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FEDERAL COAL RESOURCE OCCURRENCE AND FEDERAL COAL DEVELOPMENT POTENTIAL MAPS OF THE HACKETT 7.5-MINUTE QUADRANGLE LE FLORE COUNTY, OKLAHOMA, AND SEBASTIAN COUNTY, ARKANSAS

[Report includes 11 plates]

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INTRODUCTION

Purpose

This text is to be used in conjunction with the Federal Coal Resource Occurrence (FCRO) and Federal Coal Development Potential (FCDP) Maps of the Hackett 7.5-minute quadrangle, Le Flore County, Oklahoma, and Sebastian County, Arkansas.

This report was compiled to support the land-planning work of the Bureau of Land Management (BLM). The work was undertaken by Geological Services of Tulsa, Tulsa, Oklahoma, at the request of the United States Geological Survey under Contract No. 14-08-0001-17989. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (Public Law 94-377). Published and unpublished publicly available information was used as the data base for this study. No new drilling or field mapping was done to supplement this study, nor were any confidential or proprietary data used.

Location

The Hackett 7.5-minute quadrangle is located to the north of the Howe-Wilburton coal mining district on the eastern edge of the southeastern Oklahoma coal field and on the western edge of the Arkansas coal field. The Oklahoma-Arkansas border runs north-south through the center of the quadrangle. Hackett and Bonanza, both in Arkansas, are the largest towns in the quadrangle. The city of McAlester is about 75 miles (120 km) west of the quadrangle, and the city of Tulsa is approximately 100 miles (160 km) northwest of the quadrangle. The city of Fort Smith, Arkansas, is approximately 11 miles (18 km) north of the Hackett quadrangle.

Accessibility

The Hackett quadrangle is accessible by several railroads and state highways. Oklahoma State Route 112 runs through the northwest part of the quadrangle, and Arkansas State Route 45 runs through the east half of the quadrangle. Both roads travel north to Fort Smith. Arkansas State Route 10 runs from the State line east through the town of Hackett. In addition to these main highways, almost every section in the quadrangle is accessible by either a light-duty or unimproved dirt road.

The area is also served by two railroad lines. The Midland Valley Railroad runs through the center of the quadrangle from east to west, passing through the towns of Hackett and Rock Island. The St. Louis-San Francisco Railroad also runs generally east-west through the quadrangle, but, in addition, has a line running north past the town of Bonanza.

Physiography

The Hackett quadrangle is in the Arkoma Basin, north of the Ouachita Mountains, in the Arkansas Valley physiographic province (Hendricks, 1939). The Choctaw fault, which marks the south edge of the basin, is about 18 miles (29 km) south of the quadrangle.

Much of the region is hilly, mainly because of the action of streams on bedrock with differing capabilities for resisting erosion (Knechtel, 1949). The dominant features of the local landscape are long ridges that generally coincide with the outcrop of sandstone members. Backbone Mountain in the north half of the quadrangle is such a feature. Between these ridges are erosional valleys underlain mostly by shale (Knechtel, 1949). Folding is widespread, resulting in sandstone-capped synclinal mountains. Total relief in the Hackett quadrangle is about 400 feet (122 m), with a low of about 480 feet (146 m) in the river valleys and a high of about 880 feet (268 m) on Backbone Mountain.

The Hackett quadrangle is drained by the James Fork River, which flows generally eastward through the quadrangle. Several smaller creeks and intermittent streams also flow through the area, and some small, manmade lakes and small ponds exist within the quadrangle. In addition to these is Wofford Lake, just south of Bonanza. The Arkansas River Navigation Channel is located north of the quadrangle.

Climate and Vegetation

The climate in southeastern Oklahoma is for the most part fairly moderate. Winters are short, and extremely cold weather is rare. Summers, however, are generally long and hot. The mean annual temperature is about 62° F (17° C), and ranges from a daily average of about 41° F (5° C) in January to about 82° F (28° C) in July, though occasional periods of very hot days are not unusual (Hendricks, 1939). Annual precipitation in the area averages about 41 inches (104 cm), with rains generally abundant in the spring, early summer, fall, and winter (Hendricks, 1939).

The area supports a wide variety of vegetation, with oaks, blackjacks, hickories, elms and hackberries being most common. On the higher mountains and ridges pines can also be found. In parts of the valleys that have not been cleared for farming, thick stands of water and willow oaks, hickories, cottonwoods, willows, and wild plums may be present (Hendricks, 1939).

Land Status

Federal coal land in the Hackett quadrangle totals approximately 4,600 acres (1,862 hectares), or about 12 percent of the quadrangle. As of October 19, 1979, none of this land was leased. Approximately 1,760 acres (712 hectares) of this land is part of the Rock Island Known Recoverable Coal Resources Area (KRCRA).

GENERAL GEOLOGY

Previous Work

Much work has been done on the southeastern Oklahoma coal field. The first geologic study of the Choctaw coal field was by Chance (1890) and included a map showing the outcrops of the most important coal beds in the area. In 1897, Drake published the results of his study on the coal fields of the Indian Territory, which consisted of a map and text of the principal coal beds, general stratigraphy, and structural features.

From 1899 to 1910, Taff and his associates published several reports on the Oklahoma coal lands. These included various investigations carried out for the U.S. Geological Survey on the extent and general character of local stratigraphy, including coal beds. Much of Taff's work was a part of Senate Document 390 (1910), which represented a compilation of material collected for the purpose of determining the value and extent of coal deposits in and under the segregated coal lands of the Choctaw and Chickasaw Nations in Oklahoma.

The Oklahoma Geological Survey published a bulletin by Snider in 1914 on the geology of east-central Oklahoma, emphasizing the geologic structure and oil and gas possibilities. Further studies on the southern Oklahoma coal lands were carried out by Shannon and others (1926), Moose and Searle (1929), and Hendricks (1939). These, along with later works by Knechtel and Oakes in the 1940's, added greatly to the body of knowledge on Oklahoma coals, particularly concerning quality, chemical composition, and extent.

Various estimates as to original and remaining coal reserves have been published; among them are the figures published in papers by Trumbull (1957) and Friedman (1974). Nonproprietary information from coal test holes drilled in various years in the Hackett quadrangle was obtained from USGS files.

In recent years several master's theses have been done in the southeastern Oklahoma coal field. Agbe-Davies (1978) studied the geology of the Hartshorne coal in the Spiro and Hackett quadrangles, and much of his work has been incorporated into this report.

Stratigraphy

The Arkoma Basin, once part of the larger Ouachita geosyncline, formed as a result of subsidence beginning in Mississippian time and continuing through Early and Middle Pennsylvanian. Strata in the basin are thought to have been deposited in a deltaic environment with sediment coming primarily from eroding highlands to the northeast, north, and northwest (Branan, 1968). Evidence that the basin was becoming full is provided by coal seams in the Upper Atoka and Lower Desmoinesian section. Sedimentation continued until Late Pennsylvanian time, when the Arbuckle Orogeny of southern Oklahoma took place (Branan, 1968). In Early Permian time, Ouachita mountain building to the south of the basin compressed Arkoma Basin strata into a series of long narrow east-trending anticlinal and synclinal folds (see "Structure").

