UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to Accompany:

COAL RESOURCE OCCURRENCE MAP
COAL DEVELOPMENT POTENTIAL MAP OF THE MARSHALL NW QUADRANGLE, DUNN COUNTY, NORTH DAKOTA

[Report includes 18 plates]

By

WOODWARD-CLYDE CONSULTANTS

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INTRODUCTION

The occurrence, extent, and preliminary geologic evaluation of coal beds in the Marshall NW quadrangle in west-central North Dakota are described in this report. Subsurface data consisting of oil and gas well and exploration drill hole logs and surface data comprised of measured sections are presented on the Coal Data Map and Coal Data Sheet, Plates 1 and 3, respectively. Federal ownership of coal and total Reserve Base and Hypothetical resources of coal by section are presented on the Boundary and Coal Data Map, Plate 2. Derivative maps, consisting of coal isopachs, structure contours, overburden, mining ratios, reserve categories, and Reserves and Reserve Base, are compiled for each coal seam of Reserve Base thickness underlying the quadrangle and are presented on Plates 4 through 17, respectively. A Coal Development Potential Map for surface mining is presented on Plate 18.

This work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17118).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act of 1975 and is a part of the U.S. Geological Survey's (USGS) coal program.

This information is intended to provide basic data on coal resources for land-use planning purposes by the Bureau of Land Management, state and local governments, and the public.

LOCATION

The Marshall NW 7 1/2 minute quadrangle is located in Dunn County, North Dakota, about 2 miles (3 km) west of Marshall and 8 miles (13 km) southwest of Halliday.

ACCESSIBILITY

The area is accessible from the east by county road to State Highway 8, 1.6 miles (3 km). Manning lies on State Highway 8 which connects with Interstate 94 at Dickinson, 17 miles (24 km) to the south.

The Burlington Northern Railroad operates and maintains an east-west route which extends through Halliday, Dunn Center and Killdeer about 7 1/2 miles (12 km) north of the quadrangle. No railroad route currently passes through or closer to the quadrangle than the existing Burlington Northern route to the north.

PHYSIOGRAPHY

The quadrangle lies in the central portion of a large topographic high known as the Missouri Plateau. The plateau is being dissected by the Knife, Heart, Cannonball, and Cedar Creek Rivers. In the eastern portion of the plateau, the topography is generally hilly and along the Missouri River there are bluffs 500-600 feet high (152-183 m). The western part of the Missouri Plateau is characterized by more irregular topography than that which is prevalent throughout the remainder of the plateau. This area, known collectively as the "the Badlands", comprises an intricate maze of narrow ravines, sharp crested ridges, and pinnacles.

The Marshall NW quadrangle may be characterized as gently rolling to hilly with a maximum relief across the quadrangle of 400 feet (122 m). Knife River, the major drainage system of the area, flows from west to east in the southern portion of the quadrangle. Numerous shallow drainages feed into the Knife River throughout the quadrangle.

The vegetation is mixed prairie grasses and some of the land is cultivated.

CLIMATE

North Dakota's climate may be characterized as semi-arid; the average annual precipitation is 17 inches (43 cm) at Dunn Center, which is located 10 miles (16 km) north of the quadrangle.

Maximum precipitation occurs during the late spring and early summer with slightly over half the total annual precipitation occurring during May, June and July. Although the mean annual temperature is about 40°F (4.4°C) temperatures, as recorded at the Dunn Center weather station by the U.S. Department of Commerce, can range from 102°F (38.9°C) in summer months to -25°F (-31.7°C) in winter months. The prevailing northerly winds increase in velocity during the colder months of November through March.

LAND STATUS

The quadrangle lies in the western one-half of the Knife River Known Recoverable Coal Resource Area (KRCRA). The Federal government owns the coal rights to approximately 35 percent of the quadrangle.

PREVIOUS WORK

This report has drawn on a number of basic data reports on coal in the Knife River KRCRA, including: Law (1977), Benson (1953), and United States Geological Survey (USGS) and North Dakota Geological Survey (NDGS) (1976, 1977). Ground basic data reports in the Knife River area were also used, including: Croft (1970) and Klausing (1971, 1974, 1976).

