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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE MOUNT HARRIS QUADRANGLE, ROUTT COUNTY, COLORADO

[Report includes 13 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Mount Harris quadrangle, Routt County, Colorado. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the U.S. Geological Survey under contract Number 14-08-001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information available through April, 1978, was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor was any confidential data used.

Location

The Mount Harris quadrangle is located in southwestern Routt County in northwestern Colorado, approximately 17 miles (27 km) west of the town of Steamboat Springs and 18 miles (29 km) east of the town of Craig, Colorado, via U.S. Highway 40. The eastern part of the town of Hayden is located in the northwestern corner of the quadrangle and the abandoned townsite of Mount Harris in the northeastern corner. The Yampa Valley Airport and the Hayden Station Power Plant are located in the north-central part of the quadrangle.

Accessibility

U.S. Highway 40 crosses the northern edge of the Mount Harris quadrangle connecting Steamboat Springs to the east with Craig to the west. A paved medium-duty road runs south from U.S. Highway 40 near the Hayden Station Power Plant, crosses Windy Point in the east-central part of the quadrangle, and connects with the town of Oak Creek approximately 12 miles (19 km) to the southeast. A paved medium-duty road also serves the Yampa Valley Airfield in the northwestern part of the quadrangle. An improved light-duty road runs south from Hayden along the western side of

the quadrangle through Sage Creek Canyon to the Sage Creek Reservoir in the southern part of the quadrangle. Numerous unimproved dirt roads and trails provide access for the remainder of the quadrangle.

Railway service for the Mount Harris quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The railroad passes through the northern part of the quadrangle and serves as the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Mount Harris quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is on the northeastern edge of the Williams Fork Mountains, approximately 30 miles (48 km) west of the Continental Divide.

The landscape through the central part of the quadrangle is characterized by gentle, rolling hills and wide stream valleys, while the northeastern edge and the southwestern third of the quadrangle are dominated by steep slopes dissected by narrow canyons. Approximately 1,720 feet (524 m) of relief is present in the Mount Harris quadrangle. Altitudes range from approximately 8,080 feet (2,463 m) along the southern edge of the quadrangle (south of the Sage Creek Reservoir) to less than 6,360 feet (1,939 m) in the northwestern corner of the quadrangle.

The major drainage system in the area is the Yampa River, which flows toward the west through the northeastern corner of the quadrangle and then crosses westerly approximately 1 mile (1.6 km) north of the quadrangle boundary. Dry Creek, Sage Creek, Grassy Creek, and their tributaries flow northward through the quadrangle and drain into the Yampa River.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Mount Harris quadrangle area, with daily temperatures typically varying from 4° to 32°F (-15° to 0°C) in January and from 49°

to 85°F (9° to 29°C) in July. Annual precipitation in the area averages approximately 15 inches (38 cm). Snowfall during the winter months accounts for the major part of the precipitation in the area, but rainfall from thundershowers during the summer months also contributes to the total. Winds, averaging approximately 3 miles per hour (4.8 km per hour), are generally from the west, but wind directions and velocities vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

The typical vegetation in the Mount Harris quadrangle is sagebrush and mountain shrub. Mountain shrub covers most of the southern half of the quadrangle and includes serviceberry, Gambel oak and rabbitbrush which range from 2 to 8 feet (0.6 to 2.4 m) in height. The flatter areas in the northwestern part of the quadrangle are utilized as cropland (U.S. Bureau of Land Management, 1977).

Land Status

The Mount Harris quadrangle lies in the eastern part of the Yampa Known Recoverable Coal Resource Area. Approximately 85 percent of the quadrangle, lies within the KRCRA boundary and the Federal government owns the coal rights for approximately 54 percent of this area as shown on plate 2. Five active coal leases are present within the KRCRA, comprising approximately 30 percent of the Federally-owned land.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Mount Harris quadrangle is located was reported by Emmons (1877) as part of a survey of the Fortieth Parallel. The decision to build a railroad into the region stimulated several investigations of coal between 1886 and 1905, including papers by Chisholm (1887), Storrs (1902), Hewett (1889), Hills (1893), and Parsons and Liddell (1903). Fenneman and Gale (1906) conducted geologic studies of the Yampa Coal Field and included a description of the geology and coal occurrence in the Mount Harris

quadrangle in their report. In 1955, Bass and others expanded Fenneman and Gale's work in a report on the geology and mineral fuels of parts of Routt and Moffat Counties and this is the most comprehensive work on the area. Tweto (1976) compiled a generalized regional geologic map which included this quadrangle. More recent studies of the geology and coal resources of the Foidel Creek area to the southwest of this quadrangle have been completed by Ryer (1977).

