MUDDY CREEK COAL DRILLING PROJECT, WASATCH PLATEAU, UTAH

Archie D. Smith

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CONTENTS

Abstract 1
Introduction 1
Geology 3
  Stratigraphy 3
  Structure 3
Coal 6
  Geology 6
    Hiawatha Coal Bed 6
    Upper Hiawatha Coal Bed 11
    Muddy No. 1 Coal Bed 11
    Muddy No. 2 Coal Bed 11
    Ivie Coal Bed 11
    Upper Ivie Coal Bed 11
  Quality 12
Methane Content of Coal 12
  Quality 17

References 17

Description of Drilling 21
    BCR-4 22
    MC-7-FP 22
    MC-8-FP 23
    MC-9-FP 23
    MC-10-HM 24
    MC-11-HM 25
    MC-12-HM 25
    MC-14-HM 26
    MC-15-HM 27
    MC-16-AL 27
    MC-17-AL 28
    MC-18-AL 28
    MC-20-AL 29
    MC-21-AL 30
    MC-22-AL 30
    MC-23-AL 30
    MC-24-AL 31
    MC-25-AL 31
    MC-26-AL 31
    MC-27-AL 32
    MC-28-AL 32
    MC-29-AL 33
    MC-71-AL 33
    MC-72-AL 34
    MC-73-FP 34
    MC-74-HM 35
    MC-75-AL 35

ILLUSTRATIONS

Figure 1. Muddy Creek coal drilling project index map 2
Figure 2. Generalized section of rock formations Wasatch Plateau Coal Field, Utah. 7
Figure 3. Average column of the Lower Blackhawk in the Muddy Creek drilling area. 9
Figure 4. Map of Muddy Canyon-Emery area showing position of contact and zone of intertonguing between Star Point Sandstone and Blackhawk Formation 10

TABLES

Table 1. Muddy Creek drill hole data and formation tops 4
Table 2. Muddy Creek drilling area strikes and dips 8
Table 3. Average proximate, ultimate and sulfur forms analyses of coal cores obtained from Muddy Creek area drill holes 13
Table 4. Proximate analyses of coal cores obtained from drill holes. 13
Table 5. Ultimate analyses of coal cores obtained from drill holes. 14
Table 6. Sulfur forms analyses of coal cores obtained from drill holes 14
Table 7. Trace element determinations of coal cores obtained from drill holes 15
Table 8. Methane content determinations of coal core obtained from drill holes 16
Table 9. In-place coal reserves, Muddy Creek coal drilling project area, Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness 18
Table 9a. In-place coal reserves, Muddy Creek coal drilling project area, Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness and interburden areas less than 35 ft. thick. 19
Table 10. In-place coal reserves, Muddy Creek coal drilling project area, upper Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness 20
Table 11. In-place coal reserves, Muddy Creek coal drilling project area, Muddy No. 1, in thousands of short tons, excluding coal less than 4 ft. in thickness 21

APPENDICES

Appendix I Drill Hole Log for MC-7-FP 38
Appendix II
Plate 1. Structural contour map, Starpoint Sandstone (Ksp) Muddy Creek, Quitchupah Creek, and Convulsion Canyon areas 48
Plate 2. Area of calculated reserves, Hiawatha Coal Bed, Muddy Creek, Quitchupah Creek, and Convulsion Canyon areas. 50
Plate 3. Muddy Creek, Quitchupah Creek, and Convulsion Canyon areas. 52
Plate 4. Area of calculated reserves, Muddy No. 1 Coal Bed, Muddy Creek, Quitchupah Creek, and Convulsion Canyon areas 54
Plate 5. Interburden Isopach Map Muddy Creek, Quitchupah Creek, and Convulsion Canyon areas 56

MUDDY CREEK COAL DRILLING PROJECT, WASATCH PLATEAU, UTAH

Archie D. Smith[1]

ABSTRACT

Twenty-seven drill holes successfully tested the Lower Blackhawk Formation coal zones and penetrated the Star Point Sandstone on the Wasatch Plateau in central Utah. Reserve calculations show a total in-place measured, indicated, and inferred tonnage of 561,572,000 short tons, but not all of this coal will be recoverable. The coal is contained in 3 coal beds, the Muddy No. 1; 9,676,000 tons, Upper Hiawatha; 348,863,000 tons and Hiawatha; 203,033,000 tons, in the lower 298 feet of the Upper Cretaceous Blackhawk Formation. Perhaps 232,976,000 tons of the total may be recoverable.

The rank of the coal is high volatile C bituminous, and quality and trace elements were determined from samples taken from five drill holes from minable thicknesses of coal. The average proximate analysis, as received, is moisture, 7.4 percent; ash, 10.8 percent; volatile, 38.3 percent; and fixed carbon, 43.5 percent. The report also lists ultimate, sulfur forms, and trace element analyses. No adverse results were found in either sulfur forms or trace elements. Methane content was determined by the U. S. Bureau of Mines "Direct Method" to be less than one cubic centimeter per gram of coal and the use of normal ventilation techniques should be adequate in mining.

INTRODUCTION

The Utah Geological and Mineral Survey (UGMS), under contract with the United States Geological Survey (USGS), Conservation Division, conducted an exploratory coal drilling program in the Muddy Creek area of the Wasatch Plateau, Utah, in 1979 and 1980. The project was designed to (1) determine the existence of minable coal and (2) to provide a close approximation of the minable reserve. The demand for this type of information stems from the Federal Government's plans to renew coal leasing and their requirement to effectively manage the coal resources under their jurisdiction.

The Muddy Creek area is located in the southern part of the Wasatch Plateau in central Utah (figure 1). The northeast tip of the area is located where the boundaries of Sanpete, Sevier, and Emery counties come together. This part of the plateau is a relatively high dissected table-land, its eastern margin marked by an imposing escarpment. The cliff is supported by prominent resistant sandstone ledges that are barren of vegetation. The soft sandstone siltstone, shale, and coal slopes between the ledges are steep and generally sparsely covered with vegetation. The upper surface of the plateau upon which the drilling was undertaken consists of hills and ridges, much of which is open meadow interrupted by stands, groves, and clusters of trees and shrubs. The Muddy Creek drilling area is drained by three major streams which flow southeasterly through narrow steep-walled canyons. From north to south these are Muddy Creek, Quitchupah Creek and Convulsion Canyon. Muddy Creek marks the north boundary of the drilling area, Acord Lake and Skumpah Creek form the arbitrary west boundary, and the south boundary lies a mile or two south of Convulsion Canyon.

Access to the drilling area is provided by routes from the west, south and east (figure 1). Ingress to the drilling area from the south is accomplished via Interstate Highway 70. A paved road, extending northeasterly from Ranch Exit 72, is used for coal haulage to and from the Southern Utah Fuel Company mine in Convulsion Canyon, which is in the southern part of the area. This is the best developed route and is followed to the Acord Lake turnoff where an unimproved road jogs to the west and intersects a wide unimproved road that doubles as a landing strip. The road extends northerly past the shallow Acord Lake enroute to Lizonbee Spring. Prior to reaching Lizonbee Spring is a junction providing a right turn into the drilling area and to Duncan Mountain.

Access to the area from the west is via U. S. Highway 89 to State Highway 137 between the towns of Gunnison and Centerfield. State Highway 137 extends east to the town of Mayfield and Twelve Mile Creek to Block Mountain junction, thence to the north side of Block Mountain and Muddy Creek on an unimproved road. Access from the east is the least desirable and may be attained via State Highway 10 to about 1 mile south of the town of Emery, Utah, thence west toward the escarpment over a poorly marked unimproved dirt road to a jeep trail in Link Canyon which extends to the top of the plateau.

[1] Staff Geologist, Coal Economic Section, UGMS

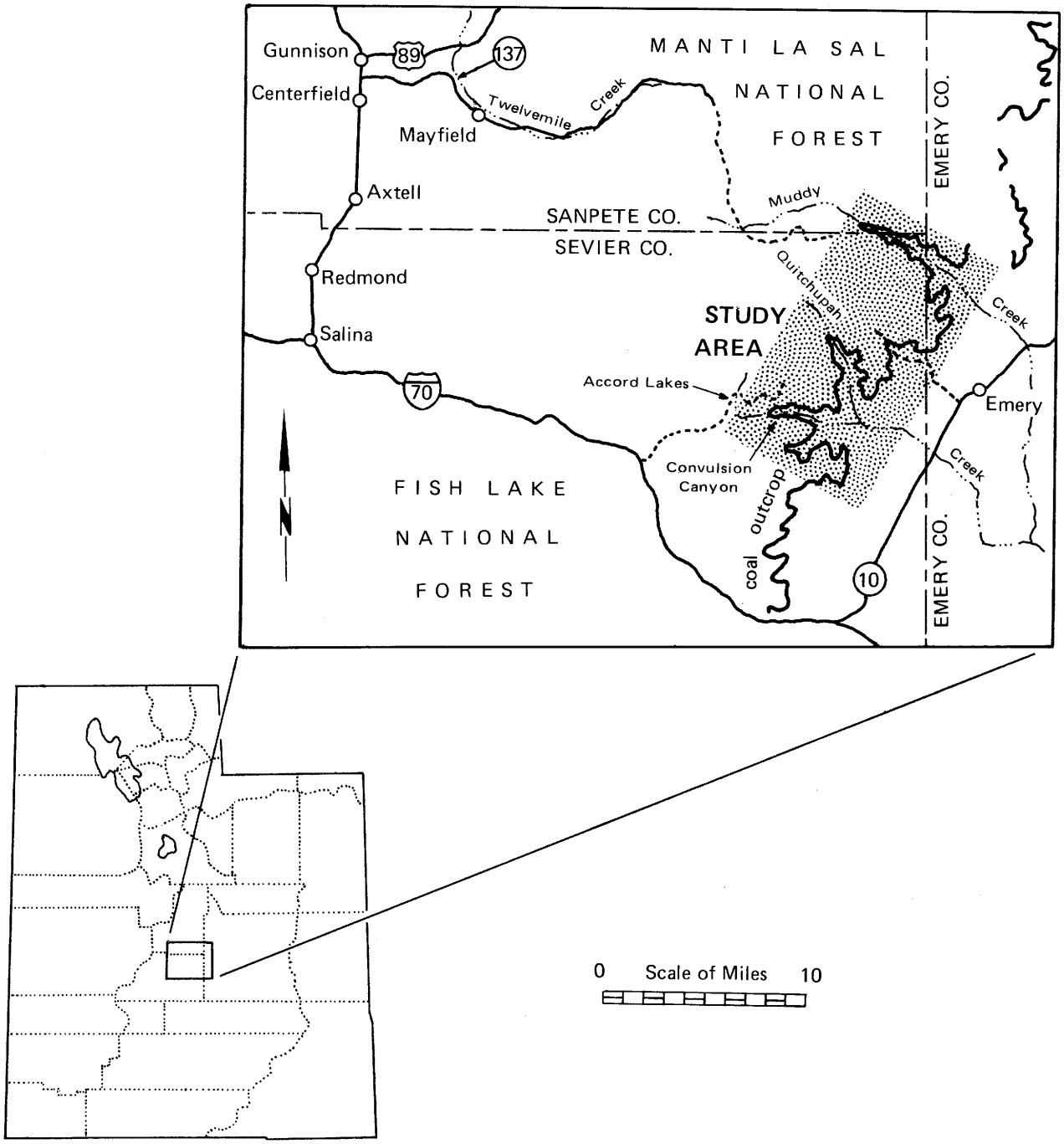

Figure 1. Muddy Creek coal drilling project index map

The drilling area is located on parts of three U. S. Geological Survey 7½-minute quadrangles; the eastern half of Acord Lake, southwest corner of Flagstaff Peak, and the southeast corner of Heliotrope Mountain. The 27 drillhole locations are given in table 1. Five of the drillholes are located in Sanpete County while the remaining 22 are in Sevier County. The Muddy Creek area consists of parts of the Manti-LaSal and Fishlake National Forests of the U. S. Department of Agriculture. Twelve of the drillholes were located on the Manti-LaSal National Forest (northeast) and 15 were located on the Fishlake National Forest (southwest).

The drilling program was accomplished through USGS contract 14-08-0001-17861, a cost-sharing agreement with UGMS. The total cost of the project was $498,179 of which the UGMS share was 1½ percent. UGMS and USGS personnel planned and located the 27 test holes, the drilling evaluation was the responsibility of UGMS personnel. Exploration and road use permits were issued by the respective offices of the National Forest Service after proper environmental assessment reports for the drillsites had been submitted and approved. UGMS subcontracted the 1979 drilling to Iron Clad Drilling Co., Inc. of Craig, Colorado and the 1980 drilling to Longyear Company of Sedalia, Colorado. Exploration drilling was accomplished under the definitions and regulations contained in 43 Code of Federal Regulation 3400, "Coal Management of Federally Owned Coal".

GEOLOGY

Stratigraphy

The stratigraphic units of concern in the drilling area are Cretaceous and Tertiary in age and include, in ascending order, the Masuk Shale, Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, and Flagstaff Limestone; they are listed and described in figure 2. A more detailed description of the units can be obtained from Spieker (1930) or Doelling (1972, p. 59-243). Stratigraphic units drilled include the Price River Formation, Castlegate Sandstone, Blackhawk Formation, and the Star Point Sandstone in descending order. The drilling target was the lower two to three hundred coaliferous feet of the Blackhawk Formation. Drilling was projected to include at least fifty feet of Star Point Sandstone to ensure intersection of all coal seams and to preclude early "TDs". Star Point appearing sandstone can occur in the lower part of the Blackhawk Formation.

Fourteen of the drill holes were spudded in the Price River Formation whose uneroded portions ranged from 25 feet to 560 feet. The remaining 13 drill holes were spudded in Castlegate Sandstone. The complete Castlegate Sandstone was drilled fourteen times and averaged 83 percent sandstone, 10 percent siltstone, and 7 percent shale in composition. The siltstone and shale generally occur as minor breaks in what is otherwise a fairly massive sandstone. The mean thickness of the unit is 226 feet and ranges from 299 feet to 94 feet; however, it appears to thin toward the south as indicated by MC-27-AL (94 feet) and MC-24-AL (109 feet).

A complete interval of the Blackhawk Formation was drilled in every hole. The mean composition by rock type is 43 percent sandstone, 35 percent siltstone, 19 percent shale, and 3 percent coal. The amount of coal ranges from 2 to 5 percent of the formation and mineable seam/seams were encountered in all but one hole. The Blackhawk Formation averages 854 feet in thickness, ranging from 788 feet to 920 feet.

The floor rock of the Hiawatha coal seam generally delineates the uppermost limit of the Star Point Sandstone. The mean interval of Star Point Sandstone drilled was 71 feet and in 18 of the holes the interval was entirely light to medium gray, fine grained sandstone; however, in nine of the holes minor siltstone and lesser shale breaks interrupted the sandstone.

Structure

The Wasatch Plateau is in a transition zone between the historically relatively stable Colorado Plateaus on the east and the historically relatively complex and unstable Basin and Range Province on the west. The drilling area is bounded by the Musinia fault zone on the west and the Pleasant Valley fault zone on the east. The strata in the drilling area are generally gently dipping to the northwest as shown by the structural contour map, plate 1.

The average strike as determined from sixteen data points is N 35° E with a standard deviation of 10 degrees. The average dip is 2° NW with a standard deviation of 3/10's of one degree.

The strike and dip was found to be anomalous in the vicinity of Mud Spring Hollow and geophysical logs give evidence of possible faulting. An inferred fault is shown on plate 1, but has not been field checked. Utilizing the logs, the displacement appears to be approximately 110 feet with the upthrown block to the east.

Table 1. Muddy Creek drill hole data and formation tops

Drill Hole Number	Collar Elevation	Drillers Depth	Geophysically Logged Depth	Location	Formation	Elevation
MC-7-FP	8319	1080	1075	SESW, Sec 34, 20S 5E	Colluvium	8319.0
					Castlegate SS	8292.0
					Blackhawk	8074.0
					Star Point SS	7286.5
MC-8-FP	8224	1128	1127	NWSE, Sec 33, 20S 5E	Colluvium	8224.0
					Castlegate SS	8191.0
					Blackhawk	7976.0
					Star Point SS	7157.5
MC-9-FP	8155	1180	1177	NESW, Sec 28, 20S 5E	Colluvium	8155.0
					Castlegate SS	8108.0
					Blackhawk	7896.5
					Star Point SS	7068.0
MC-10-HM	8152	1180	1175	SWNE, Sec 32, 20S 5E	Colluvium	8152.0
					Castlegate SS	8129.0
					Blackhawk	7929.0
					Star Point SS	7039.5
MC-11-HM	8049	1185	1179	NENE, Sec 29, 20S 5E	Colluvium	8049.0
					Castlegate SS	8046.0
					Blackhawk	7803.0
					Star Point SS	6926.0
MC-12-HM	8147	1440	1436	NESE, Sec 30, 20S 5E	Colluvium	8147.0
					Price River	8104.0
					Castlegate SS	7979.0
					Blackhawk	7680.0
					Star Point SS	6817.0
MC-14-HM	8423	1852	1852	NENW, Sec 30, 20S 5E	Colluvium	8423.0
					Price River	8393.0
					Castlegate SS	7833.0
					Blackhawk	7551.0
					Star Point SS	6671.0
MC-15-HM	8310	1360	1360	Sec 5, 21S 5E	Colluvium	8310.0
					Price River	8265.0
					Castlegate SS	8164.0
					Blackhawk	7942.5
					Star Point SS	7024.5
MC-16-AL	8253	1260	1252	800'W-Line	Colluvium	8253
				300'S-Line	Castlegate SS	8199
				Sec 18, 21S 4E	Blackhawk	7978
					Star Point SS	7116.0
MC-17-AL	8317	1260	1255	NWNE, Sec 24, 21S 4E	Colluvium	8317.0
					Price River	8315.0
					Castlegate SS	8217.0
					Blackhawk	7993.5
					Star Point SS	7108.0
MC-18-AL	8271	1222	1214	NWSW, Sec 24, 21S 4E	Colluvium	8271.0
					Price River	8246.0
					Castlegate SS	8200.0
					Blackhawk	7942.0
					Star Point SS	7082.5

(continued on pg. 5)

(Table 1. continued)

Drill Hole Number	Collar Elevation	Drillers Depth	Geophysically Logged Depth	Location	Formation	Elevation
MC-20-AL	8342	1210	1202	NWNE, Sec 25, 21S 4E	Colluvium	8342.0
					Price River	8337.0
					Castlegate SS	8312.0
					Blackhawk	8085.0
					Star Point SS	7243.0
MC-21-AL	8438	1440	1432	NENE, Sec 34, 21S 4E	Colluvium	8438
					Price River	8428.0
					Castlegate SS	8154.5
					Blackhawk	7935.0
					Star Point SS	7022.0
MC-22-AL	8184	1080	1079	SWNE, Sec 3, 22S 4E	Castlegate SS	8184.0
					Blackhawk	8022.5
					Star Point SS	7149.5
MC-23-AL	8629	1480	1480	SWSE, Sec 10, 22S 4E	Colluvium	8629.0
					Price River	8616.0
					Castlegate SS	8219.0
					Blackhawk	7979.0
					Star Point SS	7199.0
MC-24-AL	8135	1020	1007	NWSW, Sec 10, 22S 4E	Colluvium	8135.0
					Castlegate SS	8132.0
					Blackhawk	8023.0
					Star Point SS	7207.5
MC-25-AL	8398	1140	1126	NWSE, Sec 13, 22S 4E	Colluvium	8398
					Castlegate SS	8392
					Blackhawk	8333.0
					Star Point SS	7499.0
MC-26-AL	8288	1040	947	SWNE, Sec 11, 22S 4E	Castlegate SS	8288
					Blackhawk	8216.0
					Star Point SS	7483.0
MC-27-AL	8240	1100	1082	SENW, Sec 15, 22S 4E	Colluvium	8240.0
					Price River	8236.0
					Castlegate SS	8167.0
					Blackhawk	8073.0
					Star Point SS	7257.0
MC-28-AL	8285	1160	1133	SESW, Sec 2, 22S 4E	Colluvium	8285
					Castlegate SS	8275.0
					Blackhawk	8131
					Star Point SS	7372.0
MC-29-AL	8307	1225	1225	SWSW, Sec 35, 21S 4E	Colluvium	8307
					Price River	8303
					Castlegate SS	8207.0
					Blackhawk	8053.5
					Star Point SS	7134.0
MC-71-AL	8380	1420	1410	NWNE, Sec 13, 21S 4E	Colluvium	8380.0
					Price River	8335.0
					Castlegate SS	8172.0
					Blackhawk	7908.0
					Star Point SS	7037.0

(continued on pg. 6)

(Table 1. continued)

Drill Hole Number	Collar Elevation	Drillers Depth	Geophysically Logged Depth	Location	Formation	Elevation
MC-72-AL	8410	1337	1280	200 ft-E Line 2700 ft-N Line Sec 18, 21S 5E	Colluvium	8410.0
					Price River	8349.0
					Castlegate SS	8222.0
					Blackhawk	8018.0
					Star Point SS	7155.0
MC-73-FP	8244	1160	1158	SWSW, Sec 33, 20S 5E	Colluvium	8244.0
					Castlegate SS	8231.0
					Blackhawk	7985.0
					Star Point SS	7143.0
MC-74-HM	8477	1730	1730	SWSW, Sec 20, 20S 5E	Colluvium	8477.0
					Price River	8466.0
					Castlegate SS	7934.0
					Blackhawk	7697.0
					Star Point SS	6800.0
MC-75-AL	8454	1518	1520	NENE, Sec 23, 21S 4E	Colluvium	8454.0
					Price River	8362.0
					Castlegate SS	8107.0
					Blackhawk	7868.0
					Star Point SS	6989.5
BCR-4	8310	1040	1036	SWNE, Sec 2, 22S 4E	Colluvium	8310.0
					Castlegate SS	8305.0
					Blackhawk	8196.0
					Star Point SS	7336.0

Strikes and dips in the drilling area, and as a contrast, Mud Springs Hollow, are given in table 2. The table was composed by using the top of the Star Point Sandstone as datum, and then utilizing a "Three Point Problem" approach (three points located on a structural plane or datum are used to determine points of equal elevation), the attitude of the datum was determined. The average strike and dip generally works well for projection of coal beds and tops when drilling.

COAL

Geology

All of the important coal beds occur in the lower 298 feet of the Blackhawk Formation. Up to 21 coal beds have been revealed by the drilling, but only six beds exceed 4 feet in thickness, and only three appear to be continuous enough to mine. An average column representing the lower 300 feet of the Blackhawk Formation is depicted as figure 3.

Hiawatha Coal Bed

The Hiawatha bed has an average thickness of 6.7 feet with a standard deviation of 5.6 feet thick and a thickness range of 1.5 to 23 feet. The axis of drilling trends to the northeast from Convulsion Canyon on the southwest to Muddy Creek on the northeast. The bed is relatively thin from Convulsion Canyon to Duncan Draw averaging 2.8 feet thick. At Duncan Draw the bed starts to split which gains in thickness to approximately 15 feet until MC-72-AL is reached on the northeast side of Quitchupah where the split disappears. The average thickness of the coal below the split is 8.7 feet and above the split is 3 feet. Proceeding northeast, the bed is probably a solid 10 feet thick as it continues under Big Ridge, but at Cowboy Creek it again starts to split, and the split thickens toward Muddy Creek. At Cowboy Creek the coal above the split is 17 feet thick and 4 feet thick below. Both coal portions thin toward Muddy Creek. An axis of thick Hiawatha coal is depicted on plate 2 arcing northward from MC-18-AL toward Muddy Creek. The axis probably represents the deepest part of the depositional lagoonal swamp which also probably parallels the ancient offshore barrier reef. It is interesting to note that the zone of intertonguing, figure 4, from Flores, et al, subparallels this axis.

It is also noteworthy that Spieker (1930, p. 188) indicates that the Upper Hiawatha appears to ascend in the stratigraphic column in Quitchupah Canyon. Drilling

System	Series	Stratigraphic unit		Thickness Feet	Description
TERTIARY	Eocene				
	Paleocene	Wasatch Group	Flagstaff Limestone	200-1500	Dark yellow-gray to cream limestone, evenly bedded with minor amounts of sandstone, shale, and volcanic ash, ledge-former.
			North Horn Formation (Lower Wasatch)	500-2500	Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, thickens to north, slope-former.
CRETACEOUS	?				
	Maestrichthian	Mesaverde Group	Price River Formation	600-1000	Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope-former.
	Campanian		Castlegate Sandstone	150-500	White to gray, coarse-grained often conglomerate sandstone, cliff-former, weathers to shades of brown.
			Blackhawk Formation *MAJOR COAL SEAMS*	700-1000	Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick coal seams.
			Star Point Sandstone	90-1000	Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale, thickens westward.
	Santonian		Masuk Shale	300-1300	Yellow to blue-gray sandy shale, slope-former, thick in northern and central plateau area thins southward.

