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

[Report includes 60 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 Easton 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 Published and unpublished public information available through November, 1978, was used as the data base for this study.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 Easton Gulch quadrangle is located in southeastern Moffat County in northwestern Colorado approximately 21 airline miles (34 km) southwest of the town of Craig and approximately 15 airline miles (24 km) north of the town of Meeker, Colorado. The area within the quadrangle is unpopulated.

Accessibility

An improved light-duty road crosses east-west across the northern half of the quadrangle connecting the town of Maybell, approximately 12 miles (19 km) to the northwest, with the town of Hamilton, approximately 18 miles (29 km) to the east. It also connects with the Maudlin Gulch oil field in the southeast quarter of the Citadel Platuea 15-minute quadrangle to the west. U.S. Highway 40 passes approximately 10 miles (16 km) north of the quadrangle, connecting Craig and Maybell. Colorado Highway 13 (also known as Colorado Highway 789) passes approximately 6 miles (10 km) east of the quadrangle. The remainder of the quadrangle is accessible by numerous unimproved dirt roads and trails.

Railway service for the Easton Gulch quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. This railroad is the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Easton Gulch quadrangle lies at the western edge of the Southern Rocky Mountain physiographic province, as defined by Howard and Williams (1972). The quadrangle is approximately 18 miles (29 km) west-southwest of the Williams Fork Mountains and 68 miles (109 km) west of the Continental Divide. The northern part of the quadrangle lies in the Axial Basin and the southern part lies on the northern flank of the Danforth Hills.

The landscape in the quadrangle varies greatly. The Axial Basin is characterized by broad gentle slopes and low hills, while the landscape in the southern two thirds of the quadrangle is dominated by elongate ridges cut by southwest-trending gulches and by moderate to steep slopes. The topography becomes steeper and more rugged to the west and south. Altitudes range from 8,365 feet (2,550 m) in the southwestern part of the quadrangle to less than 6,200 feet (1,890 m) along Boxelder Gulch in the northeastern corner of the quadrangle.

The major streams in the Easton Gulch quadrangle, including Maudlin, Boxelder, Morgan, and Collom Gulches, flow northeasterly into the Yampa River approximately 4 miles (6 km) northeast of the quadrangle. 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 Easton Gulch quadrangle area, with daily temperatures typically 3° to 34°F (-16° to 1°C) in January and from 45° to 88°F (7° to 31°C) in July. Annual precipitation averages approximately 14 inches (36 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 wind directions and velocities vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

The predominant vegetation in the Easton Gulch quadrangle includes sagebrush and mountain shrub. Sagebrush occurs in the Axial Basin in the northern third of the quadrangle, while mountain shrub, including serviceberry, Gambel oak, and rabbitbrush, occurs throughout the southern two thirds of the quadrangle. The flat area along Morgan Gulch on the eastern edge of the quadrangle is grassland (U.S. Bureau of Land Management, 1977).

Land Status

The Easton Gulch quadrangle lies on the north-central boundary of the Danforth Hills Known Recoverable Coal Resource Area (KRCRA). Approximately three fifths of the quadrangle lies within the KRCRA boundary and the Federal government owns the coal rights for about 90 percent of this area. A Preference Right Lease Application (PRLA) area is in the southeastern part of the quadrangle as shown on plate 2.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Easton 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 (1907 and 1910) . A geologic map and report by Hancock (1925) included the Easton Gulch quadrangle. Tweto (1976) compiled a generalized regional map which included this quadrangle. Results from drilling by the U.S. Geological Survey in the Easton Gulch quadrangle during 1977 and 1978 are reported by Reheis (1978a and 1978b). The most comprehensive work on the quadrangle includes an unpublished geologic map and coal sections by Reheis (no date).