All the rock units cropping out in the Hackett quadrangle are of Pennsylvanian age, and include the Atoka Formation, as well as the Hartshorne and McAlester Formations of the Lower Desmoinesian Krebs Group. The Hartshorne and McAlester Formations are coal bearing in this quadrangle.

The Atoka Formation was named by Taff and Adams in 1900. The oldest exposed formation in the quadrangle, the Atoka crops out across the north-central part in conjunction with the Backbone fault and along Backbone Mountain (Haley and Hendricks, 1968). The formation consists mostly of gray, silty shale interbedded with ridge-forming brown or light-gray sandstone units (Knechtel, 1949).

The sandstone is highly variable in character, both from bed to bed and within a single bed. In most exposures it is fine-grained, silty and irregularly bedded; but locally it may be coarse-grained, clean, and massive to thick-bedded. The Atoka Formation thickens somewhat across the quadrangle, from about 6,500 feet (1,983 m) in the northwest to 8,000 feet (2,440 m) in the southeast (Hendricks, 1939).

The Hartshorne Formation forms the basal unit of the Desmoinesian Series. It is most probably conformable with the underlying Atoka Formation (McDaniel, 1961; Oakes and Knechtel, 1948), although the sharp and irregular contact between the Hartshorne and Atoka Formations has led some observers to conclude that a minor unconformity separates them, at least locally (Branson, 1962; Haley and Hendricks, 1968). The contact between the Hartshorne Formation and the overlying McAlester Formation is conformable (Hendricks, 1939).

The boundaries of the Hartshorne Formation have been modified several times since the unit was first mapped by H. M. Chance in 1890. Then called the "Tobucksy" Sandstone, the formation was renamed the Hartshorne Sandstone by Taff in 1899. Early workers defined the formation such that the Upper Hartshorne coal was considerd to be part of the overlying McAlester Formation. However, Oakes and Knechtel (1948) recognized a convergence of the Upper and Lower Hartshorne coals in northern Le Flore and eastern Haskell Counties, and redefined the formation to include both coals. The Hartshorne coal, undivided to the north, splits into Upper and Lower Hartshorne coals along a northeast-trending line. This split line is only approximately located through the central part of the Hackett quadrangle, because of erosion of the Hartshorne Formation in the area. The current definition of the Hartshorne Formation is one proposed by McDaniel (1961), which supports the boundaries suggested by Oakes and Knechtel (1948), but formally divides the formation into lower and upper members where applicable (based on the above-mentioned coal "split line").

The Hartshorne Formation is highly variable in character and thickness. In general it contains interbedded sandstones and shales which tend to become discontinuous as the upper and lower coals merge. The sands are mainly fine-grained, light to medium gray, silty and micaceous, and the shales are gray and sandy. Plant fossils are abundant in the shales. The formation is roughly 300 feet (92 m) thick in the Hackett quadrangle.

In the Hackett quadrangle, the McAlester Formation is 1,000-1,500 feet (305-458 m) thick, thinning to the north (Hendricks, 1939). It crops out quite extensively across the area, and lies conformably on the Hartshorne Formation. The McAlester Formation consists primarily of various unnamed shale units, but includes one shale member and several sandstone members as well. In ascending order, the McAlester Formation includes the McCurtain Shale Member, and the Warner, Lequire, Cameron, Tamaha, and Keota Sandstone Members. Between each of these sandstones and above the Keota Sandstone Member, is an unnamed shale unit.

The lowermost unit of the McAlester Formation is the McCurtain Shale Member, a blue to dark-gray, clayey shale with numerous siderite concretions and plant material (Knechtel, 1949). The McCurtain Member contains a few thin sandstone units, including a locally persistent thin sandstone with an associated unnamed local coal found approximately 300 feet (92 m) above the base.

The most persistent sandstone of the McAlester Formation is the Warner Sandstone Member, a fine-grained, argillaceous unit which forms the first prominent escarpment stratigraphically above the Hartshorne Formation. This member overlies the McCurtain Member. It is highly variable in thickness, ranging from 15 to 150 feet (5 to 46 m), and has a locally persistent coal associated with it. Above the Warner is an unnamed shale unit which is dark gray, silty and fissile, and in the northern Le Flore County generally ranges in thickness from 120 to 300 feet (37 to 92 m) (Knechtel, 1949). Siderite concretions are common, and a few thin sandstones can be found within it.

The Lequire Sandstone Member of the McAlester Formation overlies this unnamed shale. The Lequire includes lenticular sandstone beds interbedded with siltstones and shales, and can include a thin local coal. It crops out in a narrow band across secs. 17 and 18, T. 8 N., R. 27 E., forming a low, inconspicuous ridge, and around Gray Mountain on the north edge of the quadrangle (Knechtel, 1949). To the north it is either absent or so close to either the Warner or Cameron Member that it has not been recognized as a separate unit (Knechtel, 1949). Units between the Lequire and Keota Sandstone Members are highly variable in thickness and lateral extent. They comprise two unnamed shale units and the Cameron and Tamaha Sandstone Members.

The Cameron Sandstone Member is buff to gray, fine-grained, ripple-marked sandstone with interbeds and lenses of shale and sandy shale. It ranges in thickness from 10 to 20 feet (3 to 6 m) in northern Le Flore County (Knechtel, 1949). It crops out on Gray Mountain and in the southwest part of the quadrangle (Knechtel, 1949). Overlying the Cameron is an unnamed gray shale unit with siderite concretions near the base and sandstone laminae throughout (Knechtel, 1949). This unnamed shale includes the Stigler coal, which is not found in the Hackett quadrangle.

The Tamaha and Keota Sandstone Members are the upper units of the McAlester Formation. These sandstones are not found in the Hackett quadrangle.

Quaternary terrace and alluvium deposits are rather extensive in the Hackett quadrangle, and cover most of the stream valleys.

Structure

The Hackett quadrangle lies within a zone of folded Pennsylvanian rocks characterized by broad, shallow synclines and narrow anticlines (Russell, 1960). The axes of these structures are commonly en echelon, and in general run parallel to the frontal margin of the adjacent Ouachita salient marked by the Choctaw fault. The principal surface structures in the Hackett quadrangle (plate 1). They are the Central syncline, the Backbone anticline and fault, and the James Fork-Greenwood syncline.

The Central syncline is a minor flexure trending east across the northern edge of the Hackett quadrangle on Gray Mountain. The structure exposes rocks of the McAlester Formation (Knechtel, 1949; Haley and Hendricks, 1968).

The Backbone thrust fault zone extends across the central part of the Hackett anticline in a generally east direction and consists of several faults (Haley and Hendricks, 1968). Maximum displacement along the fault is more than 5,000 feet (1,525 m), exposing rocks of the Atoka Formation. The Hartshorne coals are exposed on both sides of the fault. Dips associated with the fault range from 15° to 90°; some overturned beds are present.

