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Preliminary Evaluation of the Coal Resources for Part of the Wilcox Group (Paleocene through Eocene), Central Texas

by

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Abstract

The Wilcox Group of central Texas contains shallow (<500 ft¹) coal deposits that are mined for use in mine-mouth electric power generating plants. These coal deposits range in apparent rank from lignite to sub-bituminous (Tewalt, 1986), and are similar in rank and composition to shallow coal deposits in the northeast and south Texas areas (fig. 1). The coal zones and associated strata in the central Texas study area generally dip to the southeast toward the Gulf of Mexico coastline and basin center. The central Texas resource assessment area includes parts of eight counties (fig. 2). The assessment area was selected to encompass current mining areas and because of the availability of subsurface stratigraphic data in the area. The assessment area is roughly 160 miles long and 5 to 25 miles wide and generally follows the outcrop of the Paleocene - Eocene Wilcox Group in central Texas (figs. 1 and 2). Approximately 1,800 subsurface stratigraphic records from rotary and core drill holes were used to assess the resources of the central Texas assessment area. Of the 1,800 drill holes, only 168 are public data points and are primarily located in the areas that have been permitted for surface mining (fig. 2; Appendix 1). The remaining 1632 drill holes, which are distributed throughout the assessment area, were provided to the U.S. Geological Survey (USGS) on a confidential basis by various coal companies for use in regional studies. Nine coal zones were identified and assessed in the central Texas assessment area. Several other coal zones (as many as 9 unassessed zones) were identified but were not assessed due to the thinness of the coal beds or the lack of deep stratigraphic data (fig. 3). A total of 7.7 billion short tons of coal was identified in this assessment that excluded the resources within current coal mine lease areas (fig. 2).

Corresponding maps were constructed to show the overburden, structure contour of the top of the coal zone, and cumulative coal-zone thickness for each of the nine coal zones. Warwick and Crowley (1995) offer a discussion of the general geologic setting and stratigraphy of the central Texas study area, and Tewalt (1986) presents a discussion of the coal quality aspects of the central Texas study area.

¹ The U.S. Geological Survey uses English measurements for assessments. Conversions for English measurements include: (1) 1 metric ton = 1.102 US short tons; (2) 0.454 kg = 1 lb; (3) 1 km² = 0.3861 miles² (4) 1 ft = 0.3048 m; (5) Btu = 0.252 kcal = 0.001055 MJ = 2.931 x 10⁻⁴ kWh, Btu/lb = 429.92 MJ/kg, 1 lb X/MMbtu = 0.43kg X/MJ metric ton; (6) 1 Tcf = 2 x 10¹⁶ g CH₄.

Stratigraphy

The Wilcox Group coal-bearing intervals of the Calvert Bluff and Hooper Formations in the central Texas study area contain as many as 18 coal zones. Nine of these coal zones that are currently mined have been assessed during this study. The assessed coal zones are NCZ5, NCZ6, NCZ8, NCZ9, CCZ4, CCZ5, SCZ4, SCZ6, and SCZ8 and are shown in red on figure 3. The other coal zones that were not assessed are either not mined or are not the major coal target for extraction in central Texas surface mines.

Each coal zone is composed of multiple coal beds that merge and split in distances that can be less than a few hundred feet. This rapid lateral change in lithology and the lack of closely spaced stratigraphic data prevent individual coal beds and zones from being traced throughout the entire length of the study area (160 miles). To accommodate local correlation, the central Texas study area has been divided into three subzones for the purposes of coal zone correlation and resource assessment. These areas are defined as the northern, central, and southern assessment areas of the central Texas study area (fig. 3). The coal zone nomenclature used for the northern subarea generally follows that established by the Northwestern Resources Company for the Jewett mine (Palmquist, 1987; Jewett mine permit applications on file at the Railroad Commission of Texas, Surface Mining and Reclamation Division, in Austin, Texas) (figs. 2 and 3; table 1). The coal zone names used for the central and southern assessment areas are modified from the bed numbering system that is used in the northern part of the central Texas assessment area and at the Jewett mine (fig. 3). Coal zone names in the northern assessment area have “NCZ” prefixes, central area coal zone names have “CCZ” prefixes, and coal zone names in the southern resource area have “SCZ” prefixes (figs. 3 and 4). Original mine permit coal zone or bed nomenclature is also shown on figure 3. Regional correlations carried out during this assessment are illustrated on a series of cross sections (figs. 4-7). In general the coal zones dip to the southeast toward the Gulf of Mexico basin center.

Methods

The methods used for calculating resources for the central Texas assessment blocks generally follow those described by Tewalt (1998), Roberts and others (1998), and Roberts and Biewick (1999). Stratigraphic data were collected from a number of public and private sources. Public data sources are outlined on table 1. The data were entered into a drill-hole data management software program (StratiFact) and a geologist made the correlations for the major coal zones. The presence of adjacent lithologies (sandstone, mudstone, and so forth) was taken into account as an aid in correlation. Depositional patterns of sandstones and coal beds were used to further validate the correlations. Definition of coal zones follows the procedure outlined in Wood and others (1983) where partings greater than 3/8 in were excluded from individual coal beds that form the coal zone. Coal beds separated from the coal zone by partings greater than the thickness of the overlying or underlying coal bed were not included in the coal zone. Drill hole locations and surface elevations were checked against 1:250,000- and 1:100,000-scale USGS Digital Elevation Models (DEM) and 1:24,000 scale topographic maps. Only drill hole records that have elevations within ± 25 ft of the DEM were used for the approximately 1,800 drill hole assessment data set. Once the coal zones were correlated and surface elevations checked, drill hole point names and values for point locations, elevations of coal zone tops, and cumulative coal thicknesses for each zone (Appendix 1) were imported into earthVision, a gridding and modeling software. A grid model is a net-like map generated by the computer that averages thickness and elevation data for a group of data points that fall within a particular cell of pre-set

dimensions. Grid models were made from individual coal zone thickness and structural top data. The grid created for the structural top of the coal zone was subtracted from the 1:250,000-scale DEM for the study area to produce a grid of overburden thickness for each coal zone. Areas on each structural-top grid model where the top of the coal zone exceeded the value of the DEM were used to define areas where surface erosion has removed the coal zone. The eroded areas were excluded from the resource calculations.

The resulting coal zone thickness and overburden grids were contoured using earthVision following the intervals for lignite and overburden thickness suggested by Wood and others (1983). The four lignite thickness categories suggested by Wood and others (1983) are as follows: 2.5-5 ft, 5-10 ft, 10-20 ft, and 20-50 ft. Because in some areas of the Gulf Coastal plain coal beds as thin as 1.5 ft are mined, a fifth coal thickness category (1.5 – 2.5 ft) was used for resource calculations in this assessment. The coal resource classification system outlined by Wood and others (1983) uses geologic assurance categories that are based on a measured distance from a data point or drill hole. The specified distances from drill holes (control points) are defined by reliability circles: 0-0.25 mi radius for measured category coal; 0.25-0.75 mi radius for indicated, 0.75-3 mi for inferred, and beyond 3 mi radius for hypothetical coal. In this study, the created contour maps (coal zone total coal thickness, overburden, and structure contour) were transferred to a Geographic Information System (ArcInfo) and unioned into one coverage that included (1) reliability circles of coal resources (measured, indicated, inferred, and hypothetical resources following Wood and others, 1983), (2) USGS 1:100,000-scale county boundaries, (3) USGS 7.5' topographic quadrangle boundaries, (4) coal zone eroded areas, and (5) mine permit boundaries (table 1). The unioned coverage was then transferred back to earthVision for resource calculation using the volumetrics function of the software package. The parameters for lignite density (1.29 g/cm^3) and short tons per acre-foot (1,750) follow that of Wood and others (1983). The resulting earthVision resource data table was converted to an ASCII text table and joined with the unioned resource coverage in ArcView. The resulting data attribute table was exported to an Excel spreadsheet to produce pivot tables for the resources of each coal zone. Coal resources are reported for each coal zone in millions of short tons (Appendix 2), and exclude eroded areas and areas within mine permit boundaries.