Stratigraphy

The rock formations which crop out in the Easton 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 northern third of the quadrangle along the axis of the Axial Basin anticline (Hancock, 1925; Reheis, no date) and is composed of gray to dark-gray marine shale with interbedded tan thin-bedded silty sandstone and sandy 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, approximately 1,350 to 1,450 feet (411 to 442 m) thick, crops out along an east-west-trending band across the central part and western edge of the quadrangle (Reheis, no date) and consists of fine-grained, thick-bedded to massive sandstone interbedded with shaly sandstone, sandy shale, and black carbonaceous shale (Hancock, 1925). The "rim rock" sandstone (Hancock, 1925; Konishi, 1959), the basal unit of the Iles Formation, is a light-brown to white massive sandstone and is approximately 90 feet (27 m) thick where measured in the Tennessee Gas Transmission No. 1 USA Chorney well drilled in the northeast corner of the adjacent White Rock quadrangle. The Trout Creek Sandstone Member caps the Iles Formation and consists of approximately 65 to 100 feet (20 to 30 m) of massive white sandstone (Hancock, 1925; Bass and others, 1955). Two coal-bearing sequences, the "lower" coal group and Black Diamond coal group (Hancock and Eby, 1930) occur in the Iles Formation below the Trout Creek Sandstone in the Meeker area, but these coal groups have not been identified in this quadrangle.

The Williams Fork Formation, which crops out in the southern half of the quadrangle (Hancock, 1925; Reheis, no date) is approximately 1,600 feet (488 m) thick in the Axial and Monument Butte 15-minute quadrangles (Hancock, 1925). The formation consists of tan to white massive sandstone interbedded with dark-gray shale, sandy shale, carbonaceous shale, and coal. Coals which occur in the lower 1,000 to 1,300 feet (305 to 396 m) of the formation comprise the Fairfield coal group (Hancock, 1925). Generally, the Williams Fork Formation is divided into three units: a lower coal-bearing unit, the Twentymile Sandstone Member, and an upper unit (Bass and others, 1955). However, the Twentymile Sandstone Member pinches out in the Axial quadrangle to the east (Nutt, no date) and is not present in the quadrangle.

The Browns Park Formation of Miocene age unconformably overlies the Mancos Shale in the north-central part of the quadrangle (Hancock, 1925; Reheis, no date). According to Sears (1924), the formation is at least 1,200 feet (366 m) thick in northwestern Colorado, but its total thickness in this quadrangle is unknown. It consists of chalky-white to yellowish-brown fine-grained tuffaceous sandstone with basal conglomerate beds (Hancock, 1925).

Holocene deposits of alluvium cover most of the stream valleys in the quadrangle (Reheis, no date).

The Cretaceous sedimentary rocks in the 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 marine, near-shore marine, and non-marine sediments in the Easton Gulch quadrangle (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 Iles and Williams Fork Formations 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 sandstone beds in the Iles and Williams Fork Formations, including the "rim rock" sandstone and the Trout Creek Sandstone Member, were deposited in shallow marine and near-shore marine environments as the shoreline fluctuated. Coal beds of limited areal extent 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).

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 Danforth Hills KRCRA lies in the northern part of the Piceance structural basin of west-central Colorado (Howard and Williams, 1972). The Danforth Hills area is bordered on the northeast by the Axial Basin anticline and on the west by the Yampa Plateau (Grose, 1972), approximately 20 miles (32 km) west of the quadrangle.

The axis of the north-northwest-trending Collom syncline crosses the central part of the quadrangle (Hancock, 1925; Reheis, no date). An unnamed synclinal structure intersects the Collom syncline near the center of the quadrangle and extends to the southwest and to the north from the area of intersection (Reheis, no date). The northern part of the quadrangle lies on the southern limb of the northwest-trending Axial Basin anticline, the axis of which crosses the northeast corner of the quadrangle. Numerous faults striking parallel to the axis of the

Axial Basin anticline occur in the northeastern part of the quadrangle. A northeast-striking fault is inferred in the north-central part of the quadrangle and a west-northwest-striking fault is inferred to cut the coal beds in the center of the quadrangle (Reheis, no date).

The structure contour maps of the isopached coal beds are based on a regional structure map of the Trout Creek Sandstone Member (Reheis, no date), 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 drill hole and outcrop data.

COAL GEOLOGY

Numerous coal beds in the Williams Fork Formation have been identified in coal test holes and outcrops throughout the southern two thirds of the Easton Gulch quadrangle. All of the coal beds identified lie within the Fairfield coal group in the lower Williams Fork Formation. In general, coals in the Fairfield coal group are thin, lenticular, and limited in areal extent. Coal beds exceeding Reserve Base thickness (5.0 feet or 1.5 meters) that are not formally named have been given bracketed numbers for identification purposes. In instances where coal beds have been identified at one location only and cannot be correlated, they are treated as isolated data points (see Isolated Data Points section of this report).

