves estimates and production data as reported by large operators
  - A well data table with well spud point location (latitude and longitude), field name, and well type at time of completion for VA was obtained from the USGS (Robert Milici)
  - Federal lands boundary data were provided by the Bureau of Land Management, Department of the Interior.
- State Agency Data
  - Many of the oil and gas regulatory entities and the geological surveys of the producing US states have official websites where tables with the following data can be downloaded and/or queried: well spud point location (latitude and longitude), field name, and well type at time of completion. Several states also have online interactive web-mapping (webmapper) applications where wells can be viewed on a map and queries about them can be made. A few states have constructed their own oil and gas field boundary or outline files; these were used, where available, to check the reasonableness of the field boundaries constructed for this project. Oil and gas production data, usually annual by well, is available to download or query for some states. Links to the websites used in this study are listed in Table A8-2.

Table A8-2. Links to Websites Used in Phase II

  - Some data can't be downloaded from the state websites even though they can be queried online and must therefore be obtained directly from a state agency. Certain data were obtained from the listed state agencies (and contact persons) in Table A8-3.

Table A8-3. State Agencies Contacted

- Commercial Data
  - Well data tables with spud point location (latitude and longitude), field name, and well type at time of completion for the states of FL, MS, and TN were purchased from vendor PetroDataSource
  - Well data tables with spud point location (latitude and longitude), field name, and well type at time of completion for the states of WV and MD were purchased from vendor HPDI
  - IHS Production CDs were the source of production data at the well (for gas) or the lease (for oil) for crude oil, associated-dissolved gas, nonassociated gas, and condensate production in the Rocky Mountain states (CO, NE, UT, WY), the Black Warrior Basin states (AL, MS), FL, and AK
  - IHS Well History CDs were the source of spud point location (latitude and longitude thereof generated by Tobin International, Ltd.), field names, producing formation(s), and well type at the time of completion for the Rocky Mountain states (CO, NE, UT, WY) and Alaska.

A8.4 LIMITATIONS IMPOSED BY THE AVAILABLE DATA SOURCES

A variety of shortcomings and flaws in the available data impose unavoidable limitations either on what can be done or on the achievable level of accuracy. Chief among these are:

- Field and reservoir names are frequently non-standard as concerns their content and/or spelling. This makes accurate automated—and often even manual—matching of field and well records across data sources difficult and sometimes impossible. While standardized field codes are assigned and supported by EIA, most field names and their spellings are assigned by State agencies. When reporting well or production information for a field on which the state has not yet given an official name, the field operator is free to use any name or spelling.

  An additional factor was the demise of the American Association of Petroleum Geologists' (AAPG) Committee on Statistics of Drilling, which for many years performed an essential quality control function relative to U.S. well statistics and field and reservoir names. Staffed by industry volunteers the Committee was disbanded in 1986 and its files were turned over to the American Petroleum Institute (API), which that for many years maintained them absent the "in-the-field" quality control that the AAPG Committee had provided. Eventually this task was transferred to two competing commercial data vendors for continued maintenance and updating. Both recipient firms were subsumed into IHS Energy Group.

- Related to the field name problem is the problem of unknown and/or unassigned field names. This was most prevalent in the Appalachian Basin where thousands of wells exist that are not associated with field names. Such wells were assigned field names by proximity to existing fields and by determining producing formations in common with existing fields. This process involved viewing of mapped well locations and the use of automated programs that calculated distances from unknown wells to nearby wells associated with field names. After this there were still, especially in the Appalachian basin, wells that could not be assigned field names. These were assigned temporary names with Reserves and Production Division and county name as part of the name.

- Well misclassification is a perennial problem. For the most part it is caused by insufficient recursive quality control. For example, a new well may initially be classified as a wildcat well, which by definition has discovered a new field. Subsequent drilling of extension wells in this or an adjacent field may, over time connect the two adjacent fields. At this point both fields will shift to the field name of the earliest discovered of the two. This and other similar reclassifications occur frequently, but that fact often never filters backward, i.e., in this case to re-classification of the wildcat well type to extension or even development status.

- With the notable exception of fields located on the Outer Continental Shelf, the Federal government has access to subsurface data other than the well data available in state or vendor well files and state well log files. Because seismic data and interpretations, surface and subsurface geologic maps, and many well logs are proprietary data, in the context of this inventory, this limits what can be done concerning the construction of field boundaries to a purely geometric approach based on the buffering of well locations around their surface spud points (or bottom-hole locations for AK only).

- Many wells located in the Appalachian Basin were drilled and completed in the 1800's, long before there were laws to regulate them or any government or commercial organization tracking them. Digital records do not exist for many of the oldest wells and these are not represented in the field boundaries that resulted from this study unless they were producing relatively recently or were replaced with newer wells. The state geological surveys of OH, PA and KY are addressing this issue to varying extents by digitizing older field boundary maps and integrating them with digital well records in a GIS.

For these reasons, the resultant field boundaries are approximations, the accuracy of which, in the absence of adequate subsurface information, depends to a greater or lesser extent, on the professional judgment of the EIA RPD's petroleum geologists and engineers. *Collectively the field boundaries provided here are likely to be of sufficient accuracy for policy formulation concerning access to Federal onshore lands. In specific instances they may not be accurate enough for the application of policy and regulation.*

A8.5 PROCESS OVERVIEW

Figure A8-1 is a flow chart of the major steps followed in estimation of field-level proved reserves (on the left-hand side) and the construction of field boundaries (on the right-hand side), plus their merger into the final principal reserves product. The following discussion provides details for each of the indicated steps.

Figure A8-1. Phase II Process Flows

A8.6 QUALITY CHECKING AND COMBINATION OF DATA SOURCES FOR EACH STATE

Owing to different histories of tracking of oil and gas industry activity and to non-standardization, each state's data posed unique challenges relative to assembling the most complete and accurate well data set possible for use in constructing field boundaries. State agencies were a primary source of well data for all 16 of the producing states involved in the Phase II basins. These data were augmented with vendor well data in 11 of the 16 states (see Table A8-4).

