UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

NEGRO BUTTE QUADRANGLE,

JOHNSON AND CAMPBELL COUNTIES, WYOMING

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/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 Negro Butte Quadrangle, Johnson and Campbell Counties, Wyoming. This CRO and CDP map series includes 40 plates (U. S. Geological Survey Open File Report 79-177). 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 Negro Butte Quadrangle is located in Johnson and Campbell Counties, in northeastern Wyoming. It encompasses all or parts of Townships 47 and 48 North, Ranges 76 and 77 West, and covers the area: 44°00' to 44°07'30" north latitude; 106°00' to 106°07'30" west longitude.

Main access to the Negro Butte Quadrangle is provided by a maintained gravel road which extends northwest to southeast across the eastern half of the study area. Minor roads and trails that branch from this maintained road provide additional access to the more remote areas. Interstate Highway 90 extends east to west approximately 19 miles (31 km) to the north of the quadrangle. The closest railroad is the Burlington Northern trackage approximately 20 miles (32 km) to the northeast near Echeta, Wyoming.

Primary drainage is provided by Beaver Creek and Pumpkin Creek which extend across the northern half and southwest quarter of the quadrangle, respectively. These two intermittent creeks flow westward into the Powder River, and with Culp Draw, located in the west-central portion of the quadrangle, provide the significant drainage in the study area. Minor streams supplement the drainage throughout the quadrangle. Elevations attain heights of 4,760 feet (1,451 m) above sea level in the southeast quarter of the quadrangle, approximately 600 to 700 feet (183 to 213 m) above the valley floors to the west.

The 13 of 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 Johnson and Campbell County Courthouses in Buffalo and Gillette, Wyoming, respectively. Details of mineral ownership on federal lands are available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. Federal coal ownership is shown on plate 2 of the Coal Resource Occurrence maps. The nonfederal coal ownership comprises both fee and state coal resources.

The Coal Resource Occurrence and Coal Development Potential program pertains to unleased federal coal and focuses upon 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 identified reserves and resources, and hypothetical resources. Finally, recommendations are made regarding the potential for surface mining, underground mining, and in-situ gasification of the coal beds. This report evaluates the coal resources of all unleased federal coal beds in the quadrangle which are 5 feet (1.5 m) or greater in thickness and occur at depths 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 12.5 billion tons (11.3 billion metric tons) of total, unleased federal coal-in-place in the Negro Butte Quadrangle.

The suite of maps that accompanies this report sets forth and portrays the coal resources 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 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 descend disconformably in the stratigraphic column to the top of the Wyodak-Anderson coal bed (Roland coal bed of Taff, 1909) along the eastern boundary of the coal measures. No attempt 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 Negro Butte Quadrangle is located in an area where surface rocks are classified within the Wasatch 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 600 to 700 feet (183 to 213 m) of Wasatch 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 Felix coal bed was named by Stone and Lupton (1910), and the Smith coal bed was named by Taff (1909). Baker (1929) assigned the name to the Wall coal bed, and the Pawnee coal bed was named by Warren (1959). IntraSearch informally named the Wildcat, Moyer, and Oedekoven coal beds (1978b, 1979, and 1978a).

IntraSearch's correlaton of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson and Canyon coal beds or all, or part, of the Cook and Wall coal beds to the north and west of Gillette, Wyoming. The Wyodak coal zone of the Negro Butte Quadrangle is equivalent to the Anderson-Canyon-Cook coal zone in Bogie Draw Quadrangle to the east. The Wall coal bed in Negro Butte Quadrangle is equivalent to the Lower Wall coal bed to the east in Bogie Draw Quadrangle, and to the north in Laskie Draw Quadrangle. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine.

Local. The Negro Butte Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle and is 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.

III. Data Sources

No significant coal outcrops or associated clinker in the Negro Butte Quadrangle are mapped in any publications known to IntraSearch at the time of this report. It is presumed and highly possible that no significant coal outcrops exist at the surface in the Negro Butte Quadrangle.

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 allows continued improvement in the understanding of coal bed occurrences in the eastern Powder River Basin.

The topographic map of the Negro Butte Quadrangle is published by the U. S. Geological Survey, compilation date 1972. Land network and mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Wasatch and Fort Union Formation coal beds that are present in all or part of the Negro Butte Quadrangle include, in descending stratigraphic order: the Upper Felix, Lower Felix, Upper Smith, Lower Smith, Wyodak, Wall, Local, Pawnee, Wildcat, Moyer and Oedekoven coal beds. The Wyodak coal beds, and the Wildcat-Moyer coal beds are mapped as coal zones. 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. The only mining ratios that are mapped are presented on the isopach map of the Upper Felix coal bed.

