UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

CARR DRAW QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-038
1979

This report is preliminary, and has not been edited or reviewed for conformity with United States Geological Survey standards or stratigraphic nomenclature.

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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 tons
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 Carr Draw Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-038) includes 40 plates. The project is compiled by IntraSearch Inc., 5351 South Roslyn Street, Englewood, Colorado, under KRCRA Eastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States.

The Carr Draw Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 49, 50 and 51 North, Ranges 75 and 76 West, and covers the area: 44°15' to 44° 22'30" north latitude; 105°52'30" to 106°00' west longitude.

Main access to the Carr Draw Quadrangle is provided by a maintained gravel road (Montgomery Road) which extends northwest to southeast across the northern half of the study area. Another maintained road branching from Montgomery Road extends west into the southeast quarter of the quadrangle. Minor roads and trails that branch from these gravel roads provide additional access to the more remote areas. The closest railroad is the Burlington Northern trackage, 6 miles (9.6 km) to the north at Echeta, Wyoming.

Drainage patterns generate from the high, fairly rugged terrain of Kinney Divide which extends northwest to southeast across the central portion of the quadrangle. Elevations attain heights of 4800 feet (1463 m) in the eastern half of the study area, 550 to 650 feet (168 to 198 m) above the valley floors to the north and west. Northwest-flowing Fortification Creek provides the major drainage for the northern half of the quadrangle. Carr Draw, Amos Draw, Antelope Draw, and other intermittent streams supplement the drainage in this area. South of Kinney Divide, westward-flowing Barber Creek extends across the quadrangle providing the significant drainage. Maycock Draw and other intermittent streams supplement the drainage throughout the southern half of the quadrangle. Both Fortification Creek and Barber Creek drain into the Powder River to the east. 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 12 to 14 inches (30 to 36 cm) of annual precipitation falling in this semi-arid region accrue 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°F (-32°C) to more than 100°F (38°C) have been recorded near Gillette, Wyoming, average wintertime minimums and summertime maximums range from +5° to +°15F (-15° to -9°C) and 75° to 90°F (24° to 32°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 non-federal 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 the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface, and in the subsurface. In addition, the program identifies total tons of coal in place, as well as recoverable tons. These coal tonnages are then categorized into units of measured, indicated, and inferred reserves and resources, and hypothetical resources. Finally, recommendations are made 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 3000 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 9.8 billion tons (8.9 billion metric tons) of unleased federal coal resources in the Carr Draw Quadrangle.

The suite of maps that accompany this report sets forth and portrays the coal resource and reserve occurrence in considerable detail. For the most part, this report supplements the cartographically displayed information with minimum verbal duplication of the CRO-CDP map 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 3000 feet (914 m) of the Fort Union Formation, including 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 Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo Member of the Fort Union Formation consists of light- to dark-gray very fine-grained to conglomeratic sandstone with interbedded siltstone, claystone, carbonaceous shale and thin coal beds. Thin bedded calcareous ironstone concretions interbedded with massive white sandstone and slightly bentonitic shale occur throughout the unit (Denson and Horn, 1975). The Lebo Member is mapped at the surface northeast of Recluse, Wyoming. Here, the Lebo Member is east of the principal coal outcrops and associated clinkers (McKay, 1974), and it 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 are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts through the use of subsurface data from geophysical logs, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its members for this study.

During the Paleocene epoch, the Powder River Basin tropical to subtropical depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish, but active, northeastward-discharging drainage system. These features were superimposed on an emerging sea floor, near base level. Much of the vast area 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 character, 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 it 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 two degrees 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 delicate 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 draining this lowland 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 a 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, the contact is positioned near the top of the

Roland coal bed as mapped by Olive (1957) in northwestern Campbell County, Wyoming. It is considered to descend disconformably 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 was made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program for this 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 Carr Draw Quadrangle is located in an area where surface rocks are classified within the Wasatch Formation. 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. The Felix coal bed was named by Stone and Lupton (1910), and the Smith coal bed was named by Taff (1909). 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).

The Wildcat, Moyer, and Oedekoven coal beds were informally named by IntraSearch (1978b, 1979, and 1978a).

IntraSearch's correlation of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson, Canyon and all or part of the Cook coal beds to the north and west of Gillette, Wyoming. Correlation of this suite of coal beds with the Wyodak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper 10 to 25 percent of the thick Wyodak coal bed, and the Cook and Wall or Upper Wall coal beds are equivalent to the major part of the Wyodak coal bed. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine.

