UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY: COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE CABIN CREEK NW QUADRANGLE, SHERIDAN COUNTY, WYOMING, AND POWDER RIVER COUNTY, MONTANA

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

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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/ metric ton
acre-feet	0.12335	hectare-meters
British thermal units/pound (Btu/1b)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (Btu/1b)	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 Cabin Creek NW Quadrangle, Sheridan County, Wyoming, and Powder River County, Montana. This CRO and CDP map series includes 59 plates (U. S. Geological Survey Open-File Report 79-163). 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 a 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 Cabin Creek NW Quadrangle is located in Sheridan County, in northeastern Wyoming, and Powder River County, in southeastern Montana. It encompasses all or parts of Townships 57 and 58 North, Ranges 77 and 78 West in Wyoming, and Township 9 South, Ranges 45 and 46 East in Montana, and covers the area: 44°52'30" to 45°00' north latitude; 106°07'30" to 106°15" west longitude.

Main access to the Cabin Creek NW Quadrangle is provided by a light-duty, graveled road which extends across the western and northern portions of the quadrangle. Access to more remote areas in the quadrangle is provided by minor roads and trails. The closest railroad is the Burlington Northern trackage approximately 11 miles (18 km) to the south near Leiter, Wyoming.

Drainage in the eastern and southern portions of the quadrangle is provided by the southeastward-flowing Cabin Creek, Squaw Creek, and Fence Creek. The intermittent streams are tributaries of the Powder River. The northwestern portion of the quadrangle is drained by the northwestward-flowing Iron Springs Creek and Trail Creek, which join Hanging Woman Creek to the northwest. The terrain attains an elevation of 4,309 feet (1,313 m) above sea level at Squaw Butte in the southwest part of the quadrangle. The lowest point in the quadrangle is 3,660 feet (1,116 m) along Cabin Creek in the southeastern quarter. Topographic relief in the quadrangle is 649 feet (198 m).

The 13 to 14 inches (33 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 Arvada, Wyoming, average wintertime minimums and summertime maximums range from +5° to +15°F (-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 Sheridan County Courthouse in Sheridan, Wyoming, and the Powder River County Courthouse in Broadus, Montana. Details of mineral ownership on federal lands are available from the U. S. Bureau of Land Management in Cheyenne, Wyoming, and Billings, Montana, respectively. 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 (resources), as well as recoverable tons (reserves). These coal tonnages are then categorized in measured, indicated, and inferred parts of identified 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 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 5.9 billion tons (5.3 billion metric tons) of total, unleased federal coal-in-place resources in the Cabin Creek NW Quadrangle.

The suite of maps that accompanies 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 overlying Wasatch Formation. Approximately 3,000 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 the 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. 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 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 member subdivisions 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 2 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 and in-filling of these areas 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 of 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 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 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 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 noticably to imperceptibly coarser than the underlying Fort Union clastics.