No physical or chemical analyses are known to have been published regarding the coal beds in the Negro Butte Quadrangle. For Campbell County and eastern Johnson 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							
		ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB	MOIST, M-M-F BTU/LB	COAL RANK
Felix	(**) Lab.No. 6432	5.6	35.7	25.8	32.9	0.39	8465	9010	Subbtm. C
Smith	(**) Lab.No. 6460	4.7	34.0	28.8	32.5	0.46	7862	8280	Lignite A
Upper Wyodak	(U) Hole 7310	5.9	33.9	29.1	31.2	0.44	8172	8722	Subbtm. C
Middle-Lower Wyodak	(U) Hole 7334	5.1	34.9	29.4	30.5	0.29	8329	8814	Subbtm. C
Pawnee	(U) Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A
"Wildcat"	(1) Lab.No. 11447	4.3	29.4	27.8	29.4	0.27	8410	8818	Subbtm. C

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

** Stone and Lupton (1910).

(1) Winchester (1912).

(U) U. S. Geological Survey and Montana Bureau of Mines and Geology (1974 & 1976).

The proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadrangle. For the simplification of tonnage computations, all coal beds in the Negro Butte Quadrangle are tentatively classified as subbituminous C rank.

The Coal Data Sheets, plates 3a and b, show the down-hole identification of coal beds within the quadrangle as interpreted from 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 Wyodak coal zone underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Wyodak coal zone shows the thickest coal bed occurrence throughout the study area. The Pawnee, Wildcat and Oedekoven coal beds show a moderate thickness throughout the study area. The remaining coal beds are relatively thin throughout the Negro Butte Quadrangle.

The Upper Felix coal bed thickness varies from 0 to 7 feet (0 to 2.1 m) with maximum thicknesses occurring in the southeast and west-central parts of the quadrangle. The Upper Felix coal bed thins to the north and east and is absent from approximately 30 percent of the quadrangle in these areas. Structure contours drawn on top of the Upper Felix coal bed indicate a broad, westward-plunging anticline extending across the southwest part of the study area. The coal bed in the remaining area dips gently westward. The Upper Felix coal bed occurs approximately 50 to 550 feet (15 to 168 m) beneath the earth's surface.

The Upper Smith coal bed lies approximately 400 to 500 feet (122 to 152 m) below the overlying Upper Felix coal bed and occurs throughout the quadrangle. The coal bed thickness ranges from 6 to 16 feet (1.8 to 5 m) with the maximum thickness occurring in the extreme northeast

corner of the study area. The coal bed thins to the southwest, averaging approximately 8 feet (2.4 m) throughout most of the southern half of the quadrangle. A broad, northwestward-plunging anticline extends from the southeast corner of the quadrangle into the western half. A less prominent, westward-plunging anticline is present in the northeast quarter of the study area. The Upper Smith coal bed occurs between 525 and 1,025 feet (160 and 312 m) beneath the surface throughout the quadrangle.

The Lower Smith coal bed occurs approximately 150 to 200 feet (46 to 61 m) below the overlying Upper Smith coal bed. The coal bed thickness ranges from 0 to 20 feet (0 to 6 m) with maximum thickness occurring along the northern boundary of the study area. The Lower Smith coal bed is absent from approximately 95 percent of the quadrangle. The Lower Smith coal bed is not present in any drill-hole data within the Negro Butte Quadrangle. The nearest drill-hole data indicating the presence of the Lower Smith coal bed is in Section 20, Township 48 North, Range 76 West, immediately north of the study area in the Laskie Draw Quadrangle. Where it is present, the Lower Smith coal bed lies between 800 to 1,200 feet (244 to 366 m) beneath the surface.

