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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE PINE CANYON QUADRANGLE CARBON COUNTY, UTAH

(Report includes 16 plates)

By

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INTRODUCTION

Purpose

This report was compiled to support the land planning work of the Bureau of Land Management and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the Western United States. It supplements the land planning requirements of the Federal Coal Leasing Amendments Act of 1976 (Public Law 94-377) sec. (3)(B) which states, in part, that "Each land-use plan prepared by the Secretary [of the Interior] (or in the case of lands within the National Forest System, the Secretary of Agriculture pursuant to subparagraph (A)(i)) shall include an assessment of the amount of coal deposits in such land, identifying the amount of such coal which is recoverable by deep mining operations and the amount of such coal which is recoverable by surface mining operations."

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps (15 plates) and the Coal Development Potential (CDP) Map (1 plate) of the Pine Canyon (Northeast Quarter of the Wellington 15-minute) quadrangle, Carbon County, Utah (U.S. Geological Survey Open-File Report 79-489).

Published and unpublished public information were used as data sources for this study. No new drilling nor field mapping were done to supplement this study. No confidential nor proprietary information was used.

Location

The Pine Canyon quadrangle is located in the north central part of Carbon County, Utah about 8 miles (13 km) northeast of the town of Wellington, and 7 miles (11 km) northwest of the town of Sunnyside. The

southwest corner of the quadrangle is approximately 9 miles (14 km) east and one mile (1.6 km) north of the city of Price, the county seat of Carbon County.

Accessibility

Main access into the Pine Canyon quadrangle is via State Highway 53 which passes up Soldier Creek Canyon on the west side of the quadrangle and down Nine Mile Canyon on the north side of the quadrangle. This highway is paved in the lower third of Soldier Creek Canyon and connects Wellington to the town of Myton about 54 miles (87 km) northeast of the quadrangle. Unimproved dirt or graveled roads have been built into Dugout Creek Canyon, Pace Canyon, Pine Canyon, and Whitmore Park. Jeep trails are found in some of the canyons and on some of the high ridges. A light-duty road crosses the southeast corner of the quadrangle and joins U.S. Highway 6-50 7 miles (11 km) to the south.

The nearest railroad is a branch line of the Denver and Rio Grande Western Railroad at Sunnyside Junction 7 miles (11 km) due south of the quadrangle. This branch line is used to haul coal from the Geneva and Sunnyside mines to the main line of the railroad about 5.5 miles (8.8 km) south of Sunnyside Junction. A commercial airport is located about 2 1/2 miles (4 km) east of Price.

Physiography

The Book Cliffs form a bold southward-facing escarpment of barren sandstone cliffs from 1,000 to 2,000 ft (305 to 610 m) high trending easterly and southeasterly across eastern Utah. The rock strata dip gently northward and erosion processes have sculptured precipitous cliffs and ledges on steep canyon walls. The northern three-fourths of the quadrangle is rugged and mountainous while the southern fourth consists of low hills,

dissected pediments, and shallow washes. Whitmore Park in the northwest corner of the quadrangle is a wide upland valley bounded with a dip slope on the south side and the steep Roan Cliffs on the north side.

The northwest part of the quadrangle drains into Soldier Creek which is the only perennial stream in the quadrangle. The other canyons east of Soldier Creek Canyon drain into Grassy Trail Creek which empties into Price River, a tributary of Green River. Surface elevations within the quadrangle boundary range from 5,840 ft (1,780 km) in the southwest corner to 9,039 ft (2,755 km) on a peak in the northeastern part of the quadrangle.

Climate

The Book Cliffs coal field is located in the mid-latitude steppe climate with semi-arid conditions prevailing at the lower altitudes. Annual normal precipitation ranges from about 9 inches (23 cm) in the southwest corner of the quadrangle to a maximum of 18 inches (46 cm) in the highest area (U.S. Department of Congress, (1964)). The precipitation at the elevation of the coal outcrops is approximately 10 to 12 inches (25 to 30 cm) per year. Temperatures in the lower elevations range from a summer high of about 100 degrees F (38 degrees C) to a winter low of -20 degrees F (-29 degrees C). In the high mountainous areas the summer and winter extremes are approximately 90 degrees F (32 degrees C) and -30 degrees F (-34 degrees C). Snow generally falls between January and March.