Table A8-4. Well Data Sources by State for Phase II

A8.7 MERGING OF WELL DATA FILES

For Colorado, Wyoming, Utah, Nebraska, and Alaska, a well data set with locations was available from both a state agency and the vendor IHS. For those states an initial step was added that combined the IHS Annual Production data file (includes well location and type) with the IHS Well History file location and well type. The API well number, present in both files, was the common key for this merging process.

The IHS Well History records that did not match with IHS Production records were most often dry holes, injection wells or storage wells. If these did not match well records in other state or vendor files for that state, they were discarded. To create valid field boundaries only oil and gas wells were retained, whether or not they had recorded 2001 production data, excepting in Alaska where the injection wells were retained. The spud point location data in the IHS Well History file are Tobin International, Ltd's, most accurate coordinates and were used when available. If location information was not available in the IHS Well History file, the information in the IHS Production file was used.

For the states with multiple state and/or vendor sources, the available well data sets were merged using the API number of the well (or the state permit number if the API number was not available) as the common data field. The following rules and procedures were developed and used to merge the files:

A8.7.1 Preparation of Spud Point Location Information (Well Latitude and Longitude at The Surface)

For each state with multiple well data, the wells from each source were plotted on a map using the ArcGIS software. Location quality of the data sets was checked by looking for wells located far from a field's core location, wells with locations out of state, and wells located in the wrong county. This information was used to determine which source of location coordinates was the best one to use as the primary source. If location information was not available from any source the well record was deleted from the data used for field boundary construction but was retained for merger with the Form EIA-23 database and subsequent use in the determination of production and reserve volumes.

Because more horizontal or highly deviated wells are increasingly being drilled in the U.S. onshore, it is better to use the latitude and longitude of a bottom-hole location (BHL) to locate wells rather than the surface spud-point location. Only the state of Alaska data had sufficient BHLs, so for all other states the spud point (surface) location was used.

West Virginia was one of the most problematic states for the data combination process, as EIA had four well data sources from two vendors and two state agencies.

Unfortunately, the data considered most reliable (from the WV Geologic and Economic Survey) were not complete inasmuch as the Survey would only provide EIA with well data for the 20 counties where Federal Land was believed to exist. It was therefore necessary to "mosaic" a well data set using the data deemed best from all four sources.

Some states such as Virginia provided spud point locations in a projected coordinate system such as state plane. For these data the latitude and longitude values were calculated in ArcGIS because the buffer calculation program required location coordinates in that format.

A8.7.2 Field and Reservoir Name Respelling and Renaming

Variation in field and reservoir names and spellings is common among the commercial data files and state sources. Names were altered as necessary to make them as consistent as possible across sources. To achieve better field boundaries it was assumed that the buffers created for wells should be calculated on a reservoir level where possible (otherwise on a field level) and that the field boundary would then be constructed by unioning of the reservoirs in the field. Reservoir names were only consistently available for the states of WY, CO, UT, NE, AK, MS, AL and FL.

Names carried on the IHS Production file were used when available because they were most consistent with the names in the EIA Field Code Master List. Otherwise names from the state files, non-IHS vendor files, or the IHS Well History file were used.

If a well did not have a legitimate *field* name associated with it, (e.g., the associated name was 'UNDESIGNATED', 'UNKNOWN', 'WILDCAT'), an RPD-assigned name incorporating identification of the well's county location was used to replace it (e.g. a new field name like "RPD_Washington_Cnty-1" was created). When records appeared not to have a legitimate *reservoir* name, (e.g., 'UNKNOWN', 'UNKNWN', 'WILDCAT'), "UNNAMED" was used as the reservoir name.

If a reservoir name was abbreviated, the full reservoir name was assigned. If a reservoir name was augmented by a layer/zone/horizon modifier (e.g. "11250 A Washita-Freder," "11300 Washita-Freder") the modifier was removed (e.g. all were changed to "Washita-Freder"). Most records did not contain horizon information so the zone name was used instead as the best available data for reservoir naming.

Some field names were changed based on information obtained from state data sets, state websites, and conversations with state agency personnel. A few states such as CO, UT, WY and MS have developed their own spatial data files of field boundaries. These are often digitized versions of geologic outlines originally drawn by hand on paper. When these outlines were overlaid on the field boundaries created in the present study some discrepancies were noted and investigated. The comparison resulted in additional field name edits in some instances.

A8.7.3 Missing Field Names

Well files for every state had records where the field name was missing or that contained values such as 'UNKNOWN,' 'UNKNWN' or 'WILDCAT.' For all areas except the Black Warrior and Appalachian Basins the field name data field for these wells was populated manually. Wells with missing field names were plotted on a map showing the outlines of all named fields. Unnamed field wells located within or in close proximity to a named field boundary were given the name of that field. Unnamed wells judged to be too far from named field outlines to be considered part of that field were given RPD field names as described in section (b) above.

A very large number of unnamed field wells existed in the Appalachian and Black Warrior basins, so a SAS program was created to automatically assign field names to wells depending on their distance from wells located in the nearest named fields. An interwell distance of 2700 feet for oil wells and 5300 feet for gas wells was used for a first pass assignment of such field names. If a well without a field name was within these distances to a well with a field name, it was assigned that field name. Second and third passes were made at 2 and 3 times these distances to assign field names and 'grow' a field from assigned wells to unassigned wells. Wells that did not meet these proximity criteria after the third pass were assigned an RPD field name as described in section (b) above.

A special edit was made for one KY field name. The KY Division of Oil and Gas assigns the field name CATRON CREEK to all wells in unnamed fields. CATRON CREEK is defined as only being a valid field name in Harlan Co., KY. So all CATRON CREEK wells not located in Harlan County, KY had to be reassigned new/substitute names via the SAS program.