Figure 2. Generalized section of rock formation, Wasatch Plateau Coal Field, Utah

Table 2. Muddy Creek drilling area strikes and dips

THREE POINTS ON DATUM	ATTITUDE OF DATUM	
	Strike	Dip
MC-14-HM, MC-74-HM, MC-12-HM	N 28° E	1.9° NW
MC-12-HM, MC-11-HM, MC-10-HM	N 29° E	2.0° NW
MC-11-HM, MC-9-HM, MC-10-HM	N 34° E	2.0° NW
MC-9-FP, MC-8-FP, MC-10-HM	N 34° E	1.4° NW
MC-8-FP, MC-7-FP, MC-73-FP	N 40° E	1.3° NW
MC-10-HM, MC-73-FP, MC-15-HM	N 25° E	1.7° NW
MC-74-HM, MC-11-HM, MC-12-HM	N 29° E	1.9° NW
MC-71-AL, MC-72-AL, MC-16-AL	N 11° E	1.4° NW
MC-71-AL, MC-17-AL, MC-75-AL	N 26° E	1.6° NW
MC-71-AL, MC-16-AL, MC-17-AL	N 34° E	1.2° NW
MC-75-AL, MC-18-AL, MC-17-AL	N 42° E	1.8° NW
MC-18-AL, MC-17-AL, MC-20-AL	N 44° E	2.1° NW
MC-18-AL, MC-23-AL, MC-20-AL	N 50° E	2.1° NW
MC-21-AL, MC-29-AL, MC-22-AL	N 46° E	1.6° NW
MC-29-AL, MC-22-AL, MC-28-AL	N 47° E	1.4° NW
MC-22-AL, MC-28-AL, MC-24-AL	N 45° E	1.4° NW
AVERAGE	N 35° E	1.7° NW
STANDARD DEVIATION	10°	0.3
DIPS AND STRIKES IN THE VICINITY OF THE INFERRED FAULT OF MUD SPRINGS HOLLOW		
MC-29-AL, MC-28-AL, BCR-4	N 12° E	3.5° NW
MC-26-AL, MC-28-AL, BCR-4	N 17° E	4.8° NW
MC-28-AL, MC-24-AL, MC-26-AL	N 53° E	3.2° NW
MC-24-AL, MC-26-AL, MC-27-AL	N 5° E	1.5° NW
MC-23-AL, MC-29-AL, BCR-4	N 8° E	3.7° NW
AVERAGE	N 19° E	3.3° NW
STANDARD DEVIATION	20°	1.2°

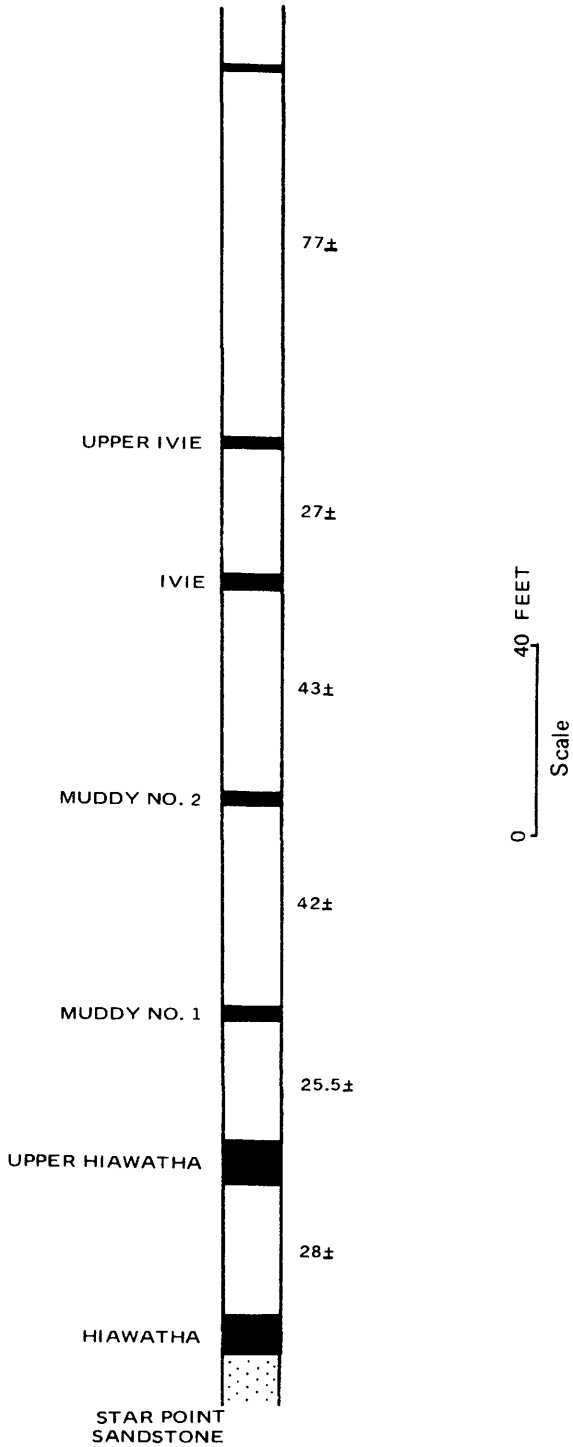

Figure 3. Average column of the Lower Blackhawk in the Muddy Creek drilling area

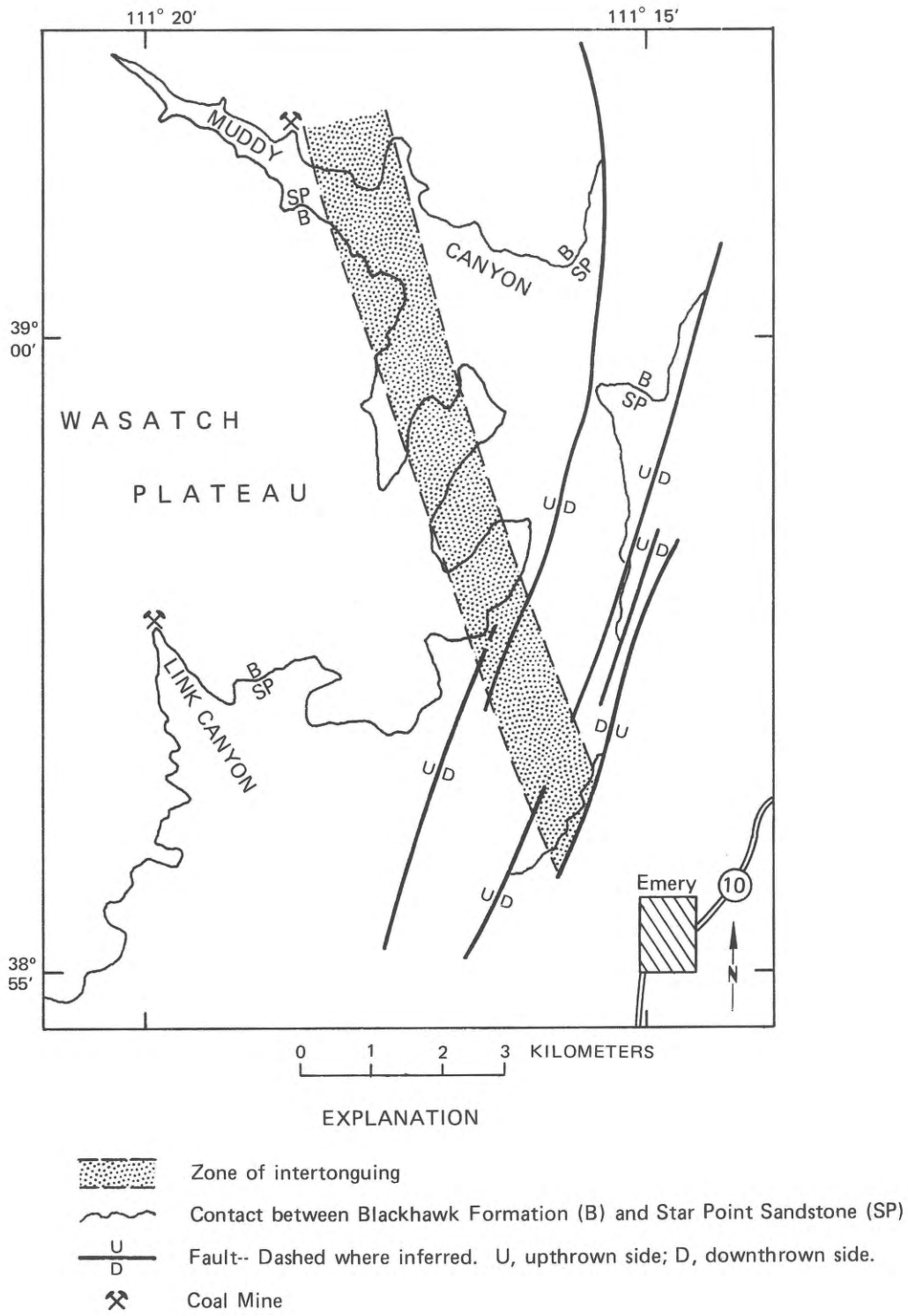

Figure 4. Map of Muddy Canyon-Emery area showing position of contact and zone of intertonguing between Star Point Sandstone and Blackhawk Formation (after Flores, et al)

indicates that the portion of coal above the split in the Hiawatha bed and other beds above do ascend in the column, but they descend again north of Quitchupah Canyon. Inspection of the lithology of the lower Blackhawk in the drill holes located across this rise shows that the formation is composed of alternating sandstone (46 percent), siltstone (32 percent), shale (18 percent) and coal (4 percent) which is not significantly different than the average for the lower Blackhawk for the entire area. Also, there does not appear to be any anomaly in the sequence or stratification thickness of the lithology, and consequently the rise cannot be attributed to differential compaction. The rise is probably the result of subsidence and a protected deposition that allowed a greater net accumulation.

The floor rock for the Hiawatha bed is the top of the Star Point Sandstone which is entirely sandstone in 83 percent of the holes. The roof rock is shale in 50 percent of the holes, siltstone in 39 percent, and sandstone in 11 percent. The lithologies alternate over broad areas and roof problems should not be greater than in other Wasatch Plateau locations.

Upper Hiawatha Coal Bed

The Upper Hiawatha bed has an average thickness of 8.2 feet with a standard deviation of 5.2 feet and a thickness range of 1 to 14 feet. The Upper Hiawatha, like its counterpart, is relatively thin from Convulsion Canyon north to Broad Hollow or MC-26-AL where it thickens to 14 feet. The bed averages 12 feet thick from Broad Hollow to Mud Spring where it thins to about 2 feet. Proceeding to Duncan Draw the bed thickens to 9 feet and averages 10 feet thick northeast to Cowboy Creek. In this interval MC-18-AL and MC-75-AL show a lenticular split up to 7 feet thick which disappears at MC-17-AL only to develop another lenticular split that reaches 5 feet thick as it crosses beneath Quitchupah Creek. Proceeding northeast under Big Ridge the bed thins to a solid 7 feet at MC-73-FP and then diminishes to 1 foot thick at MC-8-FP adjacent to Muddy Creek. An axis of thick coal, plate 3, arcs from MC-26-AL northeastward toward W-TP-5-EW and W-TP-4-EW and this axis also appears to subparallel the zone of intertonguing previously mentioned.

The roof rock is sandstone in 43 percent of the holes, shale in 33 percent and siltstone in 24 percent. The floor rock is shale in 67 percent of the holes and siltstone in 33 percent. No apparent problems were noted in floor and roof rock lithologies that would deleteriously affect mining.

Muddy No. 1 Coal Bed

The Muddy No. 1 bed has an average thickness of 2.3 feet and ranges from 1 foot to 6.5 feet thick. The bed is minable along Muddy Creek and the area of reserves is depicted in plate 4. The bed is present in most drill holes from Duncan Draw (MC-23-AL) northward to Muddy Creek and is generally about 1 foot thick until Muddy Creek is reached,where the bed averages 4.4 feet thick. The roof and floor rock are the same alternating sandstone, siltstone, and shale described for the Hiawatha and Lower Hiawatha. No apparent problems with lithology were noted; however, the average amount of interburden between Muddy No. 1 bed and the Upper Hiawatha is only 29 feet, and, therefore, will effect the recovery of Muddy No. 1 if Upper Hiawatha is mined.

Muddy No. 2 Coal Bed

The Muddy No. 2 Bed has an average thickness of 2.4 feet and ranges from 1 to 6 feet thick. The bed occurs in most of the drill holes south of Quitchupah Canyon and occurs sparsely north of Quitchupah Creek. Minable thicknesses occur in MC-27-AL, MC-21-Al, and MC-18-AL, but the coal appears to be lenticular, and of local significance.

Ivie Coal Bed

The Ivie Bed has an average thickness of 2.8 feet and ranges from 1 to 7 feet thick. The bed occurs in most drill holes south of Big Ridge. Minable thicknesses occur in MC-25-AL and MC-29-AL, and also appear to be lenticular and of local significance.

Upper Ivie Coal Bed

The Upper Ivie Bed averages 1.8 feet in thickness and ranges from 1 to 4 feet thick. The bed is traceable in most of the drill holes from Convulsion Canyon to Muddy Creek. The bed is minable at MC-21-AL, but is lenticular and of local significance.

Flores, et al, 1979 have indicated the presence of a zone of intertonguing between the Star Point Sandstone and the Blackhawk Formation. This zone lies to the east of the Muddy Creek drilling area and was not encountered in any of the holes. The thick coals parallel this zone and identification of areas where intertonguing takes place may indicate where thick and continuous coals may be found in the future in the Blackhawk Formation of the Wasatch Plateau. Areas just to the west of such zones of intertonguing should prove favorable for exploration.

Quality

Core data were obtained from drill holes, BCR-4, MC-8-FP, MC-18-AL, MC-21-AL, MC-71-AL and MC-74-HM, that essentially represent the area from south to north. These core holes were planned so that they would not be separated by more than two miles affording the best coverage from the available funds. The recovered coal cores were measured and described at the drill site, sealed in plastic sleevings and sent to Commercial Testing and Engineering Company (CT & E) in Denver, Colorado for determination of sulfur forms, proximate and ultimate analyses, and trace elements. The average overall rank of the beds is high volatile C bituminous with a moist mineral matter free BTU/LB of 12,899 with a standard deviation of 159. The rank of each bed was calculated utilizing the Parr Formula in accordance with the American Society for Testing Materials (ASTM-D-388) p. 223-225. The average ultimate, proximate, and sulfur form determinations are listed in table 3. Proximate and ultimate analyses on an as-received and dry basis are given in tables 4 and 5 respectively. Sulfur forms and trace elements are presented as tables 6 and 7 respectively.

METHANE CONTENT OF COAL

The methane content of each collected core was measured by the "Direct Method" as outlined in U. S. Bureau of Mines' Report of Investigation 8515. A summary of test results is contained in table 8.

Coal core samples were collected from drill hole MC-8-FP at two depth intervals. First, three increments were collected from drilling interval 1019.1-1022.9. The sample increments were 1019.5-1019.9, 1020.1-1020.5 and 1021.8-1022.0. Between August 5, 1980 and August 26, 1980 the complete sample desorbed 60 cubic centimeters of gas. The calculated lost gas was zero and the sample, when crushed for residual gas, contained none. Therefore, the total gas content was 60 cubic centimeters. The weight of the sample was 1671.43 grams, so the coal contained .04 cubic centimeters of gas per gram which is equivalent to 1.28 cubic feet of gas per ton in place. The long range forecast for mine gas emissions where the coal contains that amount of gas is 7.68 cubic feet per ton per day. The second three samples sealed in the containers were from the drilling interval 1054.3-1057.6. The sample increments were 1054.9-1055.3, 1056.1-1056.4 and 1057.0-1057.6. Between August 8, 1980 and August 26, 1980, the complete sample desorbed 105 cubic centimeters of gas. The lost gas was calculated to be 84 cubic centimeters and the sample, when crushed for residual gas, gave up none. The resulting total gas content was 189 cubic centimeters and the weight of the sample was 1481.9 grams. The coal, therefore, contained 0.13 cubic centimeters of gas per gram which is equivalent to 4.16 cubic feet per ton in place. The long range forecast for mine gas emissions where the coal contains that amount of gas is 24.96 cubic feet per ton of coal produced per day.

Two depth intervals were tested on MC-18-AL. The first depth interval, 1049.6-1159.1, was divided into 4 parts, but sample increments were inadvertantly not recorded. Between July 27, 1979 and August 6, 1979, the sample released 332 cubic centimeters of gas and the lost gas was calculated to be 179 cubic centimeters. No gas was obtained in the residual determination. With a total gas content of 511 cubic centimeters and a sample weight of 1201.95 grams the coal contained 0.43 cubic centimeters of gas per gram of 13.76 cubic feet per ton in place. The long range forecast for gas emissions is 82.56 cubic feet per ton of coal produced per day. The second depth interval tested on MC-18-AL was 1165.8-1173.0 and sample increments were 1169.6-1169.9, 1171.1-1171.4, 1173.1-1173.4 and 1175.2-1175.2. Between July 27, 1979 and August 17, 1979, the complete sample desorbed 309 cubic centimeters of gas. The lost gas was calculated to be 150 cubic centimeters and there was no residual gas. The weight of the sample was 1442.34 grams, so the sample contained .32 cubic centimeters of gas per gram which is equivalent to 10.24 cubic feet per ton in place. The long range forecast for gas emissions is 61.44 cubic feet per ton of coal produced per day.

One sample was tested from MC-71-AL in the depth interval 1664.5-1677.5. Sample increments were 1329.0-1329.55, 1330.4-1330.8 and 1332.2-1332.6. Between September 20, 1980 and October 8, 1980, the amount of gas desorbed was 40 cubic centimeters. The calculated lost gas was 105 cubic centimeters and crushing produced no residual gas. The sample weighed 1476.32 grams, and contained 0.10 cubic centimeters per gram of coal or 3.20 cubic feet per ton in place. The long range forecast for gas emissions is 19.2 cubic feet per ton of coal produced per day.

Three coal core samples were taken from MC-74-HM from as many depth intervals. The first depth interval was 1586.0-1593.0. The sample was divided into 3 parts, 1588.8-1589.0, 1591.2-1591.5 and 1594.2-1594.6 and tested, but no gas was obtained from this sample.

Table 3. Average proximate, ultimate and sulfur forms analyses of coal cores obtained from Muddy Creek area drill holes

	As Received	Dry Basis
AVERAGE PROXIMATE ANALYSIS		
% Moisture	7.39	
% Ash	10.83	11.67
% Volatile Matter	38.27	41.32
% Fixed Carbon	43.51	47.01
Btu/lb	11,377	12,288
AVERAGE ULTIMATE ANALYSIS		
% Moisture	7.39	
% Carbon	64.41	69.57
% Hydrogen	4.63	5.00
% Nitrogen	1.15	1.24
% Chlorine	0.03	0.03
% Sulfur	0.77	0.83
% Ash	10.83	11.67
% Oxygen	10.79	11.86
AVERAGE SULFUR FORMS		
% Pyritic	0.22	0.24
% Sulfate	0.00	0.00
% Organic	0.55	0.59
TOTAL	0.77	0.83

Table 4. Proximate analyses of coal cores obtained from drill holes

Drill Hole Number	Drilling Interval (ft)	Moisture	Ash	Volatile	Fixed Carbon	Btu/lb	Sulfur	MMF-Btu/lb	ASTM Rank
		AS RECEIVED/DRY BASIS %							
MC-8-FP	1019.1-1022.9	6.87/xxxxx	8.83/9.48	37.61/40.38	46.69/50.14	11,755/12,622	1.46/1.57	13,029	hvBb
	1054.3-1057.6	7.85/xxxxx	5.72/6.21	38.69/41.99	47.74/51.80	11,981/13,002	0.84/0.91	12,788	hvCb
MC-18-AL	1138.8-1140.7	5.78/xxxxx	14.14/15.01	40.27/42.74	39.81/42.25	11,094/11,775	0.81/0.86	13,115	hvBb
	1149.6-1154.1(U)	7.82/xxxxx	11.91/12.92	33.88/36.75	46.39/50.33	11,246/12,200	0.37/0.40	12,915	hvCb
	1154.1-1159.1(L)	8.52/xxxxx	5.07/5.54	37.50/40.99	48.91/53.47	12,080/13,205	0.35/0.38	12,787	hvCb
	1165.8-1168.4(U)	6.76/xxxxx	10.47/11.23	39.61/42.48	43.15/46.29	11,553/12,391	0.48/0.51	13,038	hvBb
	1168.4-1173.0(L)	7.73/xxxxx	4.94/5.35	43.34/46.97	43.99/47.68	12,313/13,345	0.45/0.49	13,017	hvBb
	1177.0-1181.4(U)	7.82/xxxxx	7.32/7.94	40.61/44.05	44.25/48.01	11,867/12,874	0.78/0.85	12,903	hvCb
	1181.4-1185.3(L)	6.76/xxxxx	25.72/27.58	36.26/38.89	31.26/33.53	9,073/9,731	1.36/1.46	12,599	hvCb
MC-21-AL	1295.0-1298.4	6.53/xxxxx	15.51/16.59	36.85/39.42	41.11/43.99	10,857/11,616	0.94/1.01	13,066	hvBb
MC-71-AL	~~1323.3-1331.4~~ 1329.3-1337.4	7.32/xxxxx	8.79/9.48	38.98/42.06	44.91/48.46	11,613/12,530	0.93/1.00	12,852	hvCb
MC-74-HM	1588.8-1595.6	7.55/xxxxx	6.36/6.88	38.52/41.67	47.57/51.45	12,144/13,136	0.44/0.48	13,050	hvBb
	1635.5-1646.8	7.79/xxxxx	19.33/20.96	33.49/36.32	39.39/42.72	10,047/10,896	0.47/0.51	12,710	hvCb
	1665.5-1680.4	7.28/xxxxx	11.50/12.40	38.27/41.27	42.95/46.33	11,322/12,211	0.87/0.94	12,949	hvCb
BCR-4	907.2-911.2	8.46/xxxxx	6.91/7.55	40.11/43.82	44.52/48.63	11,705/12,787	1.06/1.16	12,672	hvCb

Table 5. Ultimate analyses of coal cores obtained from drill holes

Drill Hole Number	Drilling Interval	Moisture	Carbon	Hydrogen	Nitrogen	Chlorine	Sulfur	Ash	Oxygen
		AS RECEIVED/DRY BASIS %							
MC-8-FP	1019.1-1022.9	6.87/xxxxx	66.44/71.34	4.59/4.93	1.21/1.30	0.02/0.02	1.46/1.57	8.83/9.48	10.58/11.36
	1054.3-1057.6	7.85/xxxxx	68.10/73.90	4.78/5.19	1.23/1.34	0.03/0.03	0.84/0.91	5.72/6.21	11.45/12.42
MC-18-AL	1138.8-1140.7	5.78/xxxxx	62.56/66.40	4.79/5.08	1.05/1.11	0.05/0.05	0.81/0.86	14.14/15.01	10.82/11.49
	1149.6-1154.1(U)	7.82/xxxxx	64.45/69.92	4.32/4.69	1.00/1.09	0.00/0.00	0.37/0.40	11.91/12.92	10.13/10.98
	1154.1-1159.1(L)	8.52/xxxxx	69.05/75.48	4.68/5.12	1.17/1.28	0.01/0.01	0.35/0.38	5.07/5.54	11.15/12.19
	1165.8-1168.4(U)	6.76/xxxxx	65.60/70.36	4.75/5.09	1.19/1.28	0.04/0.04	0.48/0.51	10.47/11.23	10.71/11.49
	1168.4-1173.0(L)	7.73/xxxxx	68.91/74.68	5.17/5.60	1.25/1.36	0.02/0.02	0.45/0.49	4.94/5.35	11.53/12.50
	1177.0-1181.4(U)	7.82/xxxxx	66.64/72.29	4.95/5.37	1.24/1.35	0.05/0.05	0.78/0.85	7.32/7.94	11.20/12.15
	1181.4-1185.3(L)	6.76/xxxxx	51.38/55.11	3.89/4.17	1.03/1.10	0.04/0.04	1.36/1.46	25.72/27.58	9.82/10.54
MC-21-AL	1295.0-1298.4	6.53/xxxxx	61.06/65.33	4.47/4.78	1.23/1.32	0.02/0.02	0.94/1.01	15.51/16.59	10.24/10.95
MC-71-AL	~~1323.3-1331.4~~ 1329.3-1337.4	7.32/xxxxx	65.53/70.71	4.75/5.12	1.18/1.27	0.06/0.07	0.93/1.00	8.79/9.48	11.44/12.35
MC-74-HM	1588.8-1595.6	7.55/xxxxx	68.62/74.22	4.93/5.33	1.23/1.33	0.04/0.04	0.44/0.48	6.36/6.88	10.83/11.72
	1635.5-1646.8	7.79/xxxxx	57.24/62.08	4.07/4.41	1.00/1.08	0.01/0.01	0.47/0.51	19.33/20.96	10.09/10.95
	1665.5-1680.4	6.76/xxxxx	64.64/69.71	4.49/4.84	1.03/1.11	0.01/0.01	0.87/0.94	11.50/12.40	10.18/10.99
BCR-4	907.2-911.2	8.46/xxxxx	65.87/71.96	4.82/5.26	1.23/1.34	0.01/0.01	1.06/1.16	6.91/7.55	11.64/12.72

Table 6. Sulfur forms analyses of coal cores obtained from drill holes

Drill Hole Number	Drilling Interval	Pyritic	Sulfate	Organic	Total
		AS RECEIVED/DRY BASIS %			
MC-8-FP	1019.1-1022.9	0.81/0.87	0.01/0.01	0.64/0.69	1.46/1.57
	1054.3/1057.6	0.17/0.18	0.00/0.00	0.67/0.73	0.84/0.91
MC-18-AL	1138.8-1140.7	0.09/0.10	0.00/0.00	0.72/0.76	0.81/0.86
	1149.6-1154.1(U)	0.01/0.01	0.00/0.00	0.36/0.39	0.37/0.40
	1154.1-1159.1(L)	0.01/0.01	0.00/0.00	0.34/0.37	0.35/0.38
	1165.8-1168.4(U)	0.10/0.11	0.00/0.00	0.38/0.40	0.48/0.51
	1168.4-1173.0(L)	0.01/0.01	0.00/0.00	0.44/0.48	0.45/0.49
	1177.0-1181.4(U)	0.24/0.26	0.00/0.00	0.54/0.59	0.78/0.85
	1181.4-1185.3(L)	0.48/0.51	0.00/0.00	0.88/0.95	1.36/1.46
MC-21-AL	1295.0-1298.4	0.33/0.35	0.00/0.00	0.61/0.66	0.94/1.01
MC-71-AL	~~1323.3-1331.4~~ 1329.3-1337.4	0.22/0.24	0.00/0.00	0.71/0.76	0.93/1.00
MC-74-HM	1588.8-1595.6	0.05/0.05	0.00/0.00	0.39/0.43	0.44/0.48
	1635.5-1646.8	0.07/0.08	0.00/0.00	0.40/0.43	0.47/0.51
	1665.5-1680.4	0.23/0.25	0.00/0.00	0.64/0.69	0.87/0.94
BCR-4	907.2-911.2	0.52/0.57	0.01/0.01	0.53/0.58	1.06/1.16