Land Status

The Pine Canyon quadrangle is located in the central part of the Book Cliffs Known Recoverable Coal Resource Area (KRCRA). The entire KRCRA covers a total of 129,338 acres of which approximately 16,800 acres lie within the Pine Canyon quadrangle. About 3,000 acres, or 18%, of the KRCRA lands in the quadrangle are non-Federal lands. The Federal Government owns

the coal rights to approximately 13,900 acres, or 82%, of the quadrangle KRCRA lands, approximately 9,500 acres of the Federal coal lands are under lease and about 4,400 acres are unleased. See plate 2.

GENERAL GEOLOGY

Previous Work

Clark (1928) mapped the geology and coal outcrops in the western part of the Book Cliffs coal field and Fisher (1936) reported on the area lying east of Clark's map. Anderson (1978) made a comprehensive study of the coal deposits in the Pine Canyon quadrangle and included the results of recent core drilling in his report. The stratigraphy is further described by Abbott and Liscomb (1956), Fisher, Erdmann, and Reeside (1960), Hayes and others (1977), Young (1955, 1957, and 1966), and Doelling (1972) who has summarized the geology and updated the coal data for the coal field.

Stratigraphy

The rocks exposed in the Pine Canyon quadrangle range in age from Upper Cretaceous (Mancos Shale) to Tertiary (Green River Formation).

The coal beds of economic importance in the Book Cliffs coal field are Upper Cretaceous in age, and are confined to the Blackhawk Formation of the Mesaverde Group. This group includes the following formations in ascending order: the Blackhawk Formation, Castlegate Sandstone, and the Price River Formation.

The oldest stratum exposed in the quadrangle is the massive Mancos Shale, consisting of dark bluish-gray shale which is sandy in the upper part of the formation. The area below the Book Cliffs is underlain by the Mancos which, in some places, is capped by a gravel veneer on benches of a dissected pediment.

The Mancos Shale is overlain by the Aberdeen Sandstone Member of the Blackhawk Formation. The Aberdeen is split into two parts by an eastward-projecting tongue of the Mancos Shale up to 275 ft (84 m) thick.

The coal-bearing part of the Blackhawk Formation consists of a massive yellowish-gray, cliff-forming sandstone alternating with beds of shaly sandstone, sandy shale, gray shale, carbonaceous shale, and coal. Some of the sandstone beds are as prominant as the Aberdeen and the better coal beds usually lie immediately above these sandstone beds or are separated from them by thin layers of shaly sandstone or shale. Six coal beds have been recognized and named in the quadrangle area. The Blackhawk Formation is about 750 ft (229 m) thick and thins eastward.

The Blackhawk Formation and the overlying Castlegate Sandstone form the major part of the Book Cliffs. The Castlegate ranges up to 225 ft (69 m) in thickness. It forms a vertical cliff above the Blackhawk and consists of gray to yellowish-gray, brown-weathering sandstone.

The Price River Formation is composed of two or more thick beds of sandstone interbedded with thin-bedded shale and sandy shale. The thick sandstones often form cliffs 100 ft (30 m) high, and within the quadrangle the formation ranges from 150 ft (46 m) to about 500 ft (152 m) in thickness.

The overlying Tertiary strata consist of the Wasatch Group and the Green River Formation. The Wasatch Group includes the North Horn Formation (Upper Cretaceous and Paleocene age) at the base, the Flagstaff Limestone (Paleocene age), and the Colton Formation (Eocene age). The Green River Formation (Eocene age) occurs only in the extreme northeast corner of the quadrangle.

The North Horn Formation overlies the Price River Formation and consists of variegated shale, tan to yellowish-gray sandstone and tan argillaceous limestone with minor amounts of conglomerate. The formation is around 500 ft (152 m) thick and thickens westward.

The Flagstaff Limestone is a resistant unit and caps the dip-slope on the south side of Whitmore Park. The formation consists of thin-bedded limestone, shale, and sandstone. The limestone is yellowish-gray, the shale is variegated, and the sandstone is generally reddish-brown. The formation is several hundred feet thick on the west side of the quadrangle, but thins rapidly eastward and is only a thin division between the North Horn Formation and the overlying Colton Formation at the east edge of the quadrangle.

