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HYDROGEOLOGICAL RECONNAISSANCE OF ABANDONED UNDERGROUND COAL MINES AND THE ADJACENT AREA NEAR ROUNDUP, MONTANA

by

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INTRODUCTION

Background

Developing a large-scale water supply using water stored in underground coal mine workings near Roundup, Montana, has been considered by ranchers, farmers, and former mine workers since the mines were abandoned and allowed to fill with water. Agriculture is the major economic base of this region, and since mining has stopped, it is the major water user. Near Roundup, in 8 out of 10 years sufficient irrigation water is available only until the end of June (Montana Dept. of Natural Resources and Conservation, 1982). Water-supply deficiencies were documented as early as 1932 (U.S. Bureau of Reclamation). Low flows in the Musselshell River have adversely impacted water supplies in several municipalities. For example, in both 1985 and 1988 the water supply to the town of Melstone was depleted to such an extent that upstream irrigation was shut down in order to maintain instream flows.

In cooperation with the Lower Musselshell Conservation District and the Deadmans Basin Water Users Association, and under funding of the Montana Joint Water Resources Research

Center and the Montana Bureau of Mines and Geology, the Bureau of Mines and Geology has completed a reconnaissance-level hydrogeologic study of the area. The purpose of this work has been to provide a basis for further and more-detailed investigations examining potential beneficial development of ground water in the abandoned mine workings. This report provides a general overview of the area, maps and descriptions of the mine workings, reconnaissance-level inventory and water-quality data, and discussions of information that require more comprehensive study.

Climate

The Bull Mountain area has a semi-arid climate, characteristic of the northern Great Plains. Hot daytime temperatures are common during the summer. Winter temperatures are moderate to cold with rapid fluctuations common. Precipitation ranges from about 14 inches in the higher elevations to between 11 and 12 inches per year in the lowlands. About one-half of the precipitation falls during the spring and early summer.

Geographic Setting

The study area is located in the Bull Mountain coal field of south central Montana (Figure 1). Near the northern edge of the study area is Roundup, a town currently sustained primarily

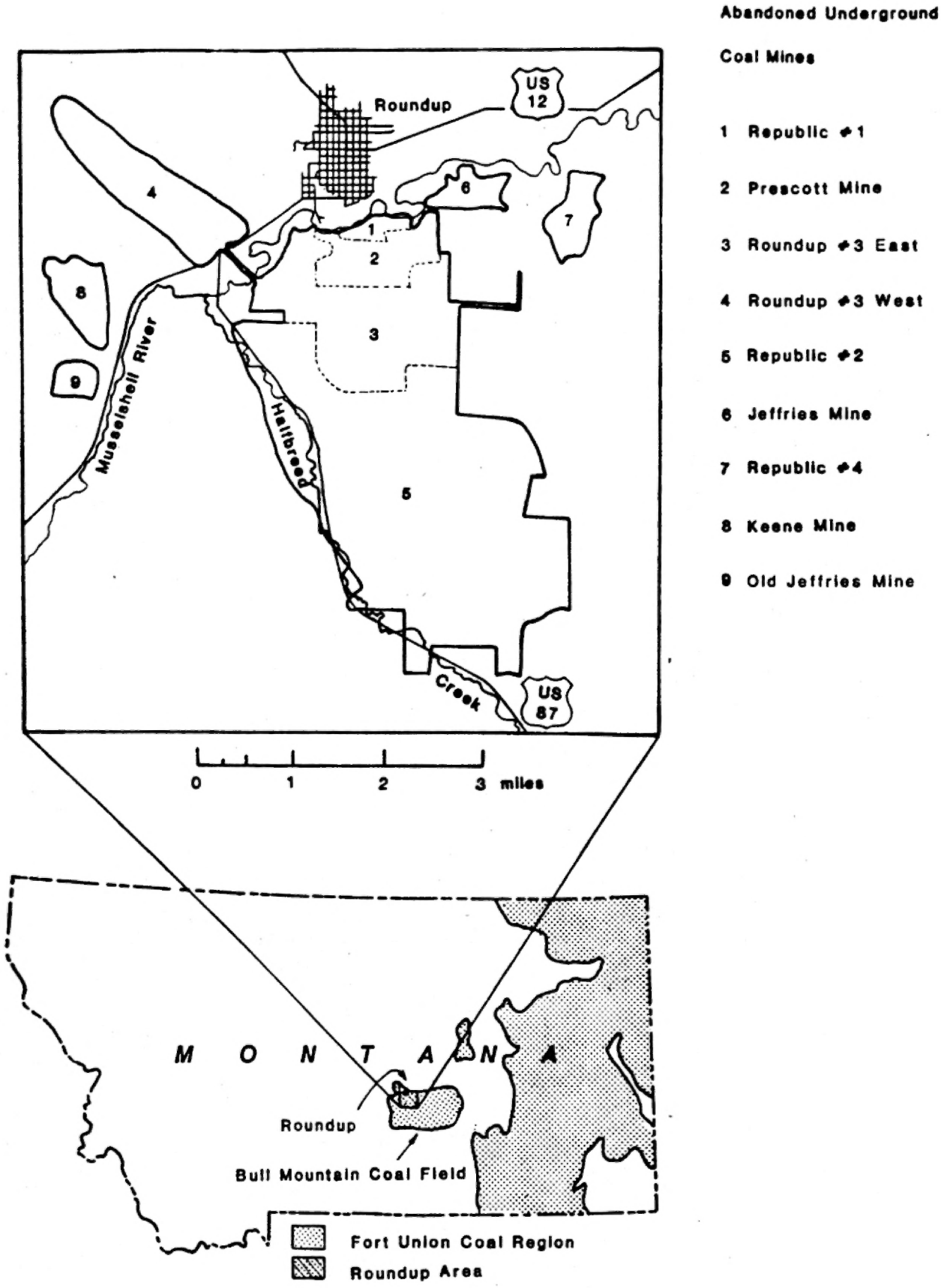


Figure 1. Index map of Bull Mountain Coal Field, naming underground workings of the Roundup coal bed.

by agriculture, but for many past years having been a center for underground coal mining. The main area of underground mining extends about 5 miles south of Roundup, occupying about 11 square miles. The area of past mining activity includes part of the Bull Mountains, which rise to elevations above 4700 feet, contrasting with elevations of about 3200 feet at Roundup. The only perennial streamflow in the area occurs in the Musselshell River and in downstream reaches of Halfbreed Creek. In all other watercourses, flow is intermittent or ephemeral (Knapton, 1982, p. 6).

Within the Bull Mountains, steep, sandstone, rimrocks border many of the drainages, and flat mesas capped by resistant clinker characterize the uplands. Valley bottoms and gentle slopes are generally underlain by claystone or silty shale deposits.

Previous Studies

Coal in the area was reported as early as 1873 (Stanley, 1874). Reconnaissance geologic and stratigraphic mapping was conducted in 1881 and reported in the Tenth Census (Eldridge, 1886). Preliminary studies reported results of geologic mapping of the Bull Mountain coal field (Woolsey, 1909; Richards, 1910). Woolsey and others (1917) provided more detail on coal outcrops, described stratigraphic sections, and presented data on coal chemistry. Additional reports on coal resources and

prospects were published by coal operators (Gilles, 1929; Gilles, 1935). Interest in mining of coal resurfaced in the late 1970's and was concerned primarily with thicker coal beds in the Bull Mountains. As a result, Connor and Griffith (1980) and Connor (1981) developed structural maps and cross-sections of additional reserves.

The first water-resources study of the area produced a report on ground water in Musselshell and Golden Valley counties by Ellis and Meinzer (1924). They described ground-water sources and potential sources, including abandoned mines, and summarized them by geologic formation and location. A similar but more abbreviated review was published by Zimmerman (1956). The U.S. Bureau of Reclamation (1932) reported on surface-water shortages in the Musselshell River valley. Offstream storage potential along the Musselshell River was evaluated in a later report (Montana Dept. of Natural Resources and Conservation, 1982). The sites evaluated were not concluded to be practical solutions for ameliorating surface-water shortages. Water chemistry and flow data collected from several small streams in the Bull Mountain are published in Knapton (1982). Tabulated well and spring inventory data of an area including the Bull Mountains were published by Rioux and Dodge (1980). Thompson (1982) published a ground-water study that investigated potential impacts of proposed surface mining there.