The Wyodak coal zone occurs approximately 250 to 550 feet (76 to 168 m) beneath the Upper Smith coal bed. The coal zone thickness varies from 97 to 173 feet (30 to 53 m). Maximum thickness occurs in the north-central part of the quadrangle, thinning to approximately 100 feet (30 m) in the east-central and south-central parts of the quadrangle. The Wyodak coal zone is a single, massive coal bed throughout

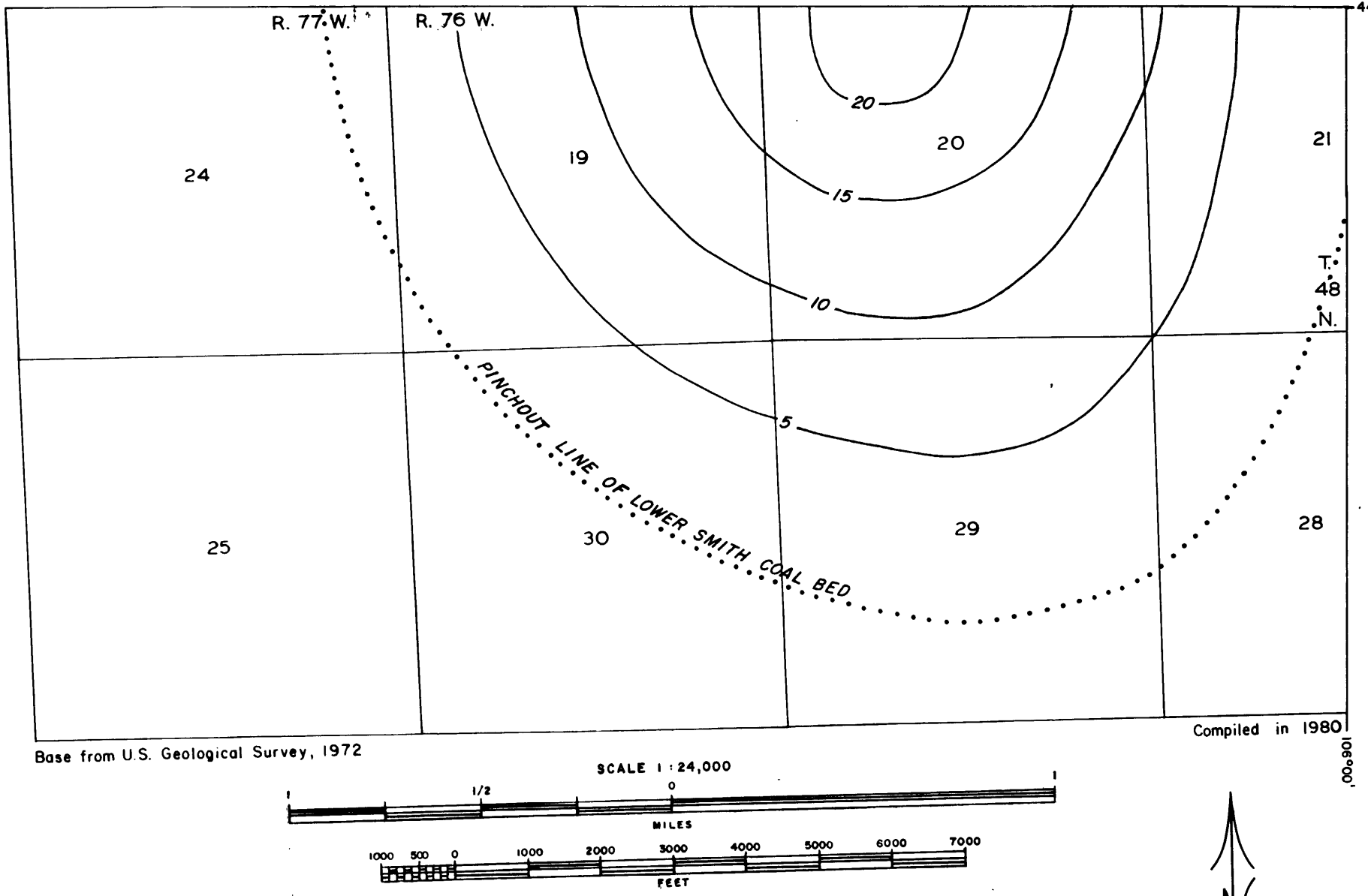
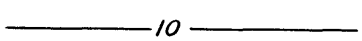


FIGURE 1
ISOPACH AND MINING RATIO MAP
OF LOWER SMITH COAL BED IN
NEGRO BUTTE QUADRANGLE,
JOHNSON AND CAMPBELL COUNTIES, WYOMING
(See following page for explanation)

EXPLANATION FOR FIGURE 1



ISOPACHS OF COAL BED-Showing thickness in feet, isopach interval 5 feet.

To convert feet to meters, multiply feet by 0.3048.

