Text to accompany:

Open-File Report 78-048

1978

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SEMINOE DAM SE QUADRANGLE, CARBON COUNTY, WYOMING

(Report includes 24 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 along with the accompanying Coal Resource Occurrence (CRO) maps and the Coal Development Potential (CDP) maps of the Seminoe Dam SE quadrangle, Carbon County, Wyoming (24 plates; U.S. Geol. Survey Open-File Report 78-048), prepared by Texas Instruments Incorporated under contract to the U.S. Geological Survey. This report was prepared to support the land planning work of the U.S. Bureau of Land Management's Energy Minerals Activities Recommendation Sytems (EMARS) program, and to contribute to a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA) in the western United States. The Coal Resource Occurrence maps and the Coal Development Potential maps for this quadrangle cover part of the northwestern portion of the KRCRA of the Hanna coal field.

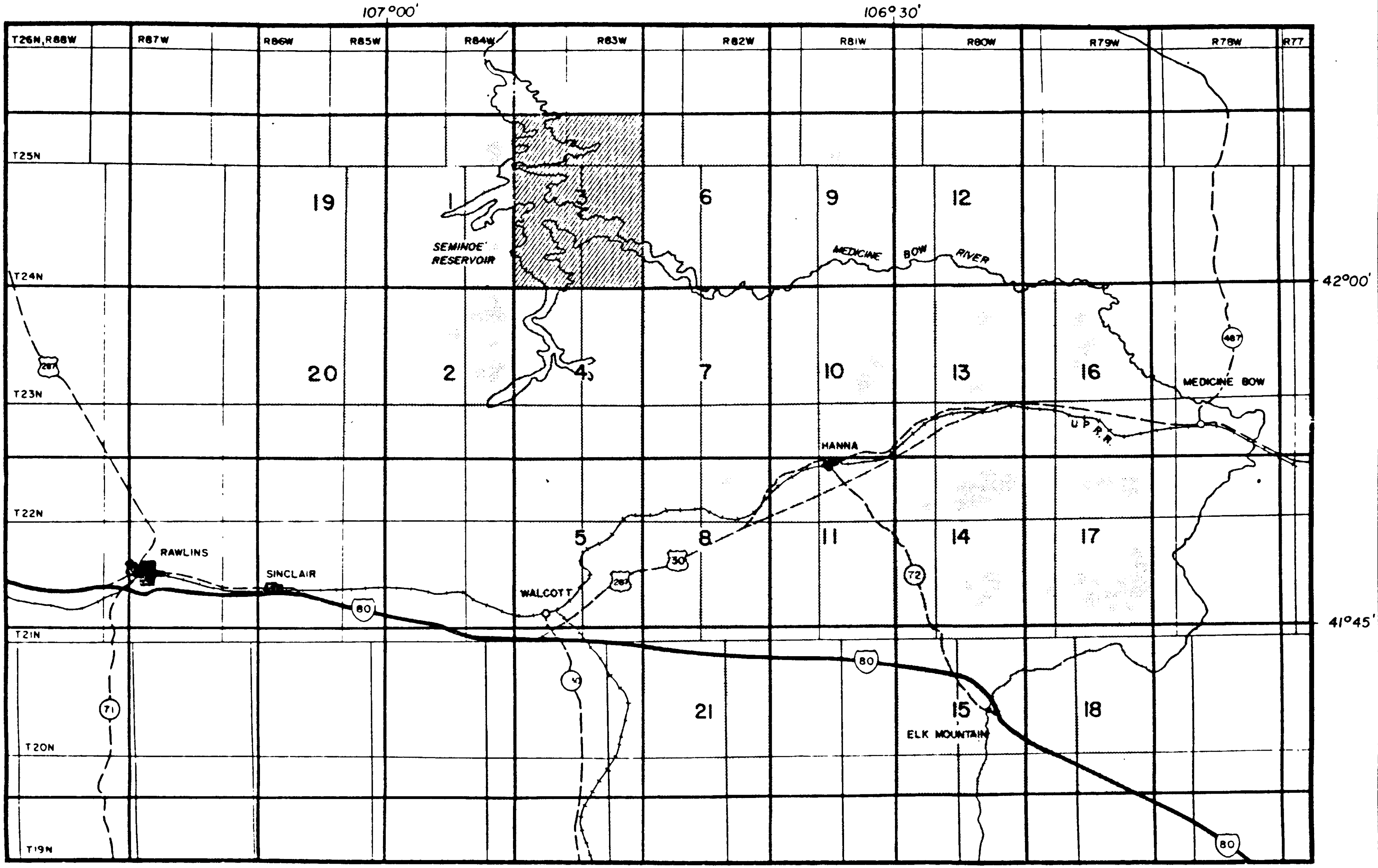
Acknowledgment

Texas Instruments Incorporated acknowledges the cooperation of the Rocky Mountain Energy Company, a wholly owned subsidiary of the Union Pacific Railroad Company, in supplying copies of survey sheets, drillers reports, electric logs, and coal analyses from the Union Pacific coal inventory program.

The Hanna and Carbon coal basins were studied as part of the inventory program and test drilling was conducted in 1970-71. More than 650 Union Pacific coal drill holes have been evaluated as part of this contract study of 21 quadrangles in Carbon County, Wyoming; the results of this evaluation and 230 coal analyses have been incorporated into these reports.

Location

The Seminoe Dam SE 7½-minute quadrangle is in the north-central part of Carbon County, Wyoming. The center of the quadrangle is approximately 29 miles (47 km) northeast of Rawlins and 19 miles (30 km) northwest of Hanna, Wyoming (Figure 1).



Seminoe Dam SE quadrangle (3)

Scale 1:446,000

Accessibility

A light-duty road crosses the northeastern part of the quadrangle. It is the access road to the Seminoe Dam site from the towns of Hanna and Medicine Bow. Several local unimproved dirt roads provide access to the ranches in the quadrangle and to the shores of the Seminoe Reservoir.

The main east-west track of the Union Pacific Railroad is 18 miles (29 km) south of the center of the quadrangle and passes through the towns of Medicine Bow, Hanna, Walcott, Sinclair, and Rawlins.

