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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HORSE GULCH QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 65 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

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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 Horse Gulch quadrangle, Moffat 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 United States Geological Survey under contract number 14-08-0001-15789. 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 Published and unpublished public information available through July, 1978, was used as the data base for this study. No new drilling or field mapping was done as part of this study.

Location

The Horse Gulch quadrangle is located in southeastern Moffat County in northwestern Colorado approximately 11 airline miles (18 km) west of the town of Craig and approximately 24 airline miles (38 km) north-northeast of the town of Meeker, Colorado. There are no major highways within the quadrangle. With the exception of several ranches, the area within the quadrangle is unpopulated.

Accessibility

The Horse Gulch quadrangle lies approximately 2 to 3 miles (3.2 to 4.8 km) south of U.S. Highway 40. An improved light-duty road crossing the southwest corner of the quadrangle connects the town of Lay (and U.S. Highway 40), approximately 9 miles (14 km) northeast of the quadrangle, with the town of Axial, approximately 7 miles (11 km) to the south. Colorado Highway 13 (also known as Colorado Highway 789) passes approximately 3 miles (5 km) south-southeast of the quadrangle. The remainder of the quadrangle is accessible along numerous unimproved dirt roads and trails.

Railway service for the Horse Gulch quadrangle is provided by the Denver and Rio Grande Railroad from Denver to the old railhead at Craig. A new railroad spur has been constructed from Craig to the Colowyo mine near Axial. This new spur follows the Yampa River westward, turning south at Milk Creek and progressing up the creek in the southeast corner of the quadrangle.

Physiography

The Horse Gulch quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle lies approximately 10 miles (16 km) west of the Williams Fork Mountains and 59 miles (95 km) west of the Continental Divide. The southwestern part of the quadrangle lies in the Axial Basin.

The topography in the northeastern half of the quadrangle and in the southwest corner (the Axial Basin) is characterized by relatively broad gentle slopes. A broad northwest-trending band across the central part of the quadrangle consists of moderate to steep slopes deeply incised by the Yampa River. Duffy Mountain, a northwest-trending escarpment in the southwestern part of the quadrangle, lies between the northeastern flank of the Axial Basin and the Yampa River.

Altitudes in the quadrangle range from more than 7,000 feet (2,134 m) on Duffy Mountain in the south-central part of the quadrangle to less than 6,000 feet (1,829 m) in the Yampa River valley at the west-central edge of the quadrangle.

Streams in the Horse Gulch quadrangle flow into the Yampa River which flows west-northwest across the center of the quadrangle. Horse Gulch, Sand Spring Gulch, and Fuhr Gulch flow southwest. Morgan Gulch and its tributaries flow northwest into the Yampa River; Milk Creek flows north into the Yampa River. With the exception of the Yampa River and Milk Creek, these streams are intermittent and flow mainly in response to snowmelt in the spring.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Horse Gulch quadrangle area, with daily temperatures typically varying from 1° to 34°F (-17° to 1°C) in January and from 46° to 86°F (8° to 30°C) in July. Annual precipitation in the area averages approximately 12 inches (30 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 (5 km per hour) are generally from the west, but directions tend to vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

The dominant vegetation in the quadrangle is sagebrush. Pinyon, Utah juniper, and Rocky Mountain juniper grow in the southeast corner and along the west-central edge of the quadrangle. Areas along Sand Spring Gulch and Fuhr Gulch in the northeast corner and east-central part of the quadrangle are utilized as cropland (U.S. Bureau of Land Management, 1977).

Land Status

The Horse Gulch quadrangle lies on the western edge of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately two thirds of the quadrangle lies within the KRCRA boundary and the Federal government owns the coal rights for approximately 90 percent of this area as shown on plate 2. There are no active coal leases in the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Horse Gulch 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 1910, including papers by Hewett (1889), Hills (1893), Storrs (1902) and Gale (1910). Fenneman and Gale (1906) conducted a geologic study of the Yampa coal field. A geologic map and report by Hancock (1925) included the Horse Gulch quadrangle. Tweto (1976) compiled a generalized regional geologic map that includes this quadrangle. Results from coal test holes drilled by the U.S. Geological Survey in the Horse Gulch quadrangle during 1976, 1977, and 1978 were reported by Brownfield (1976), Muller (1976), Johnson (1978), and Meyer (1978).

Stratigraphy

Rock formations cropping out in the Horse Gulch quadrangle range in age from Late Cretaceous to Miocene, and include the coal-bearing Iles and Williams Fork Formations of the Mesaverde Group.

The Mancos Shale of Late Cretaceous age crops out in the southwest corner of the quadrangle (Hancock, 1925). It is composed of a thick sequence of gray to dark-gray shale with a number of tan silty thin-bedded ridge-forming sandstones interbedded with sandy shale and shale in the upper 1,000 feet (305 m) of the formation (Hancock, 1925; Bass and others, 1955).

The Mesaverde Group of Late Cretaceous age conformably overlies the Mancos Shale and contains two formations, the Iles and the Williams Fork.