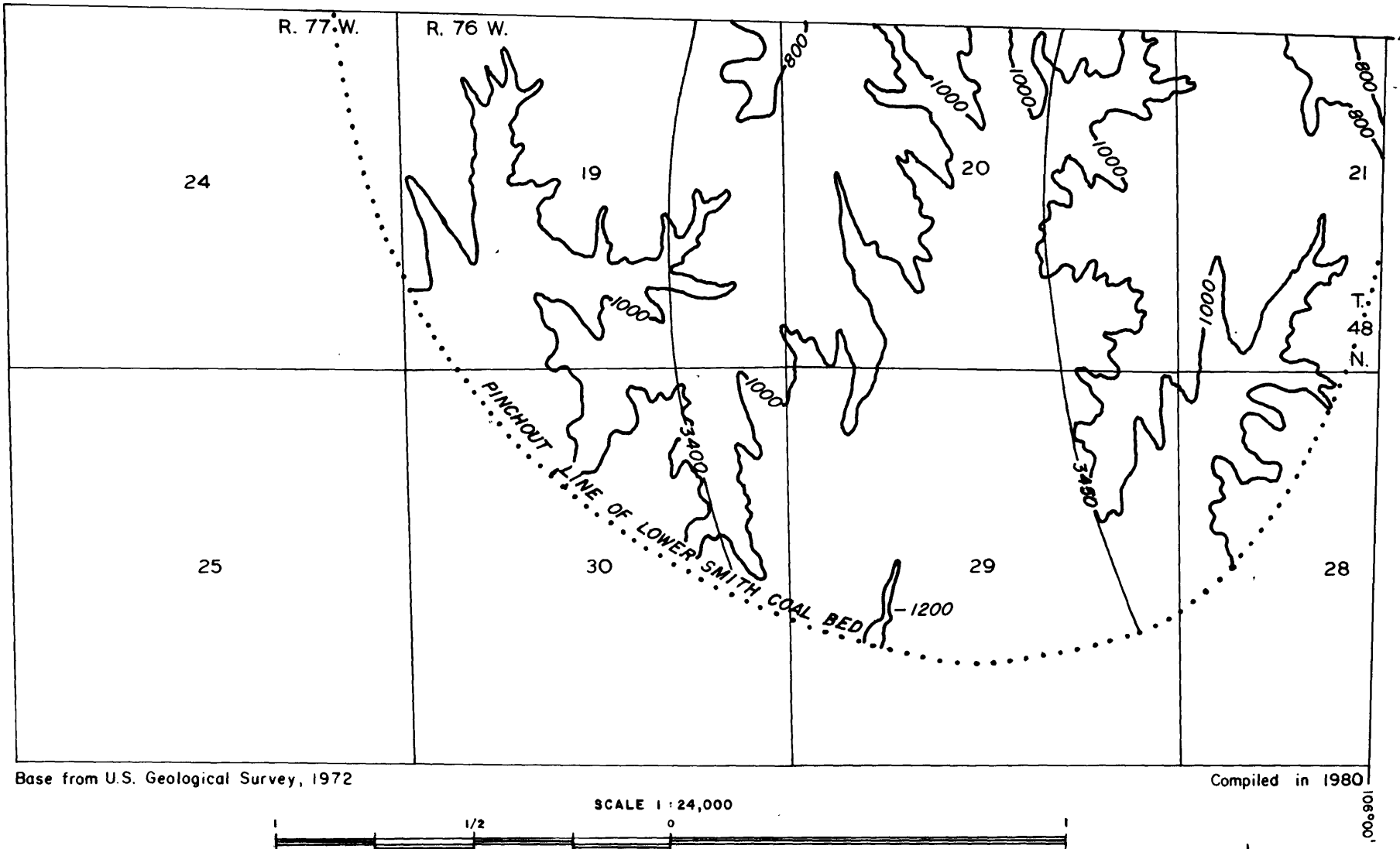
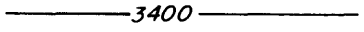
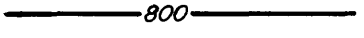


FIGURE 2
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF LOWER SMITH COAL BED IN
NEGRO BUTTE QUADRANGLE,
JOHNSON AND CAMPBELL COUNTIES, WYOMING
(See following page for explantion)

EXPLANATION FOR FIGURE 2



STRUCTURE CONTOURS-Drawn on top of coal bed. Contour interval 50 feet. Datum is mean sea level.