The state of Ohio presented a particularly unique challenge because the state well files do not yet include field name as an attribute. The OH Geological Survey, however, has constructed a field boundary polygon layer incorporating older development areas that lack digital well control (as described in the Limitations section, item (4) above). A Visual Basic program was written to place each well in a field boundary polygon and write the polygon field name as a well file attribute. Due to overlapping of the polygons many wells fell into two or more polygons and were assigned from 2 to 5 field names. The 2 to 5 field names were then ordered by the distance between the well and each polygon center, the first having the shortest distance, the second the next shortest, etc. Since completion formation data was available for the OH well records, a series of programs was written that used the completion formation name to pick the most probable field name out of these 2 to 5 possible fields.

A8.7.4 Identification of Well Types for Later Buffering

Deciding which wells to include in the buffering process is critically important in the construction of field boundaries. All wells where type = oil or type = gas in at least one of the source datasets were retained and classified as oil or gas. Wells which were not of type = oil or type = gas in at least one source were classified as a dry hole, a CO_2 producer, or an injection well. Some states such as CO and WY have interactive online

webmapping sites. These were used extensively to arbitrate well type discrepancies between data sets. Following final assignment of the well type only the positively identified oil and gas wells were retained for input to the well buffering process, with the exception of wells located in Northern AK. Since the wells drilled there as injectors had a significant impact on the field outlines, they were retained and buffered in Northern AK.

Some of the state well files mix dry holes which never produced (usually typed as "drilled and abandoned" or "D&A") with former oil or gas producing wells that are now plugged and abandoned (typed as "P&A"). This makes the task of separating present and former producers from wells that never produced difficult and, emphasizes the importance of having good historical production data records.

A8.7.5 Merging of Non-IHS Production Data

Well-level production data from state or vendor sources other than IHS were merged to the well files by API number or by drilling permit number. Some states have incomplete production data. For example, NY only has gas production data at the individual well level; oil production data are at the lease level.

A8.8 CONSTRUCTION OF WELL BUFFERS

The procedure used to generate well buffers consisted of several development and application steps. Creation of oil and gas field boundaries was accomplished using ArcGIS 8.3 software and the methodologies developed by EIA for Phase I of the inventory which are documented in detail in the original Phase I report.

The basic method used to construct field boundaries was to buffer each well in a reservoir or a field with a circle. The radius of the circle was determined by analysis of the spacing pattern for the wells in each reservoir in a field if reservoir names were consistently available, or for the wells in each field if they were not. The resulting circular buffer polygons were then unioned into a single field boundary polygon set (note that if wells are far enough apart there can be more than one non-contiguous polygon per resultant single field boundary). Given the large volume of data involved this method was used because it most effectively utilizes the available information on the different reservoir spacing patterns present within a field and is relatively easy to perform on a large data set.

A8.8.1 Determination of Nominal Well Spacing and the Assignment of Buffer Radii

An analysis of the distances between wells in a reservoir or a field, calculated from their spud point locations (or their bottom-hole locations in Northern Alaska), was used to assign a standard well spacing unit to each reservoir or field. The same technique was used in Phase I of the inventory. Nearest neighbor inter-well separation distances were calculated separately for oil wells and gas wells. The upper and lower bounds of the

observed spacing ranges are shown in the two left-hand columns of Table A8-5. The corresponding nominal standard well spacings (a geometric distribution) and buffer radii are shown in the two right-hand columns. The 75th percentile (P75) of the observed inter-well distance distribution was taken to be the observed inter-well distance. This statistic was selected because, as judged by the RPD project team, it yielded the best match to nominal well spacings in an extensive set of map trials done for Phase I. If the P75 distance fell within the corresponding interval shown in the two left-hand columns of the table then the corresponding nominal spacing was selected and its buffer size was initially assigned to every well in the reservoir (or field).

Table A8-5. Inter-Well Distance Ranges, Nominal Standard Well Spacings, and Buffer Radii

A8.8.2 Well Buffer Construction Rules Rules for the assignment of buffers were created to handle reservoirs (or fields if no reservoir names were available) that did not, for whatever reason, readily conform to a nominal spacing. The rules are based on well types and well counts

- For oil reservoirs the maximum spacing allowed was 160 acres, i.e. a buffer radius of 2,640 feet.
- If the reservoir had between 1 and 10 oil wells or the reservoir name was 'UNNAMED' a spacing of 160 acres was assigned.
- For gas reservoirs the maximum spacing allowed was 640 acres, i.e. a buffer radius of 5,280 feet.
- If the reservoir had only 1 gas well or the reservoir was named 'UNNAMED' a spacing of 640 acres was assigned.
- If a gas reservoir located in the Black Warrior Basin or a field located in the Appalachian Basin had 3 or fewer wells a spacing of 160 acres was assigned. If it had more than 3 wells and less than 10 wells the nominal spacing unit was used per Table A8-5 up to a maximum spacing of 160 acres.
- For coalbed methane wells a maximum spacing of 160 acres was assigned, i.e. a buffer radius of 2,640 feet.
- If the oil well count divided by the sum of the oil well count and the gas well count was less than or equal to 0.05 and if the oil well spacing was greater than the gas well spacing, the oil well spacing was set to the gas well spacing; otherwise, the original oil well spacing was retained.
- If the ratio of gas well count to the sum of the oil well count and the gas well count was less than or equal to 0.05 the gas well spacing was set to the oil well spacing for the field or reservoir; otherwise, the original gas well spacing was retained.

A8.9 CONSTRUCTION OF FIELD BOUNDARIES

A SAS file containing the oil and gas well data with field name attribute "Field" (and reservoir name attribute "Reservoir" if that data was available) was imported into ArcGIS as a dBase (.dbf) file. The wells were then plotted using the latitude/longitude

information in the file and converted to a geodatabase point feature class file. The coordinate system used was UTM NAD27 with the following UTM zones for each study area: Denver Basin–Zone 14, Wyoming Thrust Belt–Zone 12, Florida Peninsula, Black Warrior Basin, and Appalachian Basin–Zone 16, and Northern Alaska–Zone 7.

