UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS OF THE PITCH DRAW QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-026

1979

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

MAPS

TABLE OF CONTENTS (continued)

MAPS

CONVERSION TABLE

To Convert	Multiply By	To Obtain
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters per metric ton
acre feet	0.12335	hectare-meters
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)
Btu/lb	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9(F-32)	Celsius

I. Introduction

This report and accompanying maps set forth the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) of coal beds within the Pitch Draw Quadrangle, Campbell County, Wyoming. This CRO and CDP map series includes 41 plates (U.S. Geological Survey Open-File Report 79-026). The project is compiled by IntraSearch Inc., 1600 Ogden Street, Denver, Colorado under KRCRA Northeastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is a part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Resource Areas (KRCRA) in the western United States.

The Pitch Draw Quadrangle is located in Campbell County in northeastern Wyoming. It encompasses parts of Townships 54 and 55 North, Ranges 72 and 73 West, and covers the area: 44°37'30" to 44°45' north latitude; 105°30' to 105°37'30" west longitude.

Four maintained gravel roads provide the main access to the Pitch Draw Quadrangle. A gravel road parallels Horse Creek and angles northeast-southwest through the central portion of the quadrangle. The three remaining gravel roads extend from the south, northeast and northwest quadrangle boundaries to join the main road near the center of the study area. This gravel road joins State Highway 59, 7 miles (11 km) east of the quadrangle boundary, and also merges with U.S. Highway 14-16, 5 miles (8 km) west of the study area. Numerous oil field and ranch trails branch from these secondary roads, providing adequate accessibility throughout the quadrangle. The nearest railroad is the Burlington Northern trackage to the Rawhide coal mine approximately 14 miles (23 km) to the south of the quadrangle boundary.

Spring and Squaw Creeks flow southeastward into Horse Creek, which drains northeastward through the central part of the Pitch Draw Quadrangle. The Horse Creek drainage system flows eastward into the Little Powder River.

The somber grays, yellows, and browns of outcropping shales and siltstones contrast strikingly with the brilliant reds, oranges, and purples of "clinker," and deep greens of the juniper and pine tree growth.

The 13 to 14 inches (33 to 36 cm) of annual precipitation that falls in this semiarid region accrues principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of 6 inches (15 cm) or less generally characterize winter precipitation. Although temperatures ranging from less than $-25^{o}F$ ($-32^{o}C$) to more than $100^{o}F$ ($38^{o}C$) have been recorded near Arvada, Wyoming, average wintertime minimums and summertime maximums approach $+5^{o}$ to $+15^{o}F$ (-15^{o} and $-9^{o}C$) and 75^{o} to $90^{o}F$ (24^{o} to $32^{o}C$), respectively.

Surface ownership is divided among fee, state, and federal categories with the state and federal surface generally leased to ranchers for grazing purposes. Details of surface ownership are available at the Campbell County Courthouse in Gillette, Wyoming.

Details of mineral ownership on federal lands are available from the U.S. Bureau of Land Management in Cheyenne, Wyoming. Federal coal ownership is shown on Plate 2 of the Coal Resource Occurrence maps. The nonfederal coal ownership comprises both fee and state coal resources.

The Coal Resource Occurrence and Coal Development Potential program pertains to unleased federal coal and focuses upon: 1) the

delineation of lignite, subbituminous, bituminous, and anthracite coal at the surface and in the subsurface on federal land; 2) the identification of total tons in place as well as recoverable tons; 3) categorization of these tonnages into measured, indicated, and inferred reserves and resources, and hypothetical resources; and 4) recommendations regarding the potential for surface mining, underground mining, and in-situ gasification of the coal beds. This report evaluates the coal resources of all unleased federal coal beds in the quadrangle which are 5 feet (1.5 m) or greater in thickness and occur at depths down to 3,000 feet (914 m). No resources or reserves are computed for leased federal coal, state coal, fee coal, or lands encompassed by coal prospecting permits and preference right lease applications.