OVERBURDEN ISOPACH-Showing thickness of overburden, in feet, from the surface to the top of the coal bed. Isopach interval 200 feet.

To convert feet to meters, multiply feet by 0.3048.

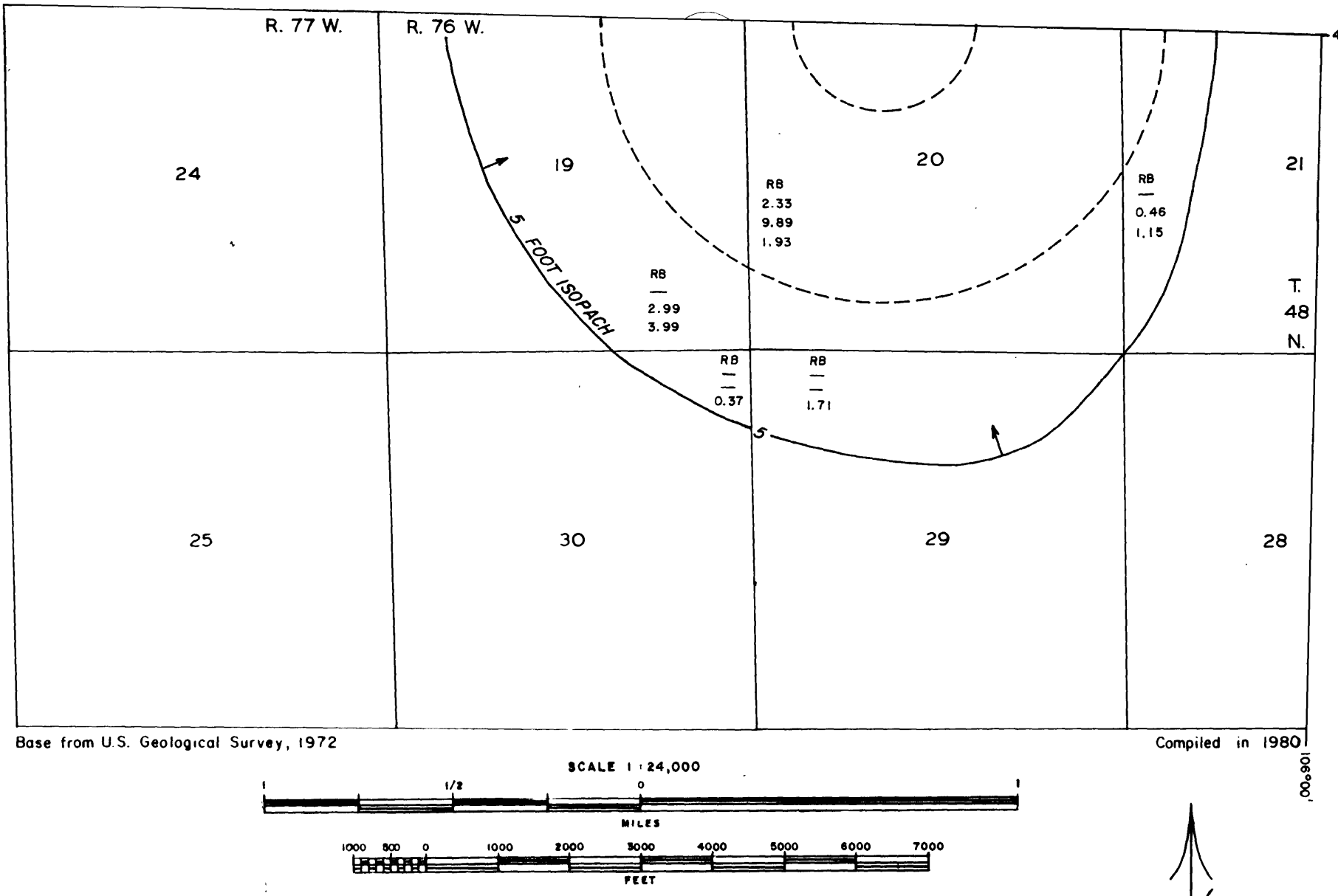
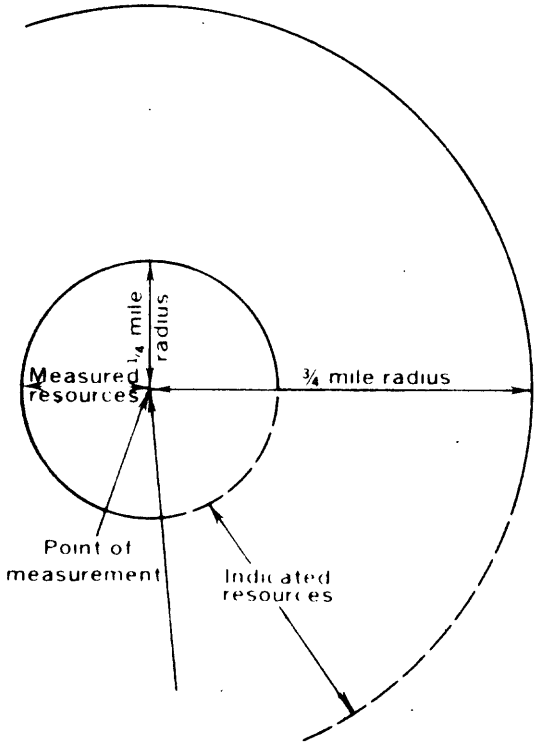


