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FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS
OF THE HEADCUT RESERVOIR 7 1/2-MINUTE QUADRANGLE,
SANDOVAL COUNTY, NEW MEXICO

[Report includes 23 plates (24 sheets)]

Prepared by Berge Exploration, Inc.

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INTRODUCTION

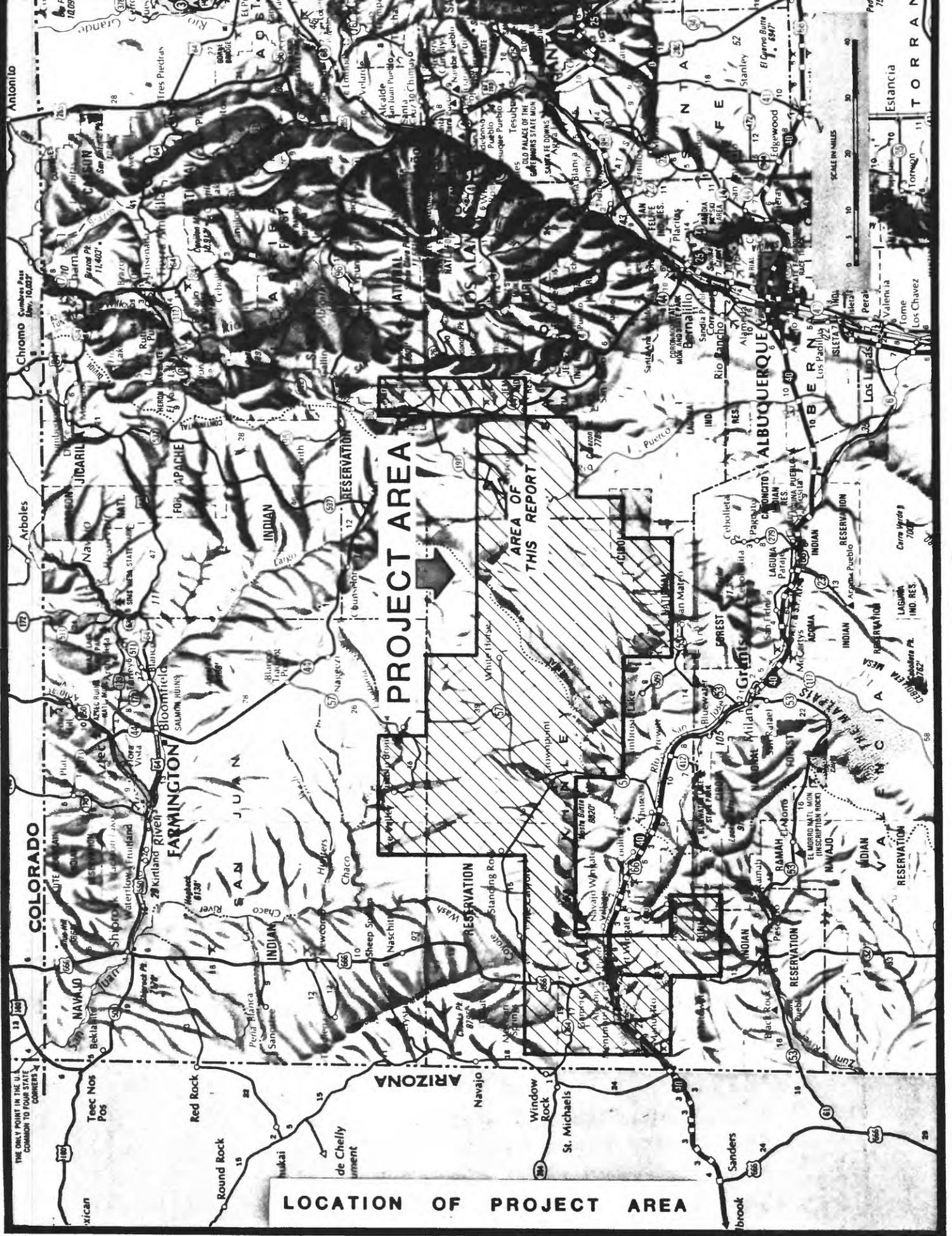
Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Headcut Reservoir 7 1/2 minute quadrangle, Sandoval County, New Mexico. These maps and report are part of an evaluation of fifty-six 7 1/2 minute quadrangles in northwestern New Mexico which were completed under U. S. Geological Survey Contract No. 14-08-0001-17459 (see figs. 1 and 2).

The purpose of this Coal Resource Occurrence-Coal Development Potential program, which was conceived by Congress as part of its Federal Coal Leasing Amendments Act of 1976, is to obtain coal resource information and to determine the geographical extent of Federal coal deposits. In addition, the program is intended to provide information on the amount of coal recoverable by various mining methods and to serve as a guide for land-use planning.

The U. S. Geological Survey initiated the program by identifying areas underlain by coal resources. These areas were designated Known Recoverable Coal Resource Areas based on the presence of minable coal thicknesses, adequate areal extent of these coal deposits, and the potential for developing commercial quantities of coal at minable depths.

This report is limited to coal resources which are 3,000 ft (914 m) or less below ground surface. Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor were any confidential data used.

