GEOLOGICAL SURVEY OF WYOMING

Gary B. Glass, State Geologist

Open File Report 89-2

COAL GEOLOGY, GEOPHYSICAL LOGS, AND LITHOLOGIC DESCRIPTIONS FROM A DRILLING PROGRAM AT THE RAWHIDE VILLAGE SUBDIVISION, CAMPBELL COUNTY, WYOMING

by

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1989

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This report has not been reviewed for conformity with the editorial standards of the Geological Survey of Wyoming.

Contents

Figures

Introduction

A drilling program was undertaken by the Geological Survey of Wyoming, in cooperation with the Land Quality Division of the Wyoming Department of Environmental Quality, to assist in a study of methane and hydrogen sulfide gases venting at Rawhide Village. Rawhide Village is approximately 6 miles north of Gillette, in the NE 1/4, sec. 20, T.51N., R.72W., Campbell County, Wyoming (**Figure** 1). Amax Coal Company's Eagle Butte mine is located east of and immediately adjacent to Rawhide Village in all or parts of secs. 16, 20, and 21, T.51N., R.72W. Carter Mining Company's Rawhide mine is located approximately 3 miles east-northeast of Rawhide Village and Triton Coal Company's Buckskin mine is located approximately 3 miles north of the subdivision.

Fourteen drill holes ranging from 40 feet to 540 feet deep were completed in Rawhide Village Subdivision between July 6 and July 10, 1987, by the Geological Survey of Wyoming (**Figure** 2). Geophysical logs and lithologic descriptions from this project are presented in **Appendix A** of this report. Additional drill hole data from monitor wells drilled by Amax Coal Company and subsequently released by the U.S. Bureau of Land Management, Casper District Office were also used in preparing the maps and cross sections in this report (see open circles, **Figure** 2). Interpretations presented in this report are based on the logs and descriptions and include stratigraphic correlation of coal beds in the area (cross sections); thickness (isopach) maps of the coal beds, interburden, and overburden; and structure contour maps on top of the coal beds.

Regional geology

Rawhide Village is located in the Powder River Basin, a structural basin bounded on the west by the Bighorn Mountains and the Casper arch, on the east by

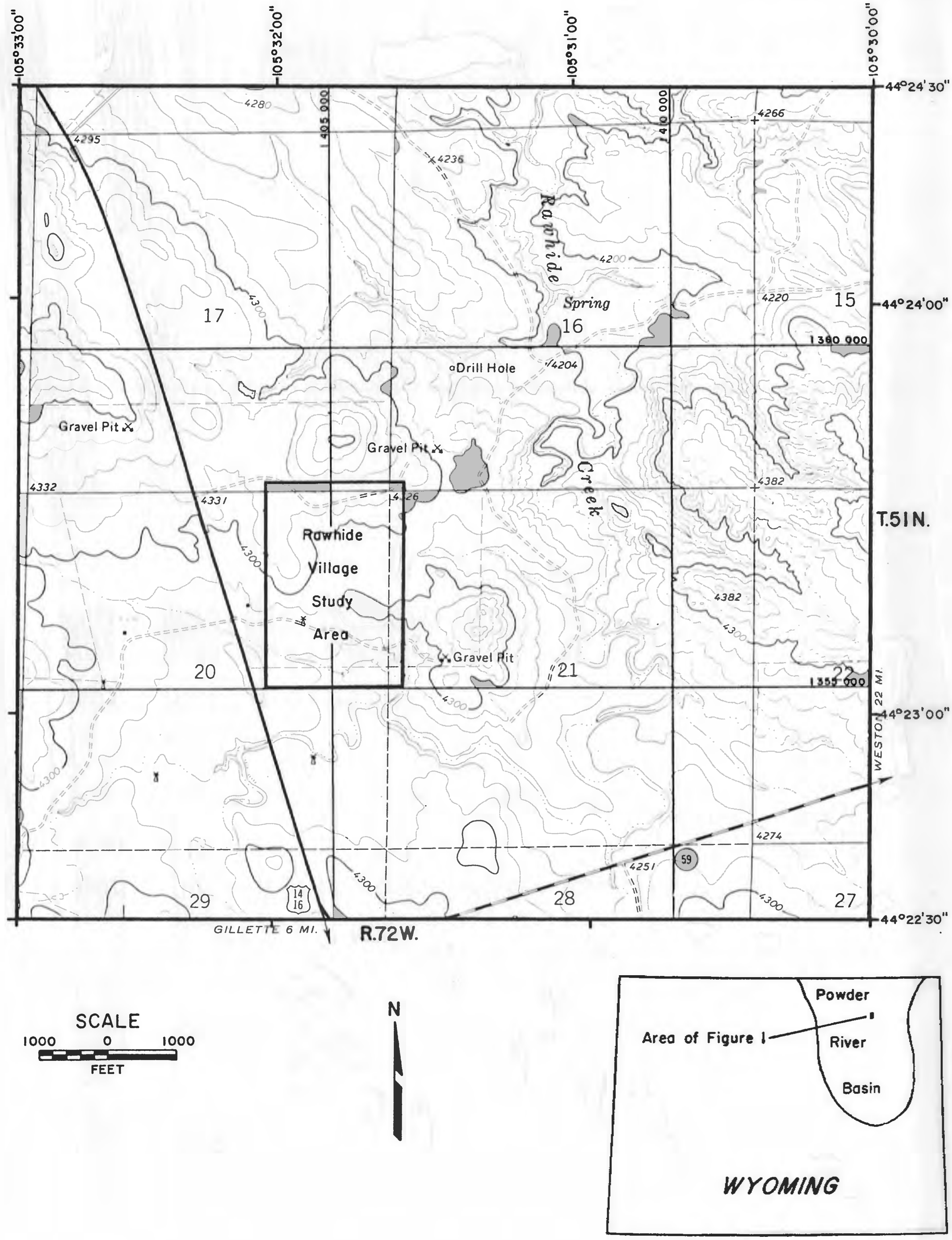


Figure 1. Location map of Rawhide Village study area.

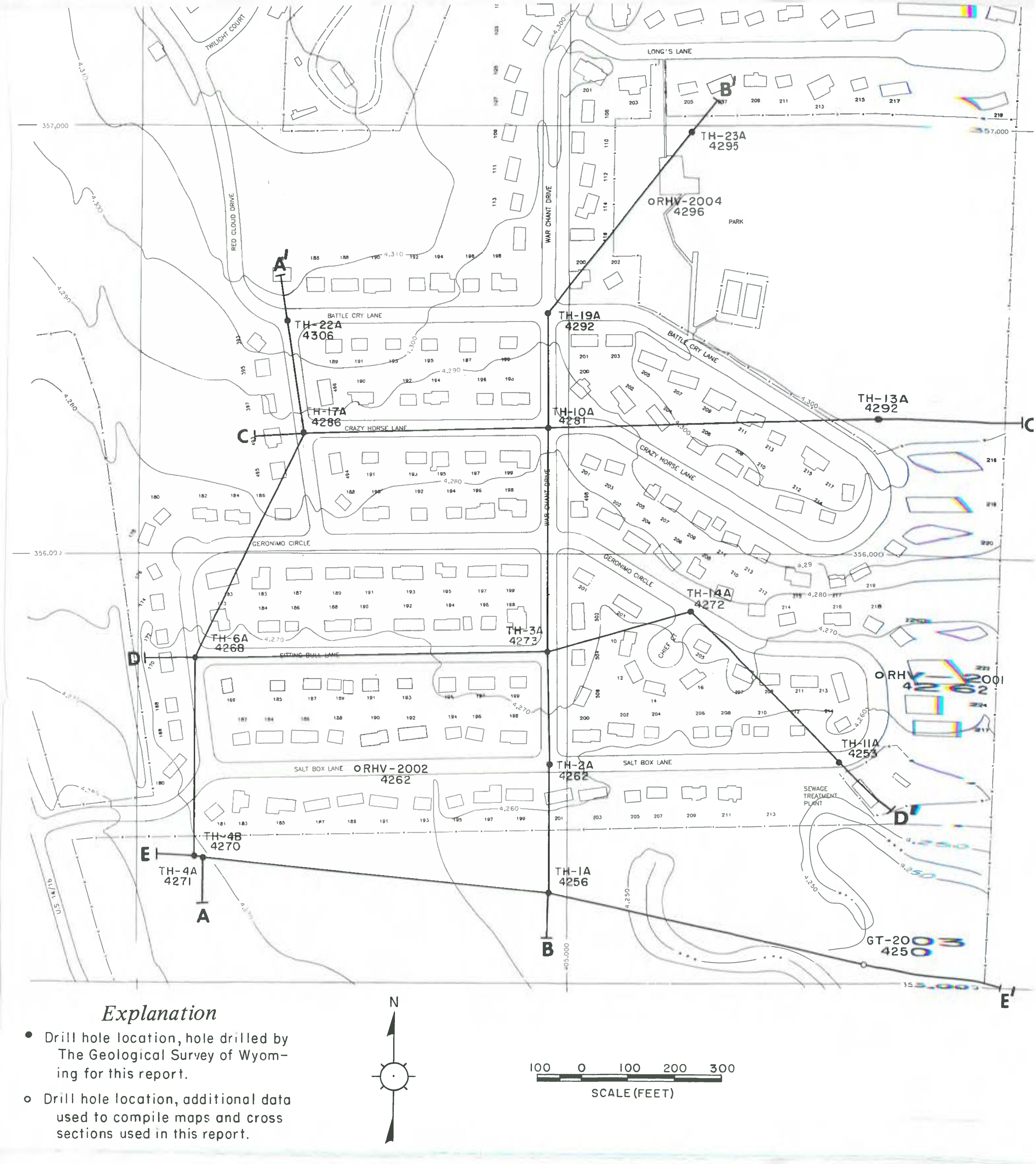


Figure 2. Base map of Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.) with surface topography, drill hole locations, and cross section locations.

the Black Hills uplift, and on the south by the Laramie Mountains and Hartville uplift (**Figure 3**). The basin is strongly asymmetric to the west; the synclinal axis follows the western edge of the basin, strikes generally north-northwest, and plunges gently toward the north. Sedimentary rocks along the western edge of the basin dip steeply to the east and are often faulted; sedimentary rocks exposed in the eastern part of the basin exhibit much gentler dips (0.5 to 3 degrees) to the west-southwest. The maximum thickness of sedimentary rocks within the basin is approximately 17,000 feet along the basin axis. The measurable structural relief between the lowest part of the basin and the highest point on the surrounding uplift of the Bighorn Mountains, measured on the top of the Precambrian basement, is approximately 21,000 feet (McDonald, 1972).

Most of the mineable coal in the eastern Powder River Basin is located in the Wyodak coal deposit, which contains one or more thick coal beds referred to in this report as the Wyodak coal. The Wyodak in this area is also known as the Roland-Smith or the Wyodak-Anderson coal bed(s). The Wyodak is stratigraphically located in the upper part of the Tongue River Member of the Fort Union Formation (**Figure 4**). The Tongue River Member consists of interbedded shales, siltstones, sandstones, and numerous coal beds. The Wyodak is the highest coal in the Tongue River Member; the top of the Wyodak coal bed is the contact between the Paleocene Fort Union Formation and the Eocene Wasatch Formation (Law, 1976). The Wyodak coal bed has an average thickness over 100 feet in the Gillette area, is subbituminous in rank, and has an average heating value that ranges from 7,900 to 8,500 Btu/pound.

Zones of "no coal" in the Tongue River Member of the Fort Union Formation in this area may be paleostream channels, where coal was never deposited, or the

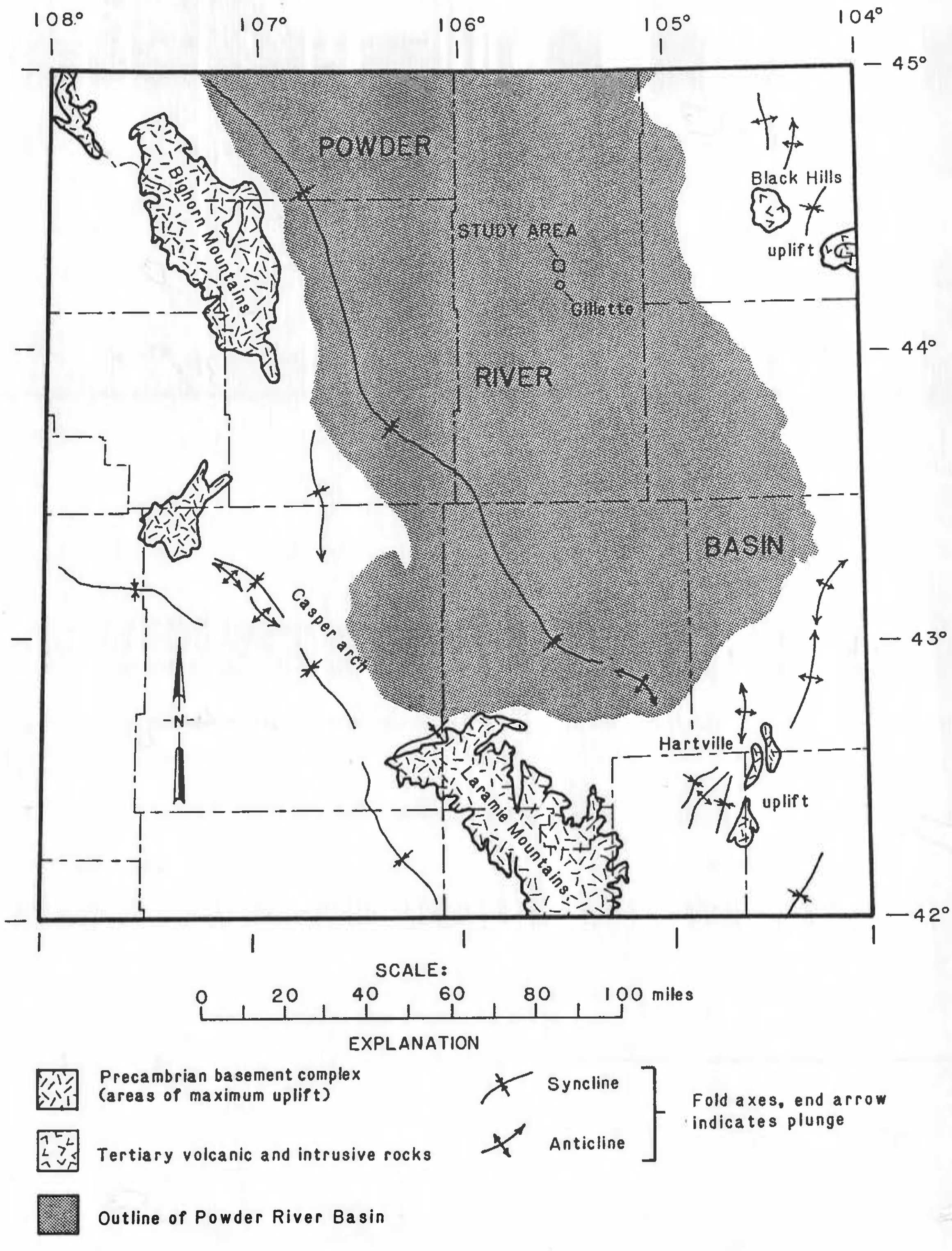


Figure 3. Regional geological setting of the Powder River Basin.

ERATHEM	SYSTEM	SERIES	STRATIGRAPHIC UNIT	
Cenozoic	Quaternary	Holocene and Pleistocene	Alluvium	
	Tertiary	Pliocene	▨	
		Miocene	▨	
		Oligocene	▨	
		Eocene	Wasatch Formation	
		Paleocene	Fort Union Formation	Wyodak coal bed
				Tongue River Member
				Lebo Member
				Tullock Member
Mesozoic	Cretaceous	Upper	Lance Formation	
			Fox Hills Sandstone	
			Pierre Shale	

Figure 4. General stratigraphic section of rocks exposed in and beneath the Rawhide Village Subdivision study area. Diagonal pattern indicates rocks not present in the study area. Modified from Martin and others, 1988.

result of erosion (removal) of previously deposited coal by near-surface oxidation (burning) or by streams channelling into the coal. In the first case, the paleochannel exists at the same time peat is being deposited in swampy areas adjacent to the channel. Amax Coal Company and Law (1976) have identified a large east-west trending paleochannel of the first type directly north and northeast of Rawhide Village. Clinker exists in the vicinity of Rawhide Village where near-surface coal has burned in place. Clinker (baked and fused rock formed when the materials overlying the oxidizing coal are heated) is usually found as a reddish or reddish brown, hard, erosion-resistant material that forms buttes or topographic ridges throughout much of the Powder River Basin.

Coal depositional history

Following the retreat of the Lewis (Pierre) seaway from the Powder River Basin (as documented by the Late Cretaceous regressive marine sand sequence known as the Fox Hills Sandstone), fluvial sandstones, shales, siltstones, and thin coal beds of the Latest Cretaceous Lance Formation were deposited. (A general stratigraphic sequence for the study area is shown as **Figure 4.**) The coal-bearing Paleocene Fort Union Formation overlies the Lance Formation. The Fort Union Formation is composed of nonmarine rocks that originated as swamp, estuarine, lacustrine, and fluvial sediments. Although these environments persisted during deposition of the older Tullock and Lebo Members of the Fort Union Formation, conditions for preservation of large quantities of plant material, which later became thick coal beds, apparently did not exist in the Powder River Basin until deposition of the Tongue River Member and the overlying Eocene Wasatch Formation. A humid subtropical climate prevailed in this area and large peat swamps dominated the Powder River Basin during deposition of these two units. Near the end of Wasatch Formation deposition, the climate became much drier and accumulation of coal-forming materials ceased.

In the eastern Powder River Basin (near the present site of Rawhide Village), the Wyodak coal bed(s) was deposited in peat swamps adjacent to an east-west oriented channel system thought to have been a trunk stream system that merged farther west with a major north-south oriented river channel system (Warwick and Stanton, 1988). Great thicknesses of peat accumulated in the interfluve (areas between the major stream channels). Periodically, sediment-laden water flooded the edges of the swamp as a crevasse splay, creating clay, silt, and sand partings now seen as "splits" that separate the Wyodak into more than one coal bed. Areas bordering the stream channels were most susceptible to these periodic floods, and in some instances numerous, sometimes thick, clay layers developed. As the major stream channels meandered across the area, thin, discontinuous, "rider" peat beds were often deposited on top of the abandoned stream channel deposits. Similarly, meandering rivers occasionally eroded previously deposited peat, creating channel areas (cutouts) where coal is no longer present. Also at various times during peat deposition, fresh-water lakes formed when subsidence exceeded accumulation of peat and (or) sediment. Today, these areas often contain very fine-grained mudstones, claystones, thin fresh-water limestones, and remains of fresh-water invertebrates.

Drill hole data acquisition

All Geological Survey of Wyoming drilling was conducted using conventional rotary drilling rigs under contract. The drilling fluid used was native mud with a 35 sec/1000 ml viscosity in a Marsh funnel. Standard bits were used for drilling and coring. Mud pits were constructed for the drill holes south of the subdivision and for holes drilled in the park. All of the test holes completed in the subdivision were drilled through existing streets utilizing portable mud pits. Standard abandonment procedures were followed after drilling and logging was completed.

All Geological Survey of Wyoming drill holes were logged by Goodwell, Inc. using gamma ray-neutron, gamma ray-density, spontaneous potential(SP), resistivity, caliper, and temperature tools. In drill holes TH-6A and TH-22A, only a gamma ray-neutron log was run because of caving and other downhole problems. The electrical and nuclear logs were used to correlate lithologic units and to assist in assigning the proper depth to the lithologic descriptions. In addition, sample cuttings were described, dried, and saved. Lithologic descriptions of rotary drill returns were completed by Geological Survey of Wyoming personnel at the drilling sites as the samples were received in 10-foot intervals. In all cases, the samples were wet and permeated with drilling mud when collected and had to be washed before they could be described. Twenty-one feet of coal core was taken from drill hole TH-4B. Overall, the samples were of poor quality with few large intact chips surviving the drilling process. Despite the poor sample quality, basic lithologic characteristics observed in the samples adequately matched the lithologies picked from the electric and nuclear logs. Coal intervals were easily recognized on both geophysical and lithologic logs.

Because of 1) the delay associated with circulating samples to the surface, 2) the imprecise depth measurement available during drilling, and 3) the fact that circulating drilling fluid can contain samples from anywhere within the drilled interval, slight adjustments were made to the lithology log depths to match the geophysical log depths. Coal intervals were used as an easily identifiable datum. Lithology descriptions were computer processed utilizing Rockware, Incorporated's LOGGER (trademark) program to produce the lithology description and strip-log displays (**Appendix A**).

Results

Drilling at Rawhide Village revealed that the subdivision is immediately underlain by thin surficial deposits and Tertiary bedrock of the Wasatch and Fort Union Formations. The surficial deposits include sand, gravel, and clinker; rock units are composed of sandstone, siltstone, shale, mudstone, claystone, and subbituminous coal (see lithology descriptions and geophysical logs, **Appendix A**). Part or all of the Wyodak coal is present in the subsurface beneath the entire subdivision (**Figure** 5). Throughout the area, the Wyodak coal can be subdivided into two separate, mappable units, referred to informally in this report as the upper and lower Wyodak coal beds. The upper Wyodak coal consists of a single coal bed that ranges from 15 to 35 feet thick. In the central part of the study area, the upper Wyodak has been replaced by paleochannel deposits and is not present (see cross sections (B) and (C), **Figure 5**). The lower Wyodak coal consists of one or more coal beds separated by relatively thin rock partings. Total thickness of the lower Wyodak ranges from 9 feet to 133 feet; several drill holes penetrated a single, continuous lower Wyodak coal bed over 90 feet thick.