The Cabin Creek NW Quadrangle is located in an area where surface rocks are classified within the Wasatch Formation and the Tongue River Member of the Fort Union Formation. Although the Wasatch Formation is reportedly up to 1,800 feet (549 m) thick (Denson and Horn, 1975), Olive (1957) mapped 700 to 800 feet (213 to 244 m). Only 100 to 200 feet (30 to 61 m) of the Wasatch Formation and 300 to 400 feet (91 to 122 m) of the underlying Tongue River Member of the Fort Union Formation are exposed in the quadrangle. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the northward extension of the Sheridan coal field, Montana (Baker, 1929), and Gillette coal field, Wyoming (Dobbin and Barnett, 1927), 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 Dietz coal bed and the Smith coal bed were named by Taff (1909). The Arvada coal bed was named by Stone and Lupton (1910). Bass (1924 and 1932) named the Knobloch coal bed , and Baker (1929) named the Roland of Baker, Anderson, Canyon, Brewster-Arnold, and Wall coal beds. The Cook coal bed was named by Bass (1932) and the Otter coal bed was named by Bryson and Bass (1973). Warren (1959) named the King coal bed. The Roberts coal bed was named by Culbertson and Klett (1975), and the Waddle and Kendrick coal beds were named by Culbertson and Klett (1979). The Roland coal bed was named by Taff (1909) in the Sheridan coal field, Wyoming. A coal bed assumed to be the same bed was called the Roland coal bed in the northward extension of the Sheridan coal field, Montana, by Baker (1929). Subsequent work in the Sheridan coal field has shown that the Roland coal bed named by Baker (1929) lies approximately 125 feet (38 m) above the Roland coal bed named by Taff (1909). The Waddle and the Dietz coal beds in the Cabin Creek NW Quadrangle are equivalent to the Smith and Dietz #1 coal beds, respectively, in the Cabin Creek NE Quadrangle to the east (IntraSearch, 1978a). The Waddle coal bed and the Smith coal bed are equivalent to the Upper Smith coal bed and the Lower Smith coal bed, respectively, as mapped by IntraSearch (1979b), in the Fawn Draw Quadrangle to the south. To the east and the south of the quadrangle, the Cook-Otter coal zone is equivalent to the Cook coal bed, and the Brewster-Arnold coal bed is equivalent to the Pawnee coal bed (IntraSearch, 1979a). The Knobloch, Roberts, and Kendrick coal beds in this quadrangle are equivalent to the Wildcat, Moyer, and Oedekoven coal beds, respectively, as mapped by IntraSearch to the south.

Local. The Cabin Creek NW Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over approximately 50 percent of the quadrangle, and is composed 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 Tongue River Member of the Fort Union Formation directly underlies the Wasatch Formation, and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Tongue River Member crops out over approximately 50 percent of the quadrangle.

The dominant structural feature within the quadrangle is a southwestward-plunging anticline, broad on some coal beds and narrow on others, superimposed on a regional, southwestward dip. On several coal beds, the anticline is flanked by a closed, southward-plunging syncline in the southeastern portion of the quadrangle or by a westward-plunging syncline in the northwestern portion of the quadrangle. Two normal faults within the Cabin Creek NW Quadrangle trend northeastward and have as much as 30 feet (9 m) of vertical displacement.

III. Data Sources

Areal geology of the coal outcrops is derived from the Spotted Horse coal field report (Olive, 1957) and the Moorhead coal field report (Bryson and Bass, 1973). The coal outcrops are adjusted to fit the current topographic map of the area.

Geophysical logs from oil-and-gas test bores and producing wells compose 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.

All geophysical logs available in the quadrangle and its 3-mile perimeter area were scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs were obtained and interpreted, and coal intervals were annotated. Maximum accuracy of coal bed identification was accomplished where gamma, density and resistivity curves were available. Coal bed tops and bottoms were identified on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles was achieved by 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 details, 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 Cabin Creek NW Quadrangle is published by the U. S. Geological Survey, compilation date 1971. Land network and mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming, and Billings, Montana. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Wasatch Formation and the Fort Union Formation coal beds that are present in all or part of the Cabin Creek NW Quadrangle include, in descending stratigraphic order: the Arvada, Roland of Baker, Waddle, Smith, Anderson, Dietz, Canyon, Cook, Otter, Wall, Brewster-Arnold, King, Knobloch, Roberts, Local, Kendrick, and local coal beds. The Canyon coal beds, and the Cook and Otter coal beds are mapped as coal zones. The King, Knobloch, Roberts, Local, and Kendrick coal beds are mapped together as a coal bed composite. A suite of maps composed of: coal isopach and mining ratio, where appropriate; structure; overburden isopach; areal distribution of identified resources; identified resources and hypothetical resources, where applicable, is prepared for each of these coal beds or coal zones. Mining ratios are presented on the isopach maps of the Arvada, Roland of Baker, Waddle, Smith, Anderson, Dietz, and Canyon coal beds.

