ADVANCED RESOURCES INTERNATIONAL, INC.

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UNDISCOVERED NATURAL GAS AND PETROLEUM RESOURCES BENEATH INVENTORIED ROADLESS AND SPECIAL DESIGNATED AREAS ON FOREST SERVICE LANDS ANALYSIS AND RESULTS

Results

Analysis of undiscovered natural gas and oil resources (technically recoverable) associated with the U.S. Forest Service's *Inventoried Roadless Areas* and *Special Designated Areas* shows the following results in **Table 1**.

Table 1
Undiscovered Natural Gas and Oil Resources Associated with the U.S. Forest Service's Inventoried Roadless Areas and Special Designated Areas

	Natural Gas, Tcf			Petroleum, MMBO		
	High	**Mean**	**Low**	**High**	**Mean**	**Low**
Inventoried Roadless Areas	23.1	11.3	3.5	1,212	550	119
Special Designated Areas	9.7	3.6	0.3	1.3	0.5	0.2
Rocky Mountain Region	641	323	119	17,574	8,218	1,456

Purpose and Methodology

The purpose of this analysis was to examine the undiscovered natural gas and oil resources associated with Inventoried Roadless Areas (IRAs) and Special Designated Areas (SDAs).

The study area covers six Rocky Mountain states (Montana, North Dakota, Wyoming, Colorado, Utah and New Mexico). Nineteen geologic provinces and basins were examined (Table 2). For the analysis, technically recoverable resources were compiled, by play, for undiscovered natural gas and oil resources in the study area. High, mean and low resources resource values were taken from the USGS 1995 Assessment, supplemented by Advanced Resources' analyses and published data for select plays, similar to the 1999 National Petroleum Council (NPC) study, *Natural Gas: Meeting the Challenges of the Nation's Growing National Gas Demand.*

Table 2
Nineteen Rocky Mountain Provinces/Basins Were Examined

Western Great Basin	Williston Basin
Eastern Great Basin	Powder River Basin
Uinta - Piceance Basin	Big Horn Basin
Paradox Basin	Wind River Basin
San Juan Basin	Wyoming Thrust Belt
Albuquerque - Santa Fe Rift	Southwestern WY
Northern Arizona	Park Basins
Montana Thrust Belt	Denver Basin
North-Central Montana	Raton Basin - Sierra Grande Uplift
Southwest Montana	

Of the 208 plays were examined; 116 have resources in IRAs or SDAs—determinations of the specific intersected areas was made using GIS analysis. Within the plays, based on discussions with DOE, the assumption of a homogeneous distribution of resources was made and resources were then allocated to the intersected areas, by play. IRAs and SDAs were considered independently in the analysis.

To further refine the analysis, areas of intersection between the plays and the IRAs or SDAs were for the subdivided into accessible and "high slope" areas. High slope areas are considered as difficult areas for exploration and drilling and were defined by grades of greater than 30%, consistent with leasing stipulations in the western U.S. High slope areas were determined using a digital elevation model obtained from the USGS.

Estimated undiscovered play resource values used in this analysis include "high", "mean", and "low". These values represent probabilities of undiscovered resource occurrence. They were taken from the USGS *1995 National Assessment of United States Oil and Gas Resources*. "High" values (F_5) corresponds to an estimated one in twenty or 5 % chance of occurring. "Low" values (F_{95}) corresponds to an estimated nineteen in twenty or 95% of occurring. Natural gas resources comprise associated and non-associated gas. Petroleum resources comprise crude oil and NGLs.

Estimates of high, mean and low resources technically recoverable resources within the IRAs and SDAs were subsequently determined using the following matrix (Table 3). The Appendix contains a listing of results by play.

Table 3
Estimates

		F5	Mean	F95
High	Slope <30%	**X**		
	Slope >30%		**X**	
Mean	Slope <30%		**X**	
	Slope >30%			**X**
Low	Slope <30%			**X**
	Slope >30%			

Inventoried Roadless Areas contain moderate to significant amounts of natural gas and oil; Special Designated Areas contain moderate to significant amounts of natural gas only as shown in Table 1.