Coal Thickness

The upper Wyodak coal bed is present north, west, and south of the paleochannel area and attains a maximum thickness of 35 feet at drill hole TH-17A (**Figure 6**). This coal bed is thinnest at drill hole RHV-2004 (13 feet); the coal bed also thins slightly in the southeastern part of the study area. The upper Wyodak has an average thickness of about 28 feet throughout the study area. The paleochannel that replaces the upper Wyodak in the central part of the study area is thought to be related to a large paleochannel system that

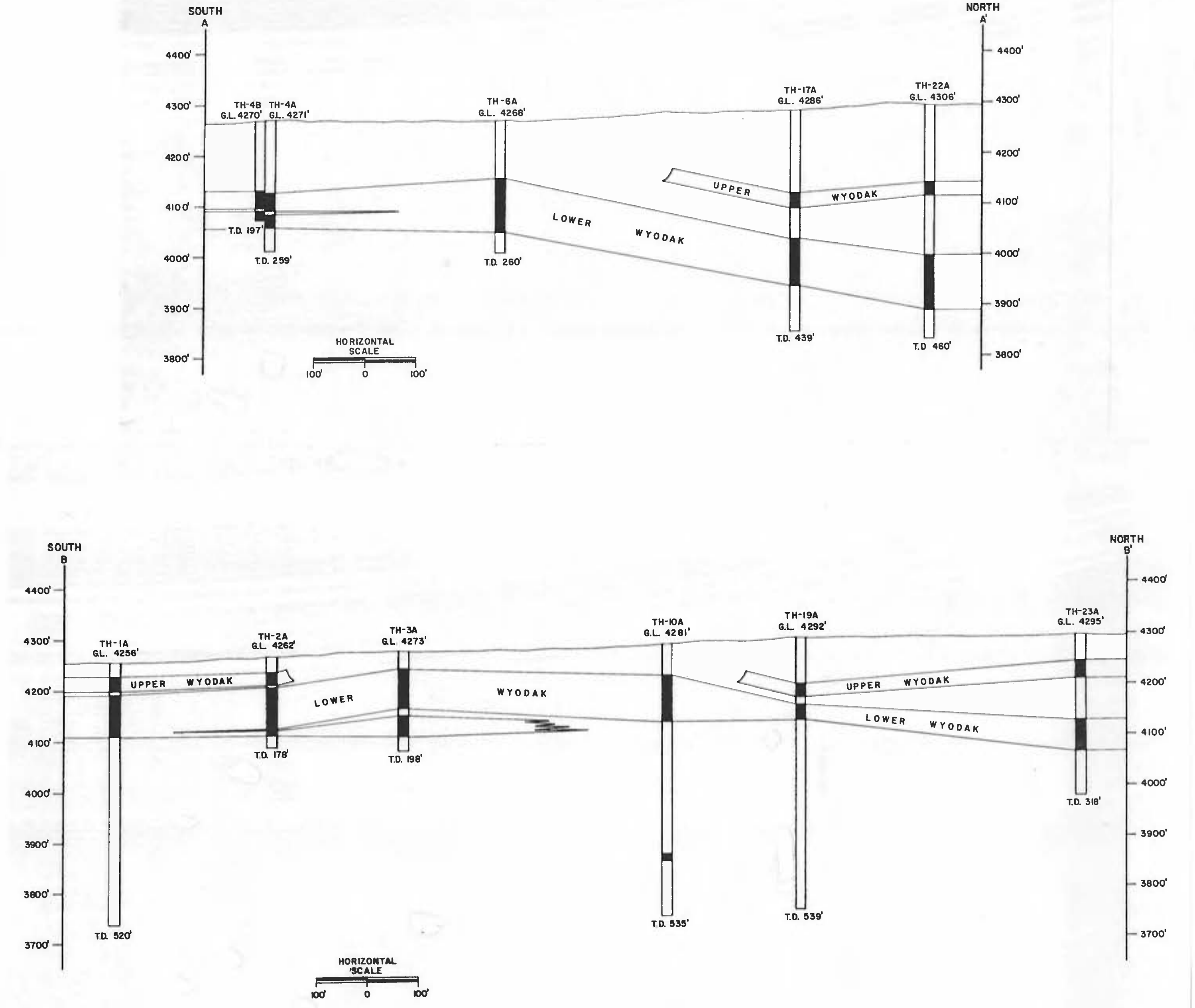
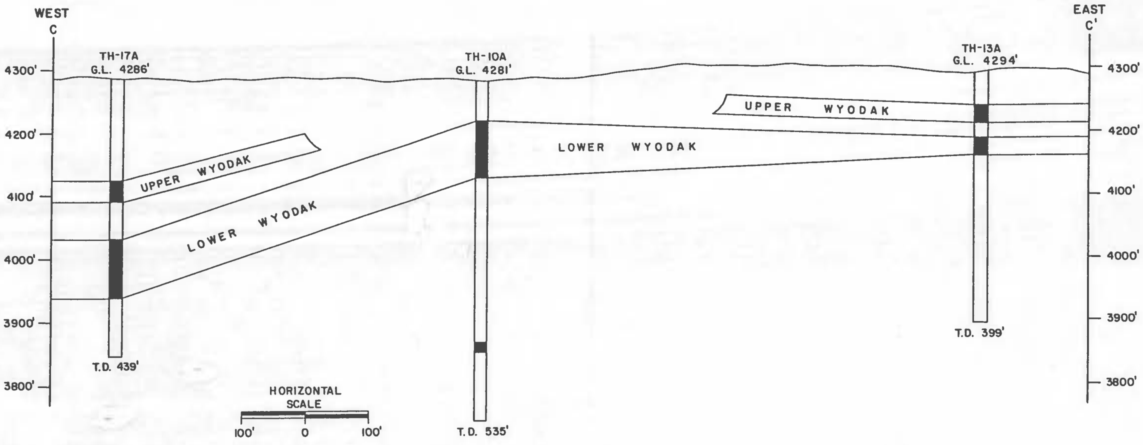
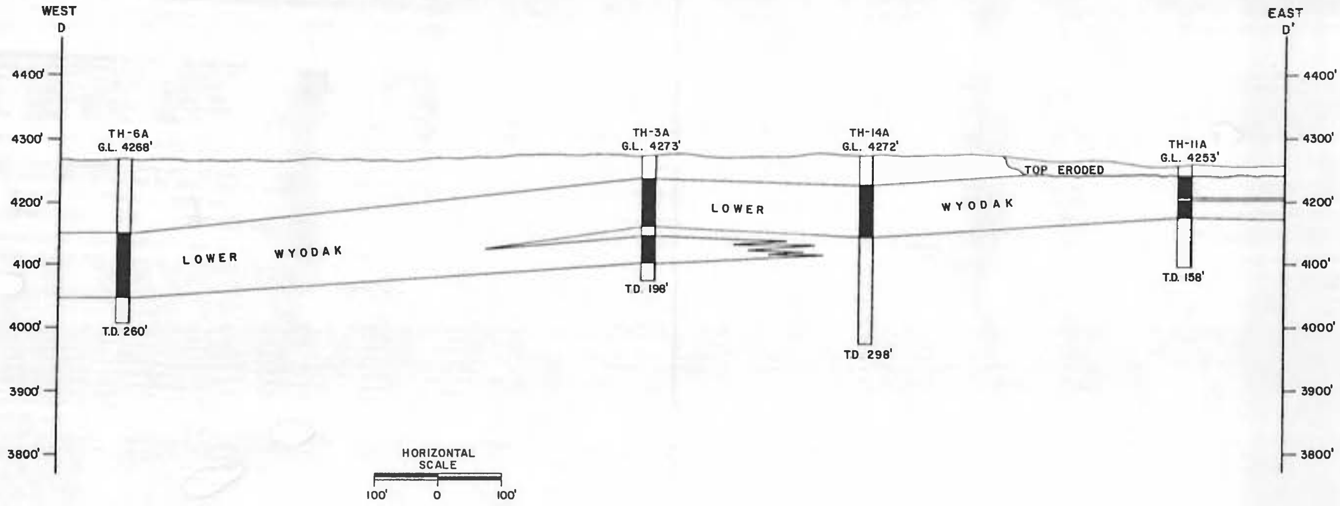
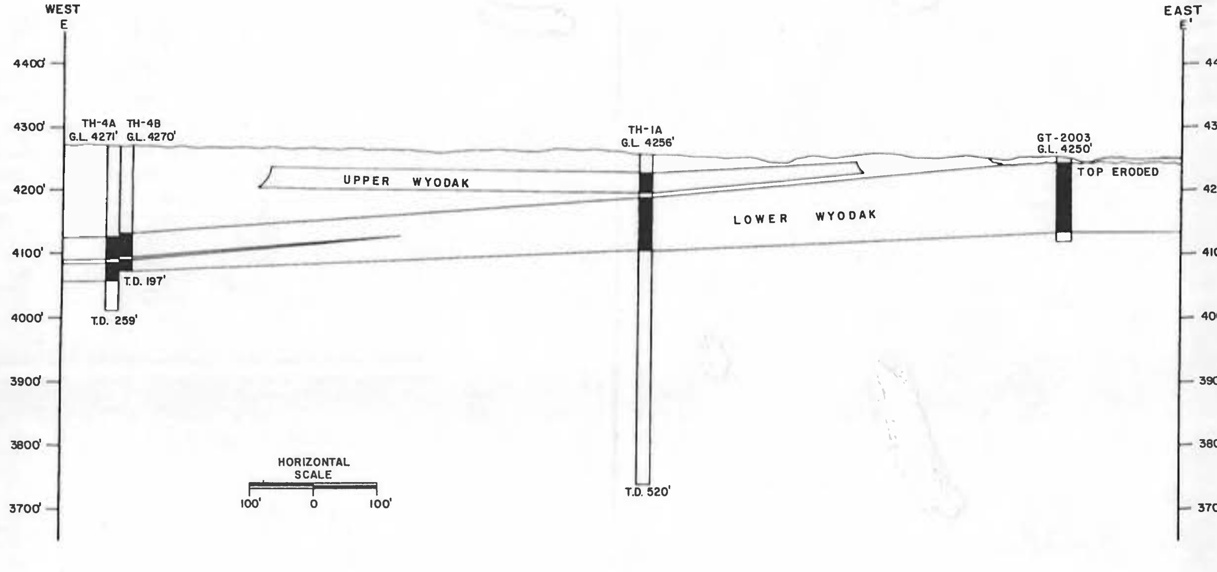


Figure 5. Cross sections through Rawhide Village Subdivision (this and facing page). Cross section locations are shown on **Figure 2.**


WEST
C
EAST
C'
TH-17A
G.L. 4286'
TH-10A
G.L. 4281'
TH-13A
G.L. 4294'
UPPER WYODAK
LOWER WYODAK
UPPER WYODAK
LOWER WYODAK
4300'
4200'
4100'
4000'
3900'
3800'
T.D. 439'
T.D. 535'
T.D. 399'
HORIZONTAL
SCALE
100'
0
100'


WEST
D
EAST
D'
TH-6A
G.L. 4268'
TH-3A
G.L. 4273'
TH-14A
G.L. 4272'
TH-11A
G.L. 4253'
TOP ERODED
LOWER
WYODAK
LOWER WYODAK
4400'
4300'
4200'
4100'
4000'
3900'
3800'
T.D. 260'
T.D. 198'
TD 298'
T.D. 158'
HORIZONTAL
SCALE
100'
0
100'


WEST
E
EAST
E'
TH-4A
G.L. 4271'
TH-4B
G.L. 4270'
TH-1A
G.L. 4256'
GT-2003
G.L. 4250'
UPPER WYODAK
LOWER WYODAK
TOP ERODED
4400'
4300'
4200'
4100'
4000'
3900'
3800'
3700'
T.D. 197'
T.D. 259'
T.D. 520'
HORIZONTAL
SCALE
100'
0
100'

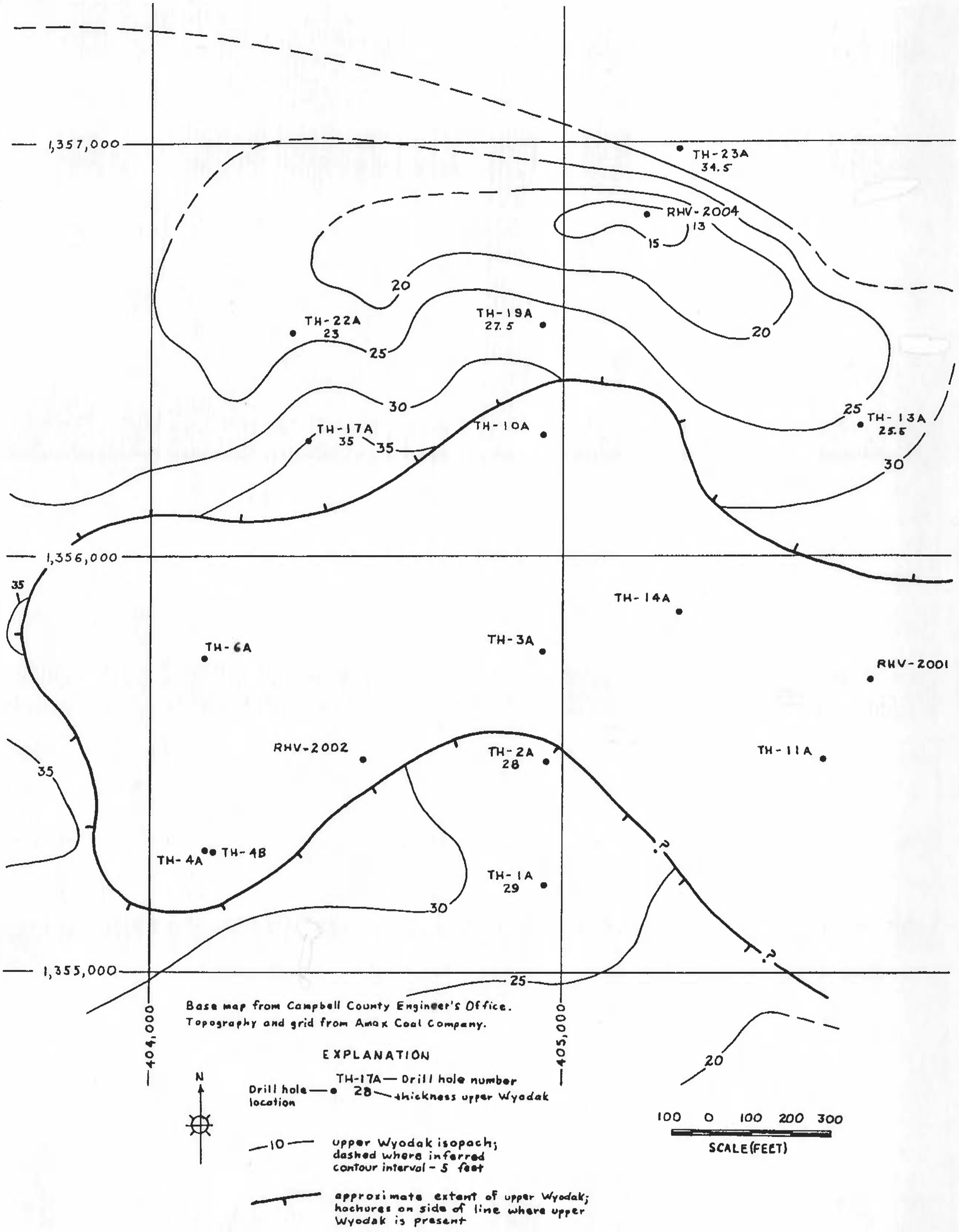


Figure 6. Isopach map of the upper Wyodak coal bed, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).

replaces the entire Wyodak (upper and lower coal beds) to the east and northeast of Rawhide Village Subdivision, as described by Law (1976).

A previous interpretation of drill hole information by Jones and others (1987) and Glass and others (1987) considered that the upper Wyodak coal bed was present in drill holes TH-4A and TH-4B in the southwestern part of the study area. This report considers the two coal beds present in each of these two drill holes to be part of the lower Wyodak coal bed only; the upper Wyodak coal bed is thought to be replaced by rocks of the paleochannel in the upper part of drill holes TH-4A and TH-4B (see cross sections A and E, **Figure** 5). Because drill holes west and south of TH-4A and TH-4B (not shown on cross sections or the maps in this report) do contain both upper and lower Wyodak coal beds, the limits of the upper Wyodak coal bed in this area can be determined.

The lower Wyodak coal bed is present in the subsurface throughout the Rawhide Village Subdivision study area (**Figure** 7). Maximum thickness occurs in the area around drill holes TH-6A, TH-3A, and RHV-2002. A rapid thinning of the upper Wyodak occurs in the northeast part of the area near drill holes TH-19A, RHV-2004, and TH-13A. The lower Wyodak there is less than 30 feet thick. In the eastern part of the study area, the top of the lower Wyodak has been eroded and weathered because it is extremely close to the surface (see cross section D and E, **Figure 5**). The average thickness of the lower Wyodak coal bed, including data points adjacent to the study area, is about 72 feet. The average thickness of the lower Wyodak for just those data points in the Rawhide Village Subdivision is about 76 feet.

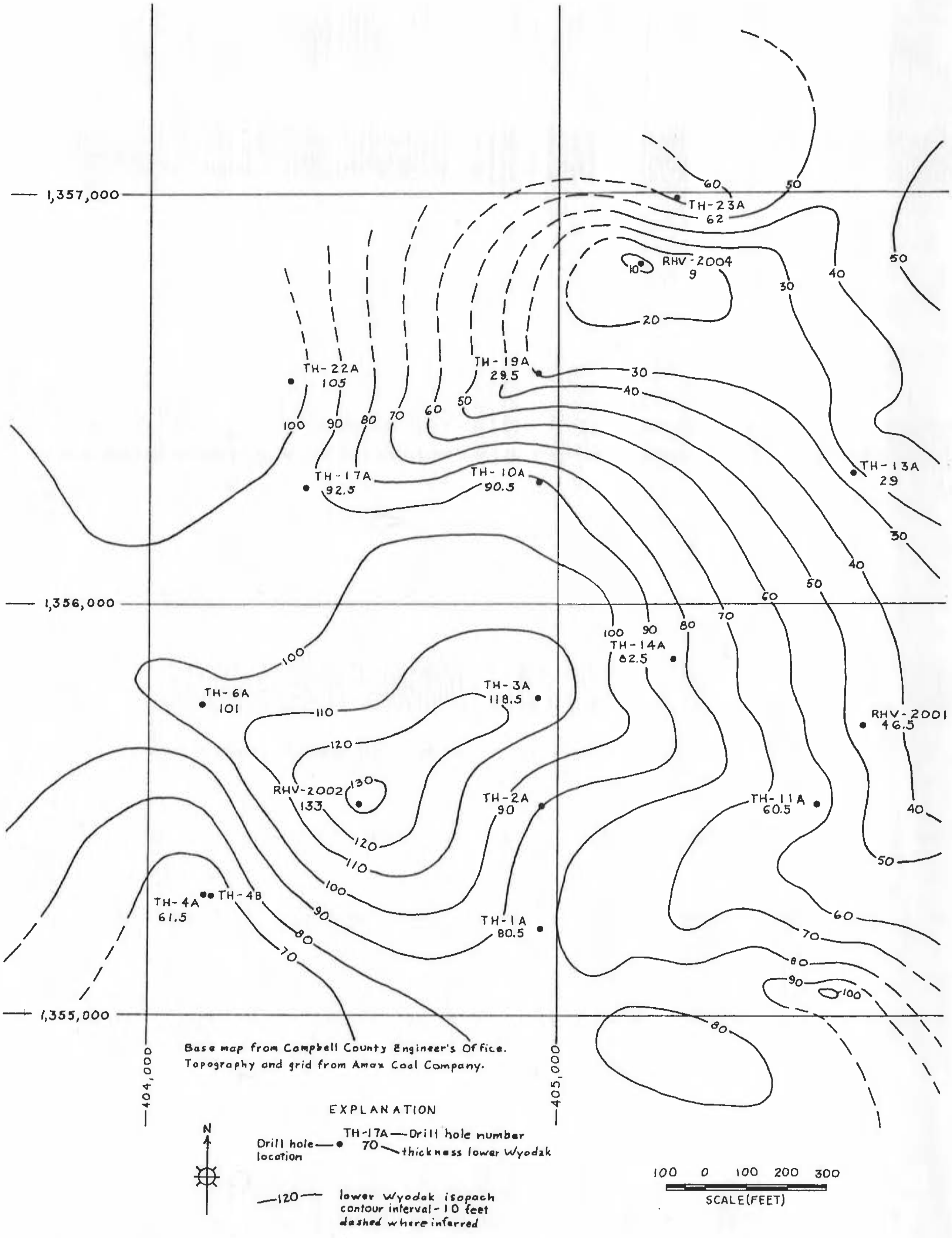


Figure 7. Isopach map of the lower Wyodak coal bed, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).

Interburden

The interburden between the upper and lower Wyodak coal beds (**Figure** 8) is greatest in the northwestern and northeastern parts of the study area. The areas of thickest interburden are probably related to the repeated influx of clastic material from a major fluvial channel north and northeast of the subdivision (Law, 1976 and Amax Coal Company records). Areas of thin interburden between the upper and lower Wyodak occur in the extreme western and southeastern parts of the study area as well as at drill holes RHV-2004 and TH-13A.

Structure

The upper Wyodak coal bed is structurally highest in the northeastern and south-central parts of the study area, adjacent to the edge of the paleochannel that cuts into the upper Wyodak (**Figure** 9). The upper Wyodak is structurally lowest in the western part of the study area farthest downdip. Maximum structural relief on top of this coal bed is about 200 feet. A structurally high area with little relief occurs near drill hole TH-2A, immediately south of the edge of the paleochannel. The only prominent structural axis on top of the upper Wyodak is a shallow syncline developed parallel to and north of the edge of the paleochannel near drill hole TH-17A.

The lower Wyodak coal bed is structurally highest in the eastern part of Rawhide Village Subdivision (**Figure** 10), especially in that part of the study area where the upper Wyodak coal bed is absent. A prominent west-plunging anticline that parallels the south edge of the paleochannel occurs in the southern part of the subdivision. A structural "bench" with relatively gentle structural relief occurs above the 4,200-foot contour in the east-central part of the study area. Other less prominent anticlinal and synclinal folds plunge

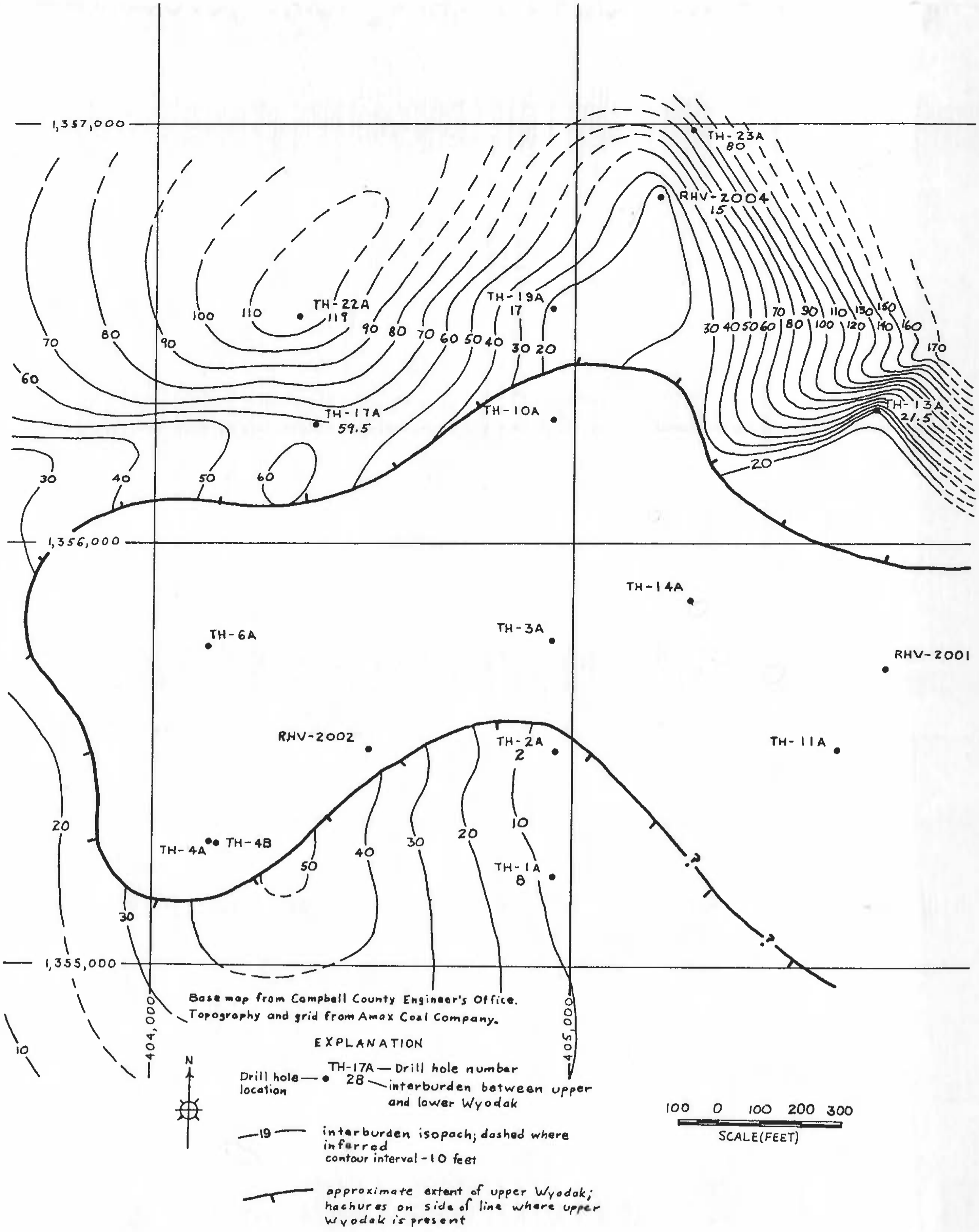
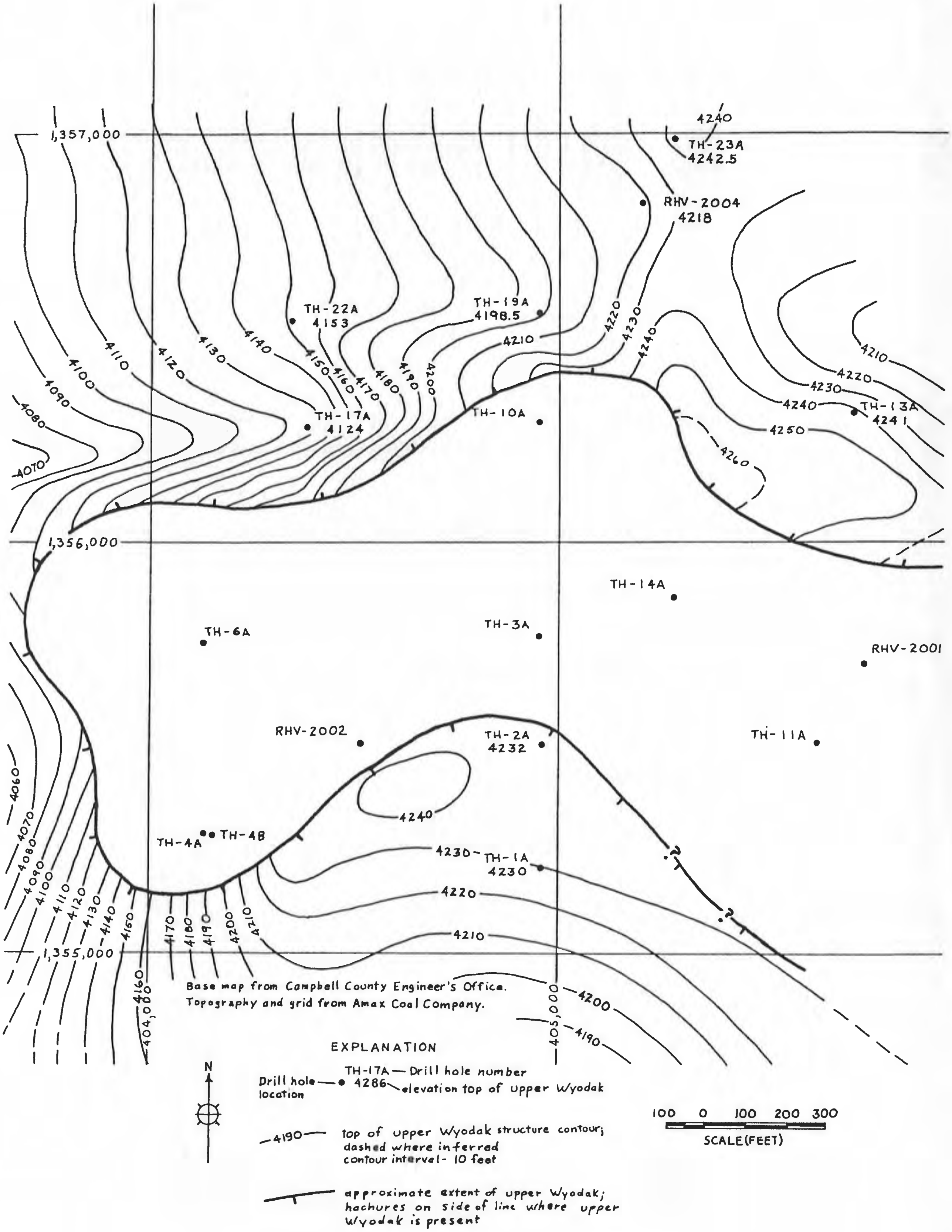


Figure 8. Isopach map of interburden between the upper and lower Wyodak coal beds, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).



