4.0 MINERAL RESOURCE POTENTIAL

The most important potential mineral resource in the RMPPA are hydrocarbon resources. The long history of production and developments in the last 80 years document the presence of source rocks, reservoir rocks, and trapping mechanisms that provide a significant hydrocarbon resource. The non-CBM gas resource has the greatest development potential. Oil and CBM are of lesser importance.

The development potential of non-fluid minerals within the RMPPA (e.g., minerals other than oil and gas) is seen to be limited due to a variety of factors. First and foremost, the surficial geology of the RMPPA, being of a primarily composed of unconsolidated deposits, is such that significant occurrences of mineralized zones are limited. Secondarily, where mineralized zones have been determined to be present, the occurrences have generally been defined as exhibiting characteristics such as limited or discontinuous mineralization (i.e., low in-place tonnage) and/or inherent impurities and/or low percentage content of the target mineral (i.e., low grade).

Those non-fluid minerals that are known to occur within the RMPPA, which are simultaneously or projected to be in demand (over the projected planning period), are limited to aggregates (i.e., sand and gravel) and decorative stone (both moss rock and boulders). Each of these commodities is considered to be an industrial mineral by definition, and each commands a relatively low per-unit valuation. With low per-unit valued commodities, the market area for consumption is generally highly localized and, therefore, sensitive to transportation costs.

4.1 Leaseable Minerals

Leaseable fluid minerals (non-CBM gas, oil, and CBM) are present in the RMPPA. Non-CBM gas and oil have been produced for many decades and recent assessments by governmental agencies indicate there are significant amounts of undiscovered recoverable hydrocarbon resources in the RMPPA. The discussion of hydrocarbon resource development potential in Sections 4.1.1 through 4.1.4 was provided by BLM's RMG Casper, Wyoming. All maps, graphs, and discussion are the product of the RMG and it is solely responsible for the content and the conclusions contained therein.

Leaseable non-fluid minerals known to be present within the RMPPA are coal, oil shale, phosphate and sodium. Each of these minerals, while present, occurs in sub-economic deposits. Furthermore, current and projected market conditions are such that exploitation of these mineral resources is highly unlikely within the projected planning period, as discussed below.

4.1.1 Hydrocarbon Plays

In 1995, the USGS conducted an assessment of the oil and gas resources of the U.S. (Beeman and others, 1996; Charpentier and others, 1996; Gautier and others, 1996). The assessment presents information about potential undiscovered accumulations of oil and gas within the RMPPA. Information from that assessment is presented below.

The 1995 USGS oil and gas assessment identified 71 geologic or structural provinces from which hydrocarbon resources are produced. The RMPPA is located in two of the hydrocarbon producing provinces. The westernmost parts of the RMPPA are located in the Wyoming Thrust Belt Province (Number 036) (Powers, 1995). Province 036 coincides with the Overthrust Belt and is located in western Wyoming, northeast Utah, and eastern Idaho. The RMPPA is located in the northernmost portion of the second province, the Southwestern Wyoming Province (Number 037) (Law, 1995). Province 037 occupies a large area in Wyoming and northwest Colorado and Utah and includes the Greater Green River, Hanna, and Laramie Basins.

Provinces are further divided into plays. A play is a set of discovered or undiscovered oil and (or) gas accumulations or prospects that are geologically related. A play is defined by the geological properties (such as trapping style, type of reservoir, nature of the seal) that are responsible for the accumulations or prospects.

Three of six conventional plays that have been identified in the Wyoming Overthrust Belt Province lie partly within the RMPPA boundaries (**Figures 4-1** and **4-2**). Hydrocarbons in conventional plays can be recovered using traditional development and production practices. Data on the three plays are summarized in **Table 4-1**. Five of nine conventional plays identified in the Southwestern Wyoming Province lie partly within RMPPA boundaries. The conventional plays in the Southwestern Wyoming Province are summarized in **Table 4-2** and **Figures 4-3** through **4-5**.

The USGS also recognized five unconventional basin-centered gas plays in the Southwestern Wyoming Province. Three of the five basin-centered gas plays lie partly within the RMPPA boundary (**Figures 4-6** through **4-8**). In addition, only one of six Southwestern Wyoming Province unconventional coalbed gas plays lies within the RMPPA boundary. Data on these plays are summarized in **Table 4-3**.

4.1.2 Hydrocarbon Resources

Law (1995) and Powers (1995) also present information about the potential resources in each potential play. For this assessment, undiscovered technically recoverable resources were defined as estimated quantities of resources hypothesized to exist on the basis of geologic knowledge,

Figure **4-1** Location of USGS Conventional Wyoming Thrust Belt Province Plays

Figure **4-2** Location of USGS Conventional Southwestern Wyoming Thrust Belt Province-Northern Thrusts Plays

Table **4-1** USGS Conventional Play Data for the Wyoming Thrust Belt Province (036)

Table **4-2** USGS Conventional Play Data for Southwestern Wyoming Province (037)

Figure **4-3** Location of USGS Conventional Southwestern Wyoming Province-Moxa Arch, La Barge and Subthrust Plays

Figure **4-4** Location of USGS Conventional Southwestern Wyoming Province-Basin Margin Anticline and Jackson Hole Plays

Figure **4-5** Location of USGS Conventional Southwestern Wyoming Province-Deep Basin Structure Play

Figure **4-6** Location of USGS Conventional Southwestern Wyoming Province-Cloverly-Frontier Basin-centered Gas Play

Figure **4-7** Location of USGS Conventional Southwestern Wyoming Province-Mesaverde Basin-centered Gas Play

Figure **4-8** Location of USGS Conventional Southwestern Wyoming Province-Fox Hills-Lance Basin-centered Gas Play

Table **4-3** USGS Unconventional Play Data for Southwestern Wyoming Province (037)

data on past discoveries, or theory, and that are contained in undiscovered accumulations outside of known fields. Estimates of resource quantities were determined to be producible using current recovery technology but without considering economic viability. Only accumulations greater than or equal to 1 million barrels of oil or 6 BCF of gas are included in this part of the assessment.

Hydrocarbon resource estimates are shown for conventional plays in the Wyoming Thrust Belt Province (**Table 4-4**) and Southwestern Wyoming Province (**Table 4-5**) and for unconventional plays in the Southwestern Wyoming Province (**Table 4-6**) that are within the RMPPA. Four types of hydrocarbons (oil, natural gas liquids, associated-dissolved gas, and non-associated gas) can be produced in the conventional plays and as many as two types (natural gas liquids and non-associated-dissolved gas) in unconventional plays. Associated-dissolved gas is produced as a by-product of oil production and natural gas liquids are produced as a by-product of non-associated gas production.

For each type of hydrocarbon, a mean estimated resource (**Tables 4-4** and **4-5**) or mean potential reserve (**Table 4-6**) volume was recorded for each play. Assuming hydrocarbons were evenly distributed across each play area, hydrocarbon volume was calculated from each play that would be contained within the RMPPA boundaries. Using data provided by the USGS (Law, 1995; Powers, 1995), it was estimated that the RMPPA contains a mean volume of 643 million barrels of undiscovered recoverable liquid hydrocarbons. It also is estimated that the RMPPA contains a mean volume of 23 TCF of undiscovered recoverable gas. For the RMPPA, the range of undiscovered recoverable liquid hydrocarbons was estimated to be between 111 and 1,245 million barrels. The range of undiscovered recoverable gas was estimated to be between 7 and 47 TCF.

Fractile values (F99 to F1 for **Tables 4-4** and **4-5** and F95 to F5 for **Table 4-6**) were used to describe the range of resource or reserve volumes that could be present in each play. Fractiles portray the potential distribution of volume of undiscovered resource. For example, F5 means that there is a 5 percent chance that more than the listed amount of resource will occur, and F95 means that there is a 95 percent chance that more than the listed amount of resource will occur.

Advanced Resources International (ARI) (ARI, 2001) prepared the most recent analysis of the hydrocarbon resource in southern Wyoming and northwestern Colorado. ARI used the USGS's 1995 assessment supplemented by data from the Wyoming State Geologic Survey and their own work to estimate undiscovered, technically recoverable, and natural gas resources for the area studied. They did not evaluate proved hydrocarbon reserves or undiscovered, technically recoverable, oil resources. For all USGS-defined plays, ARI (2001) assumed a homogenous distribution of resource within play boundaries. Using the three sources of data listed above, they

Table **4-4** USGS Conventional Play Resources of the Wyoming Thrust Belt Province (036)

Table **4-5** USGS Conventional Play Resources of the Southwestern Wyoming Province (037)

Table **4-6** USGS Unconventional Play Resources of the Southwestern Wyoming Province (037)

predicted the undiscovered, technically recoverable, gas resource for each township in the region assessed. The total predicted gas resource in the RMPPA is 30 TCF. ARI's (2001) resource prediction is greater than the 23 TCF predicted from USGS data, but is within their estimated range of 7 to 47 TCF.

Figure 4-9 shows undiscovered, technically recoverable, natural gas resources (ARI, 2001). Those gas resources are shown by township, in three resource volume ranges, and in townships where a zero gas resource is predicted. Townships with zero gas resource are located in areas of Wind River Range Precambrian granites, where traps and hydrocarbons are not known to occur. Highest predicted volumes of gas are in the Jonah Field area, along the Pinedale Anticline, and at the north end of the Green River Basin. Lowest predicted volumes of gas are located along the west flank of the Wind River Range and in the southwestern part of the RMPPA. Low volume predictions along the southwestern flank of the Wind River Range are due to the presence of significant sections of granite that would need to be drilled to encounter potential deep reservoirs. However, at Tepee Flats Field, in the Wind River Basin, it was proven that gas reservoirs are present underneath the Owl Creek Mountains Thrust Fault in a geologic setting similar to the west flank of the Wind River Mountains. Tepee Flats Field produced over 12 BCF of gas from 2 wells since its discovery in 1981 (WOGCC, 2002) from Cretaceous reservoirs below the Precambrian. Low volume predictions in the southwest are in the area of the Greater Big Piney – La Barge field complex where much of the potential gas resource has already been discovered and is being produced.