GEOLOGY

Stratigraphy and Structure

The Bull Mountain coal region is underlain by sedimentary rocks from Cambrian to Paleocene in age. Figure 2 is a generalized stratigraphic column for the study area showing the units above the Bearpaw Shale. The Bearpaw Shale, composed of 600 to 700 feet of gray to black marine shaley claystone and shale, is a significant aquitard and bounding the overlying shallow aquifer system. Conformably overlying the Bearpaw Shale is the Fox Hills Formation, 200 to 400 feet of gray to tan, fine- to medium-grained sandstone, with layers of gray shale and shaley siltstone. The Fox Hills Formation, deposited in a marine shoreline or near-shore environment, is separated from the predominantly continental deposits of the overlying Hell Creek Formation by a gradational contact. The lower Hell Creek sediments are lithologically similar to the Fox Hills sediments. The upper Hell Creek Formation consists of gray to yellowish-gray silty, clayey, carbonaceous and bentonitic shale with yellowish-gray to tan, fine- to medium-grained, silty sandstone, interbedded with thin coal beds and silty shale. The Bearpaw Shale and the Fox Hills and Hell Creek Formations are not exposed at land surface in the study area. Land-surface features are formed on the Fort Union Formation, a sequence of Paleocene fluvial-deltaic sediments which conformably overlie

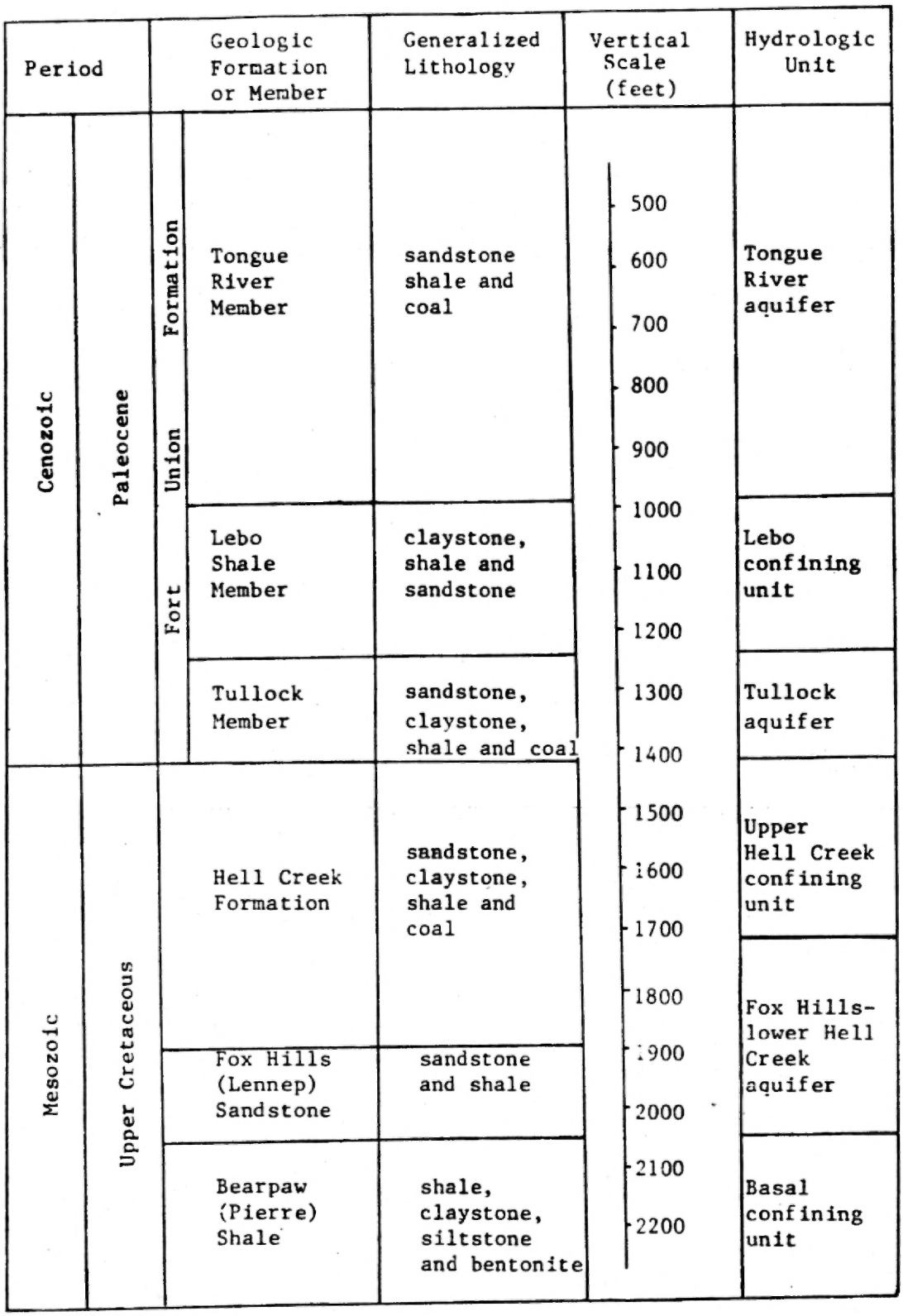


Figure 2. Generalized stratigraphic column for the Bull Mountain area.

the Hell Creek Formation. Coal beds that have been mined in the Bull Mountain Coal Field are within the Fort Union Formation. Three members of the Fort Union Formation are exposed in the Bull Mountain Coal Field. From older to younger, these are: Tullock, Lebo, and Tongue River Members. The Tullock Member consists of alternating beds of yellowish-gray sandstone, yellow and gray clay, and gray sandy shale. The sandstone beds are often resistant to weathering and form escarpments where the beds are flat-lying and hogback ridges where beds are steeply dipping. Clayey sediments, thin, uneconomical coal beds, and carbonaceous zones predominate in the Tullock Member.

The Lebo shale is composed of 150 to 200 feet of olive-green, yellow and brown, sandy clay, sandy shale, and soft sandstone. An important marker horizon in the Lebo shale is the Big Dirty bed, a stratigraphic unit of coal and carbonaceous clay that is uneconomical but can be traced throughout large areas in southeastern Montana.

Where not partially eroded, the Tongue River Member contains about 1600 feet of interbedded tan to whitish-gray sandstone, grayish-green shale, coal and minor amounts of buff fresh-water limestone. The Tongue River Member was deposited in a fluvial setting. Twenty-six coal beds ranging in thickness from 1 to 15 feet have been identified within this member in the Bull Mountain area (Woolsey and others, 1917). They were deposited in backswamps and are the most laterally continuous of the

sedimentary units. Some can be traced over a distance of many miles. One of the coal beds, the Roundup bed, became the major target of underground mining in the area and was extracted beneath the areas outlined in Figure 1. The sandstone beds range in thickness from a few inches, where interbedded with shale, to more than 50 feet. They vary in thickness over relatively short distances but, due to their resistant nature, can commonly be traced for considerable distances as a series of cliffs and benches. Fine-grained deposits of siltstone, shale, clay, and clayey, fine-grained sandstones are volumetrically the predominant units of the Tongue River Member. As a result of differential erosion modern stream and river valleys commonly overlie Tongue River silts and shales.

Sand and gravel deposits of Tertiary/Quaternary age overlie the Fort Union Formation within the Musselshell River valley, occupying the present floodplain and the flat-lying terraces above it. Finer-grained alluvium is associated with tributaries of the river.

The study area lies in a northwest-southeast-trending syncline which is part of a larger structural feature known as the Bull Mountain Basin. The axis of the syncline extends diagonally across the study area, crossing the Musselshell River near the mouth of Halfbreed Creek.

The rocks dip most steeply on the north limb of the syncline, from about 30° in the northwest to 13° near Roundup (Woolsey and others, 1917). The fold flattens towards the southeast.

Roundup Coal Bed

Areal Extent and Thickness

Discussion of the coal outcrop and the bed's thickness is drawn primarily from Woolsey and others (1917). The Roundup coal bed is in the lower third of the Tongue River member of the Fort Union Formation. Near the town of Roundup, it lies about 500 feet above the top of the Lebo shale and was the most extensively mined coal bed in the Roundup area. Its coal is classified as subbituminous, with an average calorific value of more than 11,000 British thermal units per pound.

The Roundup coal bed is thin and poorly defined along its western outcrop exposure (Plate 1). It is about 1-foot thick there, but thickens northward in the Goulding Creek drainage, and ranges from 4- to 6-feet thick near Roundup. The bed gradually thins eastward from Roundup to a thickness of 3-1/2 feet on the west side of Fattig Creek. From there it more abruptly thins to about 1-1/2 feet on the east side of Fattig Creek. The Roundup coal is split into two benches in the west part of the Roundup district. The line of the split is the

western mining limits of the No. 2 and No. 3 mines (Figure 1). West of the split, up to 20 feet of sandstone separate two thin coal benches. Total coal thickness averages about 3 feet west of the split and 5-1/2 feet east of it. Over most of the area, the coal is directly overlain by a well-indurated, thin-bedded to massive sandstone, in some places, several tens-of-feet thick. The coal is directly underlain by a uniform clay bed.

In several areas near Roundup, the coal bed subcrops at the base of Musselshell River alluvium. The extent of these subcrops is obscured by the alluvium but appears to be 3-1/2 to 4-1/2 miles.

History of Mining

Coal mining in the Roundup area started in the late 1800's. Early development consisted of ranchers opening small prospects at coal outcrops to extract coal for their own use. The coal was known to be of good quality, and significant reserves were eventually proven to be available for larger-scale mining.