The Colton Formation forms the Roan Cliffs and is exposed in the northeast corner of the quadrangle. It consists of reddish and brownish lenticular sandstone, shale, and siltstone and has a total thickness of at least 1,000 ft (305 m). The basal part of the Green River Formation is present in a small part of the northeast corner of the quadrangle and is composed of greenish-gray and white claystone.

Structure

The Book Cliffs area of east central Utah lies on the gentle northward-dipping south flank of the Uinta Basin. The structure is that of a simple homocline with the strata dipping northward from 6 to 7 degrees. In the Pine Canyon quadrangle there are very few faults that cut the coal beds and these have small displacements. Along the Roan Cliffs in the northeast quarter of the quadrangle there are several northwest-trending faults of greater displacement which may create problems if mining proceeds that far behind the outcrop.

COAL GEOLOGY

Six main coal beds have been mapped and described within the Pine Canyon quadrangle (plates 1 and 3). These beds occur in the Blackhawk Formation and are, in ascending order: the Kenilworth, Gilson, Fish Creek, Rock Canyon, Lower Sunnyside, and Upper Sunnyside beds.

The Kenilworth and Gilson beds are separated by a non-coal interval of approximately 50 ft (15 m). The Gilson and Fish Creek beds are separated by a non-coal interval ranging from 25 to 60 ft (8 to 18 m) with an average of 42 ft (13 m). The Fish Creek bed is successively overlain by: a non-coal interval approximately 50 ft (15 m) thick; the Rock Canyon coal bed; a non-interval ranging from 55 to 180 ft (17 to 59 m) thick; the Lower Sunnyside coal bed; a non-coal interval about 175 to 250 ft (53 to 76 m) thick; and the Upper Sunnyside coal bed.

Intervals reported as "bony coal," "bone," "shaly coal," or other similar terms in the data sources are shown as "rock" intervals in this report on plates 1 and 3. These intervals were not included in the coal thicknesses used to construct the coal isopach maps.

Chemical Analyses of the Coal

Doelling (1972) reports the analyses of 97 coal samples from Pine Canyon quadrangle. The coal samples were taken from several mines and coal beds. The values of the proximate analyses of these samples have been summed and averaged together in the following table taken from Doelling (1972, p. 400).

Table 1: Average proximate analysis of coals, Pine Canyon Quadrangle, Carbon County, Utah.

	No. Analyses	Percent Average	Range
Moisture	97	4.9	3.1-8.5
Volatile matter	94	38.6	37.4-40.1
Fixed Carbon	94	50.1	45.2-52.9
Ash	97	6.4	3.7-11.5
Sulphur	96	0.49	0.3-0.82
Btu/lb*	93	12,645	11,390-13,390

*To convert Btu/lb to Kj/kg multiply by 2.326

Based on the ASTM system of classification, the average analysis shown in Table 1 indicates that the coal mined in the Pine Canyon quadrangle has an average classification of high volatile bituminous B rank.

Average analyses of coal samples from the two most important mines in the quadrangle, the Dugout mine and the Soldier Canyon (Premium) mine, are shown in Table 2 (after Doelling, 1972).

Table 2. Average proximate analyses of coal from the Dugout and Soldier Canyon mines in the Pine Canyon quadrangle, Carbon County, Utah.

	Washed Coal Basis		
Mine	Dugout mine		Soldier Canyon Mine
Coal bed	Gilson	Rock Canyon	Rock Canyon
Moisture (air dried, percent)	2.1	2.0	3.2
Ash (dry, percent)	5.0	5.3	6.4
Volatile matter, percent	40.7	38.7	39.7
Fixed carbon, percent	54.3	56.0	53.9
Sulfur, percent	0.4	0.6	0.5
Btu/lb*	13,750	13,700	13,360
Ash soft temp.	2,160	2,500	2,360
Free swelling index	2½	1½	1½
Grindability	46	41	48
Oxygen (maf)	10.2	11.2	?