Table 7. Trace element determinations of coal cores obtained from drill holes

Drill Hole No.							
Drilling Interval	MC-8-FP 1019.1-1022.9	MC-8-FP 1054.3-1057.6	MC-21-FP 1295.0-1298.4	MC-71-AL 1323.3-1331.4	MC-74-HM 1588.8-1595.6	MC-74-HM 1635.5-1646.8	MC-74-HM 1665.5-1680.4
	Conc. PPM Wt.					Conc. PPM Wt.	
ELEMENT							
Uranium	0.8	1	5	0.5	1	3	3
Thorium	1	2	11	1	1	4	3
Bismuth							
Lead	0.9	2	6	1	1	4	3
Thallium							
Mercury	*0.05	*0.25	*0.21	*0.17	*0.06	*0.07	*0.17
Gold							
Platinum							
Iridium							
Osmium							
Rhenium							
Tungsten							
Tantalum							
Hafnium						0.5	
Lutetium				***1			
Ytterbium							
Thulium							
Erbium							
Holmium							
Dysprosium							
Terbium						0.1	< 0.1
Gadolinium			<2			0.5	0.4
Europium	<0.1		<1			0.2	0.2
Samarium	0.5	0.8	15		0.4	2	0.7
Neodymium	0.6	0.4	4	0.1	0.4	4	0.8
Praseodymium	0.5	0.5	4	0.3	0.4	2	1
Cerium	7	5	42		4	13	11
Lanthanum	5	8	34		3	9	8
Barium	54	***240	770		35	97	200
Cesium	0.3	<0.1	1		1	1	0.5
Iodine	0.1	0.2	4		<0.1	0.4	0.2
Terrurium		<0.2					<0.1
Antimony						0.2	0.1
Tin	0.5	0.2		0.2	0.3	2	0.3
Cadmium	0.2	0.7	1	0.4	0.2	***2	0.4
Silver							
Palladium							
Rhodium							
Ruthenium							
Molybdenum	0.3	0.4		0.5	0.8	0.5	0.4
Niobium	3	1	17	1	2	5	4
Zirconium	15	6	53	9	***95	20	49
Yttrium	4	***6	11	0.8	5	7	2
Strontium	36	58	130	38	52	65	120
Rubidium	1	0.8	7	1	2	8	29
Bromine	4	2	28	2	3	2	3
Selenium	2	0.3	3	0.3	0.4	1	2
Arsenic	1	2	3	***2	0.4	2	2
Germanium	0.1	<0.1		<0.1	0.2	0.2	0.4
Gallium	2	1	9	2	2	8	6
Zinc	3	3	21	3	***5	***26	11
Copper	9	5	44	3	***7	5	10
Nickel	0.9	0.9	<3	2	1	4	1
Cobalt	0.4	0.1	2	0.4	0.6	2	0.6

(continued on pg. 16)

(Table 7. continued)

Drill Hole No. Drilling Interval	MC-8-FP 1019.1-1022.9	MC-8-FP 1054.3-1057.6	MC-21-FP 1295.0-1298.4	MC-71-AL 1323.3-1331.4	MC-74-HM 1588.8-1595.6	MC-74-HM 1635.5-1646.8	MC-74-HM 1665.5-1680.4
Manganese	6	5	13	27	2	12	96
Chromium	6	3	9	2	8	26	38
Vanadium	10	3	25	10	7	30	25
Scandium	1	0.1	8	0.3	0.4	2	0.4
Fluorine	**33	**36	**98	**39	**33	**193	**70
Boron	5	34	68	11	17	21	7
Beryllium	0.4	0.2	0.4	0.1	0.1	0.4	<0.1
Lithium	3	1	11	2	3	13	8

All elements not detected 0.1 ppm
* Flameless Atomic Absorption
** Specific Ion Electrode
*** Heterogeneous

Table 8. *Methane content determinations of coal core obtained from drill holes

Drill Hole Number	Drilling Interval	Lost Gas CM^3	Desorbed Gas CM^3	Residual Gas CM^3	Sample Wt. Grams	Total Gas CM^3/Gram	Ft^3/Ton Coal in Place	Long Range Mine Gas Emissions Ft^3/Ton Prod./Day
MC-8-FP	1019.1-1022.9	0.0	60.0	0.0	1671.4	0.04	1.28	7.68
MC-8-FP	1054.3-1057.6	84.0	105.0	0.0	1481.9	0.13	4.16	24.96
MC-71-AL	1329.2-1332.6	105.0	40.0	0.0	1476.3	0.10	3.20	19.20
MC-18-AL	1149.6-1159.1	179.0	332.0	0.0	1201.9	0.43	13.76	82.56
MC-18-AL	1165.8-1173.0	150.0	309.0	0.0	1442.3	0.32	10.24	61.44
MC-74-HM	1586.0-1593.0	0.0	0.0	0.0	1304.4	0.0		
MC-74-HM	1635.5-1646.3	19.0	5.0	0.0	1190.7	0.02	0.64	3.84
MC-74-HM	1664.5-1677.5	0.0	0.0	0.0	1643.1	0.0		
BCR-4	906.0-912.7	0.0	43.0	0.0	1414.1	0.03	0.96	5.76

*Determined in accordance with U. S. Bureau of Mines R. I. 8515.

The second depth interval was 1635.5-1646.8, but only two sample increments were tested from this seam because of the condition of the core. The sample increments were 1641.7-1642.2 and 1645.2-1645.5, and between September 23, 1980 and October 8, 1980, the sample desorbed 5 cubic centimeters of gas. Lost gas was 19 cubic centimeters and residual gas was determined to be zero. The total gas emission was 24 cubic centimeters, the sample weighed 1190.68 grams and the gas content of the coal was 0.02 cubic centimeters per gram or 0.64 cubic feet per ton in place. The long range forecast for gas emission is 3.84 cubic feet per ton of coal produced per day.

The third depth interval was 1664.5 to 1677.5 and 4 sample increments, 1669.4-1669.75, 1671.75-1672.04, 1673.95-1674.18 and 1677.6-1677.93, were collected and sealed in the cannister at the drill site. After testing was completed, no observable gas had been detected.

One core sample, depth interval 906.0-912.7, was obtained from drill hole BCR-4 and divided into four sample increments. The sample intervals were 907.2-907.4, 908.5-908.7, 909.6-909.8 and 910.9-911.2. Between July 2, 1979 and August 17, 1979, this sample desorbed 43 cubic centimeters of gas, lost gas was calculated to be zero and residual gas was determined to be zero. The weight of the sample was 1414.06 grams with a gas content of 0.03 cubic centimeters per gram. This amounts to 0.96 cubic feet per ton of coal in place and the long range forecast for mine gas emissions is 5.76 cubic feet per ton of coal produced per day.

Even though some tests indicate zero gas, it is well to remember that all coal has some methane content and at least relatively small amounts will be released during mining. Every mining operation should incorporate the necessary ventilation systems to prevent problems.

Quality

The total in-place indicated and inferred tonnages for the Muddy Creek Drilling Project Area is calculated to be 561,572,000 short tons. As indicated, not all of this coal will be recoverable. It is thought that economic recovery can be gotten from 3 beds, the Hiawatha, upper Hiawatha, and Muddy No. 1. The Hiawatha holds 36 percent (203 million tons) of the calculated in-place reserve, the upper Hiawatha holds 62 percent (349 million tons) and the Muddy No. 1 holds 2 percent (10 million tons).

The areas for which reserves were calculated are shown on plates 2, 3, and 4. An isopach of interburden between the Hiawatha bed and the upper Hiawatha bed is presented as plate 5. The reserve estimates are presented by geographic location, township, range and section, and include bed thickness range, measured, indicated, inferred and total quantitites. Tables 9, 10 and 11 show estimates for Hiawatha, upper Hiawatha and Muddy No. 1 beds respectively. A planimeter was used on U. S. Geological Survey 7½-minute (1:24,000) topographic maps to define mine areas. An average value of 1,750 short tons per acre-foot was assigned as the weight of the coal. Reserve calculations were initiated by isopaching each coal bed after which a circle with a radius of ½-mile was struck at each drill hole location. Coal reserves within the circles are considered measured and indicated. Inferred reserves were calculated in the areas ½ to 2½ miles from the drill holes and the four-foot isopach line was used as the limiting terminus for all calculations.

A recovery factor of 55% is assigned to the upper Hiawatha and Muddy No. 1 beds as indicated by the favorable geologic conditions of the area. The interburden between the Hiawatha and upper Hiawatha beds is thin and much care will need to be employed if the lower bed is extracted. The isopach map of the interburden shows areas where the interburden exceeds 35 feet and where the second bed may be mineable. A recoverability of 40 percent is assigned in these areas and all others were excluded from recoverable coal determinations. Recoverable coal, as determined by this project, therefore amounts to 232,976,000 tons.

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Diamond, W. P. and J. R. Levine, 1981, Direct method determination of gas content of coal, procedures and results. U. S. Bureau of Mines Report of Investigation 8515.

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Table 9. In-place coal reserves, Muddy Creek coal drilling project area, Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness

Location	Thickness Rge, ft.	Measured & Indicated	Inferred	Total
T. 20 S., R. 5 E.				
S½ Sec. 19	4-10	2,160	1,203	3,363
S½ Sec. 20	10-11	4,775	1,393	6,168
SW Sec. 21	8-10	495	2,463	2,958
Sec. 28	5-10	5,764	2,073	7,837
Sec. 29	9-11	9,618	1,176	10,794
Sec. 30	4-11	5,356	1,423	6,779
Sec. 31	4-18	846	10,163	11,009
Sec. 32	7-20	11,035	1,950	12,985
Sec. 33	4-7	3,467	212	3,679
T. 21 S., R. 4 E.				
Sec. 12	4-9	3,136	4,040	7,176
Sec. 13	4-9	7,854	2,479	10,333
SE Sec. 14	4-9	1,159	106	1,265
Sec. 23	4-16	5,560	873	6,433
Sec. 24	4-16	10,604	511	11,115
Sec. 25	4-8	3,759	1,587	5,346
Sec. 26	4-10	2,285	3,206	5,491
E½ Sec. 35	4-6	939	1,123	2,062
N½ Sec. 36	5-9	2,712	1,143	3,855
T. 21 S., R. 5 E.				
W½ Sec. 4	4-6	980	339	1,319
Sec. 5	6-20	5,964	122	6,086
Sec. 6	10-19	3,218	1,128	4,346
Sec. 7	12-18	1,703	8,299	10,002
Sec. 8	6-18	2,349	8,379	10,728
W½ Sec. 9	4-5	30	2,600	2,630
W½ Sec. 16	4-5	30	2,186	2,216
Sec. 17	5-10	4,251	4,114	8,365
Sec. 18	7-12	6,152	829	6,981
Sec. 19	4-9	3,190	2,594	5,784
Sec. 20	4-18	8,763	602	9,365
W½ Sec. 21	4-12	346	4,983	5,329
N½N½, SWNW, SW, Sec. 30	4-8	345	3,788	4,133
T. 22 S., R. 4 E.				
Sec. 2	4-6	4,138	151	4,289
Sec. 11	4-5	2,352	53	2,405
SW Sec. 12	4-5	53	354	407
Total in-place reserve		125,388	77,645	203,033

Note: This table depicts overall reserves and was not used to calculate recoverable reserves because thin interburden areas are included. Recoverable reserves were calculated from Table 9A.

Table 9a. In-place coal reserves, Muddy Creek coal drilling project area, Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness and interburden areas less than 35 ft. thick

Location	Thickness Rge, ft.	Measured & Indicated	Inferred	Total
T. 20 S., R. 5 E.				
S½ Sec. 19	4-10	1,513	138	1,651
S½ Sec. 20	10-11			
SW Sec. 21	8-10			
Sec. 28	5-10	356		356
Sec. 29	9-11	4,096	499	4,595
Sec. 30	4-11	5,992	1,562	7,554
Sec. 31	4-18	846	10,161	11,007
Sec. 32	7-20	3,701	1,698	5,399
Sec. 33	4-7	1,370	32	1,402
T. 21 S., R. 4 E.				
Sec. 12	4-9	2,945	4,041	6,986
Sec. 13	4-9	7,758	2,478	10,236
SE Sec. 14	4-9	1,116	80	1,196
Sec. 23	4-16	784		784
Sec. 24	4-16	5,072	53	5,125
Sec. 25	4-8			
Sec. 26	4-10			
E½ Sec. 35	4-6			
N½ Sec. 36	5-9			
T. 21 S., R. 5 E.				
W½ Sec. 4	4-6			
Sec. 5	6-20	3,737		3,737
Sec. 6	10-19	3,218	1,128	4,346
Sec. 7	12-18	1,798	6,800	8,599
Sec. 8	6-18	2,186	1,953	4,138
W½ Sec. 9	4-5			
W½ Sec. 16	4-5			
Sec. 17	5-10			
Sec. 18	7-12	1,249	254	1,503
Sec. 19	4-9	3,132	3,047	6,178
Sec. 20	4-18	1,594	413	2,007
W½ Sec. 21	4-12	100	2,528	2,628
N½N½, SWNW, SW, Sec. 30	4-8		21	21
T. 22 S., R. 4 E.				
Sec. 2	4-6			
Sec. 11	4-5			
SW Sec. 12	4-5			
Total in-place reserve		52,560	36,887	89,447
Recoverable @ 40%				35,779

Table 10. In-place coal reserves, Muddy Creek coal drilling project area, upper Hiawatha, in thousands of short tons, excluding coal less than 4 ft. in thickness.

Location	Thickness Rge, ft.	Measured & Indicated	Inferred	Total
T. 20 S., R. 4 E.				
SE Sec. 24	7	368	1,592	1,960
NW Sec. 25	7	502	1,458	1,960
T. 20 S., R. 5 E.				
S½ Sec. 19	7	3,530	649	4,179
S½ Sec. 20	4-6	2,251	630	2,881
SW Sec. 21	4-5	140	928	1,068
Sec. 28	4-5	901	3,203	4,104
Sec. 29	4-5	3,990	1,225	5,215
Sec. 30	4-7	3,545	1,197	4,742
Sec. 32	4-7	1,608	3,391	4,999
Sec. 33	4-7	1,713	565	2,278
S½ Sec. 34	4-7	2,734	322	3,056
T. 21 S., R. 4 E.				
Sec. 12	4-6	808	105	913
Sec. 13	4-9	5,654	1,132	6,786
SE Sec. 14	4-5	459	---	459
Sec. 23	4-9	3,194	453	3,647
Sec. 24	6-12	9,645	982	10,627
Sec. 25	9-12	9,625	3,831	13,456
Sec. 26	4-10	4,187	2,453	6,640
S½ Sec. 34	4-6	749	1,129	1,878
Sec. 35	4-12	4,823	2,015	6,838
N½ Sec. 36	9-13	4,544	2,461	7,005
T. 21 S., R. 5 E.				
Sec. 3	7-9	3,631	343	3,974
Sec. 4	7-9	1,509	2,378	3,887
Sec. 5	4-7	2,022	93	2,115
Sec. 7	4-7	639	1,470	2,109
Sec. 8	4-10	769	7,062	7,831
Sec. 9	7-12	110	11,387	11,497
Sec. 10	9-13	135	12,445	12,580
S½NW, SW, S½SE, Sec. 11	11-15	903	6,082	6,985
SW Sec. 13	11-14	---	3,026	3,026
Sec. 14	13-16	11,882	4,674	16,556
Sec. 15	13-16	4,314	12,214	16,528
Sec. 16	10-16	5,879	9,411	15,290
Sec. 17	8-13	5,025	7,340	12,365
Sec. 18	5-11	5,646	429	6,075
Sec. 19	10-14	4,390	4,883	9,273
Sec. 20	11-16	14,392	1,013	15,405
T. 21 S., R. 5 E.				
Sec. 21	13-14	2,126	14,391	16,517
Sec. 22	10-15	1,260	13,062	14,322
Sec. 23	8-13	6,669	5,127	11,796
W½ Sec. 24	7-11	3,374	1,574	4,948
N½N½, SWNW, SW Sec. 30	12	509	6,862	7,371
T. 22 S., R. 4 E.				
Sec. 2	5-14	12,158	319	12,477
Sec. 3	4-9	5,817	1,044	6,861
Sec. 10	4-9	1,702	4,645	6,347
Sec. 11	9-14	10,307	2,407	12,714
Pt. SW Sec. 12	12	117	1,338	1,455
Sec. 13	4-10	5,519	1,661	7,180
Sec. 14	4-10	218	5,454	5,672
NE Sec. 15	4-7	429	587	1,016
Total in-place coal		176,421	172,442	348,863
Recoverable @ 55%				191,875

Table 11. In-place coal reserves, Muddy Creek coal drilling project area, Muddy No. 1, in thousands of short tons, excluding coal less than 4 ft. in thickness

Location	Thickness	Measured & Indicated	Inferred	Total
T. 20 S., R. 4 E.				
Sec. 24	5.5	249	---	249
Sec. 25	5.5	33	---	33
T. 20 S., R. 4 E.				
Sec. 19	5.5	2,927	---	2,927
Sec. 20	5.5	2,661	---	2,661
Sec. 21	5.5	232	---	232
Sec. 28	5.5	730	---	730
Sec. 29	5.5	2,056	---	2,056
Sec. 30	5.5	788	---	788
Total in-place reserve		9,676		9,676
Recoverable @ 55%				5,322

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DESCRIPTION OF DRILLING

An outline of pertinent information for each drill hole is presented in narrative form in this section. This data is coupled with a lithologic log of the more important intervals. Encountered minable coal seams are depicted with 25 feet of roof rock and 10 feet of floor rock. The complete logging information of the 27 drill holes was prepared as reproducible page logs and an example (drill hole MC-7-FP) is included in this publication as Appendix 1. These records give location, elvation, total depth, a lithologic log with written descriptions, and geophysical logs (caliper, natural gamma, gamma gamma density) and resistivity for each hole. These page logs are on open-file at the Utah Geological and Mineral Survey offices and all or any part may be reproduced for cost and a small handling fee.

Drill holes are identified in this report and in the open-file report by a lettering and number system. BCR-4 was a hole begun by the Branch of Coal Resources of the U.S. Geological Survey and completed by UGMS. All of the remaining holes are prefixed by the letters MC, which stands for the Muddy Creek project. The number refers to the order of drilling and missing numbers were cancelled or drilled elsewhere. The remaining letters refer to the USGS topographic quadrangle on which the hole was drilled. Thus the drill hole described in the Appendix (MC-7-FP) is Muddy Creek Project No. 7, located on the Flagstaff Peak quadrangle.

Drilling in the Muddy Creek area presents many problems and the following suggestions are presented to future drillers. Logistics are difficult because of accessibility and the distance to towns with service facilities. Establishment of a centrally located base camp with stores of fuel, lubricants, and drilling muds is recommended. All roads are unimproved and rapidly break down unless a rigid sprinkling program is followed. Because of low humidity, roads should be diligently sprinkled in the early morning and late evening. Permission must be obtained for the use of all water in the area, but it is usually abundant until the autumn season. Road work, site preparation, and rehabilitation capabilities are available locally. A mechanic's truck with a welder, cutting torch, and commonly used parts should be in the area along with "over-shot", "trash basket", and magnet for possible down-hole problems.

Of the many approaches to drilling, this area seems to be most easily drilled by utilizing air until water bearing zones are encoutered, then switching to a low up-hole velocity system such as stiff foam or aerated mud. Booster air along with stiff foam has been used with success in the area. Round the clock drilling is best because of hole instability (break-down of weak rock formations and water-sensitive units).

The Price River Formation, which contains occasional limestone beds in its upper part, generally consists of sandstone alternating with siltstone and shale, usually has good to fair penetration rates. Lost circulation can be a problem. Significant caving and washover zones are to be expected so that casing the full interval is strongly recommended.

The mean thickness of the Castlegate Sandstone is 226 feet, and generally the medium- to coarse-grained sandstone drills well and is penetrated in one shift. Water-bearing zones were encoutered in the Castlegate in some holes.

The Blackhawk Formation is predominantly sandstone alternating mostly with siltstone and with lesser amounts of shale. The lower 250 feet contain most of the coal. Generally, the Blackhawk has a 200-feet per shift penetration rate. Lost circulation zones can be expected, but the problems are manageable if up-hole problems have been eliminated.

The Star Point Sandstone is a massive, fine-grained sandstone and the penetration rate is excellent. Minor siltstone and shale partings appear in one-third of the holes. The unit usually presents no drilling problems, but there can be a recognition problem. A Star-Point-like sandstone often splits the Hiawatha coal seam, and to prevent a premature TD the practice of drilling at least 50 feet into the Star Point appears to be prudent. The mean depth of the 27 drilled holes was 1,268 feet.

BCR-4. This hole was drilled north of Spring Hollow in the SW¼ NE¼, Sec. 2, T. 22 S., R. 4 E. and the collar elevation was 8,310 feet. Drilling commenced June 25, 1979 by rotary method to a depth of 830 feet after which the hole was cored to a total depth of 1,040 feet. Seventeen coal seams were found in the Blackhawk, but only two were thicker than 4 feet and only 16 feet of interburden separated them.

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	2	
	Shale	2	
	Siltstone	6	
845-870	Shale	1	
Roof Rock	Sandstone	1	
	Shale	1	
	Siltstone	6	
	Shale	4	
	Sandstone	1	
870-883	Coal	13	
Upper Hiawatha			
	Shale	2	
	Siltstone	2	
883-899	Sandstone	6	
Interval	Shale	4	
	Silstone	2	
899-905	Coal	6	
Hiawatha			
905-915	Siltstone	5	
Floor Rock	Sandstone	5	

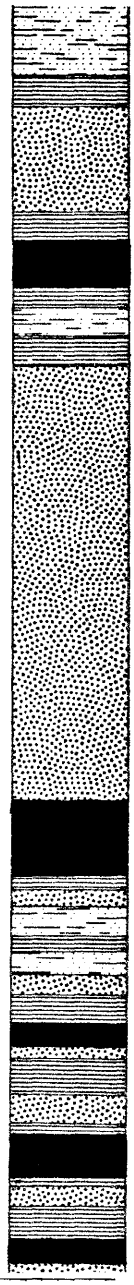
The hole was spudded in colluvium, but reached the erosional top of the Castlegate after 5 feet. The remaining Castlegate is 109 feet thick and 100 percent sandstone. The drilled Blackhawk Formation is 863 feet thick and composed of alternating siltstone (44 percent), sandstone (38 percent), shale (13 percent), and coal (5 percent). Some coals occur relatively high in the formation at this location, but they are thin and discontinuous. The minable coals are located in the lower 250 feet of the formation which is standard in this area. Sixty-three feet of Star Point Sandstone were penetrated, all of which is sandstone. Only 59 feet were geophysically logged.

MC-7-FP. This hole was drilled on the northwest rim of The Box, a tributary of Muddy Creek in the SE¼ SW¼, Sec. 34, T. 20 S., R. 6 E. The collar elevation is 8,319 feet and rotary drilling commenced July 15, 1980 and was completed July 17, 1980 at a total depth of 1,080 feet. Eight coal seams were intersected in this hole of which three were of minable thickness (greater than 4 feet).

This hole was spudded in 27 feet of colluvium to the Castlegate Sandstone. The drilled Castlegate Sandstone is 218 feet thick and is predominantly sandstone (81 percent), with siltstone (8 percent), and shale (11 percent) breaks to four feet thick that are interspersed

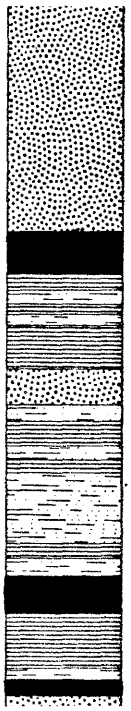
throughout. The Blackhawk Formation is 788 feet thick and consists of alternating sandstone (40 percent), siltstone (23 percent), shale (33 percent), and coal (4 percent). The 47 feet of penetrated Star Point Sandstone consisted entirely of sandstone.

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	8	
901.4-926.4	Shale	3	
Roof Rock	Sandstone	11	
	Shale	3	
926.4-930.6	Coal	4.2	
Muddy			
	Shale	2	
930.6-940.6	Siltstone	3	
Floor Rock	Shale	3	
	Sandstone	2	
959.5-984.5	Sandstone	25	
984.5-992.1	Coal	7.6	
Upper Hiawatha			
	Shale	1.5	
	Sandstone	2	
	Siltstone	3	
	Shale	2	
	Siltstone	2	
992.1-1019.6	Sandstone	2	
Interval	Shale	3.5	
	Coal	2	
	Sandstone	1.5	
	Shale	4	
	Sandstone	3	
	Shale	1	
1019.6-1023.7	Coal	4.1	
Hiawatha			
	Shale	1	
1023.7-1033.7	Sandstone	2	
Floor Rock	Shale	4	
	Coal	2	
	Sandstone	1	



MC-8-FP. This hole was drilled adjacent to and southeast of Cowboy Creek in the NW¼ SE¼, Sec. 33, T. 20 S., R. 5 E. at a collar elevation of 8,224 feet. Drilling commenced July 24, 1980 by rotary method to a depth of 880 feet after which the hole was cored to a total depth of 1,128 feet on August 9, 1980. Six coal seams were intersected in this hole, but only two are marginally (greater than 3½ feet but less than 4 feet) minable.

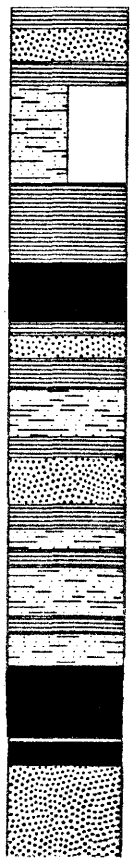
Interval (ft)	Lithology	Thickness (ft)	Column
994.1-1019.1	Sandstone	25	
Roof Rock			
1019.1-1022.9	Coal	3.8	
Upper Hiawatha			
	Shale	2	
	Siltstone	1	
	Shale	1	
	Siltstone	1	
	Shale	4	
1022.9-1054.4	Sandstone	4	
Interval	Siltstone	2	
	Shale	3	
	Siltstone	1	
	Shale	1	
	Siltstone	7.5	
	Shale	2	
	Siltstone	2	
1054.4-1058	Coal	3.6	
Hiawatha			
	Shale	6	
1058-1068	Siltstone	1	
Floor Rock	Coal	1.4	
	Sandstone	1.6	



Thirty-three feet of colluvium were penetrated before the erosional top of the Castlegate Sandstone was reached. The remaining Castlegate Sandstone is 215 feet thick and is predominantly sandstone (86 percent), with siltstone (9 percent), and shale (5 percent) breaks throughout. The Blackhawk Formation is 818½ feet thick and is composed of alternating sandstone (45 percent), siltstone (23 percent), shale (30 percent), and coal (2 percent). The 61½ feet of penetrated Star Point Sandstone consisted entirely of sandstone of which 60½ feet were logged.

MC-9-FP. This hole was drilled northwest of Greens Canyon and just southwest of Muddy Creek in the NE¼ SW¼, Sec. 28, T. 20 S., R. 5 E. The elevation of the collar was 8,155 feet. Drilling commenced July 8, 1980 by rotary method and was concluded July 9, 1980 at a total depth of 1,180 feet. Six coal seams were intersected in this hole, but only two were minable (greater than 4 feet).

