UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

FAWN DRAW QUADRANGLE,

SHERIDAN COUNTY, WYOMING

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN FILE REPORT 79-164
1980

This report was prepared under contract to the U.S. Geological Survey and has not been edited for conformity with Geological Survey standards and nomenclature. Opinions and conclusions expressed herein do not necessarily represent those of the Geological Survey.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

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/lb)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (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 Fawn Draw Quadrangle, Sheridan County, Wyoming. This CRO and CDP map series includes 59 plates (U. S. Geological Survey Open-File Report 79-164). 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 Fawn Draw Quadrangle is located in Sheridan County, in northeastern Wyoming. It encompasses all or parts of Townships 55, 56, and 57 North, Ranges 77 and 78 West, and covers the area: 44°45' to 44°52'30" north latitude; 106°07'30" to 106°15' west longitude.

Main access to the Fawn Draw Quadrangle is provided by a light-duty, graveled road which extends from north-to-south approximately 1 mile (1.6 km) west of the quadrangle. Another maintained graveled road extends from north-to-south approximately 1 mile (1.6 km) east of the quadrangle. An east-west-trending graveled road is located about 0.5 miles (0.8 km) south of the study area. Unimproved roads provide access to the more remote areas of the quadrangle. The closest railroad is the Burlington Northern trackage 1.6 miles (2.6 km) to the south near Leiter, Wyoming.

Drainage is provided by the northeastward-flowing Clear Creek, which crosses the southern half of the quadrangle, and flows into the Powder River approximately 5 miles (8.1 km) northeast of the quadrangle. Buffalo Creek flows eastward across the center of the quadrangle into Clear Creek. The terrain attains elevations of 4,150 feet (1,265 m) above sea level in the northeastern corner of the quadrangle where hills rise 550 to 600 feet (168 to 183 m) above the valley floor of Clear Creek.

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. 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 (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 4.6 billion tons (4.2 billion metric tons) of total, unleased federal coal-in-place resources in the Fawn Draw 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 Fawn Draw 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 500 to 600 feet (152 to 183 m) of Wasatch Formation and 100 to 200 feet (30 to 61 m) of the 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 Smith and Dietz coal beds were named by Taff (1909). Stone and Lupton (1910) named the Arvada coal bed. The Roland of Baker, Anderson, Canyon, and Wall coal beds were named by Baker (1929). The Cook coal bed was named by Bass (1932), and the Pawnee coal bed was named by Warren (1959). IntraSearch Inc. (1978b, 1978a, and 1979) informally named the Wildcat, Moyer, and Oedekoven coal beds.

The Upper Smith and Lower Smith coal beds in the Fawn Draw Quadrangle are equivalent to the Waddle and Smith coal beds, respectively, as mapped by us in the Cabin Creek NW Quadrangle to the north. The Cook coal bed is equivalent to the Cook-Otter coal beds to the north. The Pawnee, Wildcat, Moyer, and Oedekoven coal beds are equivalent to the Brewster-Arnold, Knobloch, Roberts, and Kendrick coal beds, respectively, as mapped by us in the Cabin Creek NW Quadrangle.

Local. The Fawn Draw Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over approximately 15 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 85 percent of the quadrangle.

The main structural feature within the quadrangle is a gentle, southwestward dip with minor flexures on some coal beds. A northeast-trending normal fault, with approximately 10 feet (3 m) of vertical displacement (up or down?) to the south, occurs in the center of the eastern edge of the quadrangle.

III. Data Sources

Areal geology of the coal outcrops is derived from the Spotted Horse coal field report (Olive, 1957) and the Powder River coal field report (Stone and Lupton, 1910). 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 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 Fawn Draw 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. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Wasatch Formation and Fort Union Formation coal beds that are present in all or part of the Fawn Draw Quadrangle include, in descending stratigraphic order: the Arvada, Roland of Baker, Upper Smith, Lower Smith, Anderson, Dietz, Upper Canyon, local, local, Lower Canyon, Cook, Wall, Pawnee, Wildcat, Moyer, Oedekoven, local and local coal beds. The Pawnee coal beds are mapped as a coal zone. The Wildcat, Moyer, and Oedekoven coal beds are mapped as a coal bed composite. The Roland of Baker coal bed was not mapped due to insufficient thickness. 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, was prepared for each of these coal beds or coal zones. Mining ratios are presented on the isopach maps of the Arvada, Upper Smith, Lower Smith, Anderson, Dietz, Upper Canyon, and Lower Canyon coal beds.

