GEOLOGICAL SURVEY CIRCULAR 917

Comparison of Computer-Based and Manual Coal Resource Estimation Methods for the Cache Coal Bed, Recluse Geologic Model Area, Wyoming

Comparison of Computer-Based and Manual Coal Resource Estimation Methods for the Cache Coal Bed, Recluse Geologic Model Area, Wyoming

By Gary B. Schneider, Sharon S. Crowley, and Mary Alice Carey

GEOLOGICAL SURVEY CIRCULAR 917

1984

Department of the Interior

WILLIAM P. CLARK, *Secretary*

U.S. Geological Survey

Dallas L. Peck, *Director*

Free on application to Distribution Branch, Text Products Section,
U. S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304

CONTENTS

ILLUSTRATIONS

TABLES

COMPARISON OF COMPUTER-BASED AND MANUAL COAL RESOURCE ESTIMATION METHODS FOR THE CACHE COAL BED, RECLUSE GEOLOGIC MODEL AREA, WYOMING

By Gary B. Schneider, Sharon S. Crowley, and Mary Alice Carey

ABSTRACT

Coal resources have been estimated, using both manual and computer methods, for the Cache coal bed in the Recluse Geologic Model Area, which covers the White Tail Butte, Pitch Draw, Recluse, and Homestead Draw SW 7½-minute quadrangles in Campbell County, Wyoming. Approximately 300 coal thickness measurements from drill-hole logs are distributed throughout the area. The Cache coal bed and associated strata are in the Paleocene Tongue River Member of the Fort Union Formation. The depth to the Cache coal bed ranges from 269 to 1,257 feet. The coal bed is as much as 31 feet thick but is absent in places. Comparisons between hand-drawn and computer-generated isopach maps show minimal differences. Total coal resources estimated by hand show the bed to contain 2,228 million short tons or about 2.6 percent more than the computer-calculated figure of 2,169 million short tons.

INTRODUCTION

In 1974, the U.S. Geological Survey initiated a project entitled "Research on Geologic Analysis of Selected Coal Model Areas" to pioneer approaches to the acquisition, synthesis, evaluation, and dissemination of geologic information related to coal resource estimation and assessment activities in the United States. The Recluse area in Campbell County, northeastern Wyoming (fig. 1), is one of the selected geologic model areas. It covers 15 minutes of latitude and longitude and is comprised of the White Tail Butte, Pitch Draw, Recluse, and Homestead Draw SW 7½-minute quadrangles. Isopach and coal resource maps of the Cache coal bed were done at 1:50,000 scale.

The Recluse Geologic Model Area provides an opportunity to demonstrate and evaluate the application of computer graphics to estimate coal resources. To make a proper evaluation, computer and manual calculation methods must be compared; ideally, the two should yield similar results. This paper compares computer-based and manual resource estimations for the Cache coal bed.

STRATIGRAPHY

GEOLOGIC SETTING

The Recluse Geologic Model Area is in the Northern Great Plains province midway between the Black Hills and the Bighorn Mountains. It lies near the Montana State line in the north-central part of the Powder River Basin in Wyoming. The topography is characterized by flat-topped buttes; long, narrow, and flat divides; and even-crested ridges that rise steeply above the valley bottoms. The rocks of the area dip to the west and southwest, but surface reversals of dip indicate shallow synclines and anticlines. Other structural features in the subsurface are known from oil and gas drill holes and geophysical data.

Rocks exposed in the area are of continental origin, and are assigned to the Tongue River Member of the Paleocene Fort Union Formation and the lower part of the Eocene Wasatch Formation. The Tongue River Member consists of sandstone, siltstone, mudstone, shale, carbonaceous shale, and coal. The rocks are predominantly yellowish gray, except where the beds have been baked by burning of underlying coal to form conspicuous beds of red, purple, and violet clinker.

The contact between the Fort Union and

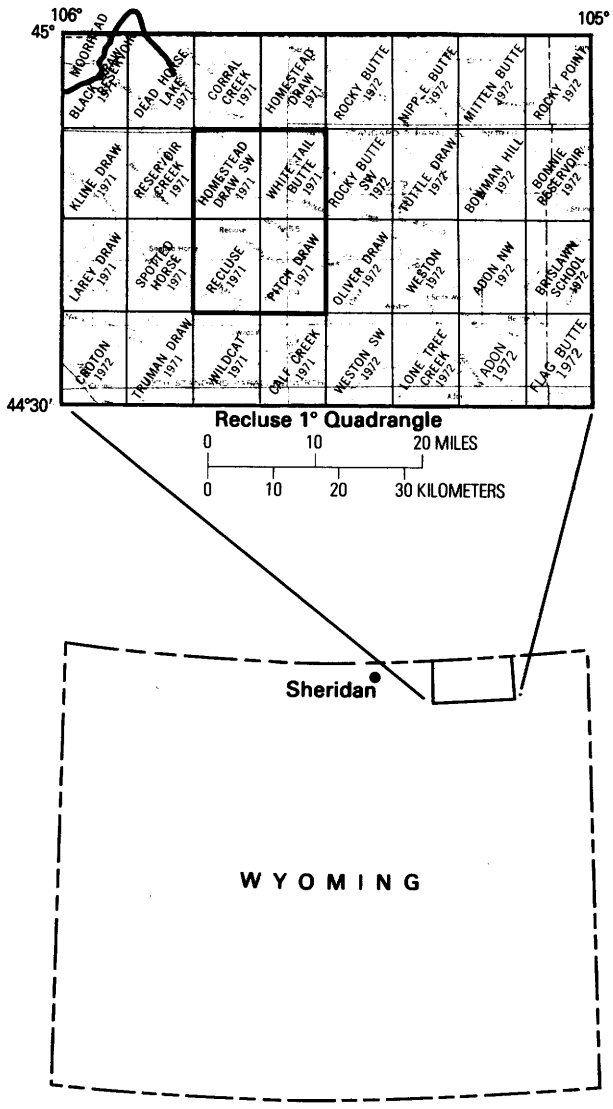

FIGURE 1. Index map showing the location of the Recluse Geologic Model Area outlined by heavy black rectangle.

Wasatch Formations, as shown in figure 2, has been problematical almost since the formations were described. Culbertson and others (1979) summarized the problem as follows:

> The Wasatch Formation overlies [the] Tongue River Member of the Fort Union Formation and also consists of sandstone, siltstone, shale, and coal. The contact between the Fort Union and Wasatch Formations was defined by Thom and Dobbin (1924) to be at the Roland bed as identified by Taff (1909) near Sheridan, Wyoming.
>
> This bed, however, pinches out a short distance from where it was named. In Montana, Baker (1929) placed the contact at a stratigraphically higher bed, which he and Bass (1924) thought to be the Roland. This bed is now referred to as the Roland of Baker (1929). Because no other contact is obvious in the gradational and changing lithologies of the Fort Union and Wasatch Formations near the Montana-Wyoming State line, most subsequent investigators in this area have used the persistent Roland coal bed of Baker (1929) as the contact between the formations, including Bryson and Bass (1973), Olive (1957), Matson, Blumer, and Wegelin (1973), and Culbertson and Mapel (1976).

Total thickness of the Fort Union Formation in the model area is about 2,500 feet, and total thickness of the overlying Wasatch Formation, which is thickest on Horse Nose Butte in the southwestern corner of the area, is 430 feet.

The only consistent general characteristic of the Wasatch Formation that distinguishes it from the underlying Fort Union Formation is a more moderate yellowish-brown color (Olive, 1957).

Coal beds in the eastern part of the Powder River Basin have a tendency to merge eastward, and the intervening strata thicken westward (Kent and others, 1980). These relations suggest that a major, through-flowing drainage channel lay west of the Recluse area during deposition of the Fort Union and Wasatch Formations. Offset stacking of sandstone units is characteristic of fluvial-deltaic deposition as is the merging and splitting of coal beds. Plant material accumulated in depressions between fluvial channels or where sand deposition was minimal. As long as the balance between base-level and subsidence remained relative and there was no major change in water depth, such deposition was continuous within the basin. Thus, the thick coal beds in the Recluse area imply stable conditions where plant material accumulated and changed to peat over long periods of time.

NOMENCLATURE OF THE COAL BEDS

Seven major coal beds (McKay, 1973; Kent and others, 1980) are recognized in a stratigraphic section about 1,300 feet thick in the Recluse Geologic Model Area (fig. 2). The coal beds from youngest to oldest are Anderson, Dietz, Canyon, Cook, Wall, Pawnee, and Cache. The Cook, Wall, Pawnee, and Cache coal beds were named in Montana coal fields many miles from the Recluse Geologic Model Area, and use of these Montana names in the Recluse area implies regional coal correlations that have not been satisfactorily established. To overcome this problem, other geologists (Kent and others, 1980) have introduced names for the coal beds below the Canyon. The authors have elected to retain the Montana names for this report.

CHARACTERISTICS OF THE CACHE BED

The Cache coal bed, considered in detail here, dips toward the axis of the Powder River Basin,

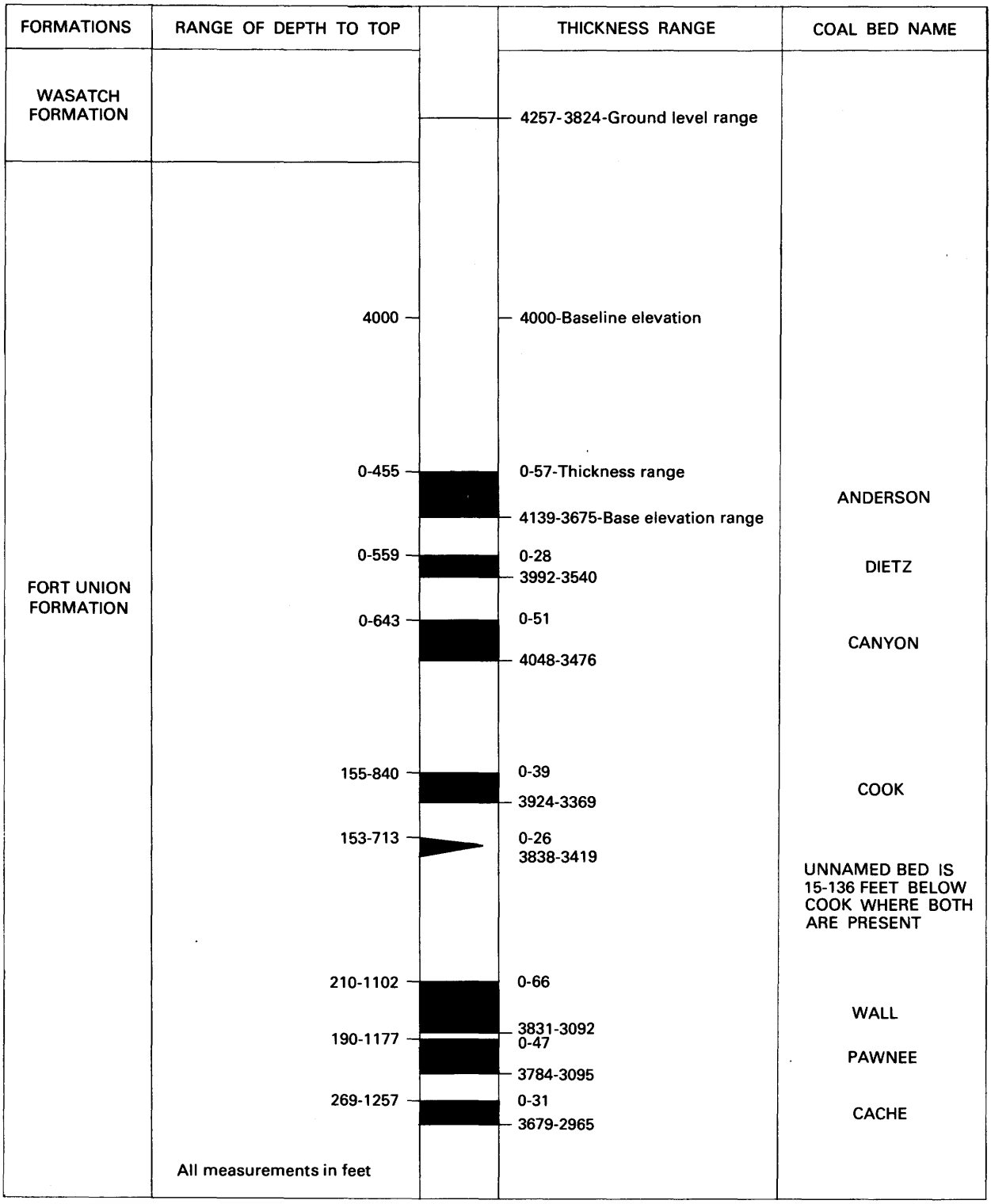

FIGURE 2. Generalized section of a part of the Tongue River Member of the Fort Union Formation and the Wasatch Formation in the Recluse Geologic Model Area, showing the relation of the Cache coal bed to other coal beds and the range of thickness and elevation for all coal beds.

which lies 20 to 30 miles to the west. Within the model area, the maximum thickness of the Cache coal bed is 31 feet, but in places it is absent. The Cache coal bed is not exposed within the four-quadrangle model area. The coal is subbituminous in rank and low (<1 percent) in sulfur. Analyses of coal from two core samples (Hobbs, 1980) show a sulfur content of about 0.4 percent and an ash content of 11.3 percent on an "as received" basis with an unweighted mathematical average heating value calculated at 6,782 Btu. Estimated total coal resources for the Cache coal bed in the model area are approximately 2.3 billion tons.

SOURCES OF INFORMATION

Figure 3 shows the locations of 298 deep oil and gas wells and coal test holes that penetrated the Cache coal bed in the model area. Information from an additional two shallow coal-exploratory holes also aided in the study. Geophysical logs, including some combinations of resistivity, formation density, and gamma ray logs, are available for all of the holes shown on figure 3. Locations of wells are listed in appendixes A through D.

The coal beds in the area generally have very high resistivity, extremely low radioactivity, and specific gravities of about 1.3. Relative responses to these properties are recorded on the geophysical logs. Lithologic materials and the salt content of water or mud affect log response in a particular way. Resistivity of a coal bed also varies with ash content. The degree of assurance of the interpretation is best where all three log types are available for the same hole.