Trending generally east across the southern part of the Hackett quadrangle is the James Fork-Greenwood syncline. This is a shallow structural trough plunging gently west-southwestward (Knechtel, 1949). Haley and Hendricks (1968) called this structure the Greenwood syncline. The structure branches out into two synclines across the State line in Arkansas, and for purposes of this report the northern branch is termed the Greenwood syncline, and the southern branch, the James Fork syncline.

COAL GEOLOGY

The only major coal seams found in the Hackett quadrangle are the Hartshorne coal and its upper and lower splits. In addition to these are two unnamed local coals measured in data point 23 which exceed the Reserve Base thickness of 1 foot (0.3 m). These have been treated as isolated data points (see below).

Hartshorne Coal Bed and Upper and Lower Splits

The Hartshorne coals occur at or near the top of the Hartshorne Formation. Ths split line for the Hartshorne coal bed has been approximately located through the center of the quandrangle, although because of erosion and Quaternary alluvium cover it has not actually not been observed. The split line is defined in this report as the 1-foot interburden line (pl. 6). North of this line only one coal seam is present; south of the line the seam is split into Upper and Lower Hartshorne coals. The structure on these coals is presented on plate 5, and the thickess of the interburden between the Upper and Lower Splits is shown on plate 6. The interburden ranges from 1 foot (0.3 m) at the split line to more than 20 feet (6 m).

All three Hartshorne coals crop out in bands trending generally east across the quadrangle and dip away from the Backbone fault zone. Haley and Hendricks (1968) have referred to the single coal cropping out north of the fault zone as the Lower Hartshorne coal. However, the authors of this report have correlated this coal with the single-seam Hartshorne in the adjacent Spiro quadrangle, and have mapped it as such. The exact location of the split line of the Hartshorne coal cannot be determined because of cover by Quaternary alluvium and erosion. The approximate location of the split line is shown on plate 4. South of this line both the Upper and Lower Hartshorne coals are found. Both coals have been mapped in Oklahoma (Knechtel, 1949), but in Arkansas only the Lower Hartshorne coal has been mapped (Haley and Hendricks, 1968). Information on the Upper and Lower Hartshorne coals comes mostly from the vicinity of their crop lines and mined-out areas. Almost no information on either seam was available in the southeastern part of the quadrangle, thus contour lines have not been extended into this area.

The Hartshorne coal (pl. 4) ranges in thickness from about 2 to 6 feet (0.6 to 1.8 m) and has undergone extensive mining, particularly in Arkansas. The Lower Hartshorne coal is about 2-5 feet (0.6-1.5 m) thick, and has also been mined extensively. The Upper Hartshorne coal is slightly thinner than either of the other two Hartshorne coals, ranging in thickness from 1.5 to 3.6 feet (0.5 to 1.1 m).

The structure map (pl. 5) for the Hartshorne coals indicates some faulting in the vicinity of secs. 8 and 9, T. 8 N., R. 27 E. There also seems to be some faulting of the Hartshorne Formation south of the James Fork-Greenwood syncline in the southern part of the quadrangle.

The thickness of interburden between the Upper and Lower Hartshorne coals ranges from about 50 feet (15 m) to at least 80 feet (24 m) in the southwest.

Chemical Analyses of Coal

Chemical analyses are available for the Hartshorne and Lower Hartshorne coals in the quadrangle. The available analyses are summarized in table 1, which shows average analyses as well as the range for all samples used to calculate each average value.

The coals are classified according to Fixed Carbon (FC), as determined on a dry, mineral-matter-free (mmf) basis. The "as received" FC values shown on table 1 were converted to dry mmf FC figures according to the following formula (American Society for Testing and Materials, 1980):

$$\text{Dry mmf FC} = \frac{\text{As rec'd FC} - 0.15\ S}{[100 - (M + 1.08\ A + 0.55\ S)]} \times 100$$

where M = moisture, A = ash, S = sulfur.

Based on the average fixed carbon values shown on table 1, both the Hartshorne and Lower Hartshorne coals are classified as low-volatile bituminous coals, with the Hartshorne having an average 82 percent dry mmf Fixed Carbon and the Lower Hartshorne having an average 83 percent dry mmf Fixed Carbon.

Isolated Data Points

In instances of single or isolated measurements of coal beds thicker than 1.0 foot (0.3 m), the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction, and usually precludes their correlation with other, better known beds. For this reason, isolated data points have been mapped on separate illustrations for non-isopached coal beds. These figures are not included in this report, but are kept on file at the USGS office in Denver. However, coal reserves from these isolated data points are shown in tables 2 and 3, and in the Reserve Base tonnages shown on plate 2.

The isolated data points in the Hackett quadrangle are measurements of two unnamed local coals at data point 23 (see plate 1 for location and plate 3 for correlation).

COAL RESOURCES

Data from drill holes, mine measured sections, outcrops, well logs and mine maps were used to construct outcrop, isopach, and structure contour maps of the various coal beds. The source of each indexed data point shown on plate 1 is listed in appendix 1.

According to the Bureau of Mines--U.S. Geological Survey (1976) system, coal resources are classified as either Identified or Undiscovered. Identified Resources are specific bodies of coal whose location, rank, quality and quantity are known from geologic evidence supported by specific measurements, whereas Undiscovered Resources are bodies of coal which are thought to exist, based on broad geologic knowledge and theory.

Table 1.--Average chemical analyses of coal beds in the Hackett quadrangle. [Source of data: Hendricks and Parks (1937) and Agbe-Davies (1978). Proximate and ultimate analyses in percent. Form of analysis: A, as received; C, moisture-free. To convert Btu/lb to Kj/kg, multiply by 2.324]

	Form of analysis	Hartshorne coal			Lower split of Hartshorne coal		
		Samples	Average	Range	Samples	Average	Range
				Proximate analyses			
Moisture	A	2	1.2	0.8- 1.5	6	3.9	2.9- 4.9
Volatile matter	A	2	16.9	15.5-18.2	6	15.8	15.3-16.6
	C	---	---	---	---	---	---
Fixed carbon	A	2	73.3	71.6-75.0	6	76.4	75.4-77.3
	C	---	---	---	---	---	---
Ash	A	2	8.7	6.0-11.4	6	3.9	2.4- 5.1
	C	---	---	---	---	---	---
				Ultimate analyses			
Sulfur	A	2	1.2	0.9- 1.4	6	0.9	0.7- 1.1
	C	---	---	---	---	---	---
Hydrogen	A	---	---	---	---	---	---
	C	---	---	---	---	---	---
Carbon	A	---	---	---	---	---	---
	C	---	---	---	---	---	---
Nitrogen	A	---	---	---	---	---	---
	C	---	---	---	---	---	---
Oxygen	A	---	---	---	---	---	---
	C	---	---	---	---	---	---
				Heating value			
Calories	A	---	---	---	6		7,867- 8,156
	C	---	---	---	---		---
Btu/lb	A	2	14,000	13,541-14,458	6		14,280-14,680
	C	2	---	---	---		---

Identified Resources may be subdivided into three categories of reliability of occurrence, according to their distance from a known point of coal-bed measurement. In order of decreasing reliabililty, these categories are: measured, indicated, and inferred. Measured coal is that which is located within 0.25 mile (0.4 km) from a measurement point; indicated coal extends 0.5 mile (0.8 km) beyond measured coal to a distance of 0.75 mile (1.2 km) from the measurement point; and inferred coal extends 2.25 miles (3.6 km) beyond indicated coal, or a maximum distance of 3 miles (4.8 km) from the measurement point.