The potential in-place CBM resource in the vicinity of the Riley Ridge Infinity Inc., pilot project is thought to be in excess of one-half TCF (Rocky Mountain Oil Journal, 2002). A prediction of recoverable gas production from this project area is difficult to make at this early stage of development. If the project proves to be economically viable, coalbed gas production could be a substantial. However, production is unlikely to be more than a small percentage of the total gas production that will be produced through 2020.

4.1.3 Hydrocarbon Occurrence Potential

Most of the RMPPA has a high potential for the occurrence of hydrocarbons (**Figure 4-10**). This rating is based on the geologic characteristics listed below:

- presence of hydrocarbon source rocks;
- presence of reservoir rocks with adequate porosity/permeability;
- potential for structural/stratigraphic traps to exist;
- opportunity for migration from source to trap; and
- other conditions, such as temperature, depth of burial, and subsurface pressures.

Figure **4-9** Undiscovered, Technically Recoverable, Natural Gas Resources

Figure **4-10** Hydrocarbon Occurrence Potential

All oil and gas plays, as defined by the USGS, are considered as areas of high occurrence potential. Approximately 80 percent of the RMPPA falls within this category.

Approximately 20 percent of the RMPPA falls outside of play areas designated by the USGS. These areas are mostly located in parts of mountain ranges that consist of Precambrian granites, where traps, reservoir strata, and hydrocarbons are not known to occur.

4.1.4 Projections of Future Activity

4.1.4.1 Oil and Natural Gas Price Estimates

Oil and gas price estimates are the single most important factor controlling the amount of future oil and gas drilling and production activity in the RMPPA. These prices can be very volatile, as shown for gas in **Figure 4-11** and for oil in **Figure 4-12**. Gas prices to 2020 (**Figure 4-11**) were estimated from two sources. Henry Hub, Louisiana, futures (the only gas futures contract location in the U.S.) prices for gas was obtained from the Enerfax Daily website (2002). The Energy Information Administration (EIA) (EIA, 2001, p. 81) estimated a 2020 gas price ranging from $2.94 to $3.65 per thousand cubic feet (MCF) of gas. Price estimates for Wyoming natural gas require subtracting a price differential from Henry Hub futures and EIA estimates. This price differential generally reflects transportation costs. A price differential of $0.50 per million British thermal units (MMBtu) was used for the low estimate projection in **Figure 4-11** and $0.25 per MMBtu was used for the high estimate projection.

The estimated cost of liquefied natural gas delivered to the east coast of the U.S. is about $1.75 to $2.75 per MMBtu (Cook, 2002). The availability of this liquefied natural gas in large quantities is expected to act as a moderating influence on gas prices, not allowing for large long-term gas price increases. Therefore, any price scenario should not consider long-term prices to exceed about $3.00 per MMBtu for natural gas produced in Wyoming.

Review of **Figure 4-11** price estimates allows some generalization about future gas drilling and production activity in the RMPPA. Future price scenarios suggest that gas exploration and production will be positively affected by increased prices only during the next few years. Starting in about 2004, gas production in southwestern Wyoming would be mainly a function of the ability of industry to discover and economically develop new accumulations, and to increase drilling, production, processing, and transportation efficiency to take advantage of higher projected prices. Beyond 2007, prices are expected to remain flat or decline. Those projected future gas prices alone are not expected to buoy exploration and production activity beyond 2007.

Figure **4-11** Historical Spot Gas Prices for Northwest Pipeline at Opal, Wyoming, with Projections to 2020

Figure **4-12** Plot of Historical Wyoming Crude Oil Prices, with Projections to 2020

U.S. demand for natural gas is expected to increase about 50 percent by 2020. Increases in future natural gas production, to meet increased demand, are projected to come partly from the Rocky Mountain area. Anticipated production increases in Wyoming are expected to be mainly from unconventional energy sources such as coalbed gas and deep basin-centered gas deposits.

Anticipated oil prices are based on a combination of futures prices for West Texas Intermediate crude oil and EIA (2001) estimates. **Figure 4-12** illustrates historical Wyoming sweet crude oil prices, futures prices, and projected prices to 2020. Although oil prices have been in the $17 to $24 per barrel range during the past 12 months and as high as $30 per barrel in the past 18 months, futures prices suggest a steady decline to an average price of about $21.00 per barrel to 2008. The EIA (2001) estimates the price of crude oil will be between $17.06 and $23.79 per barrel in 2020. However, "High World Oil Price" is projected to be as high as $30.58 per barrel. It should be remembered that much of the world's crude oil comes form politically unstable areas. Occasional unforeseen and abrupt price increases should be expected.

4.1.4.2 Leasing

General Leasing Information

After initial field evaluation, research, and subsurface mapping (which frequently includes use of seismic data), leasing is often the next step in oil and gas development. Leases on lands where the U.S. owns the oil and gas rights are offered via oral auction at least quarterly. Lease bids are based on industry speculation about amounts of potential hydrocarbons that may be present. Lowest prices are generally bid on leases with the highest risk of recovering economic amounts of hydrocarbons. Maximum lease size is 2,560 acres and the minimum bid is $2.00 per acre. An administrative fee of $75.00 per lease is charged and each successful bidder must meet citizenship and legal requirements. In addition to the lease bid, a $1.50 per acre per year rental is charged for the first 5 years and $2.00 per acre per year is charged thereafter. Leases are issued for a 10-year term. Leases that become productive are held by production and do not terminate until all wells on the lease have ceased production. A 12.5 percent royalty on all production is paid. Many private oil and gas leases contain a "Pugh clause," which allows only the developed portion of the lease to be held by production. However, federal leases have no such clause, allowing one well to hold an entire lease.

Wyoming federal oil and gas lease sales are held on even numbered months, usually in Cheyenne. However, no lease sale was held in April 1996 due to the partial government shutdown. Since August 1996, only lands requested for lease have been offered. Prior to August 1996, virtually all lands available for lease were offered at each sale. Each lease contains restrictive stipulations, which protect potentially affected resource values.

RMPPA Leasing

In April 2002, there were 1,189 federal oil and gas leases covering 1,023,186 acres in the RMPPA (**Table 4-7**). **Figure 4-13** shows the location of federal minerals leased for oil and gas. The BLM managed 94 percent of all federal leases and 88 percent of all leased federal lands. BLM leases average 807 acres in size. Those lands will be covered by decisions made during this plan update. The U.S. Forest Service (USFS) managed 6 percent of all federal leases and 12 percent of all leased federal lands. USFS leases average 1,749 acres in size. There were no leases on land managed by the Bureau of Reclamation (BOR).

Table 4-7
Distribution of Federal Acreage Covered by Active Federal Oil and Gas Leases in the RMPPA

Surface Management	Leases	Acreage
BLM	1,121	904,269
BOR	0	0
USFS	68	118,917
Total	1,189	1,023,186
Held by Production	556	354,776

Source: BLM Files.

About 35 percent of the total leased federal land is held by production. These leases will not expire until the last well on each lease ceases production. Seventy-seven percent of the BLM managed land is leased. Eight percent of the USFS managed land is leased.

As federal oil and gas leases expire, those lands may be nominated for leasing again. The number of federal acres in the RMPPA offered for lease, and leased competitively, on a year-by-year basis, is shown in **Figure 4-14**. During 1996-2001 a total of 287,230 acres were offered for lease. Fifty-five percent (156,689 acres) of the lands offered were leased competitively. A summary of bonus bid data received from leasing is shown in **Figure 4-15**. The average bid was $107 per acre. Total bonus bids received were $16.8 million. Slightly more than one fourth of the $16.8 million was from a single, 142-acre lease offer in Section 1, T28N, R109W, which sold for $32,000 per acre. This per-acre bid is the largest ever received for a federal oil and gas lease in Wyoming. By comparison, the RMPPA accounts for 3.5 percent of the acreage offered in Wyoming and 9.1 percent of the revenue received.

Figure **4-13** Location of Federal Oil and Gas Leases

Figure **4-14** Summary of Federal Acres Offered for Oil and Gas Leasing and Acres Leased Competitively, by Year, for the 1996-2001 Period

Figure **4-15** Summary of the Total Amount of Bonus Money Received from Federal Oil and Gas Leasing and the Average Bid, by Year, for the 1996-2001 Period

Half of the bonus money bid for public domain minerals went to the state of Wyoming. The remainder stayed with the federal treasury, where it was split between the conservation fund and the general fund on a 4:1 ratio, respectively.

It is anticipated that the amount of federal oil and gas acreage under lease in the RMPPA between 2001 and 2020 will range between 0.75 and 1.5 million acres. Annual federal acreage leased is projected to average between 10,000 and 50,000 acres. As new producing wells are drilled the amount of acreage held by production will increase substantially from the current 355,000 acres. During the 2001 to 2020 period gas prices, exploration success, and availability of USFS lands will determine the amount of lands leased and bonus bids received. If USFS lands near the north end of the RMPPA are available and accessible, bonus bids in that area could be high because of the large estimated amounts of recoverable gas resources (ARI, 2001). Leasing in the RMPPA should generate more than $10 million during the 2001 to 2020 period. If leasing remains at the bonus rates of the past 6 years, approximately $56 million could be received in bonus payments during the 20-year planning cycle.