COMPUTER CALCULATION OF RESOURCES

The National Coal Resources Data System (NCRDS) of the U.S. Geological Survey supports various spatial data bases that interact with digitized data and the graphic display programs. The Program to Analyze Coal Energy Resources (PACER) (Cargill and others, 1976) is the storage-retrieval system developed in-house to manage all NCRDS data bases of which the U.S. Stratigraphic Sequence file (USTRAT) is one. The Recluse Geologic Model Area data subset stored in the USTRAT data base consists of 300 drill-hole locations with their respective stratigraphic sections and of 15 control points that lie outside the map boundary. Required digitized information includes x, y locations (latitude and longitude) for each point, township-range intersections from the base map, and the thickness-of-overburden category determined by the geologist.

Graphic Analysis of Resources Using Numerical Evaluation Techniques (GARNET) (Olson, 1980) is the graphics package that is used to produce contour and coal-resource maps. Generation of an isopach map in GARNET requires latitude, longitude, and a coal thickness for every data point in the map area. This information is used to produce a gridded file for graphic display. Algorithms in GARNET generate grids using quadratic and weighted planar fit methods. The quadratic method is designed for dense (closely spaced) data with even distribution whereas the planar method is designed for diffuse data with uneven distribution. The planar method produced the most satisfactory grid because of the diffuse point distribution in this study (fig. 3). Figure 4 is a hand-drawn isopach for the Cache coal bed, and figure 5 is a computer-generated isopach map of the same bed data generated by the planar method.

Each of the gridding algorithms divides the map area into a large number of grid cells, the size of which is determined by the user. In this study, a cell size of 0.5 inch was used for the 16-inch × 22-inch, 1:50,000-scale map, creating a total of 1,408 grid cells. The 0.5-inch grid-cell size was chosen because it is the largest cell that can produce reliable resource estimates at reasonable computer costs.

The gridding algorithms assign a z-value (coal thickness in this study) to each of the grid intersections. The weighted plane method uses control points within a radius equal to one-fourth of the diagonal distance across the map area to determine the z-value at each intersection. The weighting function is exponential: points closer to a grid intersection are weighted more heavily, whereas points farther from a grid intersection are weighted more lightly. This function is expressed by:

$$WEIGHT = EXP\frac{-4^{*}\,DIST}{(AREA/(NO.POINTS))}$$

where $WEIGHT$ is the weighting function, EXP is the exponential function e^{z} (real number 2.71828...), $DIST$ represents distance (user-defined

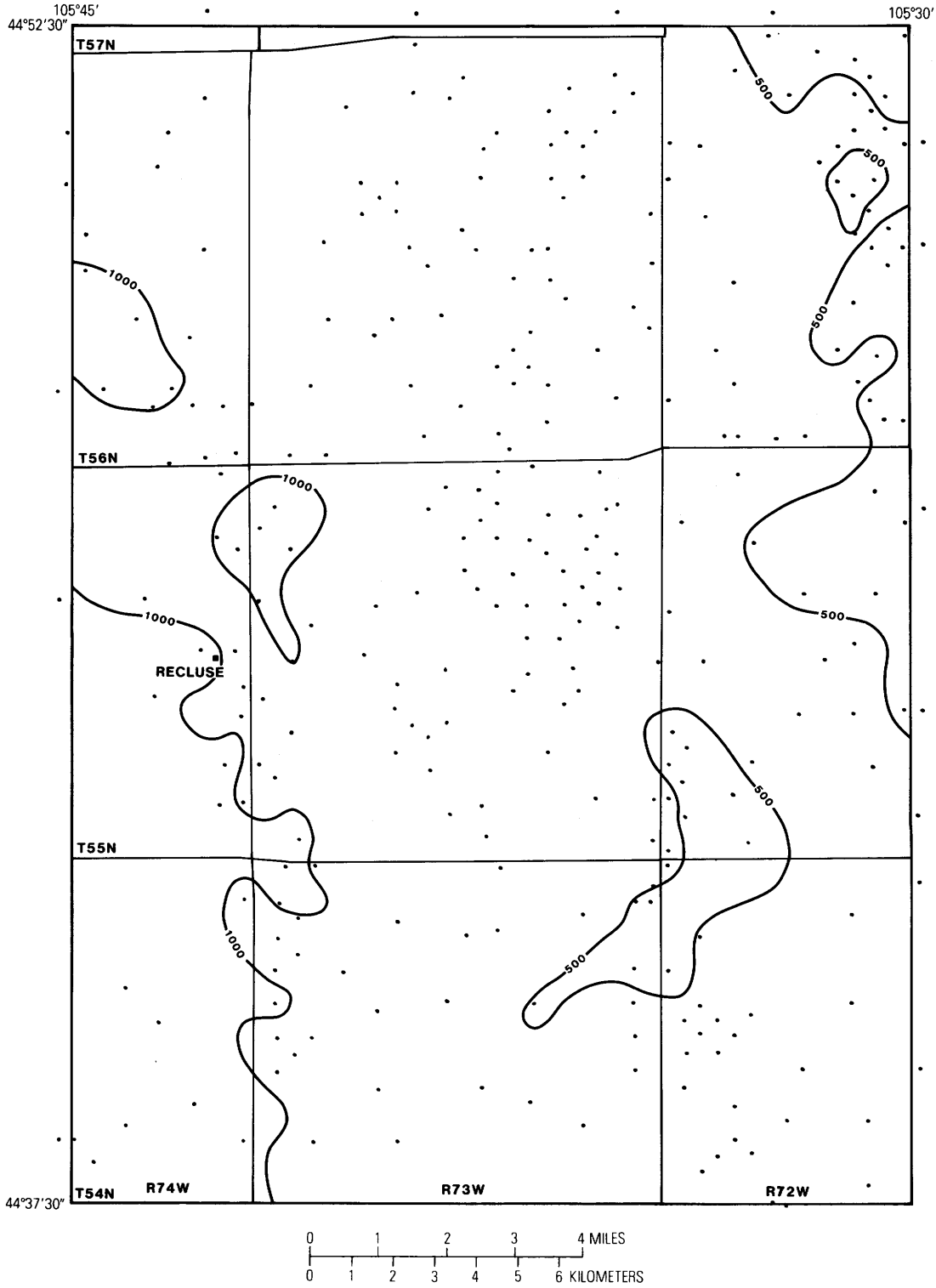

FIGURE 3. Map showing diffuse distribution of data points and the 500-foot and 1000-foot overburden contours used in this study.

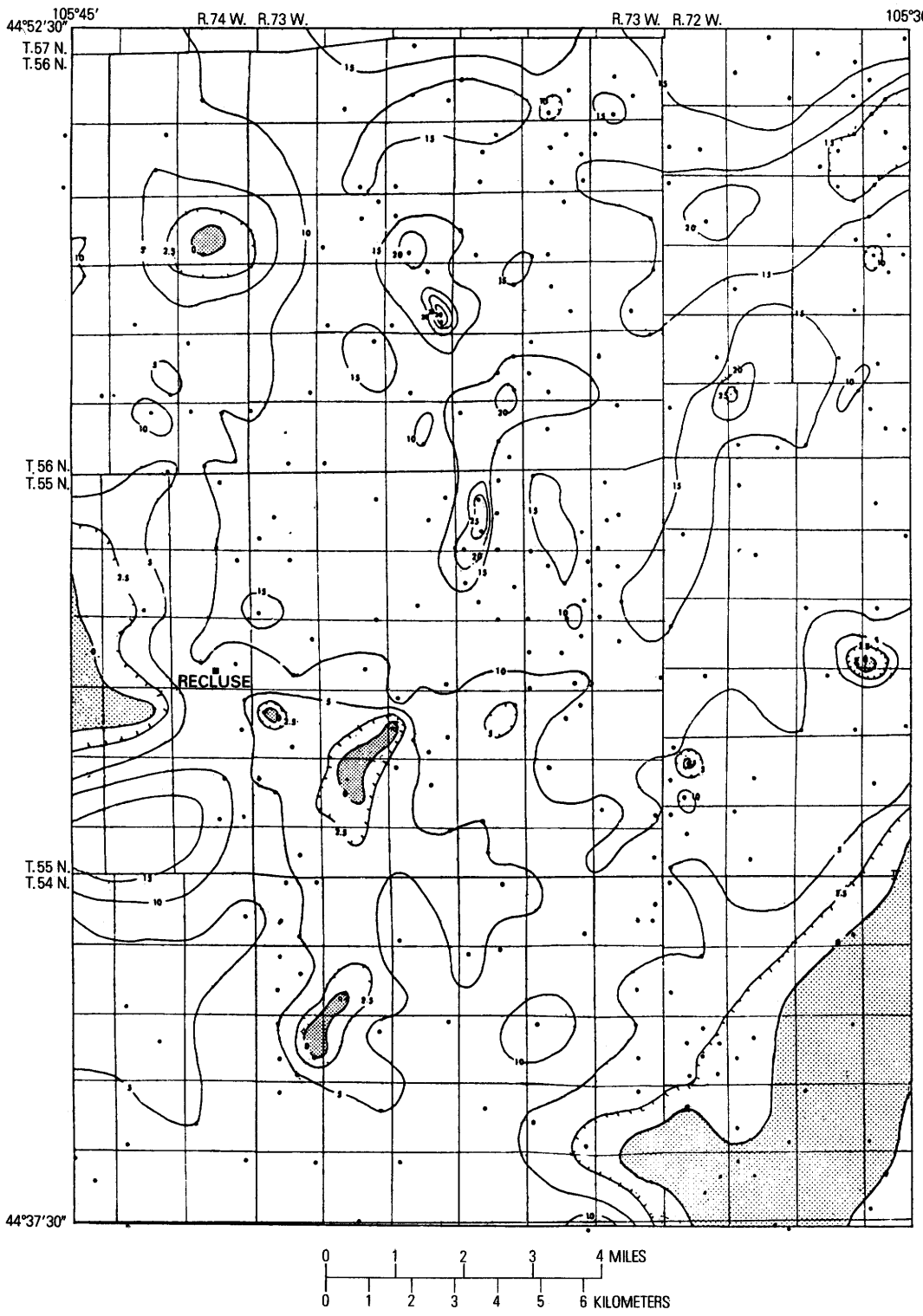

FIGURE 4. Hand-drawn isopach map of the Cache coal bed in the Recluse Geologic Model Area, Wyoming. Original scale at 1:50,000. Isopach intervals are 2.5, 5, 10, 15, 20, 25, and 30 ft. • = drill hole location.

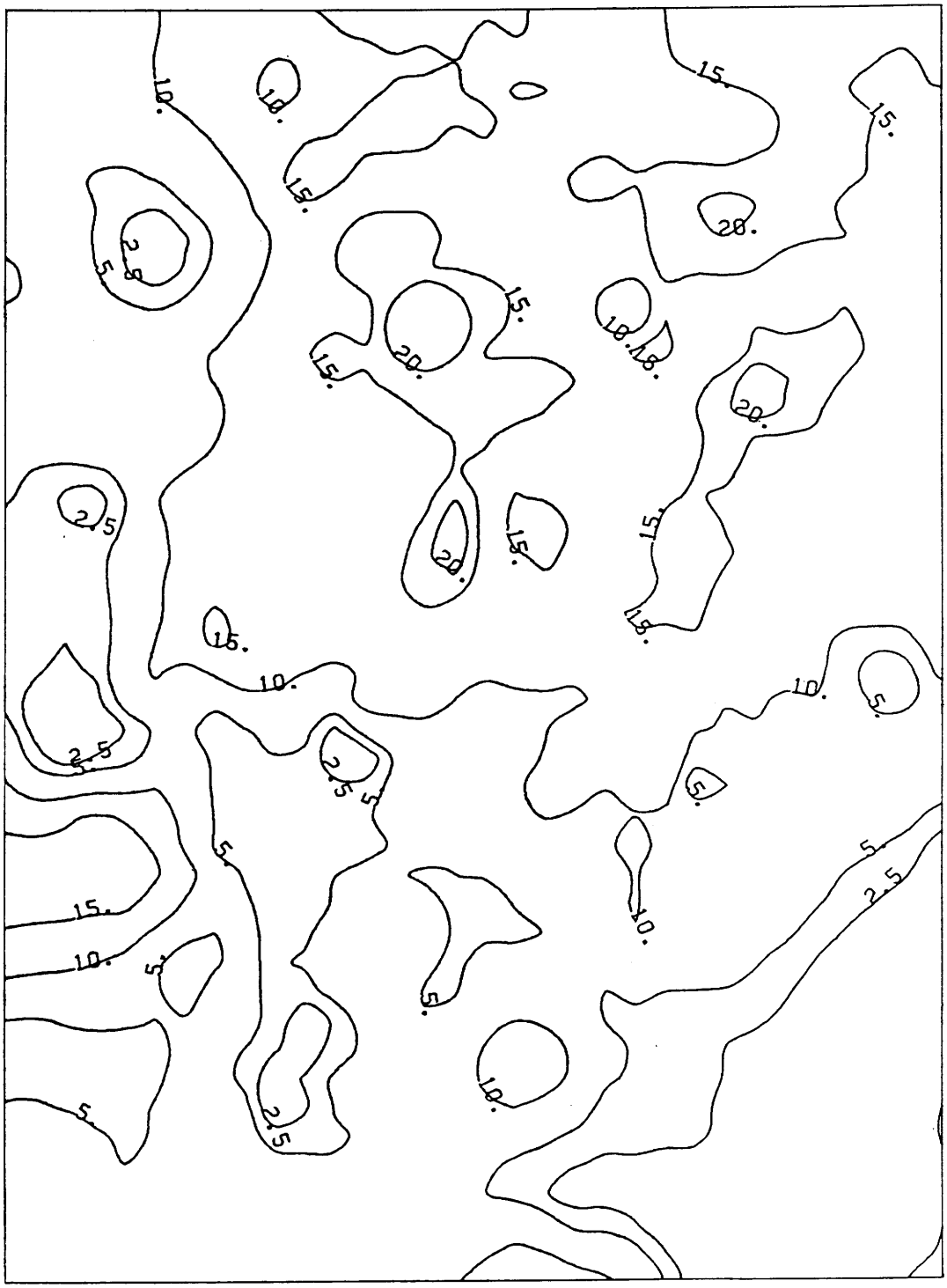

FIGURE 5. Computer-generated isopach map of the Cache coal bed in the Recluse Geologic Model Area, Wyoming. Isopachs represent thickness of the Cache coal bed. Isopach intervals are 2.5, 5, 10, 15, and 20 ft. (Latitude = 44°37′30″ to 44°52′30″ N, longitude = 105°30′00″ to 105°45′00″ W. Figure 4 covers the same area.) Original scale at 1:50,000.

units, meters-on-the-ground in this study) from the data point to a grid intersection, *AREA* is the map area, and *NO.POINTS* is the number of control points (Olson, 1977).