Physiography

The quadrangle is on the northwest edge of the Hanna structural basin which, in this area, is bounded on the north by the Seminoe Mountains. The major topographic feature in the quadrangle is the east-west trending Horseshoe Ridge which crosses the northern half of the quadrangle. Maximum relief along Horseshoe Ridge is 742 feet (226 m). The southern part of the quadrangle consists of undulating topography typical of high plains grasslands. Seminoe Reservoir, formed by impoundment of the North Platte River behind Seminoe Dam immediately to the north of the quadrangle, inundates one-third of the area of the quadrangle. The remaining land area is dissected by intermittent streams that flow into Seminoe Reservoir. Elevations within the quadrangle range from 6,358 feet (1,938 m) along the Seminoe Reservoir shoreline to 7,092 feet (2,162 m) at the crest of Horseshoe Ridge.

Climate

The climate is semiarid with a mean annual temperature of $43^{\circ}F$ ($6^{\circ}C$) and extremes ranging from $98^{\circ}F$ to $-31^{\circ}F$ (37° to $-35^{\circ}C$) as recorded at the Seminoe Dam Weather Substation (U.S. Dept. of Interior, 1975). Average annual precipitation at that location is 12 inches (30 cm). Forty-two percent of the precipitation falls as rain in April, May, and June, with the major portion of the remainder falling as snow in the winter months. High winds commonly occur throughout most of the year. The average growing season is generally 60 to 70 days, from late April to early June. High temperatures and lack of precipitation restrict vegetative growth in late summer and frosts occur from September through April.

Land Status

The quadrangle is in the northern part of the Hanna and Carbon Basins Known Recoverable Coal Resource Area. The Federal Government owns approximately 70 percent of the coal rights in the quadrangle; the remaining 30 percent is non-federally owned. Approximately 35 percent of the area of the quadrangle is included in the KRCRA, and within this region about 65 percent of the land is federally owned. There are no known active leases, permits or licenses, and no known active mining operations. Plate 2 of the CRO maps illustrates the ownership status of land in the quadrangle and the boundary of the KRCRA.

GENERAL GEOLOGY

Previous Work

Dobbin, Bowen, and Hoots (1929) mapped 80 percent of the Seminoe Dam SE quadrangle in their study of the geology and coal and oil resources of the Hanna and Carbon Basins. Berta (1951) reviewed the structure and general stratigraphy of the Hanna coal field. Weitz and Love (1952) compiled a geological map of Carbon County which incorporates available data, published and unpublished, to that date.

Blanchard and Jones (1976) have recently mapped the geology of the quadrangle, including the northern 20 percent not studied by Dobbin, Bowen, and Hoots (1929). Their field work located additional faulting and they remapped the coal bed outcrops using a notation different to that used by Dobbin, Bowen, and Hoots (1929). Since this new notation contributes nothing to the correlation of coal bed outcrops, the coal bed designations of Dobbin, Bowen, and Hoots (1929) have been retained in this contract study to assist simple correlation of coal data between adjacent quadrangles. However, the mapping of Ferris coal beds by Blanchard and Jones (1976) at the southeast boundary of this quadrangle is sufficiently different from the earlier mapping by Dobbin, Bowen, and Hoots (1929) that correlation with outcrops of Ferris coal beds 123, 124, 127-A, and 129 in the Schneider Ridge quadrangle is not possible.

Stratigraphy

Rocks exposed in the quadrangle range in age from Pennsylvanian to Quaternary. Coal beds are found in the upper part of the Mesaverde Group and the lower part of the Medicine Bow Formation, both of Late Cretaceous age, and in the Ferris Formation of Late Cretaceous/Paleocene age.

In the northeastern part of the quadrangle Blanchard and Jones (1976) map the following sequence of rocks of pre-Cretaceous age:

	Unconformity	
Jurassic	Upper Jurassic, undivided (Ju)	510 feet (155 m)
	Unconformity	
Triassic	Chugwater Formation (TRc)	
	Alcova Limestone (TRa)	1,163 feet (354 m)
	Red Peak Member (TRrp)	
Permian	Permian, undivided (Pu)	1,227 feet (374 m)
Carboniferous-Permian	Tensleep Sandstone (CPt)	

This thickness of 2,900 feet (884 m) for pre-Cretaceous rocks that crop out in sec. 22, T.25N., R.83 W. compares with 2,451 feet (747 m) of similar strata intersected in a well drilled four miles to the west in the northwestern part of the quadrangle (NE sec. 25, T.25N., R.84 W.). This well was completed at 6,469 feet (1,972 m) from surface in calcareous rocks of the Amsden Formation, after intersecting 467 feet (142 m) of Jurassic, 1,148 feet (350 m) of Triassic, and 836 feet (255 m) of Pennsylvanian, strata.

The marine sediments of pre-Cretaceous age are unconformably overlain by marine sediments of Cretaceous age totaling more than 6,500 feet (1,981 m) in thickness. Included are the Lower Cretaceous Cloverly, Thermopolis, and Mowry Formations and the Upper Cretaceous Frontier, Niobrara, Steele Shale, and Haystack Mountains Formations. The first five formations are mapped by Blanchard and Jones (1976) with a combined thickness of 2,578 feet (786 m) in secs. 23 and 26, T.25N., R.84W.; 3,920 feet (1,195 m) in secs. 21, 20, and 29, T.25N., R.83W.; 3,841 feet (1,171 m) in secs. 22 and 27, T.25N., R.83W. The Steele Shale unit is 1,737 feet (529 m) thick in secs. 25 and 36, T.25N., R.84W. and 2,378 feet (725 m) thick in sec. 28, T.25N., R.83W. and the thickness of the Haystack Mountains Formation, the oldest formation in the Mesaverde Group, varies from 2,565 feet (782 m) in sec. 34, T.25N., R.84W., to 2,234 feet (681 m) in sec. 32, T.25N., R.83W., to 2,316 feet (706 m) in sec. 34, T.25N., R.83W.