Northern Pacific Railroad opened test pits during the 1880's, and prospecting for commercial quantities of coal increased in the early 1900's, fueled by increased demand by the railroads. Much of the exploration focused on the Roundup coal bed. The first commercial mine was the No. 1 mine (Figure 1), opened in 1907 by the Republic Mining Company.

The Republic No. 1 Mine originally reached the coal by a slope excavated under the Musselshell River. Inflows of large volumes of water forced abandonment of the original mine entry and made the miners aware of potential water problems when designing subsequent mines. A new mine slope was constructed south of the river to reach the No. 1 Mine. Several mines operated near Roundup in the first half of the 20th century. By the 1950's the railroads demand for coal diminished rapidly as trains were converted to diesel engines. The last major mine closed in the mid-1960's. Since the last mine closed, most of the old mine adits and workings have been reclaimed. Concrete bulkheads cover most of the old mine entrances. Piles of waste coal have been reclaimed, and many of the old structures associated with the mines have been demolished.

Mining Methods

Nearly all of the mining was done by the room and pillar method. Coal was mined out of rooms and pillars of coal remained to support the roof rock. The amount of coal extracted was usually about 60% of the total volume. Slopes were typically excavated down the dip of the coal, with rooms mined out on both sides. Where practical, the rooms were frequently run at a slight angle updip so that gravity would help transport the coal to the slope. Loaded coal cars were pulled up the main slopes by rope. Generally within 500 to 1500 feet from the outcrop, the dip of the coal had flattened enough that electric

motors were sufficient to move the coal cars up dip to the main rope haulage. At the Republic No. 2 Mine a 350-foot vertical shaft was used to reach the coal.

Fresh air was pumped into most of the mines through air shafts drilled from the surface to the mine workings. Some may have also been used for dewatering before being used as air shafts. Dewatering the active mine workings was a major concern during operation of the mines, but little data has been found concerning the volumes of mine-water discharge. The larger mines had one or more 50- to 100-horsepower pumps operating 8 to 15 hours a day. Water was generally collected in sumps constructed by sealing off abandoned rooms and from there discharged at the surface. Once pumped to the surface the water was discharged into natural drainages that led to the Musselshell River. Water from the No. 2 Mine was discharged to Halfbreed Creek and was used for irrigation.

Barriers of coal were required by law to separate the mines. Mine maps identify a 250-foot coal barrier around the No. 1 Mine and in other mines show intersecting rooms, slopes, and waterways indicating interconnections. Former miners have also reported mining through to other workings (J.K. Kuzara, written communication, 1972).

Extent of Mining

A literature and archives search produced many maps of geology and mine workings for the Roundup area (Table 1).

TABLE 1. COAL RESOURCE AND MINE MAPS OF ROUNDUP DISTRICT
BULL MOUNTAIN COAL FIELD

MAP NAME	DATE	SCALE	LOCATION	TYPES OF INFORMATION	*SOURCE
Bull Mountains Coal Deposit Fence Diagram	01/77	1:126,720	T 6N R 26E T 7N R 27E	Fence diagram correlating major coalbeds (paper copy)	BN
Bull Mountain-Musselshell Coal Field	11/03/14	1:190,080 1"=3 miles	T 4N R 19E to T 9N R 31E	Outcrops of major coal beds, streams, mine locations, divide between Musselshell and Yellowstone River watersheds (mylar base)	BN
Structure Contours on the Top of the Bearpaw Shale in the Bull Mountains, Montana	No date Provisional	1:250,000	T 4N R 24E to T 9N R 33E	Structure of Bear Paw shale showing Bull Mountain Basin (paper copy)	USGS
Roundup District Bull Mountain Coal Field	03/62	1:12,000 1"=1000'	T 7N R 25E T 7N R 26E T 8N R 25E T 7N R 26E	Limit of mine workings for all major and several smaller mines, coal outcrop, river channel, isopach of Roundup coal bed, split in coal bed (mylar base)	BN
Holdings of the Roundup Coal Mining Co. near Roundup	09/44	1:19,200	T 7N R 25E T 7N R 26E T 8N R 25E T 8N R 26E	Coal ownership, major coal mines, location of drill holes with depth to coal and coal thickness (paper copy)	BN
Correlative Map of Roundup District	08/24	1:21,120 3"=1 mile	T 7N R 25E T 7N R 26E T 8N R 25E T 8N R 26E	Coal ownership, active and inactive mines, areas of mined coal, coal outcrop, river channel (paper copy)	BN
Prescott Mine Bair-Collins	12/03/34	1:2400	T 8N R 25E Sec. 24	Limit of mine workings, shafts and rooms in Prescott Mine, boundaries of Williams Mine, Davis Mine, No. 1 Mine and No. 3 Mine (paper copy)	BN
Prescott Mine Bair-Collins Co	01/20/31	1:1200 1"=1000'	T 8N R 25E Sec. 24	Sketch of entry setup, main slope, overburden thickness at river, top of coal elevation, strike of coal (coal cropline), Davis Mine, coal cropline No. 1 Mine, Butler 40 acre mining limits (paper copy)	BN
Prescott Mine Bair-Collins Co	01/44	1:2400 1"=200'	T 8N R 25E Sec. 24	Limit of mine workings, mine slopes, rooms, pillars, selected elevations on base of coal, areas of bad roof rock, boundary outlines of No. 1 Mine, Davis Mine, Williams Mine and No. 3 Mine (Paper copy)	EMC

TABLE 1. COAL RESOURCE AND MINE MAPS OF ROUNDUP DISTRICT
BULL MOUNTAIN COAL FIELD - Page 2

MAP NAME	DATE	SCALE	LOCATION	TYPES OF INFORMATION	*SOURCE
Prescott Mine Profile of Mine Slope Bair-Collins Co.	03/32	1:1200 (horiz) 1:240 vert	T 8N R 25E Sec. 24	River location with respect to mine slope, bedrock/ alluvium contact, pump discharge line, air shaft concrete bulkhead (paper copy)	EMC
Outcrop of Roundup Coalbed and Outline of No. 4 Mine Workings, Rebublic Coal Co.	07/39	1:4800 1"=400'	T 8N R 26E Sec. 17	Roundup bed outcrop, limits of No. 4 Mine, selected outcrop elevations, Nies Bros. Mine opening, river channel (paper copy)	BN
Mine No. 4, Republic Coal Company	N/A	1:2400 1"=200'	T 8N R 26E Sec. 17 & 20	Limit of mine workings, mine slopes, rooms, pillars elevations on base of Roundup coal bed, areas where roof rock has caved possibly because coal pillars were mined out in select areas (paper copy)	BN
Mine No. 3 West Extension Roundup Mining Co.	No date	1:2400 1"=200'	T 8N R 25E Sec. 15,16 22, & 23	Limit of mine workings, shafts, rooms, pillars, tipple 3 sheets (paper copy)	BN
Mine No. 2, Klein Mine, Republic Coal Co.	12/10/56	1:2400 1"=200'	T 7N R 26E Sec. 5	Limit of mine workings, elevation on base of Roundup coal bed, drill hole locations, coal thickness, areas of bad roof rock, rooms, pillars, inspection dates, date mine closed (paper copy)	BN
Mine No. 2, Klein Mine, Republic Coal Co.	03/27/52	1:2400 1"=200'	T 7N R 25E Sec. 1 & 6	Limit of mine workings, elevations on base of Roundup coal bed, coal thickness, areas of bad roof rock, rooms, pillars, inspection dates (paper copy)	BN
Mine No. 2, Republic Coal Co., Roundup, MT	1953 (est)	1:2400 1"=200'	T 7N R 25E Sec. 6 & 7	Limit of mine workings, mine slopes, rooms, pillars elevations on base of Roundup coalbed, areas of bad roof rock, dates rooms mined out, air shafts (paper copy)	BN
Mine No. 2 (Klein) Mine Workings, Republic Coal Co.	N/A	1:4800 1"=400'	T 8N R 25E T 7N R 26E	Limit of mine workings, mine shafts, haulage ways (paper copy)	BN

TABLE 1. COAL RESOURCE AND MINE MAPS OF ROUNDUP DISTRICT
BULL MOUNTAIN COAL FIELD - Page 3

MAP NAME	DATE	SCALE	LOCATION	TYPES OF INFORMATION	*SOURCE
Composite Map of Mine No. 3 East Workings and Mine No. 2, Roundup Coal Co. and Republic Coal Co.	08/05/60 01/02/53	1:4800 1"=400'	T 8N R 25E T 7N R 26E	Limit of mine workings, mine slopes, haulage ways, shafts, drill holes, elevations on base of coal, parts of Williams and Prescott Mines, river channel, water way between Prescott and No. 3 Mines (paper copy)	BN
Mine Map, Jeffrey Coal Mining Co.	02/26/39	1:2400 1"=200'	T 8N R 26E Sec. 18	Limit of mine workings, entrance, main slope, river bed, drill holes, pump site, pumping rate, rooms, pillars, dates mined out (paper copy)	BN
Resurvey of Jeffrey Mine	03/31/40	1:2400 1"=200'	T 8N R 26E Sec. 18	Main haulage tunnels, azimuths and distances, drill holes (paper copy)	BN
Mine No. 1, Republic Coal Co.	07/24	1:1200 1"=100'	T 8N R 25E Sec. 24	Limit of mine workings, slope; shafts, river bed rooms, pillars (paper copy)	EMC
Keene Coal Mine, Bair-Collins Co.	02/10/30	1:2400 1"=200'	T 8N R 25E Sec. 21,28	Limit of mine workings, mine slope, mine entries, rooms, pillars, drill holes, air shafts, depth to base of coal, depth to water (paper copy)	BN

*Data sources include Eastern Montana College Archives (EMC), archives of Burlington Northern Subsidiary Meridian Minerals (BN), and the US Geological Survey (USGS).