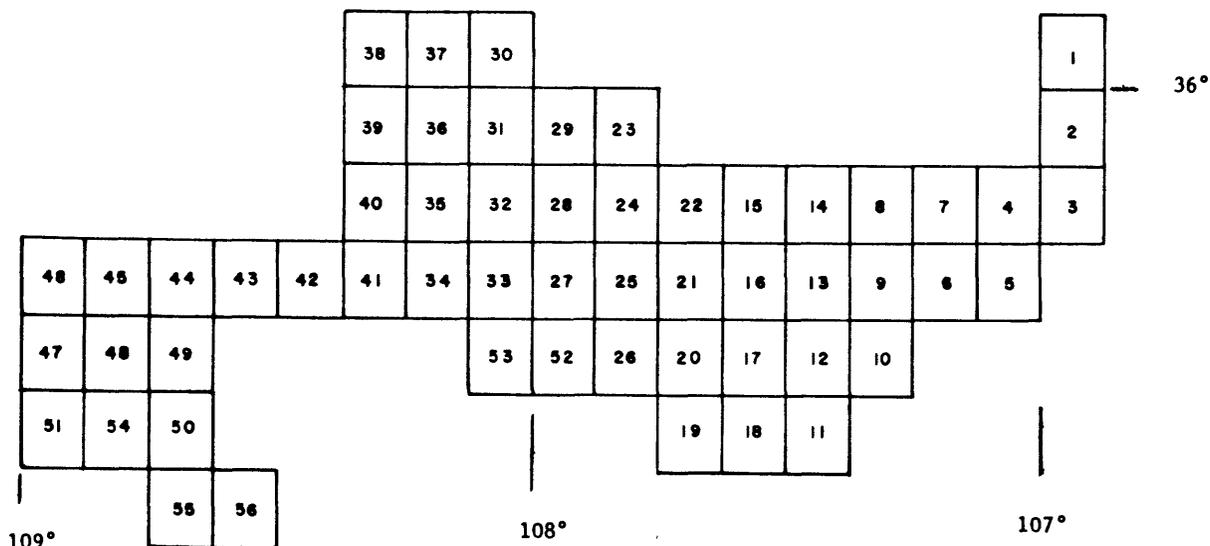


LOCATION OF PROJECT AREA

FIGURE 1

FIGURE 2.--Index to USGS 7 1/2-minute quadrangles and coal resource occurrence/
coal development potential maps for the southern San Juan Basin area, New Mexico

Map No.	Quadrangle	Open-file report	Map No.	Quadrangle	Open-file report
1	Cuba	79- 623	31	Nose Rock	79- 641
2	San Pablo	79- 624	32	Becenti Lake	79-1124
3	La Ventana	79-1038	33	Heart Rock	79- 642
4	Headcut Reservoir	79-1043	34	Crownpoint	79-1125
5	San Luis	79-1044	35	Antelope Lookout Mesa	79-1376
6	Arroyo Empedrado	79-1045	36	Milk Lake	79-1377
7	Wolf Stand	79-1046	37	La Vida Mission	79-1378
8	Tinian	79- 625	38	The Pillar 3 SE	79-1379
9	Canada Calladita	79- 626	39	Red Lake Well	79-1380
10	Cerro Parido	79- 627	40	Standing Rock	79-1381
11	El Dado Mesa	79- 628	41	Dalton Pass	80- 026
12	Mesa Cortada	79- 629	42	Oak Spring	80- 027
13	Mesita del Gavilan	79- 630	43	Hard Ground Flats	80- 028
14	Rincon Marquez	79- 631	44	Big Rock Hill	80- 029
15	Whitehorse Rincon	79- 632	45	Twin Lakes	80- 030
16	Mesita Americana	79- 633	46	Tse Bonita School	80- 031
17	El Dado	79- 634	47	Samson Lake	80- 032
18	Cerro Alesna	79- 635	48	Gallup West	80- 033
19	San Lucas Dam	79- 636	49	Gallup East	80- 034
20	Piedra de la Aguila	79-1039	50	Bread Springs	80- 035
21	Hospah	79- 637	51	Manuelito	80- 036
22	Whitehorse	79-1040	52	Borrogo Pass	80- 037
23	Seven Lakes NE	79- 638	53	Casamero Lake	80- 038
24	Kin Nahzin Ruins	79- 639	54	Twin Buttes	80- 039
25	Orphan Annie Rock	79-1041	55	Pinehaven	80- 040
26	Mesa de los Toros	79-1122	56	Upper Nutria	80- 041
27	Laguna Castillo	79- 640			
28	Seven Lakes	79-1042			
29	Seven Lakes NW	79-1123			
30	Kin Klizhin Ruins	79-1047			



Location

The Headcut Reservoir 7 1/2 minute quadrangle includes acreage in Tps. 18 and 19 N., Rs. 2 and 3 W. of the New Mexico Principal Meridian, Sandoval County, northwestern New Mexico (see figs. 1 and 2).

Accessibility

No paved roads pass through the Headcut Reservoir quadrangle. Unimproved dirt roads provide access to State Highway 44, which passes 2.8 mi (4.5 km) E. of the quadrangle. State Highway 197 passes about 4.5 mi (7.2 km) west of the area. Unimproved dirt roads and jeep trails traverse most parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railroad line passes about 38 mi (61 km) SE. of the quadrangle (see fig. 1). An abandoned railroad grade which leads to inactive coal mines in the eastern adjacent La Ventana quadrangle is about 0.5 mi (0.8 km) east of the area.

Physiography

The Headcut Reservoir quadrangle is in the Navajo section of the southernmost part of the Colorado Plateau physiographic province (U. S. Geological Survey, 1965). The area is characterized by mesa-and-canyon topography. La Ventana Mesa is a prominent mesa in the eastern part of the quadrangle.

No perennial streams are present in the area. Local drainage is provided by several intermittent arroyos including Arroyo Piedra Lumbre, Canada Candelaria, and Rincon de los Viejos. Elevations within the quadrangle range from 6,400 ft (1,951 m) in the southwest corner to 7,319 ft (2,231 m) on the La Ventana Mesa in the southeastern part of the quadrangle.

Climate

The climate of this area is semiarid to arid. The following temperature and precipitation data were reported by the National Oceanic and Atmospheric Administration for the Torreon Navajo Mission Station. The Headcut Reservoir quadrangle is about 6.5 mi (10.5 km) east of the Torreon Navajo Mission Station. Average total annual precipitation for thirteen of the previous fifteen years is 9.94 in (25.25 cm). Intense thunderstorms in July, August, and September account for the majority of precipitation. The area is susceptible to flash flooding associated with these thunderstorms. Mean annual temperature for eleven of the previous fifteen years is 49.5° F (9.7° C). The average daily temperatures in January and July are 27.4° F (-2.6° C) and 72.7° F (22.6° C), respectively.