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, although it is believed that the coal beds may continue to be greater than Reserve Base thickness beyond the dotted lines.

Chemical analyses of coal.--Analyses of the coals in this quadrangle are listed in table 1 and include samples from the Fairfield [33] coal bed and an undifferentiated Fairfield coal bed. In general, the analyses indicate that the coals in the Fairfield coal group 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).

Fairfield Coal Group

Of the 102 coal beds identified in the Fairfield coal group that exceed Reserve Base thickness, only 39 were isopached. The remaining 63 coal beds, including six located on non-Federal land, were treated as isolated data points.

The coal beds in this quadrangle occur in four general areas, in the east-central, south-central, southwest, and west-central parts of the quadrangle. A general description of each area is included below, followed by a more detailed discussion of only those coal beds which are believed to contain approximately 20.00 million short tons (18.14 million metric tons) of coal or more.

Coal beds in the east-central part of the quadrangle lie in the Collom syncline, which trends and plunges west-northwest in this area. Two faults cut the coal beds striking parallel to the fold axis. The southern limb of the syncline dips approximately 5° north-northeast and dips on the northern limb range from approximately 8° south-southwest to 6° southeast, steepening to more than 15° farther north. The coal beds in this area range in thickness from 2.5 to 11.8 feet (0.8 to 3.6 m) with rock partings ranging from 0.4 to 2.8 feet (0.1 to 0.9 m) thick occuring locally.

Coal beds in the south-central part of the quadrangle lie on the southern limb of the Collom syncline and their dips range from approximately 3° to 8° northwest to about 3° to 5° north-northeast. The coal beds in this area range in thickness from 2.0 to 12.7 feet (0.6 to 3.9 m) and include rock partings that vary from 0.4 to 2.4 feet (0.1 to 0.7 m) in thickness and occur locally. Several coal beds, including the Fairfield [121], [122], and [142], extend into the adjacent Devils Hole Gulch quadrangle to the south. The Fairfield [208] coal zone and the Fairfield [126] and [209] coal beds were not identified in the Easton Gulch quadrangle, but have been projected into the southeastern corner and south-central edge of the quadrangle based on data in the adjacent Devils Hole Gulch quadrangle, the Ninemile Gap quadrangle to the southeast, and the Axial quadrangle to the east.

In the southwestern part of the quadrangle, the coal beds generally dip to the east-southeast at about 11° to 19° and range in thickness from 1.6 to 9.9 feet (0.5 to 3.0 m). Rock partings were not identified in the coal beds in this area. The Fairfield [130] coal bed is inferred to extend into the southwestern part of this quadrangle based on thickness measurements in the Devils Hole Gulch quadrangle.

The coal beds in the west-central part of the quadrangle lie in the Collom syncline which plunges to the southeast in this area. The southern and northern limbs dip at an average of 10° to the east and south, respectively, with the northern limb steepening to greater than 15° northward. Coal beds in this area range in thickness from 1.6 to 15.0 feet (0.5 to 4.6 m) and contain local rock partings that range from 0.8 to 7.4 feet (0.2 to 2.3 m) in thickness. A rock split of 20.3 feet (6.2 m) occurs in the Fairfield [2] coal bed in sec. 31, T. 5 N., R. 94 W. (Reheis, no date). The Fairfield [27] coal bed extends into the southeast quarter of the Citadel Plateau 15-minute quadrangle to the west.

Fairfield [19] Coal Bed

The Fairfield [19] coal bed (plate 7) has been identified in three drill holes (Reheis, 1978a) in the south-central part of the quadrangle. The coal bed ranges in thickness from 9.2 to 15.1 feet (2.8 to 4.6 m) and dips north-northwest at an average of 5°.

Fairfield [121] and [122] Coal Beds

The Fairfield [121] and [122] coal beds have each been identified in two drill holes (Reheis, 1978a) in the south-central part of the quadrangle and are shown on plates 11 and 14, respectively. Both coal beds dip north-northwest at an average of about 5°.

The Fairfield [121] coal bed (plate 11) ranges in thickness from 7.2 to 12.2 feet (2.2 to 3.7 m) and attains its maximum reported thickness in sec. 33, T. 4 N., R. 94 W., where the coal bed contains a rock parting 1.0 feet (0.3 m) thick. The coal bed extends southward into the Devils Hole Gulch quadrangle and is 8.0 feet (2.4 m) thick where penetrated by a single drill hole.