Base map from Campbell County Engineer's Office.
Topography and grid from Amax Coal Company.

Figure 9. Structure contour map on top of the upper Wyodak coal bed, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).

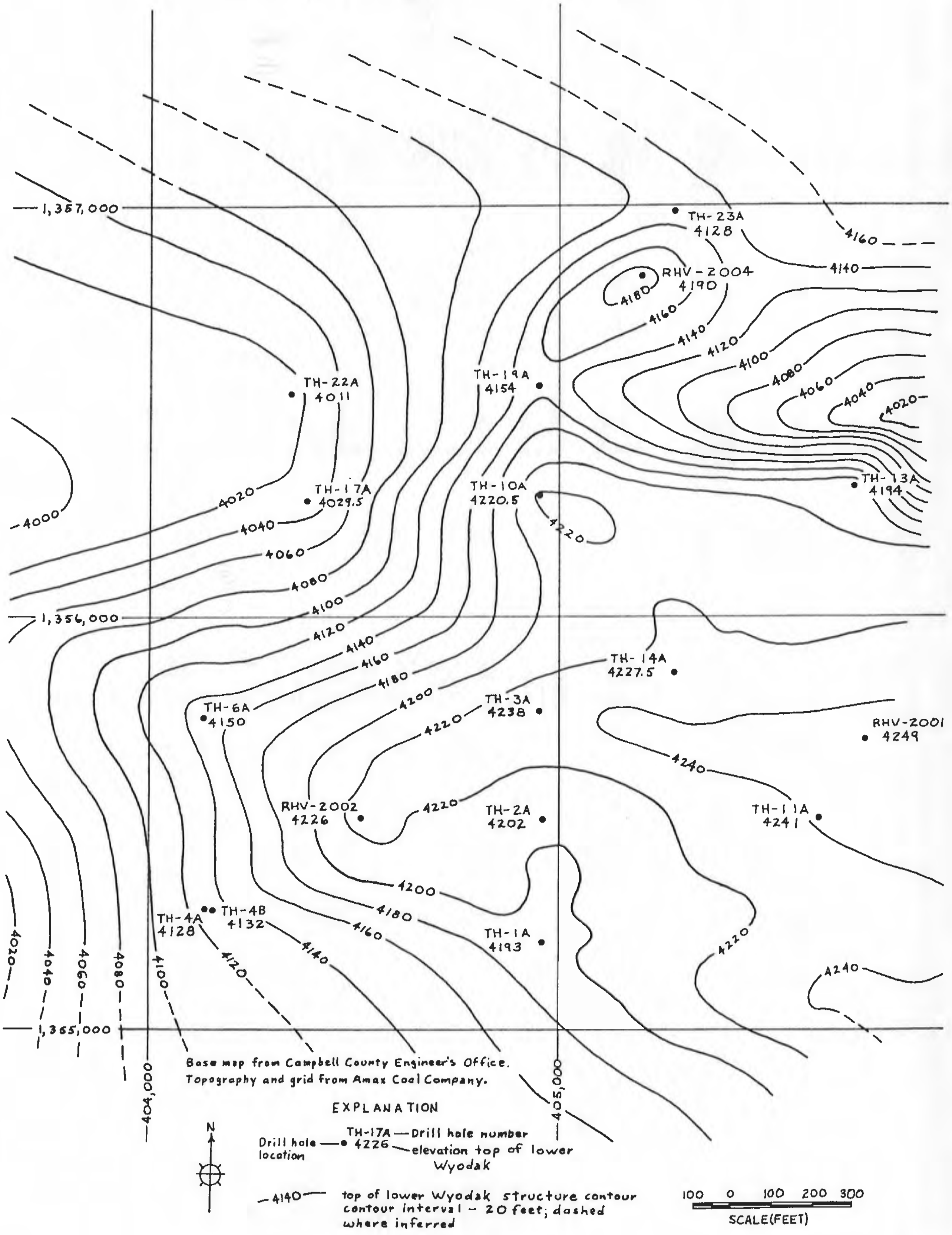
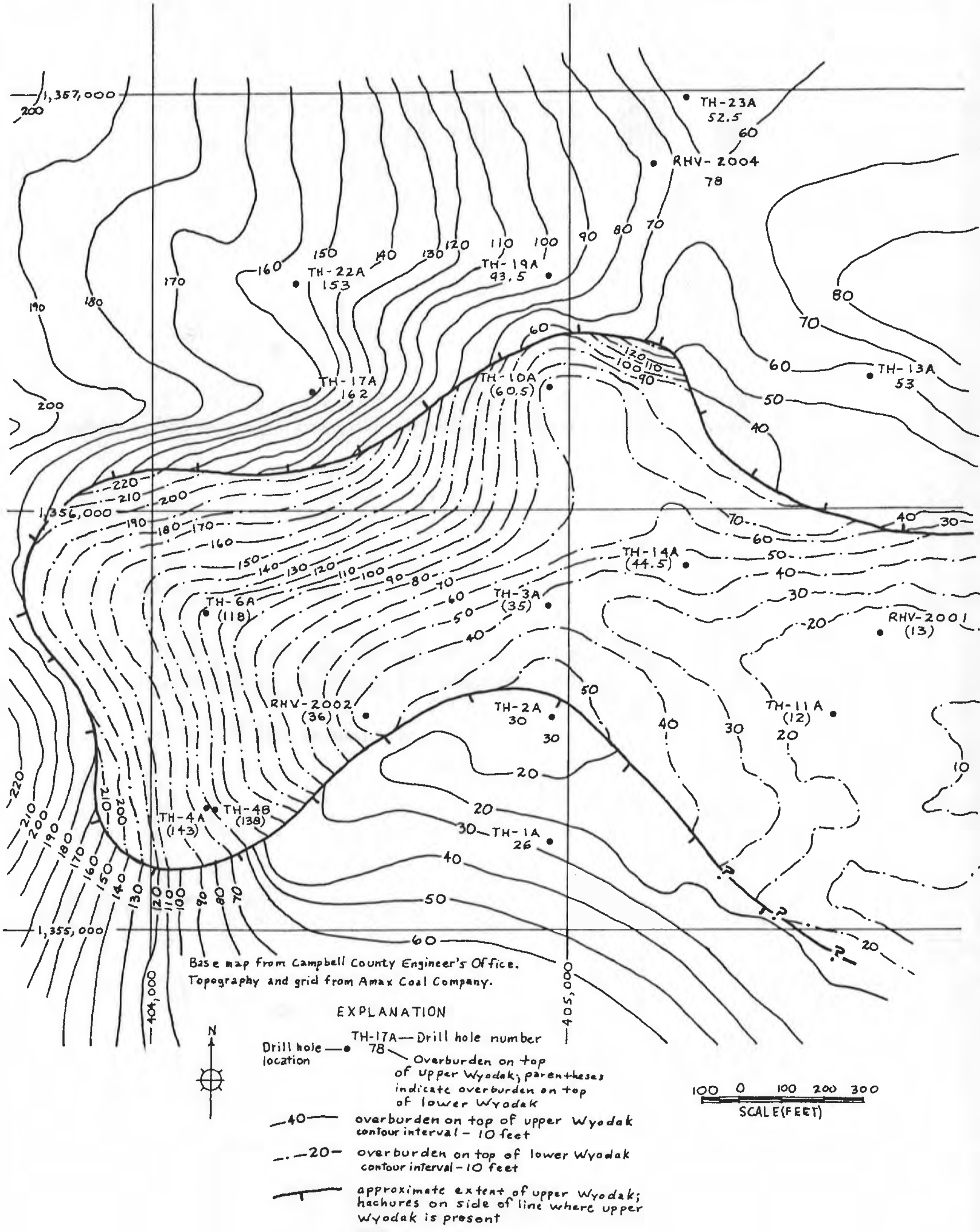


Figure 10. Structure contour map on top of the lower Wyodak coal bed, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).

west, west-northwest, and northeast in the northern part of the subdivision. Maximum structural relief on top of the lower Wyodak is almost 240 feet. The configuration of the upper surface of both the lower and upper Wyodak coal beds is related to primary sediment-deposition patterns, differential compaction of sediments, and to a lesser extent, erosion and regional tectonic deformation.

Overburden

Overburden is thickest along the west side of the subdivision and thinnest in the southeast corner (**Figure 11**). Compared to the structure contour maps of the Wyodak (**Figures 9 and 10**), overburden is, predictably, thickest where elevation of the Wyodak is lowest and thinnest where the Wyodak coal elevation is highest. In those areas where the upper Wyodak is absent (the paleochannel), overburden is shown on top of the upper Wyodak. Overburden thickness from wells drilled entirely within the subdivision varies from 12 feet at drill hole TH-11A to 162 feet at drill hole TH-17A. Data outside the study area allow projection of overburden isopach lines to over 220 feet in the western part of the study area. The rocks above the upper and lower Wyodak coal beds are primarily claystones, although significant thicknesses of sandstone do occur in overburden above the lower Wyodak in the northwestern part of the subdivision (see lithologic logs in **Appendix A**). Other significant overburden lithologies include siltstone, shale, and clinker.



Base map from Campbell County Engineer's Office.
Topography and grid from Amax Coal Company.

Figure 11. Isopach map of overburden on top of the upper Wyodak coal bed and lower Wyodak coal bed where upper Wyodak coal bed is absent, Rawhide Village Subdivision (Sec. 20, T.51N., R.72W.).

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Appendix A. Geophysical logs and lithologic descriptions.

List of drill holes

GEOPHYSICAL LOGS AND LITHOLOGIC DESCRIPTIONS

Log Header Abbreviations:

COMP. — completed

CPS/IN — counts per second per inch

CPS — counts per second

T.C. — time constant

SP — spontaneous potential

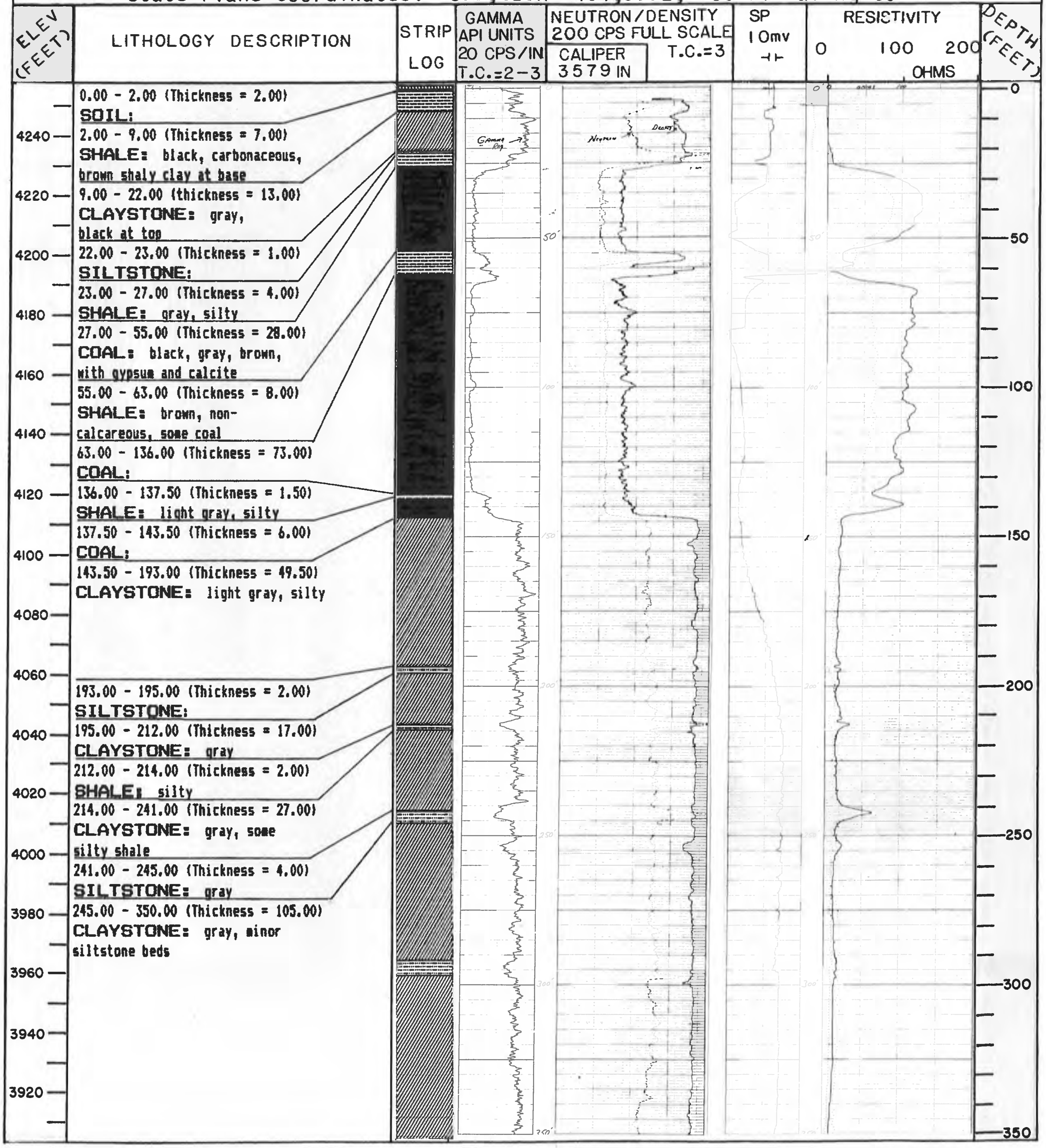
mv — millivolts

- ■ **Coal**
- ▧ **Clinker (baked and fused rock)**
- ▩ **Gravel**
- ░ **Sand or sandstone**
- ▤ **Siltstone**
- ▤ **Shale**
- ▤ **Shale and siltstone**
- ▨ **Clay or claystone**
- ▧ **Clay and silt**
- ▧ **Mudstone**
- ▩ **Soil**
- ▦ **Pavement**

THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-1A
SHEET 1 OF 4

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/6/87
DATE COMP.: 7/7/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4255.6
TOTAL DEPTH: 520'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE:
CORE FOOTAGE:
DRILLED BY: Ruby Drilling Company
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Hogle & De Bruin
LOGGED DEPTH: 520'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 355,210N 404,955E; Steel Casing to 60'



0.00 - 2.00 (Thickness = 2.00)
SOIL:

2.00 - 9.00 (Thickness = 7.00)
SHALE: black, carbonaceous, brown shaly clay at base

9.00 - 22.00 (thickness = 13.00)
CLAYSTONE: gray, black at top

22.00 - 23.00 (Thickness = 1.00)
SILTSTONE:

23.00 - 27.00 (Thickness = 4.00)
SHALE: gray, silty

27.00 - 55.00 (Thickness = 28.00)
COAL: black, gray, brown, with gypsum and calcite

55.00 - 63.00 (Thickness = 8.00)
SHALE: brown, non-calcareous, some coal

63.00 - 136.00 (Thickness = 73.00)
COAL:

136.00 - 137.50 (Thickness = 1.50)
SHALE: light gray, silty

137.50 - 143.50 (Thickness = 6.00)
COAL:

143.50 - 193.00 (Thickness = 49.50)
CLAYSTONE: light gray, silty

193.00 - 195.00 (Thickness = 2.00)
SILTSTONE:

195.00 - 212.00 (Thickness = 17.00)
CLAYSTONE: gray

212.00 - 214.00 (Thickness = 2.00)
SHALE: silty

214.00 - 241.00 (Thickness = 27.00)
CLAYSTONE: gray, some silty shale

241.00 - 245.00 (Thickness = 4.00)
SILTSTONE: gray

245.00 - 350.00 (Thickness = 105.00)
CLAYSTONE: gray, minor siltstone beds

THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-1A

SHEET 2 OF 4

AREA:

QUAD. NAME:

DATE STARTED:

DATE COMP.:

COUNTY:

STATE:

LOCATION: SEC. T. R.

FOOTAGE LOCATION:

GROUND ELEVATION:

TOTAL DEPTH:

DEPTH TO WATER:

SIZE, BIT TYPE:

DRILL TYPE:

ROTARY FOOTAGE:

CORE FOOTAGE:

DRILLED BY:

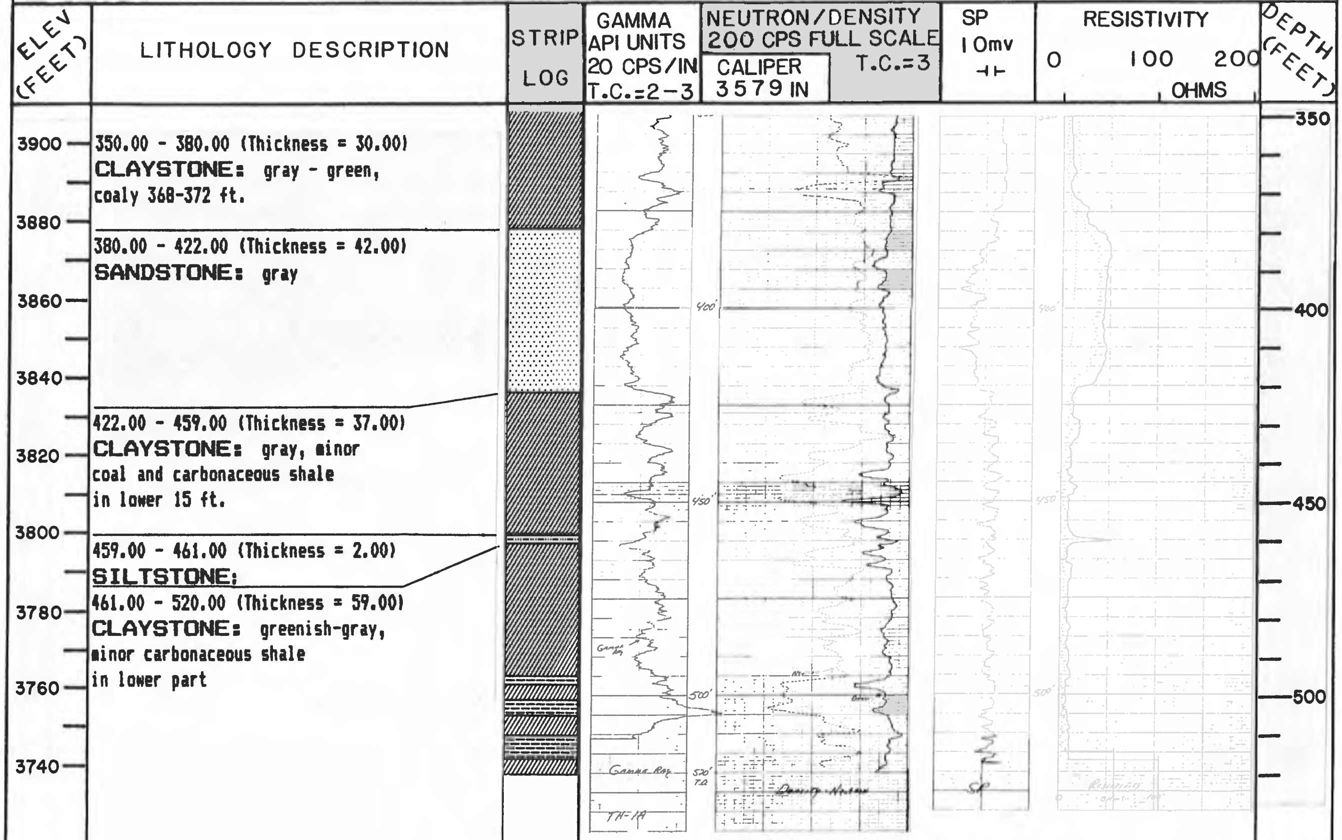
GEOPHYSICAL LOGGING BY:

LITHOLOGY RECORDED BY:

LOGGED DEPTH:

LOGGING SPEED: FT/MIN

REMARKS:



LITHOLOGY DESCRIPTION

350.00 - 380.00 (Thickness = 30.00)
CLAYSTONE: gray - green, coaly 368-372 ft.

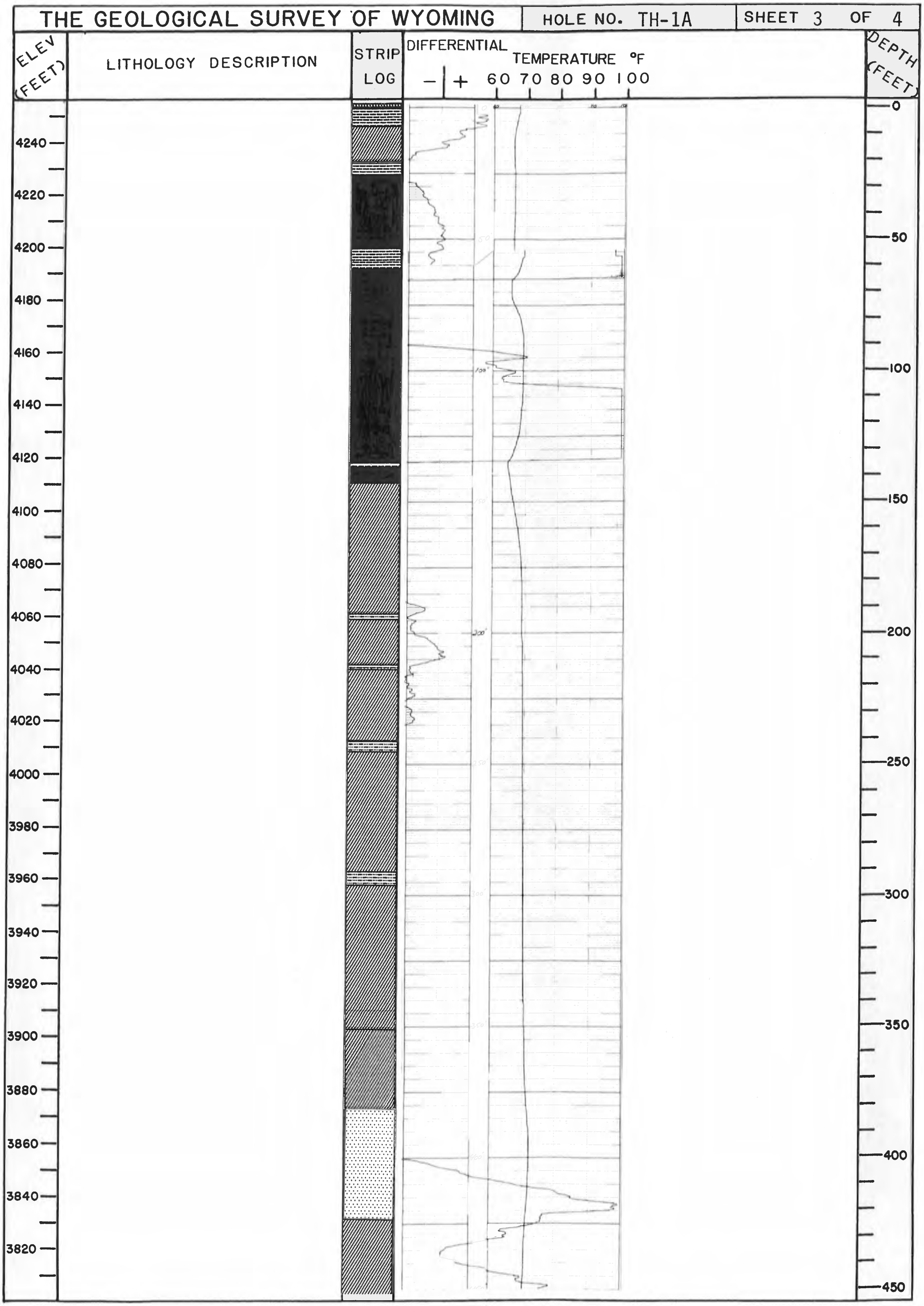
380.00 - 422.00 (Thickness = 42.00)
SANDSTONE: gray

422.00 - 459.00 (Thickness = 37.00)
CLAYSTONE: gray, minor coal and carbonaceous shale in lower 15 ft.