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 2.6 billion tons (2.3 billion metric tons) of total unleased federal coal-in-place in the Pitch Draw Quadrangle.

The suite of maps that accompany this report set forth and portray the coal resource and reserve occurrence in considerable detail. For the most part, this report supplements the cartographically displayed information with minimum word duplication of said data.

II. Geology

Regional. The thick, economic coal deposits of the Powder River Basin in northeastern Wyoming occur mostly in the Tongue River Member of the Fort Union Formation, and in the lower part of the Wasatch Formation. Approximately 3,000 feet (914 m) of the Fort Union Formation, that includes the Tongue River, Lebo, and Tullock Members of Paleocene

age, are unconformably overlain by approximately 700 feet (213 m) of the Wasatch Formation of Eocene age. These Tertiary formations lie in a structural basin flanked on the east by the Black Hills uplift, on the south by the Hartville and Casper Mountain uplifts, and on the west by the Casper Arch and the Big Horn Mountain uplift. The structural configuration of the Powder River Basin originated in Late Cretaceous time, with episodic uplift thereafter. The Cretaceous Cordillera was the dominant positive land form throughout the Rocky Mountain area at the close of Mesozoic time.

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of major coal resource occurrence in the Powder River Basin. The Lebo Member of the Fort Union Formation is mapped at the surface northeast of Recluse, Wyoming, east of the principal coal outcrops and associated clinkers (McKay, 1974), and presumably projects into the subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City, Montana) from the overlying Tongue River Member is the color differential between the lighter-colored upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists working with subsurface data, principally geophysical logs, in the basin are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its member subdivisions for this study.

During the Paleocene epoch, the Powder River Basin tropic to subtropic depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish but active northeastward discharging drainage system, superimposed on a near base level, emerging sea floor. Much of the vast areas where organic debris collected was within a reducing depositional environment. Localized uplifts began to disturb the near sea level terrain of northeastern Wyoming, following retreat of the Cretaceous seas. However, the extremely fine-grained characteristics of the Tongue River Member clastics suggest that areas of recurring uplift peripheral to the Powder River Basin were subdued during major coal deposit formation.

The uplift of areas surrounding the Powder River Basin created a structural basin of asymmetric characteristic, with the steep west flank located on the eastern edge of the Big Horn Mountains. The axis of the Powder River Basin is difficult to specifically define, but is thought to be located in the western part of the basin, and to display a north-south configuration some 15 to 20 miles (24 to 32 km) east of Sheridan, Wyoming. Thus, the sedimentary section described in this report lies on the east flank of the Powder River Basin, with gentle dips of 2^{o} or less disrupted by surface structure thought to relate to tectonic adjustment and differential compaction.

Some coal beds in the Powder River Basin exceed 200 feet (61 m) in thickness. Deposition of these thick, in-situ coal beds requires a discrete balance between subsidence of the earth's crust and in-filling by tremendous volumes of organic debris. These conditions in concert with a favorable ground water table, non-oxidizing clear water, and a climate amenable to the luxuriant growth of vegetation produce a stabilized swamp critical to the deposition of coal beds.

Deposition of the unusually thick coal beds of the Powder River Basin may be partially attributable to short distance water transportation of organic detritus into areas of crustal subsidence. Variations in coal bed thickness throughout the basin relate to changes in the depositional environment. Drill-hole data that indicate either the complete absence or extreme attenuation of a thick coal bed probably relate to location of the drill holes within the ancient stream channel system servicing this low land area in Early Cenozoic time. Where thick coal beds thin rapidly from the depocenter of a favorable depositional environment, it is not unusual to encounter synclinal structure over the maximum coal thickness due to the differential compaction between organic debris in the coal depocenter and fine-grained clastics in the adjacent areas.