Before field boundary construction the following procedure was performed to ensure that all wells in the fields of interest lay entirely inside the study area boundaries. Two dbf files were made for each state, one of all wells inside the study area and another of all wells outside the study area. SAS queries were performed on those files to identify, for each state, all field names that had wells both inside and outside the study areas. These fields were then researched to determine if they were fields that actually extended across the study area boundaries (e.g. Colville River Field in AK NPR-A, Speaker Field in CO Denver Basin) or if they were geographically separate fields (not in reservoir communication) with the same name in the same state. The latter situation is, for example, especially common in KY and TN. In instances of the latter case, county names were appended to the field names (e.g. CACTUS_Morgan vs. CACTUS_Garfield) so that they would be put into different fields when the field boundaries were constructed.

Well files for each state were built that included only those wells located inside the study area/basin boundaries and all well records for fields that extended across the study area boundaries (e.g. Colville River Field, AK as mentioned above). These files were then used to construct the field boundary polygons.

The Visual Basic for Applications (VBA) code implemented within ArcGIS for Phase I of the inventory was used to automatically create polygonal field boundaries from the buffered wells. The principal steps performed were:

- Select the "field name" attribute and “buffer distance” attribute from the well file. Select all wells with the first "field name" encountered.
- Create a buffer around each selected well using "buffer distance" (see Figure A8-2)
- Union the buffers.
- Dissolve the barriers between overlapping buffers.
- Iteratively perform the above steps for each unique "field name”.
- Output a polygon feature class with one polygon (often consisting of multiple polygon rings) for each field.
- Convert to a shapefile.

Figure A8-2. Buffering Process

Figures A8-3 and A8-4 show the buffered field boundary of a field with two reservoirs. Figure A8-3 displays buffers by reservoir: Reservoir A is composed of oil wells with 80 acre buffers while reservoir B contains oil wells with 160 acre buffers and gas wells with 640 acre buffers. The final product of the field boundary creation process with buffers for both reservoirs unioned into one polygon record is shown on Figure A8-4.

Figure A8-3. Field Buffers by Reservoir

Figure A8-4. Field Buffers by Field

A8.10 SMOOTHING OF THE FIELD BOUNDARIES

An artifact of the well buffer approach to field boundary construction is that multi-well field boundaries inevitably have an irregularly scalloped, botryoidal (grape cluster-like) appearance. Field boundaries tend to be much smoother than that in their natural reality. Other artificial results include small interior non-field “islands” and small separations between multiple polygon “rings” of a single field boundary (see Figure A8-5). It is probable that in most instances (1) the interior islands are legitimately part of the field area and should therefore be included in it, and (2) that the "outlier" polygons of a field should be joined with (i.e., bridged into) the main field boundary when the separation distance is sufficiently small. That is the way a geologist or petroleum engineer would subjectively draw the field boundary by hand based on only the well spud point location and well spacing information available (i.e., absent subsurface information). For Phase II the field boundary construction effort was therefore enhanced by development and inclusion of a methodological extension that both automatically and more closely approximates what a geologist or petroleum engineer would draw as the field boundary. To have a consistent set of field boundaries for all of the inventory phases this extended methodology was also applied to upgrade the Phase I study area/basin field boundaries.

Figure A8-5. Buffered Field Outline Issues

A Visual Basic application that could be implemented within ArcGIS to smooth the irregular boundaries and fill in the smaller spaces in an automatic, quick, systematic, consistent, and repeatable manner was developed. The guiding principles adhered to in development of the smoothing application were to (1) add field area to the concave indented portions to smooth the scalloped look, (2) not add or subtract area from the convex portions in order to maintain the well buffer spacing, (3) fill in the interior non-field “islands” that are smaller than the buffer size as these are very likely part of the actual field area, (4) join separated polygon “rings” of the same field by a “bridge” if they are sufficiently close together, and (5) minimize the concomitant increase in the field's area. A number of alternative smoothing techniques were considered, tested, and rejected before the implemented technique was selected. These included:

- Raster Filters: Buffered field boundaries were converted from vector (point-line-polygon) format to raster (pixel) format. A variety of neighborhood statistical operators (filters) were applied to the raster and then converted back to vector format. This approach was not satisfactory because it always added field area to the convex portions of boundaries.
- *Generalize* and *Smooth* methods: These two vector-based methods are built into the ArcGIS software. The *Generalize* method was not chosen because it consistently subtracts area from the convex portions of field boundaries. The

Smooth method results in inconsistent addition and subtraction of field area in the convex and concave portions of a field boundary, also not acceptable.

- Maximum angle technique: This technique first filled in and merged all interior non-field islands smaller in area than the maximum field buffer size. It then stepped along each vertex in a polygon and moved the vertex out until the angle formed by that vertex and the two vertices on either side of it was less than a maximum specified angle. Because moving one vertex out affects the angles of adjacent vertices, it required many iterations to get all angles to be less than the maximum allowed angle. Also, narrow fiord-like indentations in the field boundaries were particularly problematic with this technique and needed to be manually addressed prior to automated movement of the vertices. The increased complexity, human resource needs, longer processing time, and inconsistent handling of problems made this technique undesirable.

A technique based on tangent trapezoids was ultimately selected for field boundary smoothing because it focuses on how close wells in a field should be in order for their associated buffers to be unioned and is also simpler than the other tested techniques. It's begins by comparing the distance between each pair of wells within a field boundary to the average of the two wells' calculated buffer sizes. Three cases for the tangent trapezoid technique based on that relative distance are summarized in Figure A8-6. If the inter-well distance is less than or equal to two times the average buffer size, the buffers are either tangent (just touching) or overlapping (Figure A8-6a). When that is the case a trapezoid is constructed through both wells that extends to the full diameter of the buffers and is then unioned to the boundary polygon for that field. If the inter-well distance is between 2 to 2.5 times the average buffer size a trapezoid of one-half the buffer diameter is constructed and unioned to the boundary polygon for that field (Figure A8-6b). This thinner union of the well buffers reflects a higher uncertainty that the field is hydraulically connected in the subsurface within the space between the wells. If the inter-well distance is greater than 2.5 times the average buffer size no trapezoid is drawn and the field outline remains segmented (Figure A8-6c).