Land status

The Federal Government holds the coal mineral rights to approximately 95 percent of the Headcut Reservoir quadrangle. For the specific coal ownership boundaries, see plate 2. It is not within the scope of this report to provide detailed land-surface ownership. All of the quadrangle except about 610 acres (247 ha) along the eastern edge is within the La Ventana Known Recoverable Coal Resource Area. There are two Federal coal leases held by the Consolidation Coal Company totaling about 160 acres (65 ha) in Secs. 13 and 35, T. 19 N., R. 2 W. As of October 26, 1978, there were no coal preference right lease applications or coal exploration licenses within the Headcut Reservoir quadrangle.

GENERAL GEOLOGY

Previous work

Early reports on the area include that of Gardner (1910) who mapped the area but reported no coal outcrop measurements within the Headcut Reservoir quadrangle. Dane (1936) mapped and measured coals of the Cleary Coal, Allison and Hogback Mountain Members of the Menefee Formation. Dane also noted that several prospects and a few abandoned mines were located on coal seams of the Cleary Coal and Allison Members. Shomaker, Beaumont, and Kottlowski (1971) described persistent coal beds occurring in the upper Allison and lower Cleary Coal Members, but due to steep dips, irregular bed thicknesses and thick overburden, only small amounts of coal

could be considered minable by surface mining methods. Beaumont and Shomaker (1974) discussed Menefee Formation coal resources in the area. Tabet and Frost (1979) mapped the surface geology including coal outcrops and conducted exploration drilling in the southwestern part of the Headcut Reservoir quadrangle. Their study was completed after the compilation of these maps and should be consulted for additional coal data in this area.

Stratigraphy

Within the San Juan Basin, the shoreline positions of the Cretaceous seaways changed innumerable times. The overall regional alignment of the shorelines trended N. 60° W. - S. 60° E. (Sears, Hunt, and Hendricks, 1941). The transgressive and regressive shoreline migrations are evidenced by the intertonguing relationships of continental and marine facies. Rates of trough (geosynclinal) subsidence and the availability of sediment supplies are the major factors that controlled the transgressive-regressive shoreline sequences.

Exposed rock units in the Headcut Reservoir quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium along drainages in the area.

The Mancos Shale is stratigraphically the lowest exposed unit in the quadrangle and is approximately 2,200 ft (671 m) thick locally. It is composed of dark gray shale with interbedded buff sandstone, thin limestone and calcareous concretionary beds. The Mancos Shale becomes increasingly sandy near the top and its upper contact is transitional with the overlying Point Lookout Sandstone.

The Point Lookout Sandstone represents nearshore or littoral deposits which formed during the most extensive northeastward retreat prior to the final withdrawal of the Cretaceous seaways in the San Juan Basin (Sears, Hunt, and Hendricks, 1941). The Point Lookout Sandstone is composed of light gray to reddish-brown, fine to medium grained sandstone with interbedded shales and is 40 to 275 ft (12 to 84 m) thick locally. The continental sediments deposited inland from the beach area during deposition of the Point Lookout Sandstone compose the overlying Menefee Formation.

The Menefee Formation consists of dark gray to brown carbonaceous to noncarbonaceous shales, light gray sandstones and coal beds, and is divisible into the basal Cleary Coal Member and the upper Allison Member. A massive channel sandstone sequence defines the boundary between the two members. An upper coal-bearing unit is present in the quadrangle and is termed the Hogback Mountain Tongue (Shomaker, 1977). The Hogback Mountain Tongue represents continental deposits, which formed during a transgressive shoreline sequence, and is stratigraphically equivalent to the upper part of the Allison Member further south.

Total thickness of the Menefee Formation is about 1,050 ft (320 m) in the area, composed of about 370 ft (113 m) of the Cleary Coal Member, 515 ft (157 m) of Allison Member and from 160 to 280 ft (49 to 85 m) of the Hogback Mountain Tongue. The Hogback Mountain Tongue is defined by intertonguing with the La Ventana Tongue of the Cliff House Sandstone, which represents nearshore and beach deposits. The La Ventana Tongue is composed of light gray, medium grained, occasionally calcareous, massive sandstone with interbedded shales and ranges from 550 to 650 ft (168 to 198 m) thick in the southeastern part of the quadrangle. In this quadrangle, the upper part of the Allison Member is replaced northeastward by the La Ventana Tongue and associated Hogback Mountain Tongue.

The uppermost part of the La Ventana Tongue is stratigraphically equivalent to the Cliff House Sandstone farther west. The Cliff House is commonly a massive sandstone unit, but it is absent in this area. The marine Lewis Shale directly overlies the La Ventana Tongue in the Headcut Reservoir quadrangle. Beaumont and Shomaker (1974) note that the contact of the La Ventana Tongue and overlying Lewis Shale is transitional in this area, indicating instability of the shorelines.

The Lewis Shale is composed of gray to black, silty shale with interbedded light gray to buff, very fine to fine grained sandstones and bentonite marker beds. Thickness of the unit ranges from 260 to 400 ft (79 to 122 m) in the area. Overlying the Lewis Shale, the Pictured Cliffs Sandstone represents nearshore or littoral deposits which formed during the final northeastward regression of the Cretaceous seaways in the San Juan Basin. The Pictured Cliffs Sandstone crops out in the northwest corner of the quadrangle. Brown to yellow, thinly bedded, fine to medium grained sandstone comprises the lithology of the Pictured Cliffs Sandstone, which is about 85 ft (25 m) thick locally.

Depositional environments

The Cretaceous System sedimentary units in the quadrangle represent transgressive and regressive depositional conditions. There were innumerable minor cycles of widely varying duration and extent within the major sedimentary sequences. The paucity of data in this quadrangle and the intended scope of this report permit only general interpretations of the depositional environments.