Archives of the Burlington Northern Railroad and Eastern Montana College provided most of the information. Copies of the maps and charts were obtained and are now archived at the Montana Bureau of Mines and Geology.

Unpublished mine maps identify workings in the Roundup coal bed under approximately 6330 acres south of the Musselshell River. The Roundup coal bed thins towards the east but averages 5.5-feet thick under 5980 acres, 4.5-feet thick under 133 acres and 4.0-feet under 217 acres. Assuming a conservative 50 percent-coal-extraction rate and average coal thicknesses, the volume of mined-out coal is estimated at 7.48×10^8 cubic feet. The mined-out volume can also be derived from production records. Estimates of total production for the No. 2 mine are 20,000,000 tons. Based on the specific gravity of the Roundup coal (1.30 grams per cubic centimeter) this represents about 1800 tons per acre foot of coal (Gilles, 1935), and there are over 11,000 acre-feet mined out in the No. 2 Mine. No total production estimates are known from the other mines in the Roundup bed south of the Musselshell River. An approximate estimate of coal removed from these other mines is 11,000,000 tons, accounting for an additional 6000 acre feet of mined-out area. It is thus estimated that the total void space in these mines is 17,000 acre-feet.

Depth Below Land Surface

A structure-contour map of the base of the Roundup coal bed (Plate 1) was compiled for this study using elevations from mine

maps, outcrops, geophysical logs from oil-exploration and coal test holes, and water-well logs. The structure of the coal mimics the structure of deeper rocks in Bull Mountain Basin. Total structural relief of the Roundup bed within the area of Plate 1 exceeds 600 feet. Lowest elevations (less than 2880 feet above sea level) occur along the synclinal axis extending southeastward from the town of Roundup. Along the southwest flank of the syncline, coal elevations exceed 3480 feet, and along the northeast flank they exceed 3400 feet.

Coal-elevation contours were subtracted from land-surface-elevation contours for mapping the approximate depths of the coal bed and workings below land surface (Plate 1). In areas of highest surface elevations and lowest coal elevations along the synclinal axis, depths to the Roundup coal bed exceed 1000 feet. Depths to the mine workings range up to about 800 feet. Shallowest depths to the workings are along the coal subcrop and outcrop. South of the Musselshell River, the workings lie within 200 feet below land surface along a very narrow area parallel to the river and in a small area near the mouth of Halfbreed Creek. Steeply-dipping strata beneath sharply-rising topography produce overburden thicknesses greater than 200 feet in most places within a few hundred lateral feet south of the valley bottom. The area where workings lie 200 to 400 feet below surface is also small. By far, most coal was mined from depths greater than 400 feet.

HYDROGEOLOGY

Regional Conditions

Bearpaw Shale of low permeability underlies the shallow aquifer system of the Bull Mountain region. The overlying Fox Hills Formation and lower Hell Creek Formation are significant sources of ground-water east of the Bull Mountains. However, limited testing of these formations southwest of the Bull Mountains indicates marginal ground-water potential due to high clay content in the sands (MBMG unpublished data). The upper Hell Creek Formation contains largely fine-grained sediments of low permeability and forms a confining layer separating the Fox Hills/lower Hell Creek aquifers from the overlying Fort Union aquifers.

Sandstone and thin coal beds of the Tullock Member of the Fort Union Formation are commonly tapped as ground water supplies around the margins of the Bull Mountains. In the Bull Mountains, depths to aquifers in the Tullock Member exceed 600 feet, and water supplies are generally obtained from sandstone beds in the Tongue River Member. Aquifers in the Tullock Member and the Tongue River Member are separated by poorly permeable clay beds of the Lebo Member.

Clinker, coal, and sandstone beds form discontinuous aquifers zones in the Tongue River Member. Water moves through these sediments usually in a horizontal direction, parallel to bedding planes, due to anisotropic conditions. Both interconnected pores and fractures provide permeability in these aquifers.

Clinker is formed when a coal bed burns and the overlying shale and sandstone beds are altered by high temperatures. Clinker is intensely fractured and characteristically red or maroon in color. It exhibits very high fracture permeablity and readily accepts recharge from precipitation. Most of the clinker beds in the Bull Mountains are located at high elevations, capping buttes and mesas.

The rate of ground-water movement through coal beds depends upon the number and hydraulic continuity of secondary joints and fractures. Coal beds of the Fort Union Formation are highly anisotropic (Stone and Snoeberger, 1977; Stoner, 1981). Hydraulic conductivities for the Mammoth coal in the Bull Mountains, determined from aquifer testing, exhibit a lognormal mean of 0.1 ft/day (Thompson, 1982).

Thick, moderately well-sorted sandstone bodies of the Tongue River Member form some of the most productive aquifers in the Bull Mountains. Hydraulic conductivities determined for sandstone beds above and below the Mammoth coal exhibit a lognormal mean of 0.04 ft/day (Thompson, 1982). Primary

porosity, secondary porosity, and thickness of the sandstone bodies all contribute to the productivity of these aquifers.

Beds of siltstone, shale, and silty clayey sandstone in the Tongue River Member separate the aquifer zones. There is a low vertical flux of water through these poorly permeable beds.

Shallow alluvial aquifers overlie bedrock in the Musselshell River valley and in valleys of most tributary streams. Along the river, the alluvium is generally less than 30 feet thick with water levels between 10 and 20 feet below land surface. Stream alluvium is usually less than 15-feet thick, with water levels between 5 and 15 feet below land surface. Domestic and stock wells are common in the gravelly alluvium along the Musselshell River. Alluvium of the tributary streams is commonly too thin and fine-grained to yield water to wells.

Ground-Water Use

Wells and springs are the major sources of domestic and stock water supplies in the Bull Mountains. Most of the springs are located at higher elevations south of the area underlain by mine workings. Well depths vary over a wide range, reflecting both the highly variable topography and the numerous aquifers of the area. A system adopted for this report to describe locations of wells, springs, and other data sites is outlined in Appendix A. Data from field inventories in the 1970's and early 1980's of wells are listed in Appendix B. Similar data

collected by the Montana Bureau of Mines and Geology in the summer of 1987 are listed in Appendix C. Locations of all wells and springs that have been inventoried by site visitation are shown on Plate 2.

Ground-Water Flow

A generalized potentiometric map for the Fort Union Formation (Slagle and others, 1986) indicates that ground water on the north side of the Bull Mountains flows northward toward the Musselshell River. Although not well defined, ground-water discharge from Fort Union aquifers into the river and its alluvium is indicated.

In 1982, a discussion of ground-water flow in the Bull Mountains was presented by Thompson (p. 23-26), characterizing the hydrogeologic roles of precipitation, topography, and aquifers. His discussion related to the Mammoth coal bed, lying several-hundred feet above the Roundup coal, but applies as well to the Roundup bed. Thompson wrote:

> "The flow of ground water in the Bull Mountains is dependent on temporal variations in precipitation, on the area's topography and complex stratigraphy, and on joint and fracture systems in the sandstone and coal aquifers.
>
> Seasonal variations in precipitation cause increases or reductions in the amount of recharge to the ground-water system, which show up most prominently in the seasonality of many springs. Records of observation-well water levels showed no evidence of a recharge event in the spring of 1982. The shortness of the record and its early termination might have caused the exclusion of a recharge event with a time lag behind the period of maximum precipitation.

During drilling of observation wells, many thin, interbedded sandstone and shale strata were encountered. Several thin saturated zones of sandstone were found above dry shale or dense siltstone, and often strata below the shales or siltstones were also dry. Drill-hole cores contained open fractures or joints in sandstone and coal, and similar features were observed in outcrops. Except in a few coarser-grained, less clayey sandstones in the area, these joints and fractures are probably the most important passageways for ground water. They are the only permeable features in the coal seams. The more permeable and more densely-jointed strata are preferentially used as conducts [conduits] for ground-water flow. Less-permeable beds act as aquitards and perching beds; little ground water flows through them.