The geologist evaluates the computer-generated isopach maps and has the option of adding, editing, or deleting point data. Interpretive points are sometimes added to modify the isopach pattern. Because the coal isopach lines generated by the computer for the Cache coal bed in the Recluse Geologic Model Area approximate the thicknesses at the data points, the authors considered the addition of interpretive points to be unnecessary.

Standardized calculation of coal resources (Wood and others, 1983) requires that resource categories be delimited by coal thickness, overburden thickness (fig. 3), and the distance (¼, ¾, or 3 miles) from the point of observation. Resource calculations were further delimited by township-range. GARNET allows interactive graphic combination of digitized and computer-generated line data files to derive boundary lines of the required categories. The combinations produced 49 subfiles for the Recluse Geologic Model Area from which GARNET calculated coal resources in the following categories: measured (¼ mile), indicated (¼ to ¾ mile), and inferred (¾ to 3 miles) resources (tables 1, 2, and 3) as represented by the respective circular areas on the resource map (fig. 6). The total original resources estimated by manual and computer methods are presented by township-range in table 4.

GARNET calculates coal resources using the gridded files generated for coal isopach maps. Volumes of coal are computed for each of the reliability circles (measured, indicated, and inferred) and then multiplied by a density factor based on the rank of the coal. The density factor for subbituminous coal is 1,770 tons/acre-foot. To compute volumes at high resolution, bilinear interpolation is used to divide each grid cell into four subgrids. This interpolation technique fits a hyperbolic surface to the four grid points of each cell by creating vertical cross sections parallel to the grid boundary. The area of each cross section is computed, and the volume is determined by integrating across the cross sectional areas within the limits of required resource categories and reliability circles (Olson, 1977).

ISOPACH AND RESOURCE COMPARISON

For comparative purposes, the authors overlaid the computer-drawn contour map (fig. 5) onto the hand-drawn isopach map (fig. 4). The combination of the maps is presented in figure 7.

Initial visual comparison of the combined isopachs in figure 7 shows the geometry to be similar. Particularly note the 2.5-foot and 5-foot contours in the southeast (A) and the 10-foot contour in the northwest extending southward to the middle of the map, then continuing eastward (B-B'); the general proximity of the hand-drawn and computer-generated contours is impressive. The computer-generated contours are a direct result of gridding the original data points—additional data manipulation was not required.

Closer inspection of the map (fig. 7) indicates significant differences between the two methods of contouring. Note the following relationships between the "C" contours: (1) the hand-drawn isopach map in the upper central part shows a clustering of contours from 20 feet to 30 feet, whereas the computer-drawn isopach map displays the area as a collective relationship of 15-foot and 20-foot contours; and (2) the small areas of the 10-foot and within the 25-foot and 30-foot contours of the hand-drawn isopach in the same area are not shown on the computer-generated isopach.

Omission of contour lines on the computer-generated map can be explained by the computer gridding technique. The software assigns only one value to a given grid cell intersection and draws contours between intersections with differing values. Contours are not drawn if the values of the grid intersection remain the same. The grid cell size used in this study (0.5 inch) may have had the effect of generalizing contours, causing the omission of contours that indicate localized peaks of coal thickness. Ten other sets of hand-drawn contours labeled "D" do not appear on the computer-generated map (fig. 7). Because the "D" contours are confined to small areas, their omission on the computer-generated map may also be a function of the grid cell size. The computer does not plot contours that would occur totally within one grid cell, thereby eliminating contours less than 0.5 inch in diameter.

Additions of contour lines, however, may also occur in computer-generated maps. One computer

Table 1.—*Comparison of manually calculated and computer-calculated original resources of subbituminous coal under 500 feet or less of overburden in the Cache coal bed for the Recluse Geologic Model Area, Campbell County, Wyoming, as of Jan. 1, 1980*

[Calculations are in millions of short tons; to convert feet to meters multiply by 0.3048, to convert short tons to metric tons multiply by 0.9071; Cache coal bed is in the Tongue River Member of the Paleocene Fort Union Formation]

Reliability Category			Measured Resources				Indicated Resources				Inferred Resources			
Thickness of Coal Category (in feet)			2½-5	5-10	>10	Total	2½-5	5-10	>10	Total	2½-5	5-10	>10	Total
Mode[1]	Index[2]	Township and Range												
M	T.1	T. 54 N., R. 74 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.2	T. 55 N., R. 74 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.3	T. 56 N., R. 74 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.4	T. 57 N., R. 74 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.5	T. 57 N., R. 73 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.6	T. 56 N., R. 73 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.7	T. 55 N., R. 73 W.	---	0.337	0.538	0.875	---	0.344	0.671	1.015	---	---	---	---
C			---	---	.232	.232	---	---	1.359	1.359	---	---	---	---
M	T.8	T. 54 N., R. 73 W.	1.51	3.072	---	4.582	3.19	3.030	---	6.220	---	0.340	---	0.340
C			1.167	1.169	1.894	4.230	1.150	3.815	2.058	7.023	---	.309	---	.309
M	T.9	T. 54 N., R. 72 W.	.929	.865	---	1.794	3.519	4.49	---	8.009	0.440	.097	---	.537
C			1.32	.748	---	2.068	2.16	8.23	---	10.39	---	.455	---	1.273
M	T.10	T. 55 N., R. 72 W.	---	12.922	14.838	27.760	---	20.059	36.550	56.609	---	.359	6.010	6.369
C			.476	9.358	12.886	22.720	.218	15.662	38.659	54.539	---	---	6.390	6.390
M	T.11	T. 56 N., R. 72 W.	---	---	48.695	48.695	---	---	43.872	43.872	---	---	.009	.009
C			---	---	47.786	47.786	---	---	44.649	44.649	---	---	---	---
		TOTALS												
M			2.439	17.196	64.071	83.706	6.709	27.923	81.093	115.725	.440	.796	6.019	7.255
C			2.963	11.275	62.798	77.036	3.528	27.707	86.725	117.960	---	.764	6.390	7.972

[1]M = manual; C = computer.
[2]Computer code for township-range designation.

contour, the 10-foot contour at location E (fig. 7), does not occur near a hand-drawn contour. An examination of the coal thicknesses in this area indicates that the contour line is feasible, and omission of the contour from the hand-drawn map may have been due to a different interpretation by the geologist.

When comparing the overall appearance of the two maps, the 2.5-foot and 10-foot contours demonstrate the most similar geometries. An isopach map more closely approximating the hand-drawn map may have been obtained by using a smaller grid cell size. However, the authors felt the 0.5-inch grid cell gave adequate isopach

Table 2.—*Comparison of manually calculated and computer-calculated original resources of subbituminous coal under 500-1,000 feet of overburden in the Cache coal bed for the Recluse Geologic Model Area, Campbell County, Wyoming, as of Jan. 1, 1980*

[Calculations are in millions of short tons; to convert feet to meters multiply by 0.3048, to convert short tons to metric tons multiply by 0.9071; Cache coal bed is in the Tongue River Member of the Paleocene Fort Union Formation]

Reliability Category	Measured Resources				Indicated Resources				Inferred Resources			
Thickness of Coal Category (in feet)	2½–5	5–10	>10	Total	2½–5	5–10	>10	Total	2½–5	5–10	>10	Total
Mode[1] Index[2] Township and Range												
M ----- T.1 T. 54 N., R. 74 W.	0.893	---	---	0.893	2.118	0.068	---	2.186	---	---	---	---
C -----	.772	---	---	.772	1.057	1.666	---	2.723	---	---	---	---
M ----- T.2 T. 55 N., R. 74 W.	2.741	3.953	4.047	10.741	5.448	15.591	8.01	29.049	3.310	0.409	2.291	6.010
C -----	1.091	5.222	1.685	7.998	4.119	14.456	8.181	26.756	6.817	.621	---	7.438
M ----- T.3 T. 56 N., R. 74 W.	1.68	16.576	3.68	21.936	1.943	46.185	12.9	61.028	1.794	13.279	.761	15.834
C -----	.542	17.032	1.811	19.385	6.584	53.368	5.469	65.421	1.270	14.636	.467	16.373
M ----- T.4 T. 57 N., R. 74 W.	---	---	---	---	---	---	.269	.269	---	7.09	4.290	11.380
C -----	---	---	---	---	---	---	---	---	---	7.101	2.826	9.927
M ----- T.5 T. 57 N., R. 73 W.	---	---	.940	.940	---	---	5.577	5.577	---	---	11.556	11.556
C -----	---	---	.840	.840	---	---	5.632	5.632	---	---	10.632	10.632
M ----- T.6 T. 56 N., R. 73 W.	---	.668	193.089	193.757	---	9.350	357.147	366.497	---	8.630	31.891	40.521
C -----	---	3.358	170.340	173.698	.199	9.260	358.789	368.248	.069	10.969	27.334	38.372
M ----- T.7 T. 55 N., R. 73 W.	11.567	25.515	118.055	155.137	12.472	54.105	150.723	217.300	2.372	10.320	6.519	19.211
C -----	5.878	21.887	113.271	141.036	13.075	54.233	143.402	210.710	3.043	5.256	4.752	13.051
M ----- T.8 T. 54 N., R. 73 W.	16.221	15.477	---	31.698	41.265	72.835	---	114.100	6.765	9.612	---	16.377
C -----	6.602	21.917	1.686	30.205	16.751	99.074	10.095	125.920	.645	19.653	3.645	23.943
M ----- T.9 T. 54 N., R. 72 W.	2.176	.630	---	2.806	5.009	.304	---	5.313	4.188	---	---	4.188
C -----	2.773	.835	---	3.608	4.16	.870	---	4.990	3.132	.080	---	3.212
M ----- T.10 T. 55 N., R. 72 W.	---	14.463	25.150	39.613	1.26	44.746	63.930	109.936	.236	1.955	8.936	11.127
C -----	.730	10.587	15.197	26.514	2.910	37.063	77.093	117.066	1.876	5.967	9.761	17.604
M ----- T.11 T. 56 N., R. 72 W.	---	---	72.537	72.537	---	---	188.119	188.119	---	---	29.106	29.106
C -----	---	---	67.342	67.342	---	---	191.883	191.883	---	---	29.131	29.131
TOTALS												
M -----	35.278	77.282	417.498	530.058	69.515	243.184	786.675	1099.374	18.665	51.295	95.350	165.310
C -----	18.388	80.838	372.172	471.398	48.855	269.99	800.544	1119.349	16.852	64.283	88.548	169.683

[1]M = manual; C = computer.
[2]Computer code for township-range designation.

results and that further refinement was not worth the expenditure in terms of production time or computer costs.

A comparison of total calculated resource tonnages of 2,228 million short tons (manual) and 2,169 million short tons (computer) (table 4) shows a 2.6-percent difference. Point data coal thickness, overburden trace, category radii, and township-range limits are constants. The only real variable is the difference in the isopach lines. Because isopach lines are combined with the overburden trace and township-range limits to define areas for resource calculation, differences for several of the categories can be explained. One of these factors is the difference in the thickness value used in the respective calculations: the geologist assigns an average thickness to each area planimetered; the computer integrates areas on a cell-by-cell basis, reflecting the thickness changes illustrated by the isopach map. In simpler terms, the computer does

Table 3.—*Comparison of manually calculated and computer-calculated original resources of subbituminous coal under 1,000–2,000 feet of overburden in the Cache coal bed for the Recluse Geologic Model Area, Campbell County, Wyoming, as of Jan. 1, 1980*

[Calculations are in millions of short tons; to convert feet to meters multiply by 0.3048, to convert short tons to metric tons multiply by 0.9071; Cache coal bed is in the Tongue River Member of the Paleocene Fort Union Formation]

Reliability Category			Measured Resources				Indicated Resources				Inferred Resources			
Thickness of Coal Category (in feet)			2½–5	5–10	>10	Total	2½–5	5–10	>10	Total	2½–5	5–10	>10	Total
Mode[1]	Index[2]	Township and Range												
M	T.1	T. 54 N., R. 74 W.	2.09	7.346	---	9.436	14.49	32.345	---	46.835	8.86	17.30	12.8	38.960
C			1.867	6.789	---	8.656	13.427	33.326	---	46.753	7.219	22.258	1.937	31.414
M	T.2	T. 55 N., R. 74 W.	.308	5.68	6.47	12.458	2.325	13.380	41.40	57.105	.468	.230	2.267	2.965
C			---	3.841	6.917	10.758	1.952	6.385	18.842	27.179	2.526	5.786	13.259	21.571
M	T.3	T. 56 N., R. 74 W.	---	5.579	---	5.579	---	15.152	---	15.152	---	.989	---	.989
C			---	6.103	.376	6.479	---	15.080	.123	15.203	---	.586	---	.586
M	T.4	T. 57 N., R. 74 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.5	T. 57 N., R. 73 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.6	T. 56 N., R. 73 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.7	T. 55 N., R. 73 W.	---	.794	10.880	11.674	.054	1.08	14.046	15.180	---	---	.031	.031
C			.748	.427	9.724	10.899	.417	2.012	14.535	16.964	---	---	---	---
M	T.8	T. 54 N., R. 73 W.	3.086	.345	---	3.431	2.169	4.420	---	6.589	---	.524	---	.524
C			.685	2.584	---	3.269	.870	4.853	---	5.723	---	.453	---	.453
M	T.9	T. 54 N., R. 72 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.10	T. 55 N., R. 72 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
M	T.11	T. 56 N., R. 72 W.	---	---	---	---	---	---	---	---	---	---	---	---
C			---	---	---	---	---	---	---	---	---	---	---	---
TOTALS														
M			5.484	19.744	17.350	42.578	19.038	66.377	55.446	140.861	9.328	19.043	15.098	43.469
C			3.300	19.744	17.017	40.061	16.666	61.656	33.500	111.822	9.745	29.083	15.196	54.024

[1]M = manual; C = computer.
[2]Computer code for township-range designation.

not average area thicknesses but uses the value of each grid cell or portion thereof to calculate the numerical tonnage value of the area.

