UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

RECLUSE QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-025
1979

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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 ton
acre feet	0.12335	hectare-meters
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)
Btu/lb	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9(F-32)	Celsius

I. Introduction

The report and accompanying maps set forth the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) of coal beds within the Recluse Quadrangle, Campbell County, Wyoming. This CRO and CDP map series includes 44 plates (U.S. Geological Survey Open-File Report 79-025). The project is compiled by IntraSearch Inc., 1600 Ogden Street, Denver, Colorado under KRCRA Northeastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is a part of a program to provide an inventory of federal coal in Known Recoverable Coal Resource Areas (KRCRA) in the western United States.

The Recluse Quadrangle is located in Campbell County in northeastern Wyoming. It encompasses parts of Townships 54 and 55 North, Ranges 73 and 74 West, and covers the area: 44°37'30" to 44°45' north latitude; 105°37'30" to 105°45' west longitude.

U.S. Highway 14-16, connecting Sheridan and Gillette, Wyoming, traverses the southwest quadrant of the Recluse Quadrangle. A light-duty paved road extends south from Recluse, Wyoming, and intersects U.S. Highway 14-16 in the west-central part of the quadrangle. A maintained gravel road parallels Horse Creek eastward from U.S. Highway 14-16 near the south edge of the quadrangle. The nearest railroad is the Burlington Northern trackage between Sheridan and Gillette, approximately 14 miles (23 km) to the southwest.

Horse Creek, a tributary of the Little Powder River, flows northeastward through the southeastern part of the quadrangle, and its valley floor is approximately 4000 feet (1219 m) above sea level. Horse Creek and other minor intermittent streams drain a semi-rugged terrain that attains elevations in excess of 4600 feet (1402 m) above sea level. 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 thirteen to fourteen inches (33 to 36 cm) of annual precipitation that falls in this semi-arid region accrues principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of six inches (15 cm) or less generally characterize winter precipitation. Although temperature ranges 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 approach +5° to +15°F (-15° and -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 focuses upon: 1) the delineation of lignite, subbituminous, bituminous, and anthracite coal at the surface and in the subsurface on federal land; 2) the identification of total tons in place as well as recoverable tons; 3) categorization of these tonnages into measured, indicated, and inferred reserves and resources, and hypothetical resources; and 4) recommendations regarding the potential for surface mining, underground mining, and in-situ gasification of the coal beds. This report evaluates the coal resources of all coal beds in the quadrangle which are five feet (1.5 m) or greater in thickness and occur at depths down to 3000 feet (914 m).

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 7.4 billion tons (6.7 billion metric tons) of total federal coal-in-place in the Recluse Quadrangle.

The suite of maps that accompany this report set forth and portray the coal resource and reserve occurrence in considerable detail. For the most part, this report supplements the cartographically displayed information with minimum 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 that includes the Tongue River, Lebo, and Tullock Members of Paleocene age, are unconformably overlain by approximately 700 feet (213 m) of the Wasatch Formation of Eocene age. These Tertiary formations lie in a structural basin flanked on the east by the Black Hills uplift, on the south by the Hartville and Casper Mountain uplifts, and on the west by the Casper Arch and the Big Horn Mountain uplift. The structural configuration of the Powder River Basin originated in Late Cretaceous time, with episodic uplift thereafter. The Cretaceous Cordillera was the dominant positive land form throughout the Rocky Mountain area at the close of Mesozoic time.

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of major coal resource occurrence in the Powder River Basin. The Lebo Member of the Fort Union Formation is mapped at the surface northeast of Recluse, Wyoming, east of the principal coal outcrops and associated clinkers (McKay, 1974), and presumably projects into the subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City,

Montana) from the overlying Tongue River Member is the color differential between the lighter-colored upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists working with subsurface data, principally geophysical logs, in the basin are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes the Fort Union Formation is not divided into its member subdivisions for this study.

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

The uplift of areas surrounding the Powder River Basin created a structural basin of asymmetric characteristic, with the steep west flank located on the eastern edge of the Big Horn Mountains. The axis of the Powder River Basin is difficult to specifically define, but is

thought to be located in the western part of the basin, and to display a north-south configuration some 15 to 20 miles (24 to 32 km) east of Sheridan, Wyoming. Thus, the sedimentary section described in this report lies on the east flank of the Powder River Basin, with gentle dips of two degrees or less disrupted by surface structure thought to relate to tectonic adjustment and differential compaction.

