UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

LITTLE THUNDER RESERVOIR QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-075

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

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CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters per metric tons
acre feet	0.12335	hectare-meters
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)
Btu/lb	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9 (F-32)	Celsius

I. Introduction

This report and accompanying maps set forth the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) of coal beds within the Little Thunder Reservoir Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-075) includes 29 plates. 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 unleased federal coal in Known Recoverable Coal Areas (KRCRAs) in the western United States.

The Little Thunder Reservoir Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 42, 43 and 44 North, Ranges 71 and 72 West, and covers the area: 43° 37' 30" to 43° 45' north latitude; 105° 22' 30" to 105° 30' west longitude.

Wyoming State Highway 59 angles north-south through the western part of the Little Thunder Reservoir Quadrangle. Reno County Road extends eastward from Highway 59 in the southern portion of the study area. Numerous gravel roads that branch from these roads provide additional access throughout the quadrangle. The closest railroad is the Burlington Northern trackage, located 1 to 2 miles (1.6 to 3.2 km) east of the study area near the Black Thunder and Jacob's Ranch coal mines. This railroad extends northward to Gillette, and is under contruction southward to Douglas, Wyoming.

Little Thunder Creek flows southeastward through the northern portion of the quadrangle, and eventually drains into the Cheyenne River. Cripple Creek and Porcupine Creek provide the major drainage for the southern half of the study area. Minimum elevations of 4750 feet (1448 m) above sea level occur in the valley floor of Little Thunder Creek on the eastern quadrangle boundary. A maximum elevation of 5160 feet (1573 m) above sea level is located in the northwestern portion of the Little Thunder Reservoir Quadrangle. 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 temperatures ranging from less than -25°F (-32°C) to more than 100°F (38°C) have been recorded near Gillette, Wyoming, average wintertime minimums and summertime maximums 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. State and federal lands are 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 belongs to both fee and state owners.

The Coal Resource Occurrence and Coal Development Potential program is restricted to unleased federal coal and focuses upon: 1) the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface and in the subsurface on federal land; 2) subdivision of deposits into measured, indicated, and inferred reserve resource categories, and hypothetical resources; 3) the measurement of coal resources in place as well as recoverable reserves; and 4) the determination of the potential for surface or underground mining, and in-situ gasification of the coal beds. This report contains an evaluation of the coal resources of all unleased federal coal beds in the quadrangle, which are 5 feet (1.5 m) or greater in thickness and occur at depths down to 3000 feet (914 m). No resources or reserves are computed for leased federal coal, state coal, fee coal, or lands encompassed by coal prospecting permits and preference right lease applications.

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 6.9 billion tons (6.3 billion metric tons) of unleased federal coal resources in the Little Thunder Reservoir Quadrangle.

The suite of maps that accompany this report portray the coal resource and reserve occurrence in detail. For the most part, this report supplements the cartographic information, with minimum duplication of the 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 Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo Shale Member of the Fort Union Formation consists of light-to dark-gray very fine-grained to conglomeratic sandstone with interbedded siltstone, claystone, carbonaceous shale and thin coal beds. Thin bedded calcareous ironstone concretions interbedded with massive white sandstone and slightly bentonitic shale occur throughout the unit.

The Lebo Member 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 members 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 northeastward discharging drainage system, 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 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.

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 trememdous volumes of organic debris. These conditions in concert with a favorable ground water table, non-oxidizing clear water, and a climate amenable to the luxuriant growth of vegetation produce a stabilized swamp critical to the deposition of coal beds.

Deposition of the unusually thick coal beds of the Powder River Basin may be partially attributable to short-distance water transportation of organic detritus into areas of crustal subsidence. Variations in coal bed thickness throughout the basin relate to changes in the depositional environment. Drill hole data that indicate either the complete absence or extreme attenuation of a thick coal bed probably relate to location of the drill holes within the ancient stream channel system draining this 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 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, and 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 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, brown-to-black carbonaceous shales, and coal beds. These sediments are noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Little Thunder Reservoir Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation. Although the Wasatch Formation is reportedly 700 to 800 feet (213 to 244 m) thick (Olive, 1957), only 400 feet (122 m) are exposed in this area. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the Sheridan coal field (Baker, 1929) and Gillette coal field (Dobbin and Barnett, 1927), Wyoming, and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. The Felix coal bed was named by Stone and Lupton (1910), and the Smith coal bed was named by Taff (1909). Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds, and the Cook coal bed was named by Bass (1932), and the Pawnee coal bed was named by Warren (1959).