The Iles Formation crops out as a northwest-trending band across the southwestern part of the quadrangle (Hancock, 1925). The thickness of the formation is unknown in this quadrangle, but in adjacent quadrangles it ranges from 1,300 to 1,500 feet (396 to 457 m) thick where measured in oil and gas wells. The basal "rim rock" sandstone (Hancock, 1925; Konishi, 1959) is approximately 65 feet (20 m) thick and consists of tan to brown massive sandstone. Overlying the "rim rock" sandstone is approximately 1,020 to 1,360 feet (311 to 415 m) of light-colored thin-bedded sandstone, interbedded with gray sandy shale. The overlying Trout Creek Sandstone Member consists of approximately 75 feet (23 m) of white, fine-grained, thick-bedded to massive cliff-forming sandstone. The top of the Trout Creek Sandstone Member forms the contact between the Iles Formation and the conformably overlying Williams Fork Formation (Hancock, 1925; Bass and others, 1955).

The Williams Fork Formation crops out in a wide band extending from the east-central part to the northwest corner of the quadrangle (Hancock, 1925). It consists of approximately 1,600 feet (488 m) of alternating sandstone, sandy shale, carbonaceous shale and coal beds (Hancock, 1925). The formation is divided into three units: a lower coal-bearing unit, the Twentymile Sandstone Member, and an upper coal-bearing unit (Bass and others, 1955). The lower unit of the Williams Fork Formation consists of thin-bedded sandstone, dark-gray to black sandy shale, carbonaceous shale, and lenticular coal beds (Hancock, 1925; Bass and others, 1955). Fenneman and Gale (1906) have designated the coal in this lower unit as the Middle Coal Group.

The Twentymile Sandstone Member is approximately 100 feet (30 m) thick and is, characteristically, a white fine-grained massive sandstone (Hancock, 1925; Bass and others, 1955).

The upper coal-bearing unit of the Williams Fork Formation overlies the Twentymile Sandstone Member. It is composed of interbedded dark-gray shale, massive white sandstone, sandy shale, and coal beds (Bass and others, 1955). The coal beds in this upper unit, between the top of the Twentymile Sandstone Member and the base of the Lewis Shale, form the Upper Coal Group (Fenneman and Gale, 1906).

The Lewis Shale of Late Cretaceous age conformably overlies the Williams Fork Formation and crops out in the northern and east-central parts of the quadrangle. It consists of dark-gray shale interbedded with a few thin beds of sandstone (Hancock, 1925). The total thickness of the Lewis Shale is unknown in this quadrangle, but it ranges in thickness from 2,090 to 2,200 feet (637 to 671 m) where measured in the oil and gas wells in the Lay SE quadrangle to the north.

The Fox Hills Sandstone of Late Cretaceous age intertongues with the underlying marine Lewis Shale and the overlying brackish-water and fluviatile sandstone and shale of the Lance Formation (Haun, 1961). It consists of gray to white fine-grained fossiliferous sandstone interbedded with gray to dark-gray sandy shale, shale, and, sometimes, coal

(Dorf, 1942). The thickness of the sandstone is unknown in this quadrangle. However, where measured in oil and gas wells drilled in the Lay SE quadrangle, the Fox Hills Sandstone ranges in thickness from 130 to 155 feet (40 to 47 m). The outcrop of the Fox Hills Sandstone was not mapped by Hancock (1925).

The Lance Formation of Late Cretaceous age crops out in the northeast corner of the quadrangle along the axis of the Round Bottom syncline. It consists of a non-marine sequence of sandstone, siltstone, and carbonaceous shale (Haun, 1961). In the Lay SE quadrangle, the Lance Formation is approximately 650 feet (198 m) thick where measured in oil and gas wells, but the total thickness of the formation is unknown in this quadrangle.

The Miocene-age Browns Park Formation rests unconformably on the Williams Fork Formation and Lewis Shale in the northwestern part of the quadrangle (Hancock, 1925; Tweto, 1976). It is composed of fluvial siltstone, claystone, conglomerate, and loosely consolidated eolian tuffaceous sandstone, becoming more conglomeratic toward the base (Tweto, 1976).

Holocene deposits of alluvium cover the stream valleys and gulches throughout the quadrangle.

The Cretaceous formations cropping out in the Horse Gulch quadrangle accumulated close to the western edge of a Late Cretaceous 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, marginal-marine, and non-marine sediments in the Horse Gulch quadrangle 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 in the quadrangle area ended with the eastward migration of the shoreline, and the subsequent deposition of the Iles Formation (Konishi, 1959; Kucera, 1959).

The interbedded sandstone, shale, and coal of the Mesaverde Group were deposited as a result of minor changes in the position of the shoreline. Near-shore marine, littoral, brackish tidal, brackish and fresh water supratidal, and fluvial environments existed during the deposition of the Iles and Williams Fork Formations. The major sandstones of the Iles and Williams Fork Formations, including the "rim rock" sandstone, and the Trout Creek and Twentymile Sandstone Members, were deposited in shallow marine and near-shore environments. The lenticular coal beds of the Lower, Middle, and Upper Coal Groups 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).

Deposition of the Lewis Shale marked a landward movement of the sea. The marine sediments of the Lewis Shale were deposited in water depths ranging from a few tens of feet to several hundred feet until a regional uplift west of the Yampa Basin area caused a regression of the sea and ended the deposition of the Lewis Shale in the area (Kucera, 1959).