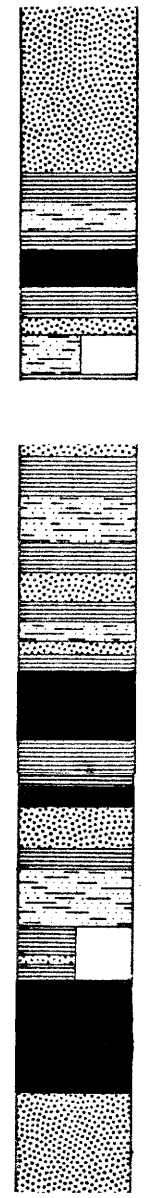
Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	2	
1010.4-1035.4	Sandstone	3	
Roof Rock	Shale	2	
	Siltstone	10	
	Shale	8	
1035.4-1041.2	Coal	5.8	
Upper Hiawatha			
	Shale	2	
1041.2-1051.2	Sandstone	2	
Floor Rock	Shale	3	
	Siltstone	3	
	Siltstone	1	
	Shale	2	
	Sandstone	5	
1052.4-1077.4	Shale	3	
Roof Rock	Siltstone	2	
	Shale	2	
	Silstone	5	
	Shale	2	
	Siltstone	3	
1077.4-1087.1	Coal	7	
Hiawatha			
	Shale	.7	
1087.1-1097.1	Coal	2	
Floor Rock	Sandstone	10	



This hole was spudded in 47 feet of colluvium which covered the Castlegate Sandstone. The penetrated Castlegate Sandstone is 211½ feet thick and consists of sandstone (80 percent), with siltstone (8 percent), and shale (12 percent) breaks no more than four feet thick scattered throughout. The Blackhawk Formation is 828½ feet thick and consists of alternating sandstone (41 percent), siltstone (32 percent), shale (24 percent), and coal (3 percent). The 93 feet of Star Point Sandstone penetrated consisted entirely of sandstone (80 percent) except for some siltstone (17 percent), and shale (3 percent) breaks in the lower 30 feet. Ninety feet of the interval were geophysically logged.

MC-10-HM. This hole was drilled west of Greens Hollow in the SE¼ NE¼, Sec. 32, T. 20 S., R. 5 E. The collar elevation was 8,152 feet and rotary drilling commenced June 28, 1980 and concluded July 3, 1980 at a total depth of 1,180 feet. Twelve coal seams were intersected in this hole and three were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	17	
566-591	Shale	3	
Roof Rock	Siltstone	3	
	Shale	2	
591-595	Coal	4	
Muddy			
	Shale	3	
595-605	Sandstone	2	
Floor Rock	Siltstone	4	
	Shale	1	
	Sandstone	2	
	Shale	4	
	Siltstone	5	
1045.5-1070.5	Shale	3	
Roof Rock	Sandstone	3	
	Shale	2	
	Siltstone	2	
	Sandstone	2	
	Shale	2	
1070.5-1077	Coal	6.5	
Upper Hiawatha			
	Shale	5	
	Coal	1.5	
	Sandstone	4.5	
1077-1102.5	Shale	2	
Interval	Siltstone	6	
	Shale	3	
	Sandstone	1	
	Shale	2.5	
1102.5-1113	Coal	10.5	
Hiawatha			
1113-1123	Sandstone	10	
Floor Rock			



Twenty-three feet of colluvium were penetrated before the erosional top of the Castlegate Sandstone was reached. The remaining Castlegate is 200 feet thick and is predominantly sandstone (73 percent) with numerous siltstone (15 percent), and shale (12 percent) intervals that do not exceed 7 feet in thickness. Breaks occur throughout the column, but are more concentrated in the lower part. The Blackhawk Formation is 890 feet thick and consists of alternating sandstone (42 percent), siltstone (28 percent), shale (26 percent),

and coal (4 percent). Sixty-two of the 67 feet of Star Point Sandstone drilled were geophysically logged and the section consisted entirely of sandstone.

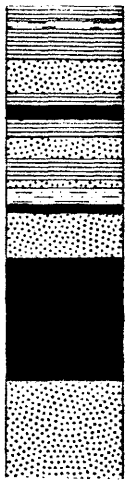
MC-11-HM. This hole was drilled southwest of the confluence of Muddy Creek and Horse Creek at an elevation of 8,049 in the NE¼ NE¼, Sec. 29, T. 20 S., R. 5 E. Rotary drilling commenced on July 17, 1980 and concluded August 13, 1980 at a total depth of 1,185 feet. Seven coal seams were intersected in this hole of which four are minable (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	2	
	Shale	2	
	Siltstone	3	
1004.1-1030.1	Sandstone	8	
Roof Rock	Siltstone	3	
	Sandstone	2	
	Shale	1	
	Siltstone	2	
	Shale	2	
1030.1-1034	Coal	3.9	
Muddy No. 2			
	Shale	1	
1034-1048.4	Sandstone	4	
Interval	Shale	3	
	Siltstone	3.4	
	Shale	3	
1048.4-1056.3	Coal	7.9	
Muddy No. 1			
	Shale	1.2	
	Sandstone	2	
	Siltstone	3	
	Coal	1.9	
1056.3-1079.4	Shale	2	
Inerval	Siltstone	3	
	Shale	2	
	Siltstone	2	
	Shale	2	
	Siltstone	2	
	Sandstone	2	
1079.4-1083.9	Coal	4.5	
Upper Hiawatha			

(continued)

(MC-11-HM continued)

	Shale	1	
	Siltstone	1	
	Shale	3	
	Sandstone	3	
	Shale	2	
1083.9-1109.9	Coal	1.5	
Interval	Shale	2	
	Sandstone	2	
	Shale	2	
	Sandstone	1	
	Siltstone	2	
	Coal	.5	
	Sandstone	5	
1109.9-1123.1	Coal	13.2	
Hiawatha			
1123.1-1133.1	Sandstone	10	
Floor Rock			



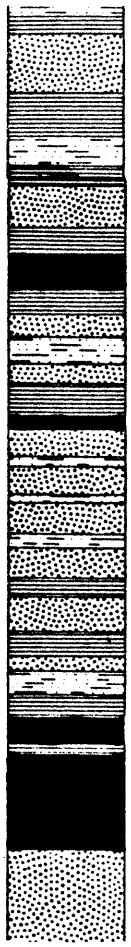
Three feet of colluvium covers the Castlegate Sandstone which is 243 feet thick and consists predominantly of sandstone (70 percent) that is interrupted by breaks of siltstone (11 percent) and shale (19 percent). The Blackhawk Formation is 877 feet thick and consists of alternating sandstone (45 percent), siltstone (22 percent), shale (29 percent), and coal (4 percent). Sixty-two feet of Star Point Sandstone were penetrated consisting of sandstone (87 percent) interrupted by siltstone (13 percent) intervals. Geophysical logging extended 56 feet into the unit.

MC-12-HM. This hole was drilled southwest of the confluence of Muddy Creek and Horse Creek in NE¼ SE¼, Sec. 30, T. 20 S., R. 5 E. at a collar elevation of 8,147 feet. Rotary drilling commenced July 10, 1980 and concluded July 13, 1980 at a total depth of 1,440 feet. Seven coal seams were intersected in this hole and two were of minable thickness (greater than 4 feet).

The erosional top of the Price River Formation was reached under 43 feet of colluvium. The remaining Price River Formation is 125 feet thick and consists of alternating sandstone (40 percent), siltstone (14 percent), and shale (46 percent). The Castlegate Sandstone is 299 feet thick and is predominantly sandstone (71 percent), with several siltstone (15 percent), and shale (14 percent) breaks throughout. The Blackhawk Formation is 863 feet thick and consists of alternating sandstone (47 percent), siltstone (19 percent), shale (31 percent), and coal (3 percent). The drilling penetrated 110 feet of the Star Point Sandstone of which 106 feet were geophysically logged. The unit is mostly

sandstone (84 percent), with siltstone (10 percent), and shale (6 percent) breaks and partings occurring in the lower 52 feet.

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	1	
	Shale	2	
	Sandstone	6	
1243.1-1268.1	Shale	5	
Roof Rock	Siltstone	2	
	Shale	2	
	Sandstone	4	
	Shale	3	
1268.1-1272	Coal	3.9	
Upper Hiawatha			
	Shale	2	
1272-1282	Sandstone	2	
Floor Rock	Siltstone	3	
	Sandstone	2	
	Shale	1	
	Sandstone	3	
	Siltstone	1	
	Sandstone	3	
	Siltstone	1	
1291.6-1316.6	Sandstone	3	
Roof Rock	Shale	2	
	Sandstone	3	
	Shale	3	
	Sandstone	1	
	Siltstone	3	
	Shale	2	
1316.6-1330.4	Coal	2.8	
Hiawatha			
1330.4-1340.4	Shale	1	
Floor Rock	Coal	10	
	Sandstone	10	



MC-14-HM. This hole was drilled southeast of the confluence of the North and South Fork of Muddy Creek in the NE¼ NW¼, Sec. 30, T. 20 S., R. 5 E. at a collar elevation of 8,423 feet. Rotary drilling commenced August 8, 1980 and concluded September 17, 1980 at a total depth of 1,852 feet. Seven coal seams were intersected and three were of minable thickness (greater than 4 feet).

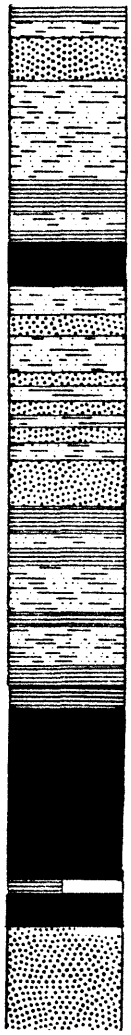
Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	15	
1631-1656	Shale	4	
Roof Rock	Sandstone	4	
	Siltstone	2	
1656-1661.4	Coal	5.4	
Muddy No. 1			
	Sandstone	4.6	
	Shale	2	
1661.4-1685	Siltstone	2	
Interval	Shale	2	
	Sandstone	3	
	Shale	10	
1685-1692.5	Coal	7.5	
Upper Hiawatha			
	Siltstone	2	
1692.5-1702.5	Sandstone	2	
Floor Rock	Shale	2	
	Coal	1.6	
	Shale	2.4	
	Sandstone	13	
	Shale	3	
1717.2-1742.2	Siltstone	2	
Roof Rock	Shale	1	
	Siltstone	1	
	Shale	5	
1742.2-1752.1	Coal	3.3	
Hiawatha	Shale	1.7	
	Coal	4.9	
1752.1-1762.1	Sandstone	10	
Floor Rock			

This hole was spudded in colluvium and the erosional top of the Price River Formation was encountered 30 feet beneath the surface. The remaining Price River Formation is 560 feet thick and consists of alternating sandstone (36 percent), siltstone (25 percent), shale (32 percent), and limestone (7 percent). All of the limestone is found in the upper 390 feet at this location. The Castlegate Sandstone is 282 feet thick and is composed of sandstone (60 percent), with siltstone (21 percent), and shale (19 percent) breaks throughout the interval. The Blackhawk Formation is 880 feet thick

and is composed of alternating sandstone (53 percent), siltstone (13 percent), shale (31 percent), and coal (3 percent). One hundred feet of Star Point Sandstone were penetrated before total depth was reached and all was geophysically logged. The entire interval is sandstone (95 percent) except for a shale (5 percent) break in the lower 35 feet.

MC-15-HM. This hole was drilled near the head of Cowboy Creek 400 feet east of the west line and 750 feet south of the north line of Sec. 5, T. 21 S., R. 5 E. from a collar elevation of 8,310 feet. Drilling commenced July 27, 1980 by rotary method and was concluded July 29, 1980 at a total depth of 1,360 feet. Two of the 6 coal seams intersected in this hole were of minable thickness (greater than 4 feet).

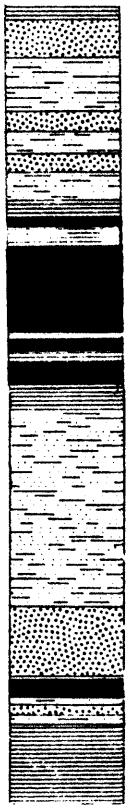
Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	2	
	Siltstone	2	
1189.5-1214.5	Sandstone	5	
Roof Rock	Siltstone	10	
	Shale	3	
	Siltstone	2	
	Shale	1	
1214.5-1219	Coal	4.5	
Upper Hiawatha			
	Siltstone	3	
1219-1229	Sandstone	2	
Floor Rock	Siltstone	4	
	Sandstone	1	
	Sandstone	4	
	Shale	3	
	Siltstone	2	
1237.5-1262.5	Shale	2	
Roof Rock	Siltstone	5	
	Shale	1	
	Siltstone	4	
	Shale	4	
1262.5-1285.5	Coal	17.5	
Hiawatha	Shale	1.2	
	Coal	4.3	
1285.5-1295.5	Sandstone	10	
Floor Rock			



The erosional top of the Price River Formation was reached under 45 feet of colluvium. The remaining Price River is 101 feet thick and is composed of sandstone (39 percent), siltstone (35 percent), and shale (26 percent). The Castlegate Sandstone is 221½ feet thick and is predominantly sandstone (96 percent) with minor siltstone (4 percent) breaks. The Blackhawk Formation is 917½ feet thick and is composed of alternating sandstone (45 percent), siltstone (28 percent), shale (23 percent), and coal (4 percent). The penetrated Star Point Sandstone is 74½ feet thick and is all sandstone except for 7 feet of siltstone found near the bottom of the hole.

MC-16-AL. This hole was drilled at the head of Quitchupah Creek 800 feet east of the west line and 300 feet north of the south line of Sec. 18, T. 21 S., R. 4 E. from a collar elevation of 8,253 feet. Drilling commenced July 24, 1979 by rotary method and was concluded August 3, 1979 at a total depth of 1,260 feet. Eight coal seams were discovered but only two were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	1	
	Sandstone	4	
	Siltstone	6	
	Sandstone	2	
1045-1070	Siltstone	2	
Roof Rock	Sandstone	2	
	Siltstone	3	
	Shale	2	
	Coal	.5	
	Shale	2.5	
1070-1079	Coal	9	
Upper Hiawatha			
	Siltstone	1	
	Coal	1	
1079-1080	Shale	2	
Floor Rock	Coal	2	
	Shale	2	
	Siltstone	2	
	Siltstone	5	
	Sandstone	7	
	Siltstone	1	
1104-1129	Coal	1	
Roof Rock	Siltstone	1	
	Sandstone	1	
	Siltstone	1	
	Shale	8	



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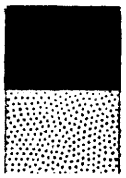
(MC-16-AL continued)

1129-1137 Hiawatha	Coal	8
1137-1147 Floor Rock	Sandstone	10



The drill hole was spudded in colluvium and at a depth of 54 feet the erosional top of the Castlegate Sandstone was encountered. The Castlegate consists of sandstone (99 percent) and shale (1 percent) and is 221 feet thick. The Blackhawk Formation is 862 feet thick and consists of alternating siltstone (44 percent), sandstone (38 percent), shale (15 percent), and coal (3 percent). The Star Point Sandstone was penetrated 123 feet before "TD" was called and consists of sandstone (89 percent) and siltstone (11 percent). Geophysical logging covers the upper 115 feet of the Star Point interval.

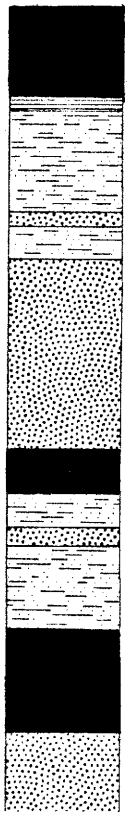
MC-17-AL. This hole was drilled north of the South Fork of Quitchupah Creek in the NW¼ NE¼, Sec. 24, T. 21 E., R. 4 E., at a collar elevation of 8,317 feet. Rotary drilling commenced August 5, 1979 and concluded August 12, 1979 at a total depth of 1,260 feet. Ten coal seams were intersected, but only four were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	14	
659-684	Shale	3	
	Sandstone	3.5	
	Siltstone	4.5	
684-689	Coal	5	
	Shale	3	
689-699	Sandstone	1.5	
	Siltstone	5.5	
	Sandstone	3	
	Siltstone	3	
	Sandstone	.5	
	Siltstone	3	
1108-1133	Coal	1.5	
Roof Rock	Sandstone	2	
	Shale	1	
	Siltstone	1.5	
	Sandstone	2	
	Siltstone	7.5	

(continued)

(MC-17-AL continued)

1133-1142 Upper Hiawatha	Coal	9
1142-1152	Shale	1.5
Floor Rock	Siltstone	8.5
1154.5-1179.5	Sandstone	1.5
Roof Rock	Siltstone	3.5
	Sandstone	20
1179.5-1183.5 Hiawatha	Coal	4
1183.5-1198.6	Siltstone	4
Split	Sandstone	2
	Siltstone	9
1198.6-1209 Hiawatha	Coal	10.4
1209-1219	Sandstone	10



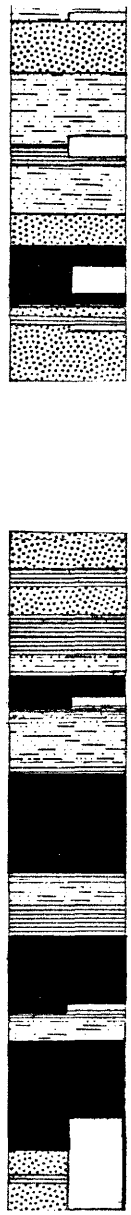
The drill hole was spudded in two feet of colluvium which covers the erosional top of the Price River Formation. The remnant Price River Formation is 98 feet thick and consits of shale (61 percent), sandstone (19 percent), and siltstone (16 percent). The Castlegate Sandstone is 223½ feet thick and consists of sandstone (85 percent), siltstone (9 percent), and shale (6 percent). The Blackhawk Formation is 885½ feet thick and is composed of sandstone (39 percent), siltstone (48 percent), shale (9 percent), and coal (4 percent). The 46 feet of Star Point Sandstone geophysically logged is entirely sandstone. The drilled interval is 51 feet.

MC-18-AL. This hole was drilled at the head of the South Fork of Quitchupah Creek in the NW¼ SW¼, Sec. 24, T. 21 S., R. 4 E. The collar elevation was 8,271 feet. Rotary drilling commenced July 23, 1979 to 925 feet after which the hole was cored to a total depth of 1,222 feet. Six coal seams were intersected; three were of minable thickness (greater than 4 feet).

Twenty-five feet of colluvium were penetrated before the erosional top of the Price River Formation was encountered. The remaining Price River Formation is 46 feet thick and consists of sandstone (73 percent), siltstone (18 percent), and shale (9 percent). The Castlegate Sandstone is 258 feet thick and is predominantly

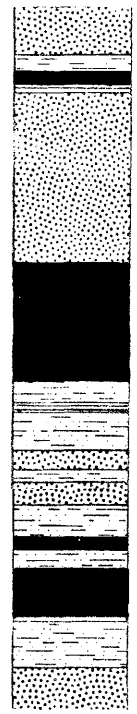
sandstone (98 percent) with minor shale and siltstone partings (2 percent) in the lower portion. The Blackhawk Formation is 859½ feet thick with alternating sandstone (45 percent), siltstone (33 percent), shale (12 percent), and coal (5 percent). The 25½ feet of Star Point Sandstone geophysically logged is all sandstone except for one thin shale parting. The drilled Star Point interval was 33 feet.

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	2	
	Sandstone	5	
980-1005	Siltstone	7.5	
Roof Rock	Shale	2	
	Siltstone	5	
	Sandstone	4	
1005-1011	Coal	6	
	Sandstone	1	
1011-1021	Shale	1	
Floor Rock	Sandstone	6	
	Shale	1	
	Sandstone	4	
	Sandstone	3	
	Shale	2	
	Sandstone	3	
1125-1150	Shale	4	
Roof Rock	Siltstone	2	
	Coal	3	
	Siltstone	6	
	Shale	1	
1150-1159	Coal	9	
Upper Hiawatha			
1159-1166	Shale	1	
Interval	Siltstone	2	
	Shale	4	
1166-1173	Coal	7	
Hiawatha			
1173-1177	Shale	1	
Split	Siltstone	3	
1177-1185	Coal	8	
Hiawatha			
1185-1195	Sandstone	3	
Floor Rock	Shale	1	
	Sandstone	6	



MC-20-AL. This hole was drilled between Duncan Mountain and the South Fork of Quitchupah Creek in the NW¼ NE¼, Sec. 25, T. 21 S., R. 4 E. The collar elevation was 8,342 feet. Rotary drilling commenced August 12, 1979 and concluded August 21, 1979 at a total depth of 1,210 feet. Eight coal seams were encountered in this drill hole, two were of minable thickness (greater than 4 feet).

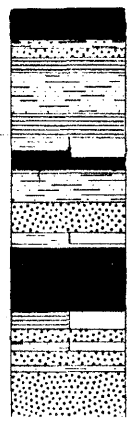
Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	5	
1031-1058	Siltstone	2	
Roof Rock	Coal	1	
	Shale	1	
	Sandstone	18	
1058-1070	Coal	12	
Upper Hiawatha			
	Siltstone	3	
	Shale	1	
	Siltstone	4	
1070-1089	Sandstone	2	
Interval	Siltstone	1	
	Sandstone	2	
	Siltstone	3	
	Coal	1	
	Siltstone	2	
1089-1093	Coal	4	
Hiawatha			
1093-1103	Shale	1	
Floor Rock	Siltstone	4	
	Sandstone	5	



This drill hole was spudded through 5 feet of colluvium to the erosional top of the Price River Formation. The 25 feet of Price River Formation drilled consists of alternating sandstone (52 percent), siltstone (32 percent), and shale (16 percent). The underlying Castlegate Sandstone is 227 feet thick and consists almost entirely of sandstone (96 percent) with a few siltstone (3 percent) and shale partings (1 percent). The Blackhawk Formation is 842 feet thick and consists of alternating sandstone (41 percent), siltstone (46 percent), shale (9 percent), and coal (4 percent), the latter scattered through the lower 780 feet. The minable seams are confined to the lower 50 feet. The 111 feet drilled into the Star Point Sandstone was geophysically logged to 103 feet and consisted entirely of sandstone except for a 4-foot shale and siltstone parting.

MC-21-AL. This test hole was drilled northeast of Lizonbee Springs at the head of Mud Spring Hollow in the NW¼ NE¼, Sec. 34, T. 21 S., R. 4 E. The collar elevation was 8,438 feet. Drilling commenced August 8, 1979 by rotary method to 1,280 feet after which the hole was cored to a total depth of 1,440 feet. Twenty-one coal seams were intersected and only one was of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Coal	2	
	Sandstone	2	
	Shale	2	
	Siltstone	4	
	Shale	2	
1273-1298	Siltstone	2	
Roof Rock	Coal	2	
	Shale	1	
	Siltstone	3	
	Sandstone	3	
	Siltstone	1	
	Shale	1	
1298-1303	Coal	5	
Muddy No. 2			
	Shale	2	
	Sandstone	1	
1303-1313	Siltstone	1	
Floor Rock	Sandstone	1.5	
	Siltstone	.5	
	Sandstone	4	



Ten feet of colluvium were drilled before the erosional top of the Price River Formation was encountered. The Price River Formation is 273½ feet thick and is composed of alternating sandstone (29 percent), siltstone (26 percent), and shale (45 percent). The Price River Formation is thought to be 600-700 feet thick in this part of the plateau but only 39-46 percent of the formation remains in place. The Castlegate Sandstone is 219½ feet thick and is predominantly a massive sandstone (84 percent). At this location the lower 92 feet of sandstone alternates with siltstone (12 percent) and shale (4 percent). The Blackhawk Formation is 913 feet thick and consists of alternating sandstone (49 percent), siltstone (40 percent), shale (7 percent), and coal (4 percent). Sixteen of the 24 drilled feet of the Star Point Sandstone were geophysically logged and all of the unit consisted of sandstone.

MC-22-AL. This hole was drilled in Pin Hollow in the SW¼ NE¼, Sec. 3, T. 22 S., R. 4 E., from a collar elevation of 8,184 feet. Rotary drilling commenced June 27, 1979 and concluded July 19, 1979 when the total depth of 1,080 feet was reached. Nine coal seams were intersected and two were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
860-885	Siltstone	18	
Roof Rock	Sandstone	3	
	Siltstone	4	
885-893	Coal	1	
Upper	Shale split	2.3	
Hiawatha	Coal	4.7	
	Shale	1	
	Siltstone	14	
	Sandstone	9.5	
893-926	Siltstone	5.5	
Interval	Sandstone	3	
926-930	Coal	4	
Hiawatha			
930-940	Sandstone	10	
Floor Rock			

This drill hole was spudded in the Castlegate Sandstone and the 161½ feet which were drilled consisted entirely of sandstone. The Blackhawk Formation is 873 feet thick and consists of alternating sandstone (39 percent), siltstone (52 percent), shale (7 percent), and coal (2 percent). All of the 45½ feet of the Star Point Sandstone drilled consisted of sandstone. Geophysical logs were made of 44½ feet of the unit.

MC-23-AL. This drill hole was located southwest of Duncan Mountain in Duncan Draw in the SW¼ SE¼, Sec. 26, T. 21 S., R. 4 E. and had a collar elevation of 8,629 feet. Drilling commenced August 22, 1980 by rotary method and was concluded August 26, 1980 at a total depth of 1,480 feet. Five coal seams were intersected in this drill hole, but only one was of minable thickness (greater than 4 feet).

Thirteen feet of colluvium were drilled before the erosional top of the Price River Formation was reached. The remaining Price River Formation is 397 feet thick and is composed almost equally of alternating siltstone (40 percent) and shale (38 percent) with lesser amounts

of sandstone (22 percent). The Castlegate Sandstone is 240 feet thick and consists predominantly of sandstone (95 percent) with minor siltstone (2 percent) and shale (3 percent) breaks. The Blackhawk Formation is 780 feet thick and consists of alternating sandstone (35 percent), siltstone (37 percent), shale (26 percent), and coal (2 percent). The Star Point Sandstone was geophysically logged to 30 feet and penetrated to 50 feet. This interval is mostly sandstone (67 percent) with siltstone (33 percent) breaks.