The Fairfield [122] coal bed (plate 14) ranges from 7.5 to 8.9 feet (2.3 to 2.7 m) in thickness and contains a local rock parting 2.3 feet (0.7 m) thick. The coal bed extends into the Devils Hole Gulch quadrangle and is 13.8 feet (4.2 m) thick in a coal test hole drilled in the NW 1/4 sec. 9, T. 3 N., R. 94 W.

Fairfield [35] Coal Bed

The Fairfield [35] coal bed (plate 29) was penetrated by three drill holes (Reheis, 1978a) in the south-central part of the quadrangle and ranges in thickness from 6.9 to 9.2 feet (2.1 to 2.8 m). The Fairfield [35] dips approximately 5° to the north-northwest.

Fairfield [59] Coal Bed

The Fairfield [59] coal bed (plate 38) ranges in thickness from 3.6 to 16.1 feet (1.1 to 4.9 m) where measured in three drill holes (Reheis, 1978a) in the south-central part of the quadrangle. Based on the projection of subsurface data, the burned outcrop of the coal bed may be in sec. 3, T. 3 N., R. 94 W., along the East Fork of Collom Gulch.

Fairfield [61] Coal Bed

The Fairfield [61] coal bed (plate 29) was identified in two drill holes (Reheis, 1978b) in the west-central part of the quadrangle. The coal bed ranges in thickness from 17.3 to 25.0 feet (5.3 to 7.6 m) and contains rock partings ranging in cumulative thickness from 3.2 to 3.3 feet (1.0 m). According to Reheis (1978b), the outcrops of this coal bed are burned, and the coal bed dips southeastward at approximately 10°.

Fairfield [64] Coal Bed

The Fairfield [64] coal bed (plate 41) was identified in three drill holes (Reheis, 1978a) in the south-central part of the quadrangle where it ranges in thickness from 11.8 to 17.4 feet (3.6 to 5.3 m). The coal bed appears to thicken to the southwest. A rock parting 1.7 feet (0.5 m) thick was reported in the drill hole located in sec. 23, T. 4 N., R. 94 W. The coal bed generally dips to the northwest at approximately 4°.

Fairfield [67] Coal Bed

The Fairfield [67] coal bed (plate 44) was reported to be 9.5 and 10.2 feet (2.9 and 3.1 m) thick where penetrated by two drill holes in the south-central part of the quadrangle. Based on the structure map by Reheis (1978b), the coal bed dips from about 3° northwest to 6° north.

Fairfield [75] Coal Bed

The Fairfield [75] coal bed (plate 47) crops out in the southeastern part of the quadrangle and ranges in thickness from 5.6 to 9.5 feet (1.7 to 2.9 m) where measured in two drill holes and at one outcrop where the coal bed is not burned. Dips of the coal bed range from about 3° north to approximately 6° northwest.

Fairfield [87] Coal Bed

The Fairfield [87] coal bed (plate 29) has been identified in two drill holes in the southwestern part of the quadrangle (Reheis, 1978b) and has measured thicknesses of 10.8 and 12.1 feet (3.3 and 3.7 m). The coal bed dips to the east from 7° to 18° and may crop out in Hurst Gulch in the NE 1/4 sec. 31, T. 4 N., R. 94 W.

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 thickness for only 1,000 feet (305 m) in all directions from thier points of measurement. Also, where the inferred limit of influence from the isolated data point is entirely within non-Federal land areas, 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 are listed in table 5.

COAL RESOURCES

Data from drill holes, mine measured sections, and outcrop measurements (Hancock, 1925; Reheis, 1978a, 1978b, and no date) were used to construct outcrop, isopach, and structure contour maps of the coal beds in the Easton Gulch 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 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 1,800 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 thicker than 5 feet (1.5 m) 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 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 580.52 million short tons (526.65 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 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 11.10 million short tons (10.07 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 59. Of the Federal land areas having a known development potential for surface mining, 70 percent are rated high, 13 percent are rated moderate, and 17 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. 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 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 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 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 45.51 million short tons (41.29 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 60. Of the Federal land areas having a known development potential for conventional subsurface mining methods, 99 percent are rated high and 1 percent is rated moderate. The remaining

Federal lands within the KRCRA boundary in this quadrangle are 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 are not faulted. The areas influenced by isolated data points in this quadrangle contain approximately 0.54 million short tons (0.49 million metric tons) of coal available for in-situ mining.