The Cretaceous coal deposits of the San Juan Basin are products of former coastal swamps and marshes. These swamps and marshes were supported by heavy precipitation and a climate conducive to rapid vegetal growth in moderately fresh water. Due to the relatively low sulfur contents of the San Juan Basin coals, Shomaker and Whyte (1977) suggest the coals formed in fresh water environments.

Most of the coal-bearing units were deposited in coastal plain environments. The majority of the peat deposits formed in a transition zone between lower and upper deltaic sediments during periods of relative shoreline stability. Coals also formed in lake margin swamps inland from the coastal area. Shoreline oscillations and the subsequent influx of continental or marine debris upon the peat accumulations produced the vertical buildup or "stacking" of peat deposits. This sediment debris represents variable ash contents, rock partings, and splits within the coal seams.

The peat accumulated in lenses or pods which were generally parallel to the ancient shorelines. The coals in the lower portions of the coal-bearing units represent regressive depositional conditions (Sears, Hunt and Hendricks, 1941). The coals in the upper portions of these units are relatively sporadic in occurrence.

Structure

The Headcut Reservoir quadrangle is in the Chaco Slope and Central Basin structural divisions in the southern portion of the structural depression known as the San Juan Basin (Kelley, 1950). The quadrangle is west of the Nacimiento Uplift. Two faults mapped by Dane (1936) displace coal beds of the Cleary Coal and Allison Members of the Menefee Formation. The rock units dip from 6° to 8° W to NW in the eastern part of the quadrangle to less than 2° W to NW in the western part.

COAL GEOLOGY

In this quadrangle, the authors identified five coal beds, three coal zones and a local coal bed from a coal test hole by Tabet and Frost (1979), an oil and gas well log and surface mapping by Dane (1936). These beds and coal zones are here informally called the Menefee Hogback Mountain No. 1 coal bed, Menefee Hogback Mountain coal zone, Menefee Allison No. 1 coal bed, Menefee Allison coal zone, Menefee Cleary coal zone, Menefee Cleary No. 5, No. 4 and No. 1 coal beds, and a local coal bed.

The Menefee Cleary No. 1 coal bed is the first persistent bed which occurs up to 4 ft (1 m) above the Point Lookout Sandstone in this quadrangle. In areas nearby, the bed is present up to 15 ft (5 m) above the Point Lookout Sandstone. The Menefee Cleary No. 4 coal bed occurs from 43 to 101 ft (13 to 31 m) above the Point Lookout Sandstone in this quadrangle. The Menefee Cleary No. 5 bed was identified in one outcrop measured section by Dane (1936). The bed was correlated as the Menefee

Cleary No. 5 bed based on data from the eastern adjacent La Ventana quadrangle. Because the bed was identified in only one outcrop measurement, its areal extent is unknown in this area.

Several thin coals which occur from 4 to 240 ft (1 to 73 m) above the Point Lookout Sandstone comprise the Menefee Cleary coal zone. These zone coals may be correlated for limited distances in portions of the area but they lack sufficient continuity with poorly defined stratigraphic position and cannot be designated as persistent coal beds.

A 2.0 ft (0.6 m) thick coal bed was identified in a drill hole log in sec. 30, T. 19 N., R. 2 W. The bed occurs 418 ft (127 m) above the Point Lookout Sandstone. Because of its isolated occurrence, it was deemed a local coal bed. Dane (1936) mapped other outcrop traces which the authors designated as local beds.

The Menefee Allison No. 1 coal bed is a persistent bed which occurs near the top of the Allison Member. Dane (1936) measured several outcrop traces of this bed. Other Allison Member coals which occur from 40 ft (12 m) below and 170 ft (52 m) above the Menefee Allison No. 1 bed are grouped into the Menefee Allison coal zone.

The Menefee Hogback Mountain coals are equivalent to the upper Allison Member coals farther south. Intertonguing of continental deposits with the La Ventana Tongue define the Menefee Hogback Mountain coals. Several beds comprise the Menefee Hogback Mountain coal zone which was identified in an oil and gas well log. The Menefee Hogback Mountain No. 1 coal bed was not mapped in this quadrangle, but was inferred to overlap from the western adjacent Wolf Stand quadrangle.

There are several published coal quality analyses of Allison Member coals from the Headcut Reservoir quadrangle. A coal quality analysis of Cleary Coal Member beds taken about 0.5 mi (0.8 km) east of this area is included in table 1. The Allison Member and Cleary Coal Member analyses were reported by the U. S. Bureau of Mines (1936). Rank of the Allison Member and Cleary Coal Member beds is subbituminous A to high volatile C bituminous in this area. No published coal quality analyses of Hogback Mountain coals are available in this area, but they are probably similar in quality to the Allison Member and Cleary Coal Member seams.

Menefee Hogback Mountain coal zone

The Menefee Hogback Mountain coal zone was identified in fourteen outcrop measured sections and two drill holes in this quadrangle. Total zone coal thicknesses range from 1.1 to 6.3 ft (0.3 to 1.9 m). The isopach map (plate 4) is based on the total zone coal thickness at each data point. Interburden values (plate 6) for each data point are the total rock thickness, excluding coal thicknesses, from the uppermost identified zone coal to the lowest identified zone bed. The Menefee Hogback Mountain coal zone occurs in the western part of the quadrangle. The zone has not been identified in the eastern part and is inferred to pinch out on La Ventana Mesa.

Table 1. - Analyses of coal samples from the Allison Member and Cleary Coal Member of the Menefee Formation.