Interval (ft)	Lithology	Thickness (ft)	Column
1366.5-1391.5	Siltstone	6	
Roof Rock	Sandstone	12	
	Siltstone	7	
1391.5-1400.5	Coal	9	
Upper Hiawatha			
1400.5-1410.5	Siltstone	7	
Floor Rock	Shale	3	

MC-24-AL. This drill hole is in Collier Hollow northeast of Convulsion Canyon in the NW¼ SW¼, Sec. 10, T. 22 S., R. 4 E. and has a collar elevation of 8,135 feet. Drilling commenced on July 2, 1979 by the rotary method and was concluded July 3, 1979 to a total depth of 1,020 feet. Eleven coal seams were intersected, but none were of minable thickness (greater than 4 feet). The spud was in 3 feet of colluvium under which 109 feet of Castlegate Sandstone were intersected. The Castlegate Sandstone is 109 feet thick and mostly sandstone (88 percent) with one siltstone (5 percent) and shale (7 percent) break in the lower portion. The Blackhawk Formation is 815½ feet thick and consists of alternating sandstone (34 percent), siltstone (57 percent), shale (7 percent), and coal (2 percent). Geophysical logging of 79½ feet of Star Point Sandstone indicated an interval entirely of sandstone. The hole penetrated 92½ feet of the unit.

MC-25-AL. This drill hole is southwest of Convulsion Canyon in the NW¼ SE¼, Sec. 13, T. 22 S., R. 4 E. and has a collar elevation of 8,398 feet. Rotary drilling commenced July 15, 1979 and concluded July 17, 1979 at a total depth of 1,140 feet. Eight coal seams were intersected; two were of minable thickness (greater than 4 feet).

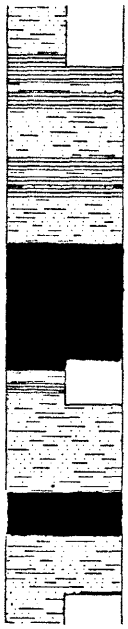
Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	2	
	Sandstone	2	
	Siltstone	4	
	Shale	2	
744-769	Siltstone	3	
Roof Rock	Sandstone	2	
	Siltstone	3	
	Shale	3	
	Coal	1	
	Siltstone	2	
	Shale	1	
769-773	Coal	4	
Ivie Bed			
773-783	Shale	3	
Floor Rock	Sandstone	6	
	Shale	1	
	Siltstone	2	
813-838	Shale	4	
Roof Rock	Siltstone	3	
	Sandstone	16	
838-846	Coal	3	
Upper			
Hiawatha	Shale	1	
	Coal	4	
846-856	Shale	2	
Floor Rock	Sandstone	4	
	Shale	4	

This hole was spudded in colluvium to a depth of six feet before the erosional top of the Castlegate Sandstone was encountered. Fifty-nine feet of Castlegate Sandstone consisting entirely of sandstone were drilled to the top of Blackhawk Formation. The Blackhawk Formation is 834 feet thick and consists of alternating sandstone (33 percent), siltstone (44 percent), shale (20 percent), and coal (3 percent). Two hundred twenty-seven of the 241 feet of Star Point Sandstone penetrated were geophysically logged. The unit consists of sandstone (83 percent) interrupted by several siltstone (17 percent) partings and interbeds.

MC-26-AL. This hole was drilled between Spring Hollow and Broad Hollow to the northwest of Convulsion Canyon in the SW¼ NE¼, Sec. 26, T. 22 S., R. 4 E. The elevation of the collar was 8,288 feet and drilling

commenced on June 27, 1979 by rotary method and was concluded June 29, 1979. Surprisingly, only three coal seams were intersected. Two of these were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	5	
	Shale	3	
	Siltstone	1	
733.5-758.5	Shale	2	
Roof Rock	Siltstone	5	
	Shale	1	
	Siltstone	1	
	Shale	2	
	Siltstone	5	
758.5-771.5	Coal	13	
Upper Hiawatha			
771.5-784.5	Siltstone	1	
Interval	Shale	1	
	Siltstone	11	
784.5-788.6	Coal	4.1	
Hiawatha			
788.6-798.6	Siltstone	10	
Floor Rock			

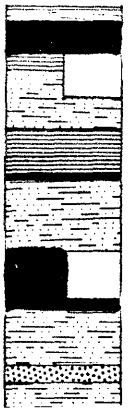


This hole was spudded in the Castlegate Sandstone and 72 feet were drilled which consisted entirely of sandstone. The Blackhawk Formation is 814 feet thick and consists of alternating sandstone (31 percent) , siltstone (61 percent), shale (6 percent), and coal (2 percent). Sixty-one of the 134 feet of Star Point Sandstone that was drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

MC-27-AL. This hole was drilled west of Jolly Mill Hollow in the SE¼ NW¼, Sec. 15, T. 22 S., R. 4 E. The collar elevation is 8,240 feet and drilling commenced on July 9, 1979 by rotary method and was concluded July 16, 1979 at a total depth of 1,100 feet. Eight coal seams were intersected, but only one was of minable thickness (greater than 4 feet).

This hole was spudded in four feet of colluvium. A 69-foot remnant of the Price River Formation was drilled consisting of alternating sandstone (35 percent), siltstone (41 percent), and shale (24 percent). The Castlegate Sandstone generally thins on the southern part of the Wasatch Plateau and in this southernmost hole was 94 feet thick. It consisted mainly of sandstone (87 percent), with siltstone (7 percent), and shale (6 percent) breaks throughout. The Blackhawk Formation is 816 feet thick and consists of alternating sandstone (34 percent), siltstone (46 percent), shale (17 percent), and coal (3 percent). The 117 feet of penetrated Star Point Sandstone consisted entirely of sandstone. Only 99 feet of the interval were geophysically logged.

Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	1	
	Siltstone	1	
	Coal	3	
885-910	Shale	2	
Roof Rock	Siltstone	6	
	Shale	4	
	Coal	1	
	Siltstone	7	
910-916	Coal	6	
Muddy No. 1			
916-926	Siltstone	6	
Floor Rock	Sandstone	2	
	Siltstone	2	



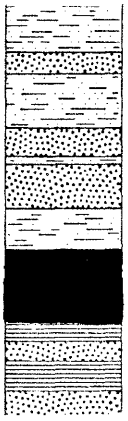
MC-28-AL. This drill hole is southwest of Spring Hollow in the SE¼ SW¼, Sec. 2, T. 22 S., R. 4 E. at a collar elevation of 8,285 feet. Drilling commenced on June 29, 1979 by rotary method and was concluded July 1, 1979 to a total depth of 1,160 feet. Five coal seams were intersected in this hole, but only one was of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	7	
	Siltstone	1	
	Shale	3	
851-876	Siltstone	2	
Roof Rock	Shale	3	
	Siltstone	1	
	Shale	1	
	Siltstone	1	
	Shale	6	
876-886	Coal	10	
Upper Hiawatha			
	Siltstone	1	
886-896	Shale	2	
Floor Rock	Siltstone	1	
	Sandstone	6	

This hole was spudded in ten feet of colluvium to the erosional top of the Castlegate Sandstone. The Castlegate Sandstone is 144 feet thick and composed entirely of sandstone. The Blackhawk Formation is 759 feet thick and is made up of alternating sandstone (45 percent), siltstone (48 percent), shale (16 percent), and coal (2 percent). One hundred fifteen of the 247 feet of Star Point Sandstone that was drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

MC-29-AL. This hole was drilled in Mud Spring Hollow from a collar elevation of 8,307 feet in the SW¼ SW¼, Sec. 35, T. 21 S., R. 4 E. Drilling commenced on July 30, 1979 by rotary method and was concluded August 8, 1979 at a total depth of 1,225 feet. Twelve coal seams were intersected in this test hole, but only one was of minable thickness (greater than 4 feet).

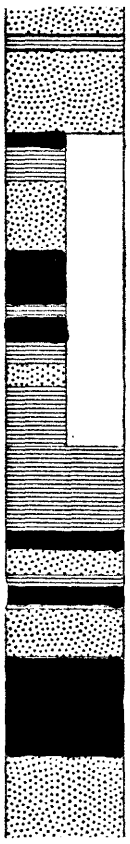
Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	4	
	Sandstone	2	
997.5-1022.5	Siltstone	6	
Roof Rock	Sandstone	3	
	Siltstone	1	
	Sandstone	5	
	Siltstone	4	
1022.5-1030	Coal	7.5	
Ivie Bed			
	Shale	2	
1030-1040	Sandstone	2	
Floor Rock	Shale	3	
	Sandstone	2.5	



This hole was spudded in four feet of colluvium to the Price River Formation, which was 96 feet thick and consisted of alternating sandstone (45 percent), siltstone (49 percent), and shale (6 percent). The Castlegate Sandstone is 153½ feet thick and is composed entirely of sandstone. The Blackhawk Formation is 919½ feet thick and consists of alternating sandstone (41 percent), siltstone (43 percent), shale (13 percent), and coal (3 percent). The total of the 52 feet of Star Point Sandstone that was drilled was geophysically logged and consisted entirely of sandstone.

MC-71-AL. This drill hole is northwest of the North Fork of Quitchupah Creek in the NW¼ NE¼, Sec. 13, T. 21 S., R. 4 E. The elevation of the collar was 8,380 feet and drilling commenced September 5, 1979 by rotary method to 1,300 feet, cored to 1,375 feet, and then by rotary method to a total depth of 1,430 feet. Seven coal seams were intersected in this hole, but only two were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	2	
	Shale	2	
1261-1286	Sandstone	8	
Roof Rock	Coal	1	
	Shale	3	
	Sandstone	7	
1286-1295	Coal	5	
Upper	Shale	1.5	
Hiawatha	Coal	2.5	
	Shale	2.5	
	Sandstone	2.5	
	Shale	11	
	Coal	.1	
	Shale	3.7	
1295-1329.3	Coal	2.1	
Interval	Sandstone	3	
	Shale	1.1	
	Coal	1.8	
	Siltstone	.5	
	Sandstone	5.3	
	Shale	.7	
1329.3-1337.4	Coal	8.1	
Hiawatha			
1337.4-1347.4	Sandstone	10	
Floor Rock			



This hole was spudded in 45 feet of colluvium to the Price River Formation. The remaining Price River Formation is 163 feet thick and is composed of alternating sandstone (40 percent), siltstone (27 percent), and shale (27 percent). The Castlegate Sandstone is 264 feet thick and is predominantly sandstone (81 percent), with siltstone (8 percent), and shale (11 percent) breaks throughout the interval. The Blackhawk Formation is 871 feet thick and is composed of alternating sandstone (57 percent), siltstone (16 percent), shale (24 percent), and coal (3 percent). Sixty-seven of the 72 feet of Star Point Sandstone drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

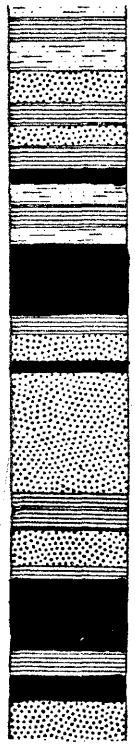
MC-72-AL. This drill hole is south of Big Ridge and northeast of the North Fork of Quitchupah Creek, 200 feet west of the east line, 2,700 feet south of the north line in Sec. 18, T. 21 S., R. 5 E. The collar elevation is 8,410 feet and drilling commenced August 20, 1980 and concluded August 22, 1980 when a 1,337 foot total depth was reached. Seven coal seams were intersected in this hole, but only two were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	5	
	Sandstone	4	
	Shale	2	
	Siltstone	3	
1188-1213	Shale	2	
Roof Rock	Siltstone	2	
	Shale	1	
	Coal	1	
	Shale	1	
	Siltstone	3	
	Shale	1	
1213-1223	Coal	10	
Upper Hiawatha			
	Shale	3	
	Siltstone	1	
	Shale	2	
	Siltstone	3	
1223-1245	Sandstone	4	
Interval	Shale	2	
	Siltstone	2	
	Shale	3	
	Siltstone	1	
	Shale	1	
1245-1255	Coal	10	
Hiawatha			
1255-1265	Sandstone	10	
Floor Rock			

This hole was spudded in colluvium 61 feet thick. The underlying Price River Formation is 128 feet thick and is composed mostly of shale (77 percent), alternating with sandstone (16 percent), and siltstone (7 percent). The Castlegate Sandstone is 203 feet thick and composed mostly of sandstone (90 percent), with equal amounts of siltstone (5 percent), and shale (5 percent) occurring as partings and interbeds in the interval. The Blackhawk Formation is 863 feet thick and consists of alternating sandstone (46 percent), siltstone (32 percent), shale (19 percent), and coal (3 percent). Twenty-five of the 82 feet of Star Point Sandstone drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

MC-73-FP. This drill hole is located southeast of Cowboy Creek in the SW¼ SW¼, Sec. 33, T. 20 S., R. 5 E. The collar elevation is 8,244 feet and drilling commenced August 13, 1980 by rotary method and concluded August 14, 1980 at a total depth of 8,244 feet. Seven coal seams were intersected in this hole, but only two were of minable thickness (greater than 4 feet).

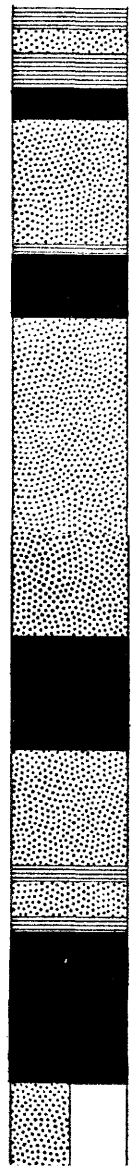
Interval (ft)	Lithology	Thickness (ft)	Column
	Siltstone	3	
	Shale	2	
	Siltstone	3	
	Sandstone	3	
1029-1054	Shale	2.5	
Roof Rock	Sandstone	2	
	Shale	2	
	Coal	1.5	
	Siltstone	2	
	Shale	2	
	Siltstone	2	
1054-1060.8	Coal	6.8	
Upper Hiawatha			
	Shale	2.2	
	Sandstone	3.1	
1060.8-1089.2	Coal	1	
Interval	Sandstone	12.9	
	Shale	5.2	
	Sandstone	4	
1089.2-1096.2	Coal	7	
Hiawatha			
1096.2-1106.2	Shale	3.2	
Floor Rock	Coal	1.8	
	Sandstone	5	



Thirteen feet of colluvium were drilled to the Castlegate Sandstone which is 246 feet thick and consists mostly of sandstone (90 percent), with minor siltstone (8 percent), and shale (2 percent). The Blackhawk Formation is 842 feet thick and is composed of alternating sandstone (53 percent), siltstone (21 percent), shale (23 percent), and coal (3 percent). Fifty-seven of the 59 feet of Star Point Sandstone that were drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

MC-74-HM. This hole is located southwest of Muddy Creek in the SW¼ SW¼, Sec. 20, T. 20 S., R. 5 E. and has a collar elevation of 8,477 feet. Drilling commenced by rotary method August 28, 1980 to a depth of 1,580 feet, cored to 1,681 feet, then by rotary method to 1,730 total depth. Four coal seams were intersected in this hole and three are of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Shale	1	
	Sandstone	3	
1560.4-1585.4	Shale	4	
Roof Rock	Coal	3	
	Sandstone	13	
	Shale	1	
1585.4-1591.3	Coal	5.9	
Muddy No.1			
1591.3-1601.3	Sandstone	10	
Floor Rock			
1605.9-1630.9	Sandstone	25	
Roof Rock			
1630.9-1642.4	Coal	11.5	
Upper Hiawaths			
1642.4-1661.8	Sandstone	11.4	
Interval	Shale	2	
	Sandstone	4	
	Shale	2	
1661.8-1676	Coal	14.2	
Hiawatha			
1676-1686	Sandstone	10	



Eleven feet of colluvium were drilled to the Price River Formation which is 532 feet thick and consists of alternating sandstone (52 percent), siltstone (26 percent), and shale (22 percent). The Castlegate Sandstone is 238 feet thick and is mostly sandstone (67 percent), with minor siltstone (14 percent) breaks and intervals of shale (19 percent) to 18 feet thick. The Blackhawk Formation is 936 feet thick and consists of alternating sandstone (48 percent), siltstone (24 percent), shale (24 percent), and coal (4 percent). All 53 feet of Star Point Sandstone drilled were geophysically logged. The examined part of the unit consists entirely of sandstone.

MC-75-AL. This hole was drilled northwest of the South Fork of Quitchupah Creek in the NE¼ NE¼, Sec. 23, T. 21 S., R. 4 E. at a collar elevation of 8,454 feet. Drilling commenced September 23, 1980 by rotary method and was concluded October 6, 1980 at a total depth of 1,520 feet. Eight coal seams were intersected in this hole; four were of minable thickness (greater than 4 feet).

Interval (ft)	Lithology	Thickness (ft)	Column
	Sandstone	7	
904-929	Shale	4	
Roof Rock	Sandstone	5	
	Shale	5	
	Siltstone	4	
929-934	Coal	5	
934-944	Shale	2	
Floor Rock	Siltstone	5	
	Sandstone	3	
	Sandstone	8	
	Shale	3	
	Sandstone	2	
1375.5-1400.5	Siltstone	1	
Roof Rock	Shale	5	
	Coal	2	
	Shale	1	
	Siltstone	3	
1400.5-1406.5	Coal	6	
Upper Hiawatha			
	Shale	2	
	Sandstone	9	
	Siltstone	2	
1406.5-1445.5	Sandstone	6	
Interval	Shale	2	
	Coal	1	
	Siltstone	5	
	Shale	7	
	Siltstone	5	

(continued on pg. 36)

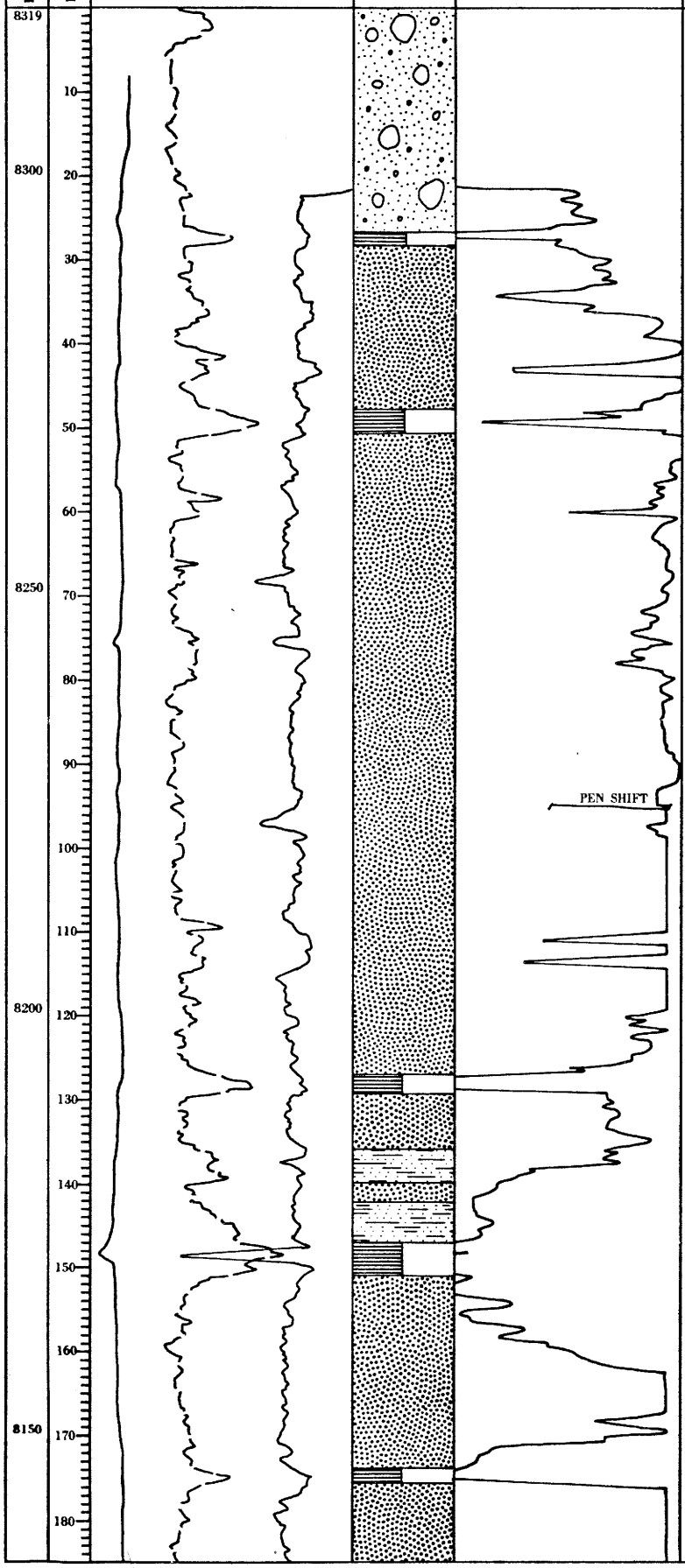
(MC-75-AL continued)

1445.5-1449.5 Hiawatha	Coal	4
1449.5-1455 Split	Shale	2.5
	Siltstone	2
	Shale	1
1455-1465 Hiawatha	Coal	10
1465-1475 Floor Rock	Sandstone	10

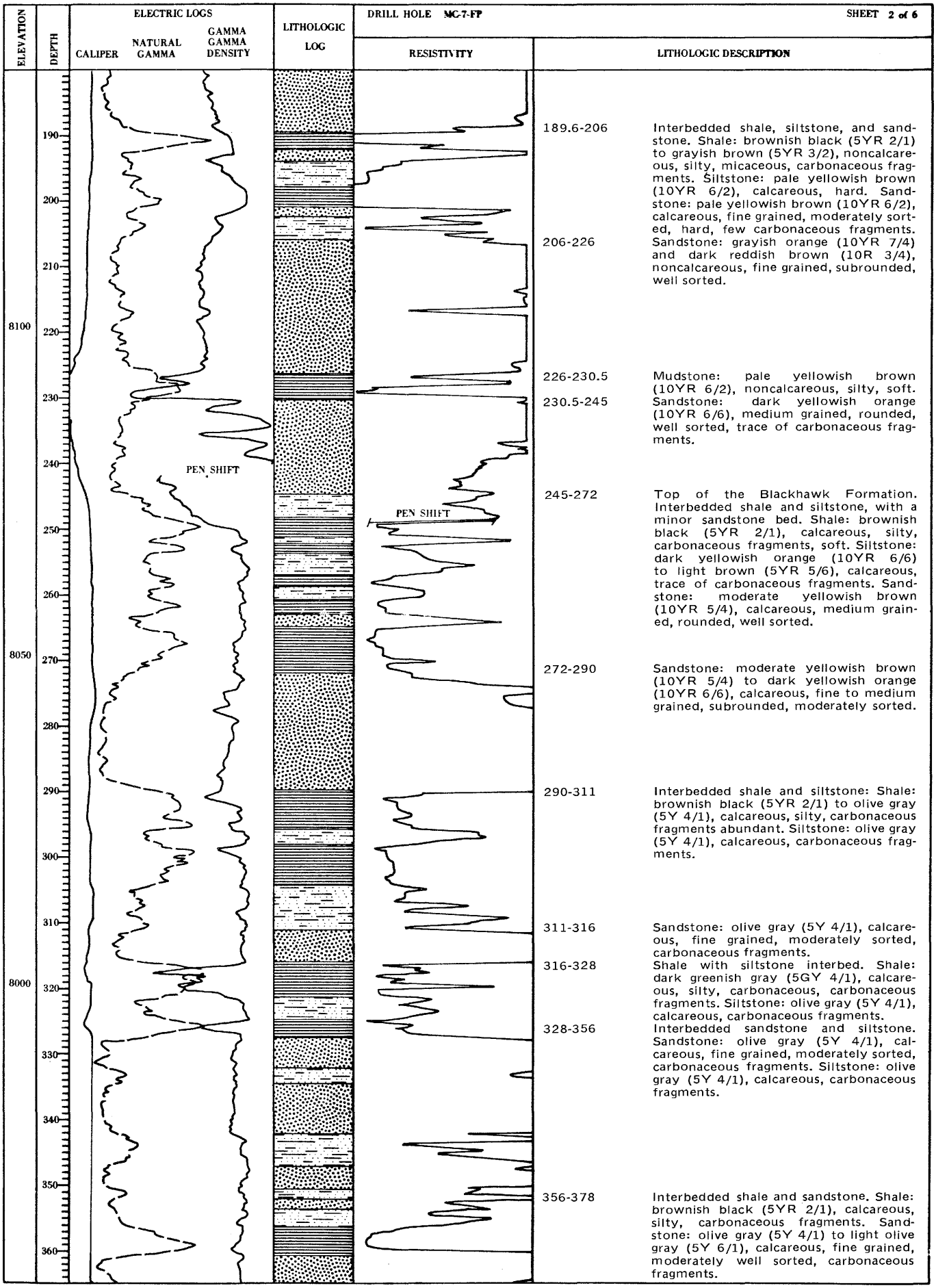
Ninety-two feet of colluvium were drilled to the Price River Formation which is 255 feet thick and consists of sandstone (9 percent), siltstone (64 percent), and shale (27 percent). The Castlegate Sandstone is 239 feet thick and although consisting mostly of sandstone (46 percent), and siltstone (34 percent), the amount of shale (20 percent) is extraordinary. The Blackhawk Formation is 879 feet thick and consists of alternating sandstone (50 percent), siltstone (21 percent), shale (25 percent), and coal (4 percent). The Star Point Sandstone penetrated is fifty-five feet thick and the interval is all sandstone and was entirely geophysically logged.