The Wasatch Formation of Eocene age crops out over most of the central part of the Powder River Basin and exhibits a disconformable contact with the underlying Fort Union Formation. The contact has been placed at various horizons by different workers; however, for the purpose of this report, in northwestern Campbell County, Wyoming, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) and is considered to disconformably descend in the stratigraphic column to the top of the Wyodak-Anderson coal bed (Roland coal bed of Taff, 1909) along the eastern boundary of the coal measures. No attempt is made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program that is a part of this CRO/CDP project.

Although Wasatch and Fort Union lithologies are too similar to allow differentiation in some areas, most of the thicker coal beds occur in the Fort Union section on the east flank of the Powder River Basin. Furthermore, orogenic movements peripheral to the basin apparently increased in magnitude during Wasatch time causing the deposition of friable, coarse-grained to gritty arkosic sandstones, fine to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales and coal beds. These sediments are noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Pitch Draw Quadrangle is located in an area where more than 95 percent of the surface rocks are classified into the Tongue River Member of the Fort Union Formation. Although the Tongue River Member is reportedly 1,200 to 1,300 feet (366 to 396 m) thick (Olive, 1957), only 500 to 600 feet (152 to 183 m) are exposed in this area. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the Sheridan coal field (Baker, 1929) and Gillette coal field (Dobbin and Barnett, 1927), Wyoming, and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee and Cache coal beds were named by Warren (1959). Three coal beds beneath the Cache coal bed were informally named by IntraSearch (1978a, 1978b, and 1979a) as the Oedekoven, Wildcat, and Moyer coal beds, respectively.

Local. The Pitch Draw Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Tongue River Member of the Fort Union Formation crops out over most of the

quadrangle. The Fort Union Formation is composed of very fine-grained sandstone, siltstone, claystone, shale, carbonaceous shale, and numerous coal beds.

A series of five, northwest-trending faults are located in Sections 19, 20, and 28, T. 54 N., R. 72 W. (McLaughlin and McKay, 1972). The southernmost fault is downthrown approximately 10 feet (3 m) to the north. The other four faults have vertical displacements of 2 to 3 feet (0.6 to 0.9 m). A north-northwest-trending fault vertically displaces strata approximately 15 feet (5 m), downthrown to the west, from the eastern edge of the quadrangle to Section 19, T. 55 N., R. 72 W. Most of the structural contours on coal bed tops reflect a north-northwest-trending anticline in the northwest quadrant of the area. Structural contours on the Anderson and Canyon coal beds define a northeast-trending anticline in the southwest corner of the quadrangle.

III. Data Sources

Coal bed outcrop configurations for the Swartz, Anderson, and Canyon coal beds are derived from the Preliminary Geologic Map of the Pitch Draw Quadrangle, Campbell County, Wyoming (McLaughlin and McKay, 1972). Regional correlations by IntraSearch from the Spotted Horse coal field to the confluence of Spring and Horse Creeks on the Pitch Draw Quadrangle suggest that the Dietz coal bed pinches out between the Powder River and Bitter Creek and is not present in the Recluse area. North of Pitch Draw in the White Tail Butte Quadrangle, subsurface data indicate that the Canyon coal bed separates into two units (IntraSearch, 1979b). Subsurface data define a single, thick Canyon coal bed in the western part of the Pitch Draw Quadrangle. IntraSearch suggests that the Canyon coal bed divides into two units in the central and eastern parts of this quadrangle and that the upper unit correlates with the Dietz coal bed of McLaughlin and McKay.

The major source of subsurface control, particularly on deep coal beds, is the geophysical logs from oil and gas test bores and producing wells. Some geophysical logs are not applicable to this study, for the logs relate only to the deep potentially productive oil and gas zones. More than 80 percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally the logs include gamma, density, and sonic curves. These logs are available from several commercial sources.