CONCLUSION

The NCRDS method and the manual method for calculating coal resources apply the rules defined by the U.S. Geological Survey (Wood and others, 1983) to produce reliable maps and resource estimates. Accuracy of both the computer and manual isopach configurations can be debated, and both can be edited to satisfy geological interpretation. The computer does not make subjective decisions concerning the configuration of the isopach; it can only apply programmed mathematical relationships to data submitted by the user.

Table 4.—*Total manually calculated and computer-calculated original resources of subbituminous coal in the Cache coal bed for the Recluse Geologic Model Area, Campbell County, Wyoming*

[Manual calculation as of Jan. 1, 1979; computer calculations as of Jan. 1, 1980. Calculations are for coal under 2,000 feet or less of overburden]

Mode[1]	Index[2]	Township and range	Total resources in millions of short tons
M	T.1	T. 54 N., R. 74 W.	98.310
C			90.318
M	T.2	T.55 N., R. 74 W.	118.328
C			101.700
M	T.3	T. 56 N., R. 74 W.	120.518
C			123.447
M	T.4	T. 57 N., R. 74 W.	11.649
C			9.927
M	T.5	T. 57 N., R. 73 W.	18.073
C			17.104
M	T.6	T. 56 N., R. 73 W.	600.775
C			580.318
M	T.7	T. 55 N., R. 73 W.	420.423
C			394.251
M	T.8	T. 54 N., R. 73 W.	183.861
C			201.079
M	T. 9	T. 54 N., R. 72 W.	22.647
X			25.541
M	T. 10	T. 55 N., R. 72 W.	251.414
C			244.833
M	T. 11	T. 56 N., R. 72 W.	382.338
C			380.791
		Totals	2228.336 M
			2169.305 C

[1]M = manual; C = computer.
[2]Computer code for township-range designation.

REFERENCES CITED

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 806-B, p. 15-67.

Bass, N. W., 1924, Coal in the Tongue River Valley, Montana: U.S. Department of Interior Press Memorandum 16748, Feb. 12, 1924.

Bryson, R. P., and Bass, N. W., 1973, Geology of the Moorhead coal field, Powder River and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 1338, 116 p. [1974].

Cargill, S. M., Olson, A. C., Medlin, A. L., and Carter, M. D., 1976, PACER—Data entry, retrieval, and update for the National Coal Resources Data System (phase I): U.S. Geological Survey Professional Paper 978, 107 p.

Culbertson, W. C., and Klett, M. C., 1975, Preliminary geologic map and coal sections of the Jones Draw quadrangle, Sheridan County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-726, scale 1:24,000, 2 sheets.

Culbertson, W. C., and Mapel, W. J., 1976, Coal in the Wasatch Formation, northwest part of the Powder River Basin near Sheridan, Sheridan County, Wyoming, *in* Wyoming Geological Association Guidebook, 28th Annual Field Conference, 1976, p. 193-202.

Culbertson, W. C., Kent, B. H., and Mapel, W. J., 1979, Preliminary diagrams showing correlation of coal beds in the Fort Union and Wasatch Formations across the Northern Powder River Basin, northeastern Wyoming and southeastern Montana: U.S. Geological Survey Open-File Report 79-1201, 11 p., 2 sheets.

Hobbs, R. G., 1980, 1976 Coal exploratory drilling: core description and coal analyses, Recluse Geologic Analysis Area, Northern Campbell County, Wyoming: U.S. Geological Survey Open-File Report 80-1160, 53 p.

Kent, B. H., Berlage, L. J., and Boucher, E. M., 1980, Stratigraphic framework of coal beds underlying the western part of the Recluse 1° × 1/2° quadrangle, Campbell County, Wyoming: U.S. Geological Survey Coal Investigations Map C-81C, 2 pls.

Matson, R. E., Blumer, J. W., and Wegelin, L. A., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p.

McKay, E. J., 1973, The preliminary geologic map of the Croton 1 NE (Homestead Draw) quadrangle, Campbell County, Wyoming: U.S. Geological Survey Open-File Report 73-168, scale 1:24,000.

Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U.S. Geological Survey Bulletin 1050, 83 p.

Olson, A. C., 1977, Graphic Analysis of Resources by Numerical Evaluation Techniques (GARNET): Computers & Geosciences, v. 3, no. 3, p. 539-545.

_____1980, GARNET—Computer applications software for the National Coal Resources Data System: U.S. Geological Survey Open-File Report 80-228, 160 p.

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U.S. Geological Survey Bulletin 341-B, p. 123-150.

Thom, W. T., and Dobbin, C. E., 1924, Stratigraphy of Cretaceous-Eocene transition beds in eastern Montana and the Dakotas: Geological Society of America Bulletin, v. 35, p. 481-506.

U.S. Geological Survey, 1971, Homestead Draw SW, Wyo., 7.5-minute quadrangle, Campbell County, Wyoming: scale 1:24,000.

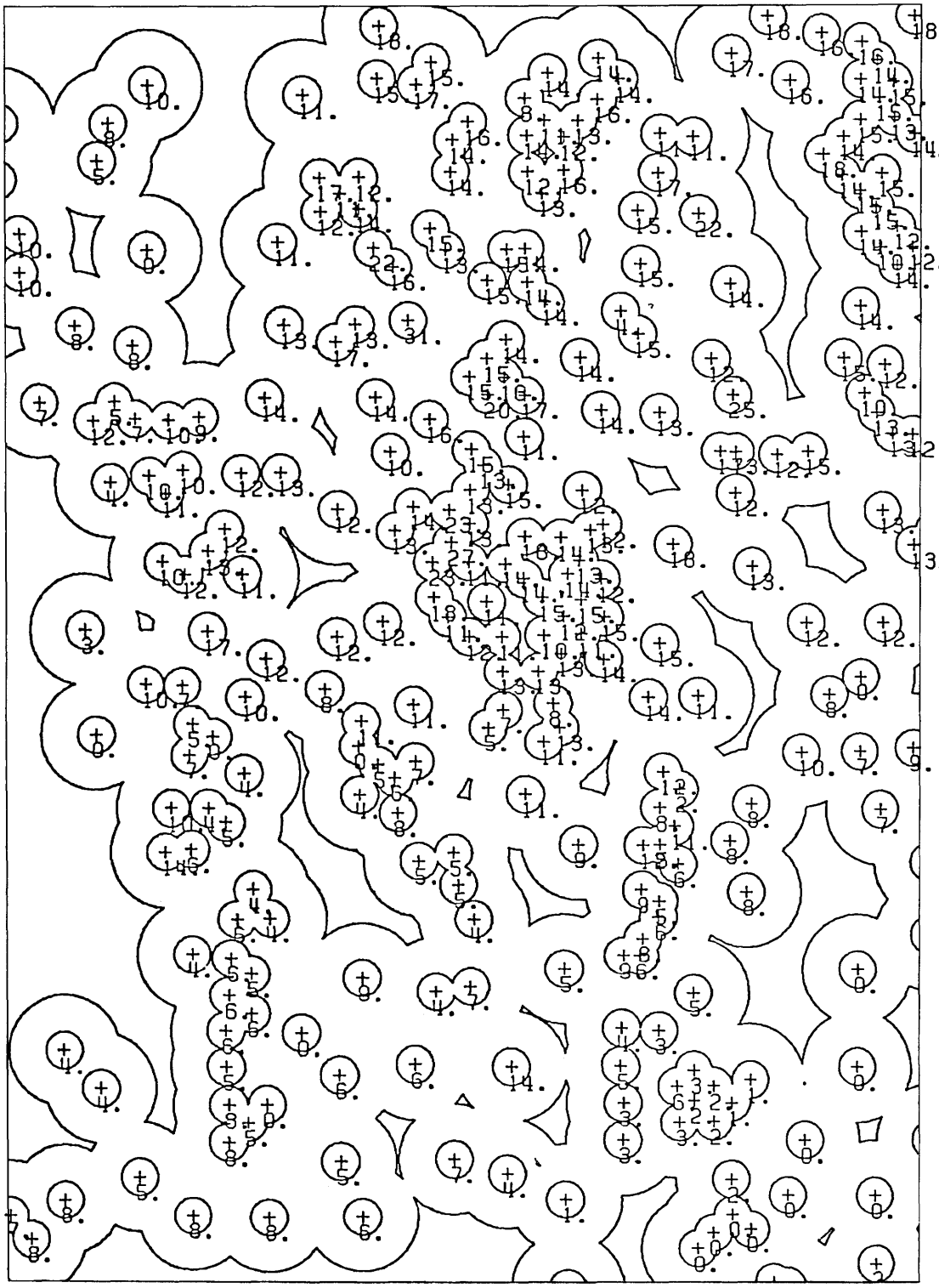

FIGURE 6. Computer-generated resource map showing location of data points and thickness of Cache coal bed at each point. Circular areas represent ¼-, ¾-, and 3-mile (not shown) radii, corresponding to outer limits of measured, indicated, and inferred coal resource reliability categories, respectively. (Latitude = 44°37′30″ to 44°52′30″ N, longitude =105°30′00″ to 105°45′00″ W. Figure 4 covers the same area.) Original scale at 1:50,000.

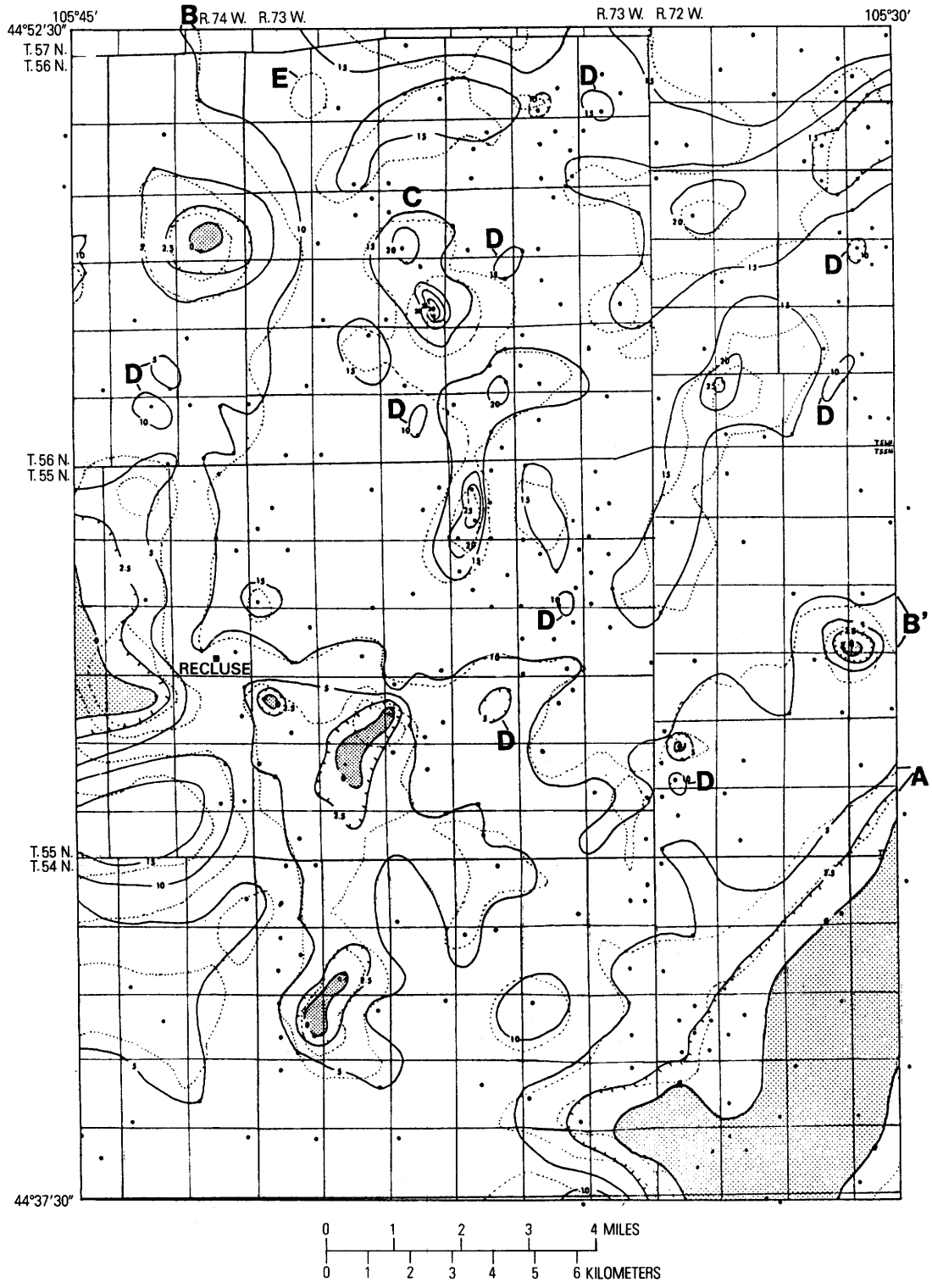

FIGURE 7. Computer-generated isopach map (dotted lines) from figure 5 superimposed on hand-drawn isopach map from figure 4 of the Cache coal bed for comparative use and discussion. Shaded area = coal is absent. Original scale at 1:50,000.