Figure 6 [3] schematically illustrates ground-water flow in the Bull Mountains. Precipitation readily infiltrates into the butte-capping, highly permeable clinker which, because of its large porosity, acts as a reservoir for temporary storage of recharge. Downward movement of recharge water is slowed by the underlying less permeable stratum so that a lens of perched water is formed within the clinker. The spring at A in Figure 6 [3] is supplied by this perched water, and discharges at the contact of the clinker and the underlying less permeable rocks. Because the rocks beneath the clinker are not completely impermeable, some downward movement of ground water does occur. As this water moves through the rocks, contrasts in permeability between various lithologic units complicate the general downward movement. Other lower perched lenses of water accumulate above low-permeability layers. This lower perched water can either spill over the edges of the perching bed (B on Figure 6 [3]) and resume its downward movement, or if the perched aquifer crops out, the water can exit as a spring from a topographically low point on the outcrop (C on Figure 6 [3]). Springs of this type generally discharge from well-developed joints in thick sandstones. Strata having a moderately low permeability, or those with a small areal extent sometimes give rise to seeps at their outcrops (D on Figure 6 [3]). They neither receive nor transmit large amounts of ground water. The general downward movement of water continues, interrupted in places, until the water table is reached. Flows from aquifers that subcrop along the valley fill (E on Figure 6 [3]) recharge the alluvial aquifers. Flow in the

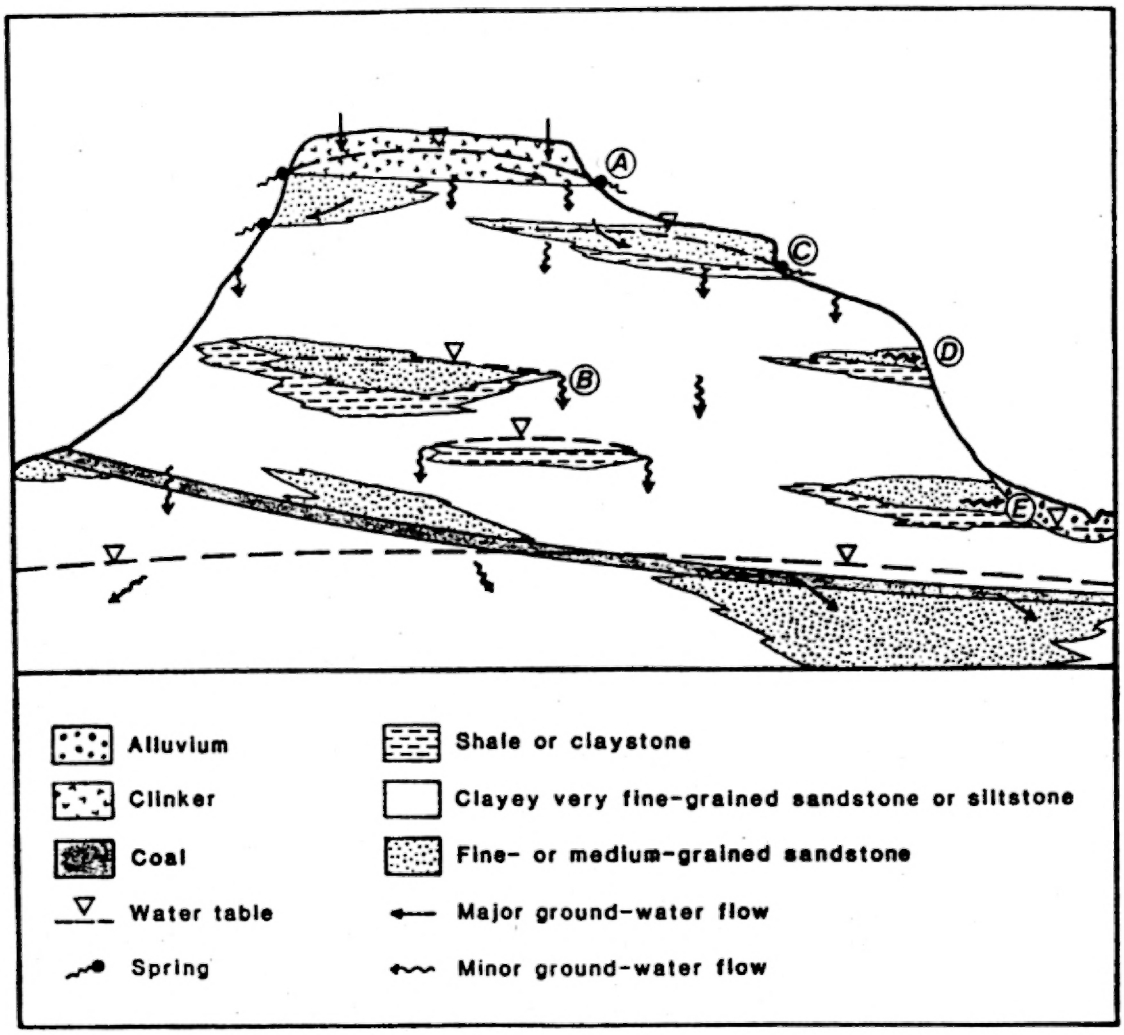


Figure 3. Idealized cross-section of the Bull Mountain area, characterizing ground-water flow (from Thompson, 1982).

alluvial aquifers is generally down-valley; depending on the type of bedrock beneath the alluvium and the bedrock's water table elevation, the ground water in the alluvium may leak downward into the bedrock.

The coal bed shown on Figure 6 [3] typifies conditions in the Mammoth coal. Generally near its outcrop in updip areas the coal is dry, downdip it is partly saturated, and still farther downdip it is fully saturated and may contain water under confined conditions."

Water-Level Monitoring

Included in Appendix C and on Plate 2 are 16 observation wells installed in alluvium along Halfbreed Creek and the Musselshell River. These wells were installed with the objective of monitoring long-term water-table reactions to precipitation and streamflow. Also, should development of mine-workings water occur, these wells will provide invaluable base-line data. Completion forms for these wells are presented in Appendix D. Monitoring at these wells began in December, 1987 (Figures 4, 5, and 6). The data show seasonal fluctuations from December 1987 to the present, caused by irrigation, evapotranspiration, and/or recharge from precipitation. To date, too short a record has been collected to define the nature and timing of seasonal events. All of the wells appear to be hydraulically connected to the adjacent watercourses through the alluvium, so the water levels should reflect conditions of low flow in Halfbreed Creek and the Musselshell River.

Figure 4 illustrates water level fluctuations in Halfbreed Creek alluvium. Water levels in RU-02 and RU-06 show very little change from the initial reading to the present. The water levels in RU-01 and RU-07 rose during the winter and have since