Undiscovered Resources may be either hypothetical or speculative. Hypothetical resources are those undiscovered coal resources that may reasonably be expected to exist in known coal fields under known geologic conditions. They are located beyond the outer boundary of inferred resources (see above) in areas where the coal-bed continuity is assumed, based on geologic evidence. Hypothetical resources are those more than 3 miles (4.8 km) from the nearest measurement point.

Speculative resources are Undiscovered Resources that may occur in favorable areas where no discoveries have been made. Speculative resources have not been estimated in this report.

Coal resources for the Hartshorne coal and its upper and lower splits were calculated using data obtained from their coal isopach maps (pl. 4). The coal-bed acreage (measured by planimeter and calculated using the trapezoidal method modified from Hollo and Fifadara, (1980) multiplied by the average thickness of the coal bed, and by a conversion factor of 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal yields the coal resources in short tons. Coal resource tonnages were calculated for Identified Resources in the measured, indicated, and inferred categories for unleased Federal coal lands. All coal beds thicker than 1 foot (0.305 m) that lie less than 3,000 feet (914 m) below the ground surface are included in these calculations. These criteria differ from those stated in U.S. Geological Survey Bulletin 1450-B, which calls for a minimum thickness of 28 inches (70 cm) and a maximum depth of 1,000 feet (305 m) for bituminous coal. Narrow strips between mines where undisturbed coal is less than 75 meters from the nearest mine are considered to have no reserves and are included within mined-out areas. Mine boundaries are only approximately located (as explained on plate 1), and therefore these narrow areas may in reality not even exist. For this reason, they are considered to have no reserves and have not been planimetered.

Reserve Base and Reserve tonnages for the above-mentioned coal beds are shown on pages 8 and 9, and have been rounded to the nearest 10,000 short tons (9,072 metric tons). In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 1 foot (0.3 m) or more thick and under less than 3,000 feet (914 m) of overburden. Reserves are the recoverable part of the Reserve Base coal. In the southeastern Oklahoma coal field, a recovery factor of 80 percent is applied toward surface-minable coal, and a recovery factor of 50 percent is applied toward subsurface-minable coal. No recovery factor is applicable for in-situ coal gasification methods.

The total tonnage per section for both Reserve Base coal, including both surface and subsurface-minable coal, is shown in the northwest corner of each section of the Federal coal land on plate 2. All values shown on plate 2 are rounded to the nearest 10,000 short tons (9,072 metric tons), and total approximately 30.79 million short tons (27.93 million metric tons) for the entire quadrangle, including tonnages in the isolated data points. Reserve Base tonnages from the various development potential categories for surface and subsurface mining and in-situ coal gasification methods are shown in tables 2 and 3.

The authors have not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdividions have been surveyed by the BLM, approximate 40-acre (16-hectare) parcels have been used to show to limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-hectare) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 hectares) within a parcel meet the criteria for a high development potential; 25 acres (10 hectares), a moderate development potential; and 10 acres (4 hectares), a low development potential; then the entire 40 acres (16 hectares) are assigned a high development potential. For purposes of this report, any lot or tract assigned a coal development potential contains coal in beds with a nominal minimum areal extent of 1 acre (0.4 hectare).

Development Potential for Surface Mining.

Areas where the coal beds of Reserve Base thickness are overlain by 150 feet (46 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 their mining ratios (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is as follows:

$$MR = \frac{t_o\ (cf)}{t_c\ (rf)}$$ where MR = mining ratio

t_o = thickness of overbuurden, in feet
t_c = thickness of coal, in feet
rf = recovery factor (80 percent for this quadrangle)
cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data are absent or extremely limited between the 150-foot (46 m) overburden line and the coal outcrop are assigned unknown development potential for surface mining methods. This applies to areas where coal beds 1.0 foot (0.305 m) or more thick are not known but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth and attitude of the coals in these areas prevents accurate evaluation of development potential in the high, moderate, or low categories. The areas influenced by isolated data points in this quadrangle contain no coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 10. A summary of all tonnage values is presented in table 2. Of Federal coal land not subject to currently outstanding coal lease, permit, license, or preference right lease application and having a known development potential for surface mining, 13 percent is rated high, 2 percent is rated moderate, and 13 percent is rated low. The remaining Federal land (72 percent) is classified as having no development potential for surface mining.

Development Potential for Subsurface Mining and In-Situ Coal Gasification Methods

Areas considered to have a development potential for conventional subsurface mining methods are those areas where the coal beds of Reserve Base thickness are between 150 and 3,000 feet (46 to 914 m) below the surface and dip 15° or less. Unfaulted coal beds lying between 150 and 3,000 feet (46 and 914 m) below the surface, dipping more than 15°, are considered to have a development potential for in-situ coal gasification.

Areas of high, moderate, and low development potential for conventional subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 150 to 1,000 feet (46 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Areas where the coal data are absent or extremely limited between 150 and 3,000 feet (46 to 914 m) below the surface are assigned unknown development potentials. This applies to areas where coal beds of Reserve Base thickness are not known, but may occur, and to those areas influenced by isolated data points. The areas influenced by isolated data points in this quadrangle contain approximately 1.58 million short tons (1.43 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 11. Tonnage values are summarized in table 3. Of Federal coal land having a known development potential for conventional subsurface mining methods, 88 percent is rated high, none is rated moderate, and none is rated low. The remaining Federal land (12 percent) in the quadrangle is classified as having no development potential for conventional subsurface mining methods.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 15° and 35°, regardless of tonnage, have a low development potential for in-situ coal gasification methods. Beds dipping from 35° to 90°, with a minimum of 50 million tons of coal in a single unfaulted bed or multiple, closely spaced, approximately parallel beds have a moderate development potential for in-situ coal gasification methods. Coal lying between the 150-foot (46-m) overburden isopach and the outcrop is not included in total coal tonnages available, because it is needed for cover and containment in the in-situ process. There is no development potential for in-situ coal gasification in the Hackett quadrangle.