_____1971, Pitch Draw, Wyo., 7.5-minute quadrangle, Campbell County, Wyoming: scale 1:24,000.
_____1971, Recluse, Wyo., 7.5-minute quadrangle, Campbell County, Wyoming: scale 1:24,000.
_____1971, White Tail Butte, Wyo., 7.5-minute quadrangle, Campbell County, Wyoming: scale 1:24,000.
Wood, G. H., Kehn, T. M., Carter, M. D., and Culbertson, W. C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

APPENDIXES: SOURCES OF COAL-BED DATA

APPENDIX A. WHITE TAIL BUTTE QUADRANGLE

APPENDIX B. HOMESTEAD DRAW SW QUADRANGLE

APPENDIX C. PITCH DRAW QUADRANGLE

APPENDIX D. RECLUSE QUADRANGLE

APPENDIX A.

SOURCES OF COAL-BED DATA IN THE WHITE TAIL BUTTE QUADRANGLE

Sources of coal-bed data in the White Tail Butte Quadrangle

[List of wells, locations, and ground elevations for all wells in the Recluse Geologic Model Area including wells that do not penetrate the Cache Coal Bed]

[To convert feet to meters multiply by 0.3048]

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-1	Petroleum, Inc. 1 Government - Phillips	NW 1/4 NE 1/4 sec. 3, T. 56 N., R. 72 W.	3,900
B-2	CRA Inc. and At..antic Richfield Co. 1-3 Gibbs - Government	SE 1/4 SW 1/4 sec. 3, T. 56 N., R. 72 W.	3,990
B-3	Pan American Petroleum Co. 1 USA - Moore	NW 1/4 SW 1/4 sec. 3, T. 56 N., R. 72 W.	3,998
B-4	J. M. Huber Corp. 1-4 Federal - Grace	SE 1/4 SE 1/4 sec. 4, T. 56 N., R. 72 W.	4,055
B-5	Southland Royalty Co. 1 Whitetail - Federal	SE 1/4 NE 1/4 sec. 4, T. 56 N., R. 72 W.	3,958
B-6	McMahon-Bullington Drilling Co. 2-4 George Emigh	SE 1/4 NW 1/4 sec. 4, T. 56 N., R. 72 W.	3,845
B-7	Kissinger Petroleum Corp. 1 Pucket Federal	SE 1/4 SE 1/4 sec. 5, T. 56 N., R. 72 W.	4,013
B-8	Southland Royalty Co. 1-5 Whitetail - USA	NW 1/4 NE 1/4 sec. 5, T. 56 N., R. 72 W.	3,921
B-9	Southland Royalty Co. 5-2 Federal	NW 1/4 SW 1/4 sec. 5, T. 56 N., R. 72 W.	4,028
B-10	Ames Oil & Gas Co. and Terra Resources 1 Terra - Ames - Federal	SE 1/4 SE 1/4 sec. 6, T. 56 N., R. 72 W.	4,138
B-11	Atlantic Richfield Co. 1-A Arco - Federal - Beard	NW 1/4 SE 1/4 sec. 1, T. 56 N., R. 73 W.	4,114
B-12	Kissinger Petroleum Corp. 3-1 Federal	SE 1/4 SW 1/4 sec. 1, T. 56 N., R. 73 W.	4,016
B-13	Powder River Oil Co. 6-1 Beason	SE 1/4 NW 1/4 sec. 1, T. 56 N., R. 73 W.	4,026

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-14	Eason Oil Co. 1-2 Moore - Hoblit	NW 1/4 SE 1/4 sec. 2, T. 56 N., R. 73 W.	4,086
B-15	Atlantic Richfield Co. 2-2-A Federal - Beard	SE 1/4 SW 1/4 sec. 2, T. 56 N., R. 73 W.	4,106
B-16	Montana Bureau of Mines and Geology US 747	SE 1/4 NE 1/4 sec. 3, T. 56 N., R. 73 W.	4,144
B-17	Kissinger Petroleum Corp. and Pan American 1-10 Snoddy	NW 1/4 NE 1/4 sec. 10, T. 56 N., R. 73 W.	4,058
B-18	Kissinger - Amoco - Exeter 6-11 Anderson - Snoddy	SE 1/4 NW 1/4 sec. 11, T. 56 N., R. 73 W.	4,100
B-19	Montana Bureau of Mines and Geology US 7410	SE 1/4 SW 1/4 sec. 11, T. 56 N., R. 73 W.	4,235
B-20	Kissinger - Exeter 14-11 Phillips - Federal	SE 1/4 SW 1/4 sec. 11, T. 56 N., R. 73 W.	4,232
B-21	Kissinger - Exeter 2-11 Phillips - Snoddy	NW 1/4 NE 1/4 sec. 11, T. 56 N., R. 73 W.	4,105
B-22	Montana Bureau of Mines and Geology US 749	NE 1/4 SE 1/4 sec. 11, T. 56 N., R. 73 W.	4,193
B-23	Kissinger Petroleum Corp. 8-11 Anderson - Phillips - Federal	SE 1/4 NE 1/4 sec. 11, T. 56 N., R. 73 W.	4,189
B-24	Kissinger - Exeter 16-11 Phillips - Federal	SE 1/4 SE 1/4 sec. 11, T. 56 N., R. 72 W.	4,142
B-25	Atlantic Richfield Co. 1-12 Federal - Arco - Beard	NW 1/4 NW 1/4 sec. 12, T. 56 N., R. 73 W.	4,167
B-26	Montana Bureau of Mines and Geology US 748	SW 1/4 NW 1/4 sec. 12, T. 56 N., R. 73 W.	4,212

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-27	Petroleum Inc. - Atlantic - Richfield Co. 2 Atlantic - Federal	NW 1/4 SW 1/4 sec. 7, T. 56 N., R. 72 W.	4,005
B-28	Petroleum Inc. 1 Government - Atlantic	NW 1/4 SE 1/4 sec. 7, T. 56 N., R. 72 W.	4,054
B-29	CRA Inc. 9-1 Gibbs - Federal	SE 1/4 SW 1/4 sec. 9, T. 56 N., R. 72 W.	4,240
B-30	CRA Inc. 789-2 Ames - Federal	NW 1/4 SE 1/4 sec. 9, T. 56 N., R. 72 W.	4,113
B-31	CRA Inc. 2-9 Kerr - Government	SE 1/4 NE 1/4 sec. 9, T. 56 N., R. 72 W.	4,104
B-32	Montana Bureau of Mines and Geology US 7420	SE 1/4 SE 1/4 sec. 9, T. 56 N., R. 72 W.	4,124
B-33	J. M. Huber Corp. 1-10 Federal - Grace	NW 1/4 NW 1/4 sec. 10, T. 56 N., R. 72 W.	4,054
B-34	CRA Inc. 3-10 Gibbs - Government	SE 1/4 NW 1/4 sec. 10, T. 56 N., R. 72 W.	4,128
B-35	Ames Oil & Gas Co. 1 Ames - Federal	NW 1/4 SE 1/4 sec. 10, T. 56 N., R. 72 W.	4,136
B-36	W. West - E. Boland 1-15 Federal	SE 1/4 SW 1/4 sec. 15, T. 56 N., R. 72 W.	3,966
B-37	CRA Inc. 1-15 Chorney - Federal	NW 1/4 NW 1/4 sec. 15, T. 56 N., R. 72 W.	4,084
B-38	Sierra Trading Corp. 2-15 Federal	NW 1/4 SW 1/4 sec. 15, T. 56 N., R. 72 W.	4,168
B-39	Sierra Trading Corp. 1-16 State	SE 1/4 SE 1/4 sec. 16, T. 56 N., R. 72 W.	4,024
B-40	CRA Inc. 2-398 State	SE 1/4 NE 1/4 sec. 16, T. 56 N., R. 72 W.	4,043
B-41	CRA Inc. 1-397 State	NW 1/4 NE 1/4 sec. 16, T. 56 N., R. 72 W.	4,060

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-42	Davis Oil Co. 1 Donald - Federal	NW 1/4 SE 1/4 sec. 18, T. 56 N., R. 72 W.	4,066
B-43	Davis Oil Co. 1-Z George Emigh	NW 1/4 NW 1/4 sec. 18, T. 56 N., R. 72 W.	4,124
B-44	Powder River Co. 8-13 Tays	SE 1/4 NE 1/4 sec. 13, T. 55 N., R. 73 W.	4,037
B-45	Anderson Oil Co. 1 Kissinger - Exeter-Federal	NW 1/4 NE 1/4 sec. 14, T. 56 N., R. 73 W.	4,133
B-46	Montana Bureau of Mines and Geology US 7411	SE 1/4 NW 1/4 sec. 14, T. 56 N., R. 73 W.	4,167
B-47	Davis Oil Co. 2 Phillips - Federal	SE 1/4 SW 1/4 sec. 14, T. 56 N., R. 73 W.	4,118
B-48	Davis Oil Co. 1 Phillips - Federal	SW 1/4 SW 1/4 sec. 14, T. 56 N., R. 73 W.	4,205
B-49	Kissinger, Pan American, Petroleum Corp. & Eason Oil 8-22 Snoddy	SE 1/4 NE 1/4 sec. 22, T. 56 N., R. 73 W.	4,106
B-50	Montana Bureau of Mines and Geology US 7412	NW 1/4 NW 1/4 sec. 23, T. 56 N., R. 73 W.	4,180
B-51	Davis Oil Co. 1 Morse - Federal	SE 1/4 NW 1/4 sec. 23, T. 56 N., R. 73 W.	4,167
B-52	Davis Oil Co. 2 Morse	NW 1/4 SE 1/4 sec. 23, T. 56 N., R. 73 W.	4,142
B-53	Montana Bureau of Mines and Geology US 7418	SW 1/4 SW 1/4 sec. 24, T. 56 N., R. 73 W.	4,218
B-54	McMahon-Bullington Drilling Co. 1-24 Morse	NE 1/4 NE 1/4 sec. 24, T. 56 N., R. 73 W.	4,001
B-55	YHS - Kissinger 1 Atlantic - Federal	NW 1/4 SW 1/4 sec. 20, T. 56 N., R. 72 W.	4,131

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-56	Davis Oil Co. 1 S. Whitetail	SE 1/4 SE 1/4 sec. 21, T. 56 N., R. 72 W.	3,877
B-57	Exeter Drilling Co. 4-22 Andrikopoulos - Federal	NW 1/4 NW 1/4 sec. 22, T. 56 N., R. 72 W.	4,012
B-58	Montana Bureau of Mines and Geology US 7419	NW 1/4 NW 1/4 sec. 22, T. 56 N., R. 72 W.	4,027
B-59	American Minerals Management 1 Whitetail	NW 1/4 NE 1/4 sec. 22, T. 56 N., R. 72 W.	3,924
B-60	Pan American Petroleum Corp. 1-B USA - Moore	SE 1/4 NW 1/4 sec. 22, T. 56 N., R. 72 W.	4,005
B-61	Davis Oil Co. 1 Quinn - Federal	NW 1/4 SW 1/4 sec. 27, T. 56 N., R. 72 W.	4,136
B-62	Davis Oil Co. 1-Z Glenn	NW 1/4 SE 1/4 sec. 28, T. 56 N., R. 72 W.	4,040
B-63	Southland Royalty Co. 1-30 Chan Federal	NE 1/4 SE 1/4 sec. 30, T. 56 N., R. 72 W.	4,121
B-64	Kissinger Petroleum Co. 1-25 Phillips - Federal	NE 1/4 NE 1/4 sec. 25, T. 56 N., R. 73 W.	4,151
B-65	Davis Oil Co. 1 Aztec - Federal	SW 1/4 NW 1/4 sec. 25, T. 56 N., R. 73 W.	4,188
B-66	Montana Bureau of Mines and Geology US 7228	SW 1/4 SE 1/4 sec. 26, T. 56 N., R. 73 W.	4,113
B-67	Montana Bureau of Mines and Geology US 7416	NE 1/4 NW 1/4 sec. 26, T. 56 N., R. 73 W.	4,164
B-68	Davis Oil Co. 1 Ben	SE 1/4 SW 1/4 sec. 26, T. 56 N., R. 73 W.	4,125
B-69	Anderson Oil Co. 2 Chorney - Federal	NW 1/4 NW 1/4 sec. 26, T. 56 N., R. 73 W.	4,070
B-70	Davis Oil Co. 1 Powell	NW 1/4 SW 1/4 sec. 26, T. 56 N., R. 73 W.	4,160

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-71	Anderson Oil Co. 1 Chorney - Oedekoven-Federal	SE 1/4 SE 1/4 sec. 27, T. 56 N., R. 73 W.	4,186
B-72	Diamond Shamrock Corp. 2-27 Hawks - Federal	SE 1/4 NE 1/4 sec. 27, T. 56 N., R. 73 W.	4,206
B-73	Diamond Shamrock Corp. 3-27 Hawks - Federal	NW 1/4 SE 1/4 sec. 27, T. 56 N., R. 73 W.	4,181
B-74	Montana Bureau of Mines and Geology US 7415	NW 1/4 SE 1/4 sec. 27, T. 56 N., R. 73 W.	4,158
B-75	Kissinger Petroleum Corp. 10-34 Morse	NW 1/4 SE 1/4 sec. 34, T. 56 N., R. 73 W.	4,170
B-76	Kissinger Petroleum Corp. 16-34 Morse	SE 1/4 SE 1/4 sec. 34, T. 56 N., R. 73 W.	4,139
B-77	Davis Oil Co. 1 Chan Federal	SE 1/4 NW 1/4 sec. 35, T. 56 N., R. 73 W.	4,144
B-78	Montana Bureau of Mines and Geology US 7417	SE 1/4 NW 1/4 sec. 35, T. 56 N., R. 73 W.	4,125
B-79	Davis Oil Co. 2 Goodstein - State	NE 1/4 NW 1/4 sec. 36, T. 56 N., R. 73 W.	4,114
B-80	Davis Oil Co. 1 Marty - Federal	SW 1/4 NW 1/4 sec. 31, T. 56 N., R. 72 W.	4,165
B-81	Atlantic Richfield Co. 1 White Elk - Federal	NW 1/4 NW 1/4 sec. 32, T. 56 N., R. 72 W.	4,121
B-82	Davis Oil Co. 1 White Elk - Federal	SW 1/4 SW 1/4 sec. 32, T. 56 N., R. 72 W.	4,115
B-83	Montana Bureau of Mines and Geology US 7227	SW 1/4 NE 1/4 sec. 32, T. 56 N., R. 72 W.	4,237
B-84	Kissinger Petroleum Corp. 1 Vessels - Hondo - Federal	SW 1/4 SW 1/4 sec. 33, T. 56 N., R. 72 W.	4,179
B-85	Montana Bureau of Mines and Geology US 7421	NE 1/4 SW 1/4 sec. 33, T. 56 N., R. 72 W.	4,223