459.00 - 461.00 (Thickness = 2.00)
SILTSTONE:

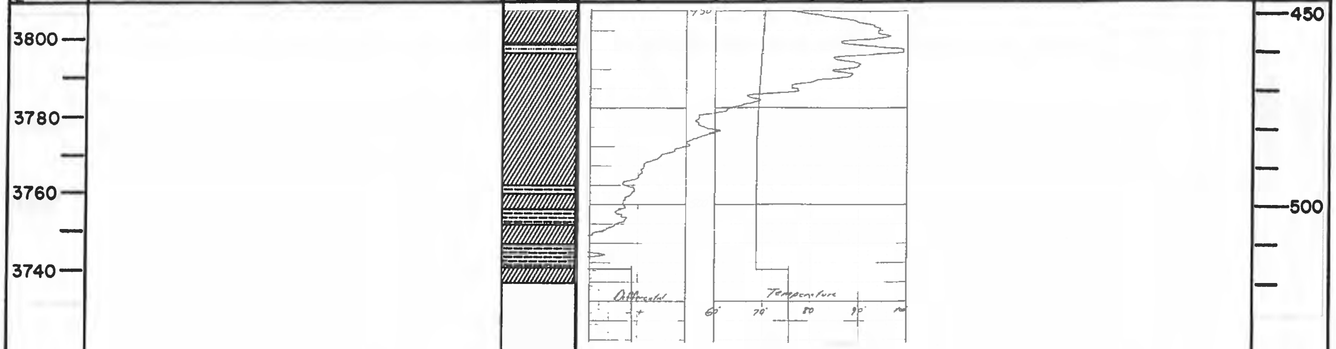
461.00 - 520.00 (Thickness = 59.00)
CLAYSTONE: greenish-gray, minor carbonaceous shale in lower part

THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-1A | SHEET 3 OF 4



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-1A | SHEET 4 OF 4

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL – | + TEMPERATURE °F 60 70 80 90 100	DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-2A | SHEET 1 OF 2

AREA: Rawhide Village | QUAD. NAME: Rawhide School, WY 7½'

DATE STARTED: 7/10/87 | DATE COMP.: 7/10/87 | COUNTY: Campbell | STATE: Wyoming

LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W | FOOTAGE LOCATION:

GROUND ELEVATION: 4262.3 | TOTAL DEPTH: 180' | DEPTH TO WATER:

SIZE, BIT TYPE: | DRILL TYPE: | ROTARY FOOTAGE: 180' CORE FOOTAGE:

DRILLED BY: Nelson Drilling Company | GEOPHYSICAL LOGGING BY: Goodwell, Inc.

LITHOLOGY RECORDED BY: Cannia | LOGGED DEPTH: 178' | LOGGING SPEED: 20 FT/MIN

REMARKS: State Plane Coordinates: 355,510N 404,960E

LITHOLOGY DESCRIPTION

0.00 - 8.00 (Thickness = 8.00)
CLAY: tan

8.00 - 15.00 (Thickness = 7.00)
CLAY: gray, some sandstone stringers

15.00 - 30.00 (Thickness = 15.00)
CLAYSTONE: gray

30.00 - 58.00 (Thickness = 28.00)
COAL: black

58.00 - 60.00 (Thickness = 2.00)
CLAYSTONE: shaley

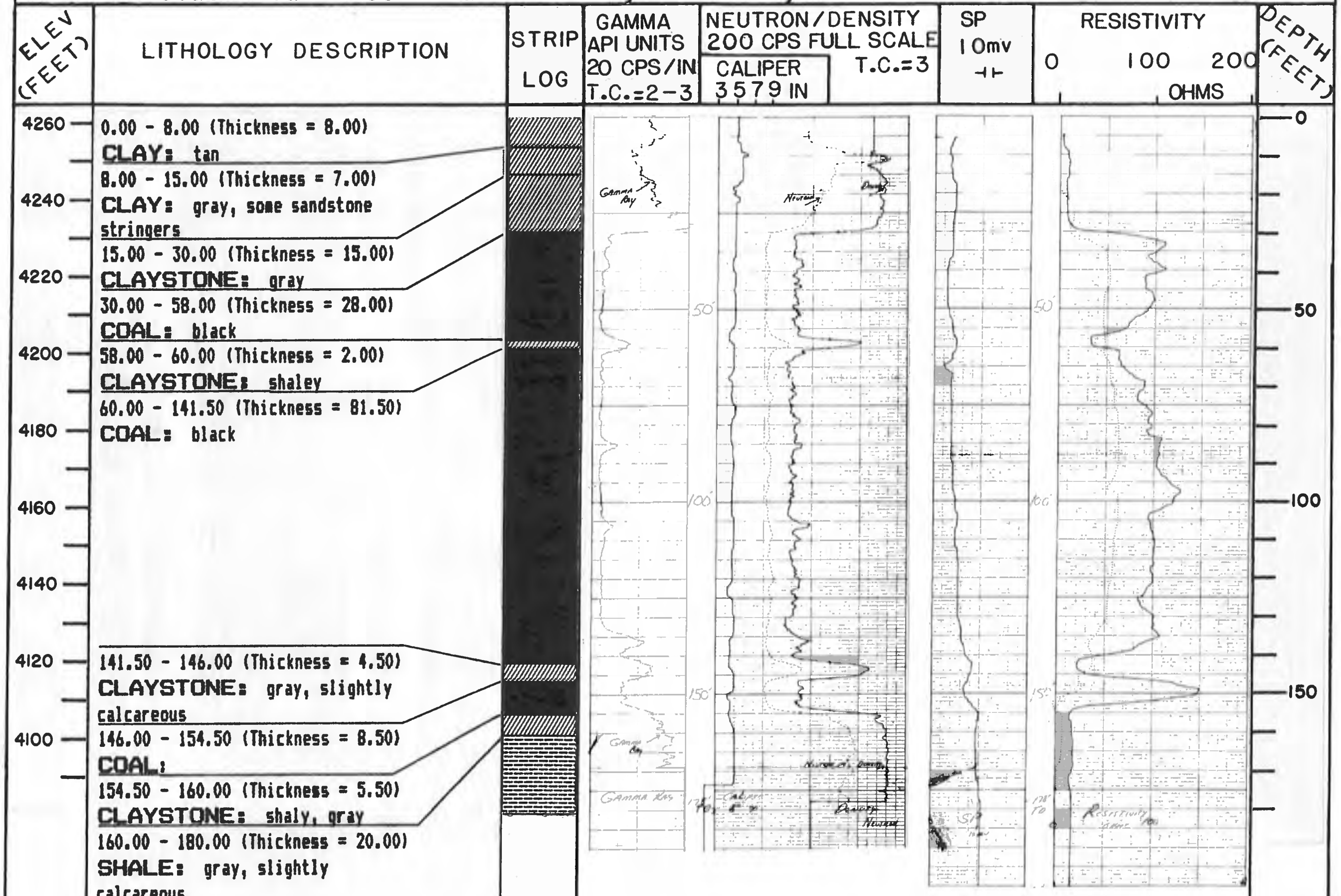
60.00 - 141.50 (Thickness = 81.50)
COAL: black

141.50 - 146.00 (Thickness = 4.50)
CLAYSTONE: gray, slightly calcareous

146.00 - 154.50 (Thickness = 8.50)
COAL:

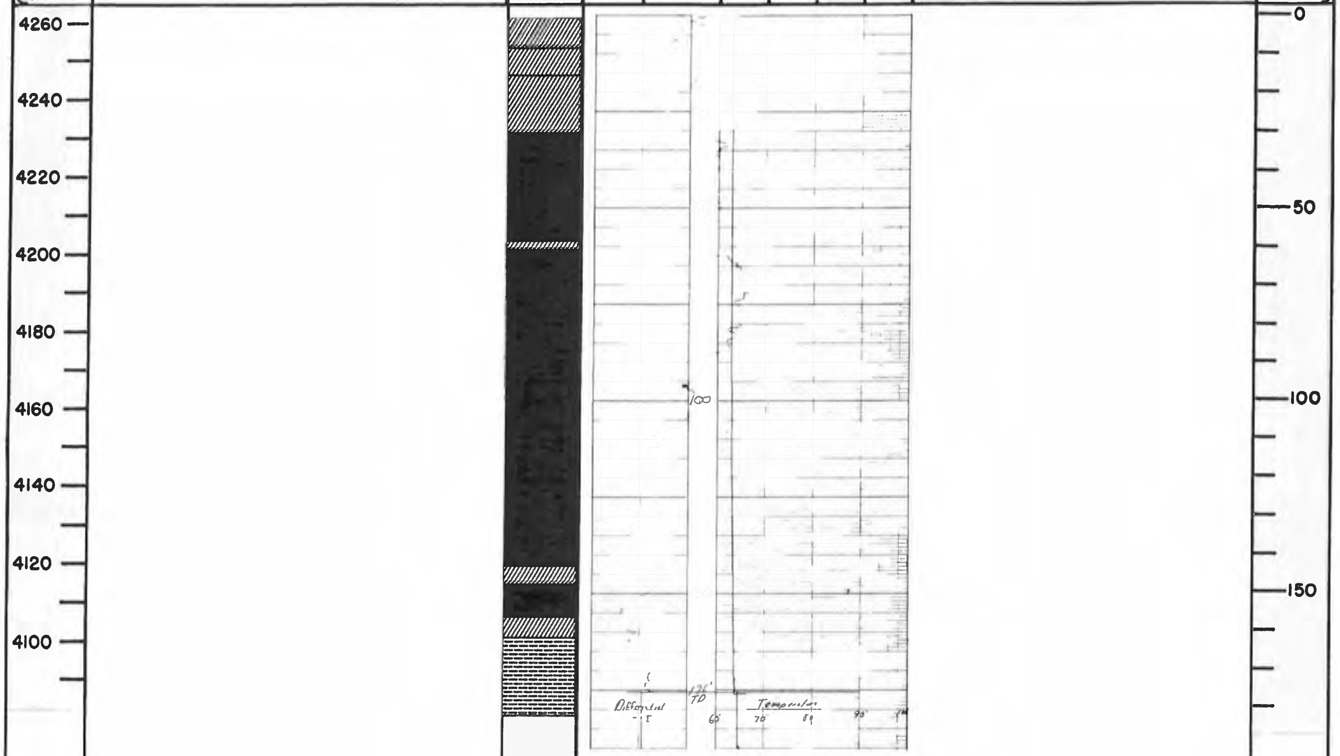
154.50 - 160.00 (Thickness = 5.50)
CLAYSTONE: shaly, gray

160.00 - 180.00 (Thickness = 20.00)
SHALE: gray, slightly calcareous



THE GEOLOGICAL SURVEY OF WYOMING	HOLE NO. TH-2A	SHEET 2 OF 2

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL TEMPERATURE °F – | + 60 70 80 90 100	DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-3A | SHEET 1 OF 2
AREA: Rawhide Village | QUAD. NAME: Rawhide School, WY. 7½'
DATE STARTED: 7/10/87 | DATE COMP.: 7/10/87 | COUNTY: Campbell | STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W | FOOTAGE LOCATION:
GROUND ELEVATION: 4273.1 | TOTAL DEPTH: 198' | DEPTH TO WATER:
SIZE, BIT TYPE: | DRILL TYPE: | ROTARY FOOTAGE: 198' | CORE FOOTAGE:
DRILLED BY: Nelson Drilling Company | GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Cannia | LOGGED DEPTH: 189' | LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 355,775N, 404,954E

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | GAMMA API UNITS 20 CPS/IN T.C.=2-3 | NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3 5 7 9 IN | SP 1 Omv | RESISTIVITY 0 100 200 OHMS | DEPTH (FEET)

4260
4240
4220
4200
4180
4160
4140
4120
4100
4080

0.00 - 5.00 (Thickness = 5.00)
SOIL: clayey, brown, gray

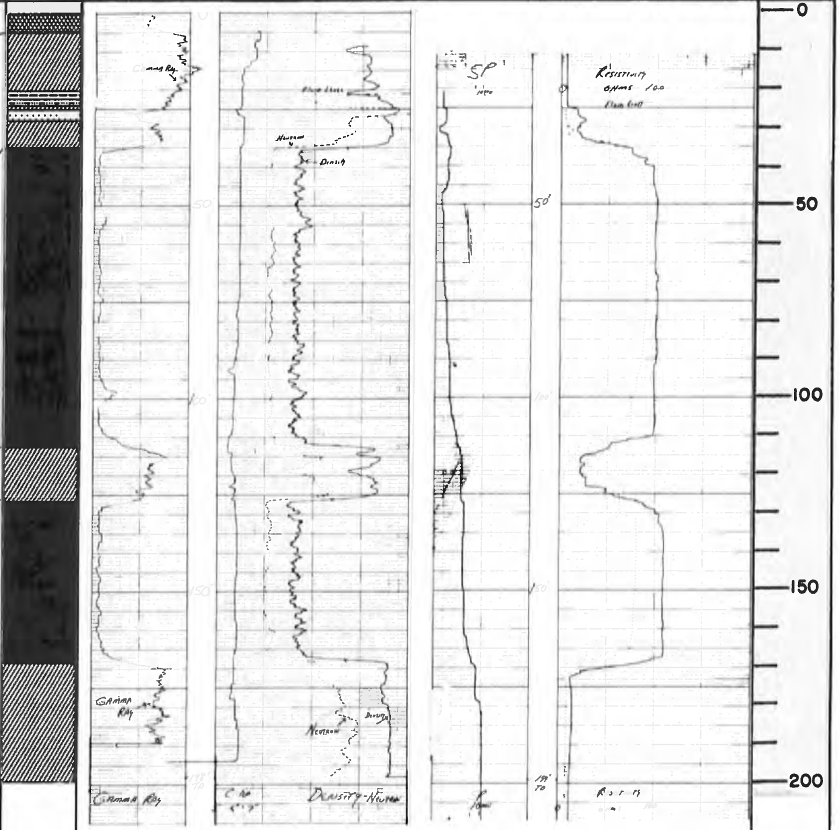
5.00 - 35.00 (Thickness = 30.00)
CLAYSTONE: gray - brown, sandy 5-20 ft.; minor carbonaceous shale 20-22 ft.; siltstone, gray 22-24 ft.; sandstone, gray 25-28 ft.; claystone, gray, minor carbonaceous shale near base 28-35 ft.

35.00 - 112.00 (Thickness = 77.00)
COAL: black

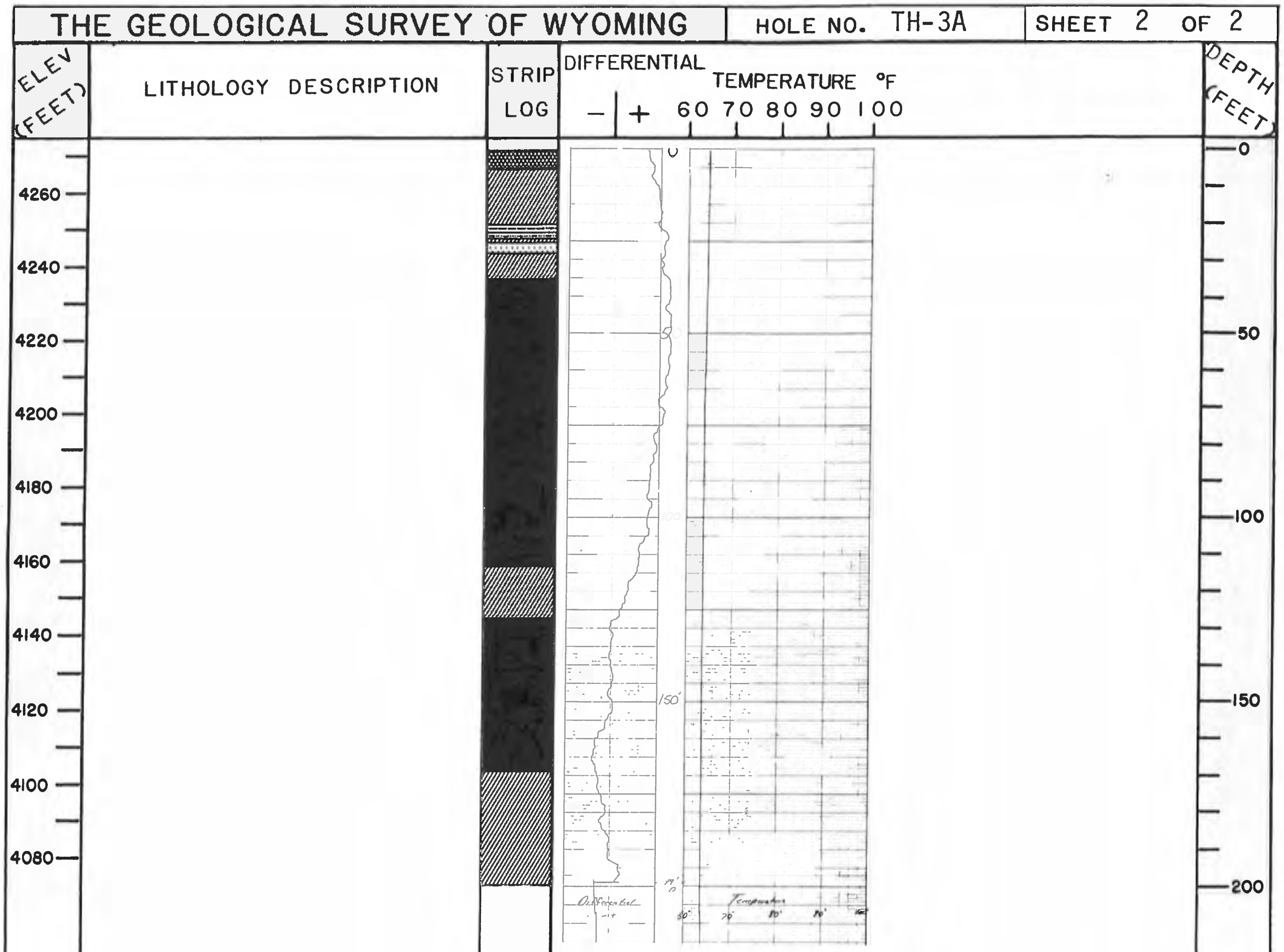
112.00 - 126.00 (Thickness = 14.00)
CLAYSTONE: gray

126.00 - 167.50 (Thickness = 41.50)
COAL: black

167.50 - 198.00 (Thickness = 30.50)
CLAYSTONE: gray



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-3A | SHEET 2 OF 2



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-4A
SHEET 1 OF 2

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/9/87
DATE COMP.: 7/9/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4270.6
TOTAL DEPTH: 260'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 260'
CORE FOOTAGE:
DRILLED BY: T. Johnson Drilling Company
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: De Bruin
LOGGED DEPTH: 259
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 355,295N 404,130E

ELEV (FEET)

4260
4240
4220
4200
4180
4160
4140
4120
4100
4080
4060
4040
4020

LITHOLOGY DESCRIPTION

0.00 - 10.00 (Thickness = 10.00)
SAND: brown, very fine grained

10.00 - 20.00 (Thickness = 10.00)
SAND: as above, silty with limonite and brick-red inclusions

20.00 - 43.00 (Thickness = 23.00)
SAND: light gray, fine grained

43.00 - 44.50 (Thickness = 1.50)
COAL: ?