Table 2.--Coal Reserve Base data for surface mining methods for Federal coal land (in short tons)

Coal bed	High development potential	Moderate development potential	Low development potential	Total
Upper Hartshorne	230,000	120,000	1,180,000	1,530,000
Hartshorne	---	30,000	1,160,000	1,190,000
Lower Hartshorne	790,000	350,000	810,000	1,950,000
TOTAL	1,020,000	500,000	3,150,000	4,670,000

Table 3.--Coal Reserve Base data for subsurface mining methods for Federal coal land (in short tons)

Coal bed	High development potential	Moderate development potential	Low development potential	Unknown development potential	Total
Upper Hartshorne	5,170,000	---	---	---	5,170,000
Hartshorne	14,290,000	---	---	---	14,290,000
Lower Hartshorne	5,080,000	---	---	---	5,080,000
Isolated Data Points	---	---	---	1,580,000	1,580,000
TOTAL	24,540,000	---	---	1,580,000	26,120,000

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APPENDIX I. SOURCE AND RELIABILITY OF DATA USED ON PLATE 1.

Listed below is a point by point accounting as to the source and reliability of all information shown on Plate 1. Also presented are any notes or comments pertaining to individual data points.

DATA POINT #	LOCATION	INCREASING RELIABILITY →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE SE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 35	Overburden	-	-	-	-	-	plate 3	tion.
1	T 7 N | R 32 W	Coal Thickness				x			
	NE SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 35	Overburden	-	-	-	-	-	plate 3	tion.
2	T 7 N | R 32 W	Coal Thickness				x			
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 35	Overburden	-	-	-	-	-	plate 3	tion.
3	T 7 N | R 32 W	Coal Thickness				x			
	SW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 35	Overburden	-	-	-	-	-	plate 3	tion.
4	T 7 N | R 32 W	Coal Thickness				x			
	SE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden	-	-	-	-	-	plate 3	tion.
5	T 7 N | R 32 W	Coal Thickness				x			
	NW SE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden		-	-	-		plate 3	tion.
6	T 7 N | R 32 W	Coal Thickness				x			
	SE SE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden		-	-	-		plate 3	tion.
7	T 7 N | R 32 W	Coal Thickness				x			
	SW SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden		-	-	-		plate 3	tion.
8	T 7 N | R 32 W	Coal Thickness				x			
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden		-	-	-		plate 3	tion.
9	T 7 N | R 32 W	Coal Thickness				x			
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 34	Overburden		-	-	-		plate 3	tion.
10	T 7 N | R 32 W	Coal Thickness				x			
	NE SE	Location			x			Haley and Hendricks, 1968,	Asssumed Bore Hole
	Section 33	Overburden		-	-	-		plate 3	
11	T 7 N | R 32 W	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	SE NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 33	Overburden		-	-	-		plate 3	
12	T 7 N | R 32 W	Coal Thickness				x			
	SE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 33	Overburden		-	-	-		plate 3	
13	T 7 N | R 32 W	Coal Thickness				x			
	CSL	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 33	Overburden		-	-	-		plate 3	
14	T 7 N | R 32 W	Coal Thickness				x			
	SE SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 33	Overburden		-	-	-		plate 3	
15	T 7 N | R 32 W	Coal Thickness				x			
	SE NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 32	Overburden		-	-	-		plate 3	
16	T 7 N | R 32 W	Coal Thickness				x			
	SW SW	Location			x			Shamrock O & G, J. A. Yates	TD Varies with log. D &
	Section 15	Overburden				x		#1, 1967	Ind. logs used.
17	T 9 N | R 27 E	Coal Thickness		x					
	SW SE	Location			x			Agbe-Davies, 1978, Bore	
	Section 17	Overburden			x			Hole VI	
18	T 9 N | R 27 E	Coal Thickness			x				
	SE SW	Location			x			USGS Files Bore Hole DCC9,	Upper & Lower Hartshorne
	Section 18	Overburden				x		1946	benches
19	T 9 N | R 27 E	Coal Thickness			x				
	SE SE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 24	Overburden		-	-	-		plate 3	
20	T 9 N | R 26 E	Coal Thickness				x			
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 19	Overburden		-	-	-		plate 3	
21	T 9 N | R 27 E	Coal Thickness				x			
	NW SW	Location			x			USGS Files Bore Hole DCC6,	Upper & Lower Hartshorne
	Section 19	Overburden				x		1946	benches
22	T 9 N | R 27 E	Coal Thickness			x				
	SE NW	Location			x			LeFlore Co. Gas & Elec., W.	Coal shown on driller's
	Section 19	Overburden			x			Pipkin #1 WL & driller's	log to be slough.
23	T 9 N | R 27 E	Coal Thickness		x				log	
	SW SW	Location			x			USGS Files Bore Hole DCC2,	Upper & Lower Hartshorne
	Section 19	Overburden				x		1946	benches
24	T 9 N | R 27 E	Coal Thickness			x				