Within the IRAs, natural gas resources are most significantly impacted in Uinta/Piceance (3.9 Tcf), Wyoming Thrust Belt (3.2 Tcf), Southwestern Wyoming (2.0 Tcf), and Montana Thrust Belt (1.6 Tcf). Oil resources are impacted most significantly in the Wyoming Thrust Belt (411 MMBO). Within the SDAs, natural gas is impacted in the Uinta/Piceance Basin (2.3 Tcf), Southwestern Wyoming (0.8 Tcf) and Wyoming Thrust Belt (0.3 Tcf). Little oil is impacted.

With respect to the 1999 NPC study analytical methodology, the disposition of the11.3 Tcf of natural gas resources that underlie IRAs are estimated to be as follows:

Table 4
Estimated Natural Gas Resources Impacted by IRAs Under NPC Categorization

NPC Categorization	IRAs Natural Gas Resource (Tcf)
Standard Lease Terms	7.0
No Access	1.9
Access Restrictions	2.4
Total	11.3

As such, with implementation of the proposed roadless areas, about 9.4 Tcf of gas beyond that determined as “no access” in the 1999 NPC study would be impacted as “standard lease terms” and “access restrictions” resources move to the “no access” category.

The nine largest plays (by resource) in the study area make up approximately 14% of the area of the IRAs but, significantly, 83% of the natural gas resource represented in the IRAs in the Rocky Mountain region as shown in Table 5. Further, these nine plays represent slightly less than 5% of the total proposed IRAs nationwide. Modification of IRAs that overlie these plays could greatly reduce the amount of natural gas resource associated with roadless areas.

Table 5
Nine Largest Plays by Resource

USGS Province	Play	Code	IRAs (acres)	Natural Gas, Bcf (mean)
Montana Thrust Belt	Imbricate Thrust Gas	2701	1,192,787	1,618
Wyoming Thrust Belt	Moxa Arch Extension	3601	206,303	1,568
Wyoming Thrust Belt	Northern Thrusts	3603	749,469	1,508
Uinta - Piceance Basin	Uinta Basin - Emery	2052	60,882	1,159
Southwestern WY	Greater Green River Basin - Mesaverde	3741	65,322	950
Uinta - Piceance Basin	Tight Gas Uinta Tertiary West	2016	12,194	789
Uinta - Piceance Basin	Tight Gas Piceance Mesaverde Williams Fork	2007	218,522	642
Southwestern WY	Greater Green River Basin - Cloverly-Frontier	3740	105,206	566
Uinta - Piceance Basin	Piceance Basin - Western Basin Margin	2054	113,576	545
	Totals		**2,724,260**	**9,346**
	Portion of total Rocky Mountain Region		**14%**	**83%**

Appendix

Appendix: Inventoried Roadless Areas and Special Designated Areas
Undiscovered Resource Analysis