Results

Maps

A total of nine coal zone intervals (fig. 3) in the central Texas study area were evaluated for coal resources using the methods described above. The zones are separated into three areas, northern, central and southern (fig. 8). The geology of each coal zone is illustrated on a series of maps (figs. 9-17). Each coal zone map series (a-d) contains: a) an outline of the coal zone boundaries used for resource calculation, public data point locations (shown only if public data are available), and mine lease boundaries and mined-out areas (as of 1998) (figs. 9a-17a); b) a structure contour map that was created from gridding the elevation values for the coal zone top derived from the stratigraphic database (figs. 9b-17b); c) an overburden map that was produced by subtracting the coal-zone-top structure contour grid from the 1:250,000 scale USGS DEM grid for the area, and eroded areas where the structure contour grid intersects the DEM grid (figs. 9c-17c); and d) a cumulative coal thickness (created by gridding the total of the coal zone thickness values derived from the stratigraphic database, figs. 9d-17d).

There are several general comments that apply to all coal zone maps. For all nine coal

zones, the amount of overburden generally increases to the southeast (figs. 9c-17c) because the structurally lowest parts of the coal zones generally occur along the southeastern boundary of the assessment area (figs. 9b-17b). These overburden and structural trends are related to the regional southeasterly dip of the Wilcox Group strata in the study area. Coal zone thickness trends indicate that a pod-like thickening of the coal zones occurs in some areas of each assessment zone. These thickness increases are probably related to the depositional trends of individual coal zones (figs. 9d-17d). The coal mines tend to be located in areas where the coal zones are thicker than found in surrounding areas. Some coal zones have thin-coal areas that are elongate northwest to southeast across the assessed coal zone (figs. 9d, 12d, 13d, and 15d-17d). Figure 11d shows a curvilinear thin-coal area in the southeastern part of the assessed area. These thin-coal areas may represent places where contemporaneous sediment-laden river channels may have continuously provided the area with clastic sediment and prevented the peat from forming a thick-coal zone. Alternatively, the thin-coal zones may represent areas where the coal zone was removed by erosion subsequent to peat deposition. Such erosional features have been observed in mine highwalls in the study area. The areas of thick coal accumulation may have been located on the flanks of sandstone-rich paleo-channel complexes. Palmquist (1987) observed such a relationship in the Jewett mine area, and suggested that thick coals form in areas away from areas of high sand deposition by contemporaneous paleo-channels. One such area is illustrated on figure 6, where coal zone NCZ6 contains thicker coal beds on the left side of the diagram and thin coal beds on the right side of the diagram where thick sandstone deposits split the coal zone.

Coal Resources

A total of 7.7 billion short tons of coal was estimated for the central Texas study area (fig. 18). The boundary of each assessment area, which was based on drill hole distribution, does not follow county boundaries, thus making tonnage comparisons between counties incomplete (fig. 2). Based on data from this study, Freestone County has more than 3 billion short tons of coal if resources from all coal zones are combined (figs. 18a-c). Within the central Texas study area, 46 percent of the total coal resource is covered by 0 to 100 ft of overburden (fig. 18a; Appendix 2a). Freestone County contains 51 percent of the resources under less than 100 ft of overburden (fig. 18a; Appendix 2a). Most of the coal resource (48 percent) in the study area falls within the 2.5 to 10 ft thickness categories and the indicated and inferred reliability categories (33 and 45 percent, respectively; figs. 18b,c, Appendix 2a).

Figures 18d-f show coal resources plotted by individual coal zones. Zone NCZ6 (from the north part of the central Texas assessment area) contains the greatest volume of coal resources when compared to the other coal zones. Most of the resource falls within the less than 200 ft overburden, 2.5 to 10-ft thickness categories, and in the indicated and inferred categories of reliability (figs. 18d-f). Zone CCZ4 contains the least volume of coal resources, with the other zones containing from less than 400 million to more than 1.8 billion short tons of coal (figs. 18d-f). Zones NCZ9 and SCZ6, being the stratigraphically lowest coal zones, have the greatest amount of overburden in the 200 to 500-ft category (fig. 18d). Zones CCZ5 and SCZ8 have the thickest section of overburden that ranges from 400- 450 ft (figs. 14c, 17c).

For summary purposes, a map of the total cumulative coal thickness for the study area is shown on figure 19. The map on figure 19 incorporates stratigraphic data from all coal zones evaluated in this study, and it includes coal thickness data for coal zones not assessed, but available to this study (fig. 3). The greatest amounts of shallow (<500 ft) coal resource are located in Freestone and Limestone counties where the regional dip of the upper Wilcox Group

coal-bearing strata is less than in areas toward the southwest where the regional dip is greater and the outcrop belt is narrow. Most of the areas with thick (20-40 ft) cumulative coal occurrence are located in the southern part of the study area in Bastrop, Lee and Milam counties. The pod-like distribution of the thick coal areas may be related to depositional trends of individual coal zones. Thin coal areas may be related to contemporaneous channel sandstone deposition and thick coal areas may represent areas of flood plain development of coal-forming peat deposits on the flanks of the river channels (Kaiser, 1978; Palmquist, 1987).

Conclusions

The central Texas study area is roughly 160 miles long and 5 to 25 miles wide and generally follows the outcrop of the Wilcox Group in central Texas (fig. 1). The central Texas study area contains a total of approximately 7.7 billion short tons of coal resources in nine coal zones (fig. 3; Appendix 2). Although complete comparisons between counties are not possible, because the assessment areas do not follow county boundaries, Freestone County has more than 3 billion short tons of coal resources in beds down to 500 ft depth (fig. 15; Appendix 2a). Zone NCZ6 (from the northern part of the central Texas assessment area) contains the greatest volume (1.9 billion short tons) of coal resources when compared to the other coal zones.

Previous studies of the shallow (<500 ft depth) coal resources of central Texas have used total coal rather than coal zones to estimate the resources (Kaiser, 1974; 1996; Kaiser and others, 1980; and Tewalt and Jackson, 1991). The estimates, which range from 4.1 to 6.5 billion short tons (Kaiser and others, 1980; Tewalt and Jackson, 1991), have varied in methodology and data availability, and are less than the 7.7 billion short tons of coal estimated in this report. These studies generally estimated coal resources by constructing total coal isopleths of all coal beds within a certain thickness range rather than correlating individual coal zones as done in this study. The increase in resources reported in this study is probably due to (1) the large number of data points used in this study (>1,800), (2) the inclusion of coal resources that range from 1.5 – 2.5 ft thick (not included in other studies), (3) the inclusion of coal resources with overburden thickness up to 500 ft, which is greater than previous studies that used a 200 ft overburden cutoff for coal resource estimates (in the case of Kaiser and others, 1980) and (4) the zone by zone correlation and the resulting estimation of resources by zone rather than coal bed isopleths.

The pod-like distribution of the thick coal areas in the central study area (figs. 9d-17d, 19) may be related to depositional trends of individual coal zones. Thin coal areas may be related to contemporaneous channel sandstone deposition and thick coal areas may represent areas of flood plain development of coal-forming peat deposits on the flanks of the river channels.

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- Fig. 1. Generalized outcrop map of the coal-bearing units and structural features in east-central and northeast Texas and northwest Louisiana. Outcrop compiled from Barnes (1992), Haley (1993), Snead and McCulloh (1984), and Warwick and others (1997); structural features after Ewing, (1991).
- Fig. 2. Location map for the central Texas resource assessment block, mine permit boundaries, and generalized coal-bearing geology (modified from Warwick and others, 1997).
- Fig. 3. Generalized stratigraphic sections of Wilcox strata in the central Texas study area showing the stratigraphic position of coal zones and names used in this study. Locations of mines are shown on the inset map and figure 2. Coal zone names used in this study are prefixed by “N” for northern resource areas; “C” for the central resource areas; “S” for the southern resource areas, and “CZ” for coal zone, are shown on the right of each stratigraphic section and generally follow the names used at the Jewett mine (Palmquist, 1987; Jewett mine permit applications on file at the Railroad Commission of Texas, Surface Mining and Reclamation Division, in Austin, Texas). Stratigraphic bed and zone names used mine permits other than the Jewett mine are shown on the left of each stratigraphic section and are found in the various mine permit applications on file at the Railroad Commission of Texas, Surface Mining and Reclamation Division, in Austin, Texas (table 1).
- Fig. 4. Generalized cross section A-A’ through the Powell Bend and Sandow mines showing correlation and variation of coal zones. Coal zone names are shown in red and on figure 3 (only zones SCZ4, SCZ6, and SCZ8 were assessed). Inset map shows line of section.
- Fig. 5. Generalized cross section B-B’ at the Calvert mine showing coal zone variation. Coal zone names are shown in red and on figure 3 (only zones CCZ4 and CCZ5 were assessed). Inset map shows line of section.
- Fig. 6. Generalized cross section C-C’ at the Jewett mine showing coal zone and lithologic variation. Coal zone names are shown in red and on figure 3 (only zones NCZ5, NCZ6, NCZ8, and NCZ9 were assessed). Inset map shows line of section.
- Fig. 7. Generalized cross section D-D’ at the Big Brown mine showing coal zone variation. Coal zone names are shown in red and on figure 3 (only zones NCZ5, NCZ6, NCZ8, and NCZ9 were assessed). Inset map shows line of section.
- Fig. 8. Regional extent of the nine coal zones evaluated for resources in study of the coal resources in central Texas. The extent of individual assessment units is limited by up-dip outcrop and data availability. a) Northern coal zones; b) central coal zones; and c) southern coal zones.
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- Fig. 11. Geology of coal northern Coal Zone 8 (NCZ8). a) Outline of Zone 8 showing coal mine permit locations, mined areas, and county boundaries. b) Structure contour map of the stratigraphic top of Zone 8. c) Map of overburden thickness for Zone 8. d) Map of the