No physical or chemical analyses are known to have been published regarding coal bed samples from the Cabin Creek NW Quadrangle. For eastern Sheridan County, Wyoming, and southern Powder River County, Montana, coal beds, the "as received" proximate analysis; the Btu value computed on a moist, mineral-matter-free basis;* and the coal rank are as follows:

COAL BED NAME		DATA SOURCE IDENTIFICATION	AS RECEIVED BASIS						MOIST, M-M-F	
			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB	BTU/LB	COAL RANK
Arvada	(**)	Hole 78-2	10.5	32.9	28.5	28.1	1.6	7575	8538	Subbtm. C
Roland of Baker	(1)	Hole SH-7029	4.7	27.8	30.2	37.3	0.24	8086	8518	Subbtm. C
Waddle	(1)	Hole SH-24	12.1	36.0	23.7	28.2	0.79	7877	9061	Subbtm. C
Anderson	(1)	Hole SM-15	6.7	35.3	28.6	29.4	0.4	7950	8568	Subbtm. C
Dietz	(1)	Hole SH-18	10.0	34.3	25.8	29.9	0.48	7722	8655	Subbtm. C
Canyon	(1)	Hole SH-62	5.6	37.6	24.2	32.5	0.25	8462	8730	Subbtm. C
Cook	(1)	Hole SH-64	3.1	36.2	30.8	30.0	0.15	7948	8225	Lignite A
Wall	(U)	Hole 7426	9.5	29.3	32.2	29.0	0.50	7279	8112	Lignite A
Brewster-Arnold	(U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A

* The moist, mineral-matter-free Btu values are calculated in the manner stipulated in the publication by American Society for Testing and Materials (1971).

** Correia, G. A. (U. S. Geological Survey, unpublished data).

(1) Matson, R. E., and Blumer, J. W. (1973).

(U) U. S. Geological Survey and Montana Bureau of Mines and Geology (1976).

The proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadrangle. In order to simplify tonnage computations, all coal beds in the Cabin Creek NW Quadrangle are tentatively classified as subbituminous C in rank.

The Coal Data sheet, plate 3, shows 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 holes and geophysical logs from oil-and-gas test bores and from producing sites. 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 Canyon coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Anderson and Canyon coal beds show the thickest coal bed occurrence throughout the study area. The other coal beds are relatively thin throughout the Cabin Creek NW Quadrangle.

The Arvada coal bed ranges in thickness from 2 to 6.8 feet (0.6 to 2.1 m), with the maximum thicknesses in the northern, eastern, and southern areas. The coal bed has been eroded from 50 percent of the Cabin Creek NW Quadrangle. The upper coal bed ranges in thickness from less than 1 foot (0.3 m) to 2.3 feet (0.7 m), and the lower coal bed ranges from 2 to 4.5 feet (0.6 to 1.4 m) in thickness. The Arvada coal beds are separated by a shale interval reaching a maximum thickness of 9.7 feet (3.0 m). Coal isopach and structure contour maps of the Arvada coal bed are based on surface measured sections and coal outcrop elevations (Olive, 1957, and Bryson and Bass, 1973). Structure contours drawn on the top of the Arvada coal bed depict a gentle, southwestward dip with a broad, southwestward-plunging anticline in the northern portion of the quadrangle. The Arvada coal bed occurs from 0 feet

(0 m) to greater than 300 feet (91 m) beneath the surface.

The Roland of Baker coal bed lies 20 to 150 feet (6 to 46 m) beneath the Arvada coal bed. The Roland of Baker coal bed is absent in the southern half of the quadrangle, and reaches a maximum thickness of 11.4 feet (3.5 m) along the northern edge. Approximately 40 percent of the Roland of Baker coal bed in this quadrangle has been eroded. Coal isopach and structure contour maps of the Roland of Baker coal bed are based on surface measured sections and coal outcrop elevations (Olive, 1957, and Bryson and Bass, 1973). The main structural configuration on the Roland of Baker coal bed is a broad, southwestward-plunging anticline in the northeastern quarter flanked by a broad, shallow, southwestward-plunging syncline to the northwest. The Roland of Baker coal bed lies from 0 feet (0 m) to greater than 200 feet (61 m) beneath the surface. A measured section on the Roland of Baker coal bed of 10 feet (3 m) (Bryson and Bass, 1973) in section 33, Township 9 South, Range 45 East, is located south of an 8-foot (2.4-m) thick coal isopach line in a trend thinning southward in the CRO/CDP report on the Bear Creek School Quadrangle, Montana, (McKay, Butler, and Robinson, 1979) to the north. The coal data presents the continuity of isopach and mining-ratio contours on the Roland of Baker coal bed between the two quadrangles.