			Inventoried Roadless Areas						Special Designated Areas					
			Natural Gas, Bcf			Petroleum, MMBO			Natural Gas, Bcf			Petroleum, MMBO		
USGS Province	Play	Play code	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low
Western Great Basin	Permian-Triassic Source Rocks Northwestern	1803	-	-	-	-	-	-	-	-	-	0.1	0.0	-
Eastern Great Basin	Unconformity "A"	1901	0.3	0.1	0.0	2.6	0.9	0.0	0.1	0.0	0.0	-	-	-
	Late Paleozoic	1902	1.3	0.2	-	2.0	0.2	-	0.2	0.0	-	-	-	-
	Younger Tertiary Basins	1905	1.1	0.2	-	0.2	0.0	-	0.3	0.1	-	-	-	-
	Sevier Frontal Zone	1907	198.8	40.6	-	19.6	4.0	-	6.6	1.1	-	-	-	-
Uinta - Piceance Basin	Piceance Tertiary Conventional	2001	112.8	70.8	5.4	0.4	0.3	-	-	-	-	-	-	-
	Uinta Tertiary Oil and Gas	2002	22.4	11.9	1.4	4.4	2.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0
	Upper Cretaceous Conventional	2003	54.8	37.5	3.6	0.4	0.3	-	9.7	5.2	0.5	-	-	-
	Cretaceous Dakota to Jurassic	2004	23.1	13.4	2.5	0.4	0.2	0.1	16.7	9.1	1.6	-	-	-
	Permian-Pennsylvanian Sandstones and Carb.	2005	270.3	81.4	3.4	37.3	11.2	0.5	0.4	0.1	0.0	-	-	-
	Tight Gas Piceance Mesaverde Williams Fork	2007	845.4	642.3	468.0	4.2	3.2	2.3	-	-	-	-	-	-
	Cretaceous Self-Sourced Fractured Shales	2009	1.2	0.8	0.5	3.9	2.6	1.6	-	-	-	-	-	-
	Tight Gas Piceance Mesaverde	2010	406.9	302.7	212.6	1.6	1.2	0.9	-	-	-	-	-	-
	Basin Margin Subthrusts	2014	15.0	2.1	-	1.6	0.3	-	7.9	1.0	-	-	-	-
	Tight Gas Uinta Tertiary East	2015	-	-	-	-	-	-	-	-	-	1.2	0.5	0.2
	Tight Gas Uinta Tertiary West	2016	1,805.3	789.4	248.8	0.6	0.3	0.1	-	-	-	-	-	-
	Basin Flank Uinta Mesaverde	2018	86.5	48.9	23.7	0.6	0.4	0.2	-	-	-	-	-	-
	Uinta Basin - Emery	2052	1,527.0	1,158.7	788.7	na	na	na	10.3	7.8	5.6	na	na	na
	Piceance Basin - Western Basin Margin	2054	685.8	544.6	417.8	na	na	na	-	-	-	na	na	na
	Piceance Basin - Divide Creek Anticline	2056	284.9	160.4	76.8	na	na	na	-	-	-	na	na	na
	Piceance Basin - Igneous Intrusion	2057	27.4	8.8	-	na	na	na	33.0	9.9	-	na	na	na
Paradox Basin	Buried Fault Blocks, Older Paleozoic	2101	16.7	6.2	0.6	3.7	1.3	0.1	3.6	1.3	0.1	-	-	-
	Porous Carbonate Buildup	2102	15.2	9.0	0.7	6.0	3.6	0.2	4.2	2.6	0.2	-	-	-
	Fractured Interbed	2103	12.6	5.0	1.2	15.8	6.3	1.5	3.3	1.3	0.3	-	-	-
	Permian-Pennsylvanian Marginal Clastics	2104	44.9	16.6	-	2.2	0.9	-	7.4	2.6	-	-	-	-
	Salt Anticline Flank	2105	18.4	8.4	0.6	1.7	0.4	0.0	4.0	1.8	0.1	-	-	-
	Permo-Triassic Unconformity	2106	0.5	0.2	-	5.2	1.9	-	0.0	0.0	-	-	-	-
	Cretaceous Sandstone	2107	30.3	14.4	1.7	0.0	0.0	-	0.0	0.0	0.0	-	-	-
San Juan Basin	Entrada	2204	0.0	0.0	-	0.1	0.1	0.0	-	-	-	-	-	-
	Dakota Central Basin Gas	2205	103.8	56.3	25.5	0.0	-	-	-	-	-	-	-	-