IntraSearch's correlation of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson, Canyon and all or part of the Cook coal beds to the north and west of Gillette, Wyoming. Correlation of this suite of coal beds with the Wyodak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper ten to twenty-five percent of the thick Wyodak coal bed, and the Cook and Wall or Upper Wall coal beds are equivalent to the major part of the Wyodak coal bed. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine. The Wildcat, Moyer, and Oedekoven coal beds were informally named by IntraSearch (1978b, 1979, and 1978a).

Local. The Little Thunder Reservoir Quadrangle is located on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle, and is comprised of friable, coarse-grained to gritty, arkosic sandstones, fine- to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from Martin (1977a). In this report, the Felix $_1$ and Felix $_2$ coal beds of Martin (1977a) are considered to be equivalent to the Upper Felix and Lower Felix coal beds of IntraSearch, respectively. The Felix $_1$ and Felix $_2$ coal bed outcrops of Martin (1977a) have been slightly adjusted by IntraSearch to conform with the topographic relief in the area. Because of regional correlations by IntraSearch, Martin's Upper C and Lower C coal beds are considered equivalent to the Smith and Upper Wyodak coal beds, respectively, of IntraSearch. The Local and Manning coal beds of Martin (1977a) correlate with the Wildcat and Moyer coal beds, respectively, of 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-CDP 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 drill holes have no identifier headings, they are not set forth on the Coal Data Sheet (Plate 3). The geophysical logs of these drill holes were not available to IntraSearch to ascertain the accuracy of horizontal location, topographic elevation, and downhole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, vary depending on: the density and quality of lithologic and geophysical logs; the detail, thoroughness, and accuracy of published and unpublished surface geological maps, and interpretative proficiency. There is no intent on the part of IntraSearch to refute nomenclature established in the literature or used locally by workers in the area. IntraSearch's nomenclature focuses upon the suggestion of regional coal bed names applicable throughout the eastern Powder River Basin. It is expected and entirely reasonable that some differences of opinion regarding correlations, as suggested by IntraSearch, exist. Additional drilling for coal, oil, gas, water, and uranium, coupled with expanded mapping of coal bed outcrops and associated clinkers will broaden the data base for coal bed correlations and allow continued improvement in the understanding of coal bed occurrences in the eastern Powder River Basin.

The topographic map of the Little Thunder Reservoir 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

Wasatch and Fort Union formation coal beds that are present in all or part of the Little Thunder Reservoir Quadrangle include, in descending stratigraphic order, the Felix, Upper-Lower Felix, Smith, Upper Wyodak, Middle Wyodak, Lower Wyodak, Pawnee, Wildcat, Moyer, and Oedekoven coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden, identified resources, and areal distribution of identified resources) is prepared for the Upper-Lower Felix, Smith, and Upper Wyodak coal beds, and the Middle-Lower Wyodak coal zone, and the Wildcat-Moyer-Oedekoven coal zone. The Pawnee coal bed is not mapped due to insufficient thickness and lack of areal extent.

No physical and chemical analyses are known to have been published regarding the coal beds in the Little Thunder Reservoir Quadrangle. However, the general "as received" basis proximate analyses for central and southern Campbell County coal beds are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix	(U)	Hole 7316	7.760	31.233	30.098	30.909	0.524	7743
Smith	(U)	Hole 7312C	16.323	29.797	25.376	28.503	2.598	7273
Upper Wyodak	(U)	Hole 7544	4.501	32.688	24.337	38.450	0.201	8953
Middle and Lower Wyodak	(U)	Hole 757	6.024	32.831	26.907	34.237	0.336	8366

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

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from U. S. Geological Survey and Montana Bureau of Mines and Geology drill holes, and from oil and gas test bores and producing sites. A datum coal bed is utilized to position columnar sections on Plate 3. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through no record (NR) intervals. Inasmuch as the Middle-Lower Wyodak coal zone underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Middle-Lower Wyodak coal zone shows the thickest coal bed occurrence throughout the quadrangle. The Felix, Smith, Upper Wyodak, Wildcat, Moyer, and Oedekoven coal beds are relatively thin throughout most of the study area.