The Waddle coal bed occurs 80 to 380 feet (24 to 116 m) beneath the Roland of Baker coal bed, and 100 to 160 feet (30 to 49 m) beneath the Arvada coal bed where the Roland of Baker coal bed is absent. The Waddle coal bed is absent in the north-central area of the quadrangle, and attains a maximum thickness of 12 feet (4 m) in the northeastern corner. The Waddle coal bed has been eroded from approximately 15 percent of the study area. Coal isopach and structure contour maps of the Waddle coal bed are based on surface measured sections and coal outcrop elevations (Olive, 1957 and Bryson and Bass, 1973). Subsurface control from the Box Elder Draw Quadrangle to the west and the Bear Creek School Quadrangle to the north allows projection of contours throughout the western and northern areas of the Cabin Creek NW Quadrangle. The dominant structural feature on the Waddle coal bed is a closed anticline in the central area of the quadrangle, flanked by a southward-plunging syncline to the east. The Waddle coal bed occurs from 0 feet (0 m) to greater than 400 feet (122 m) beneath the surface.

The Smith coal bed is located 10 to 140 feet (3 to 43 m) beneath the Waddle coal bed, and 100 to 160 feet (30 to 49 m) beneath the Roland of Baker coal bed where the Waddle coal bed is absent. The Smith coal bed is absent in the southeastern quarter of the quadrangle and along the eastern boundary, and attains a maximum thickness of 11 feet (3 m) in the north-central area of the quadrangle. The Smith coal bed has been eroded from less than 1 percent of the quadrangle. Coal isopach and structure contour maps of the Smith coal bed are based on subsurface data from one drill hole in the northern portion of the Cabin Creek NW Quadrangle, and from subsurface control located in the Box Elder Draw Quadrangle to the west and the Fawn Draw Quadrangle to the south. The main structural configuration on the Smith coal bed is a northeastern-oriented, closed anticline in the northern area of the quadrangle. The Smith coal bed lies from 0 feet (0 m) to greater than 500 feet (152 m) beneath the surface.

The Anderson coal bed is located 40 to 280 feet (12 to 85 m) beneath the Smith coal bed, and 60 to 330 feet (18 to 101 m) beneath the Waddle coal bed where the Smith coal bed is absent. The Anderson coal bed ranges in thickness from 5 feet (1.5 m) to 26 feet (8 m), with maximum thickness in the east-central part of the quadrangle, and has been eroded in a small area along the eastern edge of the quadrangle. In the northern portion of the quadrangle, the Anderson coal bed separates into two coal beds, with a maximum non-coal interval of 61 feet (19 m). The main structural configuration on the Anderson coal bed is a southwestward-plunging anticline in the northeastern quarter, flanked by synclines on both sides. The Anderson coal bed lies from 0 feet (0 m) to greater than 700 feet (213 m) beneath the surface.

The Dietz coal bed lies 30 to 160 feet (9 to 49 m) beneath the Anderson coal bed. The Dietz coal bed is absent along the southeastern boundary and in the west-central portion of the quadrangle. A maximum thickness of 10 feet (3 m) is attained in the extreme northwestern corner of the study area. Structure contours drawn on top of the Dietz coal bed depict a gentle, southwestward dip with a southwestward-plunging syncline in the northwestern portion of the study area. The Dietz coal bed occurs from less than 200 feet (61 m) to greater than 800 feet (244 m) beneath the surface.

The Canyon coal zone lies 81 to 220 feet (25 to 67 m) beneath the Dietz coal bed, and 149 to 280 feet (45 to 85 m) beneath the Anderson coal bed where the Dietz coal bed is absent. The Canyon coal zone in the

Cabin Creek NW Quadrangle is composed of one to four coal beds. Total coal zone thicknesses range from 20 feet (6 m) to 40 feet (12 m) with maximum thickness along the eastern edge. The total non-coal interval ranges from 0 to 66 feet (0 to 20 m). Structure contours drawn on top of the Canyon coal zone depict a gentle, southwestward dip, with a southwestward-plunging syncline in the northwestern quarter of the study area. The Canyon coal zone lies from less than 200 feet (61 m) to greater than 1,000 feet (305 m) beneath the surface.