Figure A8-6. Tangent Trapezoid Smoothing Rules

In addition to filling in the concave boundary areas, the tangent trapezoid technique aptly handles the matter of interior non-field "islands," fiord-like indentations in the field boundary, and spaces between multiple polygon "rings" belonging to the same field. Figure A8-7 shows an example of a field boundary before and after smoothing via the tangent trapezoid technique. The ratio of smoothed boundary area to unsmoothed boundary area was calculated in each instance to ensure that field area additions were sufficiently minimized. The mean increase in field area from unsmoothed to smoothed boundaries was 4.2 percent for all basins combined. Less than 1 percent of all fields exceeded an 8 percent change, and only 0.02 percent of all fields had a 10 to 14 percent change.

Figure A8-7. Field Boundary Before and after Smoothing with Tangent Trapezoid Technique

Field boundary polygons that crossed study area boundaries were exported as a separate file, and were then clipped to the study area boundary polygon files. For each of these fields the ratio of field area after clipping (area inside basin) to total field area (area inside + area outside basin) was calculated as the attribute INBAS_FRC (in-basin fraction). The value of this attribute is 1 for fields located entirely inside a study area/basin and ranges from greater than zero to less than 1 for those fields that cross a study area/basin boundary. It was necessary to clip these fields before calculating the Federal land fraction because the BLM-provided Federal land coverages do not always extend far enough outside the study area to permit its calculation for the entire unclipped field boundaries. The attribute INBAS_FRC is later multiplied by the field reserves to derive field reserves located inside the study area/basin boundary.

A8.11 CALCULATION OF THE FEDERAL LANDS FRACTION WITHIN A FIELD'S BOUNDARY

The Federal land ownership coverages provided by the BLM, (one coverage per study area) were intersected with the field boundary outlines to ascertain the land ownership aspect of each field's area. A definition query was used to exclude land with private and state mineral ownership and then an automated procedure (developed for Phase I) was used to calculate the fraction of Federal land within each oil and gas field polygon. The procedure intersected the Federal land coverages with the field polygons and then populated a column in the field boundary polygon table “PctFedLand.”

A8.12 REVIEW AND QUALITY CONTROL OF THE RESULTING MAPS

Maps were printed at an appropriate scale for each study area to facilitate quality checking of the constructed field boundaries both before and after the smoothing algorithm was applied. These maps displayed the wells in the field and the field boundary polygons. They also showed selected field attributes such as state, county, basin, and percent Federal land. Figure A8-8 provides an example of a quality control map.

Figure A8-8. Black Warrior Basin Quality Check Map Showing Smoothed Field Outlines and Percent Federal Land

A8.13 FIELD-LEVEL PROVED RESERVES ESTIMATION

The conditioned state/vendor well history and production data were summed to the field/operator level and then merged with the field proved reserves estimates reported on Form EIA-23 by the largest operators. Fields were classified into four types for the purpose of reserves estimation:

- Fields with no 2001 production data or reserves estimate data
- Fields that were completely reported by both IHS and the EIA survey, with 2001 production and all operators in the fields being surveyed by EIA. The proved

reserves estimates submitted by the operators for these fields were used as reported.

- Fields that were partially reported and partially imputed. These fields are represented in both the IHS and EIA survey data by 2001 production volumes, but only part of the total field reserves estimate was reported to EIA because some operators in the field were not required to report proved reserves on Form EIA-23. The remainder of the field's proved reserves were therefore imputed by RPD by assigning the weighted average reserves-to-production ratio of the reporting operators to the non-reporting operators and multiplying it by the non-reporting operators' reported production volumes as taken from state/vendor data.
- Fields that were completely estimated based on vendor/state 2001 production data because the operators of these fields were not required to submit a Form EIA-23. Although these fields constitute a sizeable fraction of the total number of fields in the study areas, their aggregate proved reserves represent only a small portion of total proved reserves. The proved reserves and corresponding production data reported on the 2001 Form EIA-23 were used to develop predictive least squares regression equations quantitatively descriptive of their relationship. These equations were then used to estimate proved reserves for this class of fields based on the vendor/state production data available for them. The estimation equations were developed using SAS statistical software, one each for oil, associated-dissolved gas, non-associated gas, and condensate, for each basin, state (including fields both in-basin and outside-basin) and the United States as a whole. The form of the equation is:

$$\log_e (\text{Proved Reserves}) = a + b \log_e (\text{Production})$$

Table A8-6 lists the resulting regression parameters. For any field where reserves were imputed, the basin-level parameters were used if available, followed in their absence by state-level parameters if available, followed in the absence of both by US-level parameters. Where no parameter is listed in the table there was not sufficient data available for that basin or state to validly estimate the parameter.

Table A8-6. Regression Equation Parameters for the Estimation of Non-Reported Reserves

The resultant crude oil proved reserves estimates were then summed with the proved condensate reserves estimates to yield the proved liquid reserves estimates. Similarly, the proved associated-dissolved gas reserves estimates and the proved non-associated gas reserves estimates were summed to yield the total proved gas reserves estimates. Lastly, a gas-to-oil ratio of 6000 cubic feet per barrel was used to convert the total proved gas reserves to their oil equivalent, which was then summed with the proved liquid reserves estimates to yield the proved barrel-of-oil-equivalent reserves estimates.

For each of the four reserve types Table A8-7 summarizes by study area the number of fields, the basin field count, the barrel-of-oil-equivalent production, and the barrel-of-oil-equivalent proved reserves. The percentage of each reserve type in the study area/basin is also shown.

Table A8-7. Field count, BOE Production & BOE Reserves for Four Reserve Types in Each Study Area

A8.14 CALCULATION OF FEDERAL RESERVES

The Federal reserves for each field were estimated by multiplying the fraction of Federal land for each field (derived by GIS analysis as described above) by the proved reserves estimates for each product. This procedure assumes that the distribution of proved reserves per unit area within a field boundary is uniform. While that is never precisely the case, this procedure is sufficiently precise for a regional study such as this one.