Local. The Carr Draw Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle, and is comprised 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. The Fort Union Formation unconformably underlies the Wasatch Formation and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

III. Data Sources

Within the Carr Draw Quadrangle, no significant coal outcrops or associated clinker are mentioned in any known publications at the time of this report. It is presumed, and highly possible, that no significant coal outcrops exist at the surface in this quadrangle.

Geophysical logs from oil and gas test bores and producing wells comprise the source of subsurface control. 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 suite of geophysical logs includes gamma, density, and sonic curves. These logs are available from several commercial sources.

Where oil and gas tests and development wells are in close proximity, and present a dense pattern of drill site location, IntraSearch has selected geophysical logs representative of these areas. Hence, some of the geophysical logs from drill holes in this quadrangle are not utilized in this report.

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 and interpreted, and coal intervals are 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.

The reliability of correlations, set forth by IntraSearch in this report, varies 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's 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 eastern Powder River Basin.

The topographic map of the Carr Draw Quadrangle is published by the U. S. Geological Survey, compilation date 1972. Land network and mineral 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

Wasatch and Fort Union Formation coal beds that are present in all or part of the Carr Draw Quadrangle include, in descending stratigraphic order: the local, local, Upper Felix, Lower Felix, local, Upper Smith, local, Lower Smith, local, Upper Anderson, Lower Anderson, Canyon, Upper Cook, Lower Cook, Wall, Pawnee, Cache, Wildcat, Moyer, Oedekoven, and Local coal beds. A complete suite of maps (coal isopach, mining ratio where appropriate, structure, overburden/interburden isopach, areal distribution of identified resources, and identified resources) was prepared for the Felix, Smith, Anderson, Canyon-Upper Cook, Wall-Pawnee-Cache, and Wildcat-Moyer-Oedekoven coal zones, and for the very deep Local coal bed. Insufficient data and/or lack of areal extent precludes any detailed mapping of the numerous local coal beds and of the Lower Cook coal bed.

No physical and chemical analyses are know to have been published regarding the coal beds in the Carr Draw Quadrangle. However, the general proximate analyses performed on an "as received" basis for Campbell and Converse County coal beds are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix	(U)	Hole 7324	6.993	35.200	25.010	32.798	0.629	8544
Upper Smith	(U)	Hole 7312C	16.323	29.797	25.376	28.503	2.598	7273
Lower Smith	(U)	Hole 7312C	6.167	33.340	29.610	30.803	1.068	8215
Anderson	(U)	Hole 7544	4.501	32.688	24.337	38.450	0.201	8953
Canyon-Upper Cook	(U)	Hole 755	4.438	35.522	27.405	32.719	0.207	8568
Wall	(U)	Hole 7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee	(U)	Hole 7424	2.880	31.029	31.910	29.183	0.386	7344
(Wildcat) "D"	(*)	Lab. No. 11447	4.3	29.4	27.8	29.4	0.27	8410

(*) - Winchester, 1912
(U) - U. S. Geological Survey and Montana Bureau of Mines and Geology - 1974, 1976a, 1976b.

The Coal Data Sheet, Plate 3, shows the down hole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores and producing sites. A datum coal bed is utilized to position columnar sections on Plate 3. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through no record (NR) intervals. Inasmuch as the Anderson coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram.

The <u>Felix</u> coal zone lies from less than 200 feet to greater than 600 feet (61 to 183 m) beneath the surface in the quadrangle, and is comprised of a moderately thick upper coal bed overlying a thinner lower coal bed. Both coal beds show uniform occurrence throughout the quadrangle and have a total coal zone thickness ranging from 8 to 26 feet (2.4 to 8 m). Maximum thicknesses occur in the southeast quarter of the study area, and minimum thicknesses occur in the northwest and southwest corners. The clastic interval separating the coal beds comprising the coal zone varies from 25 to 96 feet (8 to 29 m). Structure contours drawn on top of the Felix coal zone indicate a broad, southeast-plunging syncline extending across the southern half of the quadrangle, with gentle southwestward dip elsewhere. The Felix coal zone lies greater than 500 feet (152 m) in depth beneath the surface over approximately 60 percent of the quadrangle, generally the areas of higher elevation.