No physical or chemical analyses are known to have been published regarding coal bed samples from the Fawn Draw Quadrangle. For Sheridan County 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 BTU/LB	COAL RANK
			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB		
Arvada	(**)	Hole 78-2	10.5	32.9	28.5	28.1	1.6	7575	8538	Subbtm. C
Smith	(U)	Hole 7340	3.5	38.0	30.0	28.5	0.31	8371	8700	Subbtm. C
Anderson	(U)	Hole 746	6.3	31.1	32.6	30.0	0.33	7498	8045	Lignite A
Dietz	(1)	Hole SH-18	10.0	34.3	25.8	29.9	0.48	7722	8655	Subbtm. C
Canyon	(U)	Hole 744	4.3	32.9	35.1	27.8	0.31	7298	7650	Lignite A
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
Pawnee	(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 (1974, 1976).

Except the for Arvada coal bed, the proximate analyses presented above are from core hole outcrop locations in excess of 20 miles (32 km) from this quadrangle. In order to simplify tonnage computations, all coal beds in the Fawn Draw 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 Cook coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Cook and Wall coal beds show the thickest coal bed occurrence throughout the study area. The other coal beds are relatively thin throughout the Fawn Draw Quadrangle.

The Arvada coal bed, ranging in thickness from 2 to 12 feet (0.6 to 4 m) with maximum thickness in the southwest quarter, crops out over approximately 50 percent of the Fawn Draw Quadrangle. The Arvada coal bed separates into two coal beds, as indicated by eight measured sections, with an average shale parting of 2 feet (0.6 m). A maximum clastic interval of 8 feet (2.4 m) occurs in the southwestern portion of the quadrangle. Coal isopach and structure contour maps of the Arvada coal bed are based on surface-measured sections and coal outcrop elevations (Olive, 1957 and Stone and Lupton, 1910). Structure contours drawn on top of the Arvada coal bed depict gentle, southwestward dip with minor flexures in the south. The Arvada coal bed occurs from 0 feet (0 m) to greater than 300 feet (91 m) beneath the surface.

The Upper Smith coal bed lies 140 to 280 feet (43 to 85 m) beneath the Arvada coal bed. The Upper Smith coal bed ranges in thickness from 2 to 11 feet (0.6 to 3 m) with maximum thickness in the northern portion and southeastern corner, and is eroded from approximately 35 percent of the study area. One measured section indicates a non-coal interval of 10 feet (3 m), an upper coal bed of 7 feet (2.1 m) thick, and a lower coal bed 3 feet (0.9 m) thick. Coal isopach and structure contour maps of the Upper Smith coal bed are based on surface-measured sections and coal outcrop elevations (Olive, 1957 and Stone and Lupton, 1910). Structure contours drawn on top of the Upper Smith coal bed depict a broad, southward-plunging anticline through the central portion of the study area flanked by a southward-plunging syncline in the southeastern corner of the quadrangle. The Upper Smith coal bed lies from 0 to 510 feet (0 to 155 m) beneath the surface.

The Lower Smith coal bed occurs 50 to 240 feet (15 to 73 m) beneath the Upper Smith coal bed. The Lower Smith coal bed is absent along the eastern edge and southwestern corner of the study area, and reaches a maximum thickness of 11 feet (3 m) in the southeastern and northwestern quarters. The Lower Smith coal bed is eroded in two small areas in the northeastern quarter of the quadrangle. Coal isopach and structure contour maps of the Lower Smith coal bed are based on subsurface data in two drill holes and one surface measured section and coal outcrop elevations (Olive, 1957). Subsurface data to the north, west, and south allowed projection of coal isopach and structure contours over the western half of the quadrangle. Structure contours drawn on top of the Lower Smith coal bed depict a gentle, southward dip. The Lower Smith coal bed occurs from 0 feet (0 m) to greater than 600 feet (183 m) beneath the surface.

The Anderson coal bed is located 60 to 160 feet (18 to 49 m) beneath the Lower Smith coal bed, and approximately 200 feet (61 m) beneath the Upper Smith coal bed where the Lower Smith coal bed is absent. The Anderson coal bed is absent in the southwestern corner of the quadrangle, and reaches a maximum thickness of 15 feet (5 m) in the southeastern corner. A maximum of 9 feet (2.7 m) of clastic sediments occurs within the Anderson coal bed in the southeastern area. The Anderson coal bed is eroded in the Clear Creek and Squaw Creek valleys along the northeastern edge of the study area. Structure contours drawn on top of the Anderson coal bed depict a gentle, southwestward dip. The Anderson coal bed lies from 0 feet (0 m) to greater than 800 feet (244 m) beneath the surface.