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	SE SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 19	Overburden		-	-	-		plate 3	
25	T 9 N | R 27 E	Coal Thickness				x			
	SE NE	Location			x			USGS files Bore Hole, DCC7,	Upper & Lower Hartshorne
	Section 19	Overburden				x		1946	benches
26	T 9 N | R 27 E	Coal Thickness			x				
	CWL, of SW SW NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole
	Section 20	Overburden		-	-	-		plate 3	
27	T 9 N | R 27 E	Coal Thickness				x			
	SW SW	Location		x				Knechtel, 1949, plate 2,	
	Section 20	Overburden			x			table 3, Bore Hole #1	
28	T 9 N | R 27 E	Coal Thickness				x			
	SW NW	Location			x			USGS Files Bore Hole DCC7,	Upper & Lower Hartshorne
	Section 21	Overburden				x		1946	benches.
29	T 9 N | R 27 E	Coal Thickness			x				
	NW SW	Location			x			Haley & Hendricks, 1968,	Assumed Bore Hole
	Section 21	Overburden		-	-	-		plate 3	
30	T 9 N | R 27 E	Coal Thickness				x			
	NE SE	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 5	Overburden		-	-	-		plate 3	tion.
31	T 6 N | R 32 W	Coal Thickness				x			
	SE NE	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 5	Overburden		-	-	-		plate 3	tion.
32	T 6 N | R 32 W	Coal Thickness				x			
	NW NW	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden		-	-	-		plate 3	tion.
33	T 6 N | R 32 W	Coal Thickness				x			
	NE NW	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden		-	-	-		plate 3	tion.
34	T 6 N | R 32 W	Coal Thickness				x			
	NE NW	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden		-	-	-		plate 3	tion.
35	T 6 N | R 32 W	Coal Thickness				x			
	NW NE	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden		-	-	-		plate 3	tion.
36	T 6 N | R 32 W	Coal Thickness				x			
	NW NE	Location			x			Haley & Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden		-	-	-		plate 3	tion.
37	T 6 N | R 32 W	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden	-	-	-	-	-	plate 3	tion.
38	T 6 N R 32 W	Coal Thickness				x			
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden	-	-	-	-	-	plate 3	tion.
39	T 6 N R 32 W	Coal Thickness				x			
	SE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden	-	-	-	-	-	plate 3	tion.
40	T 6 N R 32 W	Coal Thickness				x			
	SE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 4	Overburden	-	-	-	-	-	plate 3	tion.
41	T 6 N R 32 W	Coal Thickness				x			
	SW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
42	T 6 N R 32 W	Coal Thickness				x			
	NW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
43	T 6 N R 32 W	Coal Thickness				x			
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
44	T 6 N R 32 W	Coal Thickness				x			
	SE NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
45	T 6 N R 32 W	Coal Thickness				x			
	NW NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
46	T 6 N R 32 W	Coal Thickness				x			
	NW NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
47	T 6 N R 32 W	Coal Thickness				x			
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 3	Overburden	-	-	-	-	-	plate 3	tion.
48	T 6 N R 32 W	Coal Thickness				x			
	NW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 2	Overburden	-	-	-	-	-	plate 3	tion.
49	T 6 N R 32 W	Coal Thickness				x			
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 2	Overburden	-	-	-	-	-	plate 3	tion.
50	T 6 N R 32 W	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	SE NW	Location	x					Agbe-Davies, 1978, Bore	Appears to be old driller's
	Section 27	Overburden			x			Hole V-20	log.
51	T 9 N R 27 E	Coal Thickness			x				
	SW SW NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 28	Overburden	-	-	-	-	-	plate 3	
52	T 9 N R 27 E	Coal Thickness				x			
	SE SE NW	Location			x			Agbe-Davies, 1978, Bore	Appears to be mine measured
	Section 28	Overburden	-	-	-	-	-	Hole V-21	section.
53	T 9 N R 27 E	Coal Thickness			x				
	NE NW	Location			x			USGS files, Bore Hole	Upper and Lower Hartshorne
	Section 28	Overburden				x		DCC-4A, 1946	benches.
54	T 9 N R 27 E	Coal Thickness			x				
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 28	Overburden	-	-	-	-	-	plate 3	
55	T 9 N R 27 E	Coal Thickness				x			
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 28	Overburden	-	-	-	-	-	plate 3	
56	T 9 N R 27 E	Coal Thickness				x			
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
57	T 9 N R 27 E	Coal Thickness				x			
	NE NE	Location			x			USGS files, Bore Hole DCC3	Upper and Lower Hartshorne
	Section 29	Overburden				x		1946	benches.
58	T 9 N R 27 E	Coal Thickness			x				
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
59	T 9 N R 27 E	Coal Thickness				x			
	SE NW	Location		x				Knechtel, 1949, Bore Hole	Dirty coal reported U & L
	Section 29	Overburden			x			#4, plate 2, table 3	Hartshorne benches. Unsure
60	T 9 N R 27 E	Coal Thickness				x			of correlation of L. H.
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
61	T 9 N R 27 E	Coal Thickness				x			
	SE NW	Location		x				Knechtel, 1949, Bore Hole	U & L Hartshorne benches.
	Section 29	Overburden			x			#5, plate 2, table 3	Unsure of correlation of
62	T 9 N R 27 E	Coal Thickness				x			L. H. coal. Agbe-Davies #24
	NE SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
63	T 9 N R 27 E	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NW SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
64	T 9 N | R 27 E	Coal Thickness				x			
	NE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
65	T 9 N | R 27 E	Coal Thickness				x			
	SW NW	Location		x				Knechtel, 1949, plate 3,	U & L Hartshorne benches.
	Section 29	Overburden			x			Bore Hole #3	Unsure of correlation of
66	T 9 N | R 27 E	Coal Thickness				x			L. H. Agbe-Davies #26.
	NW NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 29	Overburden	-	-	-	-	-	plate 3	
67	T 9 N | R 27 E	Coal Thickness				x			
	NW NW	Location					x	Senate Document 390, 1910,	Also in Knechtel, 1949,
	Section 29	Overburden					x	p. 67, Bore Hole #29	Bore Hole #2.
68	T 9 N | R 27 E	Coal Thickness					x		
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 30	Overburden	-	-	-	-	-	plate 3	
69	T 9 N | R 27 E	Coal Thickness				x			
	NW NE	Location		x				Knechtel, 1949, plate 2,	U & L Hartshorne benches.
	Section 30	Overburden			x			table 3, Bore Hole #6	Unsure of correlation of
70	T 9 N | R 27 E	Coal Thickness				x			L. H.
	SW NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 20	Overburden	-	-	-	-	-	plate 3	
71	T 9 N | R 27 E	Coal Thickness				x			
	SE SE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 30	Overburden	-	-	-	-	-	plate 3	
72	T 9 N | R 27 E	Coal Thickness				x			
	SW SE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 30	Overburden	-	-	-	-	-	plate 3	
73	T 9 N | R 27 E	Coal Thickness				x			
	SW SW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 30	Overburden	-	-	-	-	-	plate 3	
74	T 9 N | R 27 E	Coal Thickness				x			
	SW NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 30	Overburden	-	-	-	-	-	plate 3	
75	T 9 N | R 27 E	Coal Thickness				x			
	NE NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 36	Overburden	-	-	-	-	-	plate 3	
76	T 9 N | R 26 E	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NW NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 23	Overburden	-	-	-	-	-	plate 3	
77	T 6 N | R 32 W	Coal Thickness				x			
	NW NE SW	Location			x			Haley and Hendricks, 1968,	Mine shaft.
	Section 23	Overburden	-	-	-	-	-	plate 3	
78	T 6 N | R 32 W	Coal Thickness				x			
	SW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 23	Overburden	-	-	-	-	-	plate 3	tion.
79	T 6 N | R 32 W	Coal Thickness				x			
	SW NW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 23	Overburden	-	-	-	-	-	plate 3	tion.
80	T 6 N | R 32 W	Coal Thickness				x			
	SW NE	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 22	Overburden	-	-	-	-	-	plate 3	tion.
81	T 6 N | R 32 W	Coal Thickness				x			
	SW NE	Location			x			Haley and Hendricks, 1968,	
	Section 21	Overburden	-	-	-	-	-	plate 3	
82	T 6 N | R 32 W	Coal Thickness				x			
	SW SW	Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 21	Overburden	-	-	-	-	-	plate 3	tion.
83	T 6 N | R 32 W	Coal Thickness				x			
	NE SW	Location			x			Haley and Hendricks, 1968,	Slope mine. Surface open-
	Section 7	Overburden	-	-	-	-	-	plate 3	ing on coal bed.
84	T 8 N | R 27 E	Coal Thickness				x			
	SE SW	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 91.
	Section 7	Overburden			x			table 3, Bore Hole #2	
85	T 8 N | R 27 E	Coal Thickness				x			
	NW SE	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 92.
	Section 7	Overburden			x			table 3, Bore Hole #3	
86	T 8 N | R 27 E	Coal Thickness				x			
	NW SE	Location			x			Haley and Hendricks, 1968,	Slope mine. Surface open-
	Section 7	Overburden	-	-	-	-	-	plate 3	ing on coal bed.
87	T 8 N | R 27 E	Coal Thickness				x			
	NE SE	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 94.
	Section 7	Overburden			x			table 3, Bore Hole #4	
88	T 8 N | R 27 E	Coal Thickness				x			
	NE SE	Location					x	USGS files, Reeves Coal	Section of strip pit well.
	Section 7	Overburden			x			Co. Mine Map, 1954	
89	T 8 N | R 27 E	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NW SW	Location			x			Haley and Hendricks, 1968,	Slope mine. Surface open-
	Section 8	Overburden	-	-	-	-	-	plate 3	ing on coal bed.
90	T 8 N R 27 E	Coal Thickness				x			
	NW SW	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 94.
	Section 8	Overburden			x			table 3, Bore Hole #5	
91	T 8 N R 27 E	Coal Thickness				x			
	NW SW	Location					x	USGS files, Reeves Coal Co.	Dip 70^{o} +.
	Section 8	Overburden	-	-	-	-	-	Mine Map, 1954	
92	T 8 N R 27 E	Coal Thickness				x			
	SW SW	Location					x	USGS files, Reeves Coal Co.	
	Section 8	Overburden	-	-	-	-	-	Mine Map, 1954	
93	T 8 N R 27 E	Coal Thickness				x			
	SE SW	Location					x	USGS files, Reeves Coal Co.	
	Section 8	Overburden	-	-	-	-	-	Mine Map, 1954	
94	T 8 N R 27 E	Coal Thickness				x			
	SW SE	Location			x			USGS files, Reeves Coal Co.	
	Section 8	Overburden	-	-	-	-	-	Mine Map, 1954	
95	T 8 N R 27 E	Coal Thickness			x				
	NW SE	Location					x	BLM Emria Project, 1979	No logs from 111.0 to 122.5
	Section 8	Overburden					x	Bore Hole DH-AB-15	(last 11.5'), hit old mine
96	T 8 N R 27 E	Coal Thickness					x		workings.
	SE NW	Location		x				Knechtel, 1949, plate 2,	Top coal described as shaly
	Section 8	Overburden			x			table 3, Bore Hole #6	coal. Agbe-Davies pt. 95.
97	T 8 N R 27 E	Coal Thickness				x			
	SW NE	Location		x				Knechtel, 1949, plate 2,	3' Boney coal described as
	Section 8	Overburden			x			table 3, Bore Hole #7	"dirty coal".
98	T 8 N R 27 E	Coal Thickness			x				
	SW NE	Location			x			Haley and Hendricks, 1968,	Slope mine. Surface open-
	Section 8	Overburden	-	-	-	-	-	plate 3	ing on coal bed.
99	T 8 N R 27 E	Coal Thickness				x			
	SE NE	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 96.
	Section 8	Overburden			x			table 3, Slope Measured	
100	T 8 N R 27 E	Coal Thickness				x		Section #8	
	SE NE	Location		x				Knechtel, 1949, plate 2,	Boney coal described as
	Section 8	Overburden			x			table 3, Bore Hole #9	"dirty coal".
101	T 8 N R 27 E	Coal Thickness			x				
	NE SE	Location					x	USGS files, Reeves Coal Co.	Dip 70^{o} +.
	Section 8	Overburden				x		Mine Map, 1954	
102	T 8 N R 27 E	Coal Thickness				x			