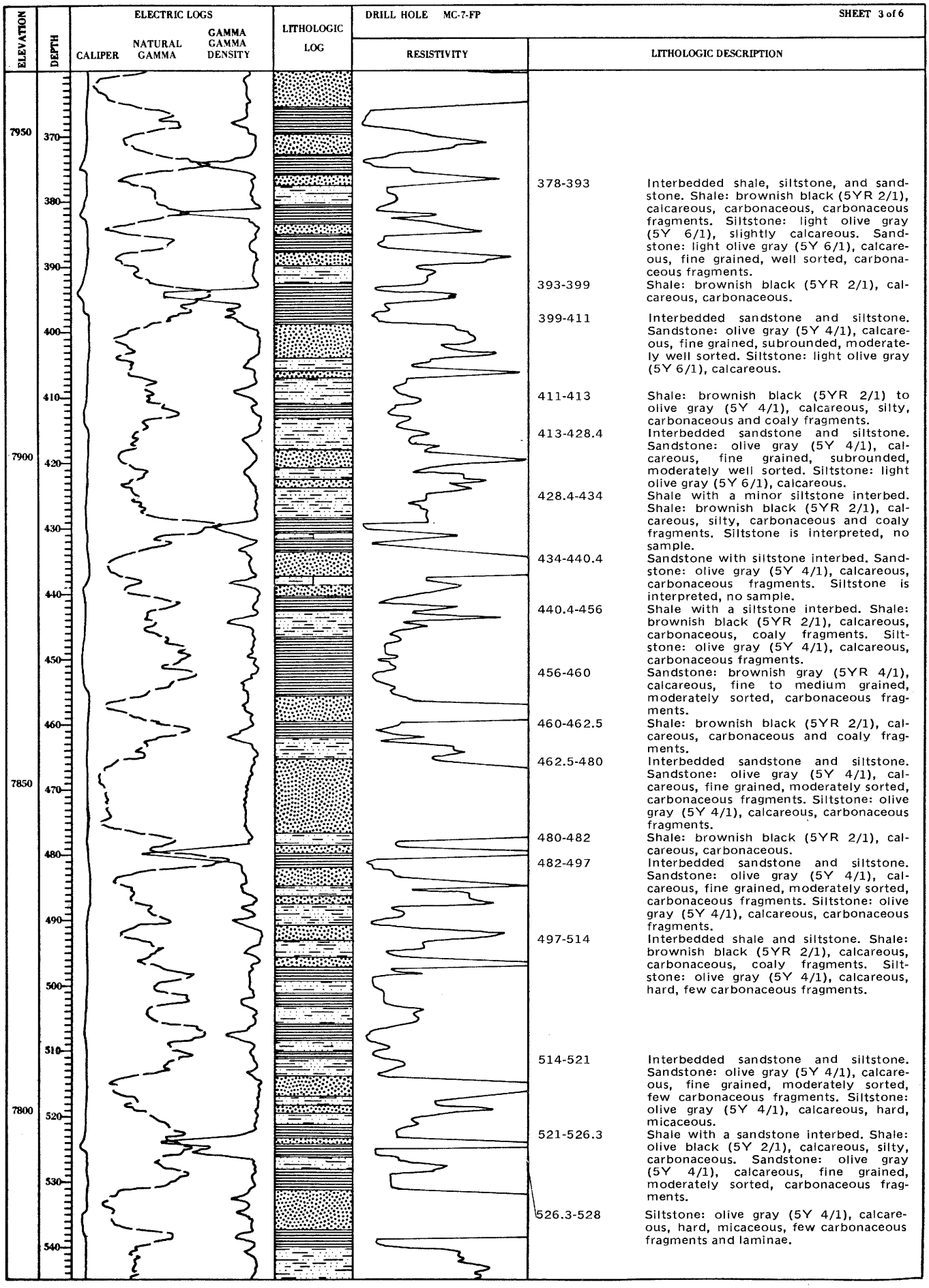
APPENDIX I

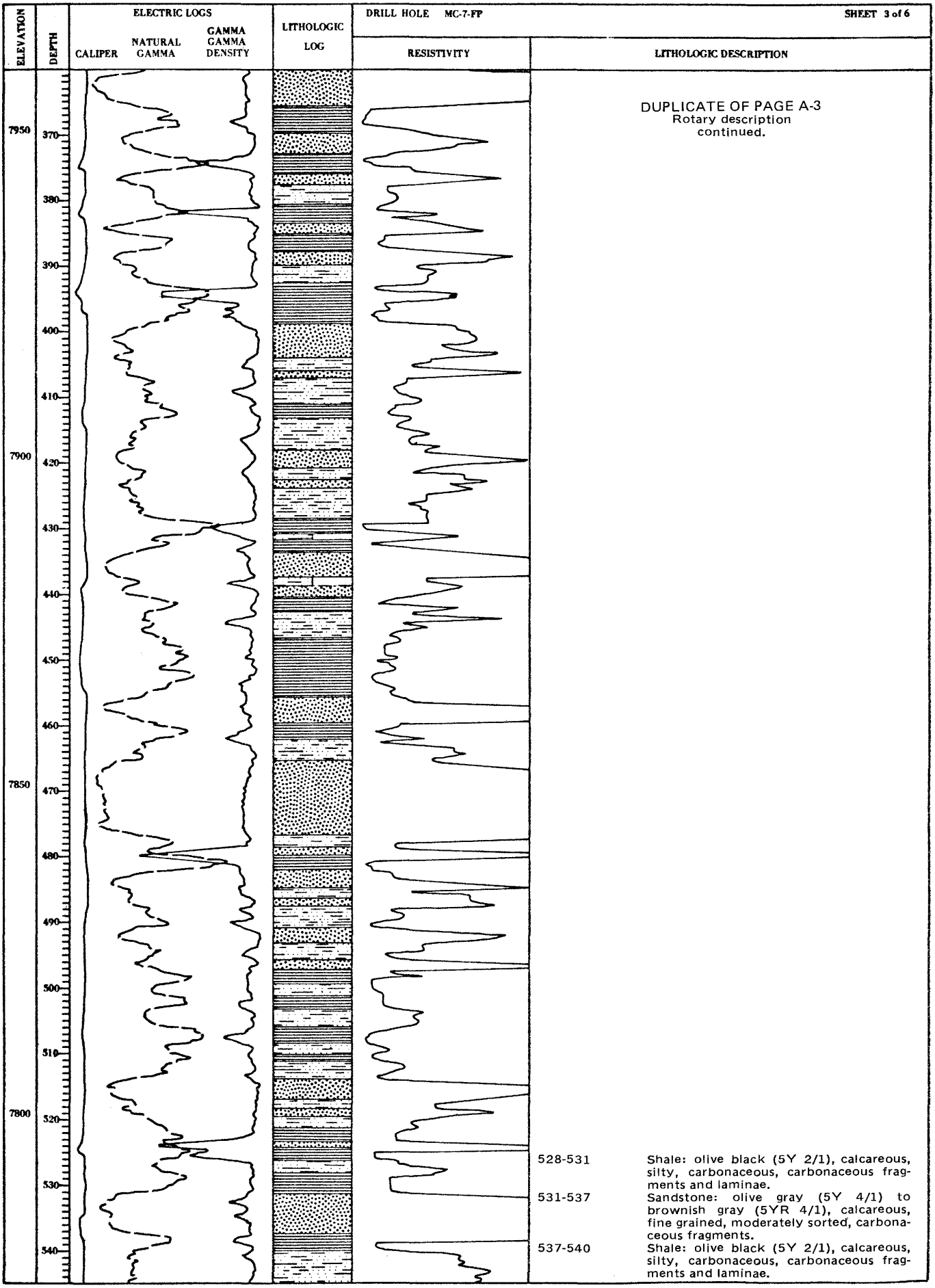
DRILL HOLE MC-7-FP SE SW, SEC. 4, T. 21 S., R. 5 E. SHEET 1 of 6



LITHOLOGIC DESCRIPTION	
0-27	Spudded in colluvium. Abundant loose sand.
27-28.6	Interpreted as shale, no sample.
28.6-41	Erosional top of the Castlegate Sandstone. Sandstone: pale yellowish orange (10YR 8/6), noncalcareous, fine grained, subrounded, fairly well sorted, poorly cemented.
41-48	Sandstone: moderate orange pink (5YR 8/4), noncalcareous, very fine to fine grained, subrounded, well sorted.
48-51	Interpreted as shale, no sample.
51-127	Sandstone: pale yellowish orange (10YR 8/6) to very pale orange (10YR 8/2), noncalcareous, fine grained, subrounded, moderately well sorted.
127-129.3	Interpreted as shale, no sample.
129.3-147	Interbedded sandstone and siltstone. Sandstone: very pale orange (10YR 8/2), noncalcareous, fine to medium grained, subrounded, well sorted, poorly cemented. Siltstone: very pale orange (10YR 8/2), noncalcareous, soft.
147-151	Interpreted as shale, no sample.
151-174	Sandstone: grayish orange (10YR 7/4), noncalcareous, medium grained, rounded, well sorted.
174-176	Interpreted as shale, no sample.
176-189.6	Sandstone: very pale orange (10YR 8/2) to dark yellowish orange (10YR 6/6), noncalcareous, very fine to fine grained, rounded, well sorted, poorly cemented.

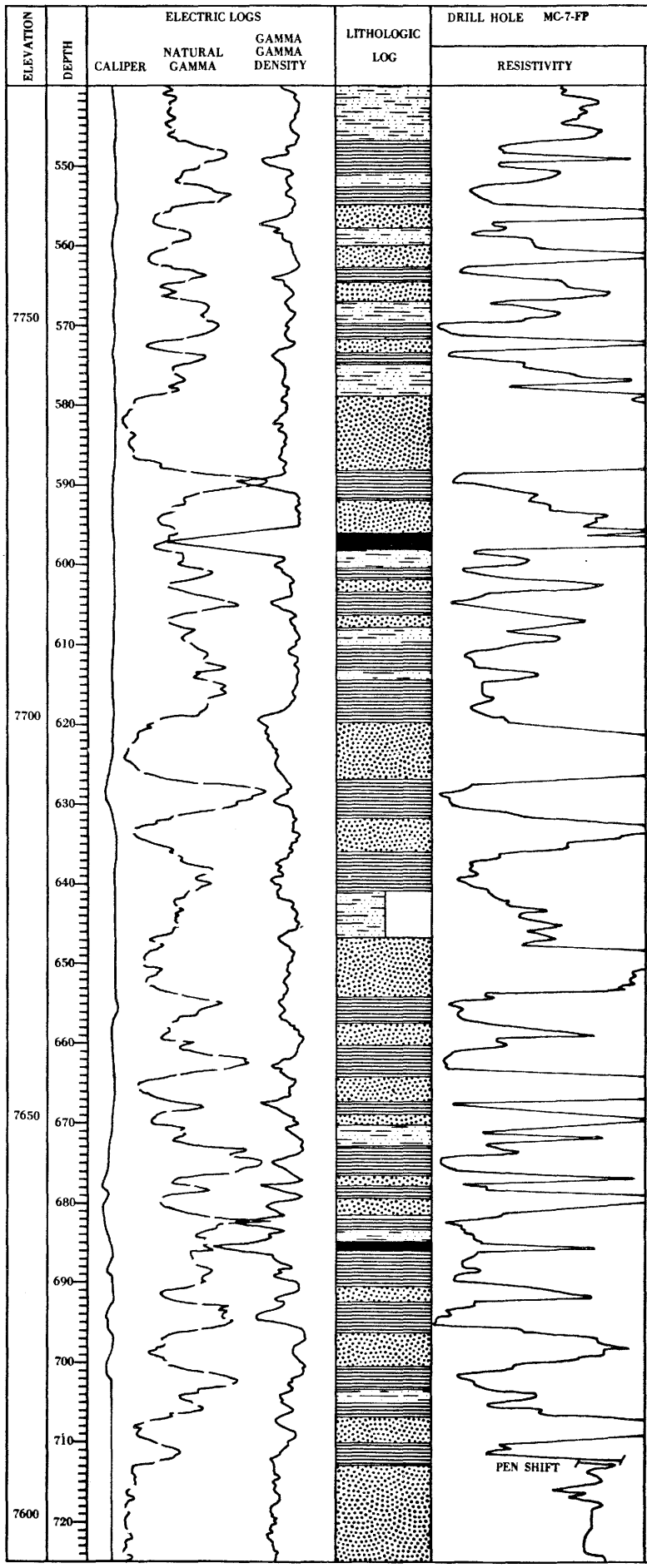

ELEVATION
DEPTH
ELECTRIC LOGS
CALIPER
NATURAL GAMMA
GAMMA GAMMA DENSITY
LITHOLOGIC LOG
DRILL HOLE MC-7-FP
SHEET 2 of 6
RESISTIVITY
LITHOLOGIC DESCRIPTION
8100
8050
8000
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
PEN SHIFT
PEN SHIFT
189.6-206
Interbedded shale, siltstone, and sandstone. Shale: brownish black (5YR 2/1) to grayish brown (5YR 3/2), noncalcareous, silty, micaceous, carbonaceous fragments. Siltstone: pale yellowish brown (10YR 6/2), calcareous, hard. Sandstone: pale yellowish brown (10YR 6/2), calcareous, fine grained, moderately sorted, hard, few carbonaceous fragments.
206-226
Sandstone: grayish orange (10YR 7/4) and dark reddish brown (10R 3/4), noncalcareous, fine grained, subrounded, well sorted.
226-230.5
Mudstone: pale yellowish brown (10YR 6/2), noncalcareous, silty, soft.
230.5-245
Sandstone: dark yellowish orange (10YR 6/6), medium grained, rounded, well sorted, trace of carbonaceous fragments.
245-272
Top of the Blackhawk Formation. Interbedded shale and siltstone, with a minor sandstone bed. Shale: brownish black (5YR 2/1), calcareous, silty, carbonaceous fragments, soft. Siltstone: dark yellowish orange (10YR 6/6) to light brown (5YR 5/6), calcareous, trace of carbonaceous fragments. Sandstone: moderate yellowish brown (10YR 5/4), calcareous, medium grained, rounded, well sorted.
272-290
Sandstone: moderate yellowish brown (10YR 5/4) to dark yellowish orange (10YR 6/6), calcareous, fine to medium grained, subrounded, moderately sorted.
290-311
Interbedded shale and siltstone: Shale: brownish black (5YR 2/1) to olive gray (5Y 4/1), calcareous, silty, carbonaceous fragments abundant. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
311-316
Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments.
316-328
Shale with siltstone interbed. Shale: dark greenish gray (5GY 4/1), calcareous, silty, carbonaceous, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
328-356
Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
356-378
Interbedded shale and sandstone. Shale: brownish black (5YR 2/1), calcareous, silty, carbonaceous fragments. Sandstone: olive gray (5Y 4/1) to light olive gray (5Y 6/1), calcareous, fine grained, moderately well sorted, carbonaceous fragments.


ELEVATION
DEPTH
ELECTRIC LOGS
CALIPER
NATURAL GAMMA
GAMMA GAMMA DENSITY
LITHOLOGIC LOG
DRILL HOLE MC-7-FP
SHEET 3 of 6
RESISTIVITY
LITHOLOGIC DESCRIPTION
7950
7900
7850
7800
370
380
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
378-393 Interbedded shale, siltstone, and sandstone. Shale: brownish black (5YR 2/1), calcareous, carbonaceous, carbonaceous fragments. Siltstone: light olive gray (5Y 6/1), slightly calcareous. Sandstone: light olive gray (5Y 6/1), calcareous, fine grained, well sorted, carbonaceous fragments.
393-399 Shale: brownish black (5YR 2/1), calcareous, carbonaceous.
399-411 Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, subrounded, moderately well sorted. Siltstone: light olive gray (5Y 6/1), calcareous.
411-413 Shale: brownish black (5YR 2/1) to olive gray (5Y 4/1), calcareous, silty, carbonaceous and coaly fragments.
413-428.4 Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, subrounded, moderately well sorted. Siltstone: light olive gray (5Y 6/1), calcareous.
428.4-434 Shale with a minor siltstone interbed. Shale: brownish black (5YR 2/1), calcareous, silty, carbonaceous and coaly fragments. Siltstone is interpreted, no sample.
434-440.4 Sandstone with siltstone interbed. Sandstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments. Siltstone is interpreted, no sample.
440.4-456 Shale with a siltstone interbed. Shale: brownish black (5YR 2/1), calcareous, carbonaceous, coaly fragments. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
456-460 Sandstone: brownish gray (5YR 4/1), calcareous, fine to medium grained, moderately sorted, carbonaceous fragments.
460-462.5 Shale: brownish black (5YR 2/1), calcareous, carbonaceous and coaly fragments.
462.5-480 Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
480-482 Shale: brownish black (5YR 2/1), calcareous, carbonaceous.
482-497 Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
497-514 Interbedded shale and siltstone. Shale: brownish black (5YR 2/1), calcareous, carbonaceous, coaly fragments. Siltstone: olive gray (5Y 4/1), calcareous, hard, few carbonaceous fragments.
514-521 Interbedded sandstone and siltstone. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, few carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous.
521-526.3 Shale with a sandstone interbed. Shale: olive black (5Y 2/1), calcareous, silty, carbonaceous. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments.
526.3-528 Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous, few carbonaceous fragments and laminae.



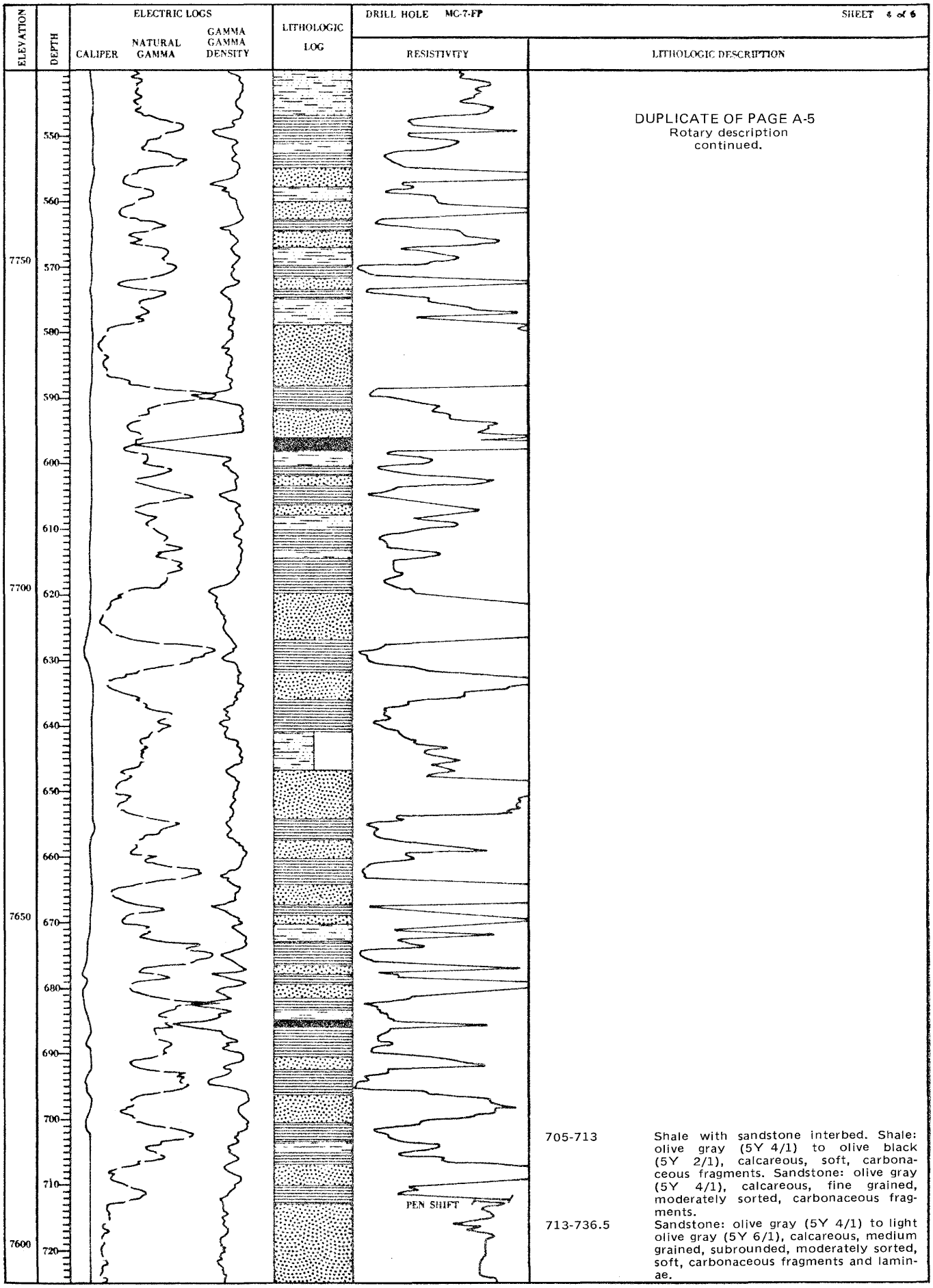
DUPLICATE OF PAGE A-3
Rotary description
continued.

528-531	Shale: olive black (5Y 2/1), calcareous, silty, carbonaceous, carbonaceous fragments and laminae.
531-537	Sandstone: olive gray (5Y 4/1) to brownish gray (5YR 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments.
537-540	Shale: olive black (5Y 2/1), calcareous, silty, carbonaceous, carbonaceous fragments and laminae.



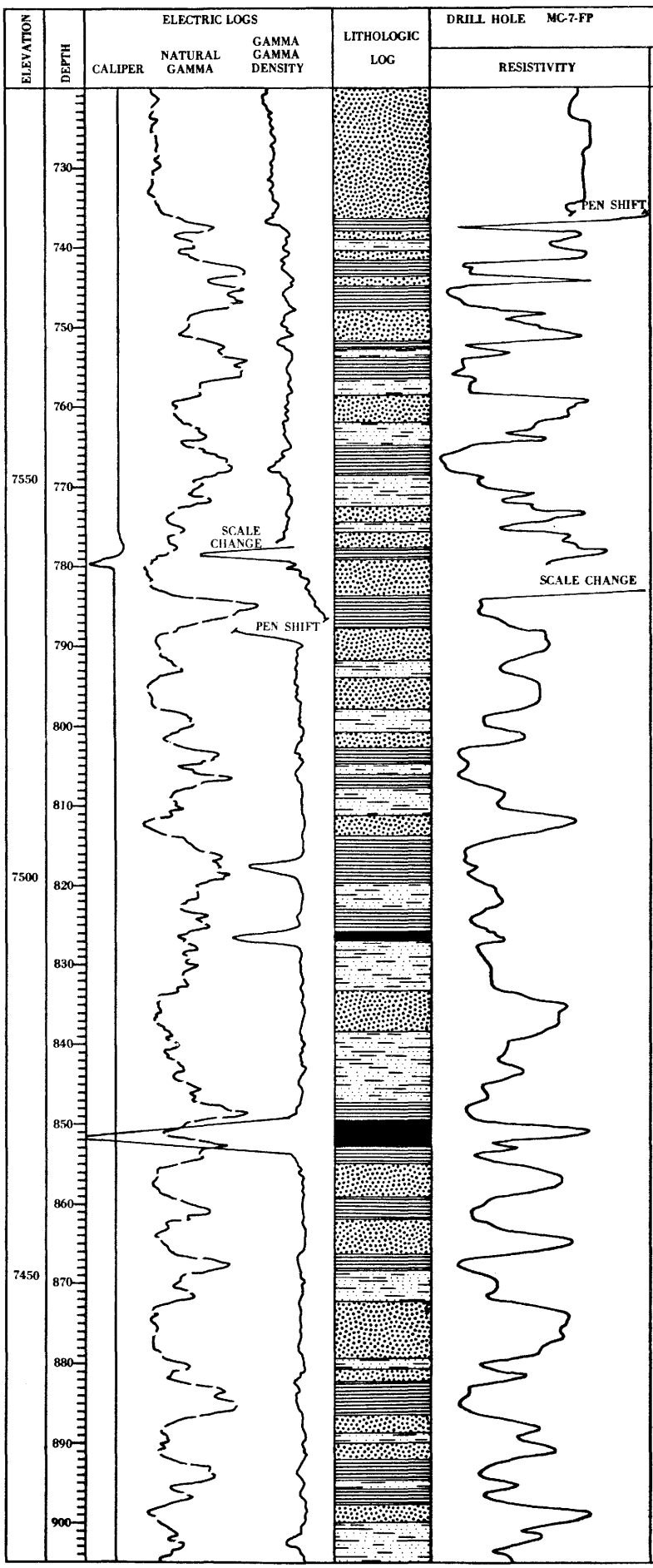
SHEET 4 of 6

	LITHOLOGIC DESCRIPTION
540-547	Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous, few carbonaceous fragments and laminae.
547-555	Shale with siltstone interbed. Shale: olive black (5Y 2/1), calcareous, silty, carbonaceous, carbonaceous fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous, few carbonaceous fragments and laminae
555-563	Sandstone with siltstone interbed. Sandstone: olive gray (5Y 4/1) to brownish gray (5YR 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous, few carbonaceous fragments and laminae.
563-579	Interbedded shale, sandstone, and siltstone. Shale: olive black (5Y 2/1), calcareous, silty, carbonaceous, carbonaceous fragments and laminae. Sandstone: olive gray (5Y 4/1) to brownish gray (5YR 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, hard, micaceous, few carbonaceous fragments and laminae.
579-596	Sandstone with a shale interbed. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, hard, well cemented, carbonaceous fragments. Shale: brownish black (5YR 2/1), noncalcareous, soft, carbonaceous.
596-598.3	Coal: black (N1) noncalcareous, shiny.
598.3-610	Interbedded sandstone, siltstone, and shale. Sandstone: light olive gray (5Y 6/1), noncalcareous, medium to fine grained, poorly sorted, few carbonaceous fragments, soft. Siltstone: olive gray (5Y 4/1), calcareous, hard, few carbonaceous fragments. Shale: olive black (5Y 2/1), noncalcareous, soft, carbonaceous, carbonaceous fragments and laminae.
610-620	Shale with small siltstone interbed. Shale: brownish black (5YR 2/1), slightly calcareous, carbonaceous, medium soft, carbonaceous fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, hard.
620-627	Sandstone: light olive gray (5Y 6/1), noncalcareous, fine grained, poorly sorted, soft, few carbonaceous fragments.
627-632	Shale: brownish black (5YR 2/1) to olive black (5Y 2/1), calcareous, carbonaceous, soft, carbonaceous fragments and laminae.
632-636	Sandstone: light olive gray (5Y 6/1), calcareous, fine grained, moderately sorted, few carbonaceous fragments.
636-641	Shale: brownish black (5YR 2/1), noncalcareous, soft, carbonaceous.
641-647	Interpreted as siltstone, no sample.
647-654	Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, moderately sorted, well cemented, moderately hard, carbonaceous fragments.
654-685	Interbedded sandstone and shale, with two minor siltstone beds. Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, moderately sorted, well cemented, carbonaceous fragments. Shale: olive black (5Y 2/1), calcareous, slightly silty, moderately soft, abundant carbonaceous fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
685-686	Coal: black (N1), dull, bony, dirty.
686-703.2	Interbedded shale and sandstone. Shale: brownish black (5YR 2/1) to olive black (5Y 2/1), noncalcareous, carbonaceous, carbonaceous fragments and laminae. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, moderately cemented, sparse carbonaceous fragments.
703.2-705	Siltstone: olive gray (5Y 4/1), calcareous, moderately soft, carbonaceous fragments and laminae.