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-86	Davis Oil Co. 4 Quinn - Federal	NE 1/4 NE 1/4 sec. 33, T. 56 N., R. 72 W.	4,180
B-87	Davis Oil Co. 5 Quinn - Federal	SW 1/4 NW 1/4 sec. 34, T. 56 N., R. 72 W.	4,125
B-88	Davis Oil Co. 1 Graham - Federal	NE 1/4 SW 1/4 sec. 34, T. 56 N., R. 72 W.	4,115
B-89	Cardinal Petroleum Co. 10-34 Federal - Andri - Arco	NW 1/4 SE 1/4 sec. 34, T. 56 N., R. 72 W.	4,091
B-90	Montana Bureau of Mines and Geology US 7423	NE 1/4 NE 1/4 sec. 3, T. 55 N., R. 72 W.	4,168
B-91	R. L. Foree 1 Brunel - Federal	SE 1/4 SE 1/4 sec. 3, T. 55 N., R. 72 W.	4,140
B-92	Davis Oil Co. 1 Bruce - Federal	NW 1/4 SW 1/4 sec. 3, T. 55 N., R. 72 W.	4,072
B-93	Davis Oil Co. 1 Gem	SW 1/4 NW 1/4 sec. 5, T. 55 N., R. 72 W.	4,088
B-94	Davis Oil Co. 3 Morse - Ranch	SE 1/4 NW 1/4 sec. 1, T. 55 N., R. 73 W.	4,082
B-95	Davis Oil Co. 1-Z Morse - Ranch	NW 1/4 SW 1/4 sec. 1, T. 55 N., R. 73 W.	4,060
B-96	Davis Oil Co. 4 Gallion - Federal	NW 1/4 NW 1/4 sec. 1, T. 55 N., R. 73 W.	4,102
B-97	Davis Oil Co. 2 Gallion - Federal	SW 1/4 SW 1/4 sec. 1, T. 55 N., R. 73 W.	4,120
B-98	Davis Oil Co. 1 Earl - Federal	NE 1/4 SE 1/4 sec. 2, T. 55 N., R. 73 W.	4,093
B-99	Montana Bureau of Mines and Geology US 7413	SW 1/4 NE 1/4 sec. 2, T. 55 N., R. 73 W.	4,066
B-100	Montana Bureau of Mines and Geology US 7414	NW 1/4 SE 1/4 sec. 2, T. 55 N., R. 73 W.	4,043

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-101	Diamond Shamrock Corp. 43-1 Hawks - Federal Tract	NE 1/4 SW 1/4 sec. 2, T. 55 N., R. 73 W.	4,100
B-102	Diamond Shamrock Corp. 43-2 Hawks - Federal Tract	NW 1/4 NW 1/4 sec. 2, T. 55 N., R. 73 W.	4,112
B-103	Kissinger - Belco - Worden 2-3 Shamrock - Federal	NW 1/4 NE 1/4 sec. 3, T. 55 N., R. 73 W.	4,098
B-104	Diamond Shamrock Corp. 46E-1 Hawks - Federal Tract	NW 1/4 SE 1/4 sec. 3, T. 55 N., R. 73 W.	4,188
B-105	Anchutz Corp. 1-3 Government 55	SW 1/4 SE 1/4 sec. 3, T. 55 N., R. 73 W.	4,139
B-106	Pan American Petroleum Corp. 1 Pan American - Clark Canadian	SW 1/4 SE 1/4 sec. 10, T. 55 N., R. 73 W.	4,041
B-107	Pan American Petroleum Corp. 1 Sacks Unit	NE 1/4 SE 1/4 sec. 10, T. 55 N., R. 73 W.	4,106
B-108	Pan American Petroleum Corp. 1-"B" USA - Pan American - Clark Canadian	SW 1/4 SW 1/4 sec. 11, T. 55 N., R. 73 W.	4,100
B-109	McMahon-Bullington Drilling Co. 2-2 Morse	SW 1/4 SW 1/4 sec. 2, T. 55 N., R. 73 W.	4,113
B-110	Clark Canadian Exploration Company 1-11 Federal	NE 1/4 NW 1/4 sec. 11, T. 55 N., R. 73 W.	4,100
B-111	Pan American Petroleum Corp. 2-B Haley	SW 1/4 NE 1/4 sec. 11, T. 55 N., R. 73 W.	4,172
B-112	Pan American Petroleum Corp. 8-A Norfolk	SW 1/4 SE 1/4 sec. 11, T. 55 N., R. 73 W.	4,102
B-113	Pan American Petroleum Corp. 1-"B" Haley	NE 1/4 SE 1/4 sec. 11, T. 55 N., R. 73 W.	4,170
B-114	Amoco Production Co. 43 Collums Unit	NE 1/4 NE 1/4 sec. 11, T. 55 N., R. 73 W.	4,133

Sources of coal-bed data in the White Tail Butte Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
B-115	Amoco Production Co. 44 Collums Unit	SW 1/4 NW 1/4 sec. 12, T. 55 N., R. 73 W.	4,128
B-116	Pan American Petroleum Corp. 1 Norfolk Unit	SW 1/4 SW 1/4 sec. 12, T. 55 N., R. 73 W.	4,146
B-117	Davis Oil Co. 1 Gallion - Federal	NE 1/4 NW 1/4 sec. 12, T. 55 N., R. 73 W.	4,179
B-118	Pan American Petroleum Corp 1 Pan American Unit	SE 1/4 SW 1/4 sec. 12, T. 55 N., R. 73 W.	4,114
B-119	Petroleum, Inc. 1 Government - Aztec - Kiel	NE 1/4 NW 1/4 sec. 7 T. 55 N., R. 72 W.	4,118
B-120	O. B. Kiel and Cardinal Petroleum Co. 1-8 Aztec - Federal	SE 1/4 NW 1/4 sec. 8, T. 55 N., R. 72 W.	3,988
B-121	National Cooperative Refinery Association 7-D Jones - Federal	NW 1/4 NE 1/4 sec. 10, T. 55 N., R. 72 W.	4,175
B-122	True Oil and Aztec Oil & Gas Co. 11-15 Jones - Federal	NW 1/4 NW 1/4 sec. 15, T. 55 N., R. 72 W.	4,111
B-123	R. G. Boekel 11-16 State	NW 1/4 NW 1/4 sec. 16, T. 55 N., R. 72 W.	3,965
B-124	Davis Oil Co. 1 Terra - Federal	SW 1/4 NW 1/4 sec. 18, T. 55 N., R. 72 W.	4,080
B-125	Davis Oil Co. 1 Conway Federal	SW 1/4 SE 1/4 sec. 32, T. 56 N., R. 72 W.	4,120
B-126	Montana Bureau of Mines and Geology US 7558	NW 1/4 NE 1/4 sec. 31, T. 56 N., R. 72 W.	4,251

APPENDIX B.

SOURCES OF COAL-BED DATA IN THE HOMESTEAD DRAW SW QUADRANGLE

Sources of coal-bed data in the Homestead Draw SW Quadrangle

[List of wells, locations, and ground elevations for all wells in the Recluse Geologic Model Area including wells that do not penetrate the Cache Coal Bed]

[To convert feet to meters multiply by 0.3048]

Well No. on map	Company and well No.	Location	Ground elevation (ft)
H-1	Powder River Oil Co. 14-3 Beason	SE 1/4 SW 1/4 sec. 3, T. 56 N., R. 73 W.	3,979
H-2	Kissinger Petroleum Corp. - Exeter 9-4 Beard - Arco - Fee	NE 1/4 SE 1/4 sec. 4, T. 56 N., R. 73 W.	3,940
H-3	Kissinger Petroleum Corp. 11-4 Anderson - State	NE 1/4 SW 1/4 sec. 4, T. 56 N., R. 73 W.	3,998
H-4	Kissinger Petroleum Corp. 3-4 Kissinger - State	NE 1/4 NW 1/4 sec. 4, T. 56 N., R. 73 W.	3,889
H-5	Powder River Oil Co. 1 Beltz	SE 1/4 SW 1/4 sec. 5, T. 56 N., R. 73 W.	3,928
H-6	Samedan Oil Corp. 1 Greenough	NE 1/4 SW 1/4 sec. 1, T. 56 N., R. 74 W.	3,945
H-7	Powder River Oil Co. 1 Greenough	NE 1/4 NW 1/4 sec. 10, T. 56 N., R. 74 W.	4,026
H-8	Atlantic Richfield Co. 6 Greenough - Government	SE 1/4 SW 1/4 sec. 10, T. 56 N., R. 74 W.	4,150
H-9	Apache Corp. 1-11 U.S. - Thomas	NW 1/4 SE 1/4 sec. 11, T. 56 N., R. 74 W.	3,950
H-10	Chandler & Associates, Inc. 1 Southland Royalty Co.	NE 1/4 NE 1/4 sec. 11, T. 56 N., R. 74 W.	3,919
H-11	Chandler & Associates, Inc. 1 Heiby Government	SW 1/4 SE 1/4 sec. 8, T. 56 N., R. 73 W.	3,890
H-12	Clyde G. Kissinger 1 Snoddy	SW 1/4 SW 1/4 sec. 9, T. 56 N., R. 73 W.	4,087
H-13	Clyde G. Kissinger 14-10 Phillips Petroleum Co.	SE 1/4 SW 1/4 sec. 10, T. 56 N., R. 73 W.	4,143

Sources of coal-bed data in the Homestead Draw SW Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
H-14	Kissinger Petroleum Corp. 6-10 Phillips - Federal	SE 1/4 NW 1/4 sec. 10, T. 56 N., R. 73 W.	4,035
H-15	Davis Oil Co. 1 Lester	SE 1/4 SW 1/4 sec. 15, T. 56 N., R. 73 W.	4,078
H-16	Kissinger Petroleum Corp. 12-15 Phillips - Federal	NW 1/4 SW 1/4 sec. 15, T. 56 N., R. 73 W.	4,006
H-17	Kissinger Petroleum Corp. - Worden 14-16 State	SE 1/4 SW 1/4 sec. 16, T. 56 N., R. 73 W.	4,003
H-18	Petroleum, Inc. 1-B State	SW 1/4 NW 1/4 sec. 16, T. 56 N., R. 73 W.	3,925
H-19	Chandler & Associates, Inc. 1 Aztec Government	NE 1/4 NE 1/4 sec. 17, T. 56 N., R. 73 W.	3,910
H-20	Chandler & Associates, Inc. 3 Aztec Government	SW 1/4 NE 1/4 sec. 17, T. 56 N., R. 73 W.	3,992
H-21	Chandler & Associates, Inc. 1 Aztec Government	SW 1/4 SW 1/4 sec. 17, T. 56 N., R. 73 W.	4,077
H-22	Ladd & Lewis - Boekel 1-13 Lockhard	SE 1/4 SW 1/4 sec. 13, T. 56 N., R. 74 W.	3,897
H-23	Apache Corp. 1 U.S. - Thomas	NW 1/4 SE 1/4 sec. 15, T. 56 N., R. 74 W.	4,140
H-24	Eason Oil Co. 5-22 Government	NW 1/4 NE 1/4 sec. 22, T. 56 N., R. 74 W.	4,157
H-25	Apache Corp. 4 U.S. - Cochise	SE 1/4 SW 1/4 sec. 23, T. 56 N., R. 74 W.	4,090
H-26	Kissinger Petroleum Corp. 13-20 Atlantic Richfield Co.	SW 1/4 SW 1/4 sec. 20, T. 56 N., R. 73 W.	4,079
H-27	Kissinger Petroleum Corp. 13-21 Snoddy	SW 1/4 SW 1/4 sec. 21, T. 56 N., R. 73 W.	4,095

Sources of coal bed data in the Homestead Draw SW Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
H-28	Kissinger Petroleum Corp. 2-21 Anderson - Federal	NW 1/4 NE 1/4 sec. 21,	4,104
H-29	Diamond Shamrock Corp. 1-21 Hawks - Government	SE 1/4 SE 1/4 sec. 21, T. 56 N., R. 73 W.	4,105
H-30	Diamond Shamrock Corp. 1-28 Hawks - Federal	SE 1/4 SW 1/4 sec. 28, T. 56 N., R. 73 W.	4,150
H-31	Powder River Oil Co. 1-29 Smith	NE 1/4 NE 1/4 sec. 29, T. 56 N., R. 73 W.	4,098
H-32	Kissinger - MacPet 16-30 Anchutz - Lester	SE 1/4 SE 1/4 sec. 30, T. 56 N., R. 73 W.	4,015
H-33	Sinclair Oil & Gas Co. 1-A Burnett - Federal	NW 1/4 NW 1/4 sec. 25, T. 56 N., R. 74 W.	4,080
H-34	Sinclair Oil & Gas Co. 1 Bradshaw - Herr - Federal	SE 1/4 SE 1/4 sec. 26, T. 56 N., R. 74 W.	4,193
H-35	Montana Bureau of Mines and Geology US 745	NE 1/4 NW 1/4 sec. 26, T. 56 N., R. 74 W.	4,133
H-36	Eason Oil Co. 4-27 Government	SE 1/4 SE 1/4 sec. 27, T. 56 N., R. 74 W.	4,053
H-37	Atlantic Richfield Co. 1 McBee	NW 1/4 NE 1/4 sec. 35, T. 56 N., R. 74 W.	4,129
H-38	The Anchutz Corp. 1 Federal 382-A	SE 1/4 SE 1/4 sec. 35, T. 56 N., R. 74 W.	4,081
H-39	The Anchutz Corp. 39-3-36 State	NW 1/4 NW 1/4 sec. 36, T. 56 N., R. 74 W.	4,156
H-40	The Anchutz Corp. 39-2-36 State	SE 1/4 SW 1/4 sec. 36, T. 56 N., R. 74 W.	4,191
H-41	The Anchutz Corp. 39-4-36 State	NW 1/4 NE 1/4 sec. 36, T. 56 N., R. 74 W.	4,133
H-42	The Anchutz Corp. 36-7 State	SE 1/4 SE 1/4 sec. 36, T. 56 N., R. 74 W.	4,095
H-43	Atlantic Richfield Co. 3 Burnett - Federal	NW 1/4 NW 1/4 sec. 31, T. 56 N., R. 73 W.	4,099