A8.15 RESERVES CLASSIFICATION

In order to sufficiently protect the proprietary proved reserves data submitted to EIA, each field was then assigned to a gross reserves size class and a Federal reserves size class, by product, per the following classification scheme:

Class Number	Proved Liquid Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 Mbbls liquid
2	Greater than 10 but less than 100 Mbbls liquid
3	Greater than 100 but less than 1000 Mbbls liquid
4	Greater than 1000 but less than 10,000 Mbbls liquid
5	Greater than 10,000 Mbbls liquid

Class Number	Proved Gas Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MMCF gas
4	Greater than 10 but less than 100 MMCF gas
5	Greater than 100 but less than 1000 MMCF gas
4	Greater than 1000 but less than 10,000 MMCF gas
5	Greater than 10,000 but less than 100,000 MMCF gas
6	Greater than 100,000 MMcf gas

Class Number	Proved Barrel-of-Oil Equivalent Reserves
0	Zero reserves (i.e., no recorded 2001 production)
1	Greater than zero but less than 10 MBOE
2	Greater than 10 but less than 100 MBOE
3	Greater than 100 but less than 1000 MBOE
4	Greater than 1000 but less than 10,000 MBOE

5 Greater than 10,000 but less than 10,0000 MBOE
6 Greater than 10,0000 MBOE

Note: M=1,000; MM=1,000,000; bbls=barrel; cf=cubic feet

A8.16 MERGING OF PROVED RESERVES CLASSES WITH FIELD BOUNDARIES AND FRACTION OF FEDERAL LAND

A GIS file was produced that contains the intersection of the Federal land coverages with the field boundaries. Owing to the existence of multiple federal land parcels within each field boundary, the resultant boundary polygons were then dissolved on the attribute "field" to union the data into one polygon record per field. A table with the reserves classes by field (range 0 to 6) and the field name was then joined to the shapefile associated with the field boundary shapefile. The latter was then converted to coverage format and thence to interchange file format (.e00).

For all study areas except the Appalachian Basin there was good correspondence between the production file and the map file with Federal land percentages. Owing to the poor condition of field names in the Appalachian Basin there was less correspondence between these files; there were approximately 1200 Appalachian Basin fields that had map locations but no 2001 production data. All of these fields were assigned to reserve class zero although because of faulty or incomplete field names some of them might properly belong to other fields for which there were 2001 production data. Approximately 130 fields appeared to have 2001 production but there were no available location data. These fields, which together accounted for less than 1 percent of the liquids production and approximately 1.5 percent of the gas production in the Appalachian Basin, were assumed not to be on Federal land because that was more likely to be the case in this basin.

A8.17 SUMMARY OF RESULTS

GIS is clearly the information conveyance method of choice where both analysis of Federal lands policy and regulations and their application are concerned. The primary proved reserves result is therefore a GIS layer containing field boundary polygons attributed with field name and a proved reserves size class for each field product. Unfortunately, none of this very detailed information can be usefully conveyed on a piece of paper this size. You have to use a GIS workstation to view it and a wide-format printer to print it at a size where the detail can be distinguished. Therefore, in lieu of a close look at the reserves results, summary statistics are provided by study area in Table A8-8.

Table A8-8. Summary of 2001 Federal Lands Proved Reserves by Study Area

A8.18 SUMMARY OF UPDATED PHASE 1 RESULTS

The land status files provided by the Department of the Interior for the Phase I study areas have been updated since the original work was done in 2002 and EIA has incrementally improved its field boundary construction process. For the purpose of maintaining a consistent set of estimates, the Phase I study areas were reprocessed to reflect these changes. Specifically:

1) The field outlines were smoothed using the algorithm described in the appendix documentation for Phase II.

2) Portions of field outlines that extended outside of the defined basin boundary were clipped to the basin boundary.

3) The projection for the GIS files of all basins except the Montana Thrust Belt were changed from UTM-12/NAD27 to UTM-13/NAD27.

Taken together these changes only very slightly impacted the Federal reserves totals and percentages, the updated version of which is shown in Table A8-9.

Table A8-9. Summary of Updated 2001 Federal Lands Proved Reserves by Phase I Study Area

APPENDIX 9

GIS METHODOLOGY

Following are further descriptions of how Federal lands were placed into the nine categories referred to in Table 2-8 and a detailed description of the GIS methodology used.

Based upon guidance from BLM and USDA-FS offices, Table A9-1 shows the NLA/LUP jurisdictions within the inventory area.

Table A9-1. Jurisdictions Classified as NLA/LUP

Table A9-2 shows how agency jurisdictions were used to categorize lands for this inventory.

Table A9-2. Federal Land Categorization

GIS files were available to define most of the access categories; however, for the NLA/LUP category, they had to be created. In these situations, the administrative boundary (such as a National Forest) was extracted from the surface ownership data and the resultant polygon was then attributed as NLA/LUP. For example in Figure A9-1, the Wasatch-Cache National Forest boundary in the Wyoming Thrust Belt is shown in green. The grey represents the area within the forest that is undergoing land use planning, which is categorized as NLA/LUP.

Figure A9-1. Creation of NLA/LUP Polygons

A9.1 STIPULATION EXCEPTIONS

Exceptions to stipulations are sometimes granted. For example, a crucial elk winter range timing limitation exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general areas during a particular year. Because records of exceptions to lease stipulations were not available, BLM and USDA-FS field personnel were asked to determine, based on their experience, which lease stipulations were granted exceptions for drilling and how often. The exception factors thus determined are shown by jurisdiction in Table A9-3.

Table A9-3. Stipulation Exception Factors by USDA-FS and BLM Office

Lease stipulations, particularly timing limitations, can overlap. Where exception factors overlap, the cumulative effect is calculated by multiplying the overlapping factors (from Table A9-3). This calculation implicitly assumes that exceptions for multiple stipulations would likely not be obtained for a given area. For example, cumulative effects of excepted stipulations for the Wyoming Thrust Belt study area are determined as shown

in Table A9-4. The application of these exception factors is described below in Section A9.3.