Coal development potential for in-situ mining methods is shown on plate 60. 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 in this quadrangle 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 5.

Table 1. -- Chemical analyses of coals in the Easton 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
SW¼ sec. 13, T. 4 N., R. 94 W., Ed Collum Mine (George and others, 1937)	Fairfield (33)	A	14.84	38.68	42.66	3.82	0.66	-	-	-	-	-	10,780
		C	-	45.42	50.09	4.49	0.78	-	-	-	-	-	12,659
NW¼ sec. 14, T. 4 N., R. 94 W., Battle Era Mine (George and others, 1937)	Fairfield	A	14.67	36.65	42.56	6.12	0.89	-	-	-	-	-	10,141
		C	-	42.95	49.88	7.17	1.04	-	-	-	-	-	11,884

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 Easton Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {130}	-	-	50,000	-	50,000
Fairfield {103}	290,000	340,000	550,000	-	1,180,000
Fairfield {102}	-	-	260,000	-	260,000
Fairfield {92}	290,000	480,000	1,400,000	-	2,170,000
Fairfield {88}	930,000	480,000	490,000	-	1,900,000
Fairfield {87}	1,750,000	960,000	780,000	-	3,490,000
Fairfield {85}	10,000	150,000	310,000	-	470,000
Fairfield {79}	-	-	280,000	-	280,000
Fairfield {76}	-	-	300,000	-	300,000
Fairfield {75}	40,000	40,000	480,000	-	560,000
Fairfield {68}	80,000	70,000	150,000	-	300,000
Fairfield {67}	50,000	270,000	500,000	-	820,000
Fairfield {66}	1,540,000	700,000	430,000	-	2,670,000
Fairfield {64}	-	-	300,000	-	300,000
Fairfield {61}	9,090,000	1,350,000	-	-	10,440,000
Fairfield {60}	200,000	160,000	640,000	-	1,000,000
Fairfield {59}	340,000	660,000	1,400,000	-	2,400,000
Fairfield {57}	30,000	110,000	730,000	-	870,000
Fairfield {55}	780,000	780,000	1,220,000	-	2,780,000
Fairfield {126}	130,000	120,000	340,000	-	590,000
Fairfield {45}	-	-	450,000	-	450,000
Fairfield {40}	1,000,000	760,000	750,000	-	2,510,000

Table 2. -- Continued. (Easton Gulch)

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {38}	-	-	10,000	-	10,000
Fairfield {35}	-	-	90,000	-	90,000
Fairfield {34}	840,000	860,000	1,250,000	-	2,950,000
Fairfield {33}	310,000	280,000	200,000	-	790,000
Fairfield {31}	120,000	230,000	220,000	-	570,000
Fairfield {27}	150,000	130,000	200,000	-	480,000
Fairfield {24}	40,000	40,000	260,000	-	340,000
Fairfield {17}	930,000	630,000	350,000	-	1,910,000
Fairfield {6}	350,000	310,000	750,000	-	1,410,000
Fairfield {3}	10,000	20,000	290,000	-	320,000
Fairfield {2}	300,000	270,000	410,000	-	980,000
Isolated Data Points	-	-	-	11,100,000	11,100,000
Totals	19,600,000	10,200,000	15,840,000	11,100,000	56,740,000

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 Easton Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {130}	460,000	-	-	-	460,000
Fairfield {103}	1,110,000	-	-	-	1,110,000
Fairfield {102}	230,000	-	-	-	230,000
Fairfield {92}	1,770,000	-	-	-	1,770,000
Fairfield {88}	770,000	-	-	-	770,000
Fairfield {87}	13,290,000	-	-	-	13,290,000
Fairfield {85}	9,650,000	-	-	-	9,650,000
Fairfield {79}	12,170,000	-	-	-	12,170,000
Fairfield {76}	14,720,000	-	-	-	14,720,000
Fairfield {75}	19,340,000	-	-	-	19,340,000
Fairfield {68}	10,000	-	-	-	10,000
Fairfield {67}	20,230,000	-	-	-	20,230,000
Fairfield {66}	460,000	-	-	-	460,000
Fairfield {64}	40,190,000	-	-	-	40,190,000
Fairfield {61}	16,540,000	-	-	-	16,540,000
Fairfield {60}	220,000	-	-	-	220,000
Fairfield {59}	26,810,000	-	-	-	26,810,000
Fairfield {57}	9,380,000	-	-	-	9,380,000
Fairfield {55}	9,050,000	-	-	-	9,050,000
Fairfield {126}	3,960,000	-	-	-	3,960,000
Fairfield {49}	2,730,000	-	-	-	2,730,000
Fairfield {45}	16,290,000	-	-	-	16,290,000
Fairfield {142}	15,790,000	1,660,000	-	-	17,450,000