The Cook-Otter coal zone occurs 90 to 280 feet (27 to 85 m) beneath the Canyon coal zone. The Cook-Otter coal zone is composed of one-to-two Cook coal beds and one Otter coal bed in the north. The Cook and Otter coal beds combine into one coal bed in the southeast, and are absent in the southwestern quarter of the quadrangle. Total coal zone thicknesses range from 0 to 28 feet (0 to 9 m) with maximum thicknesses along the eastern boundary of the study area. The Cook-Otter coal zone attains a maximum non-coal interval of 59 feet (18 m). Structure contours drawn on top of the Cook coal bed depict a gentle, southwestward dip with a broad, southwestward-plunging anticline through the central area, flanked by a southwestward-plunging syncline to the southeast. Where the Cook coal bed is pinched out, structure contours drawn on top of the Otter coal bed depict a gentle, westward dip. The Cook-Otter coal zone occurs from less than 700 feet (213 m) to greater than 1,250 feet (381 m) beneath the surface. Where the Cook coal bed is pinched out, the Otter coal bed lies from less than 1,000 feet (305 m) to greater than 1,100 feet (335 m) beneath the surface.

The Wall coal bed lies 90 to 260 feet (27 to 79 m) beneath the Cook-Otter coal zone. The Wall coal bed is absent in the southwestern quarter of the quadrangle and in the northwestern and northeastern corners. The coal bed attains a maximum thickness of 19 feet (6 m) in the north-central part of the study area. The main structural features on the Wall coal bed are a broad, southwestward-plunging anticline located in the northeastern quarter, flanked by a broad, southwestward-plunging syncline. The Wall coal bed lies from less than 750 feet (229 m) to greater than 1,250 feet (381 m) beneath the surface.

The Brewster-Arnold coal bed lies 119 to 320 feet (36 to 98 m) beneath the Wall coal bed, and 220 to 320 feet (67 to 98 m) beneath the Cook-Otter coal zone where the Wall coal bed is absent. The Brewster-Arnold coal bed thickens southward from 4 feet (1.2 m) in the north to 13 feet (4 m) in the southern portion of the quadrangle. Structure contours drawn on top of the Brewster-Arnold coal bed depict a southwestward-trending anticline, flanked on the southeast side by a southward-plunging syncline, and on the north by a shallow, southwestward-trending syncline. The Brewster-Arnold coal zone lies from less than 1,000 feet (305 m) to greater than 1,500 feet (457 m) beneath the surface.

The King-Knobloch-Roberts-Local-Kendrick coal bed composite occurs 300 to 739 feet (91 to 225 m) beneath the Brewster-Arnold coal bed. The King coal bed is separated into two coal beds by as much as 10 feet (3 m) of clastic material, and is absent in the northwestern portion of the quadrangle. The Roberts coal bed is separated locally into two coal beds by 2 feet (0.6 m) of clastic sediments. Total coal zone thicknesses range from 5 feet (1.5 m) on the eastern edge of the quadrangle to 40 feet (12 m) on the western edge. The total non-coal sediments within the coal composite range from 186 to 460 feet (57 to 140 m). The main structural configuration on the coal bed composite is a southward-plunging syncline in the western half of the study area. The King-Knobloch-Roberts-Local-Kendrick coal bed composite lies from less than 1,250 feet (381 m) to greater than 2,100 feet (640 m) beneath the surface.