The Dietz coal bed occurs 90 to 250 feet (27 to 76 m) beneath the Anderson coal bed and approximately 300 feet (91 m) beneath the Lower Smith coal bed where the Anderson coal bed is absent. The Dietz coal bed is absent in the northwestern corner of the quadrangle, and attains a maximum thickness of 11 feet (3 m) in the east-central portion, where it is separated into two coal beds by a non-coal interval 3 feet (0.9 m) thick. Structure contours drawn on top of the Dietz coal bed depict a gentle, southwestward dip. The Dietz coal bed occurs from less than 200 feet (61 m) to greater than 900 feet (274 m) beneath the surface.

The Upper Canyon coal bed lies 20 to 160 feet (6 to 49 m) beneath the Dietz coal bed, and approximately 370 feet (113 m) beneath the Anderson coal bed where the Dietz coal bed is absent. The Upper

Canyon coal bed ranges in thickness from 7 feet (2.1 m) in the south to 20 feet (6 m) in the north, where it splits into three, thin coal beds from 2 to 7 feet (0.6 to 2.1 m) thick each, with a non-coal interval of approximately 5 feet (1.5 m). Structure contours drawn on top of the Upper Canyon coal bed depict a gentle, southwestward dip. The Upper Canyon coal bed lies from less than 200 feet (61 m) to greater than 1,100 feet (335 m) beneath the surface.

The Lower Canyon coal bed lies 120 to 380 feet (37 to 116 m) beneath the Upper Canyon coal bed. The Lower Canyon coal bed is absent in the southwestern corner of the quadrangle, and reaches a maximum thickness of 14 feet (4 m) in the northeastern quarter. The Canyon coal bed is composed of 2 to 3 coal beds approximately 5 feet (1.5 m) thick, and has a non-coal interval ranging from 7 to 63 feet (2.1 to 19 m). Structure contours drawn on top of the Lower Canyon coal bed depict a gentle, southwestward dip with minor flexures. The Lower Canyon coal bed occurs from less than 500 feet (152 m) to greater than 1,250 feet (381 m) beneath the surface.

The Cook coal bed occurs 80 to 180 feet (24 to 55 m) beneath the Lower Canyon coal bed. The Cook coal bed ranges in thickness from 5 feet (1.5 m) in the northwestern corner of the quadrangle to 30 feet (9 m) in the northeastern corner of the quadrangle. Structure contours drawn on top of the Cook coal bed depict a gentle, southwestward dip and occurs from less than 750 feet (229 m) to greater than 1,500 feet (457 m) beneath the surface.

The Wall coal bed occurs 40 to 160 feet (12 to 49 m) beneath the Cook coal bed. The Wall coal bed is absent in the northwestern corner of the quadrangle, and increases in thickness to a maximum of 30 feet (9 m) along the southern edge. Structure contours drawn on top of the Wall coal bed depict a gentle, southwestward dip. The Wall coal bed lies from less than 1,000 feet (305 m) to greater than 1,500 feet (457 m) beneath the surface.

The Pawnee coal zone lies 60 to 300 feet (18 to 91 m) beneath the Wall coal bed. The Pawnee coal zone consists of a thin, upper coal bed, which pinches out southward, and occurs approximately 30 feet (9 m) above a thin, lower coal bed, which separates into two coal beds in the southern portion of the quadrangle. Total coal zone thicknesses range from 9 to 12 feet (2.7 to 4 m), with maximum thicknesses in the northern and western portions, and a non-coal interval ranging from 22 to 42 feet (7 to 13 m). Structure contours drawn on top of the Pawnee coal zone depict a gentle, southwestward dip. The Pawnee coal zone lies from less than 1,000 feet (305 m) to greater than 1,750 feet (533 m) beneath the surface.

The Wildcat-Moyer-Oedekoven coal bed composite occurs 220 to 300 feet (67 to 91 m) beneath the Pawnee coal zone, and where the Wildcat coal bed is pinched out, the Moyer coal bed occurs 350 to 500 feet (107 to 152 m) beneath the Pawnee coal zone. Total coal thicknesses range from 10 to 40 feet (3 to 12 m) with maximum thicknesses in the northwestern area of the quadrangle. The total clastic interval within the coal composite ranges from 248 to 254 feet (76 to 77 m) where the Wildcat coal bed is present. The non-coal sediments between the Moyer coal bed and the Oedekoven coal bed range from 140 to 245 feet (43 to 75 m) in thickness. The Wildcat, Moyer, and Oedekoven coal beds each consist of one or two, thin coal beds. The Moyer and Oedekoven coal beds thin to the northward, and the Wildcat coal bed is absent in the southern half of the quadrangle. Structure contours drawn on top of the Wildcat coal bed depict a gentle, southwestward dip. Where the Wildcat coal bed is absent, structure contours drawn on top of the Moyer coal bed depict a gentle, south-to-southwestward dip. The Wildcat-Moyer-Oedekoven coal bed composite lies from less than 1,250 feet (381 m) to greater than 1,800 feet (549 m) beneath the surface, and from less than 1,500 feet (457 m) to greater than 2,100 feet (640 m) beneath the surface where the Wildcat coal bed is absent.