The calculated thicknesses quoted in the two preceding paragraphs indicate that a minimum of 9,400 feet (2,865 m) of marine sediments, of early Cretaceous age or older, are present in the subsurface at the northwest corner of T.24N., R.83W. Twenty-five hundred feet (762 m) to the northeast of this locality the Precambrian basement rocks crop out, illustrating the very steep character of the northern limit of the Hanna Basin structure.

With the close of Haystack Mountains time depositional conditions in the Hanna Basin area changed from marine to primarily nonmarine. The younger formations of the Mesaverde Group (Gill and others, 1970, p.5) are the Allen Ridge Formation, the Pine Ridge Sandstone, and the Almond Formation. The presence of massive-bedded resistant sandstones in these stratigraphic units is expressed topographically in this quadrangle by Horseshoe Ridge, an east-west trending feature which is located along the northern boundary of Townships 25N., Ranges 83W. and 84 W. Total thickness of the three units is approximately 2,000 feet (610 m). The Allen Ridge Formation, which contains coal beds in the adjoining quadrangle to the west, is a thick sequence of brown fluviatile sandstones and shales, interbedded with carbonaceous shales. The Pine Ridge Sandstone unit consists mostly of light-yellowish-gray fine-grained sandstones with lesser amounts of sandy carbonaceous shales and bentonite lenses. The Almond Formation, in its lower part, consists of yellowish-gray fluvatile sandstones and brownish-gray carbonaceous shales. The upper part of the formation consists of brackish-water to shallow-marine thin-bedded very fine grained white gray and brown sandstones; olive-gray shales containing limestone concretions with marine fossils; dark carbonaceous shales; and coal beds. In this quadrangle, 3 coal beds and 19 local coal lenses in the Almond Formation crop out or are present in the subsurface (Plates 1 and 3).

Bergstrom (1951, p.68-69) measured outcrops of the Mesaverde Formation in sec. 31, T.25N., R83W., in the north-central part of the Seminoe Dam SE quadrangle, and in sec. 13, T.21N., R.85W. near Fort Steele. In each location, the sediments are 2,280 feet (695 m) thick and are of mixed continental and marine type deposited in littoral, deltaic marginal lagoon and estuarine environments, in contrast to the marine shales of the underlying Steele Shale and the overlying Lewis Shale. Gill, Merewether, and Cobban (1970, p.5) elevated the formation to group status in the area of the

Rawlins Uplift and the Hanna, Carbon, and Laramie Basins in southern Wyoming. The four units of the Mesaverde Group are 4,400 feet (1,341 m) thick in the northern half of the Seminoe Dam SE quadrangle and more than 4,300 feet (1,311 m) thick in the subsurface in secs. 11 and 26, T.24N., R.85W. in the Seminoe Dam SW quadrangle (Merewether, 1972). The doubling in thickness of Mesaverde sediments results when the Mesaverde Formation, mapped on lithologic criteria as a suite of essentially continental-type sediments between marine shales, is elevated to group status and defined by stratigraphic and faunal criteria rather than by lithology only.

The marine conditions which returned in Almond time continued with the deposition of the Upper Cretaceous Lewis Shale which conformably overlies the Mesaverde Group. This formation, about 2,570 feet (783 m) thick in sec. 4, T.24N., R.83W., consists mainly of dark gray marine shales interbedded with thick beds of gray to brown fine-grained sandstones, lesser amounts of yellowish-gray siltstones, and bentonite lenses.

The Fox Hills Formation, which overlies the Lewis Shale, was deposited during a transition from marine to nonmarine conditions. It is 350 feet (107 m) thick in the southwest part of sec. 2, T.24N., R.84W. and consists of yellowish-gray fine-grained friable sandstones interbedded with dark-gray sandy shales and lesser amounts of thin-bedded carbonaceous shales.

The Upper Cretaceous Medicine Bow Formation overlies the Fox Hills Formation and contains more than 4,800 feet (1,463 m) of continental sediments. It includes brown thin- to massive-bedded fluviatile sandstones with interbedded conglomeratic lenses, siltstones, and gray shales (in part carbonaceous). At least 10 coal beds and 18 local coal lenses have been identified in the lower part of the formation (Plates 1 and 3). The type section of the Medicine Bow Formation was measured by Bowen (1918) in this quadrangle along the banks of North Platte River, near the mouth of Medicine Bow River (secs. 11 and 14, T.24N., R.84W.), but this 6,200 feet (1,890 m) of strata may have included part of the underlying Fox Hills Formation and part of the overlying Ferris Formation. Today, the type section is beneath the waters of Seminoe Reservoir. Merewether (1972) measured 4,870 feet (1,484 m) of Medicine Bow Formation in secs. 16 and 21, T.24N., R.84W., less than two miles west of the type section locality. Knight (1951) considers the Medicine Bow Formation to be 3,000 to 4,000 feet (914 to 1,219 m) thick at two sections measured in T.24N., R.82W., nine and one-half miles (15.3 km) east of the type section locality.

Overlying the Medicine Bow Formation is the Ferris Formation, a thick sequence of continental sediments that can be divided into two parts: a lower unit of Late Cretaceous age which is about 1,100 feet (335 m) thick in the western part of the Hanna Basin and an upper unit of Paleocene age which is about 5,400 feet (1,646 m) thick. The lower unit includes conglomeratic sandstones, fine- to medium-grained sandstones, carbonaceous shales and minor coal. The conglomeratic sandstones are dark gray to dark brown, ferruginous, and contain pebbles of black, red, and yellow chert, red and gray quartzite, and sparse rhyolite and quartz latite porphyry. Plant microfossils collected by Gill, Merewether, and Cobban (1970, p.46) yielded a Late Cretaceous assemblage. The upper unit of the Ferris Formation includes mudstones, shales, sandstones, carbonaceous shales, and coal. The sandstones are white to light tan to dark orangish brown, very fine to coarse grained and conglomeratic, arkosic, ferruginous, and concretionary. Forty-seven coal beds and many local coal lenses have been identified from outcrops and from subsurface data (Plates 1 and 3A). Two plant microfossil collections yielded ages of early to middle Paleocene where collected near the base of the unit and late-middle Paleocene where collected near the top of the unit (Blanchard and Comstock, 1976).