Stratigraphy

Rock formations cropping out in this quadrangle are all Late Cretaceous in age and include the Mancos, Iles, Williams Fork, and Lewis Shale. Only the Iles and Williams Fork Formations of the Mesaverde Group are known to contain coal.

The Mancos Shale crops out along the axis of the Sage Creek anticline in the southwestern part of the quadrangle. It consists of gray to dark-gray shale with a number of tan silty sandstones interbedded with sandy shale and shale in the upper 1,000 feet (305 m) of the formation. The sandstones are thin-bedded and ledge-forming, each 40 to 75 feet (12 to 23 m) or more thick (Bass and others, 1955). The total thickness of this formation is not known in this quadrangle, but Bass and others (1955) indicate that it is about 4,900 feet (1,494 m) thick in the area they mapped.

The Mesaverde Group conformably overlies the Mancos Shale and consists of two formations, the Iles and the Williams Fork.

The Iles Formation is approximately 1,500 feet (457 m) thick and crops out in the southwestern part of the quadrangle along the axis of the Sage Creek anticline and in a small area near the southern edge of the quadrangle along the axis of the Fish Creek anticline. The Iles Formation consists of the basal Tow Creek Sandstone Member, an overlying sequence of sandstones interbedded with sandy shale, shale, and coal, and at the top of the formation, the Trout Creek Sandstone Member (Bass and others, 1955).

The Tow Creek Sandstone Member is a light-brown, fine-grained massive cliff-forming sandstone approximately 55 feet (17 m) thick where measured in the oil wells drilled in the quadrangle. The member is overlain by light-brown, light-gray and white massive ledge-forming sandstones interbedded with gray sandy shale, shale, and coal. The coal, designated as the Lower Coal Group by Fenneman and Gale (1906), is distributed throughout the middle and upper parts of the Iles Formation. This sequence is capped by the Trout Creek Sandstone Member, a white, fine-grained massive cliff-forming sandstone, approximately 100 feet (30 m) thick (Bass and others, 1955).

The Williams Fork Formation conformably overlies the Iles Formation and crops out over a large area in the southwestern third of the quadrangle along the flanks of the Sage Creek and Fish Creek anticlines and along the eastern edge of the quadrangle on the western flank of the Tow Creek anticline. It is approximately 1,100 feet (335 m) thick near Mount Harris (Bass and others, 1955) and is divided into four units by Ryer (1977): a lower coal-bearing member, a marine shale member, the Twentymile Sandstone Member, and an upper member.

The lower coal-bearing member is designated the Middle Coal Group (Fenneman and Gale, 1906) and contains about 300 feet (91 m) of interbedded gray to dark-gray siltstone, silty sandstone, very fine grained tan to gray sandstone, and coal (Ryer, 1977). Two major coal beds, the Wolf Creek and Wadge, occur in the Middle Coal Group. They are located, stratigraphically, about 50 feet (15 m) and 210 feet (64 m), respectively, above the Trout Creek Sandstone Member. The overlying marine shale member, which is about 550 to 600 feet (168 to 183 m) thick, is composed of dark-gray to dark-tan shale, silty shale, and tan siltstone which grades upward into the overlying Twentymile Sandstone Member (Ryer, 1977). The Twentymile Sandstone Member, approximately 100 to 120 feet (30 to 37 m) thick, is a massive white ledge-forming sandstone (Bass and others, 1955; Ryer, 1977). A well-defined contact exists between the Twentymile Sandstone Member and the overlying upper member. The upper member is composed of sandstone, sandy shale, dark-gray shale, and a few

local coals (Bass and others, 1955), and is approximately 200 feet (61 m) thick. Coals occurring in the upper member have been designated as the Upper Coal Group (Fenneman and Gale, 1906).