The Upper-Lower Felix coal beds crop out over approximately ten percent of the Little Thunder Reservoir Quadrangle. The outcrop occurs in the northwestern quadrant. A single unit in Township 44 North, Range 72 West, Section 36, the Felix coal bed divides into two units separated by a non-coal interval from 15 to 42 feet (5 to 13 m) thick south of the split line (Plates 4 and 5). Both the undivided unit and the separate units increase in thickness from east to west. The Upper Felix coal bed varies in thickness from less than 5 feet (1.5 m) to over 20 feet (6 m). The Lower Felix coal bed ranges in thickness from less than 10 feet (3 m) to more than 15 feet (5 m). The Upper-Lower Felix coal beds dip gently to the northwest. The Upper Felix coal bed lies less than 200 feet (61 m) beneath the surface and is separated from the Lower Felix coal bed by 0 to 80 feet (0 to 24 m) of clastic rock.

From 364 to 383 feet (111 to 117 m) of sediment separates the Smith coal bed from the overlying Lower Felix coal bed. The Smith coal bed is burned or eroded in the extreme northeastern portion of the quadrangle. Thicknesses for the Smith coal bed vary from 4 feet (1.2 m) in the eastern area to 17 feet (5 m) in the northwestern part of the quadrangle (Plate 9). Non-coal interburden within the Smith coal bed ranges from 0 to 14 feet (0 to 4 m) in thickness. Structural contours drawn on top of the Smith coal bed define a north-plunging syncline and anticline which extend from the south-central area to the northwestern portion of the Little Thunder Reservoir Quadrangle (Plate 10). The Smith coal bed lies less than 500 feet (152 m) beneath the surface throughout ninety-five percent of the study area.

The Upper Wyodak coal bed lies 107 to 196 feet (33 to 60 m) below the overlying Smith coal bed and averages approximately 6 feet (1.8 m) thick. Absent from the eastern quarter of the quadrangle, the Upper Wyodak coal bed attains a maximum thickness of over 10 feet (3 m) in the northwestern sector of the study area. Structural contours drawn on top of the Upper Wyodak coal bed define a closed synclinal feature located in Sections 12, and 13, Township 43 North, Range 72 West (Plate 15). Less than 500 feet (152 m) of sediment and coal beds overlie the Upper Wyodak coal bed throughout eighty-five percent of the quadrangle.

Occurring 67 to 329 feet (20 to 100 m) beneath the Upper Wyodak coal bed, the Middle-Lower Wyodak coal zone averages 94 feet (29 m) thick. Middle-Lower Wyodak coal zone thicknesses vary from 67 feet (20 m) in the southeastern sector to 169 feet (52 m) in Section 7, Township 43 North, Range 71 West (Plate 19). The maximum thickness of 169 feet (52 m) rapidly decrease to 78 feet (24 m), approximately 3700 feet to the south. A closed anticlinal feature is also present in this north-central portion of the study area (Plate 20). Approximately twenty-five percent of the Middle-Lower Wyodak coal zone lies less than 500 feet (152 m) below the surface in the Little Thunder Reservoir Quadrangle.

From 526 to 845 feet (160 to 258 m) of sediment separates the Wildcat-Moyer-Oedekoven coal zone from the overlying Middle-Lower Wyodak coal zone. Aggregate thicknesses for the Wildcat-Moyer-Oedekoven coal zone vary from 0 to 30 feet (0 to 9 m), with maximum thicknesses located in the southern portion of the study area (Plate 24). Non-coal intervals within the Wildcat-Moyer-Oedekoven coal zone range from 105 to 253 feet (32 to 77 m) thick. Structural contours drawn on top of the Wildcat-Moyer-Oedekoven coal zone define a westward dip of less than one degree (Plate 25). The Wildcat-Moyer-Oedekoven coal zone is from less than 1250 feet (381 m) to greater than 1750 feet (533 m) beneath the surface.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. Intra-

Search Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed or near to a drillsite shown on the topographic map, and the topographic map horizontal location is utilized. If the ground elevation on the geophysical log does not agree with the topographic elevation of the drillsite, the geophysical log ground elevation is adjusted to conformance. If there is no indication of a drillsite on the topographic map, the "quarter, quarter, quarter" heading location is shifted within a small area until the ground elevation on the heading agrees with the topographic map elevation. If no elevation agreement can be reached, the well heading or data sheet is rechecked for footage measurements and ground elevation accuracy. Inquiries to the companies who provided the oil and gas geophysical logs frequently reveal that corrections have been made in the original survey. If all horizontal location data sources have been checked and the information accepted as the best available data, the drillsite elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch Inc., considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the mining ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within and adjacent to the Little Thunder Reservoir 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 selected surface 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. 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; 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 to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a ninety-five percent recovery factor. Contours of these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed at the intersections of coal bed and overburden isopach contours using coal structure, coal isopach, and topographic control. On the Areal Distribution of Identified Resources Map (ADIR), coal bed reserves are not calculated where the coal is less than 5 feet (1.5 m) thick, where the coal occurs at a depth greater than 500 feet (152 m), where non-federal coal exists, or where federal coal leases, preference-right lease applications, and coal prospecting permits exist.