4.1.4.3 Seismic Surveys

Seismic surveys are a critical part of oil and gas exploration. They are authorized on BLM-managed surface by approval of Notices of Intent (NOIs) to Conduct Geophysical Operations. From 1990 through 2000, the number of approved NOIs has averaged 3.2 per year (**Figure 4-16**). Seismic activity is expected to remain strong. As much as 1,000 to 1,400 square miles of new 3-D seismic surveys, and about 700 miles of new two-dimensional surveys are anticipated during the 2001 to 2020 period. Most of this anticipated activity will probably occur by 2010 and will be concentrated in the central part of the RMPPA.

4.1.4.4 Projections of Future Drilling Activity

Non-CBM Hydrocarbons

It is difficult to predict what will occur a few years into the future. It is even more difficult to predict 20 years ahead. In an attempt to get more insight as to what may occur in the RMPPA, geologists and engineers in the oil and gas industry were contacted. Twenty oil and gas companies, which operate in the RMPPA, were contacted by letter and asked their opinion of what exploration and development activity will occur and where it is likely to occur. Each company was contacted by telephone about 5 days after the letters were sent. Thirteen companies responded to the data request. Eleven provided information useful in constructing our development potential maps.

Figure **4-16** Approved Seismic NOIs, by Year, on BLM-managed Surface in the RMPPA

Some companies requested that the details of the information they provided be held confidential. Due to time constraints, only a very limited review of technical data was conducted from wells in the RMPPA. Structure contour maps drawn by the Rocky Mountain Map Company (2001) were used as working base maps on which to construct development potential maps.

It is anticipated that as many as 4,850 new non-coalbed gas wells may be drilled in the RMPPA in the 2001-2020 period. In 2001, industry drilled 246 new wells in the RMPPA. For the rest of 20-year period, new wells will be drilled at an average rate of about 242 per year. This estimate does not include recompleting wells to new formations or zones, plugging back wells to test shallower formations or zones, or re-entering wells to drill deeper. Approximately 60 percent of the non-coalbed gas wells will be drilled in the Jonah-Pinedale Anticline area.

Figure 4-17 shows the results of mapping areas of development potential for the 2001 through 2020 time period. Development potential was projected for the entire RMPPA including USFS lands and excluding those lands in Teton County. Development potential is mapped as high, moderate, low, and no potential. High development potential areas are those where the average drilling density is projected to be more than 100 wells per township (36 square miles). Moderate development potential areas are those where the drilling density is projected to be between 20 and 100 wells per township. Low development potential areas are those where the drilling density is projected to be fewer than 20 wells per township. No development potential areas are those where no drilling activity is anticipated during 2001-2020. **Figure 4-17** was prepared assuming that there will be no restrictions that will preclude or greatly hinder oil and gas exploration and development during 2001-2020.

Mapped boundaries in **Figure 4-17** vary in type, depending on available data and industry information used to define those boundaries. In areas where information available was most limited, boundaries were drawn at the township (36 square miles) scale. Where information allowed potential to be defined by an approximate depth contour, boundaries were drawn at the section (640 acres) scale. The no development potential area was defined as those lands not included in hydrocarbon plays defined by the USGS (Beeman and others, 1996; Charpentier and others, 1996; Gautier and others, 1996).

Statistical data on the four development potential areas are summarized in **Table 4-8**. High and moderate development potential areas cover about one-third of the area, while low and no development potential areas cover the remaining two-thirds.

High development potential is anticipated in the area surrounding the Jonah Field and the Pinedale Anticline (**Figure 4-17**). The Jonah area is comprised of 29,200 acres and is known as the Modified Jonah Field II Natural Gas Project area. The reservoir is comprised of numerous

Figure **4-17** Non-Coalbed Methane Development Potential Areas

Table 4-8
Oil and Gas Development Potential Classifications
Determined for the RMPPA

Development Potential	Acres (thousands)	Number of Townships	Percent of RMPPA
High	122	5.3	4.10
Moderate	828	36.0	27.94
Low	1,409	61.2	47.52
No	606	26.3	20.44
Total	2,965	128.8	100.00

discontinuous, vertically stacked, sinuous sandstones. Close well spacing is necessary to effectively extract oil and gas resources from this type of reservoir. It is estimated that ultimately as many as 1250 additional wells in the Jonah area may be needed during the next 15 to 20 years in order to effectively extract the oil and gas resources present and prevent waste. An estimated 1.0 to 1.5 trillion cubic feet of additional gas may be recovered, however this figure may be higher if all the infill locations proposed are drilled. Some of the wells may be drilled to deeper or shallower horizons than those that are currently producing. It is not expected that new large compression facilities will be needed.

The stratigraphic character of reservoir rocks in the Pinedale Anticline area is similar to those in the Jonah area. However, wells in the Pinedale Anticline area are deeper than wells in the Jonah area. Initially 900 wells were projected for the Pinedale Anticline area based on 40-acre well spacing. It now appears that well spacing may be 20 acres per well in much of the productive area. Assuming 20 acre spacing, the number of wells drilled in the Pinedale Anticline area may be about 1,800. This revision is based, in part, on well performance and additional drilling proposed for the Jonah area. Oil and gas development in the Jonah area is at a more advanced stage than in the Pinedale Anticline area.

Moderate development potential is anticipated in a large area on the La Barge Platform, at approximately T25-29N, R112-113W, and in the central and north parts of the RMPPA. The north part of this moderate development potential area extends onto USFS lands. Future activity in this area will depend mainly on industry being able to obtain access to surface locations to drill new wells.

Drilling activity in the large area of moderate development potential will vary from relatively dispersed, about four wells per square mile, to more intense drilling activity in local areas. The oil and gas industry will search diligently for another Jonah-type field. If another field such as Jonah is found, well densities could be as high as 16 to 32 per square mile. There also will be extensive

areas with little or no drilling activity. In areas that are already developed, some of the new wells will be for replacement and infill.

ARI (2001) has identified what can only be described as a very large potential gas resource. They identified this resource in a six-township area comprising T37N, R110-113W and T38N, R111-112W. Undiscovered technically recoverable natural gas resources in this area are estimated to be 7.6 TCF. This is enough gas to supply Wyoming for 75 years, or to meet all household needs in the U.S. for about 18 months, based on 1998 usage. Access to the part of this potential resource on USFS lands may be problematic.

Low well densities are anticipated in the low development potential areas. Wells may be scattered (mainly exploration wells) or locally closely spaced, but the total number of wells will average less than 20 per township (36 square miles). Another Jonah-type field is possible, but not likely in this area.

No drilling activity during the 2001-2020 period is expected in the area of no development potential. As described above, the USGS has not identified any potential hydrocarbon plays in this area. This area appears to be underlain by non-hydrocarbon bearing Precambrian rocks. There will probably never be interest in testing this area, based on current concepts of hydrocarbon generation and accumulation.

It is anticipated that average well depths will continue to increase with many new wells drilled in the 12,000- to 14,000-foot range. Deep wells, greater than 15,000 feet deep, will probably be much less common. It is anticipated that only about 30 deep wells will be drilled in the 2001 to 2020 period. About 10 to 15 of these wells may be drilled in the area of present deep Madison Formation gas production (**Figure 3-9**). The remainder will probably be scattered throughout the RMPPA.

It is anticipated that as the total number of producing wells increases, gas production in the RMPPA also will continue to increase. Development drilling will continue in the Jonah Field and Pinedale Anticline areas. Additional reservoirs will almost certainly be discovered to 2020. If the Shute Creek gas plant is expanded, additional Madison Limestone Reservoir wells will be drilled and an abrupt increase in gas production should be expected. Oil production will continue to be mainly an associated byproduct of gas production and also will increase as gas production increases. Typically, the producing well count reaches a maximum a few to several years after hydrocarbon production begins to decline in a developing field or area. In the RMPPA, this trend should be expected in fields as they reach a mature development stage.

Two hypothetical estimates were calculated. One assumed no drilling beyond 2002. The other assumed continued drilling. Annual figures are not shown but were calculated. The estimates shown in **Table 4-9** were calculated by separating oil and gas wells into three areas: deep Madison Formation production (non-hydrocarbon gases were excluded), LaBarge Platform area, and the Jonah Field-Pinedale Anticline area. Type curves were estimated for the Jonah and Pinedale Anticline areas. Projections for the LaBarge Platform were made based on decline rates. Deep Madison production was assumed to continue nearly constant. It was assumed that there will be no additional large oil and gas fields discovered, although there is significant potential that large undiscovered accumulations of oil and gas exist, especially in the north part of the Hoback Basin.

Table 4-9
Summary of the Cumulative Production of Oil, Gas and Water from 1974 to 2002

	Oil in MMBO	Gas in BCFG	Water in MMBW
Cumulative 1974-2002	60	4,010	201
No Drilling 2003-2021	26	2,393	69
Continued Drilling 2003-2021	127	13,245	220

CBM Drilling

CBM production in Wyoming has increased dramatically in the past several years. **Figure 4-18** shows CBM production has risen to about 15 percent of all the gas produced in Wyoming. That percentage will almost certainly increase. The locations of the CBM play in southwestern Wyoming, as defined by the USGS, is shown in **Figure 4-19**. CBM drilling activity in the RMPPA is at a very early stage. Infinity Inc. operates a five well coabed methane pilot project in the Riley Ridge Field area of T29 and 30N, R114W. Gross producing depth range is from 2,536 to 3,354 feet (WOGCC, 2002a). Infinity Inc. has reported (Rocky Mountain Oil Journal, 2002) that the five wells have been connected to compression and gas gearing facilities and are currently generating revenues.