The Lewis Shale conformably overlies the Williams Fork Formation and crops out along the axis of the Hayden syncline in the northwestern quarter of the quadrangle and in a southeast-trending band in the southeastern quarter. It consists of homogeneous dark-gray to bluish marine shale (Bass and others, 1955). No thickness for the Lewis Shale is available in this quadrangle; however, it is approximately 2,775 feet (846 m) thick in the Rock Spring Gulch quadrangle to the northwest.

Holocene deposits of alluvium cover the valley of the Yampa River across the northern edge of the quadrangle.

The Cretaceous formations in the Mount Harris quadrangle accumulated close to the western edge of a Late Cretaceous-age epeirogenic seaway which covered part of the western interior of North America. Several transgressive-regressive cycles caused the deposition of a series of offshore marine, shallow-marine, and marginal-marine sediments in the Mount Harris area (Ryer, 1977).

The Mancos Shale was deposited in an offshore marine environment which existed east of the shifting strand line. Deposition of the Mancos Shale ended in the quadrangle area with the eastward movement of the shoreline, and the subsequent deposition of the Iles Formation (Kucera, 1959).

The interbedded sandstone, shale, and coal of the Mesaverde Group were deposited as a result of minor changes in position of the shoreline. During the deposition of the Iles and Williams Fork Formations, near-shore marine, littoral, brackish tidal, brackish and fresh water supratidal, and fluvial environments existed in northwestern Colorado. The major sandstones of the Iles and Williams Fork Formations, including the Trout Creek and Twentymile Sandstone Members, were deposited in shallow marine and near-shore marine environments. The major coal beds

which have wide areal extent were deposited near the seaward margin of the non-marine environments, probably in large brackish-water lagoons or swamps. The slow migration of this depositional environment is responsible for the wide distribution of the Wadge and Wolf Creek coal beds in the Yampa study area. Coals of limited areal extent, including those in the Lower Coal Group, were generally deposited in environments associated with fluvial systems such as back-levee and coastal plain swamps, interchannel basin areas, and abandoned channels (Konishi, 1959; Kucera, 1959).

A large rise in sea level caused a landward movement of the shoreline which resulted in the end of the deposition of the near-shore and continental sediments of the Mesaverde Group. After this rise in sea level, the marine Lewis Shale was deposited in the Mount Harris quadrangle area (Kucera, 1959).

Structure

The Yampa KRCRA lies in the southern extension of the Washakie/ Sand Wash structural basin of south-central Wyoming. The basin is bordered on the east by the Park Range, approximately 22 miles (35 km) east of the Mount Harris quadrangle, and on the southwest by the Axial Basin anticline, located approximately 25 miles (40 km) southwest of the quadrangle.

The axis of the Hayden syncline, a synclinal extension of the Washakie/ Sand Wash Basin, trends southeastward through the central part of the quadrangle, and is modified in the Mount Harris quadrangle by three major structural features, the Sage Creek and Fish Creek anticlines in the southwestern and southeastern parts of the quadrangle, and the western edge of the Tow Creek anticline along the eastern edge of the quadrangle. Several northwest-trending faults cut the Tow Creek anticline in the northeastern part of the quadrangle (Bass and others, 1955). The amount and direction of the dips of the coal-bearing rocks of the Iles and Williams Fork Formations vary greatly throughout the quadrangle.

The structure contour maps of the isopached coal beds are based on a regional structure map of the top of the Trout Creek Sandstone Member by Bass and others (1955), and it is assumed that the structure of the coal beds duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop and drill-hole data. Drill holes from which the elevations of the tops of the coal beds could not be determined are not shown on the structure maps and were not used as data points in map construction.

COAL GEOLOGY

Coal beds in the Lower, Middle, and Upper Coal Groups have been identified in this quadrangle. The Lower Coal Group includes all coal beds in the Iles Formation below the Trout Creek Sandstone Member and the Middle Coal Group includes the coal beds between the Trout Creek and Twentymile Sandstone Members in the lower coal-bearing zone of the Williams Fork Formation. The Upper Coal Group includes the Williams Fork Formation coal beds above the Twentymile Sandstone Member and extends to the contact between the Williams Fork Formation and the Lewis Shale. Coals beds in the Lower and Upper Groups are characteristically lenticular and of limited areal extent, while the coal beds in the Middle Group persist over a large area. Several of the coal beds which exceed Reserve Base thickness (5.0 feet or 1.5 meters) are not formally named, and have been given bracketed numbers for identification purposes in this quadrangle only.