METHOD OF STUDY

Lithologic and geophysical logs from two drill holes and three measured sections provided the basic data for this study. The most important sources of data were Law, (1977); and USGS and NDGS, (1977). The quality of the available coal information is variable. Lithologic and geophysical logs from exploration holes drilled by the North Dakota Geological Survey, North Dakota State Water Commission, and private coal companies generally provide the most detailed and reliable subsurface data. Lithologic logs of private water wells are less detailed and less reliable, but they provide usable information in many cases. Where the data for a specific coal bed appeared to be inaccurate or inconsistent with surrounding drill hole data, they were not included in the data base that was used for construction of derivative maps for that coal bed. For instance, in some drill holes, coal intervals were not noted and the data appeared anomalous in relation to data from adjacent drill holes; rather than plotting a zero coal thickness, the coal bed was assumed to be laterally extensive. Many coal splits were not mapped because of inconsistent data that did not allow projection of split thicknesses with reasonable reliability or accuracy.

Drill hole data and projected coal outcrop traces from previous investigations (Law, 1977) were plotted on the Coal Data Map, Plate 1. These outcrop data were than modified in accordance with structural trends in the present mapping. It was assumed that all beds extended to the surface although it is known that thick alluvial, colluvial, and glacial materials are sometimes present. Subsurface information (available to depths of 600 feet (183 m) was used to construct correlation diagrams of coal beds (Coal Data Sheet, Plate 3). Correlation diagrams for the Marshall NW quadrangle and the adjoining Werner, Ziner Butte, and Marshall quadrangles were then integrated and coal structure contours, isopachs, overburden isopachs and mining ratio maps were constructed for coal beds of reserve base thickness (5 feet minimum) (Plates 4 through 17).

GEOLOGY

STRATIGRAPHY

The oldest rocks present in the uppermost 600 feet (183 m) of the stratigraphic section in the Marshall NW quadrangle are of the coal-bearing Tongue River and Sentinel Butte members of the Paleocene age Fort Union Formation (Rehbein, 1977). Sandstones, siltstones and shales of this formation are locally mantled by erosional remnants of the Upper Paleocene-Lower Eocene Golden Valley Formation and by Quaternary glacial, eolian, and alluvial deposits.

Fort Union Formation - Paleocene.

Tongue River member - this member ranges in thickness from 350 to 900 feet (107 to 274 m) and consists of an alternating sequence of fluvially deposited sandstone, siltstone and shale, and lignite. It conformably overlies the marine Cannonball member and the time equivalent, nonmarine Ludlow member. The

Tongue River member is similar to the overlying Sentinel Butte member and in places cannot be distinguished from it. The contact between the Tongue River and Sentinel Butte members, which has been arbitrarily set at the top of the HT Butte lignite, is conformable.

Sentinel Butte member - this member averages 500 feet (152 m) in thickness and consists of an alternating sequence of fluvially deposited sandstone, siltstone, shale, carbonaceous shale, and lignite. In general, the sandstones are fine grained and poorly cemented. Shales range from soft, plastic clay to moderately indurated claystone. Locally, there are thin calcareous or silicious concretions. Shale and siltstone zones readily break down and form gentle slopes beneath the sandstone ledges.

Golden Valley Formation - Eocene.

This formation consists of about 200 feet (61 m) of alternating shales, siltstones, and cross-bedded sandstones. These sediments which conformably overlie the Sentinel Butte member, have been eroded away in much of the study area.

Channel Deposits - Pleistocene.

Sand and gravel channel deposits of indeterminate thickness lie beneath alluvial deposits. These deposits underlie early Wisconsinan glacial till and Quaternary alluvium in the area.

Glacial Till - Pleistocene.

The glacial till is a heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders which was deposited during Wisconsinan episodes of continental glaciation.

Eolian Deposits - Pleistocene and Recent.

Unconsolidated dune and loess-like deposits from several inches to more than five feet thick mantle most of the study area. The loess-like deposits consist of silty clays, clayey silt, and silty to clayey sands and are probably of late Pleistocene to Recent age. Recent dunes, consisting of silts and very fine grained uniform sand, have been deposited on the lee side of knobs and ridges.

Alluvium - Recent.

Alluvium consisting of clay, silt, sand, and gravel mantles valley floors in the study area.