	Basin Margin Dakota Oil	2206	3.6	2.2	0.3	0.9	0.6	0.1	2.1	1.1	0.1	-	-	-
	Tocito/Gallup Sandstone Oil	2207	1.7	0.8	0.1	0.4	0.2	0.0	-	-	-	-	-	-
	Mancos Fractured Shale	2208	1.1	0.5	0.2	2.2	1.1	0.4	-	-	-	-	-	-
	Central Basin Mesaverde Gas	2209	138.6	65.8	23.3	0.0	-	-	-	-	-	-	-	-
	Basin Margin Mesaverde Oil	2210	0.0	0.0	-	0.0	0.0	-	-	-	-	-	-	-
	Pictured Cliffs Gas	2211	38.3	22.4	11.4	-	-	-	-	-	-	-	-	-
	Fruitland-Kirtland Fluvial Sandstone Gas	2212	2.3	1.8	0.1	0.1	0.1	0.0	-	-	-	-	-	-
	San Juan Basin - Overpressured	2250	100.5	80.8	63.8	na	na	na	-	-	-	na	na	na
	San Juan Basin - Underpressured	2253	2.1	1.4	0.8	na	na	na	-	-	-	na	na	na
Albq. - Santa Fe Rift	Albuquerque Basin	2301	4.7	1.1	-	0.4	0.1	-	2.0	0.5	-	-	-	-
	Hagan - Santa Fe Embayment	2302	0.2	0.0	-	0.2	0.0	-	0.1	0.0	-	-	-	-
	San Juan Sag	2305	38.2	9.4	-	18.5	5.1	-	26.5	6.4	-	-	-	-
Northern Arizona	Late Proterozoic (Chuar-Sourced)	2403	45.8	6.7	-	17.1	2.7	-	2.0	0.3	-	-	-	-
Montana Thrust Belt	Imbricate Thrust Gas	2701	4,885.5	1,618.1	-	2.5	0.8	-	6,973.9	2,342.7	-	-	-	-
	Helena Salient Gas	2704	12.5	3.2	-	0.0	0.0	-	-	-	-	-	-	-
	Blacktail Salient Oil	2705	0.1	0.0	-	0.5	0.1	-	-	-	-	-	-	-
	Tertiary Basins Oil and Gas	2706	1.2	0.2	-	0.1	0.0	-	0.4	0.1	-	-	-	-
	Imbricate Thrust Oil	2707	0.9	0.1	-	0.8	0.1	-	0.6	0.1	-	-	-	-
North-Central Montana	Cambrian-Ordovician Sandstones	2802	4.7	1.3	-	0.7	0.2	-	1.3	0.4	-	-	-	-
	Bakken Shale Fracture Systems	2804	1.8	0.3	-	2.2	0.4	-	0.5	0.1	-	-	-	-
	Devonian-Mississippian Carbonates	2805	1.0	0.5	0.1	1.8	1.1	0.2	0.3	0.2	0.0	-	-	-
	Tyler Sandstone	2806	0.1	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	-	-	-
	Fractured-Faulted Carbonates in Anticlines	2807	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	-	-	-
	Jurassic-Cretaceous Sandstones	2808	0.9	0.6	0.1	0.4	0.2	0.0	0.4	0.3	0.0	-	-	-
	Shallow Cretaceous Biogenic Gas	2809	6.3	4.0	0.5	-	-	-	2.1	1.3	0.1	-	-	-
	Northern Great Plains Biogenic Gas, Modera	2811	147.5	67.6	22.3	-	-	-	0.7	0.3	0.1	-	-	-
	Northern Great Plains Biogenic Gas, Low Porosity	2812	172.3	72.9	20.1	-	-	-	-	-	-	-	-	-
Southwest Montana	Crazy Mountains and Lake Basins Cretaceous	2901	5.9	3.0	0.4	0.0	0.0	-	0.0	0.0	0.0	-	-	-
	Nye-Bowler Wrench Zone Oil and Gas	2903	5.5	1.3	-	0.8	0.2	-	2.0	0.5	-	-	-	-
	Beartooth Frontal Oil and Gas	2904	21.7	4.6	-	8.7	1.7	-	11.5	2.4	-	-	-	-
	Snowcrest-Greenhorn Frontal	2906	1.5	0.4	-	5.6	1.4	-	0.0	0.0	-	-	-	-
	Tertiary Basins Oil and Gas	2907	2.9	0.5	-	0.4	0.1	-	1.5	0.2	-	-	-	-
	Crazy Mountains and Lake Basins Oil	2910	1.2	0.2	-	1.0	0.1	-	-	-	-	-	-	-