Chemical analyses of coals.--Analyses of the coals in this area are listed in table 1 and include those for the Wolf Creek and Wadge coal beds of the Middle Coal Group. Chemical analyses were not available in the Mount Harris quadrangle for coals from the Lower and Upper Coal Groups. However, it is believed that these coals are similar in rank to the Lower Coal Group, zone 3, and Upper Coal Group, zone L coals mined, respectively, at the Nicholas Stein Mine in the Rattlesnake Butte quadrangle to the southeast and the Sleepy Cat Mine in the Hayden quadrangle to the west.

In general, chemical analyses of coals in the Lower, Middle, and Upper Coal Groups indicate that these coals are high-volatile C bituminous in rank on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Lower Coal Group

Coal beds in the Lower Coal Group crop out in the southwestern part of the quadrangle, and a series of thin beds separated by thin rock partings have been mined in sec. 11, T. 5 N., R. 88 W. Bass and others (1955) identified three coal zones in the Lower Coal Group in the Oak Creek district to the east. However, the Lower Group coal beds identified in this quadrangle could not be placed within a specific coal zone because of incomplete geologic data. Of the numerous thin, lenticular coal beds that do occur in the Lower Coal Group in the Mount Harris quadrangle, only five exceed Reserve Base thickness (5.0 feet or 1.5 meters). These beds are designated LG[1] (i.e., Lower Coal Group, coal bed [1], LG[6], LG[7], LG[9], and LG[10]. Because each of these coal beds has been measured at only one location they are treated as isolated data points (see Isolated Data Points section of this report).

Middle Coal Group

Coal beds in the Middle Coal Group are located between the top of the Trout Creek Sandstone Member of the Iles Formation and the base of the Twentymile Sandstone Member of the Williams Fork Formation. Included in the Middle Coal Group are the Wolf Creek, Wadge, and Lennox coal beds that are known to persist over large areas. Three unnamed Middle Group coal beds have also been identified in the quadrangle. However, because they were each identified at only one location and cannot be correlated, they are treated as isolated data points.

Wolf Creek Coal Bed

The Wolf Creek coal bed, located approximately 50 feet (15 m) stratigraphically above the Trout Creek Sandstone Member, has been identified in the eastern and south-central parts of the quadrangle in

outcrops, mine-measured sections, and drill holes (plate 4). It generally occurs as a single bed, but contains local rock partings ranging from 0.6 to 1.5 feet (0.2 to 0.5 m) thick. In this quadrangle, the coal bed ranges in thickness from 8.5 to 19.0 feet (2.6 to 5.8 m), excluding partings, and tends to thicken from the west to the east.

The Wolf Creek coal bed extends to the east into the western part of the adjacent Milner quadrangle where it is inferred to range from 7 to 19 feet (2.1 to 5.8 m) in thickness. In the eastern part of the adjacent Hooker Mountain quadrangle to the north, the coal bed ranges from 3 to 17 feet (0.9 to 5.2 m) in thickness.

Wadge Coal Bed

The Wadge coal bed lies approximately 210 feet (64 m) above the Trout Creek Sandstone Member. It has been mined extensively in the Seneca No. 2 strip mine and the underground Harris and Wadge mines in the northeast part of the quadrangle. Measurements of the Wadge coal bed range from 6.1+ to 12.0 feet (1.9+ to 3.7 m) in thickness in this quadrangle.

The coal bed extends into the adjacent Dunckley quadrangle to the south where it has a maximum measured thickness of 11.8 feet (3.6 m). Also, the Wadge extends into the Milner quadrangle to the east where measured thicknesses range from 6.0 to 11.0 feet (1.8 to 3.4 m).

Lennox Coal Bed

The Lennox coal bed lies approximately 40 to 50 feet (12 to 15 m) stratigraphically above the Wadge coal bed. This coal bed is not known to be of Reserve Base thickness in this quadrangle, but it is worthy of note because the coal bed has been mined in some areas in addition to the principal Wadge coal bed.

Upper Coal Group

The Upper Coal Group includes all coal beds above the Twentymile Sandstone Member in the upper coal-bearing zone of the Williams Fork Formation. Numerous coal beds have been identified in the Upper Coal

Group in the eastern part of the Yampa KRCRA, but only two coal beds in this group have been recognized in the Mount Harris quadrangle. Only one of these coal beds, the UG[12], exceeds Reserve Base thickness and has been treated as an isolated data point.