*To convert Btu/lb to Kj/kg multiply by 2.326

Based on the analyses in Table 2, the coal produced from the Gilson and Rock Canyon beds in the mines listed was high volatile A bituminous coal.

Kenilworth Coal Bed

The Kenilworth coal bed is the lowest coal bed exposed in the Pine Canyon quadrangle. Although it is one of the thinnest coal beds it is also the most constant in thickness. The coal data sheet (plate 3) indicates that the coal bed ranges in thickness from less than 1 ft (0.3 m) in Sec. 30, T. 13 S., R. 13 E. to a maximum of 3 ft (0.9 m) in a drill hole located in Sec. 10, T. 13 S., R. 13 E. and averages about 2 ft (0.6 m) thick. Generally, the Kenilworth coal bed is overlain by a shale or sandy shale and a sandstone about 5 to 10 ft (1.5 to 3 m) above the coal. In some areas the sandstone lies directly on the coal. The Kenilworth is burned less at the surface than the upper coal beds.

Gilson Coal Bed

The Gilson coal bed is the thickest bed in the quadrangle although the thickness varies considerably because of the lenticularity of the bed. The thickness ranges from less than 2 ft (0.6 m) in Sec. 18, T. 13 S., R. 12 E. to 12.9 ft (3.9 m) in Sec. 24 T. 13 S., R. 12 E. and 16 ft (4.9 m) in a drill hole located in Sec. 28, T. 12 S., R. 12 E. The isopach map (plate 12) indicates the coal bed thickens northward on the west side of the quadrangle. According to Clark (1928), the bed has been extensively burned at the surface so that few exposures remain. However, Clark (1928) says the best information available indicates that the burning has only penetrated a short distance into the coal and generally good coal will be found beyond the zone of weathering.

Fish Creek Coal Bed

The Fish Creek coal bed is mainly confined to T. 13 S., R. 12 E. It is believed to be a "split" from the Rock Canyon coal bed (Clark, 1928). The coal bed is difficult to map because of few exposures and the fact that the bed is not associated with a traceable rock stratum. The correlation is based on the stratigraphic position and thickness of the coal bed. The stratigraphic distance between the Gilson and the Fish Creek coal bed ranges from 26 ft (7.9 m) to 60 ft (18.3 m) and averages about 45 ft (13.7 m). The thickness of the coal bed ranges from 0.8 ft (0.2 m) in Sec. 17, T. 13 S., R. 12 E. to 5.2 ft (1.6 m) near Fish Creek Canyon and averages about 3.3 ft (1 m) (plate 3).

Rock Canyon Coal Bed

The Rock Canyon coal bed is one of the most valuable coal beds in the Pine Canyon quadrangle. It exhibits a wide range of thicknesses, but averages about 5 ft (1.5 m) thick over much of the quadrangle. The bed ranges in thickness from 1 ft (0.3 m) to 11 ft (3.4 m) on the surface to 9 ft (2.7 m) in a drill hole located in Sec. 32, T. 12 S., R. 12 E. (plate 8). The Rock Canyon coal bed has few outcrop exposures because of extensive burning of the coal at the surface.

Lower Sunnyside Coal Bed

The Lower Sunnyside coal bed is relatively thin throughout the Pine Canyon quadrangle and is not considered one of the major coal beds. Mapping the position of this coal bed is considered more reliable than mapping some of the other beds because it rests on the Sunnyside Sandstone which is easily traced. However, there are few good exposures of the coal because it has been extensively burned. The stratigraphic distance between the

Rock Canyon and Lower Sunnyside coal beds ranges from 55 ft (16.8 m) to about 180 ft (54.9 m). The measured thickness of the coal bed ranges from less than 1 ft (0.3 m) to 4.8 ft (1.5 m) at the surface to 11.5 ft (3.5 m) in a hole drilled in Sec. 4, T. 13 S., R. 12 E. The isopach map of the bed (plate 4) shows a lenticular thickening in the northwest quarter of the quadrangle.

Upper Sunnyside Coal Bed

The Upper Sunnyside coal bed is thin where exposed and may be absent in some places. No exposures were found west of Sec. 21, T. 13 S., R. 12 E., and no estimates can be made regarding the thickness and continuity of this bed in the western part of the quadrangle.