Table 3. -- Continued. (Easton Gulch)

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {40}	11,120,000	-	-	-	11,120,000
Fairfield {38}	8,550,000	370,000	-	-	8,920,000
Fairfield {35}	19,570,000	-	-	-	19,570,000
Fairfield {34}	440,000	-	-	-	440,000
Fairfield {33}	15,380,000	790,000	-	-	16,170,000
Fairfield {28}	12,000,000	-	-	-	12,000,000
Fairfield {27}	360,000	-	-	-	360,000
Fairfield {26}	11,740,000	-	-	-	11,740,000
Fairfield {24}	550,000	-	-	-	550,000
Fairfield {122}	24,190,000	9,590,000	-	-	33,780,000
Fairfield {121}	20,240,000	12,280,000	-	-	32,520,000
Fairfield {19}	27,150,000	9,220,000	-	-	36,370,000
Fairfield {208}	2,160,000	-	-	-	2,160,000
Fairfield {209}	370,000	-	-	-	370,000
Fairfield {17}	11,830,000	-	-	-	11,830,000
Fairfield {6}	16,140,000	-	-	-	16,140,000
Fairfield {3}	10,460,000	-	-	-	10,460,000
Fairfield {2}	2,120,000	-	-	-	2,120,000
Fairfield {1}	1,910,000	3,940,000	-	-	5,850,000
Isolated Data Points	-	-	-	45,510,000	45,510,000
Totals	431,450,000	37,850,000	-	45,510,000	514,810,000

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 Easton Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {103}	-	1,770,000	-	1,770,000
Fairfield {87}	-	4,020,000	-	4,020,000
Fairfield {68}	-	120,000	-	120,000
Fairfield {60}	-	490,000	-	490,000
Fairfield {38}	-	90,000	-	90,000
Fairfield {34}	-	410,000	-	410,000
Fairfield {33}	-	1,230,000	-	1,230,000
Fairfield {17}	-	30,000	-	30,000
Fairfield {6}	-	130,000	-	130,000
Fairfield {2}	-	140,000	-	140,000
Isolated Data Points	-	-	540,000	540,000
Totals	-	8,430,000	540,000	8,970,000

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
Fairfield [4]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	5.9 ft (1.8 m)	0	0.74	0
Fairfield [5]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	10.2 ft (3.1 m)	0	1.28	0
Fairfield [8]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	6.9 ft (2.1 m)	0	0.75	0
Fairfield [9]	Reheis (1978a)	sec. 4, T. 3 N., R. 94 W.	6.9 ft (2.1 m)	0	0.88	0
Fairfield [10]	Reheis (no date)	sec. 14, T. 4 N., R. 94 W.	14.1 ft (4.3 m)	0.35	0	0.35
Fairfield [11]	Reheis (1978a)	sec. 34, T. 4 N., R. 94 W.	6.9 ft (2.1 m)	0	0.90	0
Fairfield [12]	Reheis (no date)	sec. 13, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0.15	0.19	0
Fairfield [13]	Reheis (no date)	sec. 24, T. 4 N., R. 95 W.	8.2 ft (2.5 m)	0.16	0.23	0
Fairfield [14]	Reheis (1978a)	sec. 4, T. 3 N., R. 94 W.	8.2 ft (2.5 m)	0	0.75	0
Fairfield [15]	Reheis (no date)	sec. 14, T. 4 N., R. 94 W.	7.2 ft (2.2 m)	0.17	0	0.19
Fairfield [16]	Reheis (no date)	sec. 24, T. 4 N., R. 95 W.	5.2 ft (1.6 m)	0.10	0.14	0
Fairfield [20]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	18.0 ft (5.5 m)	0	1.96	0