All geophysical logs available in the quadrangle are scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs are obtained, interpreted, and coal intervals annotated. Maximum accuracy of coal bed identification is accomplished where gamma, density, and resistivity curves are available. Coal bed tops and bottoms are picked on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles is achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

In some parts of the Powder River Basin, additional subsurface control is available from U.S. Geological Survey open-file reports that include geophysical and lithologic logs of shallow holes drilled specifically for coal exploration. A sparse scattering of subsurface data points are shown on unpublished CRO/CDP maps compiled by the U.S. Geological Survey, and where these data are utilized, the rock-coal intervals are shown on the Coal Data Map (Plate 1). Inasmuch as these drill holes have no identifier headings, they are not set forth on

the Coal Data Sheet (Plate 3). The geophysical logs of these drill holes were not available to IntraSearch to ascertain the accuracy of horizontal location, topographic elevation, and down-hole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, vary depending on: the density and quality of lithologic and geophysical logs; the detail, thoroughness, and accuracy of published and unpublished surface geological maps, and interpretative proficiency. There is no intent on the part of IntraSearch to refute nomenclature established in the literature or used locally by workers in the area. IntraSearch nomenclature focuses upon the suggestion of regional coal bed names applicable throughout the eastern Powder River Basin. It is expected and entirely reasonable that some differences of opinion regarding correlations as suggested by IntraSearch exist. Additional drilling for coal, oil, gas, water, and uranium, coupled with expanded mapping of coal bed outcrops and associated clinkers will broaden the data base for coal bed correlations and allow continued improvement in the understanding of coal bed occurrences in the Powder River Basin.

The topographic map of the Pitch Draw Quadrangle is published by the U.S. Geological Survey, compilation date, 1971. Land ownership data are compiled from land plats available from the U.S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

Fort Union Formation coal beds that are present in all or part of the Pitch Draw Quadrangle include, in descending stratigraphic order, the Smith, Upper Anderson (Swartz of McLaughlin and McKay, 1972), Anderson, Canyon, Cook, Wall-Pawnee, Cache, Wildcat, Moyer, and Oedekoven coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden/interburden, identified resources and areal distribution of identified resources) is prepared for each of these coal beds, except for the Smith and Wildcat coal beds, where thinness and lack of areal extent preclude detailed mapping.

No physical and chemical analyses are known to have been published regarding the coal beds in the Pitch Draw Quadrangle. However, the general "as received" basis proximate analyses for northern Campbell County, Wyoming coal beds are as follows:

COAL BED NAME	HOLE	ASH*	FIXED CARBON*	MOISTURE*	VOLATILES*	SULFUR*	BTU/LB
Anderson (U)	746	6.317	31.113	32.583	29.986	0.327	7498
Canyon (P)		4.290	32.852	35.100	27.758	0.307	7298
Cook (P)		4.620	34.410	33.640	27.330	0.250	7766
Wall (U)	7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee (U)	7424	7.880	31.029	31.910	29.183	0.386	7344
Cache (U)	741	9.481	30.517	31.420	28.582	0.488	7271

(P) - Proprietary Data

(U) - U.S. Geological Survey & Montana Bureau of Mines & Geology - 1974

* Analyses are reported in percent.

The Coal Data Sheets, Plates 3a, 3b, and 3c, show the down-hole identification of coal beds within the quadrangle as interpreted from U.S. Geological Survey and Montana Bureau of Mines and Geology drill-

hole data, and from geophysical logs from oil and gas test bores and producing sites. Inasmuch as the Wall-Pawnee coal zone underlies the entire quadrangle, it is designated as datum for the correlation diagrams. The Anderson, Canyon, and Wall-Pawnee coal beds are the thickest coal beds in the quadrangle, attaining thicknesses in excess of 30 feet (9 m). The Anderson and Canyon coal beds are burned or eroded over most of the quadrangle. The Anderson, Canyon, and Cook coal beds occur less than 500 feet (152 m) beneath the surface throughout the quadrangle. The Wall-Pawnee coal zone is fairly uniform in thickness with a thin, non-coal interval separating the coal beds. The Cook coal zone is comprised of one to three coal beds. The Cache, Moyer, and Oedekoven coal beds are thin and deeply buried, and the Wildcat coal bed is both thin and discontinuous.