cumulative coal bed thicknesses that compose Zone 8.

Fig. 12. Geology of northern Coal Zone 9 (NCZ9). a) Outline of Zone 9 showing coal mine permit locations mined areas, and county boundaries. b) Structure contour map of the stratigraphic top of Zone 9. c) Map of overburden thickness for Zone 9. d) Map of the cumulative coal bed thicknesses that compose Zone 9.

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Fig. 15. Geology of southern Coal Zone 4 (SCZ4). a) Outline of Zone 4 showing coal mine permit locations, mined areas, and county boundaries. b) Structure contour map of the stratigraphic top of Zone 4. c) Map of overburden thickness for Zone 4. d) Map of the cumulative coal bed thicknesses that compose Zone 4.

Fig. 16. Geology of southern Coal Zone 6 (SCZ6). a) Outline of Zone 6 showing coal mine locations, mined areas, and county boundaries. b) Structure contour map of the stratigraphic top of Zone 6. c) Map of overburden thickness for Zone 6. d) Map of the cumulative coal bed thicknesses that compose Zone 6.

Fig. 17. Geology of southern Coal Zone 8 (SCZ8). a) Outline of Zone 8 showing coal mine permit locations, mined areas, and county boundaries. b) Structure contour map of the stratigraphic top of Zone 8. c) Map of overburden thickness for Zone 8. d) Map of the cumulative coal bed thicknesses that compose Zone 8.

Fig. 18. Coal resources for the central Texas study area by county and a) overburden thickness, b) coal zone thickness, and c) reliability categories. Coal resources for the central Texas study area are also plotted by zone and d) overburden thickness, e) coal zone thickness, and f) reliability categories.

Fig. 19. Map of the total cumulative coal resources for the central Texas study area.

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Table 1. Sources of data for the central Texas study area.

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Appendix 2—Coal zone resources by county, overburden, thickness, and reliability categories

Table 1. Sources of public data for the central Texas study area.

1) Mine permit applications that are on file at the Railroad Commission of Texas, Surface Mining and Reclamation Division (1974 - 1998).

Texas Utilities Mining Company

Big Brown Mine - 3D Permit

Northwestern Resources Company

Jewett Area E/F - 0FG0 Permit

Jewett Mine - 32E Permit

Walnut Creek Mining Company

Calvert Mine - 27E Permit

Aluminum Company of America

Sandow Mine - 1E Permit

Lower Colorado River Authority

Powell Bend Mine - 35B Permit

Note: Mine permit boundaries used in this study were digitized from mine boundaries depicted on maps (1998 and older) contained in the mine permits listed above.

2) Unpublished abandoned mine locality database on file at the Railroad Commission of Texas, Surface Mining and Reclamation Division

3) National Coal Resources Data System, USGS, Reston VA

4) U.S. Bureau of Mines Reports: Ward (1980a²,b³)

² Ward, A.E., 1980a, Evaluation of lignite resources at proposed La Grange and Columbus Bend Reservoir sites, Fayette, Bastrop, Lee, and Colorado Counties, Tex.: U.S. Bureau of Mines Unpublished Report, 35 p.

³ Ward, A.E., 1980b, Evaluation of lignite resources at proposed Richland and Tehuacana Reservoir sites, Freestone and Navarro Counties, Tex.: U.S. Bureau of Mines Unpublished Report, 42 p.

Appendix 1. Locations and intercepts for public data points used in the central Texas Assessment block. Hole locations are shown on figures 9A-17A.

- Appendix 1*a* Northern Coal Zone 5 (NCZ5) Public data points
- Appendix 1*b* Northern Coal Zone 6 (NCZ6) Public data points
- Appendix 1*c* Northern Coal Zone 8 (NCZ8) Public data points
- Appendix 1*d* Northern Coal Zone 9 (NCZ9) Public data points
- Appendix 1*e* Central Coal Zone 4 (CCZ4) Public data points
- Appendix 1*f* Central Coal Zone 5 (CCZ5) Public data points
- Appendix 1*g* Southern Coal Zone 4 (SCZ4) Public data points
- Appendix 1*h* Southern Coal Zone 6 (SCZ6) Public data points
- Appendix 1*i* Southern Coal Zone 8 (SCZ8) Public data points

Appendix 1a Northern Coal Zone 5 (NCZ5) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. All mine permit data are on file at the Railroad Commission of Texas (table 1); BEG PUB 3818 = Stenzel (1938).

Point ID	Latitude	Longitude	Coal zone thickness (ft)	Zone top elevation (ft)	Surface elevation (ft)	Source of data
C-03	31.84858	-96.08364	0.3	285.3	355	BIG BROWN PERMIT
CC-02	31.37889	-96.25356	0.8	354.6	482	JEWETT PERMIT
CC-11	31.46461	-96.18219	2.9	476.0	585	JEWETT PERMIT
CC-13	31.47228	-96.16275	0.4	352.9	411	JEWETT PERMIT
CC-14	31.45831	-96.16008	3.2	324.9	420	JEWETT PERMIT
CC-15	31.47169	-96.14669	3.4	290.8	452	JEWETT PERMIT
CC-17	31.45514	-96.13097	3.3	177.4	320	JEWETT PERMIT
CC-18	31.45525	-96.14731	2.9	268.0	350	JEWETT PERMIT
CC-20	31.47283	-96.18169	3.5	489.2	565	JEWETT PERMIT
CC-30	31.37922	-96.26317	0.7	423.5	497	JEWETT PERMIT
CC-34	31.40967	-96.20058	1.2	375.9	495	JEWETT PERMIT
CC-35	31.41853	-96.20031	3.6	383.7	490	JEWETT PERMIT
CC-36	31.41258	-96.19408	3.3	360.8	511	JEWETT PERMIT
CC-37	31.4655	-96.16675	3.2	392.6	445	JEWETT PERMIT
CC-38	31.46942	-96.16289	1.5	408.9	470	JEWETT PERMIT
CC-39	31.46531	-96.16	3.3	334.1	494	JEWETT PERMIT
CC-40	31.46614	-96.15489	5.5	331.9	385	JEWETT PERMIT
CC-41	31.46222	-96.15381	3.6	319.0	459	JEWETT PERMIT
CC-42	31.47558	-96.16258	3.3	428.5	470	JEWETT PERMIT
CC-43	31.47314	-96.15139	2.8	333.1	488	JEWETT PERMIT
CC-44	31.45042	-96.16694	3.1	365.0	470	JEWETT PERMIT
CC-46	31.40958	-96.18794	0	357.6	512	JEWETT PERMIT
CC-51	31.4725	-96.17069	0.4	434.0	500	JEWETT PERMIT
CC-52	31.46144	-96.17272	3.4	468.4	530	JEWETT PERMIT
LN-40-40	31.39449	-96.24472	0.5	422.0	460	BEG PUB 3818