Blanchard and Jones (1976) mapped at least 5,800 feet (1,768 m) of beds of Ferris age in the southern third of the quadrangle; Dobbin, Bowen, and Hoots (1929) mapped a lesser thickness because they assigned outcrops in the southeastern corner of the quadrangle (sec. 33, T.24N., R.83W.) to the overlying Hanna Formation. The Ferris Formation was named by Bowen (1918) from exposures 10 miles (16 km) south of the center of this quadrangle. The formation is about 6,500 feet (1,981 m) thick at the type locality (Gill and others, 1970, p.46).

Extensive deposits of Quaternary alluvium, colluvium, and terrace deposits overlie the older rocks in the quadrangle. The terrace deposits occur as much as 150 feet (46 m) above the present level of the Seminoe Reservoir, or nearly 250 feet (76 m) above the pre-1939 bed of North Platte River.

Structure

The Seminoe Dam SE quadrangle is on the northern edge of the intermontane Hanna Basin which is comparatively small in areal extent, but very deep. The basin extends about 40 miles (64 km) east-west, 25 miles (40 km) north-south, and in its deepest portion, the eastern half of T.24N., R.82W., contains 30,000-35,000 feet (9,140-10,670 m) of sediments overlying crystalline basement. The rapid deepening of the basin on its northern edge is illustrated in this quadrangle by the following data:

- Precambrian basement rocks crop out 500 feet (152 m) north of the northeast corner of the quadrangle.
- the well drilled in NE sec. 25, T.25N., R.84W. intersected 6,469 feet (1,972 m) of Jurassic, Triassic, and Pennsylvanian strata and was completed before reaching Precambrian basement.
- it is probable that a minimum of 9,400 feet (2,865 m) of sediments, of early Cretaceous age and older, are present in the subsurface at the northwest corner of T24N., R.83W. (see page 5).
- the structural contour map of the Precambrian surface prepared by Knight (1951, p. 46) indicates that there are 15,000 feet (4,572 m) of sediments, of Paleocene age and older, in the subsurface at the southeast corner of the quadrangle. It is probable that this thickness is considerably greater in view of the mapping of Blanchard and Jones (1976). The 9,400 feet (2,865 m) of sediments, early Cretaceous age and older, may be overlain by 2,500 feet (762 m) of Lewis Shale; 300 feet (91 m) of Fox Hills Formation beds; 4,800 feet (1,463 m) of Medicine Bow Formation beds; and 5,800 feet (1,768 m) of Ferris Formation beds. Thus, 22,800 feet (6,950 m) of post-Precambrian sediments may be a minimum thickness at the southeast corner of the quadrangle.

The principal deformation defining the present structural basin occurred during the Laramide Orogeny. The bordering highlands were raised and deformed, and sediments accumulated rapidly in the basin; consequently, the present Hanna Basin has complexly folded and faulted borders, with relatively mild deformation within the basin expressed by a few broad folds and normal faults. With the retreat of the sea in late Haystack Mountains time, and again in Fox Hills time, depositional environments changed from marine to continental.

Several large folds, faults, and steeply dipping beds which are typical of the borders of the structural basin are present in the northern half of the Seminoe Dam SE quadrangle. The principal structures are the O'Brien Springs anticline, with an east-west axial trend, and the Camp Creek syncline immediately to the north, also with an east-west axial trend. The remainder of the quadrangle is characterized by fewer faults and much gentler dips. A set of north- and northwest-trending faults is the dominant structural feature in the southern one-third of the quadrangle. These faults are normal in type and the direction of downthrow varies from fault to fault. The faults, though not consistently down-dropped on the basinward side, may represent adjustment during the period of maximum basin subsidence (Blackstone, 1951).

COAL GEOLOGY

Previous Work

The coal deposits of the Hanna and Carbon Basins have been studied by Veatch (1907), Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972 and 1975).

Twenty-six coal analyses have been published since 1913 for coal beds of the Mesaverde Group and the Medicine Bow, Ferris, and Hanna Formations within the Hanna and Carbon Basins (Appendices 1 and 2). Samples collected and analyzed prior to 1913 have not been considered in this report (American Society for Testing and Materials, 1977, p. 218). An average analysis and an apparent rank of coal beds in each of these four stratigraphic units have also been calculated from the 230 analyses included in the Union Pacific coal inventory program (Appendices 1 and 2).

Glass (1975) and U.S. Department of Interior (1975) published not only proximate analyses for 17 samples collected in the Hanna Basin, but also assays for 10 major and minor oxides, 12 major and minor elements, and 32 trace elements. Glass (1975, p. 1) stresses that these data are insufficient to characterize the chemical and physical properties of any individual coal bed, but this will be possible at a later date as the study continues. Assay results of the 17 Hanna Basin samples show that these coals contain no significantly greater amounts of trace elements of environmental concern than are found in the 42 samples collected in six other Wyoming coal fields.

General Features

In the Seminoe Dam SE quadrangle, 60 coal beds and numerous local coal lenses either have been mapped by Dobbin, Bowen, and Hoots (1929) and Blanchard and Jones (1976) or have been identified in the subsurface (Plates 1, 3, and 3A). No analyses are known to have been published for these coal beds but they probably conform to the norms of Mesaverde, Medicine Bow, and Ferris coal in the Hanna and Carbon Basins (Appendices 1 and 2). Five analyses of coal samples taken during the Union Pacific coal inventory program are shown in Appendix 3.

Mesaverde Coal Beds

Dobbin, Bowen, and Hoots (1929) mapped three coal beds and several local coal lenses in sediments of the Mesaverde Group in the northern half of the quadrangle. The coal beds, designated SEL 1, SEL 2, and 112B on Plates 1 and 3, occur at the top of the Mesaverde Group in rocks of the Almond Formation. Coal bed thicknesses vary from 1.2 feet (0.4 m) to 14.8 feet (4.5 m). Coal beds SEL 1 and SEL 2 have a maximum thickness of 6 feet (2 m) and are generally less than 5 feet (2 m) thick. Coal bed 112B ranges from 3 feet (1 m) to 14.8 feet (4.5 m) thick with an average thickness of 5.2 feet (1.6 m). All but 2 of the 19 local coal lenses intersected in the subsurface by drill holes 3, 4, and 10 are less than 5 feet (2 m) thick.