As the sea retreated to the northeast, the Fox Hills Sandstone was deposited over the Lewis Shale in a littoral and near-shore environment. Following the regression of the Cretaceous sea, broad areas of estuarine, marsh, lagoonal, and coastal swamp environment resulted in deposits of carbonaceous shales, mudstones, and thin coal beds, characteristic of the Lance Formation (O'Boyle, 1955; Weimer, 1961).

The Browns Park Formation was deposited after a long period of non-deposition and erosion. It is a continental deposit consisting mostly of fluvial and eolian deposits and much of its thickness has been removed as a result of late Cenozoic erosion (Carey, 1955).

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, about 58 miles (93 km) east-northeast of the Horse Gulch quadrangle, and on the southwest by the Axial Basin anticline, in the southwestern part of the quadrangle.

The axis of the northwest-trending Round Bottom syncline lies in the northeastern part of the quadrangle. The axis of the Axial Basin anticline, which parallels the Round Bottom syncline, is approximately 1 mile (1.6 km) southwest of the quadrangle. The average dip of the beds ranges from approximately 5° to 13° northeast, except in the northeast corner of the quadrangle on the northeastern flank of the Round Bottom syncline where beds dip approximately 8° to the southwest (Hancock, 1925).

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 Hancock (1925), and it is assumed that the structure of the coal bed nearly duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop and drill-hole data.

COAL GEOLOGY

Numerous coal beds in the Middle and Upper Coal Groups of the Williams Fork Formation have been identified in the Horse Gulch quadrangle. The Middle Coal Group includes the coal beds in the lower coal-bearing zone of the Williams Fork Formation extending from the top of the Trout Creek Sandstone Member of the Iles Formation upward to the base of the Twentymile Sandstone Member. The Upper Coal Group includes the coal beds in the upper part of the Williams Fork Formation above the Twentymile Sandstone Member.

In general, the Middle and Upper Coal Groups contain numerous coal beds that are thin, lenticular, and of limited areal extent even though many of the isopached coal beds in this quadrangle extend into adjacent quadrangles. Only about 30 percent of the coal beds exceeding Reserve Base thickness (5.0 feet or 1.5 meters) can be correlated between drill holes and/or outcrops. The remaining 70 percent of the coal beds were each identified at one location only and have been treated as isolated data points (see Isolated Data Points section of this report). Coal beds that are not formally named and exceed Reserve Base thickness have been given bracketed numbers for identification purposes.

Dotted lines shown on some of the derivative maps represent a limit of confidence beyond which isopach, structure contour, overburden isopach, and areal distribution and identified resources maps are not drawn because of insufficient data, even where it is believed that the coal beds may continue to be greater than Reserve Base thickness beyond the dotted lines.

Chemical analyses of coal.--Chemical analyses were not available for coals in the Middle and Upper Coal Groups of the Williams Fork Formation in this quadrangle, but representative analyses of these coals from George and others (1937) and Dawson and Murray (1978) are listed in table 1. In general, chemical analyses indicate that the coals in the Middle Coal Group are high-volatile C bituminous and the coals in the Upper Coal Group probably range from subbituminous A to 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).

Middle Coal Group

Forty-five coal beds and three coal zones exceeding Reserve Base thickness in the Middle Coal Group have been identified throughout the quadrangle. Seventeen of the coal beds were isopached and 29 coal beds, including three located on non-Federal land, were treated as isolated data points. Another three coal beds, the MG[102] (i.e., Middle Coal Group, coal bed [102]), MG[104], and MG[108], have not been identified in this quadrangle but have been projected into the northwest corner based on measured thicknesses of the coal beds in the adjacent Juniper Hot Springs quadrangle to the west.

Coal beds in the Middle Coal Group occur in two general areas, in the central to east-central and in the northwestern parts of the quadrangle. A general description of each area is included below, followed by a detailed discussion of only those Middle Coal Group coal beds which are believed to contain more than 10.00 million short tons (9.07 million metric tons) of coal.

The coal beds in the central to east-central part of the quadrangle lie on the southwestern limb of the Round Bottom syncline and dip to the northeast from approximately 5° to 14°. Coal beds in this area range in thickness from 1.5 to 26.7 feet (0.5 to 8.1 m). Rock partings are common and range in thickness from 1.0 to 6.5 feet (0.3 to 2.0 m). Several of the coal beds extend into adjacent quadrangles to the east and west where they have the same designation.

The coal beds identified in the northwestern part of the quadrangle range in thickness from 2.7 to 16.0 feet (0.8 to 4.9 m). Rock partings ranging from 1.0 to 9.0 feet (0.3 to 2.7 m) thick occur locally. The coal beds generally dip from approximately 6° to 13° to the northeast, steepening toward the northern border of the quadrangle where the dips range from approximately 10° to 16° east-southeast. Several of the coal beds in this area extend into adjacent quadrangles to the west, northwest, and north where they have the same designation.

Middle Coal Group, Coal Bed [1]

The MG[1] coal bed (plate 4) was identified in three coal test holes drilled in the west-central part of the quadrangle and ranges in thickness from 5.5 to 6.5 feet (1.7 to 2.0 m). Rock partings ranging from 1.0 to 1.7 feet (0.3 to 0.5 m) occur locally. The coal bed attains its maximum thickness in sec. 19, T. 6 N., R. 93 W. In the Juniper Hot Springs quadrangle to the west, the coal bed has a measured thickness of 5.7 feet (1.7 m) at one location along the outcrop in sec. 19, T. 6 N., R. 93 W.