The Anderson coal bed is burned or eroded from approximately 80 percent of the quadrangle, and varies from 14 to 55 feet (4 to 17 m) thick. In the southwest corner of the area, the Anderson coal bed is divided by a noncoal interval ranging from 10 to 17 feet (3 to 5 m) thick. The Anderson coal bed thickens from 14 feet (4 m) in the northeast corner to 38 feet (12 m) in the northwest corner, and 55 feet (17 m) in the southwest corner of the Pitch Draw Quadrangle. Structural highs extend from the central part of the quadrangle to the northwest and southwest quadrants (Plate 5).

The Canyon coal bed occurs 21 to 147 feet (6 to 45 m) beneath the Anderson coal bed, and is eroded or burned from approximately 20 percent of the quadrangle. The Canyon coal bed is 11 feet (3 m) thick in the southwest corner and attains a maximum thickness of 47 feet

(14 m) in the northwest quadrant of the study area (Plate 9). The paucity of drill-hole data along the eastern edge of the map precludes Canyon coal bed isopach mapping in that area. Structural highs extend northwest and southwest from the central part of the quadrangle. A northeast-trending synclinal feature extends from the southwest corner into the south-central and southeast corners of the quadrangle.

A rock interval of 21 to 133 feet (6 to 41 m) separates the Cook coal bed from the overlying Canyon coal bed. The Cook coal bed is absent from the northeast, southeast, and central part of the Pitch Draw Quadrangle. The maximum thickness of 33 feet (10 m) occurs along the western edge of the quadrangle, near the southwest corner. The Cook coal bed generally thins from the west to the east (Plate 14). A noncoal interval of 5 to 14 feet (1.5 to 4 m) that divides the Cook coal bed into two units, thickens in the northwest quadrant to a maximum of 74 feet (23 m). The Lower Cook coal bed is absent from the north-central portion of the quadrangle. The Cook coal bed folds to form two southwest-trending anticlines and two northeast-trending synclines in the west-central portion of the quadrangle. A north-trending, closed structural high dominates the northwest corner of the study area.

The Wall-Pawnee coal zone occurs 153 to 329 feet (47 to 100 m) beneath the Cook coal bed, and varies in thickness from 7 feet (2.1 m) in the southeast corner to 40 feet (12 m) in the northwest corner of the quadrangle. The Wall coal bed pinches out to the southeast along a line which extends from the northeast corner to the southwestern edge of the map (Plate 19). A noncoal interval of 2 to 57 feet (0.6 to 17 m) separates the Wall and Pawnee coal beds. The Wall-Pawnee coal zone

displays the same structural trends which occur in the overlying Cook coal bed (Plate 20), and lies less than 500 feet (152 m) beneath the surface over most of the Pitch Draw Quadrangle.

The Cache coal bed, absent along the south edge and the southeast corner, attains a maximum thickness of 15 feet (5 m) in the north-central parts of the quadrangle (Plate 24). The Cache coal bed is separated from the overlying Pawnee coal bed by 39 to 116 feet (12 to 35 m) of interburden. The same east-west-trending series of folds which occur on the Cook coal bed and Wall-Pawnee coal zone are present on the structure map of the Cache coal bed (Plate 25). The Cache coal bed is greater than 500 feet (152 m) beneath the surface over more than half of the quadrangle.

The Moyer coal bed, 253 to 327 feet (77 to 100 m) beneath the Cache coal bed, is absent in the north and central portions of the Pitch Draw Quadrangle. A maximum coal thickness of 10 feet (3 m) is mapped in the southeast corner of the study area. The Moyer coal bed structure map displays a gentle westward dip of 60 to 120 feet per mile (11 to 23 m per km) with minor folding in the vicinity of the faults in the south-central portion of the quadrangle (Plate 30). The Moyer coal bed is more than 500 feet (152 m) beneath the surface throughout most of the study area.