Sources of coal-bed data in the Homestead Draw SW Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
H-44	Davis Oil Co. 1 Wilson	SW 1/4 SE 1/4 sec. 31, T. 56 N., R. 73 W.	4,120
H-45	Eason Oil Co. 1 Morse - Ranch	SW 1/4 SW 1/4 sec. 32, T. 56 N., R. 73 W.	4,098
H-46	Petroleum - Lewis Corp. 10-33 Lester	NW 1/4 SE 1/4 sec. 33, T. 56 N., R. 73 W.	4,139
H-47	Kissinger Petroleum Corp. 4-34 Morse - Lester	NW 1/4 NW 1/4 sec. 34, T. 56 N., R. 73 W.	4,169
H-48	Diamond Shamrock Corp. 1 Hawks - Federal 46G	NE 1/4 SW 1/4 sec. 3, T. 55 N., R. 73 W.	4,207
H-49	Diamond Shamrock Corp. 1-C Hawks - Federal	SE 1/4 NW 1/4 sec. 3, T. 55 N., R. 73 W.	4,178
H-50	Pan American Petroleum Corp. 1 Haley Unit	SW 1/4 SW 1/4 sec. 3, T. 55 N., R. 73 W.	4,092
H-51	Diamond Shamrock Corp. 3 Hawks - Federal Tract 47	SE 1/4 NE 1/4 sec. 4, T. 55 N., R. 73 W.	4,216
H-52	Petroleum - Lewis Corp. 1-4 HMM	NW 1/4 SE 1/4 sec. 4, T. 55 N., R. 73 W.	4,202
H-53	C. E. Bream - U.S. Smelting Refining & Mining Co. 2-5 Federal 762	SE 1/4 NE 1/4 sec. 5, T. 55 N., R. 73 W.	4,116
H-54	The Anchutz Corp. 4-F Oedekoven	NE 1/4 SW 1/4 sec. 6, T. 55 N., R. 73 W.	4,166
H-55	The Anchutz Corp. 3-F Oedekoven	SW 1/4 SW 1/4 sec. 6, T. 55 N., R. 73 W.	4,177
H-56	Davis Oil Co. 3 Long	NW 1/4 NE 1/4 sec. 1, T. 55 N., R. 74 W.	4,134
H-57	The Anchutz Corp. 2 Long Federal	SW 1/4 SE 1/4 sec. 1, T. 55 N., R. 74 W.	4,138
H-58	Stonehenge Oil Co., Inc. 1 Kirby - USA	SW 1/4 SE 1/4 sec. 11, T. 55 N., R. 74 W.	4,045
H-59	The Anchutz Corp. 1-E Long - Oedekoven	NE 1/4 NE 1/4 sec. 12, T. 55 N., R. 74 W.	4,156

Sources of coal-bed data in the Homestead Draw SW Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
H-60	The Anchutz Corp. 3-E Oedekoven	SW 1/4 SW 1/4 sec. 7, T. 55 N., R. 73 W.	4,146
H-61	Chandler & Associates Oil, Inc. - Fulton Producing Co. 1 Maribo - Allard	NW 1/4 NE 1/4 sec. 7, T. 55 N., R. 73 W.	4,169
H-62	Montana Bureau of Mines and Geology US 746	SW 1/4 SE 1/4 sec. 8, T. 55 N., R. 73 W.	4,154
H-63	Petroleum-Lewis, Ltd. - Laos Petroleum Corp. 1-8 Wilson	SE 1/4 SE 1/4 sec. 8, T. 55 N., R. 73 W.	4,134
H-64	The Anchutz Corp. 1-9 State 53	SE 1/4 SW 1/4 sec. 9, T. 55 N., R. 73 W.	4,098
H-65	Pan American Petroleum Corp. 1 Haley	SW 1/4 NW 1/4 sec. 10, T. 55 N., R. 73 W.	4,089
H-66	Pan American Petroleum Corp. 3-B Pan American - Clark - Canadian	NE 1/4 SW 1/4 sec. 10, T. 55 N., R. 73 W.	4,060
H-67	Montana Bureau of Mines and Geology US 7554	NE 1/4 SE 1/4 sec. 6, T. 55 N., R. 73 W.	4,141
H-68	Montana Bureau of Mines and Geology US 7555	SE 1/4 NE 1/4 sec. 19, T. 56 N., R. 73 W.	4,082
H-69	Montana Bureau of Mines and Geology US 7556	NE 1/4 SE 1/4 sec. 30, T. 56 N., R. 73 W.	4,024
H-70	Montana Bureau of Mines and Geology US 7557	SW 1/4 SE 1/4 sec. 33, T. 56 N., R. 73 W.	4,144

APPENDIX C.

SOURCES OF COAL-BED DATA IN THE PITCH DRAW QUADRANGLE

Sources of coal-bed data in the Pitch Draw Quadrangle

[List of wells, locations, and ground elevations for all wells in the Recluse Geologic Model Area including wells that do not penetrate the Cache Coal Bed]

[To convert feet to meters multiply by 0.3048]

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-1	Davis Oil Co. 1 Basil - State	SE 1/4 SE 1/4 sec. 16, T. 55 N., R. 72 W.	4,096
P-2	Davis Oil Co. 1 Elliott	SE 1/4 SE 1/4 sec. 13, T. 55 N., R. 73 W.	3,994
P-3	Pan American Petroleum Co. 7-A Norfolk	SE 1/4 NW 1/4 sec. 13, T. 55 N., R. 73 W.	4,122
P-4	Pan American Petroleum Co. 4-A Norfolk	NE 1/4 NE 1/4 sec. 14, T. 55 N., R. 73 W.	4,140
P-5	Davis Oil Co. 1 Collums - Federal	SW 1/4 SE 1/4 sec. 14, T. 55 N., R. 73 W.	4,003
P-6	Stuarco Oil Co. 32 Government Tract 68	SW 1/4 NE 1/4 sec. 14, T. 55 N., R. 73 W.	4,013
P-7	Pan American Petroleum Co. 2-A Norfolk	SW 1/4 NW 1/4 sec. 14, T. 55 N., R. 73 W.	3,997
P-8	Diamond Shamrock Corp. 1 Hays - Government Tract 92-E	SW 1/4 SW 1/4 sec. 14, T. 55 N., R. 73 W.	4,079
P-9	Montana Bureau of Mines and Geology US 7470	SW 1/4 SE 1/4 sec. 22, T. 55 N., R. 73 W.	4,107
P-10	Diamond Shamrock Corp. 1 Hayes - Government	NE 1/4 NE 1/4 sec. 22, T. 55 N., R. 73 W.	4,073
P-11	Davis Oil Co. 4 Collums - Federal	SW 1/4 NE 1/4 sec. 23, T. 55 N., R. 73 W.	4,085
P-12	Davis Oil Co. 2 Collums - Federal	NE 1/4 NE 1/4 sec. 23, T. 55 N., R. 73 W.	4,129
P-13	O. B. Kiel, Jr. - Cardinal Petroleum 1-19 Aztec - Federal	NW 1/4 NE 1/4 sec. 19, T. 55 N., R. 72 W.	4,067

Sources of coal-bed data in the Pitch Draw Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-14	Davidor - Davidor 1-21 Government	SW 1/4 SW 1/4 sec. 21, T. 55 N., R. 72 W.	4,054
P-15	Davis Oil Co. 1 Tyree	NE 1/4 NW 1/4 sec. 21, T. 55 N., R. 72 W.	4,109
P-16	Davis Oil Co. 1 Rita	SE 1/4 SE 1/4 sec. 21, T. 55 N., R. 72 W.	4,090
P-17	True Oil Co. - Central Oil 34-22 Federal - Chorney	SW 1/4 SE 1/4 sec. 22, T. 55 N., R. 72 W.	4,039
P-18	Davis Oil Co. 1 Kinsley - Moore - Federal	NW 1/4 SW 1/4 sec. 27, T. 55 N., R. 72 W.	4,178
P-19	Davis Oil Co. 1 Eldon - Federal	NE 1/4 SW 1/4 sec. 29, T. 55 N., R. 72 W.	4,033
P-20	Pan American Petroleum Co. 1-B Norfolk	SE 1/4 NW 1/4 sec. 30, T. 55 N., R. 72 W.	3,885
P-21	Pan American Petroleum Co. 1-C Norfolk	SE 1/4 SW 1/4 sec. 30, T. 55 N., R. 72 W.	3,951
P-22	Davis Oil Co. 1-Z Norford	NW 1/4 NW 1/4 sec. 30, T. 55 N., R. 72 W.	3,929
P-23	Continental Oil Co. 1-30 Conoco - Federal	NW 1/4 SW 1/4 sec. 30, T. 55 N., R. 72 W.	3,956
P-24	Davis Oil Co. 1 Decker - Federal	SE 1/4 SE 1/4 sec. 25, T. 55 N., R. 73 W.	4,008
P-25	DELETED		
P-26	Davis Oil Co. 1 Schulte - State	SW 1/4 SW 1/4 sec. 25, T. 55 N., R. 73 W.	4,163
P-27	Southland Royalty Co. 1-3-26 Federal	NE 1/4 NW 1/4 sec. 26, T. 55 N., R. 73 W.	4,193
P-28	Pan American Petroleum Co. 1-R State of Wyoming	SE 1/4 NE 1/4 sec. 36, T. 55 N., R. 73 W.	4,042

Sources of coal-bed data in the Pitch Draw Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-29	Southland Royalty Co. 3-31 Federal	SW 1/4 SW 1/4 sec. 31, T. 55 N., R. 72 W.	3,976
P-30	Davis Oil Co. 1 Rogers - Federal	NW 1/4 NW 1/4 sec. 31, T. 55 N., R. 72 W.	4,071
P-31	Davis Oil Co. 2 Rogers - Federal	SE 1/4 NW 1/4 sec. 31, T. 55 N., R. 72 W.	4,031
P-32	Davis Oil Co. 1-Z Norland	NW 1/4 NW 1/4 sec. 32, T. 55 N., R. 72 W.	3,824
P-33	Davis Oil Co. 1 Spring Creek	SE 1/4 SW 1/4 sec. 32, T. 55 N., R. 72 W.	3,826
P-34	R. G. Boekel 42-34 Hanks	SE 1/4 NE 1/4 sec. 34, T. 55 N., R. 72 W.	3,772
P-35	Davis Oil Co. 1 Oldham - Federal	SE 1/4 NE 1/4 sec. 3, T. 54 N., R. 72 W.	3,954
P-36	Jeff Hawks and Donnel Drilling Co. 1 Heydecker	SE 1/4 SE 1/4 sec. 4, T. 54 N., R. 72 W.	4,051
P-37	Davis Oil Co. 1 Beryl - Federal	NW 1/4 NW 1/4 sec. 6, T. 54 N., R. 72 W.	3,935
P-38	Davis Oil Co. 1 Guy - Federal	SE 1/4 NE 1/4 sec. 1, T. 54 N., R. 73 W.	3,917
P-39	Davis Oil Co. 2 Guy - Federal	NE 1/4 SE 1/4 sec. 1, T. 54 N., R. 73 W.	3,886
P-40	Forest Oil Corp. 1-1-1 Government	NW 1/4 SE 1/4 sec. 1, T. 54 N., R. 73 W.	3,916
P-41	Southland Royalty Co. 2-1 Norfolk	SE 1/4 SE 1/4 sec. 2, T. 54 N., R. 73 W.	4,013
P-42	Davis Oil Co. 2 Partridge - Federal	NW 1/4 NE 1/4 sec. 3, T. 54 N., R. 73 W.	4,099
P-43	Davis Oil Co. 1 Lytle - Federal	NW 1/4 NE 1/4 sec. 10, T. 54 N., R. 73 W.	4,147
P-44	Southland Royalty Co. 1-12 Norfolk	NW 1/4 SE 1/4 sec. 12. T. 54 N., R. 73 W.	3,890

Sources of coal-bed data in the Pitch Draw Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-45	The Anchutz Corp. 1 Heydecker - Government	NW 1/4 SW 1/4 sec. 7, T. 54 N., R. 72 W.	3,930
P-46	Davis Oil Co. 1 Forest - Federal	NW 1/4 NE 1/4 sec. 7, T. 54 N., R. 72 W.	4,006
P-47	Davis Oil Co. 1 Manly - State	NE 1/4 NE 1/4 sec. 16, T. 54 N., R. 72 W.	4,116
P-48	Southland Royalty Co. 6 Norfolk	SE 1/4 NW 1/4 sec. 17, T. 54 N., R. 72 W.	4,039
P-49	Southland Royalty Co. 5 Norfolk	NW 1/4 SW 1/4 sec. 17, T. 54 N., R. 72 W.	4,019
P-50	Southland Royalty Co. 4 Norfolk	SE 1/4 SE 1/4 sec. 18, T. 54 N., R. 72 W.	4,083
P-51	Chevron Oil Co. 4 Federal (42-18)	SE 1/4 NE 1/4 sec. 18, T. 54 N., R. 72 W.	3,980
P-52	Chevron Oil Co. 3 Federal (31-18)	NW 1/4 NE 1/4 sec. 18, T. 54 N., R. 72 W.	4,105
P-53	Southland Royalty Co. 3 Norfolk	NW 1/4 SE 1/4 sec. 18, T. 54 N., R. 72 W.	4,064
P-54	Southland Royalty Co. 1 Norfolk	SE 1/4 SW 1/4 sec. 18, T. 54 N., R. 72 W.	4,070
P-55	Chevron Oil Co. 1 Federal (22-18)	SE 1/4 NW 1/4 sec. 18, T. 54 N., R. 72 W.	4,096
P-56	Davis Oil Co. 3 Merritt - Federal	NW 1/4 SE 1/4 sec. 13, T. 54 N., R. 73 W.	3,974
P-57	Davis Oil Co. 5 Merritt - Federal	NW 1/4 NE 1/4 sec. 13, T. 54 N., R. 73 W.	4,077
P-58	Davis Oil Co. 1 Bing - Federal	NW 1/4 NW 1/4 sec. 14, T. 54 N., R. 73 W.	3,962
P-59	Davis Oil Co. 1 Esther - Federal	NW 1/4 SW 1/4 sec. 23, T. 54 N., R. 73 W.	4,068
P-60	Mule Creek Oil Co. 1-4423 Mule Creek Downer	SE 1/4 SE 1/4 sec. 23, T. 54 N., R. 73 W.	4,032