[Form of analysis: A, as received; B, moisture free; C, moisture and ash free]

from U. S. Bureau of Mines, 1936

Sample	Type of Sample	Location		Form of Analysis	Proximate analysis (percent)			Sulfur	Heating Value (Btu/lb.)		
		Sec.	T. N. R. W.		Moisture	Volatile Matter	Fixed Carbon			Ash	
1 Allison Member	Mine Sample Anderson Mine SE½	35	19	2	A	18.3	33.9	43.0	4.8	0.7	10,630
					B	-----	41.5	52.6	5.9	0.9	13,000
					C	-----	44.1	55.9	---	1.0	13,820
2 Allison Member	Mine Sample Anderson Mine SE½	35	19	2	A	19.1	34.0	40.7	6.2	0.6	10,210
					B	-----	42.0	50.4	7.6	0.8	12,610
					C	-----	45.5	54.5	---	0.9	13,660
3 Cleary Coal Member	Mine Sample Cleary Mine SW¼	31	19	1	A	15.8	34.5	43.8	5.9	0.6	10,900
					B	-----	41.0	52.0	7.0	0.7	12,950
					C	-----	44.1	55.9	---	0.7	13,930

Remarks: A moist, mineral-matter-free (MMMF) calculation, using the Parr formula (American Society for Testing and Materials, 1973), yields heating values of 11,220 Btu/lb. (26,098 kJ/kg; sample 1), 10,952 Btu/lb. (25,474 kJ/kg; sample 2), 11,654 Btu/lb. (27,107 kJ/kg, sample 3). No agglomerating characteristics were included with these analyses.

Menefee Allison coal zone

The Menefee Allison coal zone was identified in thirteen outcrop measured sections and one drill hole in the Headcut Reservoir quadrangle. Up to two beds comprise the zone with as much as 5.2 ft (1.6 m) of total coal. The five outcrop measurements (plate 1 and 7) along the western quadrangle border represent partial data points taken along an outcrop that is stratigraphically higher than Menefee Allison coal zone outcrops in the southern and eastern portions of the quadrangle. The isopachs in the western portion of the quadrangle reflect the potential for greater thickness for the coal zone and were derived from the western adjacent Wolf Stand quadrangle. Thickening of the coal in the southern part of the quadrangle is the result of coal data from the southern adjacent San Luis quadrangle. The Menefee Allison coal zone is inferred to pinch out between Dane's (1936) outcrop traces in the southwest corner of the quadrangle.

Menefee Allison No. 1 coal bed

The Menefee Allison No. 1 coal bed is a persistent coal bed occurring in twenty-one measured sections and one drill hole in this quadrangle. Thickness of the bed ranges from 0.6 to 8.2 ft (0.2 to 2.5 m) and commonly contains rock partings. The procedure prescribed by the U. S. Geological Survey regarding rock partings in coal beds which are measured at outcrop is that the isopached thickness does not include coal benches less than 1.0 ft (0.3 m) thick unless either the rock parting between two coal benches is 0.2 ft (0.1 m) thick or less; or the coal bench of less than 1.0 ft (0.3 m) is between two coal benches that are each thicker than 1.0 ft (0.3 m). Following this procedure, data point #26 (plate 3) was isopached as 0.8 ft

(0.2 m) and data point #31 was isopached as 7.5 ft (2.3 m) for the Menefee Allison No. 1 bed. The 8 ft (2 m) Menefee Allison No. 1 isopach (plate 10) value along the western quadrangle boundary is based on coal bed data from the western adjacent Wolf Stand quadrangle. Because Dane (1936) did not map the bed in the southwestern corner of the quadrangle where there is structural potential for outcrop, the Menefee Allison No. 1 bed is inferred to pinch out.

Menefee Hogback Mountain No. 1 coal bed and
the Menefee Cleary No. 4 coal bed

The Menefee Hogback Mountain No. 1 and Menefee Cleary No. 4 coal beds were mapped on the same plates (plates 13, 14, and 15) and are discussed together in this report because there was no overlap of isopachs, structure contours or overburden isopachs. A coal bed separation line divides the mapped areas of the two beds and is used to avoid possible misinterpretation.

The Menefee Hogback Mountain No. 1 bed was not identified at any data point in the Headcut Reservoir quadrangle. It is inferred to be present based on data from the western adjacent Wolf Stand quadrangle. The bed is inferred to be up to 5.0 ft (1.5 m) thick in the area. Existence and character of the Menefee Hogback Mountain No. 1 bed are unknown in all but the northwestern part of the Headcut Reservoir quadrangle.

Dane (1936) identified the bed correlated by the authors as the Menefee Cleary No. 4 bed in thirteen outcrop measured sections in the eastern part of T. 18 N., R. 2 W. The bed contains up to 6.7 ft (2.0 m) of coal and contains numerous rock partings. Following U. S. Geological Survey procedure, data point #46 (plate 3) was isopached as 1.3 ft (0.4 m), data point #48 was isopached as 1.1 ft (0.3 m) and data point #53 has 1.0 ft (0.3 m) of Menefee Cleary No. 4 coal.

Because Dane (1936) did not map the Menefee Cleary No. 4 bed north of the SW $\frac{1}{4}$ Sec. 1, T. 18 N., R. 2 W., although there is structural potential for outcrop, the bed is shown to pinch out. The Menefee Cleary No. 4 coal bed is inferred for a distance west of its outcrop and is then shown to pinch out (see plate 13), because there is no subsurface data to show the presence of the coal bed in the western part of the quadrangle and the coal bed is not present in areas west of the quadrangle.

Menefee Cleary No. 1 coal bed

The Menefee Cleary No. 1 coal bed was mapped along its outcrop and identified in ten measured sections by Dane (1936). Maximum thickness of the bed is 4.6 ft (1.4 m) in the NE $\frac{1}{4}$ Sec. 35, T. 18 N., R. 2 W. The bed commonly contains rock partings, and criteria for map construction are identical to Menefee Allison No. 1 and Menefee Cleary No. 4 coal bed criteria. The bed is not present in the oil and gas well in Sec. 30, T. 19 N., R. 2 W., and is inferred to pinch out in the northwestern part of the quadrangle. Existence and character of the coal bed are unknown in the northern part of the quadrangle because of insufficient data.

COAL RESOURCES

The U. S. Geological Survey requested resource evaluations of the Menefee Allison No. 1, Menefee Hogback Mountain No. 1 and Menefee Cleary No. 1 and No. 4 coal beds, where the beds are 3.0 ft (0.9 m) or more thick. The evaluation is restricted to Federal coal lands.