Although the five Infinity Inc., wells show promise, it is very difficult to estimate large-scale development based on the available information at this early stage. It is estimated that up to 270 CBM wells could be drilled during 2001-2020. **Figure 4-20** shows areas of anticipated development potential for the period 2001 through 2020. **Table 4-10** summarizes the potential affected area. It is anticipated that CBM drilling activity will probably be limited to the area around the current wells in T29N, R114W and along an arcuate band about 6 miles wide along the east side of the La Barge Platform, mainly in T26-29N, R113W. This area is located in the CBM play

Figure **4-18** Coalbed Gas Production as a Percent of Total Natural Gas Produced in Wyoming

Figure **4-19** Location of USGS Unconventional Southwestern Wyoming Province-Coalbed Gas Play

area outlined by the USGS. High potential indicates areas where the average drilling density will be greater than 100 wells per 36 square miles during 2001-2020. Moderate potential indicates 20 to 100 wells and low potential is defined as fewer than 20 wells, and very low is defined as fewer than two wells. In areas estimated to have no development potential, no CBM wells are anticipated.

Table 4-10
Coalbed Gas Development Potential Classifications
Determined for the RMPPA

Development Potential	Acres (thousands)	Number of Townships	Percent of RMPPA
High	21	0.9	0.72
Moderate	115	5.0	3.88
Low	187	8.1	6.30
Very Low	1,659	72.0	55.96
No	983	42.6	33.14
Total	2,965	128.6	100.00

Note: Up to 270 coalbed gas wells are projected to be drilled during the 2001-2020 period.

Results from CBM pilot projects in Wyoming suggest that an insufficient number of wells have been drilled to adequately evaluate the economic viability of those projects. Past history indicates that pilot projects should contain 16 wells (4 interior wells and 12 surrounding wells) to 25 (nine interior wells and 16 surrounding wells) to adequately evaluate an area (Cook, 2002; Likwartz, 2002). They suggest that fewer wells may not adequately reduce hydrostatic pressure over a sufficient area. Also, coal heterogeneity may preclude the one interior well in a five or nine well pilot from providing the data necessary to adequately evaluate economic viability. For those reasons, CBM coalbed gas pilot projects should contain 16 to 25 wells. This will provide a better chance of obtaining adequate project feasibility data and thus, avoid duplicate projects.

Projected Surface Disturbance

The following general guidelines for access roads, drill pads, pipelines, and power lines were used to determine acres of surface disturbance associated with oil and gas exploration and development drilling activities:

Figure **4-20** Coalbed Methane Development Potential Areas

Access Roads (BLM, 1997 and 1999):

- 40 feet total width disturbance;
- 12- to 14-foot-wide travelway;
- 4.8 acres initial disturbance per linear road mile;
- 1.9 acres initial disturbance per access road (0.4 mile disturbed per well);
- 1.14 acres long-term disturbance per producing well (the distance between the edge of the barrow ditch and outer edge of the clearing widith is stabilized and revegetated within 3 years);
- 0.76 acre stabilized per producing well, after 3 years;
- 1.9 acres of access road stabilized per abandoned dry well, after 3 years; and
- 0.76 acre of access road stabilized after abandonment of each producing well, after 3 years.

Road standards are in conformance with guidelines issued in Surface Operating Standards for Oil and Gas Exploration and Development (BLM, 1989).

Drill Pads (BLM, 1999):

- 3.7 acres initial disturbance per average well pad;
- 1.5 acres long-term disturbance per producing well;
- 2.2 acres stabilized per producing well, after 3 years;
- 3.7 acres stabilized per abandoned dry well, after 3 years; and
- 1.5 acres stabilized after abandonment of each producing well, after 3 years.

Pipelines (BLM, 1997 and 1999):

- 30 feet of clearing width would be constructed adjacent to each producing well's access road to place;
- 1.5 acres initial disturbance per producing well pad, stabilized after 3 years; and
- Disturbance from sales pipelines not presently projected.

Power lines:

- 75 acres per year (based on past levels), stabilized after 3 years.

Compressor Stations (BLM, 1999):

- 7.0 acres initial and long-term disturbance per compressor station.

Table 4-11 summarizes present well numbers and associated acres of surface disturbance (through 2001) directly associated with those wells. Acres of surface disturbance are calculated from the above guidelines. In addition, it projects surface disturbance for the short-term (less than 3 years) and for the long-term (through 2020 or longer). The projections of well numbers assume that the yet to be drilled wells (4,850 non-coalbed gas wells and 270 coalbed gas wells) will be evenly distributed across the 2002 to 2020 period and assume that 12 percent of the wells will be abandoned.

Table 4-11
Projections of Short-Term and Long-Term (2020)
Drilling Activity, with Associated Surface Disturbance

	Disturbance Through 2001 (acres)	Short-Term Disturbance (acres)	Long-Term Disturbance (acres)
Abandoned Wells	1,549	3,439	
Active Wells	2,173	25,233	11,896
Total	5,737	28,672	11,896

Note: Surface disturbance associated with power lines and compressor stations is not included in these projections.

4.1.5 Coal

In order to assess the potential for significant coal production from within the RMPPA, it is necessary to evaluate historic coal production totals within the RMPPA relative to the overall Wyoming coal production (recent and projected).

Records indicate that during the year 2000, there were a total of 21 producing coal mines in Wyoming. [Note: There were additional mines that were idle, closed, or reclaimed that remained on state records.] The production statistics for the year 2000 represent a 0.7 percent increase over 1999s production of 336,459,938 tons, even though 1 mine closed and another was idled in 2000. It should be noted that as of 2000, all currently producing mines are surface mines. For comparative purposes, the production statistics (Wyoming Coal Information Committee, 2002)

listed in **Table 4-12** provide an indication of the relative distribution of coal production within the state of Wyoming.

Table 4-12
Wyoming Coal Production – 2000

Coal Field or Basin	County	Number of Mines	Production (tons)	Percent of Total[1]
Powder River Basin	Campbell	12	299,542,969	88.4
	Converse	2	23,599,855	7.0
	Sheridan	1	38,411	0.01
Green River	Sweetwater	2	9,959,737	2.94
Hams Fork	Lincoln	1	3,725,983	1.1
Hanna	Carbon	3	1,985,193	0.59
Totals		**21**	**338,852,148**	

[1]Due to rounding the percentages may not total exactly 100 percent.

It is important to note that there has been no coal production from within the RMPPA. In fact, the total production in the Hams Fork Coal Field was attributed to a single Lincoln County mine (i.e., Pittsburgh & Midway Coal Mining Company's Kemmerer surface mine), which produced 3,725,983 tons in 2000. This mine is situated in excess of 10 miles southwest of the RMPPA boundary. No other mines are currently operational within or proximal to the RMPPA.

Wyoming is the nation's leading coal-producing state. The Wyoming Coal Information Committee predicted a production increase of 3.9 percent for 2001. Actual 2001 production was tallied at 368.9 tons, an increase of 8.82 percent (Harris and others, 2002). Increases of approximately 1 percent per year for the years 2002-2005 are predicted. Approximately 97 percent of Wyoming's coal production is consumed in electrical generation in over 25 states, Canada, and overseas.

It would be anticipated that production increases would be absorbed by existing (permitted but unused) capacity available within Powder River Basin mines or in other coal producing regions within the state.

The nature and characteristics of the coal deposits within the RMPPA (relative depth, seam thickness, and coal quality parameters, etc.) suggest that there is minimal to no potential for commercial exploitation of these coal deposits within the projected 20-year planning period.

While there is minimal to no potential for coal mining within the projected planning period, those coalbed occurrences within the Mesaverde Formation (in the vicinity of Riley Ridge) do have potential for exploitation of CBM resources on a commercial basis (TRC-Mariah, 2000). This development potential has been addressed in Section 4.1.4.4.

4.1.6 Oil Shale

There has been no known commercial production of shale oil from oil shale occurrences within the RMPPA.

As indicated in Section 3.1.4, the Green River Formation oil shale deposits are thickest and richest in the southern part of the Greater Green River Basin. Accordingly, those occurrences within the RMPPA occur along the basin margins, where the Green River Formation contains only small amounts of oil shale, most of which is low grade.

Though the RMPPA does contain limited oil shale resources, there are more extensive and higher grade deposits in other parts of the Greater Green River Basin in Wyoming, the Piceance Basin in Colorado, and the Uinta Basin in Utah. Commercial exploitation of oil shale, if it were to occur, would likely take place where the more extensive and higher grade deposits occur. However, production of kerogen, or shale oil, remains in the developmental stages and is considered infeasible at this time.

The nature of the oil shale deposits within the RMPPA, in conjunction with the status of oil shale development in general, suggests that there is minimal to no potential for commercial exploitation of these oil shale deposits within the projected 20-year planning period.

4.1.7 Phosphate

There has been no known commercial production of phosphate ores from the phosphate deposits within the RMPPA.

The Phosphoria Formation in western Wyoming has been an important resource of phosphate rock. Extensive exposures are found at North and South Sublette Ridge, Cokeville, and Border, all of which occur in Lincoln County, but outside of the RMPPA. Phosphate production in Wyoming began in 1906 near Cokeville (about 30 miles northwest of Kemmerer), and it eventually became one of the major industrial materials produced in the state before the last operating phosphate mine ceased operations in 1977. No commercial phosphate mining in the state has occurred since. Those mines that were operational were located within Lincoln County. The U.S. Bureau of Mines (1950) also projected a significant phosphate resource base in Fremont County; however, those resources are considered to be low grade and as such, are not economically mineable.