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

Table 5.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Fairfield [23]	Reheis (1978a)	sec. 3, T. 3 N., R. 94 W.	19.0 ft (5.8 m)	0	2.51	0
Fairfield [25]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	6.9 ft (2.1 m)	0	0.90	0
Fairfield [29]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	9.5 ft (2.9 m)	0	1.25	0
Fairfield [30]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	14.1 ft (4.3 m)	0	1.77	0
Fairfield [32]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	8.5 ft (2.6 m)	0	1.16	0
Fairfield [36]	Reheis (1978a)	sec. 4, T. 3 N., R. 94 W.	6.9 ft (2.1 m)	0	0.88	0
Fairfield [37]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0	0.61	0
Fairfield [39]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	14.1 ft (4.3 m)	0	1.77	0
Fairfield [41]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	10.2 ft (3.1 m)	0	1.11	0
Fairfield [43]	Reheis (1978b)	sec. 17, T. 4 N., R. 94 W.	7.5 ft (2.3 m)	0	1.00	0
Fairfield [46]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	6.6 ft (2.0 m)	0	0.72	0
Fairfield [47]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	10.8 ft (3.3 m)	0	1.36	0
Fairfield [48]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	6.9 ft (2.1 m)	0	0.90	0

Table 5.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Fairfield [77]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	19.3 ft (5.9 m)	1.52	0.41	0
Fairfield [78]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	9.8 ft (3.0 m)	0	1.22	0
Fairfield [80]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	13.1 ft (4.0 m)	1.04	0.27	0
Fairfield [81]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	12.1 ft (3.7 m)	0	1.32	0
Fairfield [82]	Reheiś (1978a)	sec. 33, T. 4 N., R. 94 W.	11.5 ft (3.5 m)	0.51	1.02	0
Fairfield [83]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	10.5 ft (3.2 m)	0	1.14	0
Fairfield [84]	Reheis (1978a)	sec. 23, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0	0.75	0
Fairfield [86]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	5.9 ft (1.8 m)	0.48	0.31	0
Fairfield [89]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	10.5 ft (3.2 m)	0.81	0.64	0
Fairfield [90]	Reheis (no date)	sec. 24, T. 4 N., R. 94 W.	8.2 ft (2.5 m)	0.09	0.02	0
Fairfield [91]	Reheis (1978a)	sec. 34, T. 4 N., R. 94 W.	5.9 ft (1.8 m)	0.80	0	0
Fairfield [94]	Reheis (no date)	sec. 7, T. 4 N., R. 94 W.	8.5 ft (2.6 m)	0.30	0.07	0
Fairfield [96]	Reheis (no date)	sec. 18, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0.37	0.08	0

Table 5.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Fairfield [77]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	19.3 ft (5.9 m)	1.52	0.41	0
Fairfield [78]	Reheis (1978b)	sec. 29, T. 4 N., R. 94 W.	9.8 ft (3.0 m)	0	1.22	0
Fairfield [80]	Reheis (1978b)	sec. 18, T. 4 N., R. 94 W.	13.1 ft (4.0 m)	1.04	0.27	0
Fairfield [81]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	12.1 ft (3.7 m)	0	1.32	0
Fairfield [82]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	11.5 ft (3.5 m)	0.51	1.02	0
Fairfield [83]	Reheis (1978b)	sec. 15, T. 4 N., R. 94 W.	10.5 ft (3.2 m)	0	1.14	0
Fairfield [84]	Reheis (1978a)	sec. 23, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0	0.75	0
Fairfield [86]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	5.9 ft (1.8 m)	0.48	0.31	0
Fairfield [89]	Reheis (1978a)	sec. 33, T. 4 N., R. 94 W.	10.5 ft (3.2 m)	0.81	0.64	0
Fairfield [90]	Reheis (no date)	sec. 24, T. 4 N., R. 94 W.	8.2 ft (2.5 m)	0.09	0.02	0
Fairfield [91]	Reheis (1978a)	sec. 34, T. 4 N., R. 94 W.	5.9 ft (1.8 m)	0.80	0	0
Fairfield [94]	Reheis (no date)	sec. 7, T. 4 N., R. 94 W.	8.5 ft (2.6 m)	0.30	0.07	0
Fairfield [96]	Reheis (no date)	sec. 18, T. 4 N., R. 94 W.	5.6 ft (1.7 m)	0.37	0.08	0