44.50 - 50.00 (Thickness = 5.50)
CLAYSTONE: gray, silty

50.00 - 86.00 (Thickness = 36.00)
SILTSTONE: gray, argillaceous, minor thin carbonaceous shale beds

86.00 - 120.00 (Thickness = 34.00)
SILTSTONE: gray, argillaceous, with gray, calcareous siltstone at 92-93 and 104.5-107 ft., pyritic in places

120.00 - 129.00 (Thickness = 9.00)
CLAYSTONE: medium gray, silty

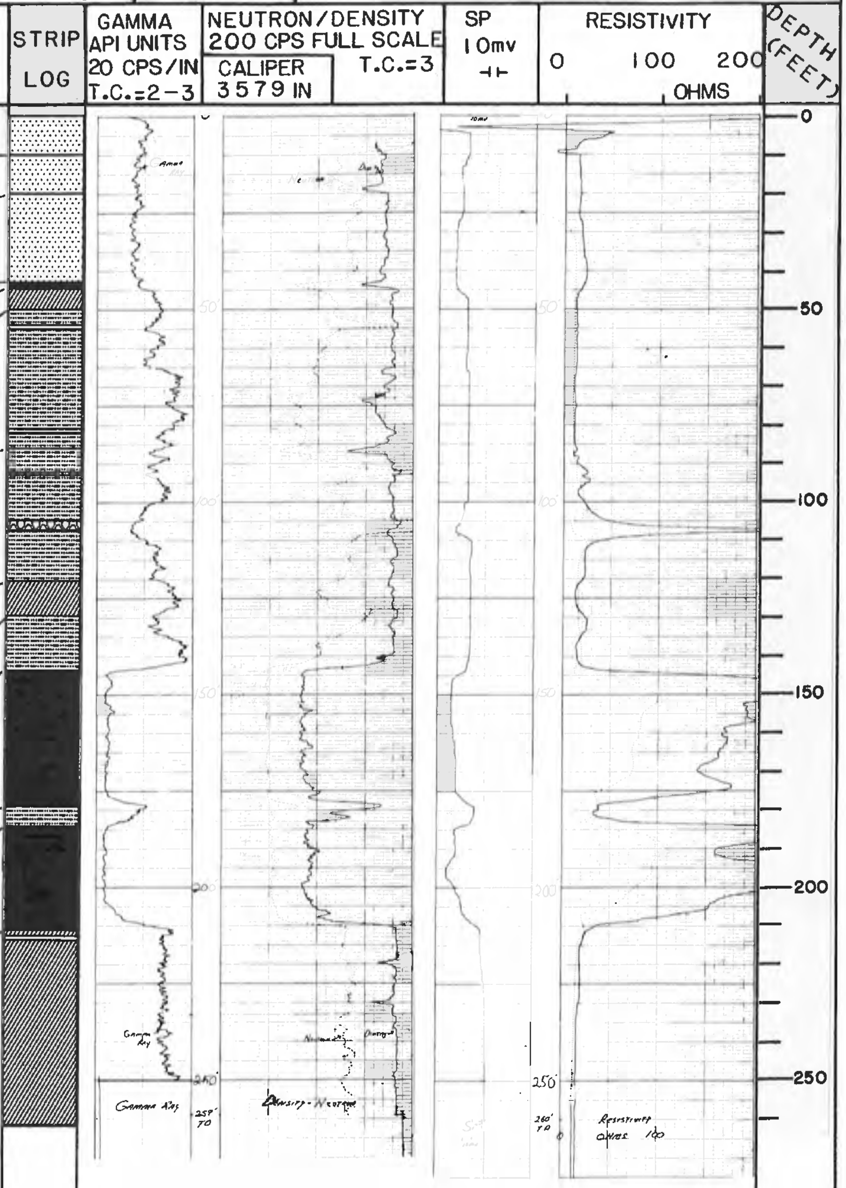
129.00 - 143.00 (Thickness = 14.00)
SILTSTONE: medium gray, argillaceous

143.00 - 178.00 (Thickness = 35.00)
COAL: black

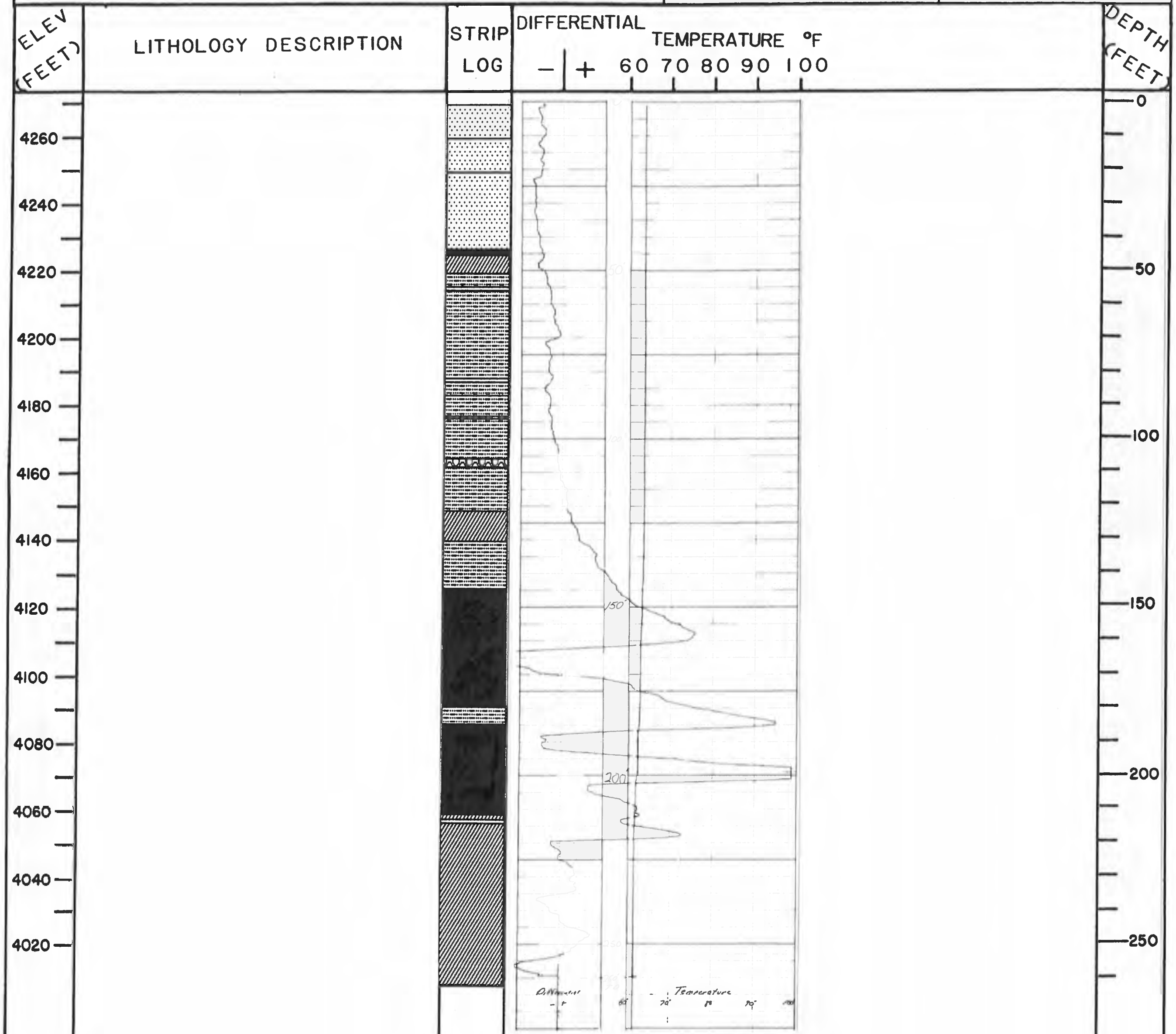
178.00 - 183.00 (Thickness = 5.00)
SILTSTONE: gray, argillaceous

183.00 - 209.50 (Thickness = 26.50)
COAL: thin, silty clay near base

209.50 - 260.00 (Thickness = 50.50)
CLAYSTONE: gray, silty, argillaceous siltstone near top of interval



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-4A | SHEET 2 OF 2



THE GEOLOGICAL SURVEY OF WYOMING
HOLE NO. TH-4B
SHEET 1 OF 2
AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/10/87
DATE COMP.: 7/10/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC.20 T.51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4269.5
TOTAL DEPTH: 204'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 204'
CORE FOOTAGE: 21'
DRILLED BY: T. Johnson Drilling Company
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Marshall
LOGGED DEPTH: 197'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 355,290N 404,150E

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | GAMMA API UNITS 20 CPS/IN T.C.=2-3 | NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3 5 7 9 IN | SP 10mv | RESISTIVITY 0 100 200 OHMS | DEPTH (FEET)

0.00 - 20.00 (Thickness = 20.00)
SAND: brown, silty, minor clay in upper 10 ft.; angular clinker fragments in lower 10 ft.

20.00 - 40.00 (Thickness = 20.00)
SAND: gray, and silt, gray, minor coal fragments

40.00 - 97.00 (Thickness = 57.00)
CLAYSTONE: and mudstone, gray, pyritic in upper 30 ft.; calcite cemented siltstone stringer at 53 ft.; 1.5 ft., coal at 80.5 ft.

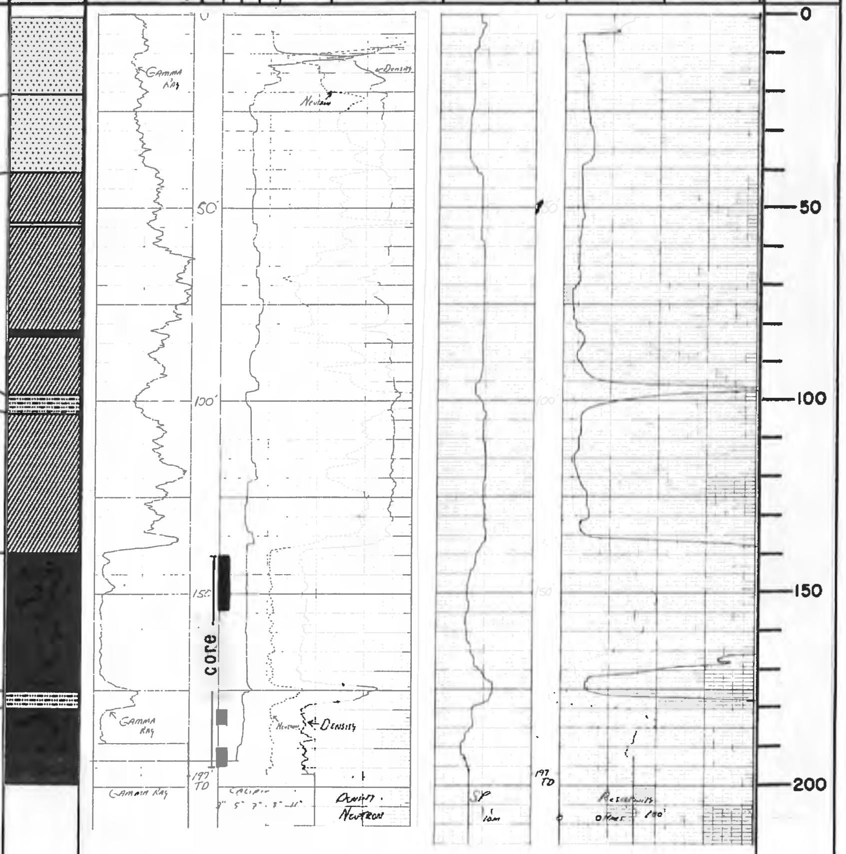
97.00 - 102.00 (Thickness = 5.00)
SILTSTONE: gray, sandy

102.00 - 138.00 (Thickness = 36.00)
CLAYSTONE: and mudstone, gray; silty in lower 20 ft.

138.00 - 173.50 (Thickness = 35.50)
COAL:

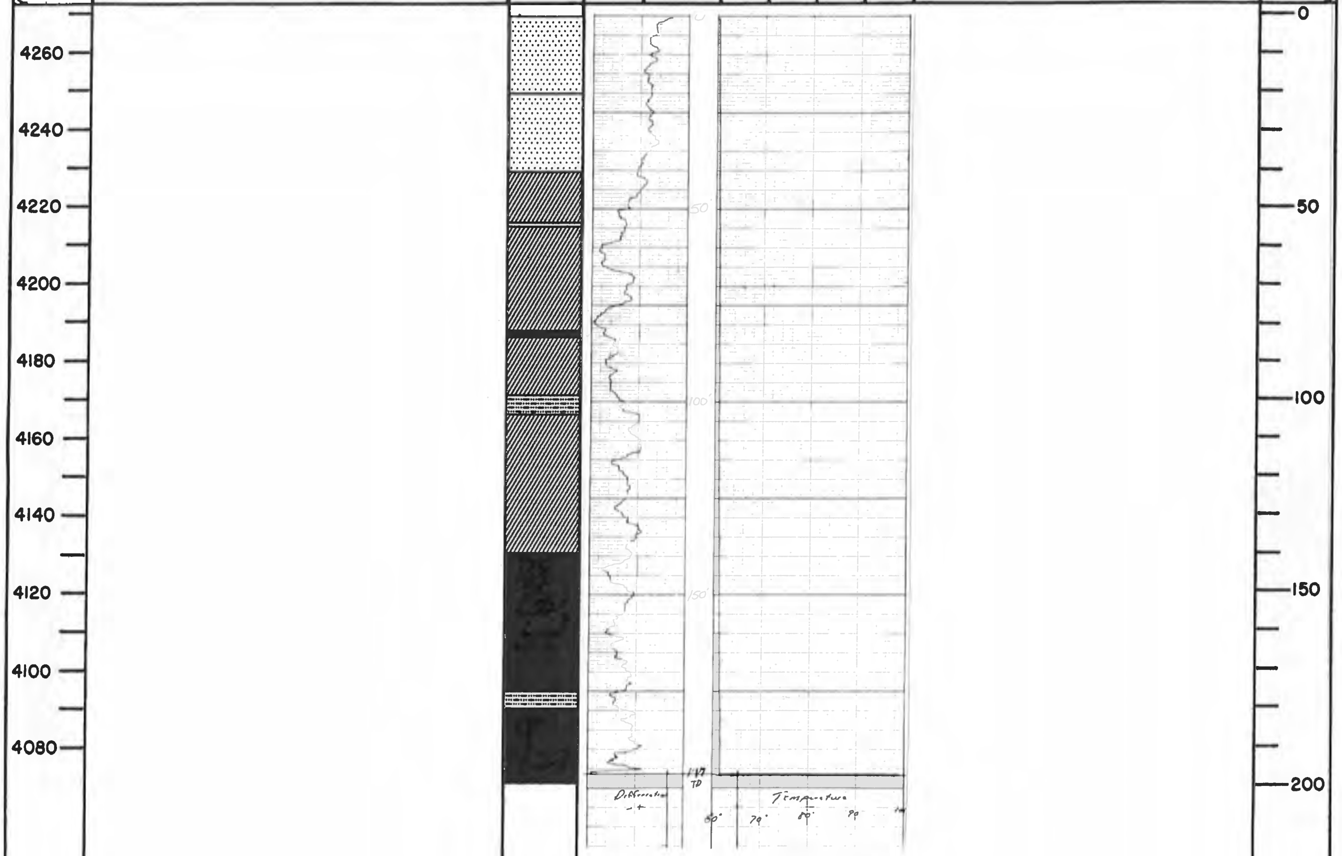
173.50 - 178.00 (Thickness = 4.50)
SILTSTONE: parting, gray

178.00 - 197.00 (Thickness = 19.00)
COAL:



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-4B | SHEET 2 OF 2

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | DIFFERENTIAL — + | TEMPERATURE °F 60 70 80 90 100 | DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-6A

SHEET 1 OF 1

AREA: Rawhide Village

QUAD. NAME: Rawhide School, WY 7½'

DATE STARTED: 7/10/87

DATE COMP.: 7/10/87

COUNTY: Campbell

STATE: Wyoming

LOCATION: SE¼ NE¼ SEC. 20 T. 51N R.72W

FOOTAGE LOCATION:

GROUND ELEVATION: 4268.2

TOTAL DEPTH: 260'

DEPTH TO WATER:

SIZE, BIT TYPE:

DRILL TYPE:

ROTARY FOOTAGE: 260'

CORE FOOTAGE:

DRILLED BY: Nelson Drilling Company

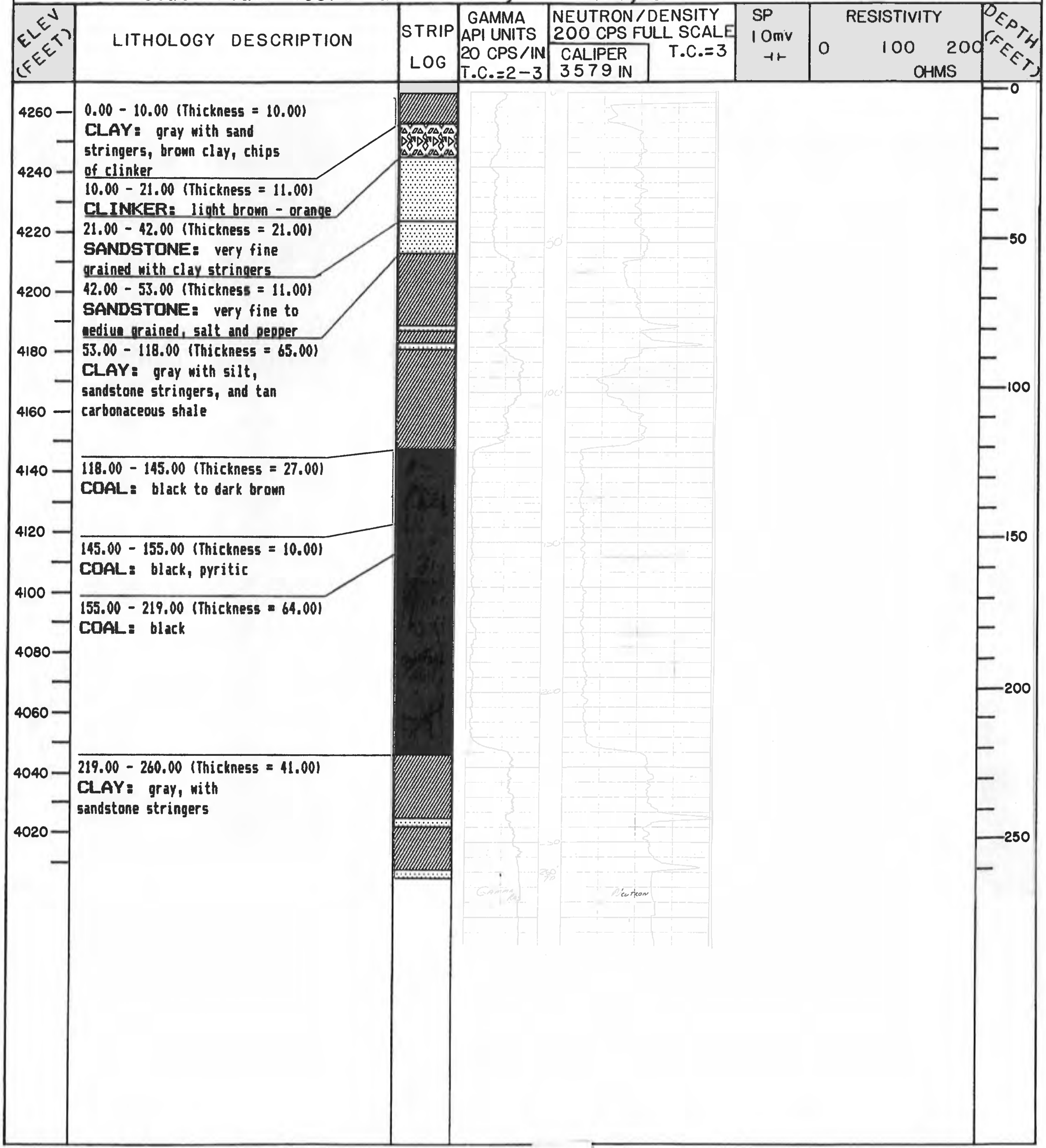
GEOPHYSICAL LOGGING BY: Goodwell, Inc.

LITHOLOGY RECORDED BY: Cannia

LOGGED DEPTH: 260'

LOGGING SPEED: 20 FT/MIN

REMARKS: State Plane Coordinates: 355,760N 404,130E



0.00 - 10.00 (Thickness = 10.00)
CLAY: gray with sand stringers, brown clay, chips of clinker

10.00 - 21.00 (Thickness = 11.00)
CLINKER: light brown - orange

21.00 - 42.00 (Thickness = 21.00)
SANDSTONE: very fine grained with clay stringers

42.00 - 53.00 (Thickness = 11.00)
SANDSTONE: very fine to medium grained, salt and pepper

53.00 - 118.00 (Thickness = 65.00)
CLAY: gray with silt, sandstone stringers, and tan carbonaceous shale

118.00 - 145.00 (Thickness = 27.00)
COAL: black to dark brown

145.00 - 155.00 (Thickness = 10.00)
COAL: black, pyritic

155.00 - 219.00 (Thickness = 64.00)
COAL: black

219.00 - 260.00 (Thickness = 41.00)
CLAY: gray, with sandstone stringers

THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-10A | SHEET 1 OF4

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/6/87
DATE COMP.: 7/7/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4281.1
TOTAL DEPTH: 535'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 535'
CORE FOOTAGE:
DRILLED BY: Wyoming Highway Department
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Hogle & De Bruin
LOGGED DEPTH: 535'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 356,295N 404,950E

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | GAMMA API UNITS 20 CPS/IN T.C.=2-3 | NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3 5 7 9 IN | SP 10mv | RESISTIVITY 0 100 200 OHMS | DEPTH (FEET)

0.00 - 5.00 (Thickness = 5.00)
PAVEMENT: pavement base and fill

5.00 - 15.00 (Thickness = 10.00)
CLAY AND SILT: brown, salt and pepper, very fine grained

15.00 - 25.00 (Thickness = 10.00)
SAND: brown, quartz grains, with black mineral

25.00 - 42.00 (Thickness = 17.00)
SANDSTONE: mostly quartz, light orange, coarser than above, with black mineral, some feldspar

42.00 - 56.00 (Thickness = 14.00)
CLAYSTONE: black, silty

56.00 - 60.00 (Thickness = 4.00)
CLAYSTONE: black, coaly

60.00 - 151.00 (Thickness = 91.00)
COAL:

151.00 - 164.00 (Thickness = 13.00)
SHALE: light gray

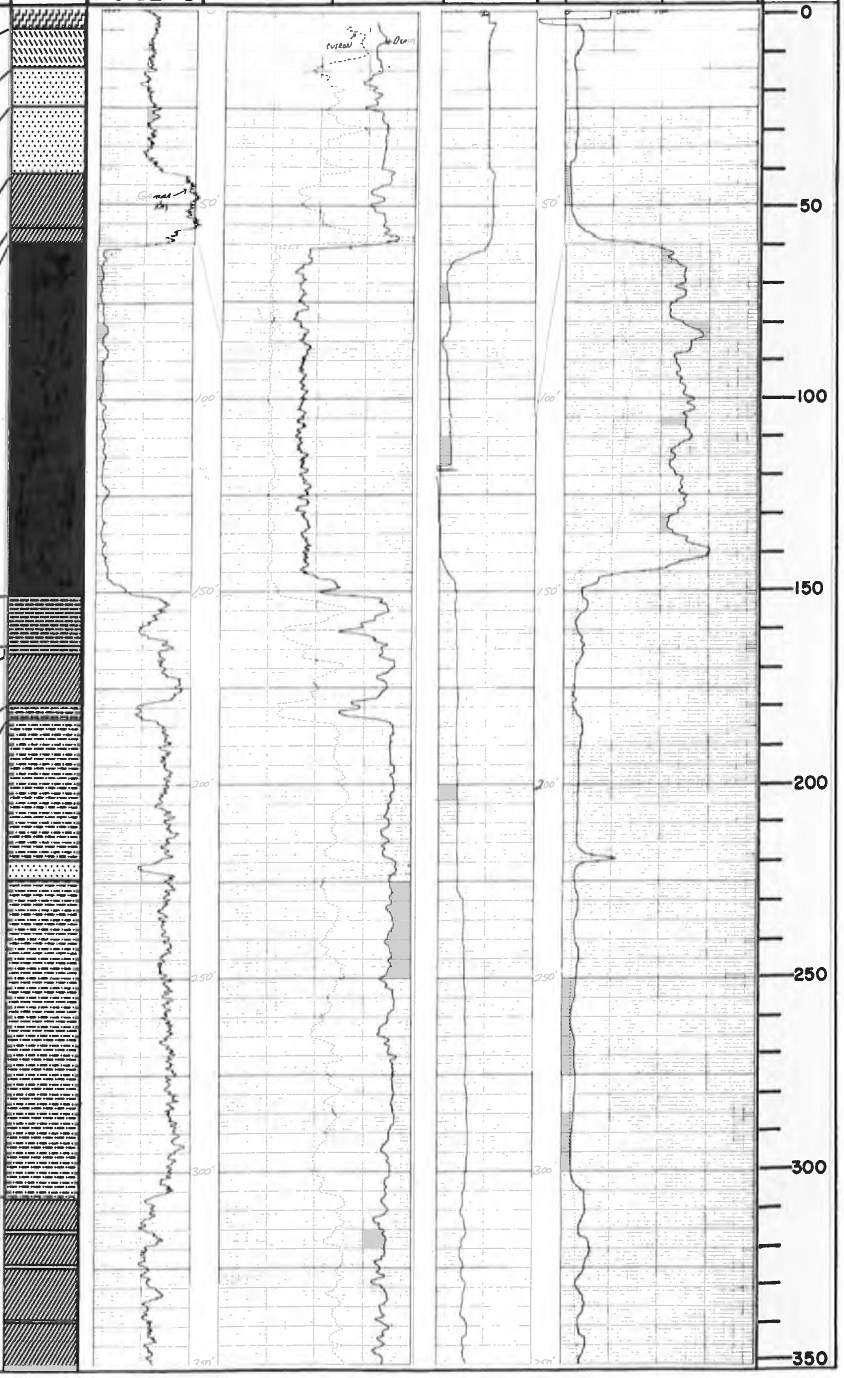
164.00 - 166.00 (Thickness = 2.00)
SHALE: carbonaceous

166.00 - 179.00 (Thickness = 13.00)
CLAYSTONE: with salt and pepper sandstone

179.00 - 183.00 (Thickness = 4.00)
SHALE: carbonaceous

183.00 - 306.00 (Thickness = 123.00)
SHALE AND SILTSTONE: gray, brown, with some salt and pepper sandstone stringers

306.00 - 414.00 (Thickness = 108.00)
CLAYSTONE: gray - brown, with siltstone, shaly mudstone stringers, some sandstone



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-10A | SHEET 2 OF 4

AREA:

QUAD. NAME:

DATE STARTED:

DATE COMP.:

COUNTY:

STATE:

LOCATION: SEC. T. R.