Appendix 1b Northern Coal Zone 6 (NCZ6) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. TUMCO = Texas Utilities Mining Company. TUMCO/USGS DATA were provided by the company. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal zone thickness (ft)	Zone top elevation (ft)	Surface elevation (ft)	Source of data
C-VI-3-OBP2-92	31.80892	-96.07762	2.5	272.5	365	BIG BROWN PERMIT
CC-56	31.35439	-96.26744	5.9	314.7	450	JEWETT PERMIT
CC-55	31.36106	-96.259	8.0	304.8	543	JEWETT PERMIT
CC-54	31.43053	-96.20328	13.8	362.9	470	JEWETT PERMIT
CC-53	31.3615	-96.26067	7.5	327.2	523	JEWETT PERMIT
CC-52	31.46144	-96.17272	14.3	391.4	530	JEWETT PERMIT
CC-51	31.4725	-96.17069	11.6	394.1	500	JEWETT PERMIT
CC-49	31.372	-96.24547	9.6	226.3	469	JEWETT PERMIT
CC-48	31.38406	-96.24647	9.7	355.0	602	JEWETT PERMIT
CC-46	31.40958	-96.18794	9.4	269.1	512	JEWETT PERMIT
CC-45	31.41781	-96.18742	3.3	314.7	482	JEWETT PERMIT
CC-44	31.45042	-96.16694	8.8	332.7	470	JEWETT PERMIT
CC-43	31.47314	-96.15139	8.4	300.5	488	JEWETT PERMIT
CC-42	31.47558	-96.16258	13.4	367.8	470	JEWETT PERMIT
CC-41	31.46222	-96.15381	11.3	275.1	459	JEWETT PERMIT
CC-40	31.46614	-96.15489	4.8	283.1	385	JEWETT PERMIT
CC-39	31.46531	-96.16	5.9	297.1	494	JEWETT PERMIT
CC-38	31.46942	-96.16289	15.3	348.0	470	JEWETT PERMIT
CC-37	31.4655	-96.16675	18.1	327.6	445	JEWETT PERMIT
CC-36	31.41258	-96.19408	13.3	285.0	511	JEWETT PERMIT
CC-35	31.41853	-96.20031	16.5	312.8	490	JEWETT PERMIT
CC-34	31.40967	-96.20058	14.5	311.7	495	JEWETT PERMIT
CC-33	31.37042	-96.25069	9.0	320.4	515	JEWETT PERMIT
CC-32	31.36936	-96.25853	7.7	357.7	462	JEWETT PERMIT
CC-31	31.37189	-96.25867	9.8	368.4	468	JEWETT PERMIT
CC-30	31.37922	-96.26317	7.9	380.7	497	JEWETT PERMIT
CC-26	31.40764	-96.21069	14.5	331.0	450	JEWETT PERMIT
CC-24	31.36833	-96.27292	8.0	376.0	439	JEWETT PERMIT
CC-23	31.36314	-96.28264	8.7	347.6	430	JEWETT PERMIT
CC-22	31.36361	-96.28628	6.6	371.5	434	JEWETT PERMIT
CC-21	31.36081	-96.29264	6.5	382.5	421	JEWETT PERMIT
CC-20	31.47283	-96.18169	15.0	413.2	565	JEWETT PERMIT
CC-19	31.46517	-96.20131	15.3	435.6	450	JEWETT PERMIT
CC-18	31.45525	-96.14731	8.0	203.1	350	JEWETT PERMIT
CC-17	31.45514	-96.13097	9.2	116.5	320	JEWETT PERMIT
CC-16	31.46281	-96.13433	9.5	152.5	350	JEWETT PERMIT
CC-15	31.47169	-96.14669	9.5	250.7	452	JEWETT PERMIT
CC-14	31.45831	-96.16008	8.2	273.5	420	JEWETT PERMIT
CC-13	31.47228	-96.16275	13.8	306.8	411	JEWETT PERMIT
CC-12	31.45583	-96.16989	9.1	362.2	410	JEWETT PERMIT

CC-11	31.46461	-96.18219	13.1	421.2	585	JEWETT PERMIT
CC-10	31.47067	-96.19389	13.9	355.4	403	JEWETT PERMIT
CC-09	31.40444	-96.19761	11.2	283.1	486	JEWETT PERMIT
CC-08	31.42383	-96.19403	5.4	333.7	501	JEWETT PERMIT
CC-07	31.43244	-96.20628	12.9	399.6	485	JEWETT PERMIT
CC-06	31.38858	-96.21133	12.1	217.0	413	JEWETT PERMIT
CC-05	31.39447	-96.224	8.4	292.6	480	JEWETT PERMIT
CC-04	31.38389	-96.24033	8.7	342.9	510	JEWETT PERMIT
CC-03	31.39022	-96.2595	8.5	407.8	458	JEWETT PERMIT
CC-02	31.37889	-96.25356	8.2	319.7	482	JEWETT PERMIT
CC-01	31.36253	-96.26369	7.5	310.0	500	JEWETT PERMIT
C-4011	31.13938	-96.56275	12.5	339.3	387	TUMCO/USGS

Appendix 1c Northern Coal Zone 8 (NCZ8) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
B-01	31.77723	-96.13094	2.3	344.9	443	BIG BROWN PERMIT
B-02	31.78394	-96.12843	4.0	353.5	417	BIG BROWN PERMIT
B-03	31.79647	-96.13001	5.8	353.2	393	BIG BROWN PERMIT
B-04	31.80289	-96.12685	6.1	330.2	360	BIG BROWN PERMIT
B-05	31.77987	-96.12061	3.7	337.8	422	BIG BROWN PERMIT
B-06	31.79429	-96.11974	3.0	349.6	398	BIG BROWN PERMIT
B-25-OB	31.78549	-96.11971	3.0	339.0	389	BIG BROWN PERMIT
B-27-UB-92	31.79078	-96.11307	3.0	342.0	419	BIG BROWN PERMIT
B-28-UB-92	31.7777	-96.11353	2.5	307.5	405	BIG BROWN PERMIT
B-5-UB	31.78097	-96.12059	3.5	338.0	422	BIG BROWN PERMIT
C-01	31.85407	-96.09032	1.2	310.6	318	BIG BROWN PERMIT
C-03	31.84858	-96.08364	6.3	283.9	355	BIG BROWN PERMIT
C-04	31.85628	-96.07396	8.1	283.9	349	BIG BROWN PERMIT
C-05	31.82381	-96.09772	6.9	285.5	390	BIG BROWN PERMIT
C-06	31.83455	-96.08731	6.7	273.5	365	BIG BROWN PERMIT
C-07	31.84607	-96.07537	8.5	259.2	351	BIG BROWN PERMIT
C-08	31.85514	-96.06856	8.8	262.7	338	BIG BROWN PERMIT
C-09	31.81046	-96.10307	4.8	325.1	421	BIG BROWN PERMIT
C-10	31.8247	-96.08621	8.2	261.0	400	BIG BROWN PERMIT
C-11	31.8394	-96.07435	7.0	226.6	360	BIG BROWN PERMIT
C-12	31.84065	-96.06091	8.5	198.4	276	BIG BROWN PERMIT
C-13	31.85318	-96.05378	3.0	237.4	324	BIG BROWN PERMIT
C-32-OB	31.82616	-96.0819	6.0	242.0	366	BIG BROWN PERMIT
C-33-OB/UB	31.831	-96.07233	7.0	227.0	333	BIG BROWN PERMIT
C-39-OB/UB	31.83976	-96.0577	7.0	185.5	298	BIG BROWN PERMIT
CVI-1	31.81024	-96.09464	4.2	268.7	396	BIG BROWN PERMIT
C-VI-1-IB-92	31.80469	-96.09437	5.5	257.0	372	BIG BROWN PERMIT
C-VI-1-UB-92	31.80452	-96.09424	6.5	258.0	373	BIG BROWN PERMIT
C-VI-1-UBP1-92	31.80461	-96.09424	6.5	258.0	373	BIG BROWN PERMIT
C-VI-1-UBP2-92	31.80471	-96.09425	7.3	258.3	373	BIG BROWN PERMIT
CVI-2	31.81158	-96.08794	7.8	236.5	382	BIG BROWN PERMIT
C-VI-2-IB-92	31.81538	-96.08712	6.3	225.7	373	BIG BROWN PERMIT
C-VI-2-IBP1-92	31.81545	-96.08703	6.7	244.3	394	BIG BROWN PERMIT
C-VI-2-IBP2-92	31.81551	-96.08695	7.0	245.0	395	BIG BROWN PERMIT
C-VI-2-UB-92	31.81526	-96.08681	7.0	244.0	395	BIG BROWN PERMIT
CVI-3	31.8018	-96.0928	5.5	242.0	391	BIG BROWN PERMIT
C-VI-3-IB-92	31.80883	-96.07746	7.0	222.0	367	BIG BROWN PERMIT
C-VI-3-UB-92	31.8087	-96.07753	6.3	222.0	368	BIG BROWN PERMIT
C-VI-3-UBP1-92	31.80876	-96.07749	7.3	223.4	368	BIG BROWN PERMIT
C-VI-3-UBP2-92	31.80905	-96.08798	6.7	220.7	366	BIG BROWN PERMIT
CVI-4	31.81899	-96.07806	6.3	220.8	388	BIG BROWN PERMIT
C-VI-4-IB-92	31.81691	-96.0731	7.2	201.2	348	BIG BROWN PERMIT
C-VI-4-UB-92	31.81731	-96.073	7.6	197.7	345	BIG BROWN PERMIT