The following procedures were prescribed by the U. S. Geological Survey for the calculation of reserve base. Criteria established in U. S. Geological Survey Bulletin 1450-B were used to areally divide the bed into measured, indicated, and inferred reserve base and hypothetical resource categories. Reserve base was calculated for each category, by section, using data from the isopach and overburden maps (plates 10, 12, 13, 15, 16 and 18). The acreage in each category (measured by planimeter) multiplied by the average coal bed thickness and a bituminous coal conversion factor (1,800 tons of coal per acre-ft) yields the reserve base for that category. Coal beds with 3.0 ft (0.9 m) minimum thickness are included in reserve base and reserve data rather than the 28 in. (71 cm) minimum thickness prescribed in U. S. Geological Survey Bulletin 1450-B. Reserve figures are derived from reserve base totals by applying recovery factors of 85 percent and 50 percent for coal beds 0 to 200 ft (0 to 61 m) and 200 to 3,000 ft (61 to 914 m) deep, respectively. All reserve base and reserve values are rounded to the nearest 10,000 short tons (9,072 t).

Total reserve base data for the Menefee Allison No. 1, Menefee Hogback Mountain No. 1, Menefee Cleary No. 4, and Menefee Cleary No. 1 coal beds, which include all reserve base categories, are shown by section on plate 2. Reserve base and reserve data in the various categories are shown on plates 19, 10 and 21.

The U. S. Geological Survey also requested resource evaluations of the Menefee Hogback Mountain coal zone and the Menefee Allison coal zone, where the total zone coal thickness is 5.0 ft (1.5 m) or greater. Total identified resources for the Menefee Hogback Mountain coal zone are 142.96 million short tons (129.69 million t). Total identified Menefee Allison coal zone resources are 27.65 million short tons (25.08 million t).

COAL DEVELOPMENT POTENTIAL

The factors used to determine the development potential are the presence of potentially coal-bearing formation, and the thickness and overburden of correlative coal beds. The U. S. Geological Survey supplied the criteria to evaluate the coal development potential for Federal lands in this quadrangle. These criteria are based on current industry practice, U. S. Geological Survey Bulletin 1450-B, and anticipated technological advances. All available data were utilized for the surface and subsurface coal development potential evaluations.

An area underlain by a potentially coal-bearing formation with 200 ft (61 m) or less of overburden has potential for surface mining. The U. S. Geological Survey designated the 200 ft (61 m) maximum depth as the stripping limit. Areas where a potentially coal-bearing formation is overlain by more than 200 ft (61 m) of overburden have no potential for surface mining. Areas with no correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) in thickness and overlain by 200 ft (61 m) or less of overburden have unknown mining potential. Areas which have a correlative coal bed 3.0 ft (0.9 m) or more thick with surface mining potential are assigned a high, moderate or low development potential based on the mining ratio (cubic yards of overburden per short ton of recoverable coal). The formula used to calculate mining ratios is:

$$MR = \frac{t_o (C)}{t_c (Rf)}$$

Where MR = Mining ratio

t_o = Thickness of overburden in feet

t_c = Thickness of coal in feet

Rf = Recovery factor

C = Volume-weight conversion factor

(.896 yd³/short ton for bituminous coal)

(.911 yd³/short ton for subbituminous coal)

High, moderate, and low development potential areas have respective surface mining ratio values of 0 to 10, 10 to 15, and greater than 15.

Any area underlain by a potentially coal-bearing formation with 200 to 3,000 ft (61 to 914 m) of overburden has potential for subsurface mining. Areas where a potentially coal-bearing formation is overlain by more than 3,000 ft (914 m) of overburden have no subsurface mining potential. Development potential for subsurface mining is unknown where a potentially coal-bearing formation within 100 to 3,000 ft (61 to 914 m) of the surface contains no identified correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) thick. High, moderate, and low development potential areas have respective overburden values of 200 to 1,000 ft (61 to 305 m), 1,000 to 2,000 ft (305 to 610 m), and 2,000 to 3,000 ft (610 to 914 m). The no and unknown development potential boundaries for surface mining methods (plate 22) are defined at the contact of the coal-bearing Menefee Formation with the overlying noncoal-bearing Lewis shale. Additional no and unknown boundaries for surface and subsurface mining methods (plate 22 and 23) are defined at the contact of the coal-bearing Menefee Formation with the underlying noncoal-bearing Point Lookout Sandstone. These contacts are approximated due to the

inaccuracies of adjusting old geologic maps to modern topographic bases.

Reserve base (in short tons) in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3, respectively.

The coal development potential maps are subject to revision. Map boundary lines and reserve base values are based on coal resource occurrence map isopachs, overburden isopachs, and coal bed correlations that are interpretive and subject to change as additional coal information becomes available.

Development potential for surface mining methods

The coal development potential for surface mining methods in the Headcut Reservoir quadrangle is shown on plate 22. The Menefee Allison No. 1 and Menefee Cleary No. 1 and No. 4 coal beds have reserves in the high, moderate, and low surface development potential categories. Refer to table 4 for reserves and planimetered acreage, by section, for Federal coal lands with development potential for surface mining methods. All remaining Federal coal lands have either no or unknown development potential for surface mining methods.

Development potential for subsurface mining
methods and in situ gasification

The coal development potential for subsurface mining methods in the Headcut Reservoir quadrangle is shown on plate 23. The Menefee Hogback Mountain No. 1 and Menefee Cleary No. 4 coal beds have reserves in the high development potential category. Reserves for the Menefee Allison No. 1 and Menefee Cleary No. 1 coal beds are in the high and the moderate potential categories. Refer to table 5 for reserves and planimetered acreage, by section, for Federal coal lands with development potential for subsurface mining methods. The remainder of the Federal coal lands in the Headcut Reservoir quadrangle have either unknown or no development potential for subsurface mining methods.

In situ gasification of coal has not been done on a commercial scale in the United States and criteria for rating the development potential of this method are unknown.