Middle Coal Group, Coal Zone [7]

Individual coal beds in the MG[7] coal zone thicken, thin, and split over short distances, ranging from less than 2 feet (0.6 m) to a maximum of 14.5 feet (4.4 m) where penetrated by three coal test holes drilled in the central part of the quadrangle. The zone contains cumulative coal thicknesses ranging from 17.0 to 25.0 feet (5.2 to 7.6 m) with rock partings totalling from 5.0 to 12.3 feet (1.5 to 3.7 m) in thickness as shown on plate 7.

Middle Coal Group, Coal Zone [15]

The coal beds in this zone are similar to those in the MG[7] coal zone. Individual coal beds range in thickness from less than 2.0 feet (0.6 m) to a maximum of 12.3 feet (3.7 m) where measured in two coal test holes and an outcrop in the central part of the quadrangle. Cumulative coal thicknesses range from 12.0 to 26.8 feet (3.7 to 8.2 m) in the zone (plate 14) and cumulative rock partings total from 2.0 to 11.3 feet (0.6 to 3.4 m) in thickness.

Peacock Coal Bed

The Peacock coal bed (plate 32) is an extensive coal bed which crops out in the northwestern part of the quadrangle. It ranges in thickness from 2.7 to 16.0 feet (0.8 to 4.9 m) in this quadrangle, the maximum reported thickness occurring in the coal test hole drilled in sec. 18, T. 6 N., R. 93 W. Local rock partings occur in the coal bed and range in thickness from 1.0 to 9.0 feet (0.3 to 2.7 m). The coal bed is burned and clinkered along the outcrop in sec. 18, T. 6 N., R. 93 W. In the Juniper Hot Springs quadrangle, the coal bed ranges in thickness from 11.7 to 17.0 feet (3.6 to 5.2 m) where measured at an outcrop and in a drill hole. In the Lay quadrangle to the northwest, the coal bed ranges in thickness from 11.5 to 14.0 feet (3.5 to 4.3 m) where measured along the outcrop and may be as much as 16 feet (4.9 m) thick in the extreme southwest corner of that quadrangle. The Peacock coal bed has not been identified in the Lay SE quadrangle to the north, but it is believed to range from 11 to 16 feet (3.4 to 4.9 m) thick in the area where it has been projected into that quadrangle.

Middle Coal Group, Coal Zone [22]

This coal zone (plate 36) is quite extensive over the northwestern and central parts of the quadrangle. Individual coal beds vary from 1.0 to 15.0 feet (0.3 to 4.6 m) in thickness where penetrated by numerous coal test holes. Cumulative thicknesses of the coal in the zone range from 11.5 feet (3.5 m) to a maximum of 27.3 feet (8.3 m), and the zone contains rock partings totalling from 3.2 to 35.7 feet (1.0 to 10.9 m) in thickness. The coal zone is believed to extend into the Juniper Hot Springs quadrangle where only one coal bed in the zone was penetrated by a drill hole in sec. 6, T. 6 N., R. 93 W. This coal bed is 6.0 feet (1.8 m) thick at that location and contains a rock parting 1.0 foot (0.3 m) thick.

Middle Coal Group, Coal Bed [36]

The MG[36] coal bed (plate 23) was identified in several drill holes and an outcrop in the central part of the quadrangle. The coal bed ranges in thickness from 3.5 to 16.0 feet (1.1 to 4.9 m), attaining its maximum reported thickness in sec. 27, T. 6 N., R. 93 W. Rock partings ranging from 3.0 to 6.5 feet (0.9 to 2.0 m) thick were reported at three locations. In cases where the thickness of the rock parting is greater than one of the coal bed splits, only the thicker of the splits has been used in constructing the isopach map.

Middle Coal Group, Coal Bed [37]

The MG[37] coal bed (plate 46) ranges in thickness from 1.5 to 12.5 feet (0.5 to 3.8 m) where penetrated by drill holes over a large area in the central part of the quadrangle. The coal bed attains its maximum thickness in sec. 22, T. 6 N., R. 93 W. Thin rock partings totalling 1.7 feet (0.5 m) in thickness were reported in the coal best hole drilled in the SW 1/4 sec. 26, T. 6 N., R 93 W.

Upper Coal Group

Twenty-three coal beds exceeding Reserve Base thickness have been identified in the Upper Coal Group, and only six of these were isopached. The remaining 17 coal beds are treated as isolated data points.

Coal beds in the Upper Coal Group occur in the east-central and central parts of the quadrangle. In this area the coal beds lie on the southwestern limb of the Round Bottom syncline and dip at an average of 7° to the north-northeast.

Upper Coal Group, Coal Bed [44]

The UG[44] coal bed (plate 53) has been penetrated by numerous drill holes in the central part of the quadrangle and exceeds Reserve Base thickness in three areas. In the easternmost area, the coal bed ranges in thickness from 3.0 feet (0.9 m) to a maximum of 10.5 feet (3.2 m), excluding two rock partings totalling 2.5 feet (0.8 m) in thickness, in sec. 36, T. 6 N., R. 93 W. Northwest of this area the coal bed ranges in thickness from 3.0 to 10.5 feet (0.9 to 3.2 m), attaining its maximum reported thickness in sec. 26, T. 6 N., R. 93 W. In the northwesternmost area, the coal bed ranges in thickness from 3.7 to 8.5 feet (1.1 to 2.6 m), the maximum thickness being reported in sec. 15, T. 6 N., R. 93 W. Thin rock partings occur randomly throughout the coal bed and range from 0.7 feet (0.2 m) to a cumulative total of 2.5 feet (0.6 m).