Appendix 1d Northern Coal Zone 9 (NCZ9) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. USBM = U.S. Bureau of Mines unpublished data. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
B-01	31.77723	-96.13094	6.5	308.2	443	BIG BROWN PERMIT
B-02	31.78394	-96.12843	6.2	308.0	417	BIG BROWN PERMIT
B-05	31.77987	-96.12061	6.0	302.1	422	BIG BROWN PERMIT
B-06	31.79429	-96.11974	5.2	303.3	398	BIG BROWN PERMIT
B-27-UB-92	31.79078	-96.11307	5.5	297.0	419	BIG BROWN PERMIT
B-28-UB-92	31.7777	-96.11353	5.0	267.0	405	BIG BROWN PERMIT
B-5-UB	31.78097	-96.12059	9.0	303.0	422	BIG BROWN PERMIT
C-01	31.85407	-96.09032	8.1	284.6	318	BIG BROWN PERMIT
C-02	31.87131	-96.06644	9.4	239.5	295	BIG BROWN PERMIT
C-03	31.84858	-96.08364	8.6	247.7	355	BIG BROWN PERMIT
C-04	31.85628	-96.07396	1.9	253.9	349	BIG BROWN PERMIT
C-05	31.82381	-96.09772	8.6	245.5	390	BIG BROWN PERMIT
C-06	31.83455	-96.08731	11.8	226.9	365	BIG BROWN PERMIT
C-07	31.84607	-96.07537	8.5	224.1	351	BIG BROWN PERMIT
C-08	31.85514	-96.06856	8.5	226.2	338	BIG BROWN PERMIT
C-09	31.81046	-96.10307	4.8	292.1	421	BIG BROWN PERMIT
C-10	31.8247	-96.08621	8.2	215.5	400	BIG BROWN PERMIT
C-11	31.8394	-96.07435	8.1	192.4	360	BIG BROWN PERMIT
C-12	31.84065	-96.06091	9.8	157.2	276	BIG BROWN PERMIT
C-13	31.85318	-96.05378	10.2	172.3	324	BIG BROWN PERMIT
C-32-OB	31.82616	-96.0819	8.0	193.0	366	BIG BROWN PERMIT
C-33-OB/UB	31.831	-96.07233	8.5	187.0	333	BIG BROWN PERMIT
C-39-OB/UB	31.83976	-96.0577	8.5	152.5	298	BIG BROWN PERMIT
CVI-1	31.81024	-96.09464	2.3	236.2	396	BIG BROWN PERMIT
C-VI-1-UB-92	31.80452	-96.09424	6.7	210.0	373	BIG BROWN PERMIT
C-VI-1-UBP1-92	31.80461	-96.09424	7.0	212.0	373	BIG BROWN PERMIT
CVI-2	31.81158	-96.08794	8.7	194.6	382	BIG BROWN PERMIT
C-VI-2-UB-92	31.81526	-96.08681	6.0	200.0	395	BIG BROWN PERMIT
CVI-3	31.8018	-96.0928	6.1	194.2	391	BIG BROWN PERMIT
C-VI-3-UBP1-92	31.80876	-96.07749	6.4	185.8	368	BIG BROWN PERMIT
C-VI-3-UBP2-92	31.80905	-96.08798	5.0	185.5	366	BIG BROWN PERMIT
CVI-4	31.81899	-96.07806	10.7	180.7	388	BIG BROWN PERMIT
C-VI-4-UB-92	31.81731	-96.073	9.2	152.5	345	BIG BROWN PERMIT
T-12	31.84056	-96.16861	2.0	338.5	365	USBM
T-13	31.83056	-96.16722	1.5	290.5	335	USBM
T-14	31.82028	-96.16861	1.5	296.5	375	USBM
T-15	31.80778	-96.18139	2.0	293.0	335	USBM

Appendix 1e Central Coal Zone 4 (CCZ4) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
5445D	31.08135	-96.64	6.0	264.0	356.0	CALVERT PERMIT
5364P	31.09266	-96.65004	2.0	304.2	384.2	CALVERT PERMIT
5347P	31.0773	-96.64902	2.0	168.1	352.1	CALVERT PERMIT
5342X	31.09156	-96.66563	4.0	340.0	408.0	CALVERT PERMIT
5340X	31.09121	-96.66547	2.0	333.3	405.3	CALVERT PERMIT
5332X	31.08861	-96.64111	3.0	316.7	365.7	CALVERT PERMIT
5331X	31.08944	-96.64097	2.0	209.3	367.3	CALVERT PERMIT
5330P	31.07403	-96.64558	9.0	186.3	343.3	CALVERT PERMIT
5329D	31.07407	-96.64565	6.0	178.3	343.3	CALVERT PERMIT
5328P	31.07577	-96.64764	5.0	166.5	345.5	CALVERT PERMIT
5327D	31.0758	-96.64768	5.0	167.2	345.2	CALVERT PERMIT
5323X	31.09082	-96.66579	5.0	324.5	403.5	CALVERT PERMIT
5319P	31.09112	-96.64514	7.0	309.2	379.2	CALVERT PERMIT
5318P	31.09116	-96.64522	5.0	299.5	379.5	CALVERT PERMIT
5305D	31.07656	-96.64245	7.0	234.0	351.0	CALVERT PERMIT
5304DP	31.07886	-96.64404	5.0	246.2	351.2	CALVERT PERMIT
5302P	31.08333	-96.64501	4.0	261.8	353.8	CALVERT PERMIT
5296P	31.08614	-96.64432	3.0	286.7	364.7	CALVERT PERMIT
5282X	31.08869	-96.64217	2.0	308.2	366.2	CALVERT PERMIT
5268X	31.08987	-96.64121	3.0	318.2	370.2	CALVERT PERMIT
5261X	31.09358	-96.6654	8.0	335.7	405.7	CALVERT PERMIT
5183C	31.08806	-96.66111	2.5	298.2	373.0	CALVERT PERMIT