Isolated Data Points

In instances where single or isolated measurements of coal beds thicker than 5 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these coal beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlations with other, better known coal beds. For this reason, isolated data points are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. Descriptions and Reserve Base tonnages for the isolated data points occurring in this quadrangle are listed in table 5.

COAL RESOURCES

Data from oil and gas wells, as well as data from drill holes, mine measured sections, and outcrop measurements (Bass and others, 1955; U.S. Geological Survey, 1933, 1958, and 1964) were used to construct outcrop, isopach, and structure contour maps of the Wolf Creek and Wadge coal beds in this quadrangle. The source of each indexed data point shown on plate 1 is listed in table 6.

Coal resources for Federal land were calculated using data obtained from the coal isopach maps (plates 4 and 8) and the areal distribution and identified resources maps (plates 7 and 11). The coal bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal, yields the coal resources in short tons of coal for each isopached coal bed. Coal beds of Reserve Base thickness that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ somewhat from those stated in U.S. Geological Survey Bulletin 1450-B which call

for a minimum thickness of 28 inches (70 cm) and a maximum depth of 1,000 feet (305 m) for bituminous coal.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on plates 7 and 11, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by the isolated data points. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 231.74 million short tons (210.23 million metric tons) for the entire quadrangle, including the tonnages for the isolated data points.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential; 25 acres (10 ha), a moderate development potential; and 10 acres (4 ha), a low development potential; then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

Areas where the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining and can be assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is shown on the following page:

$$MR = \frac{t_o\ (cf)}{t_c\ (rf)}$$

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.911 for subbituminous coal
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to areas where coal beds 5.0 feet (1.5 m) or more thick are not known, but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth, and attitude of the coal beds in these areas prevents accurate evaluation of the development potential in the high, moderate, or low categories. The areas influenced by the isolated data points in this quadrangle contain approximately 2.82 million short tons (2.56 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 12. Of the Federal land areas having a known development potential for surface mining, 93 percent are rated high, 3 percent are

rated moderate, and 4 percent are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods. Reserve Base tonnages in the various development potential categories for surface mining methods are listed in table 2.

Development Potential for Subsurface and In-Situ Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where the coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. Unfaulted coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Areas where the coal data is absent or extremely limited between 200 and 3,000 feet (61 and 914 m) below the ground surface are assigned unknown development potentials. This applies to the areas influenced by isolated data points and to those areas where coal beds of Reserve Base thickness are not known, but may occur. The areas influenced by isolated data points in this quadrangle contain approximately 22.77 million short tons (20.66 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 13. Of the Federal land areas classified as having known development potential for conventional subsurface mining methods, 52 percent are rated high and 48 percent are rated moderate.

The remaining Federal land within the KRCRA boundary is classified as having unknown development potential for conventional subsurface mining methods. Reserve Base tonnages in the various development potential categories for conventional subsurface mining methods are listed in table 3.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 35° and 90° with a minimum Reserve Base of 50 million short tons (45.4 million metric tons) for bituminous coal and 70 million short tons (63.5 million metric tons) for subbituminous coal have a moderate potential for in-situ development; coal beds dipping from 15° to 35°, regardless of tonnage, and coal beds dipping from 35° to 90° with less than 50 million short tons (45.4 million metric tons) of coal have a low development potential for in-situ mining methods. Coal lying between the 200-foot (61 m) overburden line and the outcrop is not included in the total coal tonnages available as it is needed for cover and containment in the in-situ process.

Areas where faulted coal beds of Reserve Base thickness dip greater than 15° between 200 and 3,000 feet (61 and 914 m) below the ground surface are classified as having an unknown development potential for in-situ mining methods. These criteria also apply to those areas influenced by isolated data points where the coal beds dip greater than 15° and are not faulted. The areas influenced by isolated data points in this quadrangle contain approximately 7.50 million short tons (6.80 million metric tons) of coal available for in-situ mining.

Coal development potential for in-situ mining methods is shown on plate 13. All of the Federal land areas classified as having known development potential for in-situ mining methods are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for in-situ mining methods. Reserve Base tonnages in the various development potential categories for in-situ mining methods are listed in table 4.