Though the RMPPA does contain limited phosphate resources, there are more extensive and higher grade deposits that are currently being commercially exploited. These include relatively

proximal mining and processing operations located north of the Wyoming – Idaho border, and the Vernal, Utah area. In addition, significant phosphate production emanates from operations in North Carolina and Florida. Thicker phosphate zones containing higher-grade phosphate at these locations, in combination with their existing processing and transportation infrastructure, will ensure that the majority of domestic phosphate production will continue to come from these areas.

The nature of the phosphate deposits within the RMPPA, in conjunction with the alternatively available domestic resource and/or production capacity, suggests that there is minimal to no potential for commercial exploitation of the RMPPA's phosphate deposits within the projected 20-year planning period.

4.1.8 Sodium

There has been no known commercial production of sodium from within the RMPPA, and only limited prospecting interest. Similarly, there has been no known commercial production of sodium carbonate and/or sodium sulfate from the Soda Lake occurrence, and there has been a lack of leasing interest with respect to this deposit.

Sodium production is Wyoming's most important industrial mineral in terms of value and employment. Trona is produced from five underground mines located west of Green River and refined into soda ash and other sodium products. An estimated resource of 134,400,000,000 tons of mineable trona and mixed trona and halite is present in the Green River Basin. A total of 42 trona beds are known to exist within the Wilkins Peak Member of the Green River Formation, of which 25 are considered mineable (Culbertson, 1986; Harris, 1992).

The nature of the sodium deposits within the RMPPA, in conjunction with the extensive and alternatively available domestic resource and/or production capacity, suggests that there is minimal to no potential for commercial exploitation of the RMPPA's sodium deposits within the projected 20-year planning period.

4.2 Locatable Minerals

Mineral resource development potential for locatable minerals that occur within the RMPPA has historically been and remains nominal to non-existent, because economic occurrences of these mineral classifications generally are not present within the RMPPA. Past activity associated with exploration activity and the limited production activities that have been completed to date suggests that commercial exploitation of locatable minerals is highly unlikely to occur within the projected 20-year planning period.

4.2.1 Uranium

There are currently two active uranium producers (i.e., Cameco and Rio Algom) in Wyoming, both of which produce uranium from in-situ methods in the Powder River Basin. These companies also were the only companies to conduct exploration for uranium during 2001. All drilling programs were for in-situ production objectives and/or monitoring wells associated with the producing properties (Harris and others, 2002).

Most uranium exploration activity within the RMPPA was completed during the 1960s and early 1970s (Hamilton, 1985). The most significant uranium exploration activity has been associated with the following programs:

- The (former) Utah Construction and Mining Company of Riverton, Wyoming, located a large block of unpatented claims in T34N and T35N of R110W and R111W. It is reported that the company (in 1968) drilled between 30 and 40 holes to maximum depths of 700 feet into the sandstones of the Wasatch Formation. Mineralization was apparently determined to be unfavorable for economic exploitation, and no further activity has been noted with regard to this prospect.

- Western Nuclear Corporation of Casper, Wyoming, conducted (in 1968) a drilling program within a large block of unpatented claims situated within T35N, R110W. Mineralization was apparently determined to be unfavorable for economic exploitation, and no further activity has been noted with regard to this prospect.

- Chevron Oil Company conducted (in 1973) a reconnaissance level exploration program that resulted in the drilling of an undefined number of holes within Townships 29-33N and Ranges 107-109W. Mineralization was apparently determined to be unfavorable for economic exploitation, and no further activity has been noted with regard to this prospect.

- Miscellaneous uranium exploration activity during the period 1968 through about 1980 resulted in the location of numerous claims within Townships 31N and T32N within Ranges 106W and 107W as well as in the vicinity of “the Mesa,” more specifically defined as being within T30-31N, R109W. The majority of these activities occurred on unpatented claims that have since lapsed.

Domestic exploration activity and associated claim locations attributable to uranium generally ceased as of the late 1970s and early 1980s due to depressed uranium prices and decreasing market demand. Following the Three Mile Island Nuclear Power Plant concern, yellowcake (i.e., uranium oxide) prices plummeted from a high of $40.00 per pound in 1979 to a recent

(January 2002) low of $7.10 per pound (Harris and others, 2002). The low current and projected price indices for yellowcake suggest that there will be marginal demand increases, at best, over the next 20 years.

Even if uranium market conditions were to significantly improve, immediate demand increases will likely be met by remaining active producers (i.e., uranium mines in Canada, Australia, and elsewhere) before domestic inactive or pre-development operations' productive capability could be re-established. Even under an industry expansion scenario, it is not expected that the sub-economic (due to limited tonnage and low-grade) uranium resources within the RMPPA would become attractive, given the proven resource base elsewhere.

The nature of the uranium deposits within the RMPPA, in conjunction with the weak market demand (and therefore extensive non-utilized world-wide production capacity) suggests that there is minimal to no potential for commercial exploitation of the RMPPA's uranium deposits within the projected 20-year planning period.

4.2.2 Gypsum

There is evidence of attempted small-scale mining of the gypsum resource at the extreme western portion of Ross Ridge (NW¼ NW¼ Section 35, T30N, R110W), as inferred by the 1985 presence of a screening apparatus and waste pile adjacent to the outcropping gypsum band (Hamilton, 1985). Presumably, this was a localized, non-commercial operation to extract gypsum for use as a soil conditioner.

Gypsum is used as a cement retarder, soil conditioner for agricultural use, and is used in the manufacturing of industrial building products, especially wallboard or plaster (Davis, 1989). Although Wyoming is not a major gypsum producer, the state does contain gypsum deposits that are relatively close to the Pacific Northwest and, therefore, could eventually become a principal supplier to that area (Harris, 1992). However, marketability of the gypsum products will be largely dependent on transportation costs (generally a function of distance to market).

There are three gypsum producers in Wyoming, two of which are located in the Bighorn Basin, while the third is located near Laramie. Gypsum production has remained relatively constant over the past 15 years, and currently available resources are anticipated to be sufficient to support any expanded production (Harris, 1992).

There are no known economic gypsum deposits within the RMPPA, nor have there been any known historic commercial scale gypsum mining operations. The limited occurrence(s), indicated bedding thickness, and low grade (purity) of gypsum present in the RMPPA suggest that there is

minimal to no potential for commercial exploitation of the gypsum deposits within the RMPPA for the projected 20-year planning period.

4.2.3 Metallic Minerals

Geologic literature and historic documentation indicate that only two metallic minerals are known or presumed to be present in or near the RMPPA. These metals are gold and copper. No known commercial exploitation of either gold or copper resources has occurred or are expected to occur within the RMPPA.

4.2.3.1 Gold

Limited small-scale placer activity has been completed at various locations within the RMPPA. Although test-pitting, trenching, and recreational-scale suction dredging techniques have been variously employed, no known commercial-scale gold production activities have occurred.

Unpatented placer claim location activity has been noted in the Griggs Placer area (T37N, R111W) as recently as 1990; however, the claims involved have since lapsed. Attempts at working placer claims situated west of Daniel (T34N, R111W) culminated in termination of activity and those claims were similarly allowed to lapse in 1995. A small open cut or trench operation (targeting minerals inclusive of gold and various gemstones) was developed southeast of Boulder (T31N, R106W), but has been successfully reclaimed with reclamation bond release occurring in 1998. However, with regard to the aforementioned claims, there have been informal expressions of interest in re-establishing small-scale placering activity as recently as early 2002.

There are no known economic precious metal (e.g., gold and silver) deposits within the RMPPA, nor have there been any known historic commercial-scale gold placering or mining operations. While limited recreational or small-scale placering activity may be realized on an intermittent basis at various locations, no significant development activity is anticipated for the projected 20-year planning period due to the limited occurrence(s) and low grade mineralization.

4.2.3.2 Copper

No commercial grade copper deposits are known to occur in the RMPPA. The only indicated occurrence of copper mineralization within the RMPPA is the reported 1941 location (Hamilton, 1985) of purported copper claims along La Barge Creek. In that regard, there is neither confirming assay data nor a recorded mineralogical assessment to verify that copper mineralization was indeed encountered.

There are no known economic copper deposits or historic commercial-scale copper mining operations within the RMPPA. The limited occurrence (if any) of copper mineralization suggests that there is minimal to no potential for commercial exploitation of copper deposit(s) within the RMPPA for the projected 20-year planning period.

4.2.4 Jade

As discussed in Section 3.2.4, the occurrence of nephrite jade has been reported in the Prospect Mountain area and at various locations along the Wind River Range. Most discoveries of jade specimens appear to be random occurrences, and there are no known jade-producing operations.

The marketability of jade is associated with its value as a gemstone. The limited known occurrences within the RMPPA tend to be of greater value to mineral specimen collectors rather than of commercial value. Moreover, most surficial areas of readily obtainable jade specimens have been heavily collected during the last several decades, further limiting activity in this regard.

Based on the limited occurrence(s) and nature of occurrences found to date, no significant commercial exploitation of this mineral is anticipated within the RMPPA for the projected 20-year planning period.

There are no known economic jade deposits or historic commercial-scale jade mining operations within the RMPPA. While limited recreational or small-scale specimen collecting activity may be realized on an intermittent basis and at various locations, no significant development activity is anticipated for the projected 20-year planning period.

4.2.5 Bentonite

No known bentonite exploration or mining activity has occurred within the RMPPA to date, and only modest occurrences of bentonite have been noted in the vicinity of the western extent of the RMPPA. The nearest known bentonite and clay mine in relation to the RMPPA is located north of the Town of Evanston.