Appendix 1f Central Coal Zone 5 (CCZ5) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
5181C	31.06333	-96.68972	9.6	351.0	401.0	CALVERT PERMIT
5182C	31.05917	-96.70833	5.0	337.0	389.0	CALVERT PERMIT
5183C	31.08806	-96.66111	10.0	243.2	373.0	CALVERT PERMIT
5184C	31.08667	-96.64444	10.5	253.5	368.0	CALVERT PERMIT
5185C	31.07944	-96.64667	11.9	181.8	356.0	CALVERT PERMIT
5261X	31.09358	-96.6654	10.0	291.7	405.7	CALVERT PERMIT
5268X	31.08987	-96.64121	8.0	290.2	370.2	CALVERT PERMIT
5282X	31.08869	-96.64217	11.0	282.2	366.2	CALVERT PERMIT
5284X	31.08703	-96.64194	11.0	263.4	360.4	CALVERT PERMIT
5292P	31.08477	-96.64151	10.0	257.0	359.0	CALVERT PERMIT
5294P	31.09021	-96.64728	10.0	268.1	372.1	CALVERT PERMIT
5296P	31.08614	-96.64432	13.0	253.7	364.7	CALVERT PERMIT
5298X	31.08214	-96.642	8.0	235.4	352.4	CALVERT PERMIT
5299PZ	31.08208	-96.64189	7.0	236.0	354.0	CALVERT PERMIT
5302P	31.08333	-96.64501	11.0	226.8	353.8	CALVERT PERMIT
5304DP	31.07886	-96.64404	11.0	188.2	351.2	CALVERT PERMIT
5305D	31.07656	-96.64245	8.0	183.0	351.0	CALVERT PERMIT
5316P	31.08851	-96.64302	12.0	274.3	368.3	CALVERT PERMIT
5318P	31.09116	-96.64522	12.0	278.5	379.5	CALVERT PERMIT
5319P	31.09112	-96.64514	12.0	279.2	379.2	CALVERT PERMIT
5320PZ	31.08461	-96.64146	9.0	252.8	358.8	CALVERT PERMIT
5323X	31.09082	-96.66579	10.0	267.5	403.5	CALVERT PERMIT
5327D	31.0758	-96.64768	14.0	110.2	345.2	CALVERT PERMIT
5328P	31.07577	-96.64764	6.0	108.5	345.5	CALVERT PERMIT
5329D	31.07407	-96.64565	9.0	125.3	343.3	CALVERT PERMIT
5330P	31.07403	-96.64558	12.0	126.3	343.3	CALVERT PERMIT
5331X	31.08944	-96.64097	9.0	149.3	367.3	CALVERT PERMIT
5332X	31.08861	-96.64111	9.0	283.7	365.7	CALVERT PERMIT
5340X	31.09121	-96.66547	9.0	276.3	405.3	CALVERT PERMIT
5342X	31.09156	-96.66563	10.0	285.0	408.0	CALVERT PERMIT
5346P	31.09344	-96.6462	8.0	316.3	393.3	CALVERT PERMIT
5347P	31.0773	-96.64902	9.0	107.1	352.1	CALVERT PERMIT
5364P	31.09266	-96.65004	5.0	293.2	384.2	CALVERT PERMIT
5369X	31.09267	-96.66528	3.0	295.3	407.3	CALVERT PERMIT
5370X	31.09377	-96.66497	9.0	314.7	409.7	CALVERT PERMIT
5445D	31.08135	-96.64	13.0	247.0	356.0	CALVERT PERMIT
RO-4750_A	31.09722	-96.64803	7.9	346.0	405.0	CALVERT PERMIT

Appendix 1g Southern Coal Zone 4 (SCZ4) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. ND = No Data; USBM = U.S. Bureau of Mines unpublished data. All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
C2-84	30.60042	-97.02606	1.0	402.9	448	SANDOW PERMIT
C3-84	30.59914	-97.01106	0	376.0	445	SANDOW PERMIT
C4-84	30.59911	-97.02044	4.0	419.0	445	SANDOW PERMIT
CC1-95	30.58108	-97.01469	5.8	289.5	401	SANDOW PERMIT
CC2-95	30.61942	-97.01256	5.7	419.7	472	SANDOW PERMIT
CCE2-93	30.61661	-97.01786	5.1	453.9	491	SANDOW PERMIT
E-12-11	30.60644	-97.02156	3.0	395.9	450	SANDOW PERMIT
E-20-12	30.60706	-97.01778	ND	383.9	471	SANDOW PERMIT
E-20-16	30.61272	-97.01586	ND	374.0	460	SANDOW PERMIT
E-32-8	30.60056	-97.01556	1.0	362.0	447	SANDOW PERMIT
E-7-9	30.60447	-97.02403	1.0	437.0	466	SANDOW PERMIT
T1-29	30.42022	-97.17342	1.5	368.5	430	USBM
T2-29	30.42492	-97.18631	2.5	400.0	480	USBM

Appendix 1h Southern Coal Zone 6 (SCZ6) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. USBM = U.S. Bureau of Mines unpublished data; BEG RI137 = Dietrich and Lonsdale (1958); BEG RI50 = Fisher (1963). All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
BAW3	30.09793	-97.38314	7.0	365.0	465	BEG RI137
BAW4	30.09547	-97.38386	7.0	371.0	455	BEG RI137
C-16-86	30.60425	-97.01392	4.0	338.0	458	SANDOW PERMIT
C1-84	30.60525	-97.02881	7.0	396.9	492	SANDOW PERMIT
C-1-89	30.20558	-97.32474	5.0	443.5	470	POWELL BEND PERMIT
C2-84	30.60042	-97.02606	5.0	399.0	448	SANDOW PERMIT
C-2-89	30.20762	-97.31531	8.0	417.6	475	POWELL BEND PERMIT
C3-84	30.59914	-97.01106	6.0	286.0	445	SANDOW PERMIT
C4-84	30.59911	-97.02044	5.0	354.0	445	SANDOW PERMIT
CC1-95	30.58108	-97.01469	17.0	241.0	401	SANDOW PERMIT
CC2-95	30.61942	-97.01256	15.0	410.0	472	SANDOW PERMIT
CCE1-93	30.61606	-97.02178	5.0	439.5	467	SANDOW PERMIT
CCE2-93	30.61661	-97.01786	5.0	423.6	491	SANDOW PERMIT
CS1	30.21081	-97.3017	4.0	385.0	505	BEG RI137
E-12-11	30.60644	-97.02156	2.0	390.0	450	SANDOW PERMIT
E-32-8	30.60056	-97.01556	0	334.9	447	SANDOW PERMIT
E-A-11	30.608	-97.02581	1.0	451.9	490	SANDOW PERMIT
OC2	30.08184	-97.38269	10.0	332.0	368	BEG RI50
OC3	30.1236	-97.33418	3.0	342.0	358	BEG RI50
OC5	30.17244	-97.32271	1.0	456.0	464	BEG RI50
OC6	30.17898	-97.33115	1.0	474.0	481	BEG RI50
T1-29	30.42022	-97.17342	5.0	241.5	430	USBM
TU-59-P	30.19383	-97.32444	5.0	419.0	461	POWELL BEND PERMIT

Appendix 1i Southern Coal Zone 8 (SCZ8) public data point locations with surface elevations, cumulative thickness of coal in each coal zone, and coal zone top elevations. ND = No Data; BEG RI137 Dietrich and Lonsdale (1958); BEG RI50 = Fisher (1963). All mine permit data are on file at the Railroad Commission of Texas (table 1).

Point ID	Latitude	Longitude	Coal Zone Thickness (ft)	Zone Top Elevation (ft)	Surface Elevation (ft)	Source of Data
BAW2	30.12455	-97.32011	ND	170.0	360	BEG RI137
C-16-86	30.60425	-97.01392	1.0	330.0	458	SANDOW PERMIT
C1-84	30.60525	-97.02881	14.0	382.9	492	SANDOW PERMIT
C-1-89	30.20558	-97.32474	11.6	395.7	470	POWELL BEND PERMIT
C2-84	30.60042	-97.02606	14.1	392.0	448	SANDOW PERMIT
C3-84	30.59914	-97.01106	1.1	279.0	445	SANDOW PERMIT
C4-84	30.59911	-97.02044	9.0	341.0	445	SANDOW PERMIT
CC1-95	30.58108	-97.01469	7.4	214.3	401	SANDOW PERMIT
CC2-95	30.61942	-97.01256	7.4	388.8	472	SANDOW PERMIT
CCE1-93	30.61606	-97.02178	9.0	434.5	467	SANDOW PERMIT
CCE2-93	30.61661	-97.01786	8.1	417.9	491	SANDOW PERMIT
CS1	30.21081	-97.3017	10.0	334.5	505	BEG RI137
E-12-11	30.60644	-97.02156	ND	385.9	450	SANDOW PERMIT
E-32-8	30.60056	-97.01556	0	328.9	447	SANDOW PERMIT
E-4-9	30.60453	-97.02539	1.0	386.9	471	SANDOW PERMIT
E-7-9	30.60447	-97.02403	ND	395.9	466	SANDOW PERMIT
OC1B	30.15969	-97.34283	ND	333.5	375	BEG RI50
OC4	30.16771	-97.33139	6.0	412.0	424	BEG RI50
OC5	30.17244	-97.32271	10.0	435.0	464	BEG RI50
OC6	30.17898	-97.33115	2.0	463.0	481	BEG RI50
TU-100-CH	30.19442	-97.32956	11.0	407.0	457	POWELL BEND PERMIT
TU-101	30.19289	-97.33128	15.0	433.0	470	POWELL BEND PERMIT
TU-102-CH	30.19089	-97.33128	9.0	434.0	490	POWELL BEND PERMIT
TU-104-CH	30.19486	-97.33119	7.0	421.0	440	POWELL BEND PERMIT
TU-109	30.19725	-97.3325	15.0	405.0	447	POWELL BEND PERMIT
TU-118-CH	30.20444	-97.32881	6.0	395.0	430	POWELL BEND PERMIT
TU-121	30.19369	-97.32753	10.0	395.0	442	POWELL BEND PERMIT
TU-120-CH	30.20603	-97.32803	4.0	394.0	440	POWELL BEND PERMIT
TU-141	30.19794	-97.32633	7.0	392.0	457	POWELL BEND PERMIT
TU-156	30.19683	-97.33114	10.0	416.0	438	POWELL BEND PERMIT
TU-165	30.20086	-97.33053	3.0	407.0	428	POWELL BEND PERMIT
TU-51-OB	30.1925	-97.33483	4.1	448.0	485	POWELL BEND PERMIT
TU-58-P	30.19894	-97.32944	5.0	407.0	422	POWELL BEND PERMIT
TU-59-P	30.19383	-97.32444	10.0	376.0	461	POWELL BEND PERMIT
TU-62	30.19925	-97.33131	5.0	390.0	405	POWELL BEND PERMIT
TU-95	30.19808	-97.32353	5.0	410.0	445	POWELL BEND PERMIT
TU-96-OB	30.19614	-97.32644	8.0	378.0	433	POWELL BEND PERMIT