The Almond Formation coal beds dip steeply to the south at 80°. Surface outcrops of the coal beds are all located north of the KRCRA boundary. The combination of outcrop locations north of Federal land within the KRCRA boundary, steep dips of the coal beds, and no significant thickness of coal detected in the subsurface by four drill holes, precluded any further assessment of the coal resources and reserves of Mesaverde coal beds. Two analyses of Mesaverde coal were obtained as part of the Union Pacific coal inventory program. Appendix 3 shows the results of sampling intersections of a local coal lens above coal bed 112B, and the coal bed SEL 1, in drill hole 2.

Medicine Bow Coal Beds

Ten coal beds in the Medicine Bow Formation are shown on Plates 1 and 3. These are coal beds 113 through 120, including 118A, and SEL 3. In addition, 45 local coal lenses were intersected in the subsurface by drill holes (Plate 3). The coal beds occur at the base of the formation, their strike is generally east-west, and dips are steep to the south, from 60° to 80°, along most of the outcrops. Coal bed thicknesses in outcrops vary from 0.6 feet (0.2 m) to 10 feet (3 m) and average 3.5 feet (1.1 m). Local coal lenses intersected in the subsurface by drill holes are less than 5 feet (2 m) thick, except for one 5-foot (2 m) thick coal lens intersected 143 feet (43.6 m) below coal bed 118 in drill hole 6.

Coal bed 118-118A was selected by U.S. Geological Survey for evaluation of its resource potential. The bed varies in thickness from 1 foot (0.3 m) to 12 feet (3.7 m) with its greatest thicknesses in the center part of the outcrop pattern within this quadrangle.

Analyses of two samples of coal bed 118-118A, from drill holes 5 and 6 that were part of the Union Pacific coal inventory program, are included in Appendix 3. In addition, an analysis of a sample from the local coal lens about 143 feet (43.6 m) below coal bed 118-118A in drill hole 6, is shown in Appendix 3.

Ferris Coal Beds

In this quadrangle, the Ferris Formation contains 47 coal beds and numerous local coal lenses (see Plates 1 and 3A), all occurring in the upper half of the formation that crops out in the south-central and southeastern areas. In general, the coal beds and local coal lenses are of less than Reserve Base thickness or are non-correlatable, with the existing surface and subsurface data, over any significant distance. Of the coal beds mapped, U.S. Geological Survey selected the coal beds 121, 127, and 128 for evaluation of resource potential.

Coal bed 121 crops out between the north-trending faults located in the south-central part of the quadrangle. The bed dips to the southeast at 5° to 10°. In the evaluation of this bed, the coal bed SDSE 7a and the local coal lenses immediately below were included in the total thickness for coal bed 121. Overall bed thickness therefore ranges from 10 to 40 feet (3 to 12 m). The mapping of Blanchard and Jones (1976) shows coal bed 121 has burned for approximately 0.3 miles (0.5 km) down dip from the outcrops. One result of this loss of coal in place is seen on the gamma ray log of drill hole 17, part of the Union Pacific coal inventory program. Coal bed SDSE 7 is well developed on the log but the stratigraphic interval above is badly degraded and anomalous in form, confirming that the overlying coal beds have been partially or completely destroyed by burning at this location. The coal zone has been repeatedly displaced along strike by a set of north-trending normal faults with vertical displacements from 25 to 100 feet (8 to 30 m). It is possible that in many of the faults the principal movement has been horizontal rather than vertical. For example, the northwest-trending fault in SW sec. 35, T.24N., R.84W. has a vertical displacement of 200 feet (61 m) and a horizontal displacement of about 900 feet (274 m) according to Dobbin Bowen, and Hoots (1929, p. 45).

Coal bed 127 occurs 200 to 450 feet (61 to 137 m) above the coal zone 121-SDSE 7; coal bed 128 is 140 to 270 feet (43 to 82 m) above coal bed 127. Coal bed 127 varies in thickness from 1.5 to 11 feet (0.5 to 3.4 m) and coal bed 128 is 0.9 to 20 feet (0.3 to 6.1 m) thick. The two beds dip southeast at 5° to 10° and are displaced by the same set of faults that affect coal zone 121-SDSE 7.

It should be noted that Blanchard and Jones (1976), when mapping coal bed 128 in the southeast part of the quadrangle, show this coal bed splitting up into benches either side of a north-northeast trending fault in the east half of sec. 29, T.24N., R.83W. (see their measured sections 16 through 23). On the east side of the fault their measured sections 22 and 23 show coal bed 128 to be a coal zone over 200 feet (61 m) thick. In this study, only the basal 28.1 feet (8.6 m) of coal beds and interburden are designated coal bed 128, and the overlying coal lenses are considered local coal lenses SEL 16, SEL 17, and SEL 17a (see compiled section 37, Plate 3A).

COAL RESOURCES AND RESERVES

Previous Work

Coal reserves of the Hanna and Carbon Basins have been estimated or calculated by Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972).

Method of Calculating Resources and Reserves

Data from Dobbin, Bowen, and Hoots (1929), Blanchard and Jones (1976), oil and gas well logs, and coal drill holes (written communication, Rocky Mountain Energy Company, 1977) were used to construct coal data maps (Plates 1 and 1A) and coal data sheets (Plates 3 and 3A). U.S. Geological Survey reviewed these four plates and on the basis of Reserve Base criteria, selected four coal beds for the calculation of coal resources in the Seminoe Dam SE quadrangle. In addition, calculation of coal resources was requested for isolated or noncorrelatable data points.

The coal data maps and coal data sheets were used to construct structure contour, coal isopach, and overburden isopach maps of the correlatable coal beds (Plates 4-9, 12-14, 17-19). For single coal beds, the maps were drawn using, as control points, thicknesses measured at outcrop and subsurface data from drill hole information. Where coal beds are split, cumulative coal thicknesses were used, excluding non-coal partings. Control points were generated from surface data and from drill holes by combining outcrop and subsurface thicknesses of individual beds to produce a single, cumulative thickness of the entire zone.