Upper Coal Group, Coal Bed [247]

The UG[247] coal bed (plate 57) ranges in thickness from 9.0 to 9.5 feet (2.7 to 2.9 m) where penetrated by two drill holes in the east-central part of the quadrangle and contains rock partings up to 3.0 feet (0.9 m) thick. This coal bed extends into the Round Bottom quadrangle to the east and is inferred to range from 8 to 9 feet (2.4 to 2.7 m) thick in that quadrangle.

Upper Coal Group, Coal Bed [251]

The UG[251] coal bed (plate 60) was penetrated by several coal test holes drilled in the east-central part of the quadrangle where it ranges in thickness from 2.3 to 10.5 feet (0.7 to 3.2 m). Rock partings up to 2.0 feet (0.6 m) thick occur locally. The coal bed has not been identified in the adjacent Round Bottom quadrangle, but it is believed to extend into that quadrangle and may be as much as 7 feet (2.1 m) thick at the west-central edge.

Upper Coal Group, Coal Bed [52]

The UG[52] coal bed (plate 57) ranges in thickness from 4.5 feet (1.4 m) to a maximum of 9.0 feet (2.7 m), excluding a thin rock parting 0.7 feet (0.2 m) thick, where penetrated by three coal test holes in the central part of the quadrangle.

Upper Coal Group, Coal Bed [56]

The UG[56] coal bed (plate 40) has been penetrated by drill holes in the east-central part of the quadrangle where it ranges in thickness from 4.0 to 7.5 feet (1.2 to 2.3 m). Rock partings were not reported in any of the drill holes.

Upper Coal Group, Coal Bed [63]

The UG[63] coal bed (plate 26) ranges in thickness from 4.8 to 9.0 feet (1.5 to 2.7 m) where measured in three coal test holes drilled in the east-central part of the quadrangle. The coal bed appears to be lenticular and is not known to contain rock partings.

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 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 point maps are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. Because of the extreme lenticularity of the coal beds in this quadrangle, it is assumed that these coal beds maintain their measured thicknesses for 1,000 feet (305 m) in all directions from their points of measurement. Also, where the inferred limit of influence from the isolated data point is entirely within non-Federal land, an isolated data point map is not constructed for the coal bed. Descriptions and Reserve

Base tonnages for the isolated data points occurring in this quadrangle and for the influences from isolated data points in adjacent quadrangles are listed in table 4.

COAL RESOURCES

Data from drill holes and outcrop measurements (Gale, 1910; Hancock, 1925; U.S. Geological Survey, 1962; Brownfield, 1976; Johnson, 1978; and Meyer, 1978) were used to construct outcrop, isopach, and structure contour maps of the coal beds in the Horse Gulch quadrangle. The source of each indexed data point shown on plate 1 is listed in table 5.

Coal resources for Federal land were calculated using data obtained from the coal isopach maps and the areal distribution and identified resources maps. The coal bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal and 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 coal bed. Coal beds exceeding Reserve Base thickness (5 feet or 1.5 meters) 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) for bituminous coal and a maximum depth of 1,000 feet (305 m) for both subbituminous and bituminous coal.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on the areal distribution and identified resources maps, 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 553.46 million short tons (502.10 million metric tons) for the entire quadrangle, including the tonnages for the isolated data points. Reserve

Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3.

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 were 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 potential for surface mining methods. This applies to areas where coal beds 5 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 prevents accurate evaluation of development potential in the high, moderate, and low categories. The areas influenced by isolated data points in this quadrangle total approximately 10.94 million short tons (9.92 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 64. Of those Federal land areas having a known development potential for surface mining, 78 percent are rated high, 5 percent are rated moderate, and 18 percent are rated low. The remaining Federal lands within the KRCRA boundary in this quadrangle are classified as having unknown development potential for surface mining methods.

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 coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface which 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 development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional subsurface mining are defined as areas underlain by coal beds of Reserve Base thickness 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) below the ground surface, 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 areas where coal beds of Reserve Base thickness are not known, but may occur, and to those areas influenced by isolated data points. The areas influenced by isolated data points in this quadrangle contain approximately 28.25 million short tons (25.63 million metric tons) of coal available for subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 65. Of the Federal land areas having a known development potential for conventional subsurface mining methods, 94 percent are rated high and 6 percent are rated moderate. The remaining Federal land within the KRCRA boundary is classified as having unknown development potential for conventional subsurface mining methods.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 15° and 35°, regardless of tonnage, have low development potential for in-situ mining methods. Coal lying between the 200-foot (61-m) overburden isopach and the outcrop is not included in total coal tonnages available because it is needed for cover and containment in the in-situ process.

All of the Federal lands where the dip of the coal beds exceeds 15° are rated low for in-situ development potential because only approximately 0.96 million short tons (0.87 million metric tons) of coal distributed through two different coal beds are believed to be available for in-situ mining. The remaining Federal lands within the KRCRA boundary in this quadrangle are classified as having unknown development potential for in-situ mining methods.