The surface drainage system existent during Fort Union time in the Wyoming portion of the Powder River Basin displayed a near base level profile with discharge northeastward. During Tongue River time, the flat landmass was near sea level. A tropical to subtropical climate existed, and much of the vast areas where organic debris collected was within a reducing depositional environment.

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

thickness throughout the basin relate to changes in the depositional environment. Drill hole data that indicate either the complete absence or extreme attenuation of a thick coal bed probably relate to location within the ancient stream channel system servicing this low land area in Early Cenozoic time. Where thick coal beds thin rapidly from the depocenter of a favorable depositional environment, it is not unusual to encounter synclinal structure over the maximum coal thickness due to the differential compaction between organic debris in the coal depocenter, and fine-grained clastics in the adjacent areas.

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

Although Wasatch and Fort Union lithologies are too similar to allow differentiation in some areas, most of the thicker coal beds

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

The Recluse Quadrangle is located in an area where surface rocks are classified into the Tongue River Member of the Fort Union Formation and the Wasatch Formation. Although the Tongue River Member is reportedly 1200 to 1300 feet (366 to 396 m) thick (Olive, 1957), only 200 to 300 feet (61 to 91 m) are exposed in this area. Approximately 400 feet (122 m) of lower Wasatch Formation crops out along the western edge of the quadrangle. 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 Smith coal bed was named by Taff (1909). Kent (1976) named the Norfolk coal bed, and Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee and Cache coal beds were named by Warren (1959). Three coal beds beneath the Cache coal bed were

identified but unnamed by Kent (1976). IntraSearch (1978b, 1979, 1978a) informally named these coal beds, from younger to older, the Wildcat, Moyer, and Oedekoven.

The Wasatch Formation contains four coal beds within the Recluse Quadrangle as mapped by Kent (1976); the Ulm 2, Scott, Daly, and Felix coal beds. The uppermost bed, the Ulm 2 of Kent (1976) and lower Ulm of Stone and Lupton (1910) has been correlated recently with the Truman or Truman-Parnell coal bed of the Sheridan coal field (Kent, Haddock, and Bohor, 1977). The Scott coal bed (Olive, 1957) is 40 to 60 feet (12 to 18 m) below the Ulm 2 coal bed, and the Daly coal bed (McLaughlin and Hayes, 1973) is 60 feet (18 m) below the Scott coal bed. The lowest coal bed, the Felix (Stone and Lupton, 1910) lies approximately 100 feet (30 m) beneath the Daly coal bed. Due to the paucity of subsurface data, Wasatch Formation coal beds are not mapped.

Local. The Recluse Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Tongue River Member of the Fort Union Formation is composed of very fine-grained sandstone, siltstone, claystone, shale, carbonaceous shale, and numerous coal beds.

A north-trending fault with 30 to 40 feet (9 to 12 m) of vertical displacement occurs in the northeastern corner of the quadrangle. Another small east-trending fault displaces strata in the center of the quadrangle. Most of the structural maps on the coal bed tops define a northwest trending anticline in the east-central portion of the quadrangle. The

Smith and Anderson coal beds are gently folded to form a north-trending anticline in the center of the quadrangle.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the Geologic Map and Coal Sections of the Recluse Quadrangle (Kent, 1976). In order to facilitate correlation with surrounding quadrangles, under study by IntraSearch, Kent's Norfolk coal bed outcrop is referred to as the Upper Smith coal bed outcrop. In the northwestern part of the quadrangle two drill holes (US-77227 & US-77228) have been completed that post date publication of Kent's map. Downhole data from these drill holes indicates a lowering of Kent's, approximately located Norfolk outcrop (Upper Smith of IntraSearch) to the configuration shown on Plate 1. The Swartz coal bed of Kent is referred to as the Upper Anderson by IntraSearch.

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

All geophysical logs available in the quadrangle are scanned to select those with data applicable to Coal Resource Occurrence mapping.