Coal tonnage calculations involve the planimetering of areas of measured, indicated, inferred reserves and resources, and hypothetical resources to determine their areal extent in acres. An <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 1750, or 1770 (the number of tons of lignite A or subbituminous C coal per acre-foot, respectively; 12,874 or 13,018 metric tons per hectare-meter, respectively), to determine total tons in place. Recoverable tonnage is calculated at ninety-five percent of the total tons in place. Where tonnages are computed for the CRO-CDP map series, resources and reserves are expressed in millions of tons. Frequently the planimetering of coal resources on a sectionized basis involves complexly curvilinear lines (coal bed outcrop and 500-foot stripping limit designations) in relationship with linear section boundaries and circular resource category boundaries. Where these relationships occur, generalizations of complexly curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated 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:

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

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 potential map (Plate 29) is prepared utilizing the following mining ratio criteria for coal beds 5 to 40 feet (1.5 to 12 m) thick:

1. Low development potential = 15:1 and greater ratio.
2. Moderate development potential = 10:1 to 15:1 ratio.
3. High development potential = 0 to 10:1 ratio.

The following mining ratio criteria is 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 potential is high for approximately thirty percent of the quadrangle. High potential areas in the northwest portion of the study area relate to the occurrence of the Felix coal bed near the surface. The Smith coal bed is classified as high potential in the eastern and southern sectors of the quadrangle. The thick Middle and Lower Wyodak coal zone has a mining ratio of less than 5:1 in the eastern portion of the study area, creating a high development potential for surface mining. The moderate and low potential areas in the central part of the quadrangle are due to increasing overburden thicknesses for the thin Smith and Upper Wyodak coal beds and the thick Middle and Lower Wyodak coal zone. 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 Little Thunder Reservoir Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves are not calculated for coal beds that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal resources in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3000 feet (152 to 914 m) beneath the surface. This categorization is as follows:

1. Low development potential relates to: 1) a total coal section less than 100 feet (30 m) thick that lies 500 feet (152 m) to 3000 feet (914 m) beneath the surface, or 2) coal beds 5 feet (1.5 m) or more in thickness 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 buried from 1000 to 3000 feet (305 to 914 m) beneath the surface.
3. High development potential involves 200 feet (61 m) or more of total coal thickness buried from 1000 to 3000 feet (305 to 914 m).

The coal development potential for in-situ gasification on the Little Thunder Reservoir Quadrangle is low, hence no CDP map is generated for this map series. The coal resource tonnage for in-situ gasification with low development potential totals approximately 5.2 billion tons (4.6 billion metric tons) (Table 3). None of the coal beds in the Little Thunder Reservoir 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 Little Thunder Reservoir 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
Felix	51,110,000	4,610,000	-----	55,720,000
Smith	95,590,000	83,610,000	399,390,000	578,590,000
Upper Wyodak	1,330,000	1,250,000	106,240,000	108,820,000
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(> 7:1 Mining Ratio)	
Middle and Lower Wyodak	741,360,000	203,970,000	-----	945,330,000
TOTAL	889,390,000	293,440,000	505,630,000	1,688,460,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	9,370,000	9,370,000
Upper Wyodak	-----	-----	42,760,000	42,760,000
Middle Wyodak	-----	-----	4,405,800,000	4,405,800,000
Wildcat-Moyer-Oedekoven	------	-----	714,980,000	714,980,000
TOTAL	-----	-----	5,172,910,000	5,172,910,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	9,370,000	9,370,000
Upper Wyodak	-----	-----	42,760,000	42,760,000
Middle Wyodak	-----	-----	4,405,800,000	4,405,800,000
Wildcat-Moyer-Oedekoven	-----	-----	714,980,000	714,980,000
TOTAL	-----	-----	5,172,910,000	5,172,910,000

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