Table 1. -- Chemical analyses of coals in the Mount Harris quadrangle, Routt County, Colorado.

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
SW¼, NE¼, sec. 23, T. 4 N., R. 86 W., Nicholas Stein Mine (George and others, 1937) from Rattlesnake Butte quadrangle	Lower Coal Group Zone 3	A	9.0	36.2	49.4	5.4	0.5	5.6	68.3	1.4	18.8	6,650	11,970
		C	-	39.8	54.2	6.0	0.5	5.0	75.0	1.6	11.9	7,306	13,150
		D	-	42.3	57.7	-	0.6	5.3	79.8	1.6	12.7	7,772	13,990
NE¼, sec. 15, T. 6 N., R. 87 W., International No. 1 Mine (Fieldner and others, 1918, Bass and others, 1955)	Wolf Creek	A	9.31	36.82	40.76	12.61	0.44	-	-	-	-	5,946	10,703
		B	7.4	37.8	41.9	12.9	0.5	-	-	-	-	6,105	10,990
		C	-	40.83	45.19	13.98	0.49	-	-	-	-	6,593	11,867
		D	-	47.46	52.54	-	0.57	-	-	-	-	7,664	13,795
Sec. 15, T. 6 N., R. 87 W., No. 1 Wadge Mine (Bass and others, 1955)	Wadge	A	11.5	37.8	45.9	4.8	0.4	-	-	-	-	6,390	11,500
		B	5.0	40.5	49.3	5.2	0.4	-	-	-	-	6,860	12,350
		C	-	42.7	51.9	5.4	0.5	-	-	-	-	7,215	12,990
		D	-	45.1	54.9	-	0.5	-	-	-	-	7,630	11,740
NE¼, sec. 10, T. 6 N., R. 87 W., Moauro Mine (Bass and others, 1955)	Wadge	A	11.1	33.3	49.2	6.4	0.5	5.9	64.1	1.6	21.5	6,211	11,180
		B	9.6	33.9	50.0	6.5	0.5	5.8	65.2	1.6	20.4	6,317	11,370
		C	-	37.4	55.4	7.2	0.6	5.3	72.1	1.8	13.0	6,989	12,580
		D	-	40.4	59.6	-	0.6	5.7	77.7	1.9	14.1	7,533	13,560
NW¼, sec. 16, T. 5 N., R. 88 W., Sleepy Cat Mine (Bass and others, 1955) from Hayden quadrangle	Upper Coal Group Zone L	A	14.4	32.6	48.5	4.5	0.9	6.0	63.2	1.5	23.9	6,134	11,040
		C	-	38.1	56.6	5.3	1.0	5.1	73.8	1.9	13.0	7,172	12,910
		D	-	40.3	59.7	-	1.1	5.4	78.0	1.9	13.6	7,572	13,630

Form of Analysis: A, as received
B, air dried
C, moisture free
D, moisture and ash free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2. -- Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Mount Harris quadrangle, Routt County, Colorado.

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Wadge	760,000	620,000	940,000	-	2,320,000
Wolf Creek	3,030,000	1,910,000	1,030,000	-	5,970,000
Isolated Data Points	-	-	-	2,820,000	2,820,000
Totals	3,790,000	2,530,000	1,970,000	2,820,000	11,110,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 3. -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Mount Harris quadrangle, Routt County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Wadge	22,580,000	53,330,000	-	-	75,910,000
Wolf Creek	8,470,000	63,530,000	-	-	72,000,000
Isolated Data Points	-	-	-	22,770,000	22,770,000
Totals	31,050,000	116,860,000	-	22,770,000	170,680,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 4. -- Coal Reserve Base data for in-situ mining methods for Federal coal lands (in short tons) in the Mount Harris quadrangle, Routt County, Colorado.