From 76 to 157 feet (23 to 48 m) of interburden separates the Oedekoven coal bed from the overlying Moyer coal bed. The Oedekoven coal bed is absent near the western edge in the southwest quadrant and attains a maximum thickness of 13 feet (4 m) in the south-central portion of the quadrangle. The thicker part of the Oedekoven coal bed extends from the

east-central part to the northwest corner of the Pitch Draw Quadrangle (Plate 34). The structure map of the Oedekoven coal bed (Plate 35) indicates minor east-west folding in the north-central and south-central portions of the quadrangle. The Oedekoven coal bed occurs more than 500 feet (152 m) beneath the surface throughout the entire quadrangle.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed or near to a drill site shown on the topographic map, and the topographic map horizontal location is utilized. If the ground elevation on the geophysical log does not agree with the topographic elevation of the drill site, the geophysical log ground elevation is adjusted to conformance. If there is no indication of a drill site on the topographic map, the "quarter, quarter, quarter" heading location is shifted within a small area until the ground elevation on the heading agrees with the topographic map elevation. If no elevation agreement can be reached, the well heading or data sheet is rechecked for footage measurements and ground elevation correctness. Inquiries to the companies who provided the oil and gas geophysical logs frequently reveal that corrections have been made in the original survey. If all horizontal location data sources have been checked and the information accepted as the best available data, the drill-site elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch considers this agreement mandatory for the proper construction of most subsurface maps, but in

particular, the overburden isopach, the ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within and adjacent to the Pitch Draw Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Isopach lines are also drawn to honor selected measured sections where there is sparse subsurface control. Where isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion, hence not reflective of total coal thickness. Isopach lines extend to the coal bed outcrops, the projections of coal bed outcrops, and the contact between porcelanite (clinker) and unoxidized coal in place. Attenuation of total coal bed thickness is known to take place near these lines of definition; however, the overestimation of coal bed tonnages that results from this projection of total coal thickness is insignificant to the Coal Development Potential maps. Structure contour maps are constructed on the tops of the main coal beds. Where subsurface data is scarce, supplemental structural control points are selected from the topographic map along coal outcrops.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a 95 percent recovery factor. Contours of these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed using coal structure,coal isopach, and topographic control. On the

Areal Distribution of Identified Resources Map (ADIR), coal bed reserves are not calculated where the coal is less than 5 feet (1.5 m) thick, where the coal occurs at a depth greater than 500 feet (152 m), where nonfederal coal exists, or where federal coal leases and preference right lease applications exist.

Coal tonnage calculations involve the planimetering of areas of measured, indicated, inferred reserves and resources, and hypothetical resources to determine their areal extent in acres. An Insufficient Data Line is drawn to delineate areas where surface and subsurface data are too sparse for CRO map construction. Various categories of resources are calculated in the unmapped areas by utilizing coal bed thicknesses mapped in the geologically controlled area adjacent to the insufficient data line. Acres are multiplied by the average coal bed thickness and 1,750 (the number of tons of lignite A per acre-foot; 12,874 metric tons per hectare-meter), to determine total tons in place. Recoverable tonnage is calculated at 95 percent of the total tons in place. North of the Pitch Draw Quadrangle in the Montana portion of the Powder River Basin, a recovery factor of 85 percent is utilized because of the general northward thinning of economic coal beds. Where tonnages are computed for the CRO/CDP map series, resources and reserves are expressed in millions of tons. Frequently the planimetering of coal resources on a sectionized basis involves complexly curvilinear lines (coal bed outcrop and 500-foot stripping limit designations) in relationship with linear section boundaries and circular resource category boundaries. Where these relationships occur, generalizations of complex curvilinear

lines are discretely utilized, and resources and/or reserves are calculated within an estimated 2 to 3 percent plus or minus accuracy.