The Smith coal zone occurs 406 to 537 feet (124 to 164 m) below the Felix coal zone, and is comprised of two thin, uniform coal beds. The total coal zone thickne.s ranges from 10 to 25 feet (3.0 to 8 m) with thicker coal occurring in the northeast quarter extending across the northern half and along the western edge of the quadrangle. The non-coal interval separating the coal beds of the coal zone varies from 0 to 155 feet (0 to 47 m) with no separation over the northern half of the area. Structure contours drawn on top of the Smith coal zone depict a broad, complex southwest-plunging anticline over the southern half of the area and gentle southwestward dip elsewhere. The Smith coal zone lies from less than 750 feet (229 m) to greater than 1250 feet (381 m) in the study area.

The Anderson coal zone is located 62 to 301 feet (10 to 92 m) beneath the Smith coal zone within the quadrangle. The coal zone thickness ranges from 20 to 130 feet (6 to 40 m), with maximum thicknesses occurring in the southwest quarter of the quadrangle. The Anderson coal zone locally separates into at least three coal beds with the total non-coal interval between the various members attaining 225 feet (69 m) in thickness. Structure contours drawn on top of the Anderson coal zone indicate a southwest to south-plunging anticline dominating the quadrangle. The Anderson coal zone lies from less than 1100 feet (335 m) to greater than 1500 feet (457 m) beneath the surface in the quadrangle.

The Canyon-Upper Cook coal zone lies 105 to 282 feet (32 to 86 m) below the Anderson coal zone, and is comprised of a thick Canyon coal bed and a thin Upper Cook coal bed that often merge into a single bed. The total coal zone thickness ranges from 34 to 70 feet (10 to 21 m) with maximum thicknesses in the southwest quarter of the study area. A clastic interval reaching 22 feet (7 m) in thickness locally separates the two coal beds. Structure contours drawn on top of the Canyon-Upper Cook coal zone indicate a narrow, south-plunging anticline in the southwest quarter, and a broad syncline in the southeast quarter with regional westward dip in the northern half of the quadrangle. The Canyon-Upper Cook coal zone lies from less than 1500 feet (457 m) to greater than 1750 feet (533 m) beneath the surface in the quadrangle.

The Wall-Pawnee-Cache coal zone occurs 168 to 519 feet (51 to 158 m) below the Canyon-Upper Cook coal zone, and is comprised of the thick Wall and Pawnee coal beds, and a thin, lenticular Cache coal bed. The total coal zone thickness ranges from 86 to 133 feet (26 to 41 m) with maximum coal thicknesses occurring along the western edge and extending eastward, then southward, through the central portion of the quadrangle. The observed clastic interval separating the various coal beds comprising the coal zone varies from 13 to 150 feet (4 to 46 m). Structure contours drawn on top of the Wall coal bed indicate a narrow northeast-plunging anticline separating two synclinal lows in the southwest quarter of the quadrangle with gentle southward dip over the northern half and westward dip in the southeast quarter. The Wall-Pawnee-Cache coal zone lies from less than 1750 feet (533 m) to greater than 2250 feet (686 m) beneath the surface in the quadrangle.

The Wildcat-Moyer-Oedekoven coal zone lies 49 to 232 feet (15 to 71 m) beneath the Wall-Pawnee-Cache coal zone and is comprised of three moderately thick, uniform coal beds. The total projected coal zone thickness ranges from 5 to 60 feet (1.5 to 18 m) with thickest occurrences located in the southeast quarter of the study area, and thinnest coal in the northeast quarter. The observed clastic interval separating the coal beds comprising the coal zone varies from 89 to 148 feet (27 to 45 m). Structure contours drawn on top of the Wildcat coal bed indicate regional westward dip with a southwest-plunging anticline extending across the quadrangle into the southwest quarter. A synclinal low occurs along the south-central edge of the study area. The Wildcat-Moyer-Oedekoven coal zone lies from less than 2250 feet (686 m) to greater than 2500 feet (762 m) beneath the surface in the quadrangle.