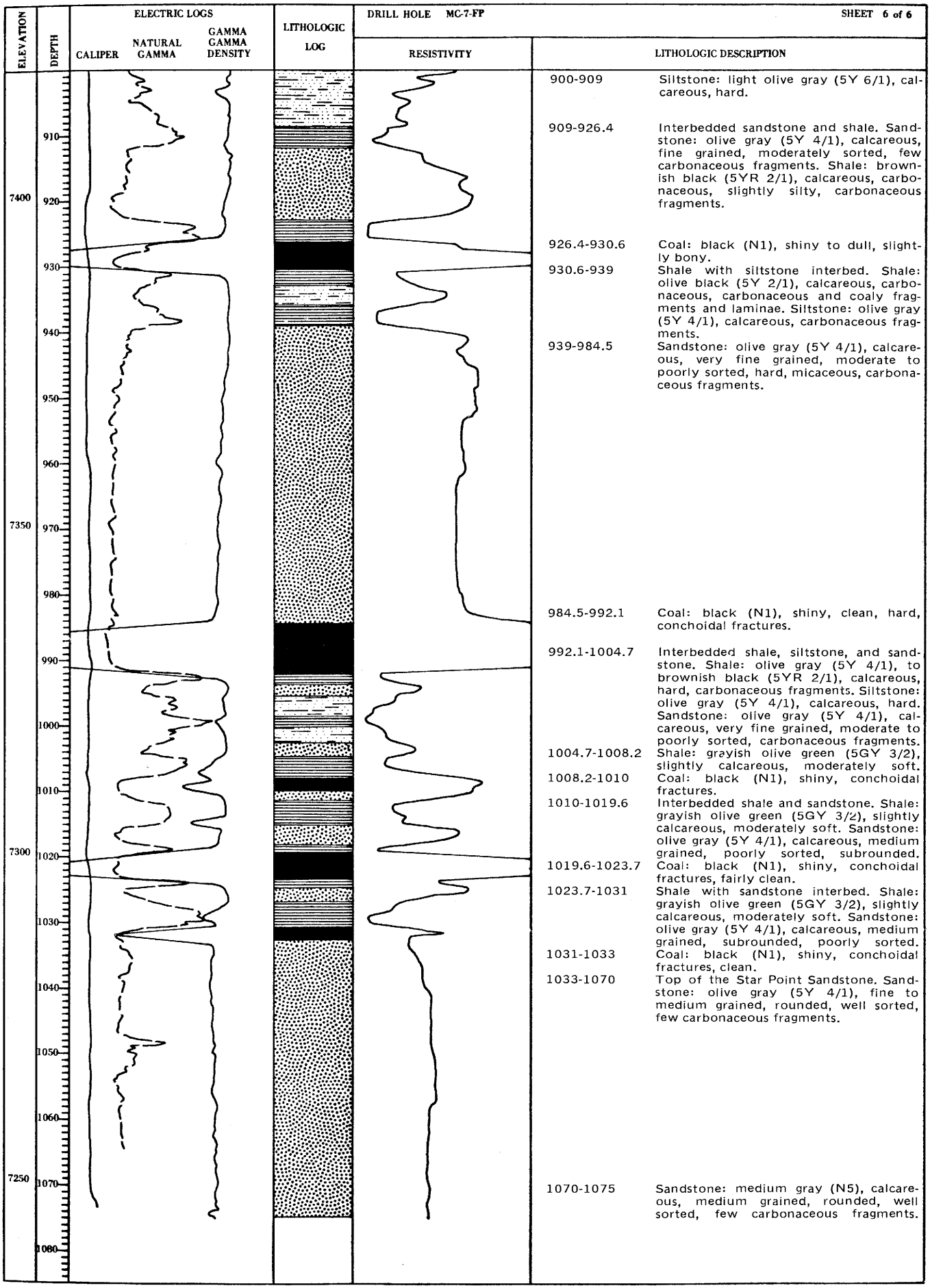


DUPLICATE OF PAGE A-5
Rotary description
continued.

705-713	Shale with sandstone interbed. Shale: olive gray (5Y 4/1) to olive black (5Y 2/1), calcareous, soft, carbonaceous fragments. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments.
713-736.5	Sandstone: olive gray (5Y 4/1) to light olive gray (5Y 6/1), calcareous, medium grained, subrounded, moderately sorted, soft, carbonaceous fragments and laminae.

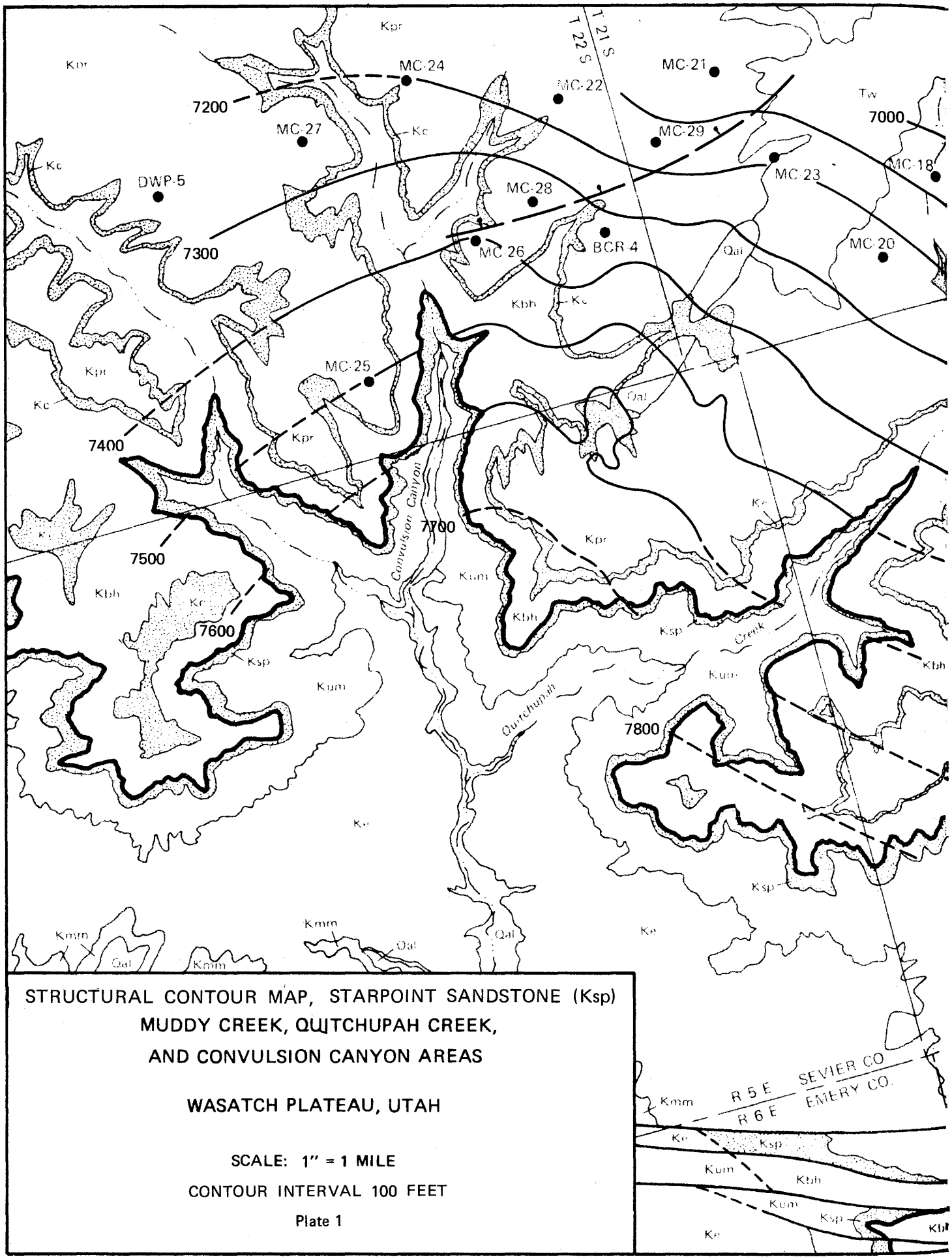


736.5-752	Interbedded sandstone and shale with a minor siltstone bed. Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, moderately sorted, hard, carbonaceous fragments. Shale: olive black (5Y 2/1), calcareous, moderately hard, carbonaceous fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, medium hard.
752-784	Interbedded shale, siltstone, and sandstone. Shale: olive black (5Y 2/1), calcareous, moderately hard, carbonaceous fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, moderately hard. Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, subrounded, moderately cemented, carbonaceous fragments.
784-788	Shale with a trace of mudstone. Shale: brownish black (5YR 2/1), noncalcareous, soft, carbonaceous, carbonaceous fragments and laminae.
788-801	Interbedded sandstone and siltstone. Sandstone: light olive gray (5Y 6/1), calcareous, fine grained, rounded to subrounded, moderately soft, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, moderately hard, carbonaceous fragments and laminae.
801-803	Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, poorly sorted, moderately hard, carbonaceous fragments and laminae.
803-812	Interbedded shale and siltstone. Shale: black (N1), noncalcareous, soft, carbonaceous with coaly laminae. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
812-814	Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, poorly sorted, moderately hard, carbonaceous fragments.
814-820	Shale: olive gray (5Y 4/1), calcareous, moderately hard, very carbonaceous, abundant carbonaceous fragments and laminae.
820-823	Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
823-826	Shale: olive black (5Y 2/1), calcareous, carbonaceous, hard.
826-827.2	Coal: black (N1), dull to shiny, bony, some pyrite.
827.2-847.4	Siltstone with a sandstone interbed. Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, hard, few carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous.
847.4-850	Shale with a trace of mudstone. Shale: olive black (5Y 2/1), calcareous, hard, carbonaceous.
850-853.1	Coal: black (N1), shiny to dull, moderately hard, fairly clean, blocky, conchoidal fractures.
853.1-869	Interbedded shale and sandstone. Shale: brownish black (5YR 2/1), calcareous, moderately hard, carbonaceous. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, medium hard, carbonaceous fragments and laminae.
869-882.4	Interbedded sandstone and siltstone: Sandstone: light olive gray (5Y 6/1), calcareous, fine grained, moderately sorted, carbonaceous and coaly fragments. Siltstone: olive gray (5Y 4/1), calcareous, abundant carbonaceous fragments.
882.4-900	Interbedded shale, siltstone, and sandstone. Shale: brownish black (5YR 2/1), slightly calcareous, coaly and carbonaceous fragments. Siltstone: light olive gray (5Y 6/1), calcareous, hard. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, carbonaceous fragments.



900-909	Siltstone: light olive gray (5Y 6/1), calcareous, hard.
909-926.4	Interbedded sandstone and shale. Sandstone: olive gray (5Y 4/1), calcareous, fine grained, moderately sorted, few carbonaceous fragments. Shale: brownish black (5YR 2/1), calcareous, carbonaceous, slightly silty, carbonaceous fragments.
926.4-930.6	Coal: black (N1), shiny to dull, slightly bony.
930.6-939	Shale with siltstone interbed. Shale: olive black (5Y 2/1), calcareous, carbonaceous, carbonaceous and coaly fragments and laminae. Siltstone: olive gray (5Y 4/1), calcareous, carbonaceous fragments.
939-984.5	Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, moderate to poorly sorted, hard, micaceous, carbonaceous fragments.
984.5-992.1	Coal: black (N1), shiny, clean, hard, conchoidal fractures.
992.1-1004.7	Interbedded shale, siltstone, and sandstone. Shale: olive gray (5Y 4/1), to brownish black (5YR 2/1), calcareous, hard, carbonaceous fragments. Siltstone: olive gray (5Y 4/1), calcareous, hard. Sandstone: olive gray (5Y 4/1), calcareous, very fine grained, moderate to poorly sorted, carbonaceous fragments.
1004.7-1008.2	Shale: grayish olive green (5GY 3/2), slightly calcareous, moderately soft.
1008.2-1010	Coal: black (N1), shiny, conchoidal fractures.
1010-1019.6	Interbedded shale and sandstone. Shale: grayish olive green (5GY 3/2), slightly calcareous, moderately soft. Sandstone: olive gray (5Y 4/1), calcareous, medium grained, poorly sorted, subrounded.
1019.6-1023.7	Coal: black (N1), shiny, conchoidal fractures, fairly clean.
1023.7-1031	Shale with sandstone interbed. Shale: grayish olive green (5GY 3/2), slightly calcareous, moderately soft. Sandstone: olive gray (5Y 4/1), calcareous, medium grained, subrounded, poorly sorted.
1031-1033	Coal: black (N1), shiny, conchoidal fractures, clean.
1033-1070	Top of the Star Point Sandstone. Sandstone: olive gray (5Y 4/1), fine to medium grained, rounded, well sorted, few carbonaceous fragments.
1070-1075	Sandstone: medium gray (N5), calcareous, medium grained, rounded, well sorted, few carbonaceous fragments.

APPENDIX II



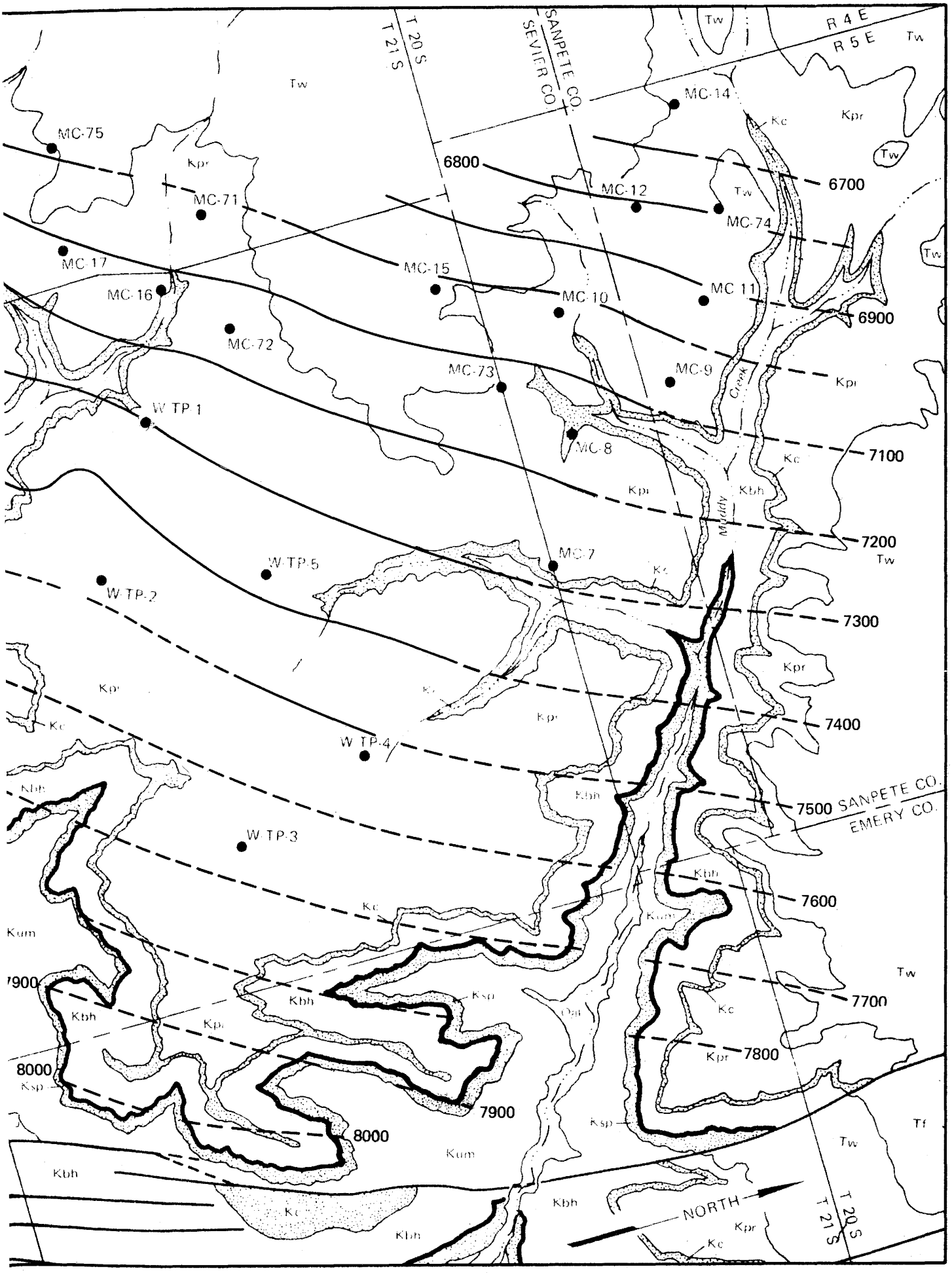
STRUCTURAL CONTOUR MAP, STARPOINT SANDSTONE (Ksp)
MUDDY CREEK, QUITCHUPAH CREEK,
AND CONVULSION CANYON AREAS

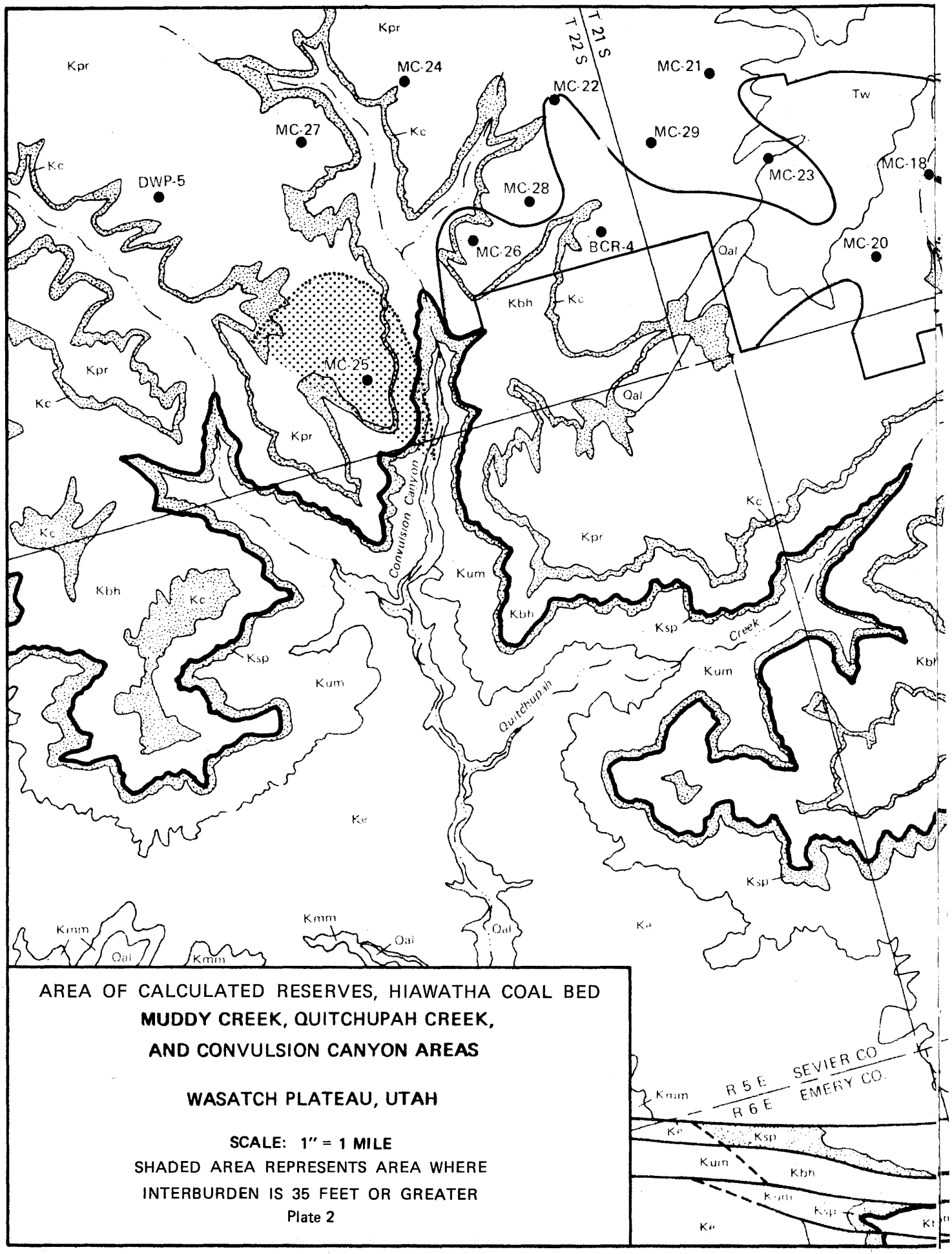
WASATCH PLATEAU, UTAH

SCALE: 1" = 1 MILE

CONTOUR INTERVAL 100 FEET

Plate 1

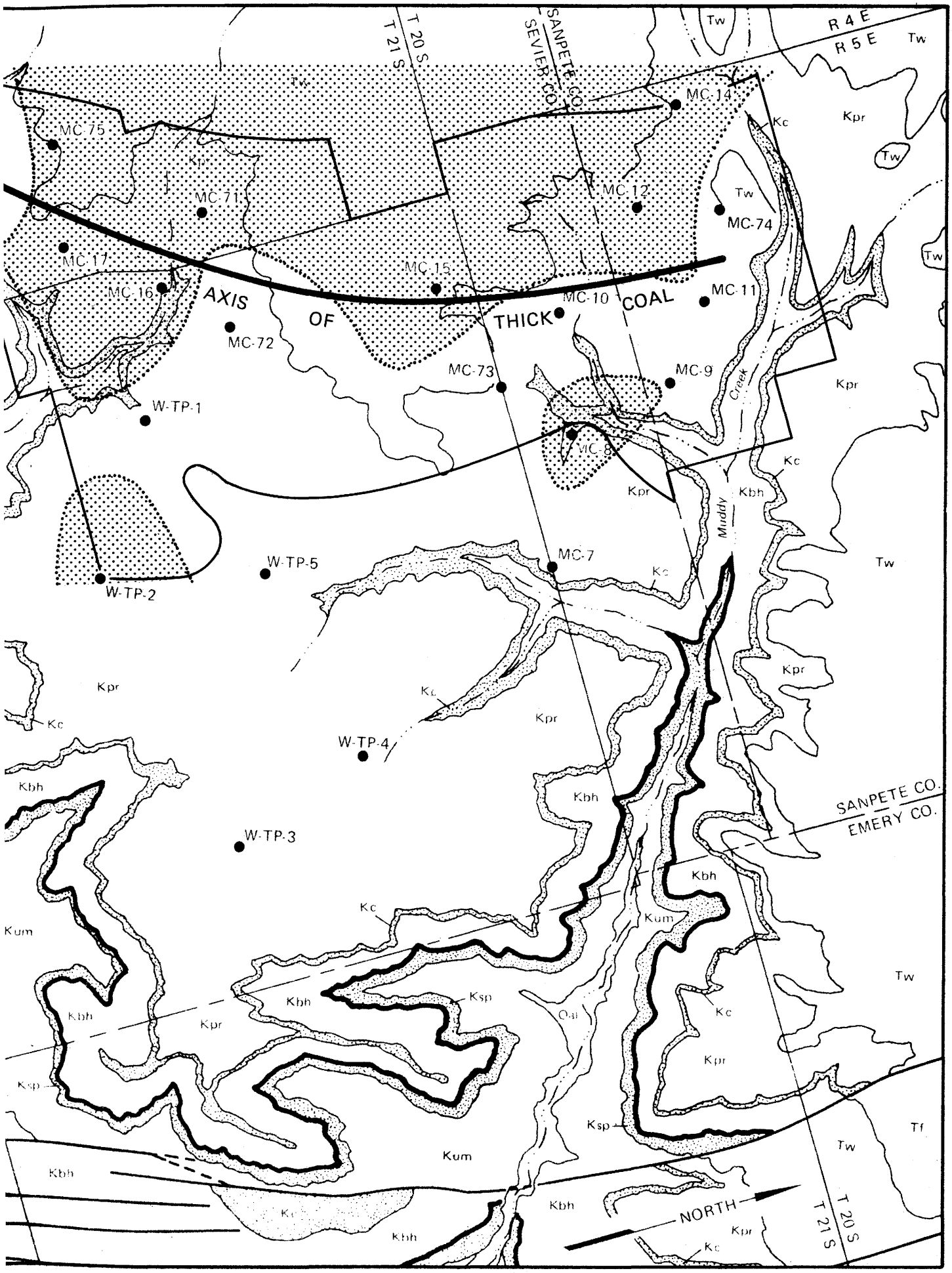

T 20 S
T 21 S
SANPETE CO.
SEVIER CO.
R 4 E
R 5 E
MC-75
MC-71
MC-17
MC-16
MC-72
MC-73
MC-15
MC-10
MC-12
MC-14
MC-74
MC 11
MC-9
MC-8
MC-7
W TP-1
W TP-2
W TP-3
W TP-4
W TP-5
6800
6700
6900
7100
7200
7300
7400
7500
7600
7700
7800
7900
8000
Muddy Creek
SANPETE CO.
EMERY CO.
NORTH
Tw
Kpr
Kc
Kbh
Kum
Ksp
Dal
Tf