FIGURE 3
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF LOWER SMITH COAL BED IN
NEGRO BUTTE QUADRANGLE,
JOHNSON AND CAMPBELL COUNTIES, WYOMING
(See following page for explanation)

EXPLANATION FOR FIGURE 3

RB
— (Measured)
2.99 (Indicated
3.99 (Inferred)

IDENTIFIED RESOURCES OF COAL BED-In millions of short tons. Dash indicates no resources in that category. (RB) indicates Reserve Base.



BOUNDARY LINES-Enclosing areas of measured, indicated and inferred coal resources of the coal bed. Dashed where projected from adjacent quadrangles.

To convert miles to kilometers, multiply miles by 1.609.

To convert short tons to metric tons, multiply short tons by 0.9072.

the eastern two-thirds of the study area. In the western third of the quadrangle, the Wyodak coal zone gradually separates into three coal beds. The clastic interval between these coal beds ranges from 0 to 349 feet (0 to 106 m) with the maximum non-coal interburden in the southwest quarter of the study area. Structure contours drawn on top of the Wyodak coal zone depict a broad, northwest-plunging anticline in the southwest quarter of the quadrangle. A broad, northwest-to-southwest-trending syncline extends across the central part of the study area. The Wyodak coal zone lies between 850 and 1,550 feet (259 and 472 m) in depth beneath the surface of the entire quadrangle.

The Wall coal bed lies approximately 125 to 325 feet (38 to 99 m) below the overlying Wyodak coal zone. The Wall coal bed in this quadrangle is thin, 4 feet (1.2 m) or less, where it is identified in the subsurface on four geophysical logs. However, it correlates with Lower Wall coal bed in quadrangles to the east, northeast, and north that are more than 25 feet (8 m) thick. These control points in adjacent quadrangles influence the Wall coal bed isopach mapping on Negro Butte Quadrangle. The coal bed thickness varies from 0 to 25 feet (0 to 8 m) with maximum thickness occurring in the northeast quarter of the quadrangle. The Wall coal bed thins to the west and south from the northeast corner, and is absent from approximately 55 percent of the study area. Structure contours drawn on top of the Wall coal bed suggest the presence of a north-plunging syncline in the eastern half of the quadrangle. The Wall coal bed occurs between 1,240 and 1,900 feet (378 to 579 m) in depth beneath the surface of the quadrangle.

The Pawnee coal bed occurs approximately 350 to 475 feet (107 to 145 m) below the overlying Wall coal bed, and approximately 425 to 700 feet (130 to 213 m) beneath the Wyodak coal zone in areas where the Wall coal bed is absent. The coal bed thickness varies from 15 to 25 feet (5 to 8 m) with the maximum thickness occurring in the northwest quarter of the quadrangle. The coal bed thickness averages approximately 22 feet (7 m) throughout the majority of the study area. The most significant structural feature on this coal bed is a northwestward-plunging anticline located in the southeastern portion of the quadrangle. A shallow, broad syncline separates this anticline from a less prominent anticline present in the northeast quarter of the study area. The Pawnee coal bed occurs between 1,700 and 2,240 feet (518 and 683 m) in depth beneath the surface of the entire quadrangle.