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 Fawn 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 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 <u>Insufficient Data Line</u> 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 and Upper Smith coal beds in the areas of outcrop in the higher elevations in the southeastern quarter, and for the Lower Smith and Anderson coal beds where they crop out along the valleys in the northern and eastern parts of the quadrangle. Approximately 10 percent of the surface-mining development potential has a moderate rating and it is scattered throughout the quadrangle. Approximately 35 percent of the area has a low development potential, mostly in the western half and northeastern corner of the quadrangle. One percent of the quadrangle is rated as having no potential for surface-mining development, which occurs where coal beds are less than 5 feet (1.5 m) thick or lie more than 500 feet (152 m) beneath the surface. The remaining 25 percent of the quadrangle is classified as non-federal coal land or leased federal coal, and is not evaluated in this report. 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 Fawn Draw 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 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 in the Fawn Draw 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, per coal bed, for in-situ gasification are listed on table 3.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Fawn Draw Quadrangle, Sheridan 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
Reserve Base Resources				
Arvada	49,020,000	11,980,000	15,470,000	76,470,000
Upper Smith	70,940,000	54,000,000	102,010,000	226,950,000
Lower Smith	14,510,000	29,140,000	215,560,000	259,210,000
Anderson	2,650,000	4,450,000	194,980,000	202,080,000
Dietz	-	-	113,470,000	113,470,000
Upper Canyon	-	-	133,150,000	133,150,000
Total	137,120,000	99,570,000	774,640,000	1,011,330,000
Hypothetical Resources				
Lower Smith	-	-	38,290,000	38,290,000
Anderson	-	-	32,870,000	32,870,000
Dietz	-	-	4,670,000	4,670,000
Total	-	-	75,830,000	75,830,000
GRAND TOTAL	137,120,000	99,570,000	850,470,000	1,087,160,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Upper Smith	-	-	10,000	10,000
Lower Smith	-	-	29,000	29,000
Anderson	-	-	40,550,000	40,550,000
Dietz	-	-	51,650,000	51,650,000
Upper Canyon	-	-	395,530,000	395,530,000
Lower Canyon	-	-	357,200,000	357,200,000
Cook	-	-	561,780,000	561,780,000
Wall	-	-	407,970,000	407,970,000
Pawnee	-	-	444,190,000	444,190,000
Wildcat-Moyer Oedekoven	-	-	1,247,590,000	1,247,590,000
Total	-	-	2,945,650,000	2,945,650,000
Hypothetical Resources				
Lower Smith	-	-	5,340,000	5,340,000
Anderson	-	-	32,870,000	32,870,000
Dietz	-	-	37,090,000	37,090,000
Upper Canyon	-	-	77,730,000	77,730,000
Lower Canyon	-	-	41,160,000	41,160,000
Cook	-	-	108,910,000	108,910,000
Wall	-	-	113,220,000	113,220,000
Pawnee	-	-	79,080,000	79,080,000
Wildcat-Moyer-Oedekoven	-	-	58,000	58,000
Total	-	-	495,980,000	495,980,000
GRAND TOTAL	-	-	3,441,630,000	3,441,630,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Upper Smith	-	-	10,000	10,000
Lower Smith	-	-	29,000	29,000
Anderson	-	-	40,550,000	40,550,000
Dietz	-	-	51,650,000	51,650,000
Upper Canyon	-	-	395,530,000	395,530,000
Lower Canyon	-	-	357,200,000	357,200,000
Cook	-	-	561,780,000	561,780,000
Wall	-	-	407,970,000	407,970,000
Pawnee	-	-	444,190,000	444,190,000
Wildcat-Moyer-Oedekoven	-	-	1,247,590,000	1,247,590,000
Total	-	-	2,945,650,000	2,945,650,000
Hypothetical Resources				
Lower Smith	-	-	5,340,000	5,340,000
Anderson	-	-	32,870,000	32,870,000
Dietz	-	-	37,090,000	37,090,000
Upper Canyon	-	-	77,730,000	77,730,000
Lower Canyon	-	-	41,160,000	41,160,000
Cook	-	-	108,910,000	108,910,000
Wall	-	-	113,220,000	113,220,000
Pawnee	-	-	79,080,000	79,080,000
Wildcat-Moyer-Oedekoven	-	-	58,000	58,000
Total	-	-	495,980,000	495,980,000
GRAND TOTAL	-	-	3,441,630,000	3,441,630,000

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