DEPOSITIONAL ENVIRONMENTS OF THE LIGNITES

The Tongue River lignites are thick and laterally extensive. The HT Butte bed, at the top of the Tongue River Formation, can be traced over thousands of square miles. The lignite beds of the Tongue River member, in contrast to the Ludlow lignites, were formed in large swamps adjacent to fluvial channels (Rehbein, 1977).

The Sentinel Butte lignites, though fewer in number, are almost as continuous as the Tongue River lignites and had a similar depositional environment.

STRUCTURE

Regionally, the Knife River KRCRA is located on the southeastern flank of the Williston Basin, approximately 60 miles (97 km) from the basin center. Generally, the sedimentary units are flat lying or gently undulating, with a northward to northeastward regional dip ranging from less than 10 feet per mile (2 m per km) to 180 feet per mile (34 m per km). Upper strata have been warped into a gentle syncline with a northeast to southwest trending axis located approximately 10 miles (16 km) east of the town of Dodge. The dips on the flanks of the syncline are approximately 18 feet per mile (3.4 m per km). The coal beds as mapped within this quadrangle show minor structural variations from the regional structural framework. More definitive descriptions of the structural aspects of the coal seams may be found in the "Coal Geology" section which follows. Major faulting has not been observed in the area (Menge, 1977). Surficial materials generally mask most of the older stratigraphic units, making it difficult to assess the importance of minor faulting.

COAL GEOLOGY

Eight major coal beds and several local coal beds are either mapped at the surface or identified in the subsurface in this quadrangle. The Meyer coal bed is stratigraphically the lowest recognized coal bed. It is successively overlain by a sequence of non-coal bearing rocks approximately 65 feet (20 m) thick; the HT Butte coal bed; a sequence of rocks approximately 90 feet (27 m) to 180 ft (55 m) thick which contains up to two local coal beds (a local bed, and Local 4, a local bed correlatable between several quadrangles); the Hazen coal bed; a sequence of rocks approximately 115 feet (35 m) thick which contain up to two local beds (a local bed and Local 3, a local bed correlatable between several quadrangles); the Beulah-Zap coal bed; a sequence of non-coal bearing rocks approximately 45 feet (14 m) thick; and the Schoolhouse coal bed, which is overlain by a rock interval containing a number of local coal beds and the Local 1 coal bed (a local bed correlatable between several quadrangles). Table 1 shows the coal bed names and their stratigraphic position.

The coal beds of the Fort Union Formation in the Knife River area are lignite in rank and contain 0.4 to 1.2 percent sulphur, less than 10 percent ash and between 5910 and 7330 BTU/lb (Table A-1). Coal analyses indicate that these coals have less than or about the same amount of trace elements as coal beds in other areas of the northern Great Plains coal province (Tables A-2 through A-5).

MEYER COAL BED

The lowest mapped coal bed, the Meyer bed does not crop

Table 1 -- Coal Bed Names and Stratigraphic Position

Bed Name	Other Names
Schoolhouse	Otter Creek
↑ 45 ft ↓	
Beulah-Zap	Dunn Center, Herman
↑ 50 ft ↓	
Local 3	
↑ 25 ft ↓	
Hazen	Spear, Hazen "B", Kruckenberg, Red Butte
↑ 100 ft ↓	
Local 4	
↑ 20 ft-80 ft ↓	
HT Butte	Hazen "A", Garrision Creek Yeager, Hagel, Berg, Keuther, Stanton
↑ 65 ft ↓	
Meyer	

out in the Marshall NW quadrangle. Based upon data from one drill hole in the quadrangle and projections from adjacent quadrangles, the Meyer probably dips southeast at 40 feet per mile (8 m per km) as shown on Plate 4.

The thickness of the bed varies from 4 feet (1 m) to 9 feet (3 m) with the bed increasing in thickness from south to northeast as shown on Plate 4. The overburden varies in thickness from 300 feet (91 m) to 700 feet (213 m) as shown on Plate 4.

Chemical Analyses of the Meyer Coal Bed - No proximate or elemental analyses of the Meyer coal bed have been found in the literature. It is assumed, however, that the quality of the coal is comparable to that of the other coal beds of the Fort Union Formation and is lignite in rank.

HT BUTTE COAL BED

The HT Butte coal bed overlies the Meyer coal bed. It is separated from the Meyer coal bed by approximately 65 feet (20 m) of rock. Records of two drill holes penetrating the HT Butte coal bed in this quadrangle were found. Based upon these records and projections from adjacent quadrangles, the HT Butte coal bed dips east at approximately 30 feet per mile (6 m per km) as shown on Plate 6.