Coal Bed	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Wadge	-	19,130,000	-	19,130,000
Wolf Creek	-	23,320,000	-	23,320,000
Isolated Data Points	-	-	7,500,000	7,500,000
Totals	-	42,450,000	7,500,000	49,950,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 5.--Descriptions and Reserve Base tonnages (in million short tons) for isolated data points

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages		
				Surface	Subsurface	In-Situ
LG[1]	Benson, Montin, and Greer, Fish Creek Unit #3-2	sec. 2, T. 5 N., R. 88 W.	6.0 ft. (1.8 m)	0	1.76	0.36
LG[6]	Bass and others (1955)	sec. 11, T. 5 N., R. 88 W.	10.6 ft. (3.2 m)	1.01	3.70	1.67
LG[7]	Ancora Corp. and Compass Exploration, Sage Creek Fed. #1	sec. 11, T. 5 N., R. 88 W.	12.0 ft. (3.7 m)	0	5.54	4.15
LG[9]	Mobil, Sage, Creek #34-14	sec. 14, T. 5 N., R. 88 W.	7.0 ft. (2.1 m)	0.37	1.99	0
LG[10]	Mobil, Sage, Creek #34-14	sec. 14, T. 5 N., R. 88 W.	6.0 ft. (1.8 m)	0.36	1.64	0
MG[3]	Benson, Montin, and Greer, Fish Creek Unit #3-2	sec. 2, T. 5 N., R. 88 W.	7.0 ft. (2.1 m)	0	2.05	0.42
MG[4]	Benson, Montin, and Greer, Fish Creek Unit #3-2 Bass and others (1955)	sec. 2, T. 5 N., R. 88 W.	10.0 ft. (3.0 m)	0.15	3.28	0.58
MG[5]	Benson, Montin, and Greer, Fish Creek Unit #3-2 Bass and others (1955)	sec. 2, T. 5 N., R. 88 W.	8.0 ft. (2.4 m)	0.03	2.81	0.32
UG[12]	Bass and others (1955)	sec. 35, T. 6 N., R. 88 W.	11.0 ft. (3.4 m)	0.90	0	0

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 6. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Harris Mines, Inc.	Drill hole No. 5
2	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Measured Section No. 158a
3	Benson, Montin, and Greer	Oil/gas well No. 3-2 Fish Creek Unit
4	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Mine-Measured Section No. 233
5	Ancora Corp. and Compass Exploration	Oil/gas well No. 1 Sage Creek-Federal
6	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Measured Section No. 234
7	↓	Measured Section No. 235
8	Mobil Corp.	Oil/gas well No. 34-14 Sage Creek
9	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section No. 167a
10	U.S. Geological Survey, 1964, Inactive Coal Lease No. Denver 035164, M. L. Moauro	Wolf Creek Drill hole No. 1
11	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Mine-Measured Section No. 168a, Moauro Mine
12	↓	Drill hole No. 169
13	↓	Mine-Measured Section No. 174, International Coal Co. No. 1 Mine

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
14	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Mine-Measured Section No. 176, Wadge Mine
15	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 6 (No. C)
16	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section No. 178
17	↓	Measured Section No. 180
18	↓	Mine-Measured Section No. 175, Victor-American Fuel Co. No. 1 Wadge Mine
19	↓	Mine-Measured Section No. 177, Harris Mine
20	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 2 (No. D)
21	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section No. 181
22	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 7
23	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section
24	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 072654, Colorado and Utah Coal Co.	Drill hole No. 5
25	↓	Drill hole No. 7D
26	↓	Drill hole No. 7B

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
27	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 7C
28	↓	Drill hole No. 4 (No. A)
29		Drill hole No. 7A
30	Bass, N. W., (no date) U.S. Geological Survey, unpublished field notes	Drill hole No. 5
31	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Harris Mines, Inc.	Drill hole No. B
32	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 5
33	↓	Drill hole No. 1
34		Drill hole No. 6
35		Drill hole No. 2
36	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Harris Mines, Inc.	Drill hole No. 2
37	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 3
38	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Harris Mines, Inc.	Drill hole No. 3
39	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Mine-Measured Section No. 189, Grassy Creek Mine

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
40	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Colorado and Utah Coal Co.	Drill hole No. 4
41	U.S. Geological Survey, 1933, Inactive Coal Prospecting Permit No. Denver 039644, Harris Mines, Inc.	Drill hole No. 8
42	U.S. Geological Survey, 1958, Inactive Coal Lease No. Denver 032654, Harris Mines, Inc.	Drill hole No. 7
43	U.S. Geological Survey, 1933, Inactive Coal Prospecting Permit No. Denver 039644, Harris Mines, Inc.	Drill hole No. 1
44	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section No. No. 245
45		Measured Section No. 246
46		Measured Section No. 248
47		Measured Section No. 247

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