Wyoming is the nation’s top producer of bentonite. After trona, it is the second most valuable industrial mineral produced in the state. It is mined entirely by low cost surface mining methods, and is usually quarried from deposits situated within a 20- to 50-mile radius of processing plants. Virtually all of the commercially-produced bentonite in Wyoming comes from upper Cretaceous strata, particularly in the Mowry and Frontier Formations and their equivalents.

Bentonite use is largely dependent on its swelling capacity. High-swelling bentonite is primarily used by the petroleum industry as an ingredient of rotary well drilling mud, and by the iron metals industry both as a binder in sand casting molds and as a binder in pelletization of taconite (iron ore). It also is used as a sealant in hydraulic structures (e.g., irrigation canals, dams and impoundments, etc.), as a filler in paper products and fire retardant gels, and in the briquetting of chars and coke. The non-swelling varieties are primarily used as fillers in insecticides, fungicides, pharmaceuticals, soaps, polishes, and other products.

Based on the limited occurrence(s) of bentonite clays within the RMPPA and the relative abundance of bentonite resources available elsewhere, no significant commercial exploitation of this mineral is anticipated within the RMPPA for the projected 20-year planning period.

4.3 Saleable Minerals

Saleable minerals include, but are not limited to common, varieties of sand, stone, gravel, pumice, pumicite, cinders, clay, and petrified wood. Of these, there are known exploitable occurrences of sand, stone, and gravel (or aggregate materials) within the RMPPA (refer to Section 3.3), and to a significantly lesser degree, there may be a limited potential for exploitation of common clay and petrified wood resources.

Extraction and sale of aggregate materials are governed by the Mineral Materials Disposal regulations codified within 43 CFR 3600 through 3622. These regulations allow for mineral materials disposal through either mineral material sales or non-exclusive disposal.

Mineral material sales can be made on the initiative of the authorized BLM officer or be made subsequent to receipt of a request to purchase by an applicant. Sales can be made under a competitive bid basis or under a non-competitive bid basis, subject to certain volume or weight equivalent limitations.

Non-exclusive disposal of mineral materials can occur through sale or “free-use,” and can be made from the same deposit within areas designated by the BLM authorized officer. These areas are designated as community pit sites (defined sites) or common-use areas (generally a broad geographic area), neither of which is necessarily limited in size.

The differentiating factor between a community pit site and a common-use area is that designation of a community pit constitutes a superior right to remove the material as against any subsequent claim or entry of the lands, whereas designation as a common-use area does not constitute a superior right. However, a person authorized by permit or sale has a superior right against any subsequent claim or entry.

Mineral materials may be disposed through “fair market value” sales from either community pit sites or common-use areas. In addition, “free-use permits” can be can be issued to any federal or state agency, unit or subdivision, including municipalities and, under certain conditions and limitations, to non-profit organizations.

4.3.1 Aggregates (Sand and Gravel)

Natural construction aggregate is one of the most abundant and widely used natural resources. Aggregates consist of crushed and sized rock (either quarried stone of crushed gravel) or natural sand and gravel, which are not crushed, but sized. Sand and gravel is less expensive than crushed stone aggregate, but crushed stone has the advantage of consistency in size and angularity.

Construction aggregates are the lowest priced of all mined products. Since they are low priced, transportation costs from the pit to the point of use can become the major part of their cost to the consumer. For example, crushed rock that may cost $2.00 per ton to produce can be subject to transportation costs on the order of $1.00 per ton-mile or greater. As such, at transportation distances of even two miles, the cost of transportation can easily exceed the cost of production. Therefore, it is imperative that aggregate sources be located as close as possible to the point of use.

It is anticipated that demand for aggregate production within the RMPPA will be proportional to expanding oil and gas exploration and production activity. The oil and gas industry requires a significant volume of aggregate products primarily for purposes of constructing and/or stabilizing drill pad installations and access/service roadways. While the oil and gas industry will be the primary consumer of aggregate products over the projected 20-year planning period, additional consumption also will occur relative to increased town/city public works and county and state highway departments’ requirements. These governmental and quasi-governmental entities require aggregate materials for road construction and maintenance as well as infrastructure/public works projects.

It is probable that the greatest proportion of oil and gas industry demand for aggregate will be fulfilled through the utilization of existing and development of new Community Pits. Currently, a total of 14 Community Pits representing a total authorized or permitted surface are of approximately 444 acres are present within the RMPPA (**Table 4-13**). Of the originally authorized 444 acres, field estimates indicate that approximately 268 acres of aggregate reserves remain intact as in-place reserves (i.e., unmined).

Table 4-13
Designated Community Pits

Pit Name	Serial Number	Township	Acreage	
			Authorized	Remaining[1]
Antelope Run	WYW-140049	T33N, R113W	5	0.8
Calpet	WYW-129725	T27N, R113W	60	17.1
Daniel	WYW-073162	T33N, R111W	10	1.0 (near closure)
Deer Hills	WYW-091077	T30N, R113W	40	36.4
Dry Piney	WYW-133464	T28N, R112W	44	24.2
East River	WYW-116848	T31N, R110W	15	1.0 (near closure)
Half Moon	WYW-146207	T34N, R108W	5	1.0 (near closure)
La Barge	WYW-129730	T26N, R112W	36	21.0
Jonah Sand Pit	WYW-127968	T29N, R108W	4	0
Oil Patch	WYW-130753	T29N, R113W	80	67.8
Pan Am	WYW-133388/137874	T29N, R113W	50	38.6
Red Castle/Sublette	WYW-148064/5	T32N, R113W	45	43.0
Shriver	WYW-089575	T34N; R109W	10	0 (permit area exceeded, in violation)
"351"	WYW-136997	T30N, R110W	40	19.2

[1]BLM field estimate as of July 2002.

The remaining in-place aggregate reserve within the 15 existing Community Pits (representing the unmined 268 acres) is estimated to constitute on the order of 3.9 million cubic yards (yd^3).

$$268.1 \text{ acres} \times \frac{43{,}560 \text{ ft}^2}{\text{acre}} \times 15 \text{ ft} \times \frac{\text{yd}^3}{27 \text{ ft}^3} \times 0.60 = 3{,}892{,}812 \text{ yd}^3$$

[Note: This estimate is based a nominal 15-feet thickness continuous aggregate zone over the authorized areal extent and a nominal 60 percent recovery factor to allow for losses attributable to topsoil/overburden dilution, interbedding of clay lenses, contained fines, etc. In addition, it should be noted that material volumes have been calculated on the basis of "raw" cubic yards. That is, no consideration has been given as to "bank" versus "loose" volumetric classification, nor has consideration been given to material swell factors associated with excavation, loading or placement and/or consolidation resulting from crushing, screening, and sorting.]

Projected RMPPA aggregate demand over the 20-year planning period is estimated at 6,775,000 cubic yards (**Table 4-14**), indicating a potential shortfall (based on existing permitted reserve limitations) of roughly 2.9 yd^3.

Table 4-14
Estimated Gravel Resource Requirement

Demand Source	Tons
Oil and Gas Industry (Direct) Demand	775,000
State/County/Municipal Demand	5,750,000
Other	250,000
Total	6,775,000

Evaluation of the projected 2.9 million ton shortfall indicates that additional aggregate Community Pits will be required to fulfill demand projections over the 20-year planning period. Utilizing the same reserve calculation basis (as indicated above), the 2.9 million tons translate to approximately 200 acres of required Community Pit surface area. Assuming a representative Community Pit size (area) of 40-acres, this would suggest that an additional five (5) 40-acre (or equivalent thereof) Community Pits will be required.

Locational considerations should incorporate proximity to major areas of oil and gas development activity. Demand is likely to remain relatively constant, but will likely be front-loaded to reflect initial infrastructure requirements. Accordingly, it may be advantageous to consider siting/location and permitting of two (2) pits within the 0-5 year time frame, followed by an additional two (2) pits within the 6-15 year time frame, and the final pit at or after the 15-year point.

The aggregate estimates demand over the projected 20-year planning period have been formulated on the following bases.

4.3.1.1 Oil and Gas Industry (Direct) Demand

The most significant increase in aggregate demand will originate from oil and gas activity occurring in the Pinedale Anticline and Jonah Field regions. Due to the transportation cost sensitivity of aggregates, aggregate sources proximal to these areas will provide the majority of the aggregate production before more distant sources are utilized.

The total aggregate demand associated with (direct) oil and gas industry requirements has been estimated to be on the order of 775,000 yd^3 for the four identified categories of consumptive use. Due to limiting factors associated with BLM-administered lands (e.g., seasonal restrictions, etc.), it is probable that the oil and gas industry will become increasingly reliant upon privately-sourced aggregates to fulfill demand requirements. Accordingly, a nominal 25 percent reduction has been applied against the total estimated demand (**Table 4-15**).

Table 4-15
Estimated Aggregate Demand for Oil and Gas Development

Category	Volume (Yd^3)
Wellpads Surfacing/Stabilization and Maintenance	118,120
Resource Road Construction and Maintenance	118,297
Local Road Construction and Maintenance	170,584
Collector Road Construction and Maintenance	621,273
Subtotal	**1,028,274**
(Less 25 Percent Private-Sourced)	-257,069
Total Demand for BLM Aggregate	**771,205**

4.3.1.2 Oil and Gas Industry Aggregate Demand Projections

In order to assemble the aggregate demand projections for oil and gas industry requirements, a number of assumptions have been made based upon data extracted from Section 4.1.4.4 of this report.