Table 1. -- Chemical analysis of coals in the Horse Gulch quadrangle, Moffat 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
NW¼ sec. 6, T. 5 N., R. 91 W., Wise Mine (George and others, 1937) from Round Bottom quadrangle	Middle Coal Group	A	13.3	33.5	45.8	7.4	0.5	-	-	-	-	-	10,510
		C	-	38.6	52.9	8.5	0.6	-	-	-	-	-	12,110
SW¼ SE¼ sec. 31, T. 6 N., R. 91 W., Ratcliff Mine (George and others, 1937) from Round Bottom quadrangle	Middle Coal Group	A	13.5	35.5	47.8	3.5	0.3	-	-	-	-	-	11,010
		C	-	41.0	55.3	3.7	0.4	-	-	-	-	-	12,720
Sec. 31, T. 6 N., R. 91 W., Wisehill #5 (Eagle #5) Mine (Dawson and Murray, 1978) from Round Bottom quadrangle	Upper Coal Group	A	16.0	-	-	5.8	0.5	-	-	-	-	-	10,600
NW¼ SW¼ sec. 29, T. 6 N., R. 91 W., Haubrich Mine (George and others, 1937) from Round Bottom quadrangle	Upper Coal Group	A	17.8	30.4	48.0	3.8	0.5	-	-	-	-	-	10,340
		C	-	37.0	58.4	4.6	0.6	-	-	-	-	-	12,570

Form of Analysis: A, as received
C, moisture 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 Horse Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
UG {63}	460,000	320,000	1,970,000	-	2,750,000
UG {56}	250,000	270,000	940,000	-	1,460,000
UG {52}	280,000	350,000	2,570,000	-	3,200,000
UG {251}	850,000	560,000	2,740,000	-	4,150,000
UG {247}	110,000	150,000	490,000	-	750,000
UG {44}	1,060,000	650,000	2,340,000	-	4,050,000
MG {40}	10,000	10,000	150,000	-	170,000
MG {37}	510,000	360,000	1,000,000	-	1,870,000
MG {36}	2,320,000	1,030,000	830,000	-	4,180,000
MG {31}	-	-	60,000	-	60,000
MG {108}	-	-	-	-	-
MG {22}	12,800,000	3,160,000	320,000	-	16,280,000
Peacock	610,000	430,000	670,000	-	1,710,000
MG {102}	110,000	80,000	70,000	-	260,000
MG {15}	2,850,000	430,000	120,000	-	3,400,000
MG {7}	8,030,000	340,000	-	-	8,370,000
MG {1}	690,000	520,000	2,640,000	-	3,850,000
Isolated Data Points	-	-	-	10,940,000	10,940,000
Totals	30,940,000	8,660,000	16,910,000	10,940,000	67,450,000

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 Horse Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
UG {63}	6,250,000	-	-	-	6,250,000
UG {56}	5,350,000	-	-	-	5,350,000
UG {52}	4,610,000	-	-	-	4,610,000
UG {251}	33,430,000	2,160,000	-	-	35,590,000
UG {247}	5,230,000	-	-	-	5,230,000
UG {44}	19,690,000	-	-	-	19,690,000
MG {43}	3,990,000	-	-	-	3,990,000
MG {40}	4,340,000	410,000	-	700,000*	5,450,000
MG {37}	27,810,000	-	-	-	27,810,000
MG {36}	13,320,000	-	-	-	13,320,000
MG {32}	3,320,000	210,000	-	-	3,530,000
MG {31}	1,260,000	-	-	-	1,260,000
MG {29}	7,020,000	-	-	-	7,020,000
MG {28}	140,000	-	-	-	140,000
MG {26}	1,290,000	-	-	-	1,290,000
MG {108}	190,000	-	-	-	190,000
MG {104}	80,000	-	-	-	80,000
MG {22}	124,100,000	36,560,000	-	-	160,660,000
Peacock	16,230,000	15,220,000	-	260,000*	31,710,000

*Tonnages for coal beds dipping greater than 15 degrees.

Table 3. -- Continued (Horse Gulch)

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
MG {102}	1,070,000	960,000	-	-	2,030,000
MG {21}	1,230,000	850,000	-	-	2,080,000
MG {19}	650,000	1,960,000	-	-	2,610,000
MG {18}	1,060,000	3,300,000	-	-	4,360,000
MG {17}	1,480,000	6,480,000	-	-	7,960,000
MG {15}	10,840,000	16,650,000	-	-	27,490,000
MG {209}	960,000	6,250,000	-	-	7,210,000
MG {7}	29,460,000	17,960,000	-	-	47,420,000
MG {1}	16,440,000	6,990,000	-	-	23,430,000
Isolated Data Points	-	-	-	28,250,000	28,250,000
Totals	340,840,000	115,960,000	-	29,210,000	486,010,000

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

Table 4.--Descriptions and Reserve Base tonnages (in million short tons) for isolated data points