Appendix: Inventoried Roadless Areas and Special Designated Areas
Undiscovered Resource Analysis

			Inventoried Roadless Areas						**Special Designated Areas**					
			Natural Gas, Bcf			Petroleum, MMBO			Natural Gas, Bcf			Petroleum, MMBO		
USGS Province	Play	Play code	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low
Williston Basin	Madison (Mississippian)	3101	1.5	0.8	0.1	1.6	0.9	0.1	-	-	-	-	-	-
	Red River (Ordovician)	3102	3.1	1.8	0.2	0.9	0.5	0.1	-	-	-	-	-	-
	Middle and Upper Devonian (Pre-Bakken)	3103	1.0	0.6	0.1	0.4	0.3	0.0	-	-	-	-	-	-
	Pre-Prairie Middle Devonian and Silurian	3105	2.7	1.9	0.2	1.0	0.7	0.1	-	-	-	-	-	-
	Post-Madison through Triassic Clastics	3106	0.1	0.0	0.0	0.2	0.1	0.0	-	-	-	-	-	-
	Pre-Red River Gas	3107	2.9	1.1	0.1	0.1	0.0	-	-	-	-	-	-	-
	Bakken Fairway	3110	13.0	7.9	4.4	14.5	8.9	4.9	-	-	-	-	-	-
	Bakken Intermediate	3111	1.2	0.8	0.4	1.6	1.0	0.6	-	-	-	-	-	-
Powder River Basin	Basin Margin Subthrust	3301	8.0	1.4	-	8.3	1.5	-	-	-	-	-	-	-
	Basin Margin Anticline	3302	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Leo Sandstone	3303	0.2	0.1	-	3.0	0.9	-	-	-	-	-	-	-
	Upper Minnelusa Sandstone	3304	0.1	0.1	0.0	1.8	1.0	0.1	-	-	-	-	-	-
	Lakota Sandstone	3305	0.4	0.2	0.0	0.9	0.4	0.0	0.0	0.0	0.0	-	-	-
	Fall River Sandstone	3306	2.4	1.1	0.1	4.1	1.9	0.2	0.0	0.0	0.0	-	-	-
	Muddy Sandstone	3307	6.6	3.2	0.2	1.3	0.6	0.0	0.0	0.0	0.0	-	-	-
	Deep Frontier Sandstone	3309	5.6	2.6	0.3	1.7	0.8	0.1	-	-	-	-	-	-
	Turner Sandstone	3310	0.2	0.1	0.0	0.2	0.1	0.0	-	-	-	-	-	-
	Sussex-Shannon Sandstone	3312	0.6	0.3	0.0	0.8	0.3	0.0	-	-	-	-	-	-
	Mesaverde-Lewis	3313	0.9	0.4	0.0	0.9	0.4	0.0	-	-	-	-	-	-
Big Horn Basin	Basin Margin Subthrust	3401	28.8	5.8	-	12.4	2.4	-	1.1	0.2	-	-	-	-
	Basin Margin Anticline	3402	1.1	0.5	0.1	0.4	0.2	0.0	0.1	0.1	0.0	-	-	-
	Deep Basin Structure	3403	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	-
	Sub-Absaroka	3405	1.4	0.6	-	68.6	29.3	2.4	4.8	2.0	-	-	-	-
	Phosphoria Stratigraphic	3406	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Tensleep Paleotopography	3407	0.1	0.0	-	0.8	0.2	-	0.0	0.0	-	-	-	-
	Greybull-Cloverly-Muddy SS Stratigraphy	3408	1.7	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-	-	-
Wind River Basin	Basin Margin Subthrust	3501	12.8	4.4	0.4	2.9	0.9	0.1	3.4	1.2	0.1	-	-	-