Table 5.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Fairfield [97]	Reheis (no date)	sec. 18, T. 4 N., R. 94 W.	15.0 ft (4.6 m)	0.91	0.40	0
Fairfield [98]	Reheis (no date)	sec. 18, T. 4 N., R. 94 W.	5.2 ft (1.6 m)	0.26	0	0
Fairfield [99]	Reheis (no date)	sec. 19, T. 4 N., R. 94 W.	8.5 ft (2.6 m)	0.42	0.25	0
Fairfield [100]	Reheis (no date)	sec. 19, T. 4 N., R. 94 W.	9.2 ft (2.8 m)	0.42	0	0
Fairfield [101]	Hancock (1925)	sec. 24, T. 4 N., R. 94 W.	7.4 ft (2.3 m)	0.26	0.18	0
Fairfield [104]	Reheis (no date)	sec. 13, T. 4 N., R. 95 W.	9.5 ft (2.9 m)	0.20	0.22	0

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

Plate 1 Index Number	Source	Data Base
1	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 11
2	Reheis, 1978a, U.S. Geological Survey Open-File Report 78-272	Drill hole No. D-50-EG
3	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 24
4	Reheis, 1978a, U.S. Geological Survey Open-File Report 78-272	Drill hole No. D-45-EG
5	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 25
6	↓	Measured Section No. 26
7	↓	Measured Section No. 35
8	↓	Measured Section No. 36
9	Hancock, 1925, U.S. Geological Survey Bulletin 757, p. 129	Measured Section No. 614
10	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 37
11	↓	Measured Section No. 38
12	↓	Measured Section No. 39
13	↓	Measured Section No. 1
14	↓	Measured Section
15	↓	Measured Section No. 47
16	↓	Measured Section No. 48

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
17	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 46
18	↓	Measured Section No. 5
19	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 17 and p. 130	Measured Section No. 92
20	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 12
21	↓	Measured Section No. 13
22	↓	Measured Section No. 14
23	↓	Measured Section No. 15
24	↓	Measured Section No. 16
25	↓	Measured Section No. 19
26	↓	Measured Section No. 20
27	↓	Measured Section No. 17
28	↓	Measured Section No. 18
29	Reheis, 1978b, U.S. Geological Survey Open-File Report 78-1031	Drill hole No. D-51-EG
30	↓	Drill hole No. D-53-EG
31	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section
32	↓	Measured Section
33	↓	Measured Section

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Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
34	Reheis, 1978b, U.S. Geological Survey Open-File Report 78-1031	Drill hole No. D-38-EG
35	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section
36		Measured Section
37		Measured Section No. 22
38		Measured Section No. 27
39		Measured Section No. 28
40		Measured Section No. 21
41	Reheis, 1978a, U.S. Geological Survey Open-File Report 78-272	Drill hole No. D-44-EG
42	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 9
43		Measured Section No. 6
44		Measured Section No. 7
45		Measured Section No. 8
46	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 17 and p. 125	Measured Section No. 25
47	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 2
48		Measured Section No. 3
49		Measured Section No. 4
50		Measured Section No. 10
51		Measured Section No. 29

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Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
52	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section
53	↓	Measured Section No. 30
54	↓	Measured Section No. 31
55	Reheis, 1978b, U.S. Geological Survey Open-File Report 78-1031	Drill hole No. D-49-EG
56	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 32
57	↓	Measured Section No. 42
58	↓	Measured Section
59	↓	Measured Section No. 40
60	↓	Measured Section
61	Reheis, 1978b, U.S. Geological Survey Open-File Report 78-1031	Drill hole No. D-42-EG
62	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 33
63	↓	Measured Section No. 34
64	Reheis, 1978a, U.S. Geological Survey Open-File Report 78-272	Drill hole No. D-39-EG
65	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 23
66	Reheis, 1978a, U.S. Geological Survey Open-File Report 78-272	Drill hole No. D-41-EG
67	↓	Drill hole No. D-40-EG
68	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
69	Reheis, (no date), U.S. Geological Survey, unpublished data	Measured Section No. 45
70	↓	Measured Section No. 44
71		Measured Section No. 43
72		Measured Section No. 41
73		Measured Section No. 51
74		Measured Section No. 50
75		Measured Section No. 49

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