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages	
				Surface	Subsurface
MG[2]	Brownfield (1976)	sec. 18, T. 6 N., R. 93 W.	5.2 ft (1.6 m)	0	0.61
MG[3]	Meyer (1978)	sec. 27, T. 6 N., R. 93 W.	13.2 ft (4.0 m)	0	1.70
MG[4]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	5.1 ft (1.6 m)	0	0.68
MG[5]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	5.5 ft (1.7 m)	0	0.68
MG[6]	Brownfield (1976)	sec. 19, T. 6 N., R. 93 W.	5.5 ft (1.7 m)	0.25	0.15
MG[10]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	11.0 ft (3.4 m)	0	0.79
MG[12]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	5.5 ft (1.7 m)	0	0.68
MG[13]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	6.0 ft (2.4 m)	0	0.78
MG[14]	Meyer (1978)	sec. 27, T. 6 N., R. 93 W.	6.0 ft (1.8 m)	0	0.76
MG[16]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	6.0 ft (1.8 m)	0	0.44
MG[23]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	8.8 ft (2.7 m)	0	1.15
MG[24]	Johnson (1978)	sec. 32, T. 6 N., R. 92 W.	10.0 ft (3.0 m)	0	1.14

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

Table 4.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Reserve Base Tonnages Subsurface
MG[25]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W	9.7 ft (3.0 m)	0	1.26
MG[27]	Meyer (1978)	sec. 26, T. 6 N., R. 93 W.	7.5 ft (2.3 m)	0	0.79
MG[33]	Brownfield (1976)	sec. 18, T. 6 N., R. 93 W.	7.0 ft (2.1 m)	0	0.85
MG[34]	Brownfield (1976)	sec. 17, T. 6 N., R. 93 W.	5.5 ft (1.7 m)	0	0.66
MG[35]	Hancock (1925)	sec. 21, T. 6 N., R. 93 W.	8.9 ft (2.7 m)	0.56	0.18
MG[38]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	5.5 ft (1.7 m)	0	0.40
MG[39]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	9.5 ft (2.9 m)	0	0.70
MG[41]	Brownfield (1976)	sec. 18, T. 6 N., R. 93 W.	9.6 ft (2.9 m)	0	1.16
MG[42]	Brownfield (1976)	sec. 18, T. 6 N., R. 93 W.	6.5 ft (2.0 m)	0	0.79
MG[65]	Hancock (1925)	sec. 6, T. 5 N., R. 92 W.	6.7 ft (2.0 m)	0.04	0.01
MG[66]	Hancock (1925)	sec. 1, T. 5 N., R. 93 W.	7.3 ft (2.2 m)	0.20	0.20
MG[67]	Hancock (1925)	sec. 1, T. 5 N., R. 93 W.	12.3 ft (3.7 m)	0.49	0.27
MG[70]	Hancock (1925)	sec. 20, T. 6 N., R. 93 W.	5.3 ft (1.6 m)	0.11	0

Table 4.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Reserve Base Tonnages Subsurface
MG[71]	Gale (1910)	sec. 21, T. 6 N., R. 93 W.	6.8 ft (2.1 m)	0.18	0.15
UG[45]	Brownfield (1976)	sec. 17, T. 6 N., R. 93 W.	7.1 ft (2.2 m)	0.52	0.34
UG[46]	Meyer (1978)	sec. 27, T. 6 N., R. 93 W.	5.3 ft (1.6 m)	0.56	0.04
UG[47]	Hancock (1925)	sec. 22, T. 6 N., R. 93 W.	6.5 ft (2.0 m)	0.48	0.06
UG[48]	Meyer (1978)	sec. 31, T. 6 N., R. 92 W.	6.2 ft (1.9 m)	0.04	0.41
UG[49]	Hancock (1925)	sec. 15, T. 6 N., R. 93 W.	5.9 ft (1.8 m)	0.49	0
UG[50]	Meyer (1978)	sec. 27, T. 6 N., R. 93 W.	6.5 ft (2.0 m)	0.37	0
UG[53]	Brownfield (1976)	sec. 22, T. 6 N., R. 93 W.	7.9 ft (2.4 m)	0.89	0
UG[54]	Meyer (1978)	sec. 22, T. 6 N., R. 93 W.	6.0 ft (1.8 m)	0.74	0.04
UG[55]	Brownfield (1976)	sec. 15, T. 6 N., R. 93 W.	7.0 ft (2.1 m)	0.10	0.79
UG[57]	Meyer (1978)	sec. 25, T. 6 N., R. 93 W.	9.0 ft (2.7 m)	0	1.14
UG[58]	Brownfield (1976)	sec. 15, T. 6 N., R. 93 W.	6.0 ft (1.8 m)	0.30	0.47
UG[59]	Brownfield (1976)	sec. 15, T. 6 N., R. 93 W.	10.9 ft (3.3 m)	0.84	0.53