A total of 5,120 wells (oil, natural gas, and coal bed gas) are projected over the planning period. Assuming a nominal 88 percent completion rate as indicated by historic data, it would be anticipated that approximately 4,506 wells would be active production facilities.

1. **Wellpads** – Based on the indicated average wellpad dimension of 1.5 acres, and assuming a nominal four-inch lift of surface-stabilizing gravel utilized across a nominal 5 percent of the wellpad surface, each wellpad will require (on average) an estimated 40 yd^3 of gravel material for initial surface stabilization, calculated as follows:

$$\left(\frac{1.5 \text{ acres/wellpad} \times 43{,}560 \text{ ft}^2/\text{acre} \times 0.33 \text{ ft}}{27 \text{ ft}^3/\text{d}^3}\right) \times 0.05 = 40 \text{ yd}^3/\text{wellpad}$$

   Allowing for pad maintenance on a regular basis, a nominal 10 yd^3 per wellpad (for 10 percent of the pads) is assumed to be required every other year. Therefore, the total amount of gravel required (over the 20-year planning period) for wellpad surface stabilization at 2,363 wellpads would be the total of initial surfacing placement plus biennial maintenance, resulting in an estimated total requirement of 94,620 yd^3, calculated as follows:

$$[4{,}506 \text{ wellpads} \times 40 \text{ yd}^3/\text{wellpad}] + 450 \text{ well pads} \times (10 \text{ yd}^3) = 184{,}740 \text{ yd}^3$$

2. **Access roads** – access roads will (to varying degrees, dependent on classification) require gravel surfacing, primarily in areas of weak soils not conducive to supporting loads or volumes

associated with anticipated traffic. BLM road standards (Manual 9113) provide for three types of access roads, as follows:

Collector Roads: These roads normally provide access to large blocks of land and connect with or are extensions of a public road system. Collector roads usually require application of the highest standards used by the BLM. Design speed is 30 to 50 mph, and subgrade width is a minimum of 28 feet (24-feet full surfaced travelway).

Local Roads: These minimum volume roads usually provide the internal access network within an oil and gas field. Design speed is 20 to 50 mph and subgrade width is a minimum of 24 feet (20-feet full surfaced travelway).

Resource Roads: These are normally spur roads that provide point access. Roads servicing individual wellpads typically fall within this classification. Design speed is 15 to 30 mph and subgrade width is a minimum of 16 feet (12-feet full surfaced travelway).

Projections for access road development indicate an average access road (classified as "resource roads") requirement of 0.4 mile per well. Thus, given the projected incremental total of 4,506 active wellpads over the 20-year planning period, a total of 1,802 miles of new resource roads are projected. Projected aggregate (gravel) requirements are estimated in the following manner:

4.3.1.3 Resource Roads

Basis: Assume a nominal 10 percent of the projected total resource road miles (1,802 miles x 0.10 = 180.2 miles) will initially require gravel stabilization (4-inch lift) across the entire 16-foot subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 1,000 yd^3 on an annual basis over the 20-year planning period.

$$\left(\frac{180.2 \text{ miles} \times 5{,}280 \text{ ft./mile} \times 16 \text{ ft.} \times 0.33 \text{ ft.}}{27 \text{ ft}^3/\text{yd}^3} + 20\ (1{,}000 \text{ yd}^3)\right) = 206{,}063 \text{ yd}^3$$

4.3.1.4 Local Roads

Basis: Assume total mileage to be a nominal 25 percent of the projected total resource road miles (1,802 miles x 0.25 = 451 miles) and that a nominal 30 percent of the resulting miles (451 miles x 0.30 = 135.2 miles) will require gravel stabilization (4-inch lift) across the entire 24-foot subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 3,000 yd^3 on an annual basis over the 20-year planning period.

$$\frac{135.2 \text{ miles} \times 5{,}280 \text{ ft./mile} \times 24 \text{ ft.} \times 0.33 \text{ ft.}}{27 \text{ ft}^3/\text{yd}^3} + 20\ (3{,}000\ \text{yd}^3) = 278{,}123\ \text{yd}^3$$

4.3.1.5 Collector Roads

Basis: Assume total mileage to be a nominal 10 percent of projected total resource road miles (1,802 miles x 0.10 = 180.2 miles) and that 100 percent of the resulting mileage will require gravel surfacing and/or stabilization (12-inch lift) across the entire 28-foot subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 10,000 yd^3 on an annual basis over the 20-year planning period.

$$\frac{180.2 \text{ miles} \times 5{,}280 \text{ ft./mile} \times 28 \text{ ft.} \times 1.0 \text{ ft.}}{27 \text{ ft}^3/\text{yd}^3} + 20\ (5{,}000\ \text{yd}^3) = 1{,}086{,}695\ \text{yd}^3$$

Therefore, the total oil and gas industry development demand for aggregate is estimated to be the total of all of the above, as shown in **Table 4-15**.

4.3.1.6 State/County/Municipal Demand

State/County/Municipality demand projections are based upon direct inquiry to the Wyoming Department of Transportation (WYDOT) and Sublette County. [Note: Analysis of data pertaining to BLM mineral material disposal records for the 5-year period 1997 through 2001 indicates fluctuating mineral disposal volumes under the category “Free Use Permit – Government Subdivisions” that are likely not indicative of current and future demand scenarios.]

Most aggregate utilized by state/county/municipal entities is consumed in roadway construction and/or maintenance and other related paving or construction applications. As oil and gas development intensifies (as projected), it would be reasonable to anticipate that the need public road construction and/or maintenance and other infrastructure improvements would increase proportionately.

Typically, major infrastructure improvements are incurred in the early to middle stages of a natural resources “boom” period. As such, the gravel demand estimate for state/county/municipal consumption is based on 2001 consumption (as the base year), with a projected escalation in demand over the first 10 years of the planning period. A leveling of demand is projected thereafter, for the remainder of the planning period.

State/county/municipal gravel requirements are estimated to be on the order of 5.75 million yd^3 (over the projected 20-year planning period) (**Table 4-16**).

Table 4-16
Estimated Gravel Requirements for State/County/Municipal Roads

Year	Volume (yd^3)
2001 (base)	100,000
2002	200,000
2003	250,000
2004	275,000
2005	300,000
2006	375,000
2007	375,000
2008	375,000
2009	375,000
2010	375,000
2011	300,000
2012	300,000
2013	300,000
2014	300,000
2015	300,000
2016	250,000
2017	250,000
2018	250,000
2019	250,000
2020	250,000
Total	**5,750,000**

Sublette County has indicated that approximately 90 percent of the county's aggregate demand is provided via BLM-sourced material, with the remainder provided from private sources. WYDOT has indicated that minimal volumes of aggregate are obtained from BLM-sourced materials, with the majority of aggregate demand provided from private sources.

4.3.1.7 Other Aggregate Demand

Other aggregate demand requirements include, but are not necessarily limited to private entity demand (disposal through negotiated or non-negotiated sales) and free-use permit disposal (e.g., non-profit entity demand).

This demand has been estimated at a nominal 12,500 yd^3 per year over the 20-year planning period, resulting in a total estimated demand of approximately 250,000 yd^3.

4.3.2 Decorative Rock

Decorative rock (i.e., moss rock or boulders) has been produced within the RMPPA for a number of years, with demand increasing proportional to population increases in the region. The moss rock is generally utilized as either a structural or decorative building material, whereas the boulders are generally utilized for landscaping purposes.

4.3.2.1 Moss Rock

Significant deposits of moss rock (defined as a moss or lichen covered, salmon-pink sandstone) are known to occur in talus slopes along La Barge Creek Road and in the Miller Mountain area. Under current conditions, recoverable deposits are generally limited to those that are readily accessible (proximal to existing roadways) and obtainable through manual extraction or retrieval. However, as demand for moss rock increases, there will be an increasing need to establish greater accessibility (new roadways) to more remote deposits, or there will likely be increased unauthorized off-road activity and/or trespass. It is unlikely that recovery methods will vary significantly, as mechanized removal would damage the rock's desirability by scarring or scraping the moss or lichen veneer. As such, manual (by hand) extraction will likely remain the primary mode of removal.

It would be anticipated that moss rock demand would increase at least in direct proportion to population increases and/or the number of structural building permits issued. In fact, the demand curve may well exceed the region's growth rate as the rock's desirability is increasingly recognized by the existing populace and/or determined to be desirable for architectural renovation of existing structures. Further, interest in the rock may extend to areas outside of the region (e.g., Jackson area).

Material disposal records do not clearly indicate that a total tonnage of moss rock were extracted/sold during the 5-year period (1997 through 2001). However, estimates were in excess of 100 tons per year during 2 of the 5 years. The 100-ton years are attributed to single account sales. However, there have been no sales at that level during the past 2 years. It is anticipated that there will be increased demand for the moss rock reflective of increasing population as well as increased or more widespread usage of the moss rock as a building material. With time (owing to stabilization of the population influx), it would be anticipated that there would be a leveling of demand, followed by a marginal drop in demand.

In all likelihood, the relative rate of increase in demand will level off in approximately 8 to 10 years as the oil and gas driven population growth slows due to maturation of the Pinedale Anticline and

Jonah Fields. For purposes of estimating overall demand, it has been assumed that any over-estimate error introduced by reduction in demand (attributable to the leveling effect) would effectively offset any under-estimate error attributable to non-consideration of increased demand originating from outside the immediate area. [Note: No attempt has been made to estimate this external demand factor due to the fact that resource potential and/or limitations external to the RMPPA have not been evaluated as part of this mineral report.]

Estimated moss rock demand is anticipated to be on the order of 4,750 tons (possibly ranging to in excess of 5,000 tons) over the projected 20-year planning period (**Table 4-17**).