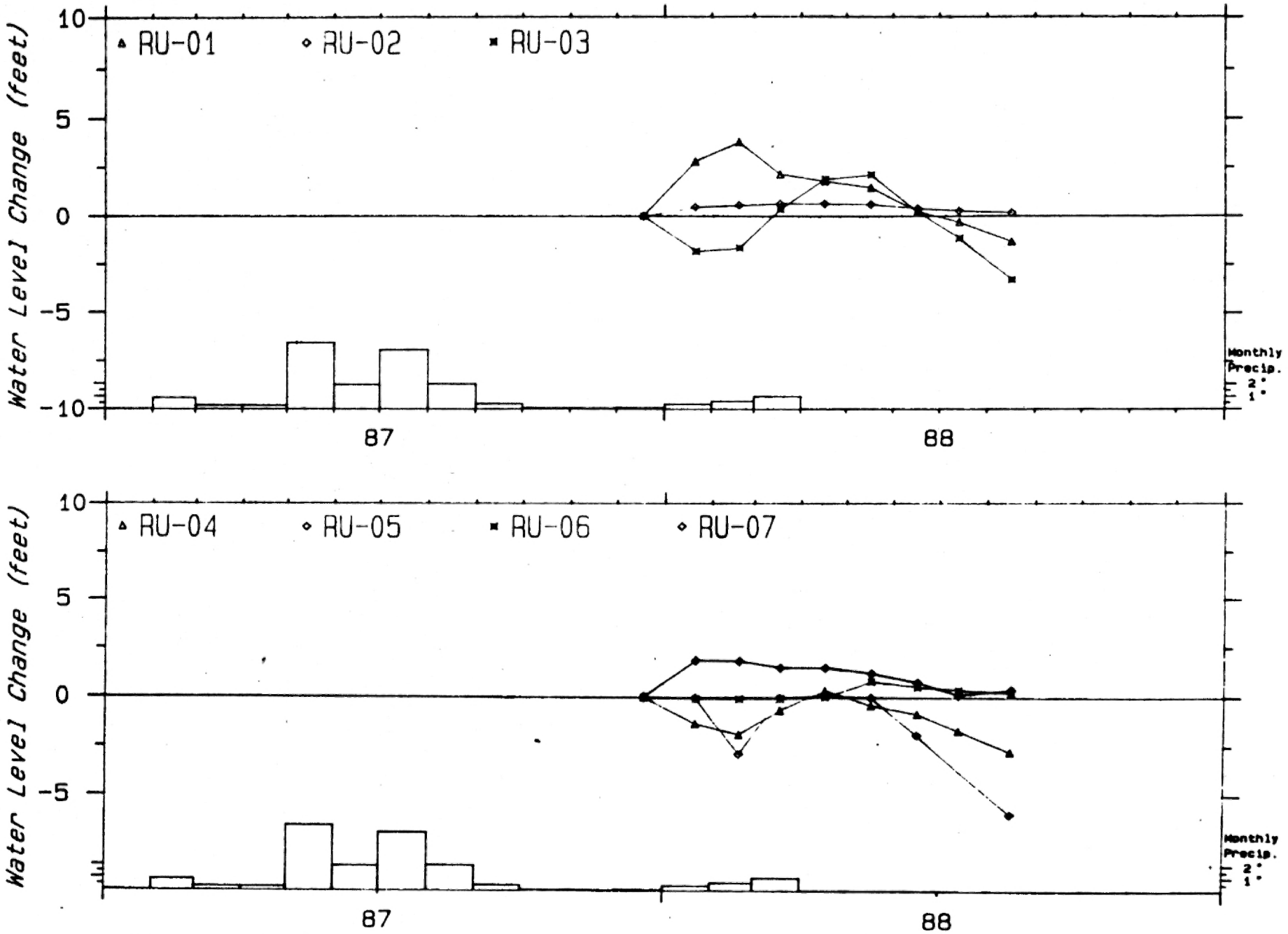
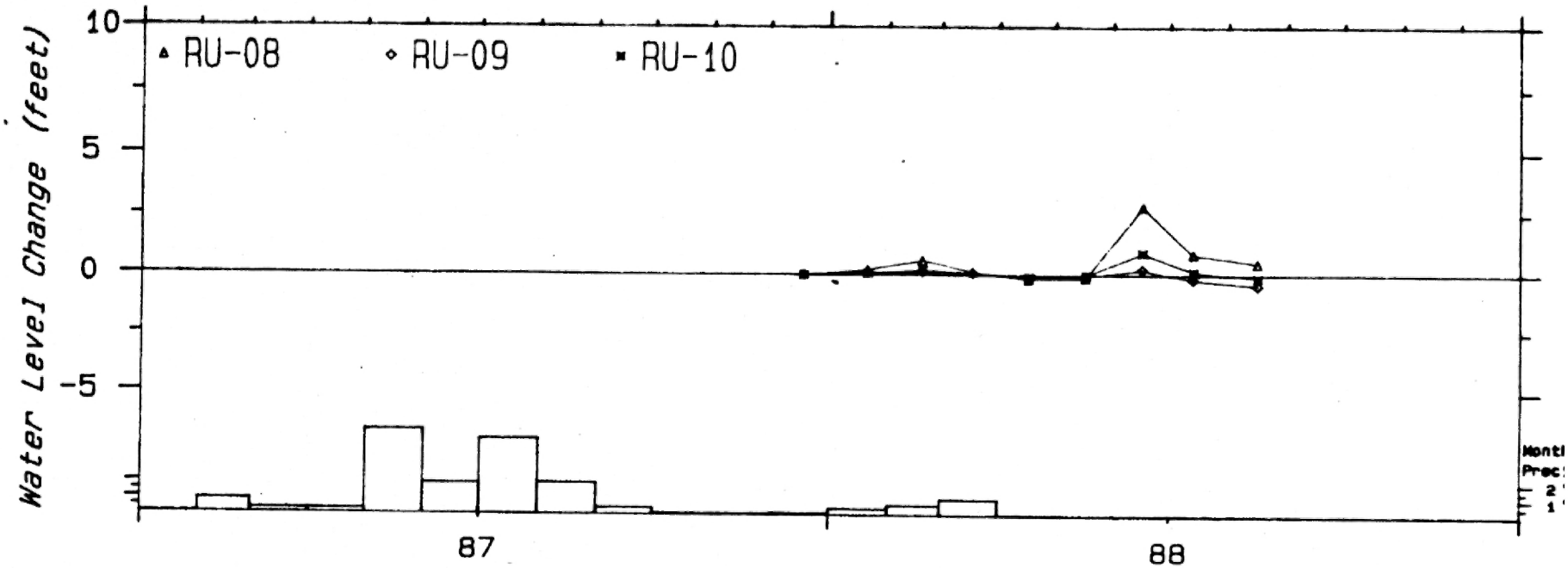


Figure 4. Hydrographs of water levels in alluvium along Halfbreed Creek.