Table 4.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Reserve Base Tonnages Subsurface
UG[60]	Meyer (1978)	sec. 30, T. 6 N., R. 92 W.	8.0 ft (2.4 m)	0	1.00
UG[61]	Meyer (1978)	sec. 30, T. 6 N., R. 92 W.	7.0 ft (2.1 m)	0.55	0.26
UG[62]	Meyer (1978)	sec. 23, T. 6 N., R. 93 W.	6.0 ft (1.8 m)	0	0.75
UG[64]	Brownfield (1976)	sec. 8, T. 6 N., R. 93 W.	11.5 ft (3.5 m)	0	1.50
UG[72]	Hancock (1925)	sec. 25, T. 6 N., R. 93 W.	7.9 ft (2.4 m)	0.48	0
		From Juniper Hot Springs quadrangle			
MG[105]	Muller (1976)	sec. 6, T. 6 N., R. 93 W.	15.0 ft (4.6 m)	0.06	0.10
		From Round Bottom quadrangle			
MG[91]	Johnson (1978)	sec. 8, T. 5 N., R. 92 W.	8.0 ft (2.4 m)	0	0.52
MG[92]	Johnson (1978)	sec. 8, T. 5 N., R. 92 W.	8.0 ft (2.4 m)	0	0.52
MG[93]	Johnson (1978)	sec. 8, T. 5 N., R. 92 W.	7.0 ft (2.1 m)	0.23	0.20
MG[94]	Johnson (1978)	sec. 8, T. 5 N., R. 92 W.	14.5 ft (4.4 m)	0.66	0.27
MG[95]	Johnson (1978)	sec. 8, T. 5 N., R. 92 W.	15.5 ft (4.7 m)	0.64	0.23

Table 4.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Reserve Base Tonnages Subsurface
UG[37]	U.S. Geological Survey (1962)	sec. 5, T. 5 N., R. 92 W.	5.5 ft (1.7 m)	0.36	0
UG[38]	U.S. Geological Survey (1962)	sec. 5, T. 5 N., R. 92 W.	5.5 ft (1.7 m)	0.36	0
UG[39]	U.S. Geological Survey (1962)	sec. 5, T. 5 N., R. 92 W.	6.8 ft (2.1 m)	0.44	0
UG[96]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	10.0 ft (3.0 m)	0	0.23
UG[97]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	5.5 ft (1.7 m)	0	0.13
UG[98]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	6.0 ft (1.8 m)	0	0.13
UG[99]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	15.0 ft (4.6 m)	0	0.35
UG[100]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	6.0 ft (1.8 m)	0	0.13
UG[101]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	10.0 ft (3.0 m)	0	0.23
UG[102]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	5.5 ft (1.7 m)	0	0.13
UG[103]	Johnson (1978)	sec. 5, T. 5 N., R. 92 W.	5.5 ft (1.7 m)	0	0.13
UG[149]	Johnson (1978)	sec. 20, T. 6 N., R. 92 W.	5.5 ft (1.7 m)	0	0.26
UG[150]	Johnson (1978)	sec. 20, T. 6 N., R. 92 W.	8.0 ft (2.4 m)	0	0.38

Table 5. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Geological Survey, 1962, Inactive Coal Prospecting Permit No. Colorado 066620, Utah Construction and Mining Co.	Drill hole No. S-10
2	↓	Drill hole No. S-1
3	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 10	Measured Section No. 405
4	Hancock, 1925, U.S. Geological Survey Bulletin 757, fig. 6, p. 80	Measured Section No. 103
5	↓	Measured Section No. 100
6	Meyer, 1978, U.S. Geological Survey Open-File Report 78-366	Drill hole No. R-10-HG
7	↓	Drill hole No. R-13-HG
8	↓	Drill hole No. R-11-HG
9	↓	Drill hole No. R-12-HG
10	Johnson, 1978, U.S. Geological Survey Open-File Report 78-229	Drill hole No. E-16-HG
11	Brownfield, 1976, U.S. Geological Survey Open-File Report 76-817	Drill hole No. Y-17-HG
12	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section Nos. 128-133
13	Brownfield, 1976, U.S. Geological Survey Open-File Report No. 76-817	Drill hole No. Y-15-HG
14	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section Nos. 137-149

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Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
15	Brownfield, 1976, U.S. Geological Survey Open-File Report 76-817	Drill hole No. Y-14-HG
16	↓	Drill hole No. Y-18-HG
17	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section Nos. 122-124
18	Brownfield, 1976, U.S. Geological Survey Open-File Report 76-817	Drill hole No. Y-13-HG
19	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section No. 136
20	Gale, 1910, U.S. Geological Survey Bulletin 415, p. 230	Mine-Measured Section
21	Meyer, 1978, U.S. Geological Survey Open-File Report 76-366	Drill hole No. R-3-HG
22	Brownfield, 1976, U.S. Geological Survey Open-File Report 76-817	Drill hole No. Y-16-HG
23	Meyer, 1978, U.S. Geological Survey Open-File Report 78-366	Drill hole No. R-2-HG
24	↓	Drill hole No. R-4-HG
25	↓	Drill hole No. R-5-HG
26	↓	Drill hole No. R-9-HG
27	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section No. 155
28	Meyer, 1978, U.S. Geological Survey Open-File Report 78-366	Drill hole No. R-8-HG

Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
29	Meyer, 1978, U.S. Geological Survey Open-File Report 78-366	Drill hole No. R-7-HG
30	↓	Drill hole No. R-14-HG
31	Brownfield, 1976, U.S. Geological Survey Open-File Report 76-817	Drill hole No. Y-19-HG
32	Meyer, 1978, U.S. Geological Survey Open-File Report 78-366	Drill hole No. R-6-HG
33	↓	Drill hole No. R-1-HG
34	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 9	Measured Section No. 150
35	Brownfield, 1976, U.S. Geological Survey Open-File Report 78-817	Drill hole No. Y-20-HG

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