It is anticipated that this projected tonnage (4,750 tons) of moss rock is available in the Miller Mountain area. However, in order to maximize the resource base and optimize resource utilization within the already identified areas, consideration will need to be given to: 1) establishing and maintaining routes of accessibility when and where needed; and, 2) establishing commercial-scale operations and providing for private product stockpile/transfer points locations (in order to avoid seasonal limitations on production or retrieval of the moss rock products).

As available moss rock inventories immediately adjacent to existing roadways are depleted, it may be necessary to extend existing or construct new spur roads or access drives into the talus fields to enable continued roadside collection of the rock.

Seasonal avoidance criteria will result in the establishment of seasonal limitations on moss rock collection, and in turn, may result in a recognition that offsite stockpiling might be a viable means of ensuring year-round accessibility to the moss rock resource.

4.3.2.2 Boulders

Significant deposits of boulders (arbitrarily defined as alluvial debris over 18 inches in diameter) are known to occur in and around lateral and terminal moraines located along the western flank of the Wind River Range. More specifically, currently identified and accessible deposits are known to be present in the vicinity of and along permanent access roadways leading to Boulder Lake, Soda Lake, and Burnt Lake. It is likely that numerous other areas exist within the RMPPA where boulders are recoverable, given enhanced accessibility conditions.

Under current conditions, recoverable deposits are generally limited to those that are readily accessible (proximal to existing roadways) and obtainable through manual extraction or retrieval. However, as demand for boulders increases, there will be an increasing need to establish greater accessibility (new roadways) to the more remote deposits, or there will likely be increased unauthorized off-road activity and/or trespass.

Table 4-17
Moss Rock Demand Projection

Year	Tons Required
2001 (base)	25
2002	50
2003	75
2004	125
2005	225
2006	300
2007	300
2008	300
2009	300
2010	300
2011	300
2012	300
2013	300
2014	300
2015	300
2016	250
2017	250
2018	250
2019	250
2020	250
Total	**4,750**

It is likely that boulder extraction/recovery methods will continue unchanged. Most boulders are individually obtained through mechanized removal (e.g., backhoe or front-end loader) or by hand, where size and mass allow. Stipulations imposed on boulder extraction will ensure that a combination of hand and mechanized removal of individual boulders will continue to be the primary mode of removal.

The market demand rate of increase for boulders should not vary significantly from that projected for moss rock. In addition, a variable demand factor relating to governmental entity (e.g., Wyoming Game and Fish) usage of boulders for stream restoration and/or habitat enhancement has been integrated as 2,500 tons per year on an every other year basis (as indicated below).

Utilizing 2001 as the base year and applying the demand forecast for moss rock, a total reserve base on the order of 30,000 tons of boulders will be required to meet demand requirements over the 20-year planning period (**Table 4-18**).

Table 4-18
Boulder Demand Projection

Year	Tons Required
2001 (base)	25
2002	100 + 2,500
2003	125
2004	150 + 2,500
2005	175
2006	250 + 2,500
2007	250
2008	300 + 2,500
2009	300
2010	350 + 2,500
2011	350
2012	350 + 2,500
2013	350
2014	350 + 2,500
2015	350
2016	300 + 2,500
2017	300
2018	300 + 2,500
2019	300
2020	300 + 2,500
Total	**30,275 tons**

As in the case with moss rock, in all likelihood, the rate of demand increase will level off in approximately 10 years as the oil and gas-driven population growth slows due to maturation of the Pinedale Anticline and Jonah Fields. It has been assumed that the reduced demand introduced by any leveling effect would effectively offset any error that might have been introduced by not giving due consideration to increased demand originating from outside of the immediate area. [Note: No attempt has been made to estimate this external demand factor due to the fact that resource potential and/or limitations external to the RMPPA have not been evaluated as part of this mineral report.]

It is anticipated that the required boulder tonnage (30,275 tons) cannot be fully accommodated by those readily accessible inventories currently defined within the existing three boulder resource areas, and as such, additional boulder resource areas must be identified.

Existing permitted or identified potential boulder resource areas are generally described as being the rights-of-way associated with access roads to Boulder Lake, Soda Lake, and Burnt Lake (**Table 4-19**).

Table 4-19
Decorative Boulder Permitted Areas and
Identified Potential Boulder Resource Areas

Pit or Area Name	Serial Number	Date Established	Township
Boulder Lake Road	WYW134550	1995	T33N, R107W
Soda Lake Road #1	WYW122366	1992	T34N, R109W
Soda Lake Road #2	WYW146206	1998	T35N, R105W
Burnt Lake Road	N/A[1]	Identified/Not Open	T33N, R108W

[1]Not Applicable.

In order to maximize the resource base as well as optimize resource utilization within these already identified areas, consideration will need to be given to: 1) establishing and maintaining routes of accessibility when and where needed; and, 2) establishing commercial-scale operations and providing for private product stockpile/transfer points locations (in order to avoid seasonal limitations on production or retrieval of the decorative boulder products).

In addition, additional boulder resource areas must be identified and developmental requirements identified. At this juncture, it would appear that the most probable area(s) for boulder development would be associated with access roadways in and around the terminal and lateral moraines situated generally north, east, and southeast of Pinedale and along the western flank of the Wind River Mountains.

As the available boulder inventories that are immediately adjacent to existing roadways are depleted, it may be necessary to construct spur roads or access drives into boulder fields, where present, to enable continued roadside collection of the boulders.

Seasonal avoidance criteria will result in the establishment of seasonal limitations on boulder collection, and in turn, may result in a recognition that offsite stockpiling might be a viable means of ensuring year-round accessibility to the decorative boulder resource.

4.3.3 Common Clay

Limited quantity clay resources are likely present along the western portion of the RMPPA. However, there has been no known exploration or production activity associated with common clay products within the RMPPA.

It is possible, but highly improbable, that localized demand for clay materials may evolve for special use applications (e.g., landfill or lagoon liner material, etc.). However, the relative remoteness of the potential clay resource (distance from developed areas) would likely render this potential non-existent.

Based on the limited occurrence(s) of common clay within the RMPPA and the relative availability of suitable and cost-effective alternatives (e.g., synthetic liners, etc.), no significant commercial exploitation of common clay resources is anticipated within the RMPPA for the projected 20-year planning period.

4.3.4 Petrified Wood

While known occurrences of petrified wood are present at various locations within the RMPPA, it is not anticipated that the development potential of this resource would exceed that of limited quantity collecting (free-use). Mineral material disposal regulations allow that persons may collect limited quantities of petrified wood for non-commercial purposes under terms and conditions consistent with the preservation of significant deposits as a public recreational resource (40 CFR 3622.1). In that regard, petrified wood is considered to be not only a saleable mineral, but also a paleontological resource, and may accordingly be subject to protective measures afforded thereto under certain circumstances.

Under the free-use collection scenario, no permit is required except for specimens over 250 pounds in weight. Other rules apply, as follows:

- One person is allowed to remove a maximum of 25 pounds plus one piece of petrified wood per day, subject to a limitation of 250 pounds per year.

- No explosives or mechanized equipment may be used for the excavation or removal of petrified wood. Light trucks (up to 1-ton capacity) may be used as a principal means of transporting/hauling.

- Free-use petrified wood may not be bartered or sold to commercial dealers.

- Extraction and removal of specimens must be done in a manner that avoids damage to the surface.

There are no specific reporting requirements associated with free-use collection; however, the BLM has the authority to establish and publish additional rules to supplement those contained within 40 CFR 3622.

As such, there is no basis upon which to estimate demand or development potential, other than stating that collection quantities will likely diminish as readily observable and accessible specimens are depleted.

4.4 Mineral Potential Summary

The primary mineral occurrence and development potential within the RMPPA is associated with oil and natural gas, coalbed methane, aggregates, and decorative stone. The RMPPA is a proven hydrocarbon producing area for over 80 years, and estimates of undiscovered resources indicate that the area will provide abundant supplies of hydrocarbons (especially natural gas) through the end of the 20-year planning period and beyond. While coalbed methane is still an unproven resource and the RMPPA currently contains only one active CBM development project (in its initial development stage), coalbed methane may represent a significant hydrocarbon resource within the RMPPA, albeit in limited areas of occurrence. It is anticipated that hydrocarbon development projects will drive the exploitation of aggregate resources (to supply infrastructure development needs).

A number of other minerals are present within the RMPPA; however, noted occurrences are typically sub-economic or development potential is “low”, based on varying demand parameters (generally dependent on the mineral being considered).

The BLM (1985) in its Manual 3031 (Energy and Mineral Assessment) specifies the following classification system for mineral potential (utilized to rank the potential for presence or occurrence, as opposed to the potential for development or extraction):

Level of Potential

Classification	Level of Potential
O	The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.
L	The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.

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

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

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

Level of Certainty

Classification Level of Certainty

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

B The available data provide indirect evidence to support or refute the possible existence of mineral resources.

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

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

Based on the BLM classification system (BLM 1985), the RMPPA mineral potential for those minerals determined present is as follows:

Mineral	**Classification**
Leasable Minerals	
Oil	H/D
Natural Gas	H/D

Coalbed Methane	H/D
Coal	M/C
Oil Shale	M/C
Phosphate	L/C
Sodium	L/C

Locatable Minerals

Uranium	L/C
Gypsum	L/C
Gold	L/B
Copper	L/B
Jade	L/C
Bentonite	L/C

Saleable Minerals

Aggregates	H/D
Decorative Stone	H/C
Common Clay	L/B
Petrified Wood	M/B