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 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 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 Cabin Creek NW 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 only selected measured sections where there is sparse subsurface control. Where coal isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion: hence, these surface measurements ~~they~~ are not reflective of true ~~total~~ coal thickness. Isopach lines extend to the coal bed outcrops, the projections of coal bed outcrops, and the contact between porcellanite (clinker) and unoxidized coal in place. Attenuation of total coal bed thickness is known to take place near these lines of definition as just listed; 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 are 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 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 (reserves). 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), and 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, and inferred parts of identified 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, or 1,770--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 tonnages (reserves) were 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 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 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 59) was prepared utilizing the following mining ratio criteria for coal beds 5 feet 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 high for approximately 30 percent of the quadrangle. These high development potential areas result from low overburden-to-coal thickness ratios for the Arvada coal bed, where it outcrops on the tops of ridges, and for the Roland of Baker coal bed where it outcrops along the hillsides in the northern portion of the quadrangle. The Waddle, Smith, Anderson, and Canyon coal beds have high surface-mining development potential along the valley floors. Approximately 20 percent of the surface-mining development potential for the Cabin Creek NW Quadrangle is moderate, existing in small areas scattered throughout the quadrangle. The surface-mining development potential is low for approximately 35 percent of the quadrangle, resulting from the thin coal beds which are overlain by thick overburden. Less than 5 percent of the quadrangle is rated as having no potential for surface-mining development, because no known coal beds 5 feet (1.5 m) or more thick lie within 500 feet (152 m) of the surface. The remaining 10 percent of the study area is classified as non-federal coal land. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Cabin Creek NW Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves (recoverable coal tonnages) are not calculated for coal beds that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated underground-minable coal resources in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification development 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 1,000 feet (305 m) to 3,000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness that lies 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 Cabin Creek NW Quadrangle is rated as low. The total coal section more than 1,000 feet (305 m) beneath the surface is less than 100 feet (30 m) thick throughout the quadrangle. The coal resource tonnage totals for in-situ gasification are listed by coal bed on table 3.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Cabin Creek NW Quadrangle, Sheridan County, Wyoming, and Powder River County, Montana.

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
Reserve Base Resources				
Arvada	34,090,000	10,730,000	13,400,000	58,220,000
Roland of Baker	29,320,000	12,430,000	9,730,000	51,480,000
Waddle	14,660,000	12,990,000	47,210,000	74,860,000
Smith	8,280,000	20,970,000	94,280,000	123,530,000
Anderson	80,890,000	202,540,000	362,300,000	645,730,000
Dietz	550,000	3,370,000	22,900,000	26,820,000
Canyon	81,510,000	241,370,000	17,940,000	340,820,000
Total	249,300,000	504,400,000	567,760,000	1,321,460,000
Hypothetical Resources				
Waddle	-	-	3,830,000	3,830,000
Smith	-	-	80,760,000	80,760,000
Anderson	-	-	5,830,000	5,830,000
Total	-	-	90,420,000	90,420,000
GRAND TOTAL	249,300,000	504,400,000	658,180,000	1,411,880,000

Table 2.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Cabin Creek NW Quadrangle, Sheridan County, Wyoming and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Anderson	-	-	84,480,000	84,480,000
Dietz	-	-	5,850,000	5,850,000
Canyon	-	-	1,353,530,000	1,353,530,000
Cook-Otter	-	-	767,330,000	767,330,000
Wall	-	-	317,450,000	317,450,000
Brewster-Arnold	-	-	502,260,000	502,260,000
King-Knobloch-Roberts-Local-Kendrick	-	-	1,340,550,000	1,340,550,000
Total	-	-	4,371,450,000	4,371,450,000
Hypothetical Resources				
Anderson	-	-	520,000	520,000
Wall	-	-	140,000	140,000
Total	-	-	660,000	660,000
GRAND TOTAL	-	-	4,372,110,000	4,372,110,000

Table 3.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Cabin Creek NW Quadrangle, Sheridan County, Wyoming, and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Anderson	-	-	84,480,000	84,480,000
Dietz	-	-	5,850,000	5,850,000
Canyon	-	-	1,353,530,000	1,353,530,000
Cook-Otter	-	-	767,330,000	767,330,000
Wall	-	-	317,450,000	317,450,000
Brewster-Arnold	-	-	502,260,000	502,260,000
King-Knobloch-Roberts-Local-Kendrick	-	-	1,340,550,000	1,340,550,000
Total	-	-	4,371,450,000	4,371,450,000
Hypothetical Resources				
Anderson	-	-	520,000	520,000
Wall	-	-	140,000	140,000
Total	-	-	660,000	660,000
GRAND TOTAL	-	-	4,372,110,000	4,372,110,000

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