VI. Coal Development Potential

Strippable Coal Development Potential. Areas where coal beds are 5 feet (1.5 m) or more in thickness and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and are 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 is as follows:

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

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor
0.911 = conversion factor (cu. yds/ton)

A surface mining potential map is prepared utilizing the following mining ratio criteria for coal beds 5 to 40 feet (1.5 to 12 m) thick:

1. Low development potential = 15:1 and greater ratio.
2. Moderate development potential = 10:1 to 15:1 ratio.
3. High development potential = 0 to 10:1 ratio.

The following mining ratio criteria is utilized for coal beds greater than 40 feet (12 m) thick:

1. Low development potential = 7:1 and greater ratio.
2. Moderate development potential = 5:1 to 7:1 ratio.
3. High development potential = 0 to 5:1 ratio.

The surface mining potential is high for most of the Pitch Draw Quadrangle. The thick Anderson and Canyon coal beds occur at depths less than 500 feet (152 m) beneath the surface throughout the Pitch Draw Quadrangle. Where

these coal beds are neither eroded or oxidized, the surface mining potential is high. The depth of burial and total coal thickness of the Cook coal bed and Wall-Pawnee coal zone establish a high potential rating in the valley of the Horse Creek near the central and east-central portions of the quadrangle. In the northeast quadrant, moderate and low surface mining potentials result from the absence of the Anderson coal bed, and the thinness of the Canyon and Cook coal beds (Plate 39). Table 1 sets for the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Pitch Draw Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves are not calculated for coal beds buried more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal reserve base in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3,000 feet (152 to 914 m) beneath the surface. This categorization is as follows:

1. Low development potential relates to: 1) a total coal section less than 100 feet (30 m) thick that lies 500 feet (152 m) to 3,000 feet (914 m) beneath the surface, or 2) coal beds 5 feet (1.5 m) or more in thickness that lie 500 feet (152 m) to 1,000 feet (305 m) beneath the surface.

2. Moderate development potential is assigned to a total coal section from 100 to 200 feet (30 to 61 m) thick, and buried from 1,000 to 3,000 feet (305 to 914 m) beneath the surface.

3. High development potential involves 200 feet (61 m) or more of total coal thickness buried from 1,000 to 3,000 feet (305 to 914 m).

The coal development potential for in-situ gasification on the Pitch Draw Quadrangle is low, hence no CDP map is generated for this map series. The reserve base tonnage for in-situ gasification with low development potential totals approximately 749 million tons (680 million metric tons) (Table 3). None of the coal beds in the Pitch Draw Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Pitch Draw Quadrangle, Campbell County, Wyoming.

(Development potentials are based on mining ratios (cubic yards of overburden/ton of recoverable coal).)

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Anderson	432,540,000	----------	----------	432,540,000
Canyon	619,600,000	56,970,000	1,310,000	677,880,000
Cook	9,770,000	65,030,000	179,440,000	254,240,000
Wall-Pawnee	42,760,000	225,650,000	82,510,000	350,920,000
Cache	----------	----------	27,500,000	27,500,000
Moyer	----------	----------	----------	----------
Oedekoven	----------	----------	----------	----------
TOTAL	1,104,670,000	347,650,000	290,760,000	1,743,080,000

Table 2.--Coal Reserve Base Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Pitch Draw Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Anderson	---------	---------	---------	-----
Canyon	---------	---------	---------	-----
Cook	---------	---------	---------	-----
Wall-Pawnee	---------	---------	391,920,000	391,920,000
Cache	---------	---------	142,360,000	142,360,000
Moyer	---------	---------	51,320,000	51,320,000
Oedekoven	---------	---------	163,360,000	163,360,000
TOTAL	---------	---------	748,960,000	748,960,000

Table 3.--Coal Reserve Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Pitch Draw Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Anderson	---	---	---	---
Canyon	---	---	---	---
Cook	---	---	---	---
Wall-Pawnee	---	---	391,920,000	391,920,000
Cache	---	---	142,360,000	142,360,000
Moyer	---	---	51,320,000	51,320,000
Oedekoven	---	---	163,360,000	163,360,000
TOTAL	---	---	748,960,000	748,960,000

SELECTED REFERENCES

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geol. Survey Bull. 806-B, p. 15-67.

Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geol. Survey Bull. 831-B, p. 19-105.

Brown, R. W., 1958, Fort Union Formation in the Powder River Basin, Wyoming: Wyo. Geol. Soc. Guidebook, Thirteenth Annual Field Conf., p. 111-113.

Dobbin, C. E., and Barnett, V. H., 1927, The Gillette coal field, northeastern Wyoming, with a chapter on the Minturn district and northwestern part of the Gillette field by W. T. Thom, Jr.: U.S. Geol. Survey Bull. 796-A, p. 1-50.

Glass, G. B., 1975, Review of Wyoming coal fields, 1975: Wyoming Geol. Survey Public Information circ. 4, p. 10.

IntraSearch, Inc., 1978a, Coal resource occurrence and coal development potential of the Cabin Creek Northeast Quadrangle, Sheridan and Campbell Counties, Wyoming; and Powder River County, Montana: U.S. Geol. Survey Open-File Report 78-064, 21 p.

_____1978b, Coal resource occurrence and coal development potential of the Rocky Butte Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey Open-File Report 78-830, 22 p.

_____1979a, Coal resource occurrence and coal development potential of the Larey Draw Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey Open-File Report 79-023, 29 p.

_____1979b, Coal resource occurrence and coal development potential of the White Tail Butte Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey Open-File Report 79-021, 25 p.

Jacob, A. F., 1973, Depositional Environments of Paleocene Tongue River Formation: Am. Assoc. of Petroleum Geologists Bull., vol. 56, no. 6, p. 1038-1052.

McKay, E. J., 1974, Preliminary geologic map of the Bertha 2 NW (Rocky Butte) Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey Open-File Report 74-173, scale 1:24,000.

McLaughlin, R. J., and McKay, E. J., 1972, Preliminary geologic map of the Pitch Draw Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey Open-File Report, scale 1:24,000.

Micklich, N. E., 1977, Preliminary coal resource and occurrence map of the Pitch Draw Quadrangle, Campbell County, Wyoming: U.S. Geol. Survey unpublished report, scale 1:24,000.

Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U.S. Geol. Survey Bull. 1050, 83 p.

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U.S. Geol. Survey Bull. 341-B, p. 123-150.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geol. Survey Bull. 1450-B, 7 p.

U.S. Geological Survey and Montana Bureau of Mines and Geology, 1974, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell County, Wyoming: U.S. Geol. Survey Open-File Report 74-97, 241 p.

_____1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming; Custer, Prairie, and Garfield Counties, Montana; and Mercer County, North Dakota: U.S. Geol. Survey Open-File Report 76-319, 377 p.

_____1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell, Converse, and Sheridan Counties, Wyoming; and Big Horn, Richland, and Dawson Counties, Montana: U.S. Geol. Survey Open-File Report 76-450, 382 p.

_____1978, Preliminary report of 1977 coal drilling in eastern Montana and northeastern Wyoming; geophysical logs for Campbell and Converse Counties, Wyoming: U.S. Geol. Survey Open-File Report 77-721 E, 202 p.

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U.S. Geol. Survey Bull. 1072-J, p. 561-585.

Weimer, R. J., 1977, Stratigraphy and tectonics of western coals, in Geology of Rocky Mountain Coal, A Symposium, 1976: Colorado Geol. Survey Resource Series 1, p. 9-27.