The bed varies from 6 feet (2 m) to 8 feet (2 m) thick with the thickness increasing from northwest to south and northeast as shown on Plate 7, and has one parting 20 feet (6 m) thick. The overburden varies from 200 feet (61 m) to 500 feet (152 m) thick, as shown on Plate 6.

Chemical Analyses of the HT Butte Coal - Proximate (as received) and elemental analyses of the HT Butte coal bed are presented in Tables A-1 and A-2, respectively, and indicate that the HT Butte coal is lignite in rank. No coal analyses are available for this quadrangle, but analyses of coal samples from the Center quadrangle indicate the following: ash, 5.9%; sulfur 0.7% and BTU/lb, 7024.

HAZEN COAL BED

The Hazen coal bed overlies the HT Butte coal bed. It is separated from the HT Butte coal bed by approximately 180 feet (55 m) of rock and one local coal bed. The Hazen coal bed underlies approximately 70 percent of the quadrangle. In the remainder of the quadrangle the Hazen coal bed has been removed by erosion. Records of one drill hole and three measured sections penetrating the Hazen coal bed in this quadrangle were found. Based upon these records and projections from adjacent quadrangles, the Hazen coal bed dips southeast at approximately 40 feet per mile (8 m per km) as shown on Plate 9.

The bed varies in thickness from 2 feet (0.6 m) to 6 feet (2 m) thick, with the thickness increasing from northeast to west as shown on Plate 10, and it has up to two partings totaling up to 25 feet (7.6 m) thick. The overburden varies from 50 feet (15 m) to 450 feet (137 m) thick, as shown on Plate 9.

Chemical Analyses of the Hazen Coal - Proximate (as received) and elemental analyses of the Hazen coal bed are presented in Tables A-1 and A-3, respectively, and indicate that the Hazen coal is lignite in rank. No coal analyses are available from this quadrangle, but analyses of samples from the Hazen coal bed near Center, in Oliver County indicate the following: ash, 4.2%; sulfur, 0.5%; and BTU/lb, 6290.

BEULAH-ZAP COAL BED

The Beulah-Zap coal bed overlies the Hazen coal bed. It is separated from the Hazen coal bed by approximately 110 feet (33.5 m) of rock and two local coal beds. The Beulah-Zap coal bed underlies approximately 70 percent of the quadrangle. In the remainder of the quadrangle the Beulah-Zap coal bed has been removed by erosion. Records of one drill hole penetrating the Beulah-Zap coal bed in this quadrangle were found. Based upon this record and projections from adjacent quadrangles, the Beulah-Zap coal bed dips east at approximately 30 feet per mile (6 m per km) as shown on Plate 12.

The bed varies in thickness from 5 feet (2 m) to 19 feet (5.6 m) thick, with the thickness increasing from the southeast and northwest toward the center of the quadrangle as shown on

Plate 13, and it has up to two partings which can total up to 4 feet (1 m) thick. The overburden ranges from 0 feet (0.0 m) to 300 feet (91 m) thick, as shown on Plate 12.

Chemical Analyses of the Beulah-Zap Coal - Proximate and elemental analyses of the Beulah Zap coal bed are presented in Tables A-1 and A-4 and indicate that the coal is of lignite rank. No coal analyses are available for this quadrangle, but analyses of samples from the Beulah-Zap coal bed in the Dunn Center quadrangle indicate the following: ash, 8.0%; sulfur 0.8%; and BTU/lb, 6800.

SCHOOLHOUSE COAL BED

The Schoolhouse coal bed is the uppermost mapped coal bed in the quadrangle. It is present in only about 50% the quadrangle, having been removed by erosion. Where present the bed overlies the Beulah-Zap coal bed and is separated from it by 45 feet (14 m) of rock and a thin local coal bed. The bed dips to the east at approximately 20 feet per mile (2 m per km) as shown on Plate 15.

Where the bed is present it ranges in thickness from 3 feet (0.9 m) to 10 feet (3 m) and increases in thickness from east to west as shown on Plate 16, and it has no rock partings. The overburden varies from 0 feet (0.0 m) to 300 feet (91 m) thick, as shown on Plate 15.