The Wildcat-Moyer coal zone lies below the Pawnee coal bed approximately 200 to 275 feet (61 to 84 m). The coal zone consists of a single, uniform Wildcat coal bed overlying two to three thin, sporadic Moyer coal beds. The clastic interval separating the various coal beds composing the coal zone varies from 55 to 115 feet (17 to 35 m). Maximum coal zone thickness occurs along the eastern boundary of the study area. The westward thinning of the total coal zone is attributed to the absence of the Moyer coal beds along the western boundary in addition to the westward thinning of the overlying Wildcat coal bed. Structure contours drawn on top of the Wildcat coal bed indicate a northwest-to-westward-plunging anticline extending across the southern half of the quadrangle. A shallow, broad syncline separates this anticline from another less prominent anticline located in the northeast quarter of the study area. The Wildcat-Moyer coal zone occurs between 1,900 and 2,525 feet (579 and 770 m) beneath the surface thoughout the quadrangle.

The Oedekoven coal bed lies approximately 45 to 80 feet (14 to 24 m) below the overlying Moyer coal bed and 120 to 200 feet (37 to 61 m) below the Wildcat coal bed in areas where the Moyer coal beds are absent. The Oedekoven coal bed thickness varies from 11 to 20 feet (3 to 6 m). Maximum thickness occurs primarily across the southern half of the quadrangle. The coal bed thins slightly to the west and north. A small clastic interval ranging from 0 to 25 feet (0 to 8 m) locally separates the Oedekoven coal bed. The most significant structural feature is a westward-plunging anticline which extends across the southern half of the quadrangle. A minor anticline is present in the northeast quarter of the study area. The Oedekoven coal bed lies between 2,100 and 2,650 feet (640 to 808 m) beneath the surface throughout the quadrangle.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed 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 Negro Butte Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Structure contour maps are constructed on the tops of the main coal beds.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden above a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a 95 percent recovery factor. Contours of these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed 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) are 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 39) 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 low for approximately 25 percent of the quadrangle. This low development potential area occurs

in the southeast quarter and west-central part of the quadrangle, and results from high overburden to recoverable coal tonnage ratios for the Upper Felix coal bed. The remaining coal beds occur greater than 500 feet (152 m) beneath the surface or are less than 5 feet (1.5 m) thick. The remaining area is either classified as no potential for surface mining development, or is 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 Negro Butte Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves are not calculated for coal beds that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal resources in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification 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 (plate 40) on the Negro Butte Quadrangle is high for approximately 62 percent of the study area. This high potential area covers most of the northern two-thirds of the quadrangle, and is attributed to the massive thickness of the Wyodak coal zone. A moderate potential area occurs primarily along the southern boundary of the study area, and covers approximately 30 percent of the quadrangle. Thinning of the Wyodak coal zone causes the moderate potential rating in these areas. A low potential rating covers 2 percent of the quadrangle in the northeast quarter. The area of low potential occurs where the thick Wyodak coal zone is less than 1,000 feet (305 m) in depth. The remaining 6 percent of the quadrangle is classified as non-federal coal land.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Negro Butte Quadrangle, Johnson and Campbell Counties, 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				
Upper Felix	-	-	61,070,000	61,070,000
Total	-	-	61,070,000	61,070,000
Hypothetical Resources				
Upper Felix	-	-	11,240,000	11,240,000
Total	-	-	11,240,000	11,240,000
GRAND TOTAL	-	-	72,310,000	72,310,000

Table 2.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Negro Butte Quadrangle, Johnson and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base				
Upper Felix	-	-	130,000	130,000
Upper Smith	-	-	545,990,000	545,990,000
Lower Smith	-	-	24,820,000	24,820,000
Wyodak	-	-	8,392,100,000	8,392,100,000
Wall	-	-	165,250,000	165,250,000
Pawnee	-	-	1,165,240,000	1,165,240,000
Wildcat-Moyer	-	-	1,184,580,000	1,184,580,000
Oedekoven	-	-	960,390,000	960,390,000
Total	-	-	12,438,500,000	12,438,500,000
Hypothetical Resources				
Smith	-	-	1,740,000	1,740,000
Wyodak	-	-	28,130,000	28,130,000
Total	-	-	29,870,000	29,870,000
GRAND TOTAL	-	-	12,468,370,000	12,468,370,000

Table 3.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Land in the Negro Butte Quadrangle, Johnson and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base	7,692,360,000	3,898,990,000	847,150,000	12,438,500,000
Hypothetical Resources	-	-	29,870,000	29,870,000
TOTAL	7,692,360,000	3,898,990,000	877,020,000	12,468,370,000

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