The Local coal bed occurs 249 to 377 feet (76 to 115 m) below the Wildcat-Moyer-Oedekoven coal zone. The coal bed thickness ranges from 0 to 15 feet (0 to 5 m) with maximum thicknesses occurring in the southwest quarter of the study area. The Local coal bed thins to the north and is absent from approximately 52 percent of the quadrangle, generally over the northern one-third and extending to the south-central edge. Structure contours drawn on top of the Local coal bed indicate a gentle southwestward dip. The Local coal bed lies from less than 2750 feet (838 m) to greater than 3000 feet (914 m) beneath the surface throughout the entire study area.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. Intra-Search Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed on or near to a drillsite 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 drillsite, the geophysical log ground elevation is adjusted to conformance. If there is no indication of a drillsite 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 accuracy. 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 drillsite elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch Inc., considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the mining ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within, and adjacent, to the Carr 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. Structure contour maps are constructed on the tops of the main coal beds.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden above 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 at the intersections of coal bed and overburden isopach contours 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 non-federal coal exists, or where federal coal leases, preference-right lease applications, and coal prospecting permits 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 1750, or 1770--the number of tons of lignite A or subbituminous C coal per acre-foot, respectively (12,874 or 13,018 metric tons per hectare-meter, respectively), to determine total tons in place. Recoverable tonnage is calculated at 95 percent of the total tons in place. 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 complexly 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 for subbituminous coal is as follows:

$$MR = \frac{to\ (0.911)^*}{tc\ (rf)}$$

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

*A conversion factor of 0.922 is used for lignite.

A surface mining development potential map (Plate 39) was 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 are 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 development potential is moderate for approximately 2 percent of the Carr Draw Quadrangle. A low development potential rating covers approximately 22 percent of the study area. These moderate and low development potential ratings are attributed to moderate to low overburden to coal ratios for the Felix coal zone. The areas designated as low and moderate potential for surface mining coincide with the significant drainages in both the northern and southern portions of the quadrangle. None of the quadrangle qualifies for a high potential rating. The remaining 76 percent of the study area is classified as either having no development potential for surface mining or as non-federal coal land.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Carr 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 that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal resources 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 3000 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 1000 feet (305 m) to 3000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness which lies 500 feet (152 m) to 1000 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 1000 to 3000 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 1000 to 3000 feet (305 to 914 m).

The coal development potential for in-situ gasification within the Carr Draw Quadrangle is high for approximately 55 percent of the study area, generally over the northeastern half and small areas in the southwest quadrant. A small area in the northeast quarter of the quadrangle is rated as moderate development potential. The remainder of the study area is non-federal coal land and has not been evaluated for in-situ gasification development potential. The coal resource tonnage totals for in-situ gasification with high and moderate development potentials are given on Table 3. The tonnage figures on Table 3 for low development potential for in-situ gasification are for coal beds or coal zones that lie 500 feet to 1000 feet (152 to 304 m) beneath the surface. These coal beds or coal zones lie above areas of high and moderate development potential for in-situ gasification and are not depicted as low development potential on Plate 40.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Carr 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
RESOURCE BASE				
Felix	-----	1,460,000	125,550,000	127,010,000
HYPOTHETICAL REOSURCES				
	-----	-----	145,710,000	145,710,000
TOTAL	-----	1,460,000	271,260,000	272,720,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
Felix	-----	-----	335,600,000	335,600,000
Smith	-----	-----	386,150,000	386,150,000
Anderson	-----	-----	1,102,880,000	1,102,880,000
Canyon-Upper Cook	-----	-----	1,114,390,000	1,114,390,000
Wall-Pawnee-Cache	-----	-----	2,831,910,000	2,831,910,000
Wildcat-Moyer-Oedekoven	-----	-----	631,180,000	631,180,000
Local	-----	-----	35,690,000	35,690,000
TOTAL	-----	-----	6,437,800,000	6,437,800,000
HYPOTHETICAL RESOURCES				
Felix	-----	-----	49,410,000	49,410,000
Smith	-----	-----	269,190,000	269,190,000
Anderson	-----	-----	406,250,000	406,250,000
Canyon-Upper Cook	-----	-----	593,920,000	593,920,000
Wall-Pawnee-Cache	-----	-----	1,547,400,000	1,547,400,000
Wildcat-Moyer-Oedekoven	-----	-----	215,910,000	215,910,000
TOTAL	-----	-----	3,082,080,000	3,082,080,000
GRAND TOTAL	-----	-----	9,519,880,000	9,519,880,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
	5,761,640,000	213,690,000	462,470,000	6,438,490,000
HYPOTHETICAL RESOURCES				
	-----	-----	3,082,080,000	3,082,080,000
TOTAL	5,761,640,000	213,690,000	3,544,550,000	9,519,880,000

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