FOOTAGE LOCATION:

GROUND ELEVATION:

TOTAL DEPTH:

DEPTH TO WATER:

SIZE, BIT TYPE:

DRILL TYPE:

ROTARY FOOTAGE:

CORE FOOTAGE:

DRILLED BY:

GEOPHYSICAL LOGGING BY:

LITHOLOGY RECORDED BY:

LOGGED DEPTH:

LOGGING SPEED: FT/MIN

REMARKS:

ELEV (FEET)

3920
3900
3880
3860
3840
3820
3800
3780
3760

LITHOLOGY DESCRIPTION

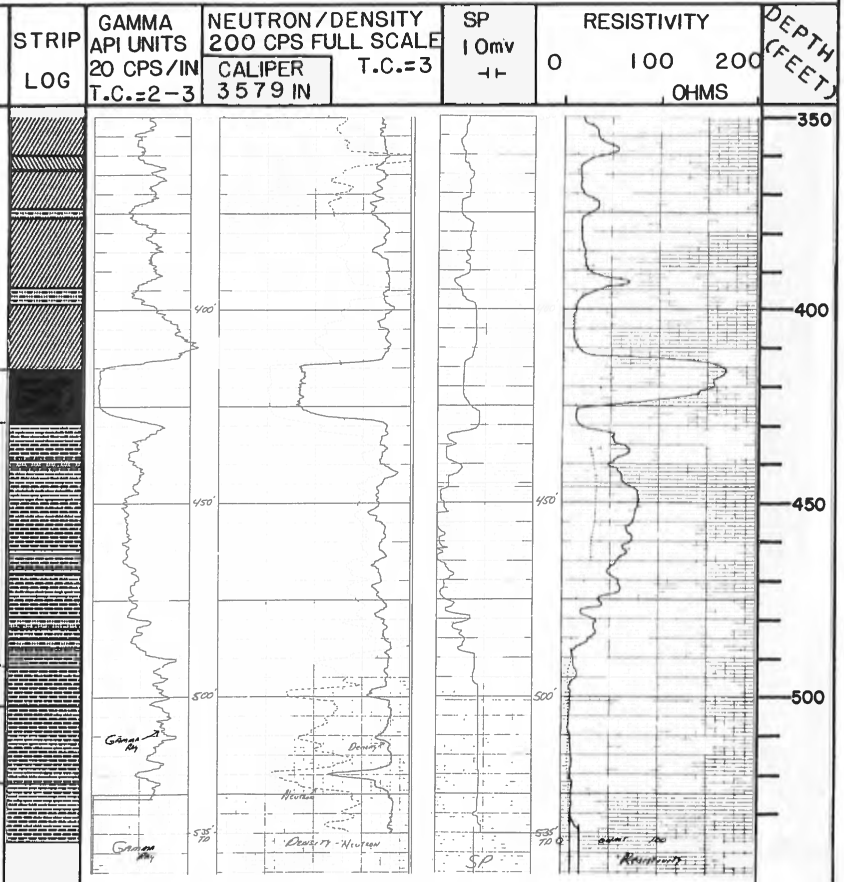
414.00 - 428.00 (Thickness = 14.00)
COAL: black

428.00 - 490.00 (Thickness = 62.00)
SHALE: gray - brown, with some coal, carbonaceous material, pyrite, and siltstone stringers

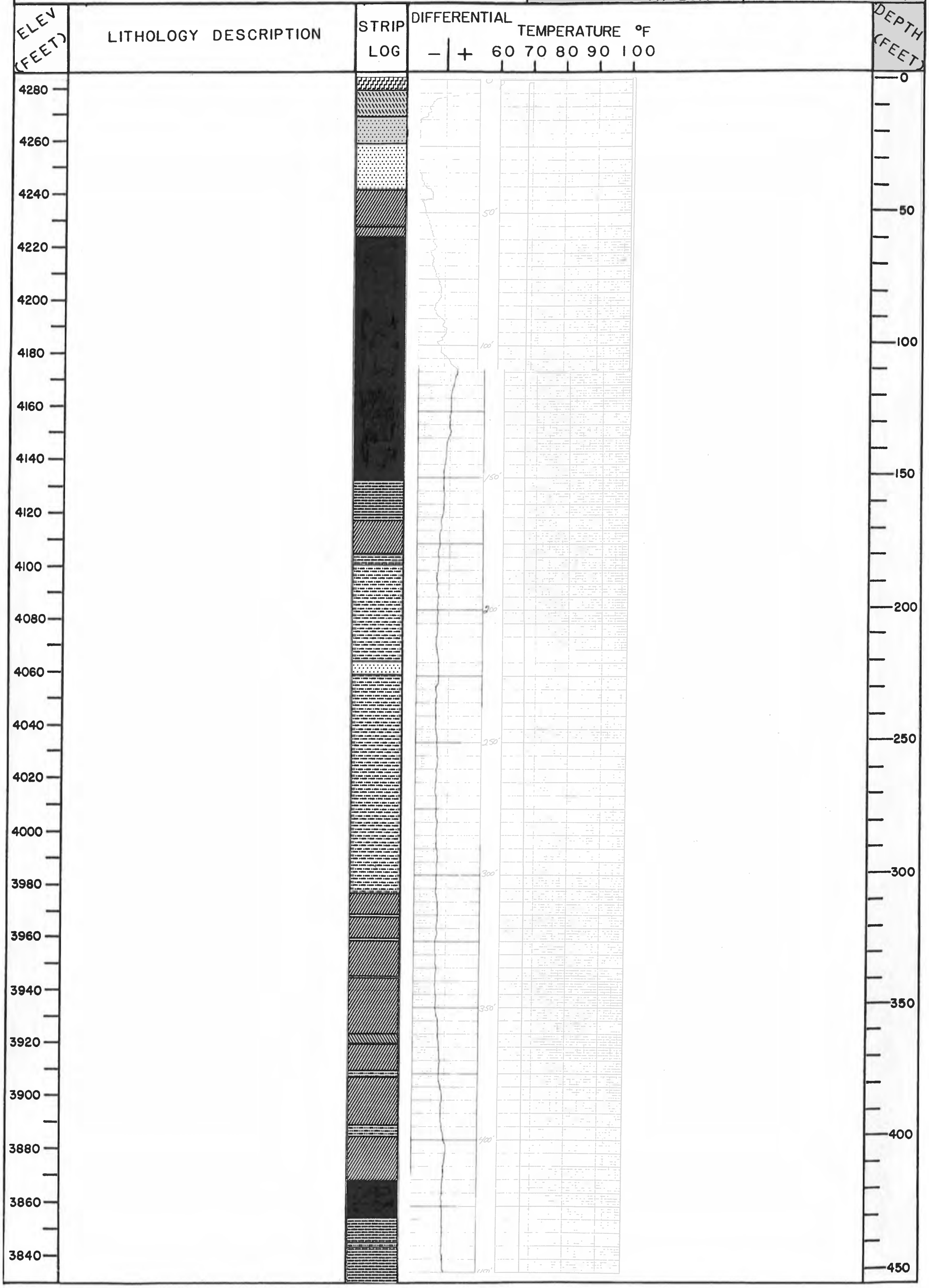
490.00 - 500.00 (Thickness = 10.00)
SHALE: dark brown with white sandstone

500.00 - 520.00 (Thickness = 20.00)
SHALE: light gray

520.00 - 535.00 (Thickness = 15.00)
SHALE: calcareous, light brown - yellow

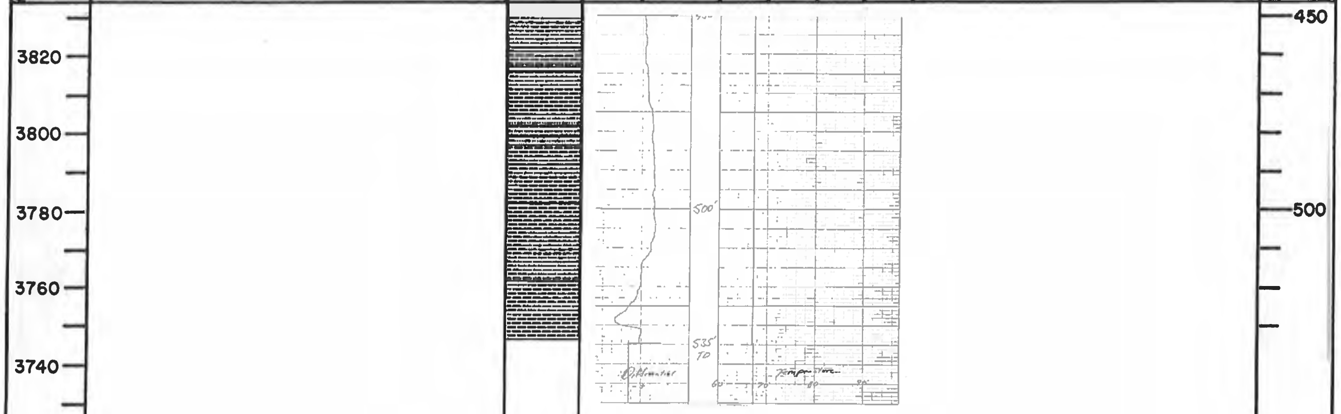


THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-10A | SHEET 3 OF 4



THE GEOLOGICAL SURVEY OF WYOMING	HOLE NO. TH-10A	SHEET 4 OF 4

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL — | + TEMPERATURE °F 60 70 80 90 100	DEPTH (FEET)

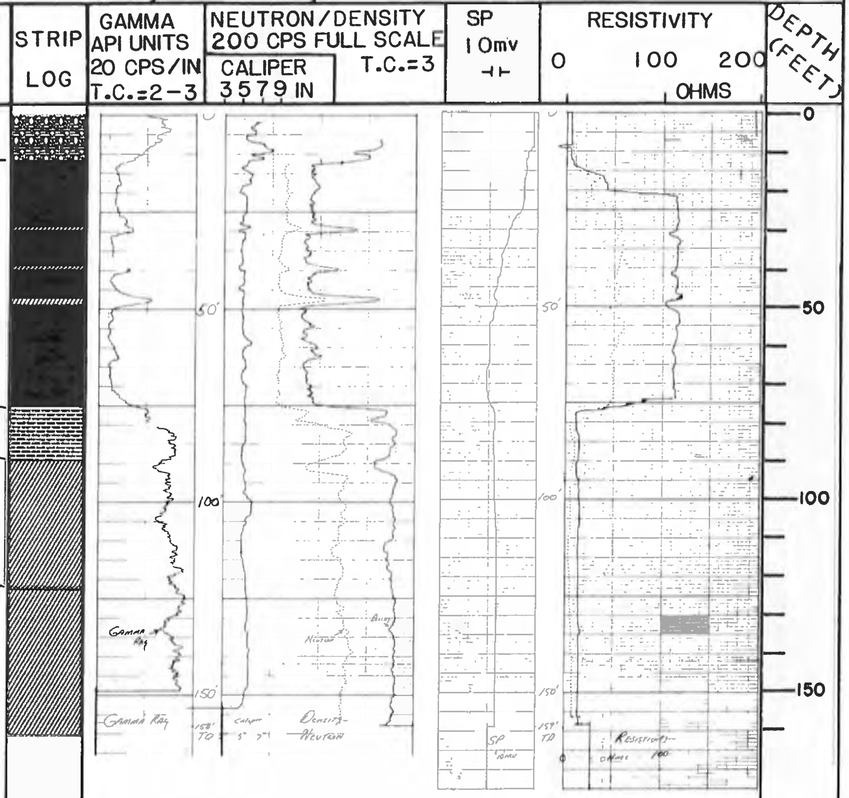


THE GEOLOGICAL SURVEY OF WYOMING	HOLE NO. TH-11A	SHEET 1 OF 2

AREA: Rawhide Village	QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/9/87 DATE COMP.: 7/9/87	COUNTY: Campbell STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W	FOOTAGE LOCATION:
GROUND ELEVATION: 4253.2 TOTAL DEPTH: 160'	DEPTH TO WATER:
SIZE, BIT TYPE: DRILL TYPE:	ROTARY FOOTAGE: 160' CORE FOOTAGE:
DRILLED BY: Wyoming Highway Department	GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Hogle	LOGGED DEPTH: 158' LOGGING SPEED: 20 FT/MIN

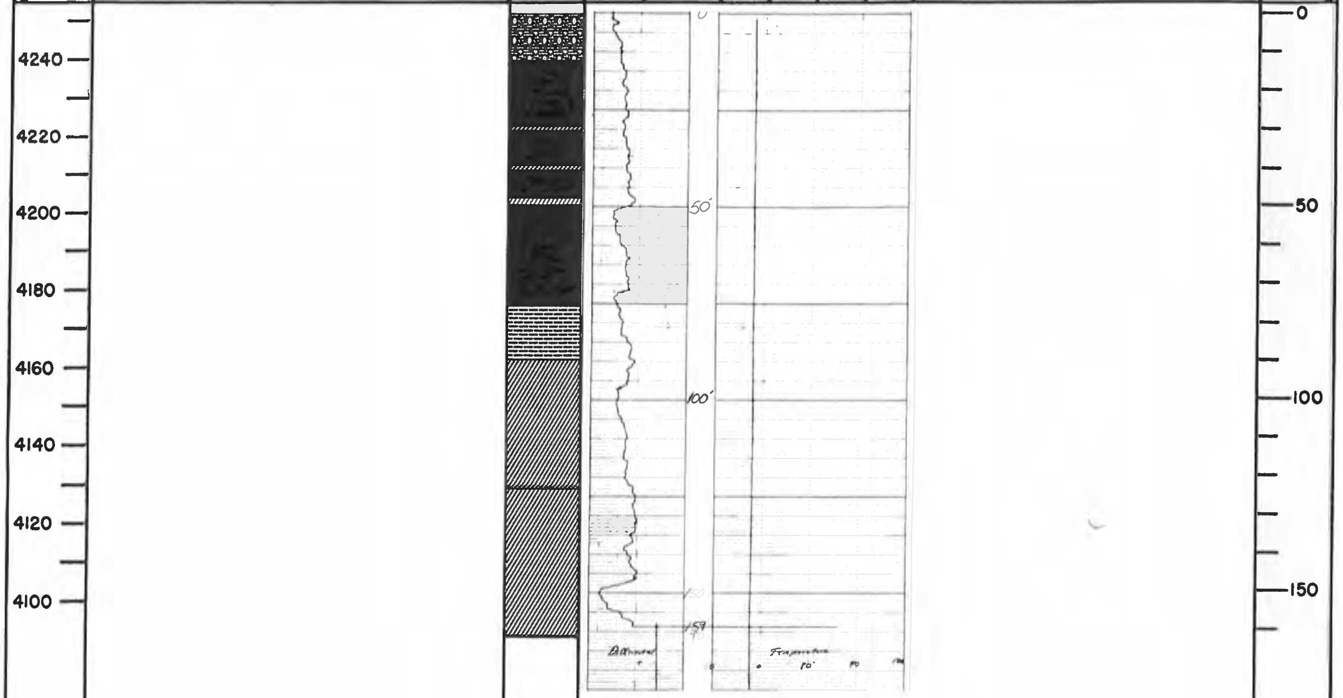
REMARKS: State Plane Coordinates: 355,515N 405,635E

ELEV (FEET)	LITHOLOGY DESCRIPTION
4240	0.00 - 12.00 (Thickness = 12.00) **GRAVEL:** road fill
4220	12.00 - 75.00 (Thickness = 63.00) **COAL:** black; clay partings at 29-30, 39-40, 47-49 ft.
4200	
4180	75.00 - 89.00 (Thickness = 14.00) **SHALE:** with claystone
4160	89.00 - 122.00 (Thickness = 33.00) **CLAYSTONE:** black, carbonaceous
4140	
4120	122.00 - 160.00 (Thickness = 38.00) **CLAYSTONE:** light gray slightly calcareous
4100	



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-11A | SHEET 2 OF 2

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL – | +	TEMPERATURE °F 60 70 80 90 100	DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING | **HOLE NO.** TH-13A | **SHEET** 1 **OF** 3

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/9/87 **DATE COMP.:** 7/9/87
COUNTY: Campbell **STATE:** Wyoming
LOCATION: SE¼ NE¼ **SEC.** 20 **T.** 51N **R.** 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4294.1 **TOTAL DEPTH:** 400'
DEPTH TO WATER:
SIZE, BIT TYPE: **DRILL TYPE:**
ROTARY FOOTAGE: 400' **CORE FOOTAGE:**
DRILLED BY: Wyoming Highway Department
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Hogle
LOGGED DEPTH: 399' **LOGGING SPEED:** 20 FT/MIN
REMARKS: State Plane Coordinates: 356,320N, 405,720E

LITHOLOGY DESCRIPTION

0.00 - 5.00 (Thickness = 5.00)
SOIL: brown with gravel, mudstone

5.00 - 32.00 (Thickness = 27.00)
CLINKER: red to yellow - brown, with soil and gravel

32.00 - 45.00 (Thickness = 13.00)
CLAY: light gray, silty in part

45.00 - 53.00 (Thickness = 8.00)
CLAY: gray, grading into coal

53.00 - 78.50 (Thickness = 25.50)
COAL: black

78.50 - 100.00 (Thickness = 21.50)
CLAY: gray, shaly - silty in part

100.00 - 129.00 (Thickness = 29.00)
COAL: black

129.00 - 173.00 (Thickness = 44.00)
MUDSTONE: and claystone, gray - brown

173.00 - 178.00 (Thickness = 5.00)
SILTSTONE:

178.00 - 192.00 (Thickness = 14.00)
CLAYSTONE: shaly

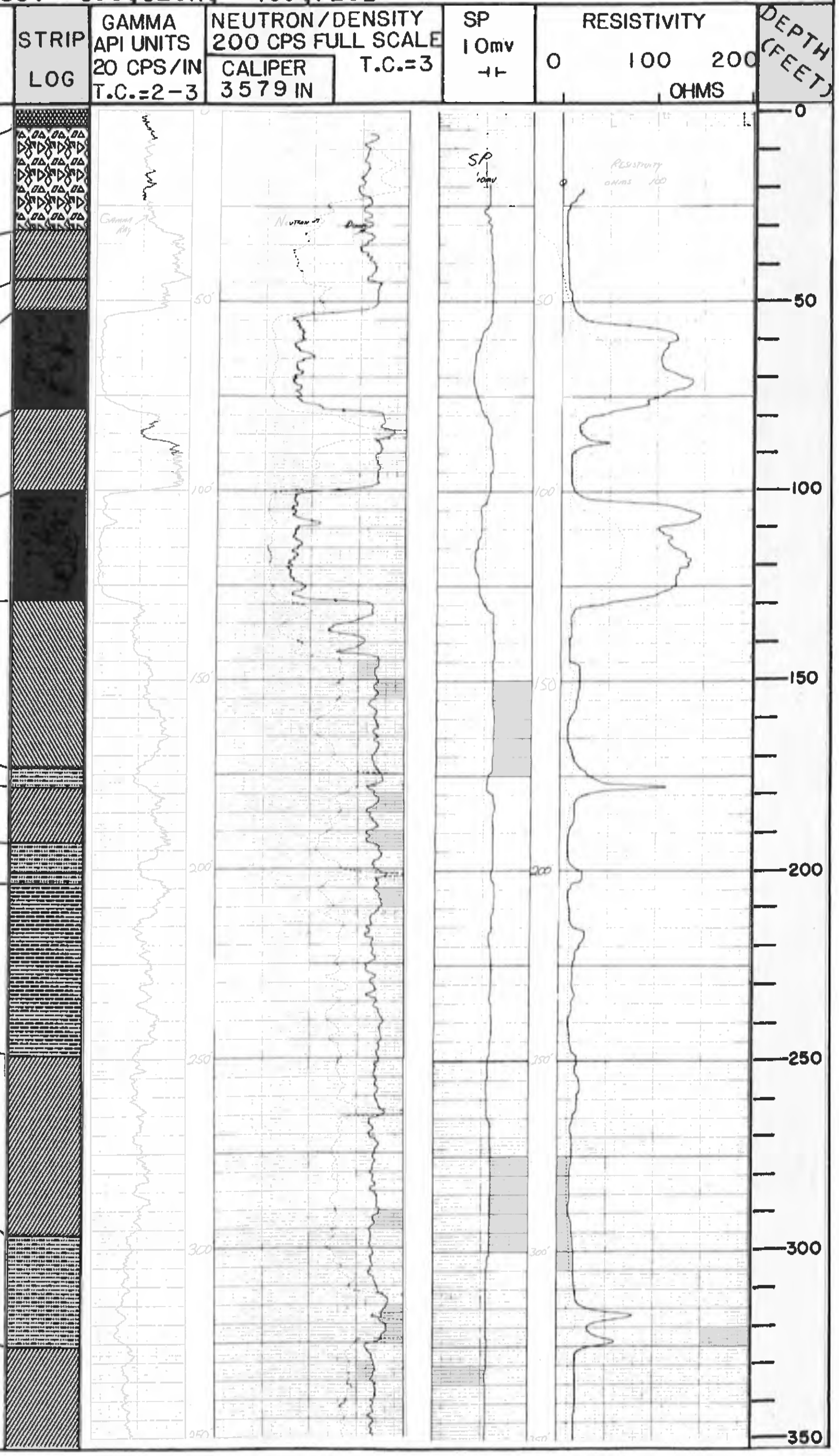
192.00 - 203.00 (Thickness = 11.00)
SILTSTONE:

203.00 - 248.00 (Thickness = 45.00)
SHALE: gray - brown, with siltstone stringers

248.00 - 295.00 (Thickness = 47.00)
CLAYSTONE: light gray, slightly calcareous, with silty shale and gray to gray - brown salt and pepper siltstone

295.00 - 324.00 (Thickness = 29.00)
SILTSTONE: with claystone and sandstone, very fine grained, salt and pepper

324.00 - 360.00 (Thickness = 36.00)
CLAYSTONE: with gray, salt and pepper, Fe-rich, very fine grained siltstone, and some sandstone



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-13A

SHEET 2 OF 3

AREA:

QUAD. NAME:

DATE STARTED:

DATE COMP.:

COUNTY:

STATE:

LOCATION: SEC. T. R.