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

In some parts of the Powder River Basin, additional subsurface control is available from U.S. Geological Survey open-file reports that include geophysical and lithologic logs of shallow holes drilled specifically for coal exploration. A sparse scattering of subsurface data points are shown on unpublished CRO-CTP maps compiled by the U.S. Geological Survey, and where these data are utilized, the rock-coal intervals are shown on the Coal Data Map (Plate 1). Inasmuch as these drillholes have no identifier headings, they are not set forth on the Coal Data Sheets (Plate 3). IntraSearch was unable to obtain geophysical logs of these drill holes to ascertain the accuracy of horizontal location, topographic elevation, and down-hole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, vary depending upon: 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. The thrust of the IntraSearch intent focuses upon the suggestion of a regional nomenclature 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 Recluse Quadrangle is published by the U.S. Geological Survey, compilation date, 1971. Land ownership data is compiled from land plats obtained from the U.S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

Fort Union Formation coal beds that are present in all or part of the Recluse Quadrangle include,in descending stratigraphic order, the Smith, Anderson, Canyon, Cook, Wall-Pawnee, Cache, Wildcat, and Moyer. A complete suite of maps (structure, isopach, mining ratio, overburden/interburden, identified resources and areal distribution of identified resources) is prepared for each of these coal beds.

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

COAL BED NAME		ASH	FIXED CARBON	MOISTURE	VOLATILES	SULPHUR	BTU/LB
Smith (P)		6.440	31.390	35.370	26.800	0.450	7125
Anderson (U)	Hole 7406	6.317	31.113	32.583	29.986	0.327	7498
Canyon (P)		4.290	32.852	35.100	27.758	0.307	7298
Cook (P)		4.620	34.410	33.640	27.330	0.250	7766
Wall (U)	Hole 7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee (U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344
Cache (U)	Hole 741	9.481	30.517	31.420	28.582	0.488	7271

(P) - Proprietary Data
(U) - U.S. Geological Survey & Montana Bureau of Mines and Geology - 1974

The Coal Data Sheets, Plates 3a, b, and c, show the downhole identification data of coal beds within the quadrangle as interpreted from Montana Bureau of Mines & Geology shallow hole data, and geophysical logs from oil and gas test bores and producing sites. Inasmuch as the Canyon coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Canyon and Cook coal beds are the thickest coal beds in the quadrangle. The Anderson coal bed, present throughout the quadrangle, splits into two coal beds in the south-central part. The Wall-Pawnee coal zone consists of the Wall coal bed that overlies the thick Pawnee coal bed which divides into two coal beds in some areas. Throughout much of the Recluse Quadrangle, the Wall and Upper Pawnee coal beds are a single, thick coal bed. The Smith coal zone comprises two or three coal beds and is extensively burned and eroded. The Wildcat and Moyer coal beds are either thin or absent from much of the

quadrangle. Inasmuch as the Oedekoven coal bed is thin and discontinuous, it is not mapped on the quadrangle.

The Smith coal zone is eroded from approximately 40 percent of the quadrangle. This coal zone contains two to three coal beds with a combined thickness of 15 feet (5 m) in the northwest corner and 34 feet (10 m) in the west-central part of the quadrangle (Plate 4). The Smith coal beds thin from west to northeast. The Upper Smith coal bed thickness varies from 6 to 23 feet (1.8 to 7 m) while the Lower Smith coal bed varies from 0 to 13 feet (0 to 4 m) thick. The Smith coal zone interburden is 2 feet (0.7 m) thick in the north-central part of the quadrangle, 11 feet (3 m) thick in the west-central area, and 93 feet (28 m) thick in the northwest corner of the quadrangle (Plate 6). A structural low is present in the northeast corner of the quadrangle, and a structural high extends southwest from the east-central part of the area.

The Anderson coal bed is eroded along Horse Creek in the southeast corner of the Recluse Quadrangle. It occurs 100 to 200 feet (30 to 61 m) below the Lower Smith coal bed, and varies in thickness from 5 feet (1.5 m) on the western edge to 44 feet (13 m) in the northeast corner of the quadrangle. (Plate 9). The Anderson coal bed divides into two coal beds from the center to the southern edge of the quadrangle. The interval between the Upper Anderson and Lower Anderson coal beds attains a maximum of 147 feet (45 m) in the south-central area (Plate 11). The Upper Anderson coal bed varies from 0 to 19 feet (0 to 6 m) thick, while

the Lower Anderson is 4 to 20 feet (1.2 to 6 m) in thickness. A closed structural low occurs in the center of the quadrangle, and another synclinal feature is present in the southwest corner. A structural high extends south from the south-central part of the quadrangle.