Plates 4-9, 12-14, 17-19 provide the data for calculating the coal resources and reserves within the KRCRA boundary of the quadrangle in accordance with the classification system given in U.S. Geological Survey Bulletin 1450-B and the instructions provided by U.S. Geological Survey on approval of these 12 plates. Calculation of the resources and reserves is in accordance with the following criteria:

- Identified coal resources of the quadrangle, as selected by U.S. Geological Survey, are contained within coal beds 118-118A, 121, 127, and 128, and the resources defined by isolated or noncorrelatable data points.

- Coal bed thicknesses from surface mapping are true thicknesses; thicknesses from subsurface data are apparent thicknesses for coal beds 121, 127, and 128. Due to high dip angles, true bed thicknesses have been calculated for coal bed 118-118A.

- Strippable coal resources (the resources capable of being extracted by strip-mining methods) are composed of single coal beds at least 5 feet (1.5 m) thick and having 200 feet (61 m) or less of overburden.

- Nonstrippable coal resources (subsurface resources minable by underground methods) are single or multiple coal beds with a minimum thickness of 5 feet (1.5 m); a maximum dip of 15^{o}; an overburden, or combined overburden and interburden, thickness of 0 to 3,000 feet (914 m). To avoid duplicating strippable coal Reserve Base and reserve values, no nonstrippable coal Reserve Base and reserve values are calculated where a coal bed(s) occurs above the stripping limit. When calculating nonstrippable coal Reserve Base values, an average thickness for each coal bed is determined from the coal bed thicknesses at control points within a measured area. When calculating nonstrippable coal reserve values, the average thickness for each coal bed is determined in a like manner after coal bed thicknesses greater than 12 feet (3.7 m) have been reduced to 12 feet (3.7 m).

- All coal deeper than 3,000 feet (914 m) is excluded.

- Reliability or geologic assurance categories (measured, indicated, and inferred resources) are defined according to proximity of the coal to a data point. Measured resources occur within 0.25 mile (402 m) of a data point; indicated resources occur within an area that is 0.25 to 0.75 mile (402 m to 1.2 km) from a data point; inferred resources occur within an area that is 0.75 to 3 miles (1.2 to 4.8 km) from a data point. A data point is either a measured coal thickness in a drill hole or a measured coal thickness location on a mapped outcrop.

- Identified coal resources located beneath unleased Federal land in any 40-acre (16 ha) parcel that is partially, or completely, covered by waters of Seminoe Reservoir, are not assigned to one of the three preceding categories. Such resources are tabulated separately and recorded as "not applicable". A nominal 40-acre (16 ha) parcel is the smallest cadastral subdivision considered in this project study.

- Coal resources from isolated or noncorrelatable data points are calculated for a single coal bed at least 5 feet (1.5 m) thick or for an aggregate thickness of multiple coal beds each at least 5 feet (1.5 m) thick. The single coal bed, or the stratigraphically highest bed in an aggregate of coal beds, is locally projected up dip to the surface to establish an inferred outcrop. Strippable coal resources for the projected bed or beds are considered to occur from surface to a depth of 200 feet (61 m); nonstrippable coal resources are considered to occur from surface to a depth of 3,000 feet (914 m). Only the coal resources underlying an area within 0.5 miles (804 m) of a drill hole or a measured surface outcrop are considered and they are assigned to the inferred category of reliability.

- Coal resources are calculated for unleased Federal land within the KRCRA boundary (Plate 2). Information pertaining to leased or fee acreage and to non-Federal land is considered proprietary and not for publication.

In preparing a map for evaluating the areal distribution of identified resources for the isolated or noncorrelatable coal beds, some data require a unique solution. For example:

- Where short segments of coal bed outcrop have data points that indicate a coal thickness of 5 feet (1.5 m) or more, an arc with a radius equal to half the outcrop length is drawn down dip from the outcrop, connecting to the ends of the outcrop. The resulting contained area defines the total coal resource, segmented into strippable and nonstrippable resource sections.

- Where a coal bed outcrop has data points with coal thicknesses less than 5 feet (1.5 m) a 5-foot (1.5-m) cut-off point is interpolated and the resulting segments with values greater than 5 feet (1.5 m) are used to generate arcs (radii equal to half the outcrop length) for defining the extent of the coal resources. When several data points occur on the outcrop of a resource area, an average of their coal thickness values is used to calculate a tonnage of coal.

- Where areas within outcrop segment arcs and areas within 0.5 mile (804 m) of a drill hole coincide, the areas are combined and drill hole coal thickness values are averaged with outcrop coal thickness values.

- When evaluating multiple coal beds of an isolated or noncorrelatable data point, the interburden between subsurface coal beds may be too great to allow the aggregate thickness of coal to be considered as one planar unit. In such instances, a conservative judgment is made and the resources for each coal bed are calculated separately and then totaled.

Results

The areal distribution of leasable Federal coal resources within the KRCRA boundary is shown on Plates 10 and 15 for two of the four selected coal beds. Evaluation of coal bed 128 showed that all coal resources which meet Reserve Base criteria are located beneath unleased Federal land in 40-acre (16 ha) parcels that are partially, or completely, covered by waters of Seminoe Reservoir. Consequently, a plate showing areal distribution and identified resources of coal bed 128 was not compiled; the coal resources were calculated and recorded as "not applicable". Evaluation of coal bed 118-118A showed that no mappable coal resources are present beneath unleased Federal land; therefore, the coal bed is excluded from Reserve Base and reserve calculations.