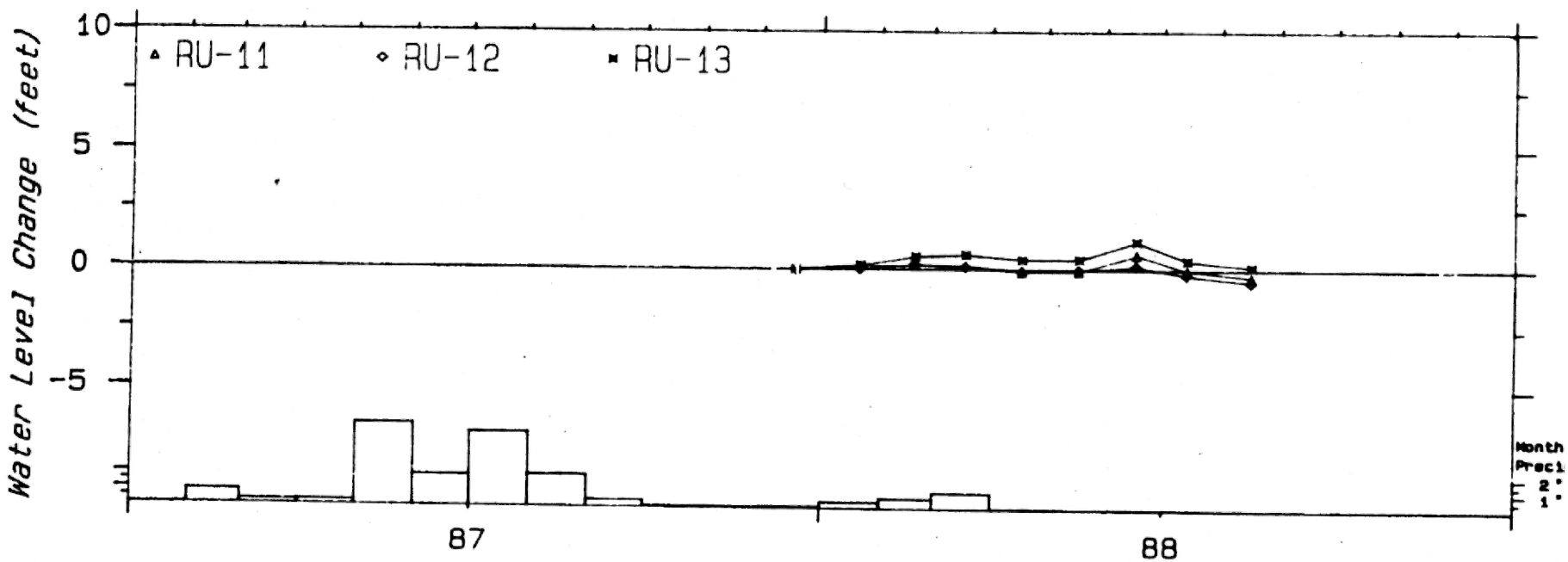


Figure 5. Hydrographs of water levels in alluvium along the Mo

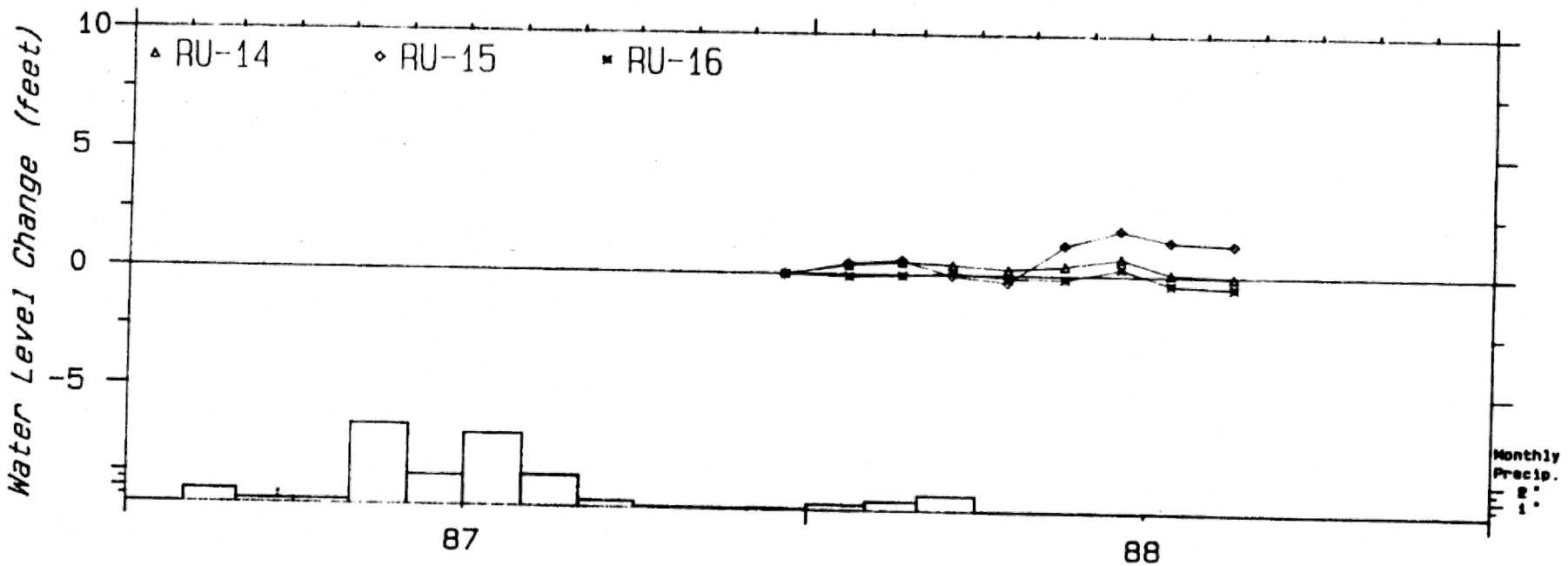


Figure 6. Hydrographs of water levels in alluvium along the Musselshell River.

declined steadily. Water levels in RU-03, RU-04, and RU-05 declined in the winter, rose during the spring, and have steadily declined during the summer. Four out of seven wells had August 1988 water levels significantly below the initial readings, probably due to the 1987-88 drought.

Figures 5 and 6 show a series of hydrographs from Musselshell River alluvial wells. These hydrographs all have similar patterns and show only minor water-level changes during most of the record. A water-level rise from May to June is followed by a decline of similar magnitude from June to July. Since only minor amounts of precipitation have occurred during the monitoring period, the water-level rise may be a response to change in stream stage or to irrigation return flows. Water levels in six of the nine Musselshell River alluvial wells was lower in August than the initial readings, again probably due to the drought conditions.

Ground-Water Quality

In Table 2, analyses of ground-water samples, primarily from the Fort Union Formation, are listed and are annotated with approximate stratigraphic positions using well-bottom elevations relative to elevations of the Roundup coal bed (Plate 1). Chemical concentrations are highly diverse, showing no discernable trends, either areally or stratigraphically. The diverse quality reflects the interbedded nature of clays, silts, and sands of the Fort Union Formation and the limited areal continuity of individual beds. Calculated-dissolved-solids contents for samples from the Fort Union Formation are less than

TABLE 2. WATER-QUALITY DATA FOR WELLS IN THE BULL MOUNTAIN AREA

SAMPLE LOCATION	DATE OF SAMPLE	GEO-LOGIC UNIT	SOURCE OF DATA	DEPTH OF WELL	SPECIFIC CONDUCT-ANCE (MICROSIEMENS PER CM AT 25 C)	CALCULATED DISSOLVED SOLIDS (MG/L)	pH (LAB)	TEMPER-ATURE (DEG C)	CALCIUM (MG/L)	MAGNESIUM (MG/L)	SODIUM MG/L	POTASSIUM (MG/L)	SODIUM AND POTASSIUM (MG/L)
06N26E02DCDA	04/03/73	125FRUN	USGS	70	2000	1470		10.0	63.0	79.0	330.0	6.0	336.0
06N26E10AADB	03/23/78	125FRUN	USGS	97	1590	1090	7.10	9.0	120.0	120.0	85.0	5.0	90.0
06N26E12DBAB	06/26/81	125FRUN	MBMG	200	2620	1700	8.00	11.5	22.0	11.0	550.0	4.0	554.0
06N26E13CCAC	04/20/78	125FRUN	USGS	200	2850	2070	7.30	10.0	270.0	240.0	58.0	7.0	65.0
06N26E14DBAA	06/16/81	125FRUN	MBMG	180	3100	2760	6.60	11.5	200.0	360.0	170.0	14.0	184.0
06N26E22CBAB	03/23/78	125FRUN	USGS	530	1240	850	7.60	7.5	60.0	56.0	150.0	4.0	154.0
06N26E24DCAB01	03/30/82	125FRUN	MBMG	170	2770	1910	7.10	12.5	65.0	17.0	570.0	7.0	577.0
06N27E07ACDB	06/24/81	125FRUN	MBMG	308	1750	1280	7.30	12.0	40.0	22.0	390.0	7.0	397.0
06N27E07ADDD	06/25/81	125FRUN	MBMG	254	2200	1550	7.80		20.0	11.0	490.0	8.0	498.0
06N27E07BCCD	06/24/81	110ALVM	MBMG	60	1850	1490	7.20	14.2	150.0	150.0	120.0	11.0	131.0
06N27E07CCDC	03/23/78	125FRUN	USGS	190	2510	1730	7.50	8.7	28.0	14.0	550.0	5.0	555.0
06N27E10BBBD01	04/06/82	125TGRV	MBMG	277	2200	1510	7.60	9.7	11.0	4.0	500.0	4.0	504.0
06N27E10BBBD02	04/05/82	125TGRV	MBMG	16	1700	1140	7.80	11.5	10.0	8.0	380.0	2.0	382.0
06N27E14DDAA01	04/01/82	125TGRV	MBMG	456	3010	2140	7.80	11.3	21.0	6.0	680.0	8.0	688.0
06N27E17BBCD	06/11/81	125FRUN	MBMG	340	2400	1860	7.60		97.0	84.0	400.0	10.0	410.0
06N27E18ACDD	06/18/81	125FRUN	MBMG	175	1920	1270	8.10	10.8	78.0	83.0	220.0	6.0	226.0
06N27E18DDAD	08/25/72	125TGRV	USGS		1350	967	8.00	10.5	71.0	140.0	46.0	8.0	54.0
06N27E19CBBB	04/13/78	125FRUN	USGS	350	2600	1500	7.80	8.0	80.0	60.0	330.0	9.0	339.0
07N25E08BD	07/31/56	110ALVM		36	2320	790	8.30	9.4	5.8	1.3	325.0	1.7	
07N26E10DACC	03/30/73	125FRUN	USGS		2320	1680	8.50	11.5	11.9	4.9	582.0	3.4	585.0
07N26E10DDB	03/30/73	125TGRV	USGS	341	2150	1660		11.5	12.0	5.0	580.0	3.0	583.0

TABLE 2. WATER-QUALITY DATA FOR WELLS IN THE BULL MOUNTAIN AREA (CONTINUED)

SAMPLE LOCATION	DATE OF SAMPLE	BICARBONATE (MG/L)	CARBONATE (MG/L)	SULFATE (MG/L)	CHLORIDE (MG/L)	FLUORIDE (MG/L)	NITRATE NO3 AS N (MG/L)	SODIUM ADSORPTION RATIO	HARDNESS AS CaCO3 (MG/L)	ALKALINITY AS CaCO3 (MG/L)	IRON (MG/L)	MANGANESE (MG/L)	LITHIUM (MG/L)	VERTICAL DISTANCE TO ROUNDUP COAL (FEET)
N26E02DCDA	04/03/73	620.0		670.0	8.0	0.3	0.02	6.00	480	510	0.31	0.04		600
N26E10AADB	03/23/78	480.0		500.0	13.0	0.2	0.86	1.00	770	400	0.02	0.04		460
N26E12DBAB	06/26/81	530.0		830.0	9.0	0.6		23.70	100	440	0.09	0.02		550
N26E13CCAC	04/20/78	500.0		1200.0	24.0	0.2	11.00	0.60	1600	410	0.03	0.02	0.15	500
N26E14DBAA	06/16/81	1070.0		1460.0	32.0		0.06	1.70	2000	870	0.03	0.04		670
N26E22CBAB	03/23/78	390.0		350.0	27.0	0.1		3.00	380	320	0.04	0.07	0.03	210
N26E24DCAB01	03/30/82	800.0		846.0	8.0	0.5	0.08	16.20	230	656	0.03	0.16	0.10	850
N27E07ACDB	06/24/81	500.0		560.0	10.0	0.4		12.30	190	410	0.08	0.03		560
N27E07ADDD	06/25/81	450.0		780.0	15.0	0.8		21.80	95	370	0.25	0.14		670
N27E07BCCD	06/24/81	590.0		750.0	20.0	0.3	1.00	1.80	980	490	0.08	0.02		740
N27E07CCDC	03/23/78	440.0		870.0	37.0	0.4	0.33	21.00	130	360	0.05	0.02	0.11	830
N27E10BBBD01	04/06/82	460.0		750.0	9.0	1.3	0.18	33.10	42	376	0.01	0.01	0.04	780
N27E10BBBD02	04/05/82	500.0		474.0	6.0	1.7	0.05	21.00	61	409		0.01	0.04	900
N27E14DDAA01	04/01/82	560.0		1130.0	13.0	1.1	0.47	33.20	70	458		0.05	0.11	480
N27E17BBCD	06/11/81	580.0		960.0	20.0	0.3		7.30	590	470		0.10		630
N27E18ACDD	06/18/81	490.0		620.0	8.0	0.2	0.03	4.10	540	400		0.04		680
N27E18DDAD	08/25/72	480.0		440.0	10.0	0.2	0.20	0.70	770	400				
N27E19CBBB	04/13/78	370.0		830.0	4.0	0.2	0.10	7.00	450	300	0.10	0.09		530
N25E08BD	07/31/56	787.0		14.0	47.0	3.0		32.00	20		0.50			
N26E10DACC	03/30/73	583.0	17.0	763.0	8.4	0.2	0.36	35.86	50	507	0.03			
N26E10DDB	03/30/73	580.0	17.0	760.0	8.0	0.2		36.00	50	510	0.03	0.01		580