Table A9-4. Exception Factors Example for Overlapping Stipulations (WTB Study Area)

A9.2 TREATMENT OF NSO AREAS

Directional drilling (or "extended reach drilling") is technology that can be employed to reach subsurface targets not located directly underneath the drilling rig. In this inventory resources beyond a certain EDZ are assumed to not be technically recoverable (Figure A9-2). While it is true that directional drilling horizontally out to distances of 5 or 6 miles is possible in production settings such as Alaska, this type of drilling is not the general case in the lower 48 and is impracticable for exploration.

Figure A9-2. Extended Drilling Zone Conceptual Diagram

Directional drilling for exploratory purposes occurs in some areas but is much more limited in scope. As in the case of stipulation exceptions, BLM and USDA-FS field personnel were interviewed to determine the practicable width of the EDZ. The width of the EDZ is partially a function of the depth to the drilling objective—generally the deeper the objective, the larger the EDZ. The EDZ distances supplied by the offices and used in this inventory are shown in Table A9-5.

Table A9-5. Extended Drilling Zones by Jurisdiction

The effect of the inclusion of the EDZs in the analysis is to remove an area of land from the perimeters of NSO polygons. The width of this area removed via GIS processing is determined by Federal jurisdiction (Table A9-5) as determined by each field office. The area removed then defaults to the resource access category that would otherwise apply in the absence of the NSO stipulation. The net effect is that the underlying resource is no longer considered inaccessible even though the surface above it cannot be occupied by drilling equipment.

Figure A9-3 shows an actual example from the Wyoming Thrust Belt. Areas shown in light blue represent a 1/2-mile extended drilling zone removed from the NSO areas for the resource categorization. Areas shown in blue represent the resource Net NSO. The black area depicts an area of no leasing; as such the EDZ was not applied to these lands as a rig cannot be sited in no lease areas.

Figure A9-3. Removal of the Extended Drilling Zone from NSO Areas

A9.3 Analytical Modeling of Federal Lands and Resources

The analytical goal of the inventory is to calculate the area of Federal lands (including non-Federal lands overlying federally owned oil and gas estate [split estate]) in each access category in the hierarchy and the volume of oil and gas resources underlying the

Federal lands in each access category, while at the same time accounting for stipulation exceptions and the accessibility of the EDZ.

One of the primary objectives for the development of the categorization is to achieve geographic independence for a given parcel of land subject to overlapping stipulations (hence, the use of the categorization hierarchy where that parcel of land would be subject to only one category). The following discussion illustrates the application of the land access categorization for an area of multiple stipulations from the Kemmerer, WY, BLM FO in the Wyoming Thrust Belt, where sage grouse leks and nesting habitat and big game winter range define an access category. These types of stipulations are among the most common found in the study areas.

Figure A9-4 shows a selected point where the stipulations overlap and the resultant categorization is “Timing Limitation Stipulations >6 to ≤9”. A query at that point brings up a dialog box which lists the stipulations in effect. Table A9-6 contains the corresponding stipulation data extracted from a corresponding master stipulations list.

Figure A9-4. Display of Overlapping Timing Limitations (WTB Study Area)

Table A9-6. Sample Master Stipulations List for a Selected Area

Figure A9-5 shows the land categorization as determined by the stipulations listed in the relevant land use plan. Note that the core nesting habitat of the sage grouse (shown in blue), is designated a "no surface occupancy” area. The remaining area is under various timing limitations (colored in shades of red), controlled surface use (gold) or standard lease terms (green).

Figure A9-5. Display of Federal Land Access Categorization (WTB Study Area)

Note that in the inventory, with regard to NSO areas, lands and resources are treated differently due to the application of EDZs. Figure A9-6 shows the effect where the EDZ is applied to NSO areas to determine the resource categorization. Note that the application of the EDZ in this example renders the resources under the sage grouse nest area accessible. While the acreage figures for each access category faithfully reflect the management prescriptions contained in the land use plans, the oil and gas volumes are calculated using this adjustment. The net result is that more oil and gas resources are accessible than would be assumed if NSO stipulations were taken at face value.

Figure A9-6. Display of Resource Access Categorization with Extended Drilling Zone Applied (WTB Study Area)

In addition, to account for stipulation exceptions, the GIS model determined the effects due to the presence or absence of the stipulations by selectively removing excepted stipulations in the computer. This is illustrated by Figure A9-7, which shows an example for the Wyoming Thrust Belt where the sage grouse nesting habitat stipulation has been removed. Note that in the case of an excepted stipulation, the analysis defaults to the underlying stipulation or standard lease terms, as appropriate.

Figure A9-7. Display of Federal Land Access Categorization with Extended Drilling Zone Removed and with Sage Grouse Nesting Habitat Stipulation Excepted (WTB Study Area)

For example, if sage grouse nesting stipulations are excepted 10 percent of the time (as shown on Table A9-6), then, for an area represented by the sage grouse polygon (where sage grouse stipulations do not overlap other excepted stipulations), 90 percent of the resources is categorized according to the stipulation and 10 percent is categorized according to the underlying stipulation category next in the hierarchy. This calculation is performed accordingly for all of the exception factors within a given office jurisdiction (see Table A9-3) or where combinations of these exceptions exist (see Table A9-4).

Access categorization of the Federal lands and resources was determined in aggregate based upon discrete examination of individual GIS polygons using the following equation:

$$FLorRs = \sum((1-EF) * FLorRs_{(EDZ)} + (EF * FLorRs_{(EDZ\ w/\ Excepted)}))$$

Where FlorRs = Federal Lands or Resources
EF = Exception Factor (e.g., see Table A9-4)
$FLorRs_{(EDZ)}$ = FLorRs determined using the Extended Drilling Zone
$FLorRs_{(EDZ\ w/\ Excepted)}$ = FLorRs determined using the EDZ plus removal of stipulations for which exceptions are granted

This equation accounts for the occurrence of the extended drilling zone and stipulation exceptions. For excepted stipulations the model defaults to the underlying stipulation category in the hierarchy.

This process results in the generation of numerous individual GIS polygons for each study area. These data are then summed and reported by access category and Federal management agency. For oil and gas resources, categorization is provided by specific resource type (see folder “Detailed Spreadsheets” on accompanying DVD).