FOOTAGE LOCATION:

GROUND ELEVATION:

TOTAL DEPTH:

DEPTH TO WATER:

SIZE, BIT TYPE:

DRILL TYPE:

ROTARY FOOTAGE:

CORE FOOTAGE:

DRILLED BY:

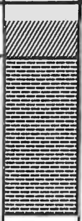
GEOPHYSICAL LOGGING BY:

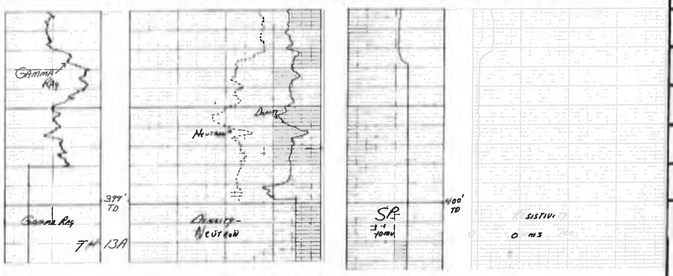
LITHOLOGY RECORDED BY:

LOGGED DEPTH:

LOGGING SPEED: FT/MIN

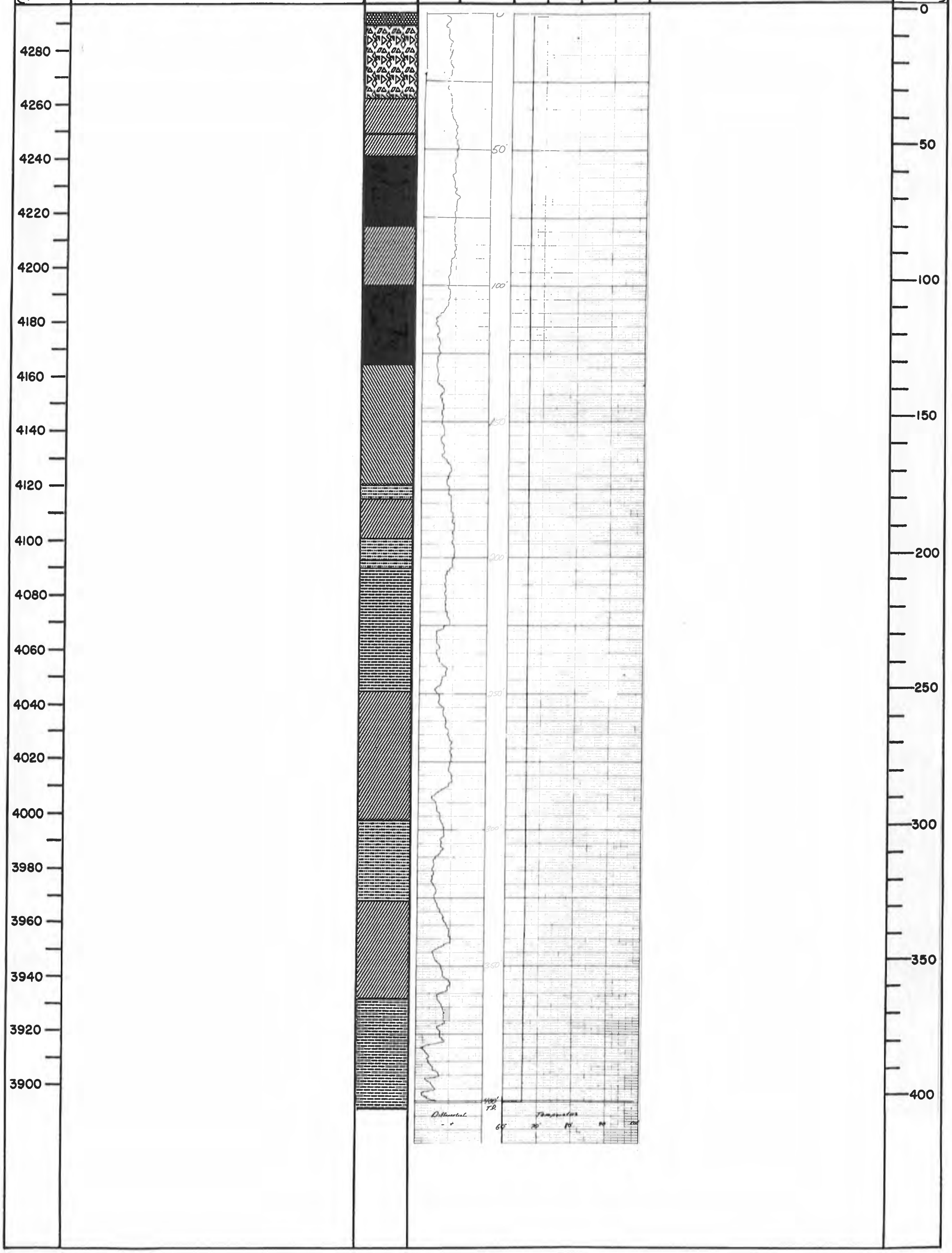
REMARKS:

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	GAMMA API UNITS 20 CPS/IN T.C.=2-3	NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3579 IN	SP 10mv ⊣⊢	RESISTIVITY 0 100 200 OHMS	DEPTH (FEET)
3940 3920 3900	360.00 - 400.00 (Thickness = 40.00) **SHALE:** with claystone and minor argillaceous salt and pepper sandstone, silty in part						350 400



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-13A | SHEET 3 OF 3

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | DIFFERENTIAL − | + TEMPERATURE °F 60 70 80 90 100 | DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-14A | SHEET 1 OF 2

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/10/87
DATE COMP.: 7/10/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4272.4
TOTAL DEPTH: 300'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 300'
CORE FOOTAGE:
DRILLED BY: Nelson Drilling Company
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Cannia
LOGGED DEPTH: 298'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 355,865N 405,285E

ELEV (FEET)
4260
4240
4220
4200
4180
4160
4140
4120
4100
4080
4060
4040
4020
4000
3980

LITHOLOGY DESCRIPTION

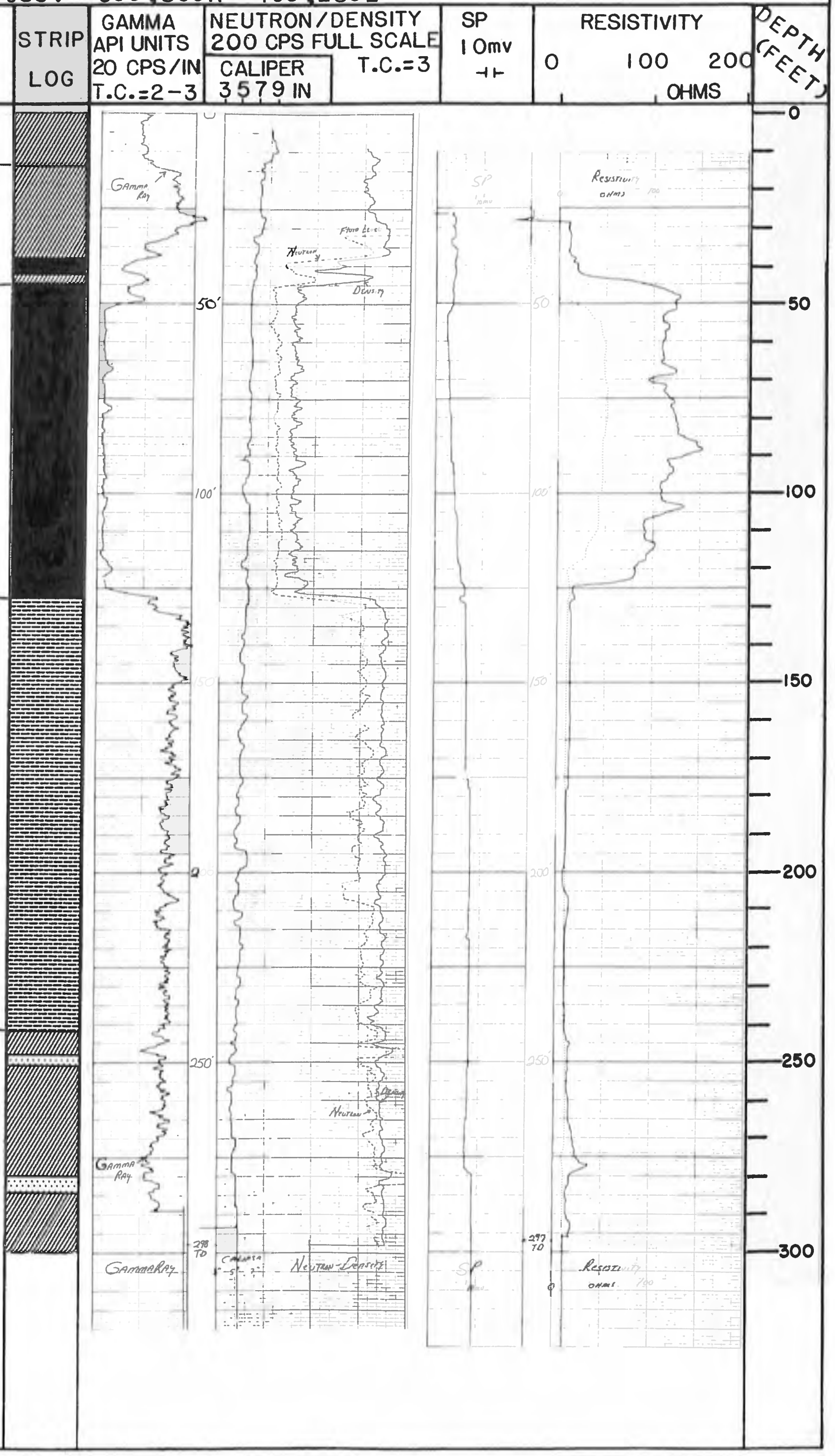
0.00 - 14.00 (Thickness = 14.00)
CLAY: brown - gray

14.00 - 44.50 (Thickness = 30.50)
CLAYSTONE: gray, with thin coal at 38-42 ft.

44.50 - 127.00 (Thickness = 82.50)
COAL: black

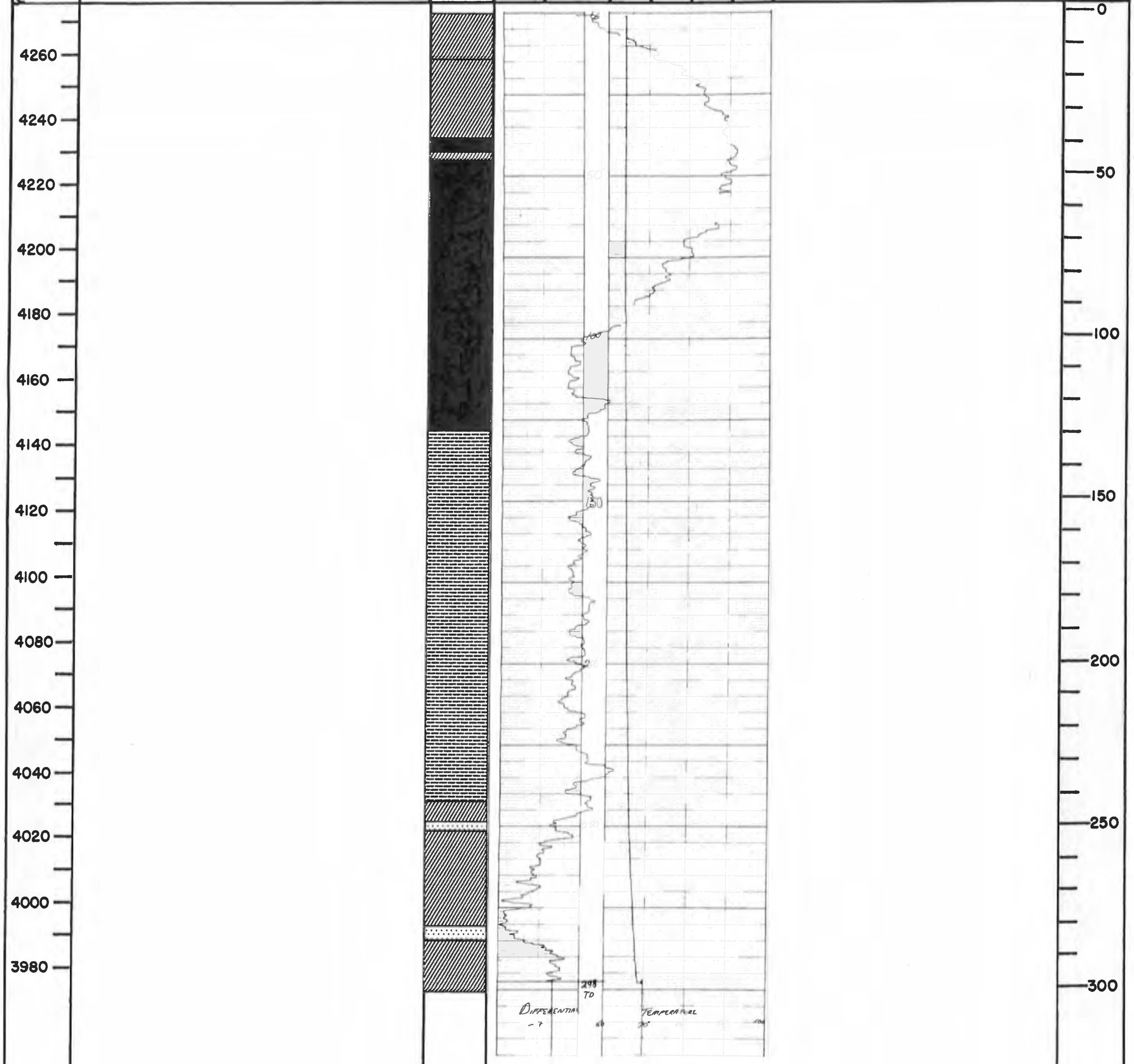
127.00 - 240.00 (Thickness = 113.00)
SHALE: gray

240.00 - 298.00 (Thickness = 58.00)
CLAYSTONE: gray, with sandstone stringers



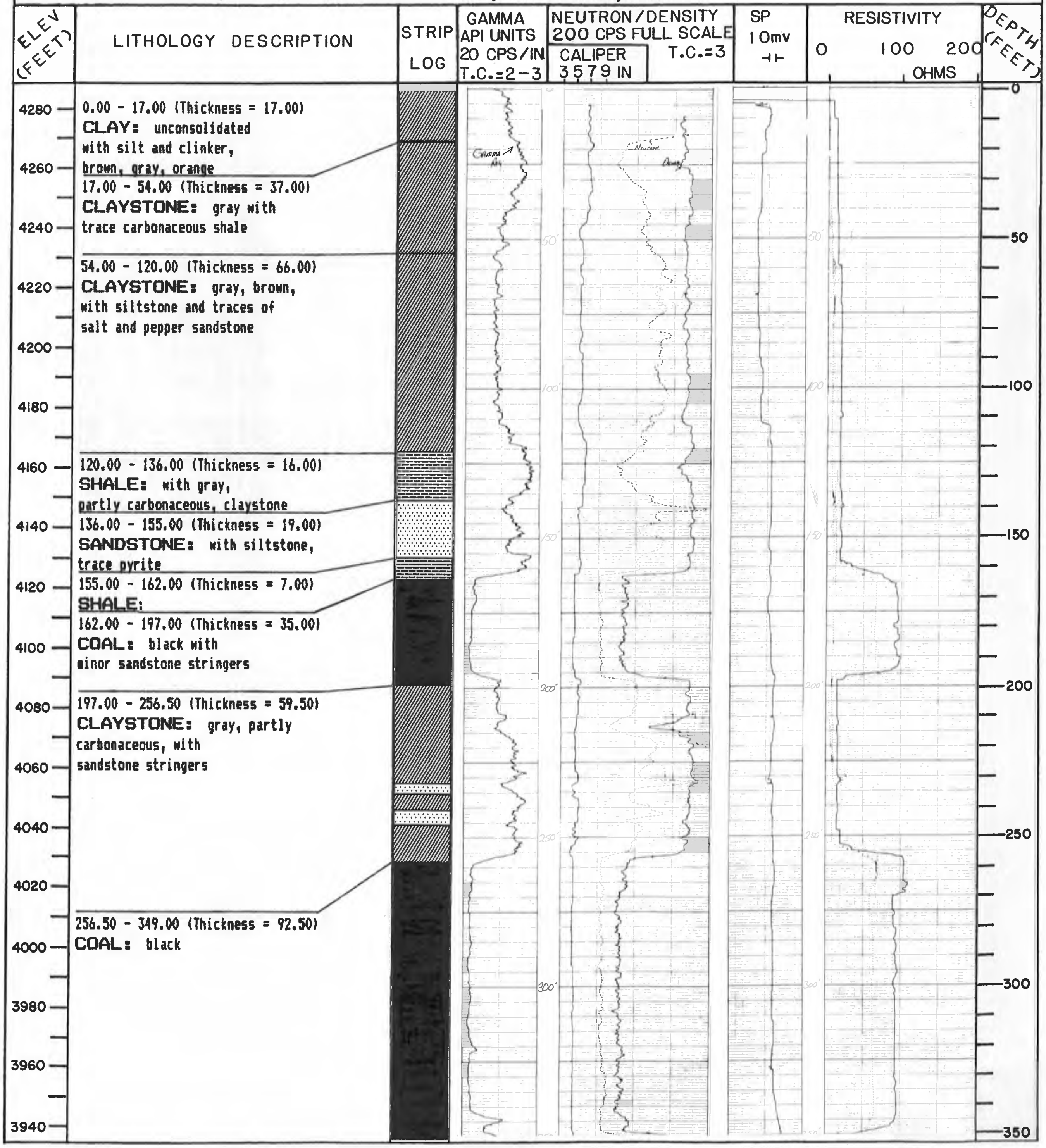
THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-14A | SHEET 2 OF 2

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | DIFFERENTIAL — + | TEMPERATURE °F 60 70 80 90 100 | DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-17A
SHEET 1 OF 3
AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/9/87
DATE COMP.: 7/9/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4285.9
TOTAL DEPTH: 440'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 440'
CORE FOOTAGE:
DRILLED BY: T. Johnson Drilling Company
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Cannia
LOGGED DEPTH: 439'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 356,285N 404,380E



0.00 - 17.00 (Thickness = 17.00)
CLAY: unconsolidated with silt and clinker, brown, gray, orange

17.00 - 54.00 (Thickness = 37.00)
CLAYSTONE: gray with trace carbonaceous shale

54.00 - 120.00 (Thickness = 66.00)
CLAYSTONE: gray, brown, with siltstone and traces of salt and pepper sandstone

120.00 - 136.00 (Thickness = 16.00)
SHALE: with gray, partly carbonaceous, claystone

136.00 - 155.00 (Thickness = 19.00)
SANDSTONE: with siltstone, trace pyrite

155.00 - 162.00 (Thickness = 7.00)
SHALE:

162.00 - 197.00 (Thickness = 35.00)
COAL: black with minor sandstone stringers

197.00 - 256.50 (Thickness = 59.50)
CLAYSTONE: gray, partly carbonaceous, with sandstone stringers

256.50 - 349.00 (Thickness = 92.50)
COAL: black

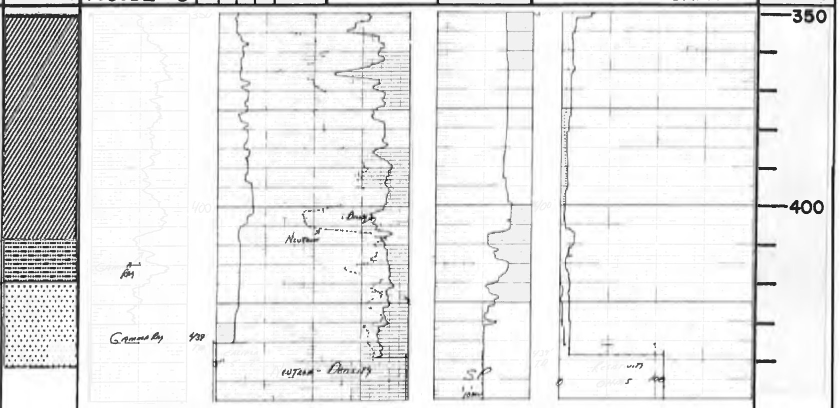
THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-17A

SHEET 2 OF 3

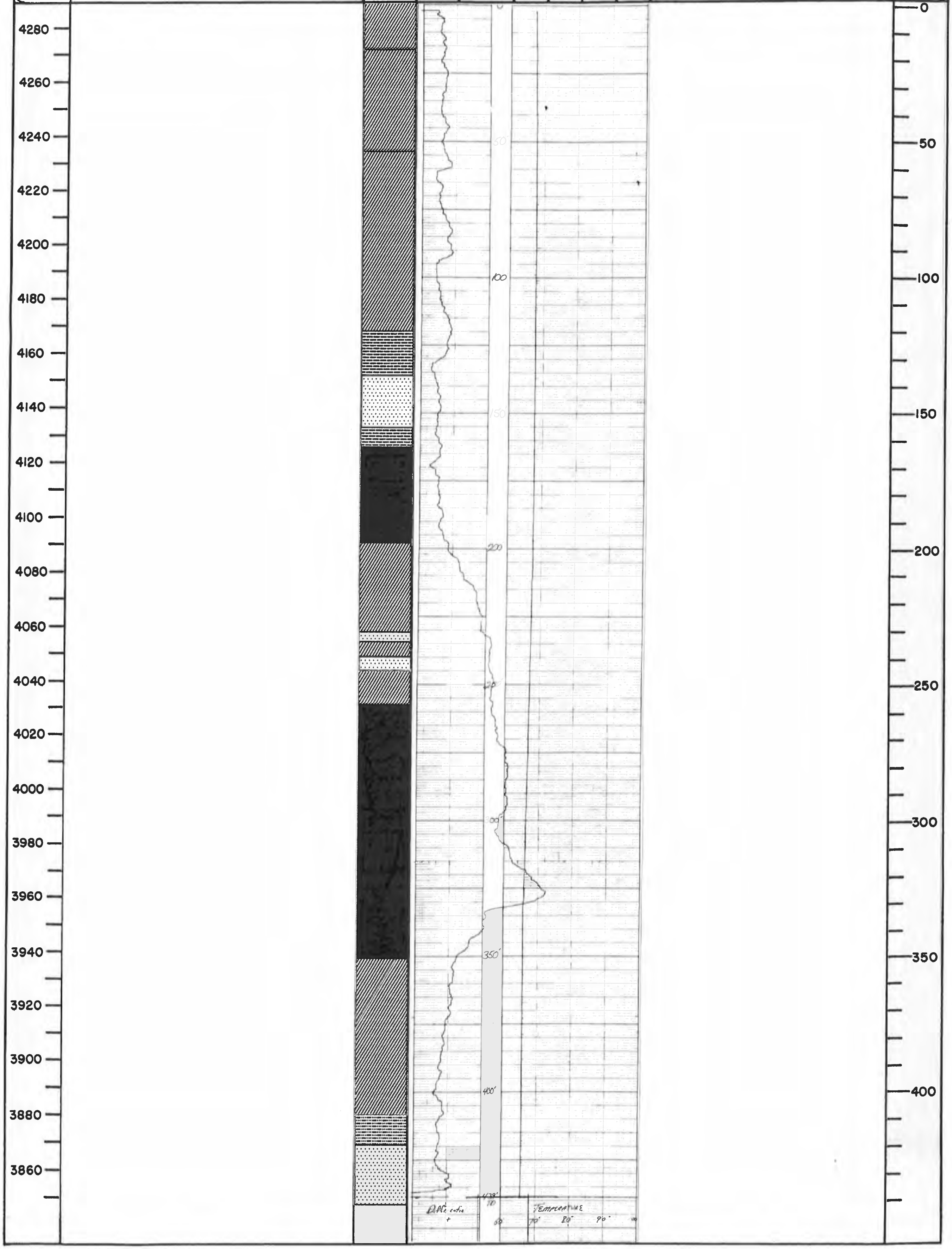
AREA:
QUAD. NAME:
DATE STARTED:
DATE COMP.:
COUNTY:
STATE:
LOCATION: SEC. T. R.
FOOTAGE LOCATION:
GROUND ELEVATION:
TOTAL DEPTH:
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE:
CORE FOOTAGE:
DRILLED BY:
GEOPHYSICAL LOGGING BY:
LITHOLOGY RECORDED BY:
LOGGED DEPTH:
LOGGING SPEED: FT/MIN
REMARKS:

ELEV (FEET)	LITHOLOGY DESCRIPTION
3920	349.00 - 406.00 (Thickness = 57.00) **CLAYSTONE:** gray
3900	
3880	406.00 - 417.00 (Thickness = 11.00) **SILTSTONE:** gray, tan, with claystone
3860	417.00 - 439.00 (Thickness = 22.00) **SANDSTONE:** gray, fine grained



THE GEOLOGICAL SURVEY OF WYOMING	HOLE NO. TH-17A	SHEET 3 OF 3

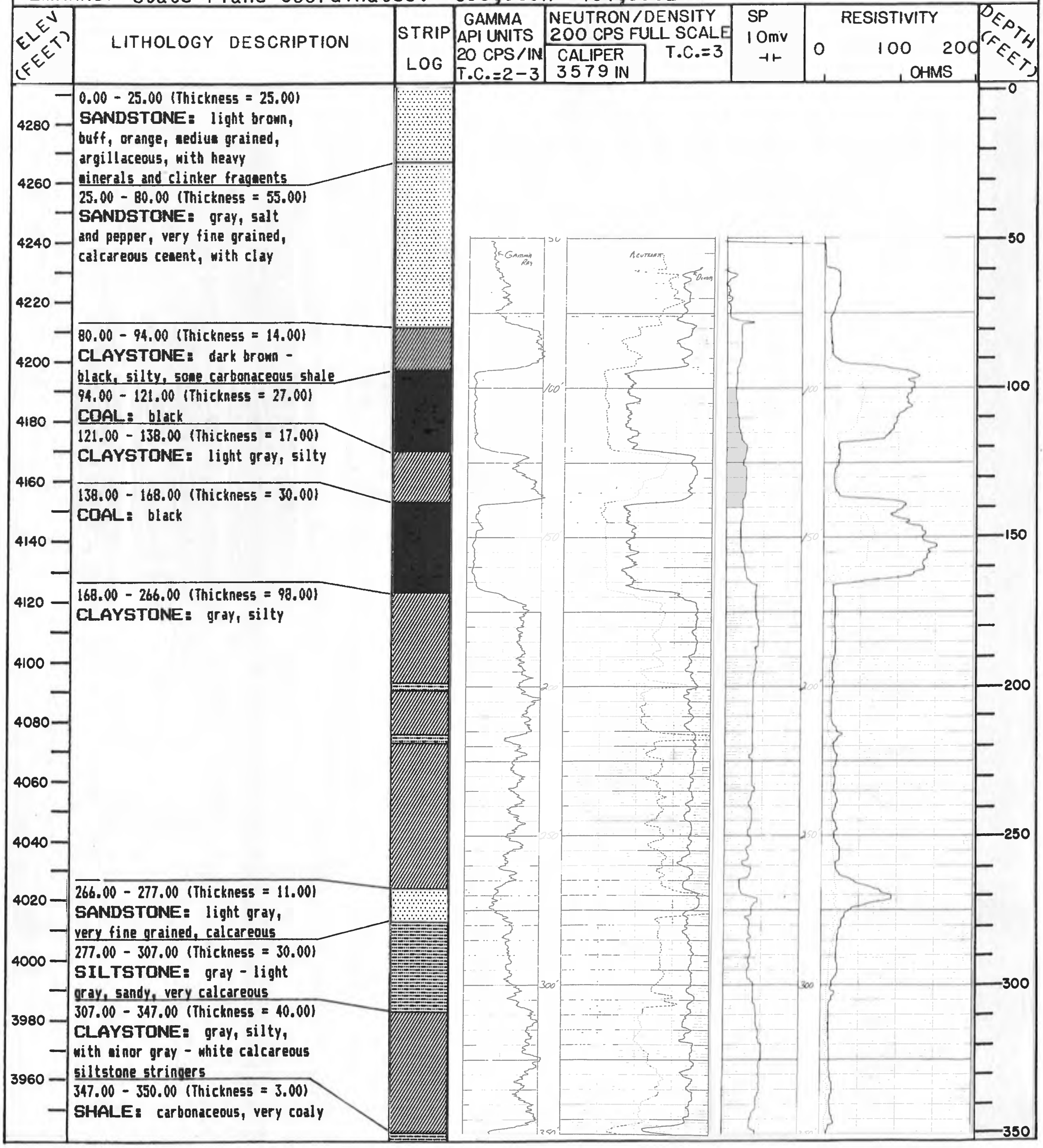
ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL – | +	TEMPERATURE °F 60 70 80 90 100	DEPTH (FEET)