The thickness of the Upper Sunnyside coal bed ranges from 1 ft (0.3 m) in Sec. 21, T. 13 S., R. 12 E., to 6.0 ft (1.8 m) excluding partings in Sec. 25, T. 13 S., R. 12 E. The rock interval between the Upper and Lower Sunnyside coal beds averages about 20 ft (6.1 m).

Mining Operations

Active coal mining within the Pine Canyon quadrangle began around 1906. Although several mines have produced coal since then, only one is presently active. California Portland Cement Company is producing the Rock Canyon coal bed in the Soldier Creek mine (1979).

Most of the coal mined in the Pine Canyon quadrangle has come from the Gilson and Rock Canyon coal beds. Doelling (1972) reported that the total coal production from the quadrangle amounted to a little less than 2.6 million short tons (2.4 million metric tons) and that overall recoverability had been about 50 percent.

Table 3 lists four mines in the quadrangle area. No production figures for the Pace Canyon and Spring Canyon mines are known. It was assumed

by Doelling, (1972) that the production, if any, from these two mines was small and that they may never have exceeded the prospect stage. The Dugout Canyon mine produced the Rock Canyon and Gilson beds and extracted approximately 1,326,000 short tons (1,202,947 metric tons) of coal up to the time it closed in 1965. The Soldier Canyon mine produced 1,200,000 short tons (1,088,640 metric tons) of coal from the Rock Canyon bed up to 1970 (Doelling, 1972). Production of the mine from 1970 to 1979 is unknown.

Table 3. Mines in the Pine Canyon quadrangle, Carbon County, Utah.

Mine	Location	Remarks
Dugout Canyon mine (ESO, Branch Bros., Knight-Ideal)	SE¼ NW¼ 23-13S-12E	Active 1906; 1920-1965
Pace Canyon mine (Snow mine)	NW¼ NW¼ 30-13S-13E	Active 1906; 1932-1940
Soldier Canyon mine (Premium mine, California Portland Cement)	NW¼ NE¼ 18-13S-12E.	1906 some prospecting; 1931-
Spring Canyon mine	NE¼ NW¼ 21-13S-12E	Active 1906-1910

COAL RESOURCES

The principal sources of data used in the construction of the coal isopach maps, structure contour maps, and the coal-data maps were Doelling (1972), Clark (1928), and Anderson (1978).

Coal resource tonnages were calculated for measured, indicated, and inferred categories in unleased areas of Federal coal land within the KRCRA boundary. Data obtained from the coal isopach maps (plates 4, 8, and 12) were used to calculate the Reserve Base values. The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,800 short tons of coal per acre-

foot of bituminous coal yields the coal resources in short tons of coal per acre-foot of bituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve values for the Gilson, Rock Canyon, and Lower Sunnyside beds are shown on plates 7, 11, and 15, and are rounded to the nearest tenth of a million short tons. Reserve values are based on a subsurface mining recoverability factor of 50 percent.

The Kenilworth and Fish Creek coal beds are not of Reserve Base thickness in any parts of the unleased Federal KRCRA coal land in the quadrangle. Therefore Reserve Base and Reserve values were not calculated for the Kenilworth and Fish Creek coal beds and Areal Distribution and Identified Resources maps were not made for those beds.

The Reserve Base tonnage for one coal bed of limited areal extent was calculated. A small area of unleased Federal coal land is underlain by the Upper Sunnyside coal bed where it is of Reserve Base thickness (index number 57, plate 1). The Reserve Base tonnage for this bed is listed on plate 2 and in Table 4 as a non-isopached coal bed.

"Measured resources are computed from dimensions revealed in outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20 percent of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than ½ mile (0.8 km) apart. Measured coal is projected to extend as a ¼ mile (0.4 km) wide belt from the outcrop or points of observation or measurement.

"Indicated resources are computed partly from specified measurements and partly from projection of visible data for a reasonable distance on the basis

of geologic evidence. The points of observation are 1/2 (0.8 km) to 1 1/2 miles (2.4 km) apart. Indicated coal is projected to extend as a 1/2 mile (0.8 km) wide belt that lies more than 1/4 mile (0.4 km) from the outcrop or points of observation or measurement.