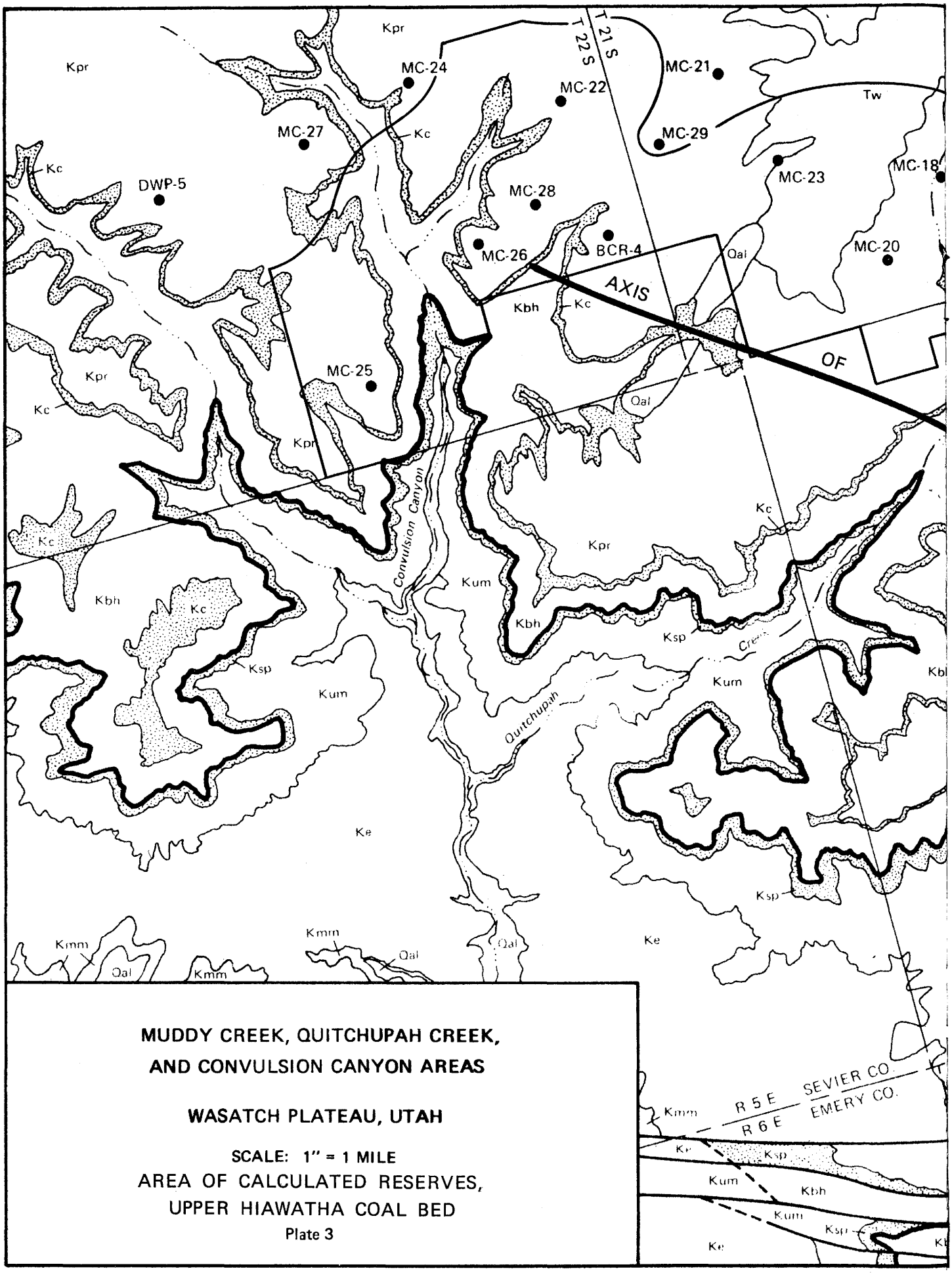


AREA OF CALCULATED RESERVES, HIAWATHA COAL BED
MUDDY CREEK, QUITCHUPAH CREEK,
AND CONVULSION CANYON AREAS

WASATCH PLATEAU, UTAH

SCALE: 1" = 1 MILE
SHADED AREA REPRESENTS AREA WHERE
INTERBURDEN IS 35 FEET OR GREATER
Plate 2


R 4 E
R 5 E
T 20 S
T 21 S
SANPETE CO.
SEVIER CO.
SANPETE CO.
EMERY CO.
AXIS OF THICK COAL
MC-75
MC-71
MC-17
MC-16
MC-72
MC-15
MC-14
MC-12
MC-74
MC-11
MC-10
MC-9
MC-73
MC-8
MC-7
W-TP-1
W-TP-2
W-TP-3
W-TP-4
W-TP-5
Muddy Creek
NORTH
Tw
Kpr
Kc
Kbh
Kum
Ksp
Qal
Tf



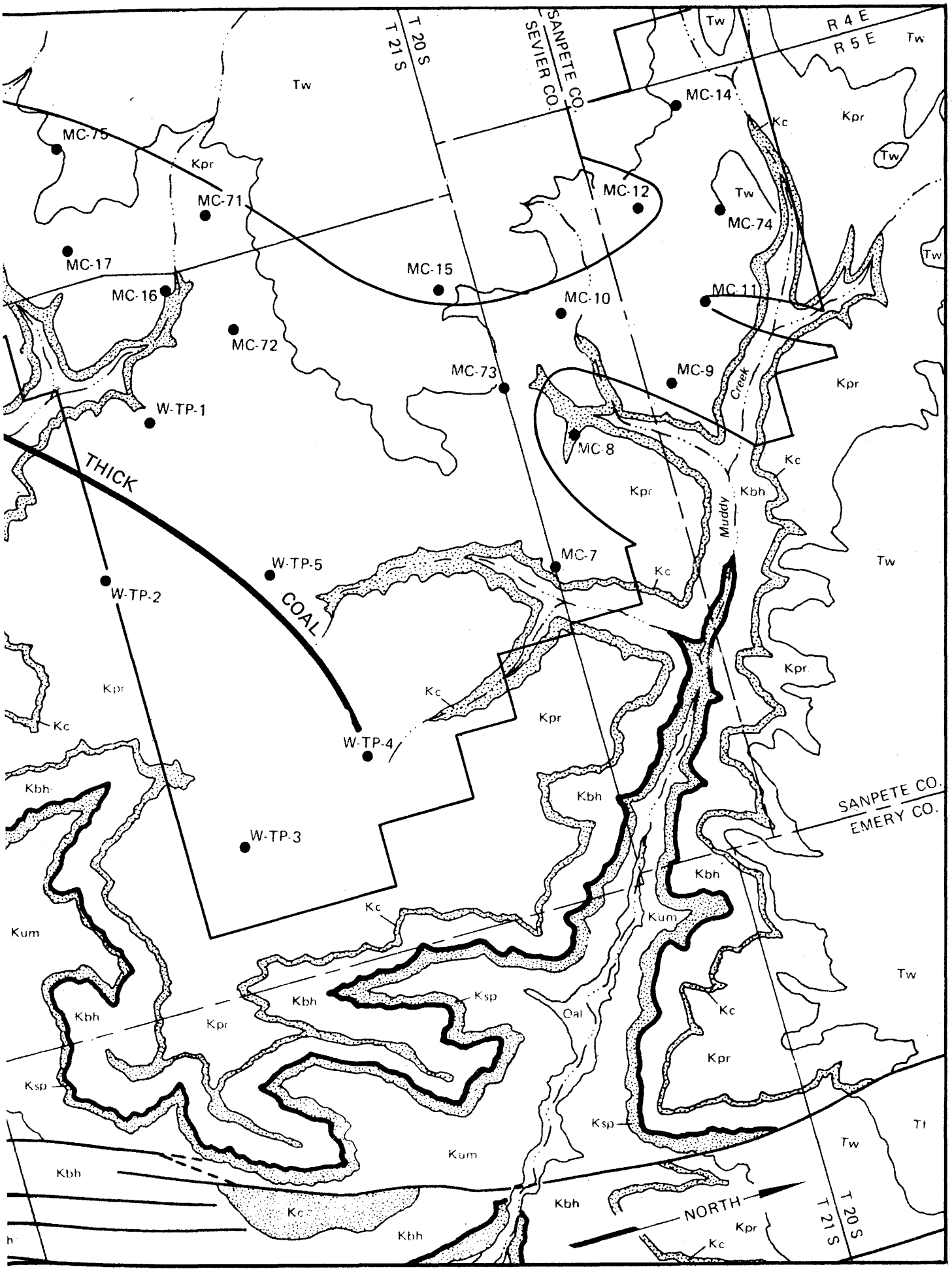
MUDDY CREEK, QUITCHUPAH CREEK, AND CONVULSION CANYON AREAS

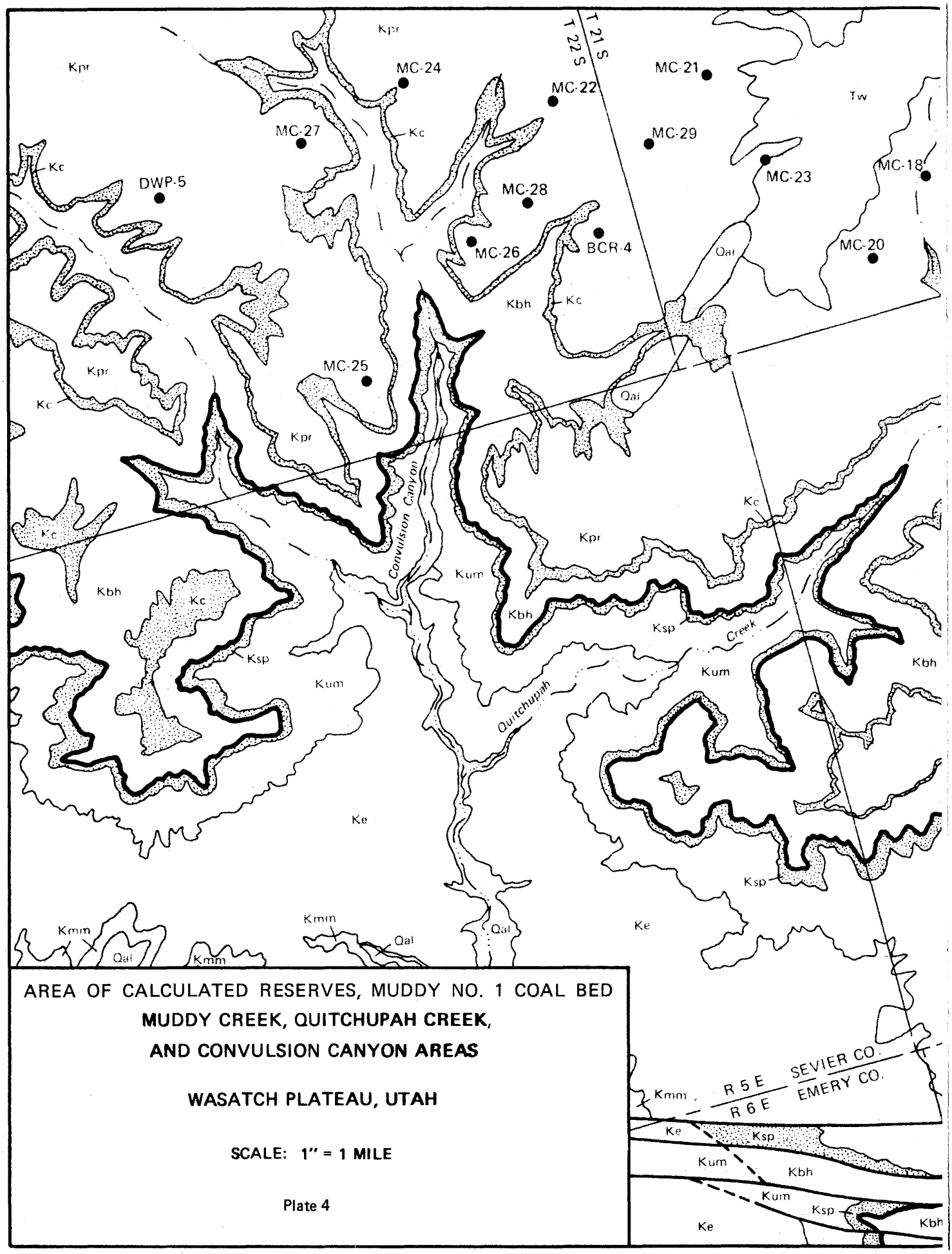
WASATCH PLATEAU, UTAH

SCALE: 1" = 1 MILE

AREA OF CALCULATED RESERVES, UPPER HIAWATHA COAL BED

Plate 3


T 20 S
T 21 S
SANPETE CO.
SEVIER CO.
R 4 E
R 5 E
Tw
MC-14
MC-75
MC-71
MC-12
MC-74
MC-17
MC-15
MC-16
MC-10
MC-11
MC-72
MC-73
MC-9
W-TP-1
MC-8
THICK
COAL
W-TP-5
MC-7
W-TP-2
W-TP-4
W-TP-3
Kpr
Kc
Kbh
Kum
Ksp
Qal
Tf
Muddy
Creek
SANPETE CO.
EMERY CO.
NORTH

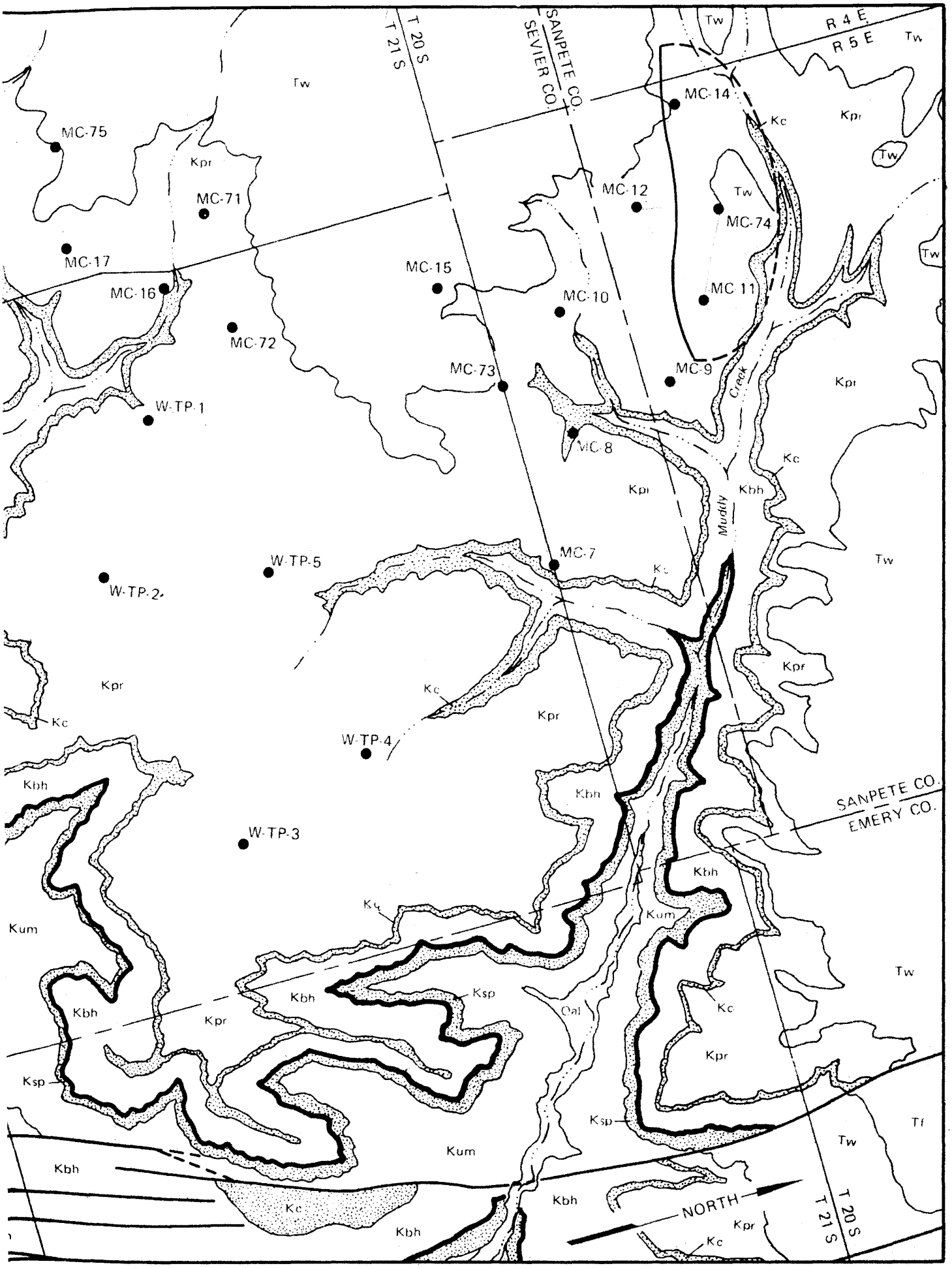


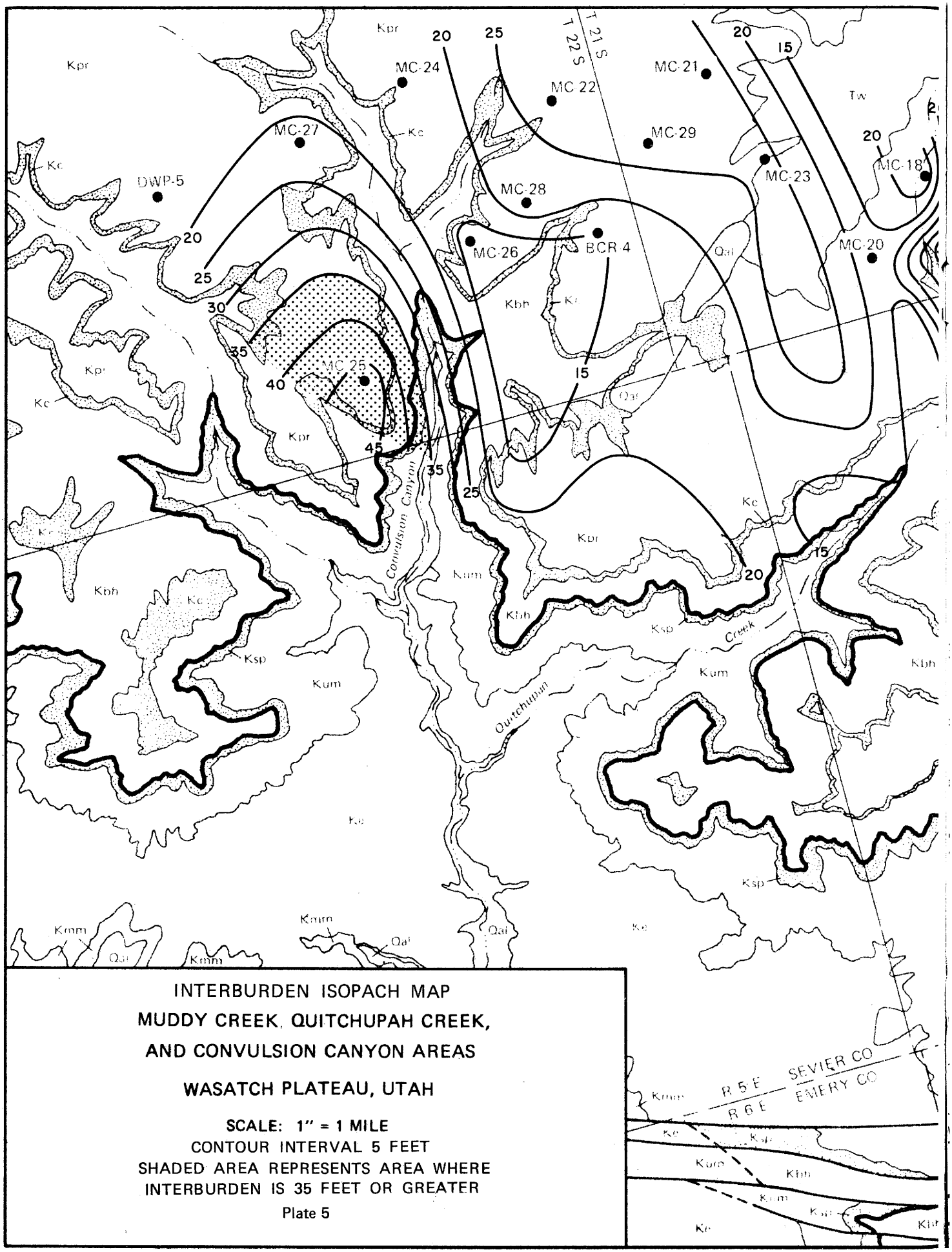
AREA OF CALCULATED RESERVES, MUDDY NO. 1 COAL BED
MUDDY CREEK, QUITCHUPAH CREEK,
AND CONVULSION CANYON AREAS

WASATCH PLATEAU, UTAH

SCALE: 1" = 1 MILE

Plate 4

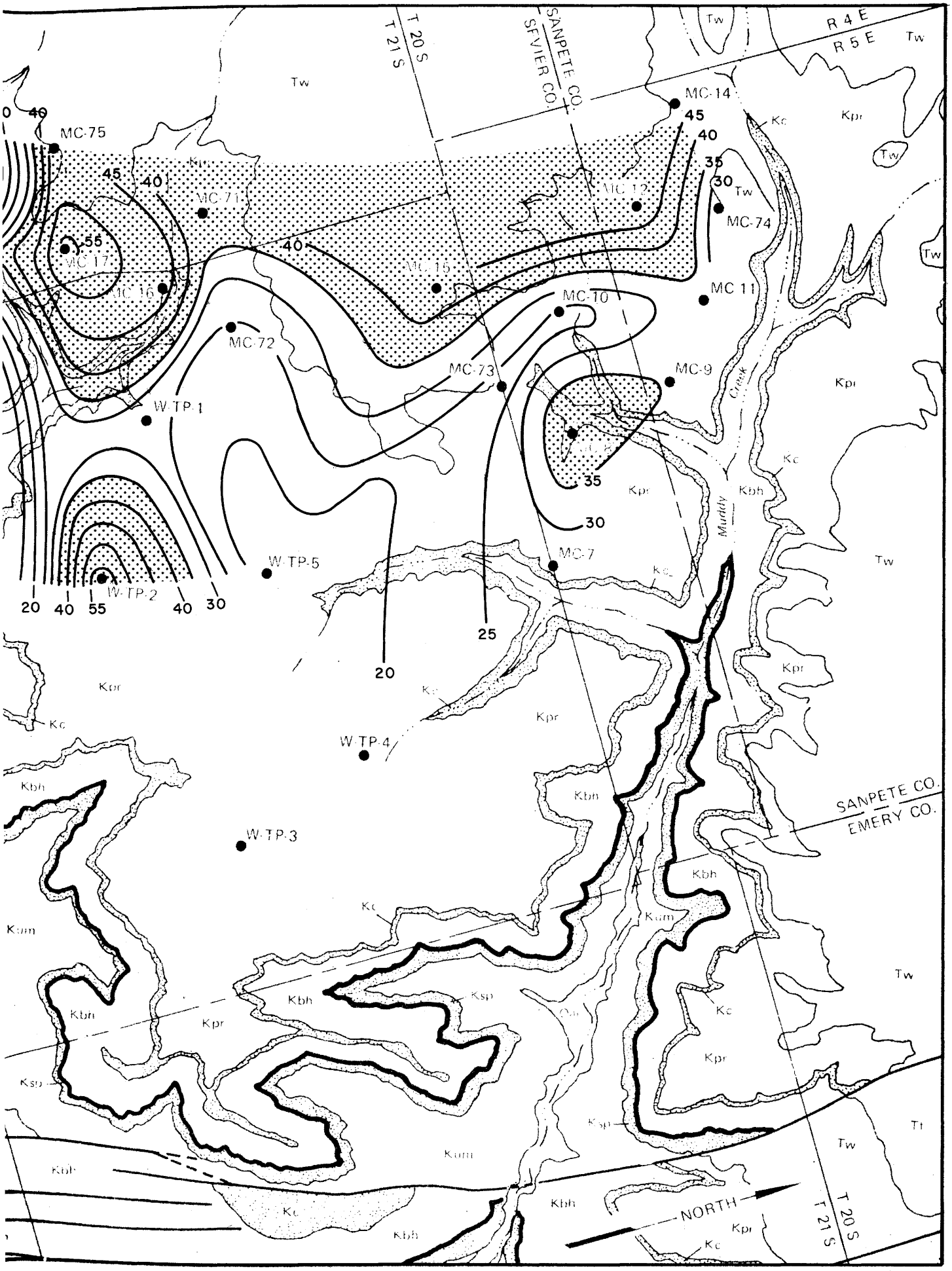

T 20 S
T 21 S
SANPETE CO.
SEVIER CO.
R 4 E.
R 5 E
Tw
MC-75
MC-71
MC-17
MC-16
MC-72
MC-15
MC-73
MC-14
MC-12
MC-74
MC-11
MC-10
MC-9
MC-8
MC-7
W-TP-1
W-TP-2
W-TP-3
W-TP-4
W-TP-5
Kpr
Kc
Kbh
Muddy
Creek
Kum
Ksp
Qal
Tf
SANPETE CO.
EMERY CO.
NORTH



INTERBURDEN ISOPACH MAP
MUDDY CREEK, QUITCHUPAH CREEK,
AND CONVULSION CANYON AREAS
WASATCH PLATEAU, UTAH

SCALE: 1" = 1 MILE
CONTOUR INTERVAL 5 FEET
SHADED AREA REPRESENTS AREA WHERE
INTERBURDEN IS 35 FEET OR GREATER

Plate 5


R 4 E
R 5 E
T 20 S
T 21 S
SANPETE CO.
SEVIER CO.
SANPETE CO.
EMERY CO.
NORTH
Muddy Creek
MC-75
MC-71
MC-17
MC-16
MC-15
MC-14
MC-12
MC-74
MC 11
MC-10
MC-72
MC-73
MC-9
MC-8
MC-7
W-TP-1
W-TP-2
W-TP-3
W-TP-4
W-TP-5
Tw
Kpr
Kc
Kbh
Kum
Ksp
Tt
20
25
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35
40
45
55

Archives Approval No. 8100230
Account Number 016103

UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
Salt Lake City, Utah 84108

THE UTAH GEOLOGICAL AND MINERAL SURVEY is a Division of the Utah Department of Natural Resources and Energy and operates under the guidance of a Governing Board appointed by the Governor from industry and the public-at-large. The Survey is instructed by law to collect and distribute reliable information concerning the mineral resources, topography, and geology of the state, to investigate areas of geologic and topographic hazards that could affect the citizens of Utah, and to support the development of natural resources within the state. The *Utah Code annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-1 through 12,* describes the Survey and its functions.

The Survey publishes bulletins, maps, a quarterly newsletter, and other publications that describe the geology of the state. Write for the latest list of publications available.

THE SAMPLE LIBRARY is maintained to preserve well cuttings, drill cores, stratigraphic sections, and other geological samples. Files of lithologic, electrical, and mechanical logs of oil and gas wells drilled in the state are also maintained. The library's collections have been obtained by voluntary donation and are open to public use, free of charge.

THE UTAH GEOLOGICAL AND MINERAL SURVEY adopts as its official policy the standard proclaimed in the Governor's Code of Fair Practices that it shall not, in recruitment, appointment, assignment, promotion, and discharge of personnel, discriminate against any individual on account of race, color, religious creed, ancestry, national origin, or sex. It expects its employees to have no interest, financial or otherwise, that is in conflict with the goals and objectives of the Survey and to obtain no personal benefit from information gained through their work as employees of the Survey. For permanent employees this restriction is lifted after a two-year absence, and for consultants the same restriction applies until publication of the data they have acquired.