A9.4 Quality Control of Modeling Results

A rigorous quality control (QC) check was instituted for the Phase II model. During processing a typical study area will generate more than one million discrete GIS polygons, each with unique characteristics in terms of land status, oil and gas resources, stipulations and exception factors. Complex study areas generate two to three million polygons each. As such, imprecision in GIS mapping data that are insignificant for individual polygons can be amplified in the aggregate. Such imprecision is a direct function of the quality of the data received from the various sources contributing to the inventory.

For all study areas, the quality of the model output is high. For QC purposes, input oil and gas resource volumes and land areas were compared to outputs. A comparison of the study areas revealed percentage differences ranging from zero to 1.32 percent, with most well below 0.5 percent. For a limited number of offices (e.g., Monongahela NF, Vernal, UT, BLM FO, and Allegheny NF) corrections were made to bring errors down to within two percent of input values. Corrections entailed removal of topological errors occurring in the GIS source data.

The model's land output data differs by 0.26 percent from the input data on an aggregate basis. For oil and gas resources, model output data differs by 0.34 percent from the input data on an aggregate basis.

The QC logs for the study area lands areas and resources are presented on spreadsheets on the accompanying DVD.

APPENDIX 10

FEDERAL LAND USE PLANNING DOCUMENTS USED FOR THE PHASE II INVENTORY

Alabama NFs Revised Land and RMP, 2004

Allegheny NF Land and RMP, 1986

Arapaho-Roosevelt NFs, Pawnee NG Revision of the Land and RMP, 1997

Ashley NF Stipulation for Lands of the NF System, 1992

Beaverhead NF EIS, 1996

Berlin Lake Project DR, 1990

Big Cypress General Management Plan/ Final EIS, 1991

Black Hills NF Plan of Land and RMP, 1991

Book Cliffs RMP/ROD and Rangeland Program Summary, 1985

Bridger-Teton NF Land and RMP, 1990

Bureau of Reclamation in Wyoming Special Stipulations

Bureau of Reclamation in New Mexico–Navajo Reservoir Stipulations

Carson NF Plan, 1986

Cedar/Beaver/Garfield/Antimony RMP, 1986

Cibola NF Plan, 1985

Conemaugh River Lake Project EA, 1985

Daniel Boone NF Revised Land and RMP, 2004

Diamond Mountain Recreation Area RMP/ROD, 1994

Farmington Oil and Gas Leasing Amendment, 1991

Florida RMP/ROD, 1995

Garnet RMP, 1986

George Washington NF Final revised Land and RMP, 1993

Glenwood Springs Resource Area Plan Amendment, 1999

GMUG NFs Oil and Gas Leasing File EIS ROD, April 1993

Grand Junction Resource Area Management Plan and ROD, 1987

Headwaters RMP/EIS, 1983

Helena NF Plan and ROD, 1986

Isotract MFP, 1985

Jefferson NF Revised Land and RMP, 2004

Kemmerer RMP/ROD, 1986

La Sal NF Land and RMP–Manti, 1986

Lander RMP, 1987

Lewis and Clark NF, Oil and Gas Leasing Final EIS, 1997

Little Snake BLM Leasing Stipulations

Miles City BLM Oil and Gas Amendment, 1994

Mississippi EA Report–O&G leasing on the NFs, 1976

Monongahela NF and Amendments Land and RMP, 1986

Montana State Office, BLM–Billings

Mosquito Creek Lake DR, 2000

Nebraska NF Revised Land and RMP, 2000

Nebraska RMP, 1992

Newcastle FO, ROD & Approved RMP, 2000

Northeast NPRA Final Integrated Activity Plan/EIS Amendment, 2006

Northwest NPRA Final Integrated Activity Plan/EIS, 2003

Pike & San Isabel NF, Cimarron & Comanche NG, O&G Leasing Final EIS, 1992

Pinedale RMP, 1988, Amended 2000

Platte River RMP Revised & Updated Decisions, 2001

Pocatello & Medicine Lodge Resource Areas RMP, 1988

Randolph MFP, 1980

Rawlins BLM Lease Stipulations, 2001

Rock Springs BLM Lease Stipulations

Rio Puerco RMP, 1992

Routt NF Land and RMP 1997 Revision

Royal Gorge RMP and NE Royal Gorge RMP, 1991

San Juan/San Miguel RMP Amendment, October 1991

Santa Fe NF Plan 1987, 1996 Amendment, O&G EA NM 85795

Seneca Army Depot and Sampson State Park, 1993

St. George FO–ROD and RMP, 1999

Targhee NF Revised Forest Plan, 2000

Thunder Basin Nat. Grassland Land and RMP, 2002

Uinta NF Land and RMP Revision, 2003

Utah BLM Lopez Project, Statewide Stipulations for Fillmore

Utah BLM Lopez Project, Statewide Stipulations for Kanab

Utah BLM Lopez Project, Statewide Stipulations for Moab

Utah BLM Lopez Project, Statewide Stipulations for Monticello

Utah BLM Lopez Project, Statewide Stipulations for Price

Utah BLM Lopez Project, Statewide Stipulations for Richfield

Utah BLM Lopez Project, Statewide Stipulations for Salt Lake

Wasatch-Cache NF, Revised Forest Plan, 2003

Wayne NF Land and RMP, 1988

White River NF, Oil and Gas Final EIS/ROD, 1993

White River Resource Area RMP

Wyoming BLM Mitigation Guidelines for Surface-disturbing and Disruptive Activities

APPENDIX 11

FEDERAL OIL AND GAS SURFACE MANAGEMENT PRESCRIPTIONS

This appendix contains the text of stipulations applicable to the Phase II inventory. Note that only the pages of the land use plans that contain stipulations used in the inventory are reproduced. The stipulations used are annotated with an EPCA code, e.g., [EPCA Code: UFSashley003] for a stipulation in the Ashley National Forest.

Note also that the various jurisdictions are presented by study area. They are presented only once in the study area in which they dominantly occur even though they may be present in more than one.