"Inferred quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and where few measurements of bed thickness are available. The estimates are based primarily on an assumed continuation from Demonstrated coal for which there is geologic evidence. The points of observation are 1 1/2 (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2 1/4 mile (3.6 km) wide belt that lies more than 3/4 mile (1.2 km) from the outcrop or points of observation or measurement." (U.S. Bureau of Mines and U.S. Geological Survey, 1976).

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 94.5 million short tons (85.7 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the Pine Canyon quadrangle.

AAA Engineering and Drafting, Inc. has not made any determination of economic mineability for any of the coal beds described in this report.

Table 4: Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Pine Canyon quadrangle, Carbon County, Utah.

(To convert short tons to metric tons, multiply by 0.9072)

Coal Bed Name	High development potential	Moderate development potential	Low development potential	Total
Lower Sunnyside	1,400,000	12,000,000	24,200,000	37,600,000
Rock Canyon	2,800,000	11,000,000	9,200,000	23,000,000
Gilson	4,100,000	9,600,000	20,100,000	33,800,000
Non-isopached coal bed	100,000	-0-	-0-	100,000
Total	8,400,000	32,600,000	53,500,000	94,500,000

COAL DEVELOPMENT POTENTIAL

Development Potential for Surface Mining Methods

No development potential for surface mining methods exists in the area of this quadrangle because of the rugged topography, steep-sided canyons, extreme relief, and thick overburden. There may be very small areas where some rim stripping could be done, but in general the area is not conducive to surface mining methods.

Development Potential for Subsurface Mining Methods and In Situ Gasification

The coal development potential for the subsurface mining of coal is shown on plate 16. In this quadrangle the areas where coal beds 5 ft (1.5 m) or more in thickness are overlain by less than 1,000 ft (305 m) of overburden are considered to have a high development potential for subsurface mining.

Areas where such beds are overlain by 1,000-2,000 ft (305-610 m) and 2,000-3,000 ft (610-914 m) of overburden are rated as having a moderate and a low development potential respectively. Areas that contain no known coal in beds 5 ft (1.5 m) or more thick, but coal-bearing units are present at depths

of less than 3,000 ft (914 m) are classified as areas of unknown coal development potential. Areas where no coal beds are known to occur or where coal beds are present at depths greater than 3,000 ft (914 m) have no coal-development potential. There are approximately 4,400 acres of unleased Federal coal lands in the Pine Canyon quadrangle of which 720 acres fall within the "high" development potential classification, 1,360 acres in the "moderate" development potential, 1,860 acres fall in the "low" development potential, 420 acres in the "unknown" development potential, and 40 acres in the "no" development potential classification.

The designation of a coal devleopment potential rating is based on the occurrence of the highest-rated coal-bearing area that may occur within any fractional part of a 40-acre BLM land grid area or lot area of unleased Federal coal land. For example, a certain 40-acre area is totally underlain by a coal bed with a "moderate" development potential. If a small corner of the same 40-acre area is also underlain by another coal bed with a "high" development potential, the entire 40-acre area is given a "high" development potential rating even though most of the area is rated "moderate" by the lower coal bed. Another possibility is a 40-acre area devoid of any coal except a small corner where a 5-ft (1.5 m) coal bed crops out. In this case the 40-acre area will have a "high" development potential rating.

The in situ coal gasification methods of development potential classification are based on the dip and depth of coal beds having a minimum thickness of 5 ft (1.5 m). There are only two development potential classifications--moderate and low. The criteria for in situ classification include coal bed dips of 15 to 90 degrees and coal bed depths of 200-3,000 ft (61-914 m).

Inasmuch as the coal beds dip less than 15 degrees in the Pine Canyon quadrangle, the in situ coal gasification methods of development potential classification do not apply.

Table 5. Sources of data used on plate 1.