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-19A
SHEET 1 OF 4

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/8/87
DATE COMP.: 7/8/87
COUNTY: Campbell
STATE: Wyoming
LOCATION: SE¼ NE¼ SEC.20 T.51N R.72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4292.2
TOTAL DEPTH: 540'
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE: 540'
CORE FOOTAGE:
DRILLED BY: Wyoming Highway Department
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: Hogle
LOGGED DEPTH: 538'
LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 356,565N 404,950E



0.00 - 25.00 (Thickness = 25.00)
SANDSTONE: light brown, buff, orange, medium grained, argillaceous, with heavy minerals and clinker fragments

25.00 - 80.00 (Thickness = 55.00)
SANDSTONE: gray, salt and pepper, very fine grained, calcareous cement, with clay

80.00 - 94.00 (Thickness = 14.00)
CLAYSTONE: dark brown - black, silty, some carbonaceous shale

94.00 - 121.00 (Thickness = 27.00)
COAL: black

121.00 - 138.00 (Thickness = 17.00)
CLAYSTONE: light gray, silty

138.00 - 168.00 (Thickness = 30.00)
COAL: black

168.00 - 266.00 (Thickness = 98.00)
CLAYSTONE: gray, silty

266.00 - 277.00 (Thickness = 11.00)
SANDSTONE: light gray, very fine grained, calcareous

277.00 - 307.00 (Thickness = 30.00)
SILTSTONE: gray - light gray, sandy, very calcareous

307.00 - 347.00 (Thickness = 40.00)
CLAYSTONE: gray, silty, with minor gray - white calcareous siltstone stringers

347.00 - 350.00 (Thickness = 3.00)
SHALE: carbonaceous, very coaly

THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-19A | SHEET 2 OF 4

AREA:

QUAD. NAME:

DATE STARTED: | DATE COMP.: | COUNTY: | STATE:

LOCATION: SEC. T. R. | FOOTAGE LOCATION:

GROUND ELEVATION: | TOTAL DEPTH: | DEPTH TO WATER:

SIZE, BIT TYPE: | DRILL TYPE: | ROTARY FOOTAGE: | CORE FOOTAGE:

DRILLED BY:

GEOPHYSICAL LOGGING BY:

LITHOLOGY RECORDED BY:

LOGGED DEPTH: | LOGGING SPEED: FT/MIN

REMARKS:

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	GAMMA API UNITS 20 CPS/IN T.C.=2-3	NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3579 IN	SP 10mv	RESISTIVITY 0 100 200 OHMS	DEPTH (FEET)

Elevation scale: 3960, 3940, 3920, 3900, 3880, 3860, 3840, 3820, 3800, 3780, 3760

350.00 - 416.00 (Thickness = 66.00)
CLAYSTONE: gray, slightly silty, minor dark gray shale

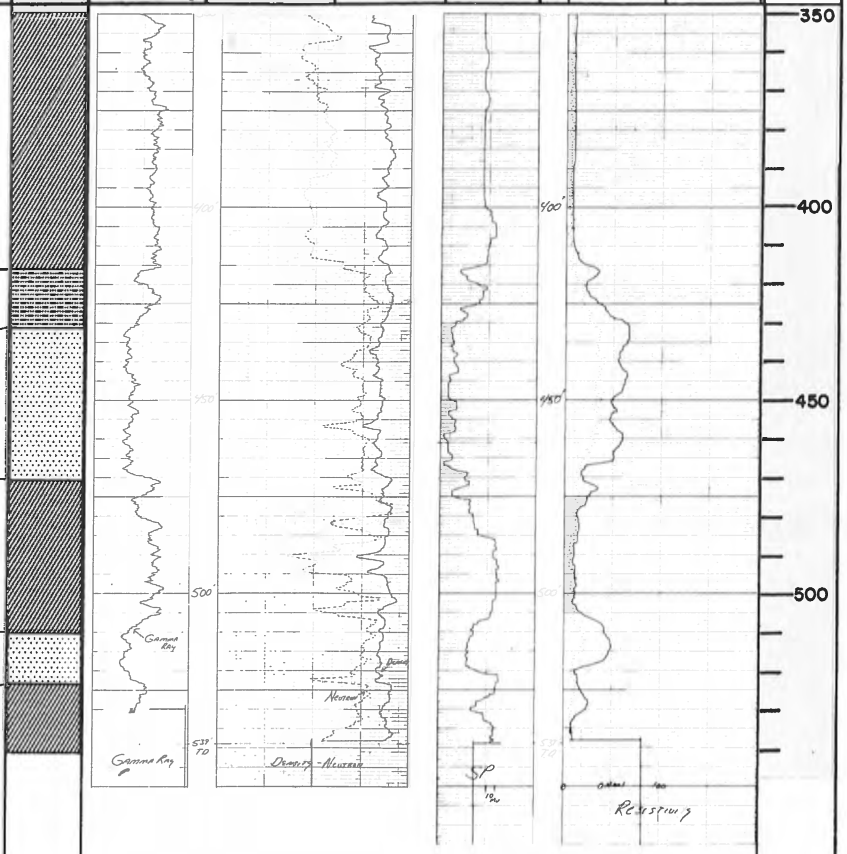
416.00 - 431.00 (Thickness = 15.00)
SILTSTONE: light gray, argillaceous, minor claystone

431.00 - 470.00 (Thickness = 39.00)
SANDSTONE: light gray, quartz rich, fine grained

470.00 - 509.00 (Thickness = 39.00)
CLAYSTONE: light gray, argillaceous, with minor dark gray siltstone and carbonaceous shale

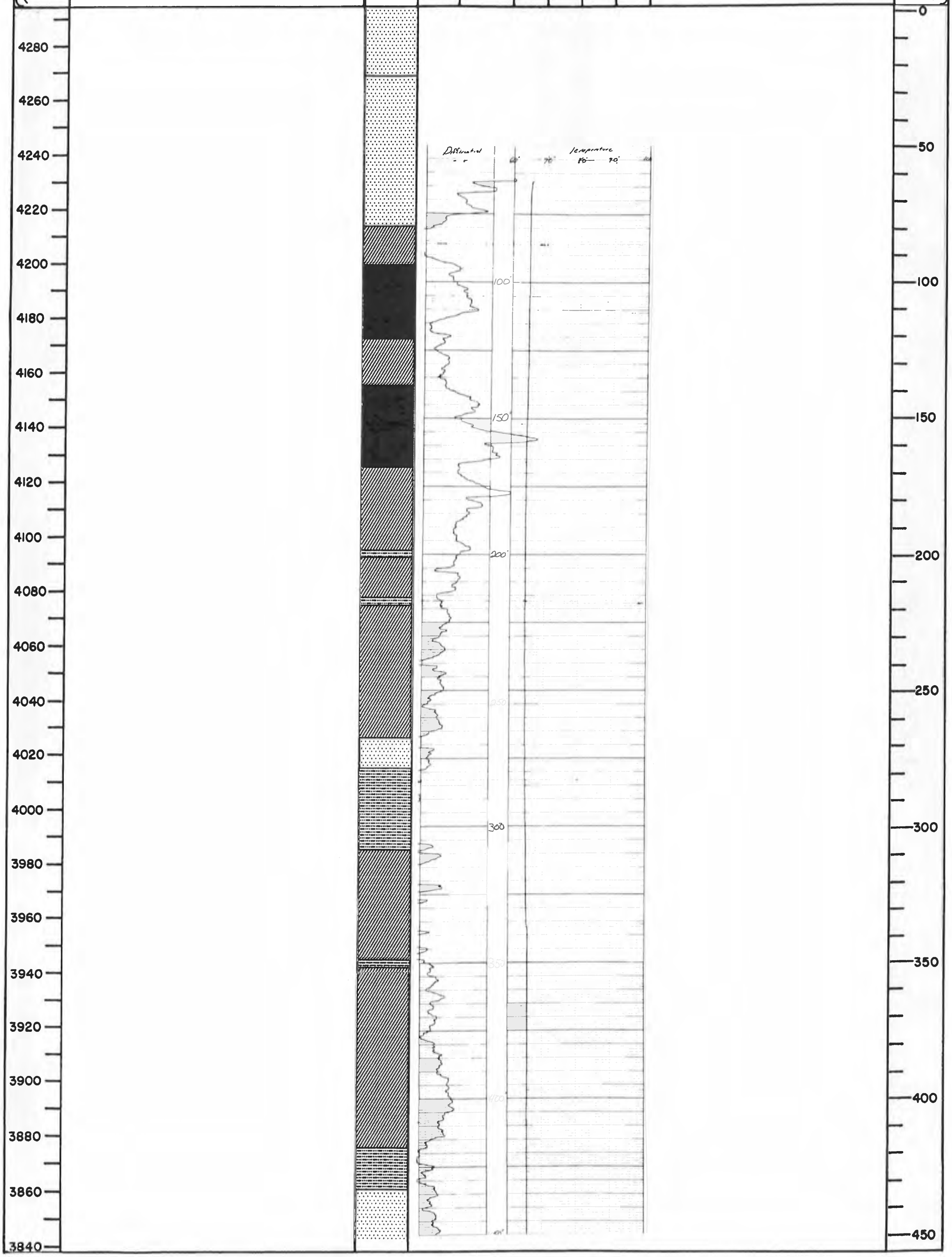
509.00 - 522.00 (Thickness = 13.00)
SANDSTONE: light gray, very fine grained

522.00 - 540.00 (Thickness = 18.00)
CLAYSTONE: with siltstone, light gray, and minor dark brown carbonaceous shale



THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-19A | SHEET 3 OF 4

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | DIFFERENTIAL − | + TEMPERATURE °F 60 70 80 90 100 | DEPTH (FEET)

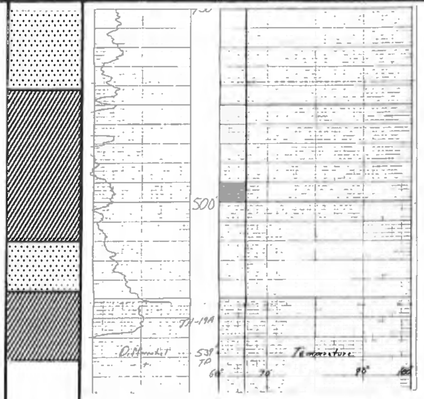


THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-19A | SHEET 4 OF 4

ELEV (FEET) | LITHOLOGY DESCRIPTION | STRIP LOG | DIFFERENTIAL − | + | TEMPERATURE °F 60 70 80 90 100 | DEPTH (FEET)

ELEV (FEET): 3840, 3820, 3800, 3780, 3760

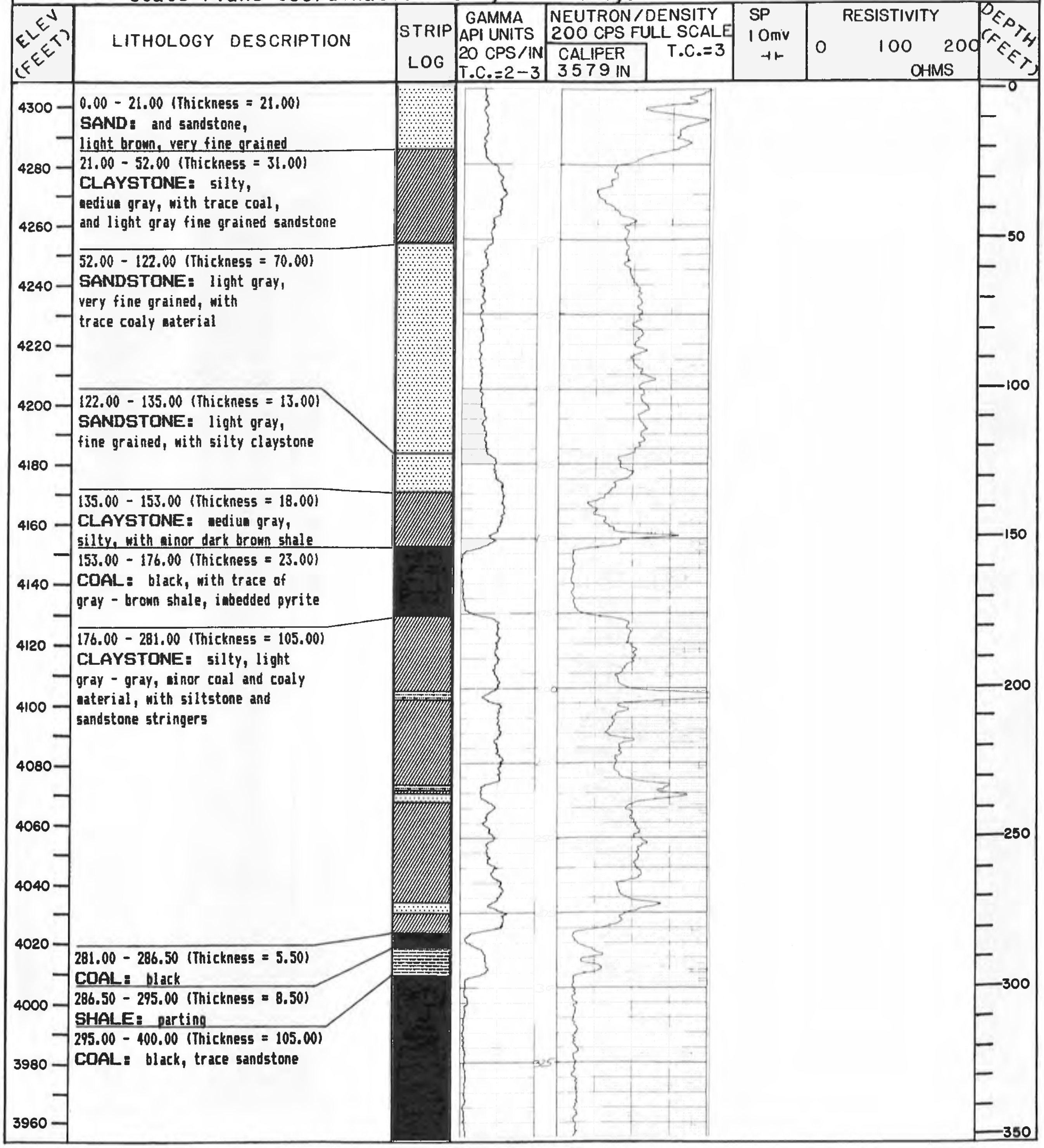
DEPTH (FEET): 450, 500



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-22A | SHEET 1 OF 2

AREA: Rawhide Village
QUAD. NAME: Rawhide School, WY 7½'
DATE STARTED: 7/10/87 DATE COMP.: 7/10/87
COUNTY: Campbell STATE: Wyoming
LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W
FOOTAGE LOCATION:
GROUND ELEVATION: 4305.8 TOTAL DEPTH: 460'
DEPTH TO WATER:
SIZE, BIT TYPE: DRILL TYPE:
ROTARY FOOTAGE: 460' CORE FOOTAGE:
DRILLED BY: Wyoming Highway Department
GEOPHYSICAL LOGGING BY: Goodwell, Inc.
LITHOLOGY RECORDED BY: De Bruin & Cannia
LOGGED DEPTH: 380' LOGGING SPEED: 20 FT/MIN
REMARKS: State Plane Coordinates: 356,545N 404,340E



0.00 - 21.00 (Thickness = 21.00)
SAND: and sandstone, light brown, very fine grained

21.00 - 52.00 (Thickness = 31.00)
CLAYSTONE: silty, medium gray, with trace coal, and light gray fine grained sandstone

52.00 - 122.00 (Thickness = 70.00)
SANDSTONE: light gray, very fine grained, with trace coaly material

122.00 - 135.00 (Thickness = 13.00)
SANDSTONE: light gray, fine grained, with silty claystone

135.00 - 153.00 (Thickness = 18.00)
CLAYSTONE: medium gray, silty, with minor dark brown shale

153.00 - 176.00 (Thickness = 23.00)
COAL: black, with trace of gray - brown shale, imbedded pyrite

176.00 - 281.00 (Thickness = 105.00)
CLAYSTONE: silty, light gray - gray, minor coal and coaly material, with siltstone and sandstone stringers

281.00 - 286.50 (Thickness = 5.50)
COAL: black

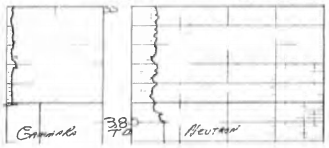
286.50 - 295.00 (Thickness = 8.50)
SHALE: parting

295.00 - 400.00 (Thickness = 105.00)
COAL: black, trace sandstone

THE GEOLOGICAL SURVEY OF WYOMING	HOLE NO. TH-22A	SHEET 2 OF 2

AREA:
QUAD. NAME:
DATE STARTED:
DATE COMP.:
COUNTY:
STATE:
LOCATION: SEC. T. R.
FOOTAGE LOCATION:
GROUND ELEVATION:
TOTAL DEPTH:
DEPTH TO WATER:
SIZE, BIT TYPE:
DRILL TYPE:
ROTARY FOOTAGE:
CORE FOOTAGE:
DRILLED BY:
GEOPHYSICAL LOGGING BY:
LITHOLOGY RECORDED BY:
LOGGED DEPTH:
LOGGING SPEED: FT/MIN
REMARKS:

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	GAMMA API UNITS 20 CPS/IN T.C.=2-3	NEUTRON/DENSITY 200 CPS FULL SCALE T.C.=3 CALIPER 3579 IN	SP 10mv ⊣⊢	RESISTIVITY 0 100 200 OHMS	DEPTH (FEET)
3940 3920							350
3900 3880	400.00 - 440.00 (Thickness = 40.00) **CLAYSTONE:** gray, very silty, slightly calcareous, slightly coaly						400
3860	440.00 - 460.00 (Thickness = 20.00) **SILTSTONE:** gray - brown						450



THE GEOLOGICAL SURVEY OF WYOMING

HOLE NO. TH-23A

SHEET 1 OF 2

AREA: Rawhide Village

QUAD. NAME: Rawhide School, WY 7½'

DATE STARTED: 7/10/87

DATE COMP.: 7/10/87

COUNTY: Campbell

STATE: Wyoming

LOCATION: SE¼ NE¼ SEC. 20 T. 51N R. 72W

FOOTAGE LOCATION:

GROUND ELEVATION: 4294.6

TOTAL DEPTH: 320'

DEPTH TO WATER:

SIZE, BIT TYPE:

DRILL TYPE:

ROTARY FOOTAGE: 320'

CORE FOOTAGE:

DRILLED BY: Wyoming Highway Department

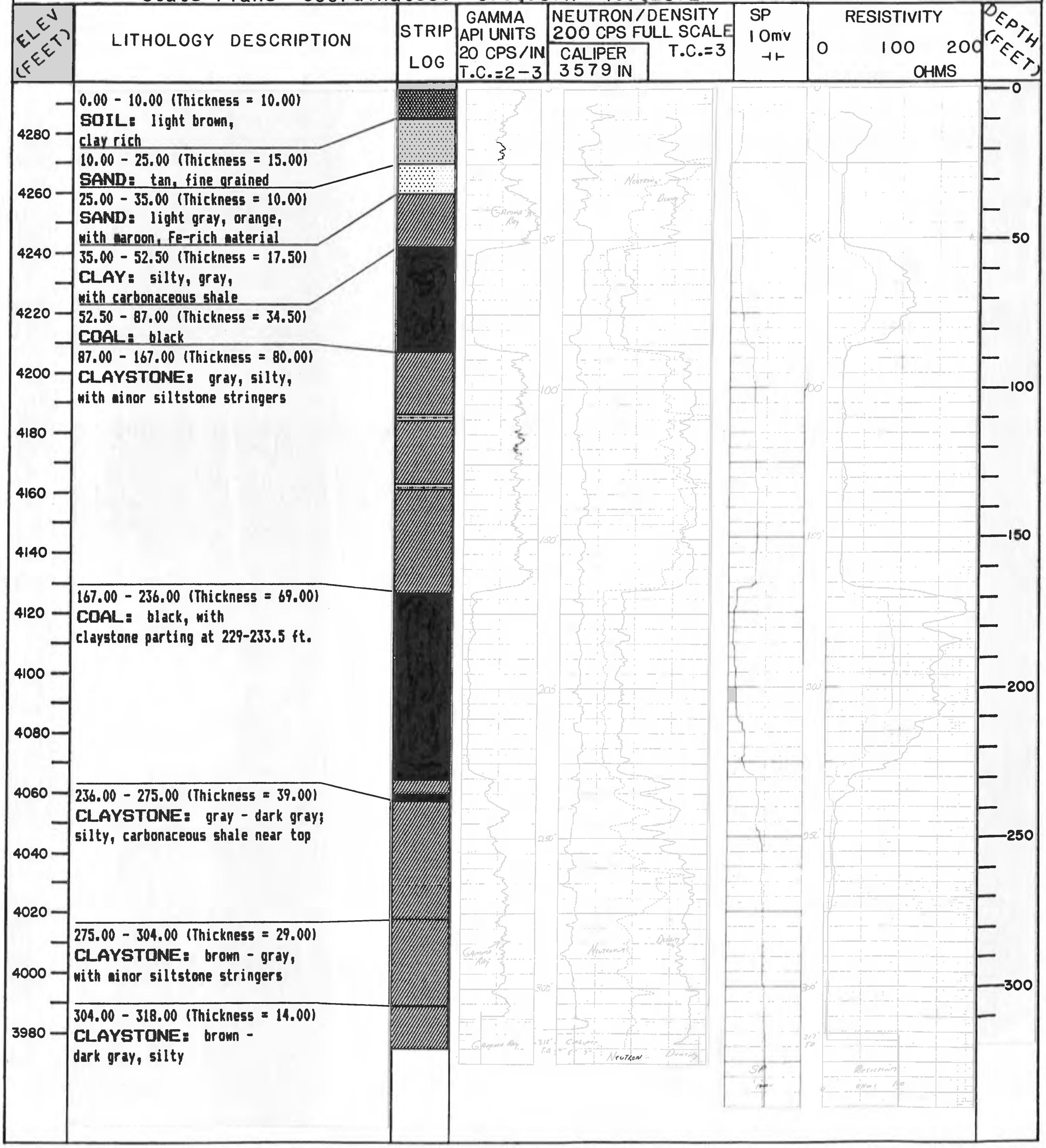
GEOPHYSICAL LOGGING BY: Goodwell, Inc.

LITHOLOGY RECORDED BY: De Bruin

LOGGED DEPTH: 317'

LOGGING SPEED: 20 FT/MIN

REMARKS: State Plane Coordinates: 356,985N 405,285E



0.00 - 10.00 (Thickness = 10.00)
SOIL: light brown, clay rich

10.00 - 25.00 (Thickness = 15.00)
SAND: tan, fine grained

25.00 - 35.00 (Thickness = 10.00)
SAND: light gray, orange, with maroon, Fe-rich material

35.00 - 52.50 (Thickness = 17.50)
CLAY: silty, gray, with carbonaceous shale

52.50 - 87.00 (Thickness = 34.50)
COAL: black

87.00 - 167.00 (Thickness = 80.00)
CLAYSTONE: gray, silty, with minor siltstone stringers

167.00 - 236.00 (Thickness = 69.00)
COAL: black, with claystone parting at 229-233.5 ft.

236.00 - 275.00 (Thickness = 39.00)
CLAYSTONE: gray - dark gray; silty, carbonaceous shale near top

275.00 - 304.00 (Thickness = 29.00)
CLAYSTONE: brown - gray, with minor siltstone stringers

304.00 - 318.00 (Thickness = 14.00)
CLAYSTONE: brown - dark gray, silty

THE GEOLOGICAL SURVEY OF WYOMING | HOLE NO. TH-23A | SHEET 2 OF 2

ELEV (FEET)	LITHOLOGY DESCRIPTION	STRIP LOG	DIFFERENTIAL – | + TEMPERATURE °F 60 70 80 90 100	DEPTH (FEET)