The Canyon coal bed is present throughout the quadrangle and occurs approximately 40 to 322 feet (12 to 98 m) beneath the Anderson coal bed. The coal bed is 10 feet (3 m) thick in the southwest corner and reaches a maximum thickness of 41 feet (13 m) in the northeast corner (Plate 14). Three closed structural lows occur in the western half of the quadrangle. Two closed structural highs are mapped, one in the west-central part and the other in the north-central portion of the quadrangle.

An interval that varies from 7 to 185 feet (2.1 to 56 m) separates the Canyon coal bed and underlying Cook coal bed. The Cook coal bed develops a maximum thickness of 40 feet (12 m) in the southwest quadrant of the quadrangle and thins to 10 feet (3 m) along the eastern edge (Plate 19). An east-west-trending area of maximum coal thickness occurs about 3 miles (4.8 km) north of the southern edge of the map, and thins to the north and south. A closed structural low is present in the northeast corner of the quadrangle in Section 20, T. 55 N., R. 73 W. A structural high occurs in the east-central part of the area.

The Wall-Paunee coal zone is 102 to 302 feet (31 to 92 m) below the Cook coal bed and varies in thickness from 29 feet (9 m) in the southeast corner to 65 feet (20 m) in the southwest corner of the quadrangle.

The Wall coal bed, combined with the Upper Pawnee coal bed in the southwest quadrant, is separated from the Upper Pawnee coal bed by 110 feet (34 m) of interburden in the north-central sector. Although the Wall coal bed attains a maximum thickness of 24 feet (7 m), it pinches out in the southeast corner of the quadrangle. The Isopach and Mining Ratio Map of the Wall-Pawnee Coal Zone, Plate 24, sets forth the combined thicknesses of the Wall, Upper Pawnee and Lower Pawnee coal beds. Interburden contours on the Isopach Map of Overburden/Interburden of the Wall-Pawnee Coal Zone, Plate 26, indicate the total thickness of sedimentary rocks between the Wall and Upper Pawnee and the Upper and Lower Pawnee coal beds. The Upper Pawnee coal bed varies from 7 to 36 feet (2.1 to 11 m) in thickness. The Lower Pawnee coal bed is separated from the Upper Pawnee coal bed by 0 to 133 feet (0 to 41 m) of clastic sediments and varies in thickness from 6 to 16 feet (1.8 to 5 m). The Wall-Pawnee coal zone is buried more than 500 feet (152 m) throughout most of the Recluse Quadrangle, and the total non-coal in the coal zone varies from 8 feet (2.4 m) in the east-central part to 217 feet (66 m) in the southeast (Plate 26). A structural low extends from the western edge of the quadrangle to the northeastern part of the area. Where the Wall coal bed pinches out in the southeastern corner of the quadrangle, the structural contours on top of the Pawnee coal bed are approximately 200 feet (61 m) lower than the contours on the Wall coal bed.

The Cache coal bed, absent from small areas (less than ten percent of the quadrangle) in the northwest and southeast quadrants, attains a maximum thickness of 15 feet (4.5 m) in the north-central part of the quadrangle (Plate 29). The Cache coal bed is separated from the overlying Lower Pawnee coal bed by 34 to 138 feet (10 to 42 m) of interburden. A closed structural high is present in the northwest corner of the quadrangle, and another anticlinal feature extends west from the east-central part of the area. A closed synclinal low occurs in the northeast corner of the quadrangle.

The Wildcat coal bed is 106 to 188 feet (32 to 57 m) below the Cache coal bed, and varies from 0 to 10 feet (0 to 3 m) thick (Plate 34). The non-coal area involves approximately 30 percent of the quadrangle and covers most of the west side and the northeast corner of the area. Small lenses of the Wildcat coal bed thicker than 5 feet (1.5 m) are located along the north, east, and south boundaries of the Recluse Quadrangle. A single drill hole in the east-central area indicates 10 feet (3 m) of thickness for the Wildcat coal bed. Two anticlinal features extend west from the northeast and east-central portions of the quadrangle.