Source	Plate 1 Index Number	Data Base: Drill hole or Measured Section No.	Data Base: Page or Plate
Anderson, P. B., 1978.	1	1	pl. 9
	3	3	pl. 9
	4	4	pl. 9
	5	5	pl. 9
	6	6	pl. 9
	7	7	pl. 9
	9	9 and 10	pl. 9
	10	11	pl. 9
	13	14	pl. 9
	15	15	pl. 9
	17	16	pl. 9
	23	21	pl. 9
	25	22	pl. 9
	28	23	pl. 9
	31	24	pl. 9
	33	26	pl. 9
	34	27	pl. 9
	36	28	pl. 9
	37	31	pl. 9
	38	33	pl. 9
	39	34 and 35	pl. 9
	40	36	pl. 9
	42	37	pl. 9
	43	38 and 39	pl. 9
	44	40 and 41	pl. 9
	45	42	pl. 9
	46	44	pl. 9
	49	45	pl. 9
	50	46 and 47	pl. 9
	51	48	pl. 9
	52	49	pl. 9
	55	52	pl. 9
	57	54	pl. 9
	59	55	pl. 9
	61	56	pl. 9
	64	58	pl. 9
	65	59	pl. 9
	66	Walton DDH	pl. 8
	67	C. Heiner DDH H3	pl. 8
	68	Pacific Gas and Electric DDH 4-1	pl. 8
	69	C. Heiner DDH H-5	pl. 8
	70	Pacific Gas and Electric DDH 17-1	pl. 6
	71	Pacific Gas and Electric DDH 8-1	pl. 6
	72	Pacific Gas and Electric DDH 4-2	pl. 8
	73	Pacific Gas and Electric DDH 9-2	pl. 6

Source	Plate 1 Index Number	Data Base: Drill hole or Measured Section No.	Page or Plate
Anderson P. B., 1978	74	Pacific Gas and Electric DDH 16-1	pl. 6
	75	Pacific Gas and Electric DDH 3-1	pl. 6
	76	Pacific Gas and Electric DDH 9-1	pl. 8
	77	C. Heiner DDH H-2	pl. 6
	78	Pacific Gas and Electric DDH 15-2	pl. 6
	79	Pacific Gas and Electric DDH 10-1	pl. 8
	80	Pacific Gas and Electric DDH 11-1	pl. 6
	81	Pacific Gas and Electric DDH 22-1	pl. 7
	82	Pacific Gas and Electric DDH 15-1	pl. 8
	83	C. Heiner DDH H-4	pl. 7
	84	Pacific Gas and Electric DDH 14-1	pl. 6
Clark, F. R., 1928.	2	93, 118, 144, 157, and 167	pl. 5
	4	94, 119, and 175	42 and pl. 5
	8	95, 120, and 145	pl. 5
	10	11	pl. 5
	11	121 and 149	52 and pl. 5
	13	123, 151, and 161	pl. 5
	18	97, 126, 152, and 162	pl. 5
	19	98, 127, 153, and 163	pl. 5
	20	99, 128, 154, and 164	pl. 5
	21	102	pl. 7
	22	101 and 129	pl. 7
	24	102 and 131	pls. 5 and 7
	25	103 and 132	pl. 7
	26	104	pl. 7
	27	105	pl. 7
	28	106 and 179	pl. 7
	29	133	pl. 7
	30	107 and 134	pl. 7
	32	108, 136, and 186	pl. 5
	33	137, 155, 165, 165a, and 187	pl. 5
	34	138, 156, 156a, and 189	pl. 5
	35	109	pl. 7
	37	112, 140, and 190	pl. 5
	41	114 and 142	49 and 50
	43	82 and 192	pls. 5 and 7
	48	178 and 183	pl. 7
	53	143	pl. 7

Source	Plate 1 Index Number	Data Base: Drill hole or Measured Section No.	Data Base: Page or Plate
Clark, F. R., 1928.	54	116	pl. 7
	58	199 and 209	57 and 58
	59	210	pl. 58
	60	211 and 217	58 and pl. 8
	61	193 and 200	57 and pl. 8
	62	212	pls 5 and 8
	63	194 and 201	pls 5 and 8
Doelling, H. H., 1972.	3	18	398
	4	20	398
	6	25	398
	7	35	398
	12	38 and 53	398 and 399
	14	67	399
	16	98	399
	23	74	399
	34	110	399
	38	6 and 88	398 and 399
	47	28	398
	56	119	399
	57	14	398

Note: Index numbers listed more than once are shown as composite measured sections on plate 1 and include data taken from more than one source.

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