Sources of coal-bed data in the Pitch Draw Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-61	Forest Oil Corp. 1-24-1 Government	NW 1/4 NE 1/4 sec. 24, T. 54 N., R. 73 W.	4,085
P-62	Montana Bureau of Mines and Geology US 7344	SW 1/4 SW 1/4 sec. 19, T. 54 N., R. 72 W.	4,212
P-63	Stuarco Oil Co. - Bel Oil Corp. 22-19 Harrington - Federal	SE 1/4 NW 1/4 sec. 19, T. 54 N., R. 72 W.	4,180
P-64	Sinclair Oil Co. 1 Williams - Batz	NW 1/4 SW 1/4 sec. 20, T. 54 N., R. 72 W.	4,124
P-65	Davis Oil Co. 1 Batz - Federal	SE 1/4 SE 1/4 sec. 20, T. 54 N., R. 72 W.	4,159
P-66	Petroleum Inc. 1-C Government - Aztec	NW 1/4 NW 1/4 sec. 21, T. 54 N., R. 72 W.	4,223
P-67	Davis Oil Co. 1 Federal - Bing	SW 1/4 SW 1/4 sec. 22, T. 54 N., R. 72 W.	4,183
P-68	Walter Duncan Oil Properties 1 Collins - Government	NE 1/4 NE 1/4 sec. 22, T. 54 N., R. 72 W.	4,224
P-69	Walter Duncan - Inter. Am. 14-27A Government	SW 1/4 SW 1/4 sec. 27, T. 54 N., R. 72 W.	4,093
P-70	Davis Oil Co. 1 Mee - Federal	SE 1/4 NW 1/4 sec. 29, T. 54 N., R. 72 W.	4,257
P-71	Davis Oil Co. 1 Brad - Federal	NW 1/4 NW 1/4 sec. 29, T. 54 N., R. 72 W.	4,256
P-72	Stuarco Oil Co. 30-42 Harrington - Federal	SE 1/4 NE 1/4 sec. 30, T. 54 N., R. 72 W.	4,197
P-73	Forest Oil Corp. 2-30-2 Government	NW 1/4 SE 1/4 sec. 30, T. 54 N., R. 72 W.	4,159
P-74	Montana Bureau of Mines and Geology US 7346	SE 1/4 NW 1/4 sec. 26, T. 54 N., R. 73 W.	4,205

Sources of coal-bed data in the Pitch Draw Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
P-75	Davis Oil Co. 1 Williams	NE 1/4 NE 1/4 sec. 35, T. 54 N., R. 73 W.	4,187
P-76	Davis Oil Co. 3 Harrington - Federal	NW 1/4 NE 1/4 sec. 32, T. 54 N., R. 72 W.	4,061
P-77	Davis Oil Co. 2 Harrington - Federal	NE 1/4 NE 1/4 sec. 32, T. 54 N., R. 72 W.	3,974
P-78	Montana Bureau of Mines and Geology US 7559	SE 1/4 SE 1/4 sec. 25, T. 55 N., R. 73 W.	3,975

APPENDIX D.

SOURCES OF COAL-BED DATA IN THE RECLUSE QUADRANGLE

Sources of coal-bed data in the Recluse Quadrangle

[List of wells, locations, and ground elevations for all wells in the Recluse Geologic Model Area including wells that do not penetrate the Cache Coal Bed]

[To convert feet to meters multiply by 0.3048]

Well No. on map	Company and well No.	Location	Ground elevation (ft)
R-1	Mule Creek Oil Co. 1-4416 Government - Meyer	SE 1/4 SE 1/4 sec. 16, T. 55 N., R. 73 W.	4,110
R-2	DELETED		
R-3	The Anchutz Corp. 1 Reed	NW 1/4 SE 1/4 sec. 17, T. 55 N., R. 73 W.	4,109
R-4	Petro - Lewis, Ladd, Gary, CRA Inc. 1-18 Wilson	SE 1/4 NE 1/4 sec. 18, T. 55 N., R. 73 W.	4,095
R-5	Petroleum Inc. 5-18 Federal	SW 1/4 SE 1/4 sec. 18, T. 55 N., R. 73 W.	4,197
R-6	The Anchutz Corp. 2-D Oedekoven	NE 1/4 SE 1/4 sec. 13, T. 55 N., R. 74 W.	4,091
R-7	The Anchutz Corp. 3-D Oedekoven	NE 1/4 SW 1/4 sec. 13, T. 55 N., R. 74 W.	4,119
R-8	Amarillo Oil Co. 1 Ralph Taylor	SE 1/4 NE 1/4 sec. 23, T. 55 N., R. 74 W.	4,166
R-9	The Anchutz Corp. 1-C Oedekoven	NE 1/4 SE 1/4 sec. 24, T. 55 N., R. 74 W.	4,112
R-10	The Anchutz Corp. 7-C Oedekoven	NE 1/4 NE 1/4 sec. 24, T. 55 N., R. 74 W.	4,103
R-11	The Anchutz Corp. 3-C Oedekoven	SW 1/4 NW 1/4 sec. 19, T. 55 N., R. 74 W.	4,112
R-12	The Anchutz Corp. - Phillips Petroleum Co. 2-B Oedekoven	SW 1/4 SE 1/4 sec. 19, T. 55 N., R. 73 W.	4,137
R-13	Davis Oil Co. 4-A Paul - Federal	SW 1/4 NW 1/4 sec. 21, T. 55 N., R. 73 W.	4,045

Sources of coal-bed data in the Recluse Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
R-14	Davis Oil Co. 3 Paul - Federal	NW 1/4 NW 1/4 sec. 21, T. 55 N., R. 73 W.	4,123
R-15	The Anchutz Corp. 2-88 Federal	NE 1/4 SW 1/4 sec. 21, T. 55 N., R. 73 W.	4,069
R-16	Montana Bureau of Mines and Geology US 7469	NE 1/4 SW 1/4 sec. 21, T. 55 N., R. 73 W.	4,063
R-17	The Anchutz Corp. 1-87 Government	SW 1/4 SE 1/4 sec. 21, T. 55 N., R. 73 W.	4,078
R-18	Stuarco Oil Co., Inc. 21-43 Government	NE 1/4 SE 1/4 sec. 21, T. 55 N., R. 73 W.	4,056
R-19	Davis Oil Co. 1 Squaw Creek - Federal	SE 1/4 SW 1/4 sec. 27, T. 55 N., R. 73 W.	4,086
R-20	Davis Oil Co. 1 Vincent	SW 1/4 NE 1/4 sec. 28, T. 55 N., R. 73 W.	4,093
R-21	The Anchutz Corp. 1-88 Government	NW 1/4 NW 1/4 sec. 28, T. 55 N., R. 73 W.	4,029
R-22	Phillips Petroleum Co. 2-A Vincent	SE 1/4 NW 1/4 sec. 30, T. 55 N., R. 73 W.	4,139
R-23	The Anchutz Corp. - Phillips Petroleum - Petroleum Inc. 2-A Oedekoven	SW 1/4 NW 1/4 sec. 30, T. 55 N., R. 73 W.	4,153
R-24	Phillips Petroleum Co. 3-A Vincent	SE 1/4 SE 1/4 sec. 25, T. 55 N., R. 74 W.	4,136
R-25	J. M. Huber Corp. 1-25 Federal - Sullivan	SW 1/4 NE 1/4 sec. 25, T. 55 N., R. 74 W.	4,211
R-26	R. G. Boekel 31-36 State	SW 1/4 SE 1/4 sec. 25, T. 55 N., R. 74 W.	4,228
R-27	The Anchutz Corp. 1 Butcher	SW 1/4 NE 1/4 sec. 31, T. 55 N., R. 73 W.	4,139

Sources of coal-bed data in the Recluse Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
R-28	Montana Bureau of Mines and Geology US 7468	NW 1/4 SE 1/4 sec. 32, T. 55 N., R. 73 W.	4,074
R-29	Davis Oil Co. 1 Partridge - Federal	NE 1/4 NE 1/4 sec. 33, T. 55 N., R. 73 W.	4,009
R-30	Davis Oil Co. 1 Rothwell - Federal	SE 1/4 NW 1/4 sec. 34. T. 55 N., R. 73 W.	4,018
R-31	Exeter - Union Texas 1 Carson - Federal	SW 1/4 SW 1/4 sec. 4, T. 54 N., R. 73 W.	4,153
R-32	Kewanee Oil Co. 1 Henry	NE 1/4 NE 1/4 sec. 6, T. 54 N., R. 73 W.	4,164
R-32A	Petroleum Inc. 1 Kewanee	NE 1/4 NW 1/4 sec. 6, T. 54 N., R. 73 W.	4,228
R-33	Belco Petroleum 1-6 Cook	SW 1/4 SE 1/4 sec. 6, T. 54 N., R. 73 W.	4,110
R-34	Belco Petroleum 1-6 Wolff	NE 1/4 SW 1/4 sec. 6, T. 54 N., R. 73 W.	4,146
R-35	Trend Exploration, Ltd. 1-C Oedekoven	NE 1/4 SE 1/4 sec. 1, T. 54 N., R. 74 W.	4,094
R-36	Fred Goodstein 1-11 MKM	SW 1/4 SW 1/4 sec. 11, T. 54 N., R. 74 W.	4,174
R-37	All Minerals 1 Oedekoven	NE 1/4 SW 1/4 sec. 7, T. 54 N., R. 73 W.	4,169
R-38	Belco Petroleum 2 Oedekoven	NE 1/4 NW 1/4 sec. 7, T. 54 N., R. 73 W.	4,126
R-39	All Minerals 1 Schaffer	SW 1/4 NE 1/4 sec. 7, T. 54 N., R. 73 W.	4,057
R-40	Peet Oil Co. 1 Federal	NE 1/4 SW 1/4 sec. 8, T. 54 N., R. 73 W.	4,075
R-41	Davis Oil Co. 1 Breene - Federal	NW 1/4 NW 1/4 sec. 10, T. 54 N., R. 73 W.	4,181
R-42	Davis Oil Co. 1 Mohawk State	NE 1/4 NE 1/4 sec. 16, T. 54 N., R. 73 W.	4,047

Sources of coal-bed data in the Recluse Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
R-43	Southland Royalty Co. 1-17 Davis - Federal	NE 1/4 NE 1/4 sec. 17, T. 54 N., R. 73 W.	4,098
R-44	Texaco, Inc. 1-K State of Wyoming	NE 1/4 SE 1/4 sec. 18, T. 54 N., R. 73 W.	4,168
R-45	Texaco, Inc. 2-K State of Wyoming	SW 1/4 SE 1/4 sec. 18, T. 54 N., R. 73 W.	4,127
R-46	Texaco, Inc. 1 Government - Simms Nct-1	NE 1/4 SW 1/4 sec. 18, T. 54 N., R. 73 W.	4,142
R-47	Texaco, Inc. 1 Carson	NE 1/4 NW 1/4 sec. 18, T. 54 N., R. 73 W.	4,189
R-48	Cayman Corp. 1 Reed	SW 1/4 NE 1/4 sec. 14, T. 54 N., R. 74 W.	4,113
R-49	Aztec Oil & Gas Co. 1-23 Federal SC	SW 1/4 SW 1/4 sec. 23, T. 54 N., R. 74 W.	4,257
R-50	MKM Exploration 1-A Parnell	NW 1/4 SW 1/4 sec. 24, T. 54 N., R. 74 W.	4,174
R-51	Texaco, Inc. 1-M State of Wyoming	NE 1/4 NW 1/4 sec. 19, T. 54 N., R. 73 W.	4,095
R-52	Davis Oil Co. 1 Great Northern - State	SE 1/4 NE 1/4 sec. 20, T. 54 N., R. 73 W.	4,242
R-53	Southland Royalty Co. 1 Bing - Wylie	SE 1/4 NW 1/4 sec. 22, T. 54 N., R. 73 W.	3,988
R-54	Davis Oil Co. 1 Norfolk - State	NW 1/4 NW 1/4 sec. 28, T. 54 N., R. 73 W.	3,992
R-55	Davis Oil Co. 1 Joan - State	NE 1/4 NE 1/4 sec. 30, T. 54 N., R. 73 W.	4,163
R-56	Montana Bureau of Mines and Geology US 7466	NW 1/4 SE 1/4 sec. 30, T. 54 N., R. 73 W.	4,068
R-57	Glen A. Dow - Trend Exploration 1 Government - Aztec	NE 1/4 NE 1/4 sec. 25, T. 54 N., R. 74 W.	4,162

Sources of coal-bed data in the Recluse Quadrangle--Continued

Well No. on map	Company and well No.	Location	Ground elevation (ft)
R-58	Miami Oil 1-430 Federal	SW 1/4 NE 1/4 sec. 27, T. 54 N., R. 74 W.	4,190
R-59	Midwest Oil Co. 1 Sorenson	NE 1/4 NW 1/4 sec. 27, T. 54 N., R. 74 W.	4,215
R-60	Montana Bureau of Mines and Geology US 7552	NW 1/4 SW 1/4 sec. 24, T. 54 N., R. 74 W.	4,181
R-61	Montana Bureau of Mines and Geology US 7553	SE 1/4 NE 1/4 sec. 3, T. 54 N., R. 74 W.	4,143