The Moyer coal bed, 110 to 187 feet (34 to 57 m) beneath the Wildcat coal bed, is absent in the northern and northwestern parts of the Recluse Quadrangle. A maximum thickness of 9 feet (2.7 m) is attained in the southeast. A synclinal feature extends northeast from the southwest corner of the quadrangle, and the degree of southwesterly dip increases in the northeastern area adjacent to a minor anticlinal feature.

V. Geological and Engineering Mapping Parameters

Subsurface mapping is based on geologic data within and adjacent to the Recluse 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 measured sections where there is sparse subsurface control. Where isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion, hence not reflective of total coal thickness. Structure contour maps are constructed on the tops of the main coal beds. Where subsurface data is scarce, supplemental structural control points are selected from the topographic map along coal outcrops.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a 95% recovery factor. Contours on these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed using coal structure, coal isopach, and topographic control. On the Areal Distribution of Identified Resources Map (ADIR), coal bed reserves are not calculated where the coal is less than 5 feet (1.5 m) thick, where the coal occurs at a depth greater than 500 feet (152 m), and where non-federal coal exists.

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. Acres are multiplied by the average coal bed thickness and 1750 (the number of tons of lignite A per acre-foot; 12,874 metric tons per hectare-meter) to determine total tons in place. Recoverable tonnage is calculated at 95% of the total tons in place. North of the Recluse Quadrangle, in the Montana portion of the Powder River Basin, a recovery factor of 85 percent is utilized because of the general northward thinning of economic coal beds. Where tonnages are computed for the CRO-CDP map series, resources and reserves are expressed in millions of tons. Frequently the planimetering of coal resources on a sectionized basis involves complexly curvilinear lines (coal bed outcrop and 500-foot stripping limit designations) in relationship with linear section boundaries and circular resource category boundaries. Where these relationships occur, generalizations of complex curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated two to three percent plus or minus accuracy.

VI. Coal Development Potential

Strippable Coal Development Potential. Areas where coal beds are 5 feet (1.5 m) or more in thickness and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and are assigned a high, moderate, or low development potential

based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios is as follows:

$$MR = \frac{t_o\ (0.922)}{t_c\ (rf)}$$

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

A surface mining potential map was prepared utilizing the following mining criteria:

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 surface mining potential is high for most of the Recluse Quadrangle as a result of the thick Smith, Anderson, and Canyon coal beds occurring near the surface (Plate 44). Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Recluse Quadrangle is considered low. 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 a total coal section less than 100 feet (30 m) thick, or coal beds that lie 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 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 on the Recluse Quadrangle is low, hence no CDP map is generated for this map series. The resource tonnage for in-situ gasification with low development potential totals approximately 4.1 billion tons (3.7 billion metric tons) (Table 3). None of the coal beds in the Recluse Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Recluse 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
Smith	554,920,000	69,160,000	9,320,000	633,400,000
Anderson	761,780,000	154,710,000	159,380,000	1,075,870,000
Canyon	229,420,000	326,990,000	351,170,000	907,580,000
Cook	6,290,000	139,030,000	274,120,000	420,240,000
Wall-Pawnee	-	12,330,000	20,470,000	32,800,000
TOTAL	1,522,410,000	703,020,000	814,460,000	3,069,890,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-	-	1,590,000	1,590,000
Anderson	-	-	30,300,000	30,300,000
Canyon	-	-	300,500,000	300,500,000
Cook	-	-	866,420,000	866,420,000
Wall-Pawnee	-	-	2,392,550,000	2,392,550,000
Cache	-	-	305,360,000	305,360,000
Wildcat	-	-	73,850,000	73,850,000
Moyer	-	-	141,750,000	141,750,000
TOTAL	-	-	4,112,320,000	4,112,320,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-	-	1,590,000	1,590,000
Anderson	-	-	30,300,000	30,300,000
Canyon	-	-	300,500,000	300,500,000
Cook	-	-	866,420,000	866,420,000
Wall-Pawnee	-	-	2,392,550,000	2,392,550,000
Cache	-	-	305,360,000	305,360,000
Wildcat	-	-	73,850,000	73,850,000
Moyer	-	-	141,750,000	141,750,000
TOTAL	-	-	4,112,320,000	4,112,320,000

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