Appendix 2. Coal resources by county, reliability, overburden, and coal zone thickness categories.

- Appendix 2a Resources of all coal zones
- Appendix 2b Resources of Northern Coal Zone 6 (NCZ6)
- Appendix 2c Resources of Northern Coal Zone 8 (NCZ8)
- Appendix 2d Resources of Northern Coal Zone 9 (NCZ9)
- Appendix 2e Resources of Central Coal Zone 4 (CCZ4)
- Appendix 2f Resources of Central Coal Zone 5 (CCZ5)
- Appendix 2g Resources of Southern Coal Zone 4 (SCZ4)
- Appendix 2h Resources of Southern Coal Zone 6 (SCZ6)
- Appendix 2i Resources of Southern Coal Zone 8 (SCZ8)

Appendix 2a Central Texas total coal resources for all assessed coal zones in millions of short tons. The coal resources located within the mine permit areas are not included in this table. "<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'					0' - 100' Total	100' - 200'					100' - 200' Total	200' - 500'					200' - 500' Total	Grand total		
		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'	20' - 40'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'	20' - 40'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'	20' - 40'				
Total coal thickness (ft)																						
Bastrop	Reliability						54	2	19	38	15		74	<	10	21	11				42	170
	Measured	6	21	21	6		54	2	19	38	15		74	<	10	21	11				42	170
	Indicated	11	53	40	10		110	6	59	86	19		170	1	31	40	34				110	390
	Inferred	8	28	9	13		57	3	76	62	23		160	2	24	37	11				74	290
	Hypothetical								2	1			3		4						4	7
Bastrop total		25	101	70	29		220	12	160	190	57		410	3	69	98	56				230	860
Freestone	Measured	14	35	17	4		71	10	39	26	<		76	2	6	3					11	160
	Indicated	54	190	87	19		350	46	200	91	<		340	11	28	14					53	740
	Inferred	110	620	140	3		870	130	480	77			690	97	82	26					200	1,800
	Hypothetical	45	410	75			530	28	86				110	12	26						37	680
Freestone total		220	1,200	320	26		1,800	220	810	190	1		1,200	120	140	43					310	3,300
Lee	Measured	2	4	4	1		10	<	2	7	9	2	21	2	2	2	5	1			12	44
	Indicated	8	13	3			24	4	14	8	<	<	26	8	16	18	13	6			61	110
	Inferred	28	21	3			52	6	34	13			53	32	41	19	13	1			110	210
	Hypothetical	<					<		<				<	3	<						4	4
Lee total		37	38	10	1		86	11	50	28	9	2	99	46	60	39	31	9			180	370
Leon	Measured	1	8	16	<		26	3	5	12	6		26	1	2	2	<				6	57
	Indicated	3	13	21	<		38	6	13	25	11		55	3	11	11	6				31	120
	Inferred	1	6	6	<		14	11	8	9	17		45	15	20	18	15				68	130
	Hypothetical	<					<		<				<									<
Leon total		6	28	44	1		79	20	26	46	33		130	19	34	31	22				100	310
Limestone	Measured	6	25	35	58	7	130	2	8	7	<		17	2	5	<					7	150
	Indicated	14	53	59	110	22	260	8	38	18	<		64	12	22						34	360
	Inferred	31	87	33	49	2	200	27	120	18			160	42	120	2					160	530
	Hypothetical	4					4						<	<	<						<	4
Limestone total		55	170	130	220	31	600	37	170	44	<		250	55	150	3					200	1,000
Milam	Measured	1	6	6	15	<	28	3	35	22	8		68	2	19	11	19				52	150
	Indicated	1	10	11	22		45	2	54	36	7		99	3	23	52	11				89	230
	Inferred	<	4	<	4		9	<	18	4	<		22	2	10	24	2				37	69
Milam total		3	20	18	41	<	82	6	110	62	15		190	7	52	88	32				180	450
Robertson	Measured	4	17	45	69		130	4	15	35	34		89	<	<	4	17				20	240
	Indicated	15	57	110	130		310	7	41	87	59		190	2	2	9	66				79	580
	Inferred	49	73	72	13		210	6	52	74	25		160	11	22	12	49				94	460
	Hypothetical	10	<				10	3	6				9	9	5						15	34
Robertson total		78	150	230	210		660	20	110	200	120		450	23	29	24	130				210	1,300
Grand total		420	1,700	820	520	31	3,500	320	1,400	760	230	2	2,700	270	530	320	270	9			1,400	7,700

Appendix 2b Central Texas total coal resources for northern Zone 5 (NCZ5) in millions of short tons. The coal resources located within the mine permit areas are not included in this table. "<" = less than 1 million tons.

	Overburden (ft)	0' - 100'				0' - 100' Total	100' - 200'			100' - 200' Total	200' - 500'		200' - 500' Total	Grand total
Total coal thickness (ft)		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'		
County name	Reliability													
Freestone	Measured	4	5	4	<	14	2	7	3	12	<	<	1	26
	Indicated	15	34	28	4	80	7	34	13	54	1	2	2	140
	Inferred	38	160	100	1	310	14	47	28	89	1	3	4	400
	Hypothetical	16	320	75		410		3		3				420
Freestone total		72	530	210	5	810	23	90	44	160	2	5	7	980
Leon	Measured	1	1	2		3	<	1	1	2				5
	Indicated	1	2	2		5	<	2	5	7				12
	Inferred	1	2	3		6	3	5	3	11				17
Leon total		3	5	7		14	3	8	9	20				34
Limestone	Measured	0				<								<
	Indicated	2				2	<			<				2
	Inferred	9				9	<			<				9
	Hypothetical	4				4								4
Limestone total		15				15	1			1				15
Robertson	Measured	<	<	2		2			<	<				3
	Indicated	4	<	5		9			1	1				10
	Inferred	26	22	2		50								50
	Hypothetical	7	<			7								7
Robertson total		37	23	8		69			1	1				70
Grand Total		130	550	220	5	910	27	98	54	180	2	5	7	1,100

Appendix 2c Central Texas total coal resources for northern Zone 6 (NCZ6) in millions of short tons. The coal resources located within the mine permit areas are not included in this table.