	Basin Margin Anticline	3502	0.1	0.1	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Wyoming Thrust Belt	Moxa Arch Extension	3601	3,354.0	1,568.4	226.3	100.6	47.1	6.9	268.4	132.1	19.5	-	-	-
	Crawford-Meade Thrusts	3602	9.2	3.6	0.3	0.1	0.0	-	-	-	-	-	-	-
	Northern Thrusts	3603	3,134.4	1,508.2	111.9	652.2	310.7	33.7	491.9	240.6	17.9	-	-	-
	Absaroka Thrust	3604	260.6	157.8	9.9	84.0	53.6	3.9	-	-	-	-	-	-
	Hogsback Thrust	3606	4.6	2.3	0.2	0.9	0.4	0.0	-	-	-	-	-	-
	Cretaceous Stratigraphic	3607	0.0	0.0	-	0.2	0.1	0.0	-	-	-	-	-	-
Southwestern WY	Axial Uplift	3703	0.7	0.3	0.1	0.4	0.2	0.0	-	-	-	-	-	-
	Moxa Arch-LaBarge	3704	3.5	1.8	0.1	0.3	0.1	0.0	-	-	-	-	-	-
	Basin Margin Anticline	3705	9.6	3.1	0.3	1.7	0.6	0.1	7.6	2.4	0.2	-	-	-
	Subthrust	3706	44.8	12.8	-	10.8	3.0	-	27.3	7.7	-	-	-	-
	Platform	3707	3.4	1.1	0.2	2.5	0.9	0.2	0.1	0.0	0.0	-	-	-
	Jackson Hole	3708	10.3	3.6	0.8	1.9	0.7	0.1	13.0	4.5	1.0	-	-	-
	Greater Green River Basin - Cloverly-Frontier	3740	1,286.2	565.9	171.8	15.3	6.7	2.1	1,230.9	541.4	164.3	-	-	-
	Greater Green River Basin - Mesaverde	3741	1,651.1	950.1	401.1	16.8	9.7	4.1	295.2	169.8	71.7	-	-	-
	Greater Green River Basin - Fox Hills-Lance	3743	442.8	206.4	64.8	4.4	2.1	0.6	86.1	40.1	12.6	-	-	-
	Greater Green River Basin - Iles	3751	38.1	15.9	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Williams Fork	3752	208.3	134.9	80.3	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Almond	3753	62.2	30.2	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Lance	3754	11.9	3.8	-	na	na	na	-	-	-	na	na	na
	Greater Green River Basin - Fort Union	3755	83.8	25.4	-	na	na	na	154.0	46.7	-	na	na	na
Park Basins	Cretaceous - Upper Jurassic Structural	3801	2.0	0.7	0.1	3.1	1.2	0.2	0.3	0.1	0.0	-	-	-
	Subthrust	3802	4.7	0.8	-	7.5	1.3	-	1.2	0.2	-	-	-	-
Denver Basin	Dakota Group (Combined J and D Sandstones)	3905	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
	Permian-Pennsylvanian	3908	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Raton Basin - SG Uplift	Upper Cretaceous - Lower Tertiary	4101	2.6	0.9	-	0.1	0.0	-	-	-	-	-	-	-
	Northern Raton Basin	4150	82.6	69.8	42.8	na	na	na	-	-	-	na	na	na
Totals			**23,071**	**11,307**	**3,545**	**1,212**	**550**	**69**	**9,721**	**3,590**	**296**	**1.3**	**0.5**	**0.2**

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na=not assessed (typically a CBM play that would not contain oil)