The coal resource acreage for each section of unleased Federal land was determined by planimeter. Coal Reserve Base values are obtained by multiplying the coal resource acreage for the planimetric portion of each section of unleased Federal land by the average isopach value of the coal bed, times the conversion factor for subbituminous coal, 1,770 short tons (1,606 t) of coal per acre-foot. The coal Reserve Base tonnages are recorded as follows:

- from coal beds 121, and 127: 2.39 million short tons (2.17 mill. t); assigned to measured, indicated, or inferred categories; shown on Plates 10 and 15; included in the coal Reserve Base totals shown on Plate 2.
- from coal beds 121, 127, and 128 beneath 40 acre (16 ha) parcels that are partially, or completely, covered by waters of Seminoe Reservoir: 1.19 million short tons (1.08 million t), not assigned any resource category, recorded as "not applicable," included in the coal Reserve Base totals shown on Plate 2.
- from isolated or noncorrelatable data points: 11.37 million short tons (10.31 million t) of strippable resources and 19.37 million short tons (17.57 million t) of nonstrippable resources, assigned to the inferred resource category, included in the coal Reserve Base totals shown on Plate 2.

In summary, the total Reserve Base for all coal beds thicker than 5 feet (1.5 m), that lie less than 3,000 feet (914 m) below the ground surface of unleased Federal land within the KRCRA in the Seminoe Dam SE quadrangle, is 34.32 million short tons (31.14 million t).

Coal reserves for the quadrangle are calculated by applying recovery factors to the measured, indicated, and inferred resources of coal beds 121 and 127, only. The identified resources of coal beds beneath 40-acre (16 ha) parcels of land adjacent to the shoreline of Seminoe Reservoir, although included in the coal Reserve Base, are excluded from coal reserve calculations; similarly, the inferred resources determined from the isolated or noncorrelatable data points are excluded. For strippable resources, a recovery factor of 0.85 is used; for nonstrippable resources, the recovery factor is 0.50. Reserve tonnages, to the nearest ten thousand short tons, are shown on Plates 10 and 15. Total coal reserves for unleased Federal land within the KRCRA in the Seminoe Dam SE quadrangle, are 1.40 million short tons (1.27 million t), consisting of 0.7 million short tons (0.64 million t) recoverable by strip mining or by underground mining, and 0.7 million short tons (0.64 million t) recoverable by underground mining only.

COAL DEVELOPMENT POTENTIAL

Method of Calculating Development Potential

Following the calculation of Reserve Base values and coal reserves, the coal resources of the KRCRA of the Seminoe Dam SE quadrangle, except those coal resources determined from isolated or noncorrelatable data points, are evaluated for their development potential in each of two mining-method categories, surface and subsurface.

Strippable and nonstrippable resources are assigned to one of four development potential categories (high, moderate, low, and unknown) according to the following criteria:

Strippable Resources

- Assignment is based on calculated mining ratio values for subsurface data points (wells and drill holes) and for points of intersection of coal isopachs (Plates 5, 8, 13, and 18) and overburden isopachs (Plates 6, 9, 14, and 19).

- The formula used to calculate mining ratios was provided by U.S. Geological Survey as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where

MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor (0.85 for strip mining)

0.911 = a constant

- If mining ratio is 0-10, resources have high development potential.

  If mining ratio is 10-15, resources have moderate development potential.

  If mining ratio is greater than 15, resources have low development potential.

- If insufficient data prevent the construction of mining ratio contours, the resources are assigned to unknown development potential category, provided that there is reasonable assurance the coal bed is present in that area.

- If resources are located beneath a 40-acre (16 ha) parcel that is partially, or completely, covered by waters of Seminoe Reservoir, they are not assigned a development potential. However, they are mapped and tabulated as "not applicable". A nominal 40-acre (16 ha) parcel is the smallest cadastral subdivision considered in this project area.

Nonstrippable Resources

- Coal beds must be more than 5 feet (1.5 m) thick. Coal beds less than 5 feet (1.5 m) thick are excluded from the Reserve Base coal resources. Where coal beds are more than 12 feet (3.7 m) thick, only 12 feet (3.7 m) of the total thickness is used for Reserve Base calculations.

- If the overburden is between 0 and 1,000 feet (0 and 305 m), resources have high development potential; if the overburden is between 1,000 and 2,000 feet (305 and 610 m), resources have moderate development potential; if the overburden is between 2,000 and 3,000 feet (610 and 914 m), resources have low development potential.

- If insufficient data prevents the construction of coal isopachs or overburden isopachs, or if the correlatable coal bed in the area is located completely above the stripping limit, the resources are assigned to the unknown development potential category, provided that there is reasonable assurance the correlatable coal bed is present in the area.

- If resources are located beneath any 40-acre (16 ha) parcel that is partially, or completely, covered by waters of Seminoe Reservoir, they are not assigned a development potential category; they are mapped and tabulated as "not applicable".

By applying the above criteria, mining-ratio maps (Plates 11, 16, and 20) were prepared for coal beds 121, 127, and 128. A mining-ratio map is omitted for coal bed 118-118A because of insufficient data within the unleased Federal land of the KRCRA.

Development potential acreages were then blocked out, as shown on CDP Plates 21 and 22. Acreage for strippable and nonstrippable resources of selected coal beds is shown in Table 1 for each of the four development potential categories. In accordance with a constraint imposed by the U.S. Bureau of Land Management, the highest development potential affecting any portion of a 40-acre (16 ha) parcel is applied to the entire parcel. For example, if 5 acres (2 ha) within a parcel are assigned 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.

Table 1. — Development potential for identified resources of the selected coal beds within the KRCRA of the Seminoe Dam SE quadrangle

Coal bed	Development potential (acres)							
	Strippable resources			Nonstrippable resources			Unknown category	
	High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
118-118A	0	0	0	0	0	0	200	0
121	120	0	0	120	90	0	320	1,000
127	160	0	80	40	0	0	120	840
128	0	0	0	0	0	0	760	1,440
Totals	280	0	80	160	90	0	1,400	3,280

Additionally, at the direction of the U.S. Geological Survey, an unknown development potential is assigned to coal resources calculated for any coal bed that, although not selected for coal resource evaluation, is accepted to be of Reserve Base thickness in the absence of data to the contrary.

Development Potential for Strippable Resources

Development potential for strippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 21 and Table 2 show the highest surface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to that subdivision.