Chemical Analyses of the Schoolhouse Coal - Proximate and elemental analyses of the Schoolhouse coal bed are presented in Tables A-1 and A-5, respectively and indicate that the Schoolhouse coal is lignite in rank. Although no coal analyses are available for this quadrangle, analyses of samples from the Schoolhouse coal bed near Center in Oliver County indicate the following: ash, 5.7%; sulfur 1.2%; and BTU/lb, 6720.

LOCAL COAL BEDS

In the Marshall NW quadrangle, five local coal beds, varying in thickness from 1 to 10 feet (0.3 to 3 m), occur in the Tongue River and Sentinel Butte members of the Fort Union Formation. The thickest coal bed is Local 4, a local bed that is correlatable between several quadrangles. Generally, the coal beds are thin, usually less than 5 feet thick, and of limited areal extent. Derivative maps were not constructed and coal resources and reserves were not calculated for the local coal beds due to their lenticular nature, insufficient data, and thickness.

COAL RESOURCES

Coal resource classification, as used in this report, is based on the degree of geological assurance of the existence and minability of the coal bed. The criteria for resouce classification is based on the distance from the data point.

The resource categories are:

Identified

measured - within 1/4 mile radius of data point

indicated - between 1/4 and 3/4 mile radius of data point

inferred - between 3/4 and 3 mile radius of data point

Hypothetical - beyond 3 mile radius of data point

Coal resource/reserve calculations are made using data presented on isopach and overburden contour maps for all Federal government coal lands in the quadrangle.

In areas suitable for surface mining, Reserve Base and Reserve tonnages are calculated for identified coal resources. Reserves are not calculated for hypothetical coal resources.

In areas suitable for underground mining (coal bed thickness of 5 feet or greater and overburden from 200 to 1000 feet), Reserve Base and Hypothetical coal resource tonnages are calculated.

The resource tonnages are estimated by a computer algorithm which is interactive with an automated planimeter-digitizer. Each area is traced with a magnifying cursor and when a section is completed, a check is made to see that partial areas stored on diskettes sum to the area of the whole section.

The areas measured are converted by the algorithm using given parameters (lignite = 1750 tons per acre foot (1750 tons per acre foot = 12871 metric tons per hectare meter); recovery factor for strippable coal = 0.85) to yield Reserve Base and Reserves in millions of short tons per section for each class. Reserve Base values for the Meyer, HT Butte, Hazen, Beulah-Zap and Schoolhouse beds are shown in Plates 5, 8, 11, 14 and 17, respectively. Reserve Base and Reserve values are rounded off to the hundredth of one million short tons.

Total reserve base data for the five coal beds mapped in this quadrangle is shown on Plate 2.

COAL DEVELOPMENT POTENTIAL

Areas considered to have strip mining potential are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal).

Coal outcrop traces were projected from structure contour maps and checked against previously projected outcrops (Law, 1977). An overlay of the structure contour and topographic maps provides data for computation of overburden thickness. The coal isopach map was overlain by the overburden isopach map and a mining ratio calculated using the following the formula:

$$MR = \frac{To\ (.922)}{Tc\ (.85)}$$

where:

MR = cubic yards of overburden per ton of recoverable coal

To = thickness of overburden

Tc = thickness of coal

0.922 = factor to convert thickness of overburden and thickness of coal to cubic yards per ton

0.85 = coal recovery factor (85%)

The Coal Development Potential (CDP) map is compiled by overlaying each mining ratio map for the quadrangle on the property base and noting for all Federal coal land whether each 40-acre tract contains Reserve Base coal in any of the mining ratio categories (Plate 18). Areas of high, moderate, and low development potential for surface mining methods are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15. The highest rating for each tract is plotted on the CDP map. Areas beyond the outcrop are designated "not applicable" and areas of less than 5 feet coal thickness are designated "0" development potential. Mining ratios are not calculated where coal thicknesses are less than 5 feet or overburden thickness exceeds 200 feet.

The coal development potential for subsurface mining is considered low in this quadrangle because no criteria for its classification have been established.

DEVELOPMENT POTENTIAL FOR SURFACE MINING METHODS

The coal development potential for surface mining methods (less than 200 feet (61 m) of overburden) is shown on Plate 18 and summarized in Table 2.

The strippable reserves are distributed uniformly throughout the quadrangle as can be seen on Plate 18.