DATA POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE SE	Location					x	USGS files, Reeves Coal Co.	Dip 70° +.
	Section 8	Overburden				x		Mine Map, 1954	
103	T 8 N R 27 E	Coal Thickness				x			
	NE SE	Location					x	USGS files, Reeves Coal Co.	Dip 70° +.
	Section 8	Overburden				x		Mine Map, 1954	
104	T 8 N R 27 E	Coal Thickness				x			
	SE SE	Location					x	USGS files, Reeves Coal Co.	Dip 70° +, with "no dip"
	Section 8	Overburden				x		Mine Map, 1954	interburden, approx. 50'.
105	T 8 N R 27 E	Coal Thickness				x			
	SW NW	Location		x				Knechtel, 1949, plate 2,	
	Section 9	Overburden			x			table 3, Bore Hole #10	
106	T 8 N R 27 E	Coal Thickness				x			
	SE NW	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 9	Overburden	-	-	-	-	-	plate 3	
107	T 8 N R 27 E	Coal Thickness				x			
	SE NW	Location		x				Knechtel, 1949, plate 2,	
	Section 9	Overburden			x			table 3, Bore Hole #11	
108	T 8 N R 27 E	Coal Thickness				x			
	NW SE	Location		x				Knechtel, 1949, plate 2,	Both coals described as
	Section 9	Overburden			x			table 3, Bore Hole #12	"dirty". Agbe-Davies pt.
109	T 8 N R 27 E	Coal Thickness				x			98B.
	SE NE	Location		x				Knechtel, 1949, plate 2	
	Section 9	Overburden			x			table 3, Bore Hole #13	
110	T 8 N R 27 E	Coal Thickness			x				
	NE SE	Location					x	BLM Emria project, 1979,	
	Section 9	Overburden					x	Bore Hole #DH-AB-14	
111	T 8 N R 27 E	Coal Thickness					x		
	SW NW	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 99. Boney
	Section 10	Overburden			x			table 3, Bore Hole #14	coal described as "dirty
112	T 8 N R 27 E	Coal Thickness			x				coal".
	SE SW NW	Location			x			Haley and Hendricks, USGS	Assumed Bore Hole.
	Section 10	Overburden	-	-	-	-	-	Prof. Papers, 1968, plate 3	
113	T 8 N R 27 E	Coal Thickness				x		536-A	
	SE NW	Location		x				Knechtel, 1949, plate 2,	Agbe-Davies pt. 99C.
	Section 10	Overburden			x			table 3, Bore Hole #15	
114	T 8 N R 27 E	Coal Thickness				x			
	CSW NE	Location			x			Haley and Hendricks, 1968,	Assumed Bore Hole.
	Section 10	Overburden	-	-	-	-	-	plate 3	
115	T 8 N R 27 E	Coal Thickness				x			

DATA POINT #	LOCATION		INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE NE		Location			x			Haley and Hendricks, 1968,	Assumed composite mine sec-
	Section 29		Overburden	-	-	-	-	-	plate 3	tion.
116	T 6 N	R 32 W	Coal Thickness				x			
	NE NE SW		Location			x			Paul DeCleva, Farrar #1,	Ind. Gamma logs.
	Section 19		Overburden				x		1971	
117	T 8 N	R 27 E	Coal Thickness	-	-	-	-	-		
	SE NW		Location			x			Kingwood Oil, Farrar #1,	Ind. Gamma logs.
	Section 29		Overburden				x		1966	
118	T 8 N	R 27 E	Coal Thickness	-	-	-	-	-		

APPENDIX II TABLES OF OIL AND GAS TEST HOLES

Note: "Top Log Int." refers to the measured depth to the top of the interval logged by the particular sonde. Driller log total depth, referenced to K.B. or D.F., has been abbreviated to T.D. (Note: This may vary from T.D. referenced to G.L.). The measured depth at which coal is reported on the scout card appears in the column titled "Scout Card Coal". The column titled "Harts./Drill./Scout" contains the measured depths drilled to the top of the Hartshorne Sandstone, as reported by the driller logs and the scout cards.