Table 2. - Highest development potential for identified resources of selected coal beds within the KRCRA of the Seminoe Dam SE quadrangle

Development potential (acres)							
Strippable resources			Nonstrippable resources			Unknown category	
High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
240	0	80	160	50	0	440	960

There are approximately 8,540 acres (3,455 ha) of unleased Federal land within the KRCRA of this quadrangle. Of this area, 760 acres (307 ha) or 8.9 percent of the total, are estimated to be underlain by coal resources from the selected coal beds, with development potential for surface mining. Of the 760 acres (307 ha), a high development potential is assigned to 240 acres (97 ha), a low development potential to 80 acres (32 ha), and an unknown development potential to 440 acres (178 ha).

Of the 8,540 acres (3,455 ha) of unleased Federal land, there are 2,750 acres (1,113 ha) or 32 percent of the total, which are classifiable as of unknown surface mining potential on the basis of both (a) the presence of outcrops of noncorrelatable coal beds of unknown thickness and (b) data gaps on beds selected for coal resource evaluation.

Development Potential for Nonstrippable Resources

Development potential for nonstrippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 22 and Table 2 show the highest subsurface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to that subdivision.

Of the 8,540 acres (3,455 ha) of unleased Federal land within the KRCRA of this quadrangle, 1,140 acres (461 ha) or 13.3 percent of the total, are estimated to be underlain by coal resources, from the selected coal beds, with development potential for underground mining. Of the 1,140 acres (461 ha), a high development potential is assigned to 160 acres (65 ha), a moderate development potential to 50 acres (8 ha), and an unknown development potential to 960 acres (388 ha).

Of the 8,540 acres (3,455 ha) of unleased Federal land, there are 1,960 acres (793 ha) or 23 percent of the total, which are classifiable as of unknown subsurface mining potential on the basis of both (a) the presence of outcrops of noncorrelatable coal beds of unknown thickness and (b) data gaps on beds selected for coal resource evaluation.

- 4,585 acres (1,855 ha), or 53.7 percent of the total, which are in 40-acre (16 ha) parcels partially, or completely, covered by waters of Seminoe Reservoir. Nonstrippable resources located beneath this acreage are not assigned a development potential category; they are mapped and recorded as "not applicable".

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Appendix 1. — Average analyses of coal samples from the Hanna and Carbon Basins

Source of Data	Number of samples (1)	Total footage Ft	in	Average analyses — as received basis: Percent: Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Calorific Value, Btu/lb: Moist, mineral-matter-free basis (2)	Apparent rank of coal (3)
Published analyses	26	318	6	12.5	7.1	36.2	44.2	0.6	10,553	11,438	sub A or hvCb
Union Pacific coal inventory program	230	1,605	10	12.48	8.74	35.12	43.68	0.82	10,398	11,494	sub A or hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 2. — Average analyses of coal grouped by coal-bearing formations in the Hanna and Carbon Basins

Source of data	Formation or Group	Number of samples (1)	Total footage Ft	in	Average analyses — as received basis: Percent Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Calorific Value, Btu/lb Moist, mineral-matter-free basis (2)	Apparent rank of coal (3)
Published analyses	Mesaverde	1	4	0	14.1	7.8	36.5	41.6	1.1	10,290	11,251	sub A or hvCb
	Medicine Bow	2	10	1	12.8	3.8	33.3	50.2	0.8	11,050	11,534	hvCb
	Ferris	10	93	1	.13.0	8.3	34.3	44.3	0.4	9,970	10,956	sub A or hvCb
	Hanna	13	211	4	12.0	6.6	38.1	43.3	0.7	11,946	11,797	hvCb
Union Pacific coal inventory program	Mesaverde	13	70	5	9.45	8.41	35.42	46.72	0.77	11,112	12,237	hvCb
	Medicine Bow	16	93	4	13.09	4.03	35.46	47.42	0.80	10,927	11,446	sub A or hvCb
	Ferris	114	863	1	12.69	7.96	34.39	44.97	0.44	10,331	11,309	sub A or hvCb
	Hanna	87	579	0	12.51	10.67	35.96	40.85	1.33	10,280	11,640	hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec. 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 3. — Coal analyses, Seminoe Dam SE quadrangle

Drill hole	Location			Coal bed	Sample interval				Sample width		Analyses — as received basis					
					From		To				Percent					Btu per pound
	Sec.	Twp.	Rge.		Ft	in	Ft	in	Ft	in	Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	
2	1	24N	84W	L	253	4	259	0	5	8	7.80	7.10	36.43	48.67	0.53	11,643
2	1	24N	84W	SEL 1	436	3	438	7	2	4	7.77	10.85	34.08	47.30	0.70	11,101
5	7	24N	83W	118	551	0	556	7	5	7	10.59	4.04	36.35	49.02	0.82	11,372
6	7	24N	83W	118	83	0	91	3	8	3	10.12	4.67	36.90	48.31	1.92	11,295
6	7	24N	83W	L	244	8	249	8	5	0	10.52	5.12	35.77	48.59	1.91	11,193

Data from Rocky Mountain Energy Company (1977)
[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254.
To convert Btu per pound to kilojoules per kilogram, multiply by 2.326.]

Appendix 4. — Coal Reserve Base Data for Federal coal lands (in short tons) in the Seminoe Dam SE quadrangle, Carbon County, Wyoming.

Strippable coal Reserve Base data for Federal coal lands (in short tons) in the Seminoe Dam SE quadrangle, Carbon County, Wyoming [Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072]

Coal Bed	High Development Potential (0-10 mining ratio)	Moderate Development Potential (10-15 mining ratio)	Low Development Potential (>15 mining ratio)	Total
121	410,000	70,000	20,000	500,000
127	120,000	140,000	140,000	400,000
Total	530,000	210,000	160,000	900,000

Non-strippable coal Reserve Base data for Federal coal lands (in short tons) in the Seminoe Dam SE quadrangle, Carbon County, Wyoming. (To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential (0-1000 ft of overburden)	Moderate Development Potential (1000-2000 ft of overburden)	Low Development Potential (2000-3000 ft of overburden)	Total
121	1,300,000	0	0	1,300,000
127	460,000	0	0	460,000
Total	1,760,000	0	0	1,760,000