In the northeast portion of the Marshall NW quadrangle coal development potential is rated low because the Beulah-Zap bed is almost 200 feet (61 m) deep. In the northern 2/3 of the map, the coal development potential is generally rated high. The high ranking is due to the fact that the 6 to 7 feet (1.8 to 2.1 m) thick Schoolhouse bed is near the surface in this area. A few scattered areas of low development potential in the northern 2/3 of the map are dependent on the rating of the HT Butte bed. Other low coal development potential areas in the east central portion of the map are governed by the very thick overburden covering the Schoolhose coal bed. The southern 1/3 of this coal development potential map shows a variable ranking. A high development potential results from the Beulah-Zap coal bed being very close to the ground surface. Moderate coal development potential for the southern 1/3 of this map is governed by the occurrence of the HT Butte coal bed

Table 2 - Strippable coal reserve base for Federal Coal Lands (in millions of short tons) in the Marshall, NW Quadrangle, Dunn County, North Dakota.

Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tonnes, multiply by 0.9072; to convert mining ratios in $yard^3$/ton to m^3/t, multiply by 0.8423.

Coal Bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Schoolhouse	33.22	11.07	10.69	54.98
Beulah-Zap	85.88	39.01	29.46	151.35
Hazen	6.00	3.33	16.17	25.50
HT Butte	.00	9.43	32.38	41.81
Meyer	.00	.00	.00	.00
	125.1	62.84	88.70	273.64

where approximately 100 feet (31 m) of overburden covers the 7 to 8 feet (2.1 to 2.4 m) of coal. The low coal development potential areas in the far southwest corner of this quadrangle show that the HT Butte coal bed is covered by overburden in excess of 100 feet (31 m). Other low coal development potential ratings in the southeast corner of the map are caused by overburden thicknesses between 100 to 200 feet (31 to 61 m) covering the HT Butte coal bed.

DEVELOPMENT POTENTIAL FOR UNDERGROUND MINING METHODS AND IN SITU GASIFICATION

The Meyer coal bed, which is the lowest identified coal bed in the quadrangle, and the HT Butte, Hazen and Beulah-Zap coal beds all have substantial quantities of non-strippable (greater than 200 feet of overburden) coal resources as shown in Table 3. The areal distribution of the coal resources is shown on Plates 5, 8, 11 and 14 respectively.

The development potential for underground mining methods is considered low in this quadrangle because there are no active or planned underground mines in the quadrangle, and no criteria for its classification have been established.

No criteria have been established for rating the development potential by in situ gasification of coal methods in this area.

Table 3 - Nonstrippable coal reserve base for Federal Coal Lands (in millions of short tons) in the Marshall NW Quadrangle, Dunn County, North Dakota.

Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tonnes, multiply by 0.9072; to convert mining ratios in $yard^3/ton$ to m^3/t, multiply by 0.842.

Coal Bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Schoolhouse	.00	.00	.84	.84
Beulah-Zap	.00	.00	22.49	22.49
Hazen	.00	.00	1.31	1.31
HT Butte	.00	.00	109.50	109.50
Meyer	.00	.00	118.81	118.81
	.00	.00	252.95	252.95

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APPENDIX A

PROXIMATE AND ELEMENTAL ANALYSES

Table A-1 Proximate Analyses (as received)

Bed Name	No. of Samples	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Sulphur (Ultimate) %	Btu/lb*	Data Source
HT Butte	2	36.6	27.9	29.5	5.9	0.7	6970	Pollard et al., 1972
HT Butte	2	32.4	31.6	30.3	5.9	0.7	7024	Brant, 1953
HT Butte	3	35.5	28.6	31.1	4.9	0.5	7150	Johnson & Kunkel, 1959
Hazen	1	41.0	25.9	28.9	4.2	0.5	6290	Johnson & Kunkel 1959
Beulah-Zap	15	36.1	26.9	30.7	6.2	0.73	6890	Sondreal, Kube Elder, 1968
Beulah-Zap	3	34.0	29.0	29.0	8.0	0.8	6800	Pollard, et al., 1972
Beulah-Zap	1	39.5	28.3	25.3	6.9	0.4	5910	Johnson & Kunkel, 1959
Beulah-Zap	2	35.7	28.5	30.8	4.9	0.6	7018	Brant, 1953
Beulah-Zap	2	35.88	27.66	30.18	6.27	1.00	6566	Leonard, et al., 1925
Beulah-Zap	4	36.3	28.1	29.6	6.0	1.16	7028	USGS & Mont.Bur. of Mines & Geol. 1976
Beulah-Zap	10	29.6	29.6	34.2	6.7	0.5	7330	Swanson et al., 1976
Schoolhouse	1	35.8	26.9	31.7	6.6	1.0	6910	Pollard, et al., 1972
Schoolhouse	3	38.1	27.5	28.7	5.7	1.2	6720	Johnson & Kunkel 1959
Ave. Dunn Co.	-	40.6	-	-	7.0	0.6	6310	USDI, 1977
Ave. N.D.	-	36.0	28.0	29.0	6.0	0.7	6600	Leonard, et al., 1925