Table 2. - Reserve base data (in short tons) for surface mining methods for Federal coal lands in the Headcut Reservoir quadrangle, Sandoval County, New Mexico.

[Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tonnes, multiply by 0.9072; to convert mining ratios in yds³/ton coal to m³/t, multiply by 0.842].

Coal Bed	High Development Potential (0-10 Mining Ratio)	Moderate Development Potential (10-15 Mining Ratio)	Low Development Potential (greater than 15 Mining Ratio)	Total
Menefee Allison No. 1	680,000	310,000	17,800,000	18,790,000
Menefee Cleary No. 4	560,000	330,000	2,250,000	3,140,000
Menefee Cleary No. 1	180,000	260,000	2,280,000	2,720,000
Total	1,420,000	900,000	22,330,000	24,650,000

Table 3. - Reserve base data (in short tons) and hypothetical resources for subsurface mining methods for Federal coal lands in the Headcut Reservoir quadrangle, Sandoval County, New Mexico.

[Development potentials are based on thickness of overburden. To convert short tons to metric tonnes, multiply by 0.9072].

Coal Bed	High Development Potential (200'-1000' overburden)	Moderate Development Potential (1000'-2000' overburden)	Low Development Potential (2000'-3000' overburden)	Total
Menefee Allison No. 1	175,140,000	29,500,000	---	204,640,000
Menefee Cleary No. 4	7,850,000	---	---	7,850,000
Menefee Hogback Mountain No. 1	10,160,000	---	---	10,160,000
Menefee Cleary No. 1	3,840,000	710,000	---	4,550,000
Total	196,990,000	30,210,000	---	227,200,000
<u>Hypothetical Resources</u>				
Menefee Allison No. 1	670,000	---	---	670,000
Total	670,000	---	---	670,000

Table 4. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with surface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T.	N.	R.	W.	Acres (planimetered)	Reserves (in short tons)
High	Menefee Allison No. 1	32	18			2	13.7	70,000
		33					1.5	less than 10,000
		29					1.4	less than 10,000
		22					7.3	30,000
		11					13.7	110,000
	Menefee Cleary No. 4	35	19			2	19.1	230,000
		25					5.5	60,000
		35	18			2	23.6	120,000
		34					2.7	less than 10,000
		26					16.4	140,000
Moderate	Menefee Cleary No. 1	25					2.7	10,000
		23					6.8	50,000
		14					8.2	20,000
		11					13.7	70,000
		35	18			2	3.9	10,000
	Menefee Allison No. 1	26					10.9	50,000
		25					12.3	50,000
		32	18			2	9.7	50,000
		33					3.0	10,000
		29					2.7	10,000
Menefee Cleary No. 4	22					7.1	40,000	
	11					5.5	40,000	
	35	19			2	2.7	30,000	
	25					2.7	30,000	
	35	18			2	16.5	90,000	
		34				2.7	10,000	
		26				8.2	70,000	

Table 4. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with surface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T. N.	R. W.	Acres (planimetered)	Reserves (in short tons)	
Moderate	Menefee Cleary No. 4	23	18	2	2.7	20,000	
		14			5.5	20,000	
		11			6.8	20,000	
	Menefee Cleary No. 1	35	18	2	16.4	100,000	
		26			9.7	50,000	
		25			8.2	40,000	
Low	Menefee Allison No. 1	32	18	2	50.6	280,000	
		33			6.1	40,000	
		29			284.2	1,660,000	
		28			19.2	90,000	
		27			17.8	110,000	
		22			45.6	320,000	
		23			1.4	10,000	
		21			299.4	1,880,000	
		20			402.1	2,320,000	
		18			124.6	610,000	
		17			456.0	2,430,000	
		16			36.9	230,000	
		15			88.3	790,000	
		14			21.9	240,000	
		11			11.3	90,000	
		10			93.7	1,040,000	
		9			12.3	90,000	
		8			16.4	80,000	
		3			94.4	950,000	
		2			82.1	740,000	
		14		18	3	20.5	100,000
		13		19	2	23.3	110,000
		35				19.2	230,000
		26				8.2	90,000
		25				31.5	390,000