* Logged interval stratigraphically below Hartshorne Coals.

Sec-Tn-Rg	Operator/Farm Location	Driller Logs Coal Reported Thickness & Depth	Scout Card Coal	Harts. Drill. Scout	Top Log Int. Gamma Elec.	Top Log Int. Dens. Sonic	T.D. Year
3-5-32	Stephens/#1 Williams						7950
	1145 FNL 640 FWL		NR	NR			1973
8-5-32	Stephens/#1 Cox						11615
	100 FNL 825 FWL of SE/4		NR	NR			1972
9-5-32	Stephens/#1 Bell Unit						9741
	400 FNL 400 FEL of SW/4		NR	NR			1972
10-5-32	Stephens/#1 Skyline Farm						8094
	540 FSL 540 FWL of NE/4		NR	NR			1972
11-5-32	No information, location only						
1-6-32	No information, location only						
2-6-32	Shell Oil/#1 Young						8150
	1980 FSL 1980 FWL		NR	NR			1963
3-6-32	Shell Oil/#2-3 Acee Pure Milk						8230
	1500 FSL 1320 FEL		NR	NR			1975
3-6-32	Shell Oil/#1 Acee Milk						8182
			NR	NR			1963
4-6-32	Shell Oil/#1 Douglas						
	1446 FSL 1477 FEL		NR	NR			1964
5-6-32	Ark. La Gas/#1 Clarkland, Inc.						
	475 FSL 925 FEL NE/4						
3-8-27	Oxley/#1 Spradley			NR	*		7704
	W/2 E/2 W/2 E/2 or 2640 FSL 3528 FWL	NR	NR	NR			1971
4-8-27	Monsanto/#1 Bustin			NR	816*		8493
	NE SW NW	NR	NR	NR	816*		1966

il

Sec-Tn-Rg	Operator/Farm Location	Driller Logs Coal Reported Thickness & Depth	Scout Card Coal	Harts. Drill. Scout	Top Log Int. Gamma Elec.	Dens. Sonic	T.D. Year
4-8-27	Oxley/#1 Bassinger			NR	2000*		7875
	2140 FSL 1910 FWL	NR	NR	NR	2000*		1969
5-8-27	Galaxy/#G.I.A. Sweeten			NR	947*		8283
	SW NW NW NE	NR	NR	NR	947*		1970
5-8-27	Diamond-Shamrock/#1 F. Sweeten			NR	B		8235
	1432 FSL 1164 FWL of SE/4	NR	NR	NR			1974
6-8-27	Shell/#1-16 Hargrove			NR	740*		7708
	1920 FSL 1020 FWL SE NW SE	NR	NR	NR	740		1965
7-8-27	Leflore G&E/#27 McClure			NR			2771
	NW NE SW NW	NR					1923
7-8-27	Hadson/#1-7 Moser			NR			
	1320 FSL 2454 FWL of NW/4	NR					
8-8-27	Diamond-Shamrock/#1-8 Dean Bustin			NR	418		8260
	S/2 SW NE NE	NR			418		1973
9-8-27	Diamond-Shamrock/#1 E. Johnson			NR	450	450	8100
	1400 FSL 1340 FWL of NE/4	NR	NR	NR	450		1970
9-8-27	Diamond-Shamrock/#2 E. Johnson			NR	432	404	7457
	1520 FNL 1320 FEL	NR	NR	NR	432		1977
10-8-27	Diamond-Shamrock/#1 C. S. Cantwell			NR	150	400	7905
	1300 FSL 675 FWL of NE/4	NR	NR	NR	150		1969
15-8-27	No information, location only						
16-8-27	Monsanto/#1 Frankie			NR		1800*	7038
	SE NW	NR	NR	NR	675		1966
18-8-27	LeFlore G & E/#26 Littman			NR			2657
	NW NE NE NW	NR					1922
19-8-27	P. DeCleva/#1 Farrar			NR	796		6064
	CNE NE SW	NR	NR	NR	796		1971
20-8-27	Cotton/#1 Farrar			NR			7015
	1470 FSL 1320 FWL	NR	NR	NR			1975
29-8-27	Kingwood/#1 Farrar			NR	795	6510*	8011
	SE NW	NR	NR	1345	795		1966
29-8-27	Headington/#1 Howard			NR			5966
	CSW	NR	NR	NR			1974
32-8-27	LeFlore G & E/#22 Mooneyham			NR			2487
	NW SE NW NW	NR	NR				1921

Sec-Tn-Rg	Operator/Farm Location	Driller Logs Coal Reported Thickness & Depth	Scout Card Coal	Harts. Drill. Scout	Top Log Int. Gamma Elec.	Dens. Sonic	T.D. Year
34-8-27	Stephens/#3 W. Waters			NR	1148		8777
	2040 FSL 1570 FWL	NR	NR	NR	1148		1972
15-9-27	Shamrock/#1 J. A. Yates (OWWO)			NR	608	608	8475
	NE SW SW	NR	NR	NR	608		1967
19-9-27	LeFlore G & E/#1 W. Pipkins			NR			6757
	SE NW	4' @ 496	497	NR			1956
19-9-27	French & Walker/#1 Morris						7177
	CSW NE NW		NR	NR			1978
19-9-27	S. Gose/#1 Love			NR		6650	8222
	3382 FSL 3382 FWL	NR			640		1964
28-9-27	Stephens/#1 W. D. Freeman			NR	600		7764
	NW NW SE	NR	NR	NR			1967
29-9-27	Monsanto/#1 Noe			NR	832	2150	7770
	NW NW SE	NR	NR	NR	832		1967
29-9-27	Texas O & G/#1 Zahn			1874			8400
	W/2 W/2 E/2 SW	NR	NR	1874			1978
31-9-27	LeFlore G & E/#1 Backbone						4845
	CSW SW		NR	NR			1946
31-9-27	LeFlore G & E/#1 Tompos			NR			4840
	CSW SW	NR	NR	NR			1943
31-9-27	Oxley/#1 Johnson				721		8338
	60 FSL 1300 FWL of NE/4		NR	NR	721		1971
31-9-27	No information, location only						
32-9-27	Monsanto/#1 Hardin			NR			8220
	SE NW SE	NR	NR	NR	815		1966
33-9-27	Hamon & Oxley/#1 P.H. Hardin "C"			NR	913	4400	8252
	NE SW	NR	NR	NR	913		1968
34-9-27	Oxley/#1 Miller			NR		4600	7776
	1371 FSL 1321 FEL of SW/4	NR	NR	NR	680		1971