* To convert Btu/lb to Kilojoules/Kilogram, multiply by 2.326

Table A-2 -- Elemental Analysis of HT Butte Coal Bed

Element	Concentration in % Sample No.* D-80824	Sample No.* D-80825	Sample No.* D-80823
Sulphur	0.6	0.4	0.4
Hydrogen	6.8	6.9	6.9
Carbon	41.5	43.1	42.3
Nitrogen	0.7	0.6	0.7
Oxygen	44.0	45.0	45.5

*Johnson and Kunkel, 1959.

Table A-3 -- Elemental Analysis of Hazen Coal Bed

Element	Concentration-in % Sample No.* D-55178	Sample No.* 49875
Sulphur	0.5	
Hydrogen	7.0	
Carbon	38.0	
Nitrogen	0.6	
Oxygen	49.7	
U		0.0001
Ge**		ND
Ga**		0.002
V**		0.005
Cu**		0.004
Cr**		0.002
Zn**		0.01
Ni**		0.005
Co**		0.002
Be**		0.0003
Y**		0.01
La**		0.02
Mo**		ND

* Johnson and Kunkel, 1959
** Results in percent of ash

Table A-4 -- Elemental Analysis of Beulah-Zap Coal Bed

Element	Concentration in %			
	Sample No.* 49879	Sample No.*** ND-KR-Bu	Sample No.**** ND-TT-DS	Sample No.***** D175930 to D17539
Sulphur				0.5
Hydrogen				6.2
Carbon				44.6
Nitrogen				0.7
Oxygen				41.3
U	0.0003			0.00005
Ge**	ND	0.001	ND	ND
Ga**	0.002	0.002	0.004	0.0015
V**	0.008	0.005	0.007	0.0035
Cu**	0.005	0.007	0.02	0.0055
Cr**	0.006	0.005	0.004	0.0025
Zn**	ND	ND	ND	0.0025
Ni**	0.005	0.003	0.006	0.0020
Co**	0.002	0.001	0.002	0.0010
Be**	0.0002	0.0008	0.0008	0.0003
Y**	0.01	0.004	ND	0.0025
La**	0.01	0.004	ND	0.01
Mo**	ND	0.002	0.004	0.0010
B**		0.24		0.110
Ti**		0.2		0.70******
Sn**		ND		---

* Johnson and Kunkel, 1959
** Results in percent of ash
*** Zubovic et al., 1961, average of 4 samples
**** Zubovic et al., 1961, average of 2 samples
***** Swanson et al., 1976
****** as TiO_2

Table A-5 - Elemental Analaysis of Schoolhouse Coal Bed

Element	Sample No.* D-55179	Sample No.* D-55176	Sample No.* D-55175	Sample No.* 49874	Sample No.* 49880
	Concentrations in %				
Sulphur	0.9	0.5	2.1		
Hydrogen	7.1	6.9	6.7		
Carbon	39.9	40.4	39.2		
Nitrogen	0.6	0.6	0.6		
Oxygen	46.4	47.4	43.6		
U				0.0001	0.0001
Ge**				ND	ND
Ga**				0.002	0.002
V**				0.01	0.006
Cu**				0.02	0.004
Cr**				0.007	0.005
Zn**				0.7	0.06
Ni**				0.002	0.003
Co**				0.001	0.001
Be**				0.001	0.0007
Y**				0.01	ND
La**				0.02	ND
Mo**				ND	ND

* Johnson and Kunkel, 1959
** Results in percent of ash