Table 4. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with surface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T.	N.	R.	W.	Acres (planimetered)	Reserves (in short tons)
Low	Menefee Cleary No. 4	35	18			2	79.6	420,000
		34					49.2	250,000
		27					5.5	20,000
		26					38.3	270,000
		23					12.3	100,000
		14					47.9	220,000
		11					110.8	560,000
	Menefee Cleary No. 1	35	18			2	157.3	1,020,000
		34					21.9	120,000
		26					140.2	760,000
		25					4.1	10,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with subsurface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T.	N.	R.	W.	Acres (planimetered)	Reserves (in short tons)
High	Menefee Allison No. 1	32	18			2	17.8	50,000
		29					34.5	110,000
		27					16.4	60,000
		22					333.7	1,410,000
		21					120.3	420,000
		20					4.1	10,000
		18					179.4	510,000
		17					161.1	520,000
		16					158.6	520,000
		15					515.1	2,370,000
		14					34.2	210,000
		11					31.6	180,000
		10					527.4	3,330,000
		9					630.4	2,550,000
		8					625.0	1,970,000
		7					640.0	2,010,000
		6					615.4	1,990,000
		5					605.8	1,960,000
		4					601.7	2,710,000
		3					506.8	2,990,000
		2	18				2	780,000
		14	18				3	1,420,000
		13					3	1,070,000
		12					321.4	2,300,000
		11					638.6	2,680,000
		1					454.8	3,000,000
		36	19				3	3,290,000
		35					3	3,050,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with subsurface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T. N.	R. W.	Acres (planimetered)	Reserves (in short tons)
High	Menefee Allison No. 1	26	19	3	332.3	2,090,000
		25			444.5	2,260,000
		24			24.6	120,000
		31	19	2	642.7	2,250,000
		32			641.4	2,130,000
		33			635.9	2,690,000
		34			640.0	3,000,000
		35			389.1	2,520,000
		25			160.0	1,080,000
		26			634.5	4,400,000
		27			642.7	3,010,000
		28			641.4	2,310,000
		29			637.3	2,070,000
		30			568.9	2,040,000
		19			2.7	10,000
		20			365.1	1,150,000
		21			637.3	2,230,000
		22			640.0	2,880,000
		23			645.5	3,310,000
		24			201.0	960,000
14			213.3	880,000		
15			132.7	530,000		
	Menefee Cleary No. 4	34	18	2	46.5	140,000
		27			10.9	30,000
		26			20.5	70,000
		23			36.9	140,000
		14			56.9	150,000
		15			5.5	10,000
		11			311.8	920,000
		10			432.1	1,240,000
		3			255.7	730,000
		2			154.5	440,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Headcut Reservoir quadrangle with subsurface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T.	N.	R.	W.	Acres (planimetered)	Reserves (in short tons)	
High	Menefee Hogback Mountain No. 1	36	19			3	4.1	10,000	
		35					213.3	690,000	
		26					443.4	1,880,000	
		25					135.4	400,000	
		24					79.3	230,000	
		23					433.2	1,570,000	
		14					72.5	220,000	
		35	18				2	43.8	160,000
		34						190.0	600,000
		33						23.3	60,000
27						221.5	680,000		
26						132.1	400,000		
Moderate	Menefee Allison No. 1	26	19			3	114.9	720,000	
		25					184.6	980,000	
		24					612.7	3,080,000	
		23					451.3	2,760,000	
		14					152.0	920,000	
		13					202.4	1,040,000	
		30	19			2	73.4	270,000	
		29					1.4	less than 10,000	
		20					270.8	890,000	
		19					631.8	2,470,000	
		18					218.8	880,000	
		17					216.1	700,000	
		14	18			3	1.4	less than 10,000	
11					123.1	350,000			

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#4

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GLOSSARY

- coal bed--A stratified sequence of coal, composed of relatively homogeneous material, exhibiting some degree of lithologic unity and separated from the rocks above and below by physically rather well defined boundary planes.
- coal bed separation line--A line on a map plate separating areas where different coal beds or zones are mapped.
- coal bench--One of two or more divisions of a coal bed separated by rock.
- coal conversion factor--A factor used to convert acre-feet of coal into short tons of coal; bituminous coal is 1800 tons/acre-ft; subbituminous coal is 1770 tons/acre-ft.
- coal development potential--A subjective determination of the comparative potential of Federal coal lands for development of a commercially viable coal mining operation.
- coal exploration license--An area of Federal coal lands in which the licensee is granted the right, after outlining the area and the probable methods of exploration, to investigate the coal resources. An exploration license has a term not to exceed 2 years and does not confer rights to a lease.
- coal lease--An area of Federal coal lands in which the Federal Government has entered into a contractual agreement for development of the coal deposits.
- coal split--A coal bed resulting from the occurrence of a noncoal parting within the parent coal bed which divides the single coal bed into two or more coal beds.
- coal zone--A distinctive stratigraphic interval containing a sequence of alternating coal and noncoal layers in which the coal beds may so lack lateral persistence that correlating individual beds in the zone is not feasible.
- Federal coal land--Land for which the Federal Government holds title to the coal mineral rights, without regard to surface ownership.
- hypothetical resources--Undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions. In general, hypothetical resources are in broad areas of coal fields where points of observation are absent and evidence is from distant outcrops, drill holes or wells. Exploration that confirms their presence and reveals quantity and quality will permit their reclassification as a Reserve or Identified Subeconomic Resource.
- identified resources--Specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by engineering measurements.
- indicated--Coal for which estimates for the rank, quality, and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.
- inferred--Coal in unexplored extensions of demonstrated resources for which estimates of the quality and quantity are based on geologic evidence and projections.
- isopach--A line joining points of equal bed thickness.
- Known Recoverable Coal Resource Area (KRCRA)--Formerly called Known Coal Leasing Area (KCLA). Area in which the Federal coal land is classified (1) as subject to the coal leasing provisions of the Mineral Leasing Act of 1920, as amended, and (2) by virtue of the available data being sufficient to permit evaluation as to extent, location, and potential for developing commercial quantities of coal.
- measured--Coal for which estimates for rank, quality, and quantity can be computed, within a margin of error of less than 20 percent, from sample analyses and measurements from closely spaced and geologically well known sample sites.
- mining ratio--A numerical ratio equating the in-place volumes, in cubic yards, of rocks that must be removed in order to recover 1 short ton of coal by surface mining.
- overburden--A stratigraphic interval (composed of noncoal beds and coal beds) lying between the ground surface and the top of a coal bed. For coal zones, overburden is the stratigraphic interval lying between the ground surface and the structural datum used to map the zone.
- parting--A noncoal layer occurring along a bedding plane within a coal bed.
- Preference Right Lease Application (PRLA)--An area of Federal coal lands for which an application for a noncompetitive coal lease has been made as a result of exploration done under a coal prospecting permit. PRLA's are no longer obtainable.
- quality or grade--Refers to measurements such as heat value; fixed carbon; moisture; ash; sulfur; phosphorus; major, minor, and trace elements; coking properties; petrologic properties; and particular organic constituents.
- rank--The classification of coal relative to other coals, according to degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite (Classification of coals by rank, 1973, American Society for Testing and Materials, ASTM Designation D-388-66).
- recovery factor--The percentage of total tons of coal estimated to be recoverable from a given area in relation to the total tonnage estimated to be in the Reserve Base in the ground.
- reserve--That part of identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.
- reserve base--That part of identified coal resource from which Reserves are calculated.
- stripping limit--A vertical depth, in feet, measured from the surface, reflecting the probable maximum, practical depth to which surface mining may be technologically feasible in the foreseeable future. The rock interval, expressed in feet, above the stripping limit is the "strippable interval."
- structure contour--A line joining points of equal elevation on a stratum or bed.