"<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'					0' - 100' Total	100' - 200'				100' - 200' Total	200' - 500'				200' - 500' Total	Grand total
		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'	20' - 40'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		
Freestone	Reliability																	
	Measured	1	2	5	3		12	1	9	9	<	20	<	3	<		3	36
	Indicated	7	14	30	16		67	7	52	23	<	82	1	13	2		15	160
	Inferred	27	100	17	2		150	34	140	<		170	4	24	<		28	340
	Hypothetical	27	46				74	20	23			43	<	<			<	120
Freestone total		63	160	52	21		300	62	220	32	1	320	5	39	2		46	660
Leon	Measured	1	7	14	<		22	<	1	8	2	12			2	<	2	36
	Indicated	1	10	18	<		29	<	4	14	2	21	<	1	7	6	14	64
	Inferred		4	4	<		8	<	2	2	16	21		<	8	15	23	51
Leon total		2	21	36	1		59	1	7	25	20	53	<	1	17	22	39	150
Limestone	Measured	1	4	24	58	7	94		<	<	<	1						95
	Indicated	3	10	49	110	22	200	<	1	2	<	3						200
	Inferred	6	20	32	49	2	110	1	2	2		4						110
Limestone total		10	35	100	220	31	400	1	4	4	<	9						410
Robertson	Measured	1	9	24	48		82	1	1	5	2	8			1		1	92
	Indicated	7	34	66	110		220	2	4	38	15	59			6		6	280
	Inferred	23	46	62	13		140	4	36	60	22	120		7	7		14	280
	Hypothetical	3	<				3	1	6			7	<	5			5	15
Robertson total		33	89	150	170		440	7	47	100	39	200	<	12	15		26	670
Grand total		110	310	350	410	31	1,200	72	280	160	60	570	5	52	33	22	110	1,900

Appendix 2d Central Texas total coal resources for northern Zone 9 (NCZ9) in millions of short tons. The coal resources located within the mine permit areas are not included in this table.
 "<" = less than 1 million tons.

	Overburden (ft)	0' - 100'			0' - 100' Total	100' - 200'			100' - 200' Total	200' - 500'			200' - 500' Total	Grand total
		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'		
Total coal thickness (ft)														
County name	Reliability													
Freestone	Measured	3	6	1	10	4	14	4	22	1	2	2	5	38
	Indicated	14	38	4	55	22	59	26	110	6	11	12	29	190
	Inferred	30	130	4	170	46	170	32	250	57	41	26	120	540
	Hypothetical	2	13		16	6	38		43	8	21		28	88
Freestone total		50	190	9	250	79	280	63	420	72	75	40	190	860
Leon	Measured					1	<		2	1	1		1	3
	Indicated					3	<		4	1	2		3	7
	Inferred					<	<		<	1	<		1	1
Leon total						5	<		5	3	3		6	11
Limestone	Measured	1	1	<	2	1	4	6	11	2	2	<	4	17
	Indicated	4	2	<	7	5	14	9	27	12	11		23	56
	Inferred	7	3	<	10	15	37	14	67	41	43	2	86	160
	Hypothetical									<			<	<
Limestone total		12	5	1	18	21	55	29	110	55	56	3	110	240
Grand total		62	200	10	270	100	340	92	530	130	130	42	310	1,100

Appendix 2e Central Texas total coal resources for central Zone 4 (CCZ4) in millions of short tons. The coal resources located within the mine permit areas are not included in this table.
 "<" = less than 1 million tons.

Overburden (ft)		0' - 100'			0' - 100' Total	100' - 200'			100' - 200' Total	200' - 500'			200' - 500' Total	Grand total
Total coal thickness (ft)		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'		
County name	Reliability													
Robertson	Measured	2	5	3	10	3	9	4	16	<			<	26
	Indicated	4	9	5	18	4	24	10	37	1	1	1	4	58
	Inferred	<	1		1	<	10	1	12	2	13	4	20	33
Robertson total		6	15	8	29	7	43	15	66	3	14	5	23	120
Grand total		6	15	8	29	7	43	15	66	3	14	5	23	120

Appendix 2f Central Texas total coal resources for central Zone 5 (CCZ5) in millions of short tons. The coal resources located within the mine permit areas are not included in this table.

"<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'				0' - 100' Total	100' - 200'				100' - 200' Total	200' - 500'		200' - 500' Total	Grand total
		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		5' - 10'	10' - 20'		
Total coal thickness (ft)															
Robertson	Measured	<	1	16	21	38	<	2	25	33	60	2	17	19	120
	Indicated		9	35	18	62	<	7	37	43	88	2	66	68	220
	Inferred		4	8	<	12		<	10	3	13		49	49	75
Robertson total		<	14	59	39	110	<	10	72	79	160	4	130	140	410
Grand total		<	14	59	39	110	<	10	72	79	160	4	130	140	410

Appendix 2g Central Texas total coal resources for southern Zone 4 (SCZ4) in millions of short tons. The coal resources located within the mine permit areas are not included in this table.

"<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'			0' - 100' Total	100' - 200'			100' - 200' Total	200' - 500'				200' - 500' Total	Grand total
		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		
Total coal thickness (ft)															
Bastrop	Measured	4	6	<	11	1	1	<	2	<				<	13
	Indicated	3	13		16	3	17	1	21	<	<			<	37
	Inferred		11		11	<	61	7	68		3			3	82
	Hypothetical						2	1	3		4			4	7
Bastrop total		7	29	<	37	4	81	9	94	<	8			8	140
Lee	Measured	1	2		3	<	<		<	<	1			1	5
	Indicated	7	8		16	3	<		3	<	7			7	26
	Inferred	28	18		46	4	14		18	<	8			8	72
	Hypothetical	<			<	<			<	<				<	<
Lee total		37	29		65	7	15		22	<	16			16	100
Milam	Measured	1	5	2	7	2	28	11	41	1	12	2	2	18	65
	Indicated	1	7	4	13	1	31	21	53	1	10	18	<	29	95
	Inferred	<	2	<	3	<	2	2	4		<	8		8	14
Milam total		2	14	6	22	3	61	34	98	2	22	28	2	54	170
Grand total		46	72	6	120	14	160	43	210	3	46	28	2	79	420

Appendix 2h Central Texas total coal resources for southern Zone 6 (SCZ6) in millions of short tons. The coal resources located within the mine permit areas are not included in this table. "<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'					0' - 100' Total	100' - 200'					100' - 200' Total	200' - 500'					200' - 500' Total	Grand total	
		Total coal thickness (ft)	1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		20' - 40'	1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		20' - 40'	1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'			20' - 40'
Bastrop	Measured	2	14	14			30	1	12	12			26	<	3	6			9	65	
	Indicated	8	38	24	3		73	4	27	16			47	<	12	10			22	140	
	Inferred	8	13	6	1		27	2	7	11			20	<	8	21			29	77	
Bastrop total		18	65	45	3		130	8	46	39			93	<	23	37			61	280	
Lee	Measured	<	2	4	1		7	<	2	7	9	2	20	<	1	2	5	1	9	37	
	Indicated	<	5	3			8	1	11	8	<	<	20	1	7	18	13	6	44	72	
	Inferred	<	3	3			6	2	10	13			25	5	17	19	13	1	56	86	
Lee total		<	9	10	1		21	4	22	28	9	2	64	6	25	39	31	9	110	190	
MILAM	Measured		<	3	15	<	18	1	6	10	8		25	1	6	9	17		33	76	
	Indicated		<	2	3	22	28	1	18	12	7		38	1	14	34	10		59	120	
	Inferred		<		4		5	<	13	1	<		14	1	10	16	2		29	48	
Milam total			<	3	6	41	50	2	37	23	15		77	3	29	59	29		120	250	
Grand Total			18	76	61	46	<	200	13	100	90	25	2	230	9	77	130	60	9	290	730

Appendix 2i Central Texas total coal resources for southern Zone 8 (SCZ8) in millions of short tons. The coal resources located within the mine permit areas are not included in this table. "<" = less than 1 million tons.

County name	Overburden (ft)	0' - 100'				0' - 100' Total	100' - 200'				100' - 200' Total	200' - 500'				200' - 500' Total	Grand total
		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		1.5' - 2.5'	2.5' - 5'	5' - 10'	10' - 20'		
Total coal thickness (ft)																	
County name	Reliability																
Bastrop	Measured	<	1	7	6	14	<	6	25	15	46	<	7	15	11	32	92
	Indicated	<	2	15	7	25		16	69	19	100	1	19	30	34	84	210
	Inferred		4	3	12	19	<	8	44	23	76	2	13	16	11	42	140
Bastrop total		<	7	25	25	57	<	30	140	57	220	3	38	61	56	160	440
Lee	Measured						<	<			<	2	<			2	2
	Indicated						<	3			3	7	2			10	13
	Inferred							10			10	27	16			43	53
	Hypothetical											3	<			3	3
Lee total							<	13			13	40	19			59	72
Milam	Measured		1	2		3	<	1	1		3	<	1	<		2	8
	Indicated		1	4		4	<	5	3		8	1	<			1	13
	Inferred		2	<		2		3	1		4	1	<			1	7
Milam total			4	6		10	<	9	5		14	2	1	<		4	28
Grand total		<	11	31	25	67	1	52	140	57	250	44	59	61	56	220	540