TABLE 2. WATER-QUALITY DATA FOR WELLS IN THE BULL MOUNTAIN AREA

SAMPLE LOCATION	DATE OF SAMPLE	GEO-LOGIC UNIT	SOURCE OF DATA	DEPTH OF WELL	SPECIFIC CONDUCT-ANCE (MICROSIEMENS PER CM AT 25 C)	CALCULATED DISSOLVED SOLIDS (MG/L)	pH (LAB)	TEMPER-ATURE (DEG C)	CALCIUM (MG/L)	MAGNESIUM (MG/L)	SODIUM MG/L	POTASSIUM (MG/L)	SODIUM AND POTASSIUM (MG/L)
07N26E14BAD	05/31/73	125TGRV	USGS	114	1400	895		10.5	85.0	94.0	99.0	5.0	104.0
07N26E14BCDD01	03/15/82	125FRUN	MBMG	180	2128	1470	7.50	10.8	14.0	11.0	510.0	6.0	516.0
07N26E14BCDD02	03/15/82	125FRUN	MBMG	152	2734	1950	7.80	10.3	19.0	7.0	677.0	6.0	683.0
07N26E15BBCA	05/31/73	125TGRV	USGS	209	2170	1640	8.30	9.0	63.0	92.0	375.0	6.0	383.0
07N26E31CBAD	07/31/79		USGS	515	1280	880	8.70	12.5	5.1	2.1	312.0	1.6	314.0
07N27E06DDDD	03/08/73	125TGRV	USGS	120	1200	780		10.0	47.0	43.0	170.0	4.0	174.0
07N27E07CA	02/20/73	125TGRV	USGS		2000	1420		9.0	63.0	91.0	310.0		
07N27E15ABCB01	03/23/78		MBMG		1140	758	7.40	11.1	68.0	82.0	80.0	5.0	85.0
07N27E19DBBD	04/13/78	125TGRV	USGS	59	1950			9.5	82.0	140.0	150.0	9.0	159.0
07N27E23DBBB	02/16/73	125FRUN	USGS	157	1900	1460		8.5	130.0	110.0	190.0	9.0	199.0
07N27E25BABD	02/15/73	125FRUN	USGS		1950	1440	8.00	5.5	87.0	118.0	230.0	8.3	238.0
07N27E33CDAC01	03/31/82	125TGRV	MBMG	378	1840	1210	7.40	11.6	17.0	11.0	400.0	5.0	405.0
07N27E33CDAC02	08/30/82	125TGRV	MBMG	59	3810	2990	7.20	10.1	200.0	110.0	660.0	17.0	677.0
08N25E13CD	01/11/18	110ALVM	USGS	30		796			116.0	50.0			64.0
08N25E13D	04/01/59		BLM			1340			132.0	85.0			190.0
08N25E13DCD	03/19/75		MDH		1948	1350	7.50		122.0	76.0	220.0	3.1	223.0
08N25E16BD	07/31/56	125FRUN	MBMG		1440	955	8.10	9.5	95.0	81.0	115.0	5.1	120.0
08N25E24BA	02/26/48	110ALVM	MBMG	40		1070			109.0	59.0			167.0
08N25E24CACC	09/09/78	125FRUN	USGS	280	2040	1390	7.70	13.0	63.0	52.0	343.0	5.0	348.0
08N26E06AA	10/31/51	211HLCK	USGS	150		5120			119.0	25.0			1560.0
08N26E34ADB	08/22/72	125TGRV	USGS	80	2260	1640	8.00	10.5	63.0	110.0	340.0	7.0	347.0

TABLE 2. WATER-QUALITY DATA FOR WELLS IN THE BULL MOUNTAIN AREA (CONTINUED)

SAMPLE LOCATION	DATE OF SAMPLE	BICARBONATE (MG/L)	CARBONATE (MG/L)	SULFATE (MG/L)	CHLORIDE (MG/L)	FLUORIDE (MG/L)	NITRATE NO3 AS N (MG/L)	SODIUM ADSORPTION RATIO	HARDNESS AS CaCO3 (MG/L)	ALKALINITY AS CaCO3 (MG/L)	IRON (MG/L)	MANGANESE (MG/L)	LITHIUM (MG/L)	VERTICAL DISTANCE TO ROUNDUP COAL (FEET)
07N26E14BAD	05/31/73	670.0		260.0	12.0	0.3		1.76	600	550	1.40	0.06		850
07N26E14BCDD01	03/15/82	715.0		556.0	12.0	1.6	0.06	24.00	82	586	0.25	0.02	0.05	870
07N26E14BCDD02	03/15/82	839.0		805.0	16.0	1.3	0.68	33.80	76	688	0.03	0.06	0.05	300
07N26E15BBCA	05/31/73	710.0		726.0	12.0	0.6	0.54	7.00	535	580	0.29	0.03		470
07N26E31CBAD	07/31/79	331.0	16.8	353.0	19.0	0.8		29.40	21	300	0.01		0.02	150
07N27E06DDDD	03/08/73	460.0		270.0	8.0	0.1		4.00	290	380	0.10	0.02		230
07N27E07CA	02/20/73	700.0		590.0	12.0	0.3	3.10	6.00	530	570	0.05	0.01		410
07N27E15ABCB01	03/23/78	490.0		240.0	29.0	0.2	2.00	1.50	510	400	0.02		0.02	320
07N27E19DBBD	04/13/78					0.3		2.00	790	510	0.02	0.01	0.04	710
07N27E23DBBB	02/16/73	520.0		740.0	8.0	0.3		3.00	780	420	0.05	0.10		290
07N27E25BABD	02/15/73	613.0		668.0	12.0	0.3	0.95	3.80	711	503	0.04			460
07N27E33CDAC01	03/31/82	540.0		500.0	7.0	1.9	0.21	18.50	87	444		0.03	0.08	610
07N27E33CDAC02	03/30/82	1260.0		1350.0	16.0	0.5	0.09	9.20	960	1030	1.80	1.50	0.13	930
08N25E13CD	01/11/18	180.0		443.0	18.0		0.20		495					
08N25E13D	04/01/59	336.0		743.0	24.0	1.0	2.40		678		0.60			
08N25E13DCD	03/19/75	331.0		715.0	28.0	0.7			616	312	0.92			
08N25E16BD	07/31/56	494.0		385.0	18.0	0.2	0.60	2.10	572		0.21			
08N25E24BA	02/26/48	342.0		532.0	26.0	0.4		3.20	515		0.20			
08N25E24CACC	09/09/78	454.0		685.0	8.0	0.4		7.80	370	370	0.05	0.04	0.02	-30
08N26E06AA	10/31/51	38.0	40.0	2910.0	445.0			34.00	400		0.40			
08N26E34ADB	08/22/72	606.0		778.0	30.0	0.3	3.70	6.00	610	497	0.03	0.02		490

3000 mg/L (milligrams per liter); average concentration is 1430 mg/L. In the four analyses of water from alluvium, calculated-dissolved-solids concentrations are less than 1500 mg/L. In the one sample of water from an aquifer stratigraphically below the Fort Union Formation, the Hell Creek Formation, calculated dissolved solids exceeded 5000 mg/L.

Specific conductance is a measure of the dissolved ions that create the electrolytic behavior of water. As such, there is a relation between specific conductance and the total content of dissolved solids in any given water sample; therefore, dissolved-solids concentration can be estimated by knowing the water's specific conductance. For all but one of the water analyses on Table 2, the calculated-dissolved solids content found by laboratory analysis equals 0.67 $\pm$ .09 times the specific conductance (Figure 7). Therefore, additional dissolved-solids contents can be estimated from the well-inventory data (within about 15 percent) by multiplying specific-conductance values from Appendices B and C by the factor 0.67.

In most respects, water quality for Bull Mountain area springs (Table 3) does not differ greatly from that for wells of the area. Calculated dissolved-solids contents have approximately the same range, and the diversity of concentrations of individual constituents is similar. One difference, however, is evident in the occurrences of relatively high nitrate

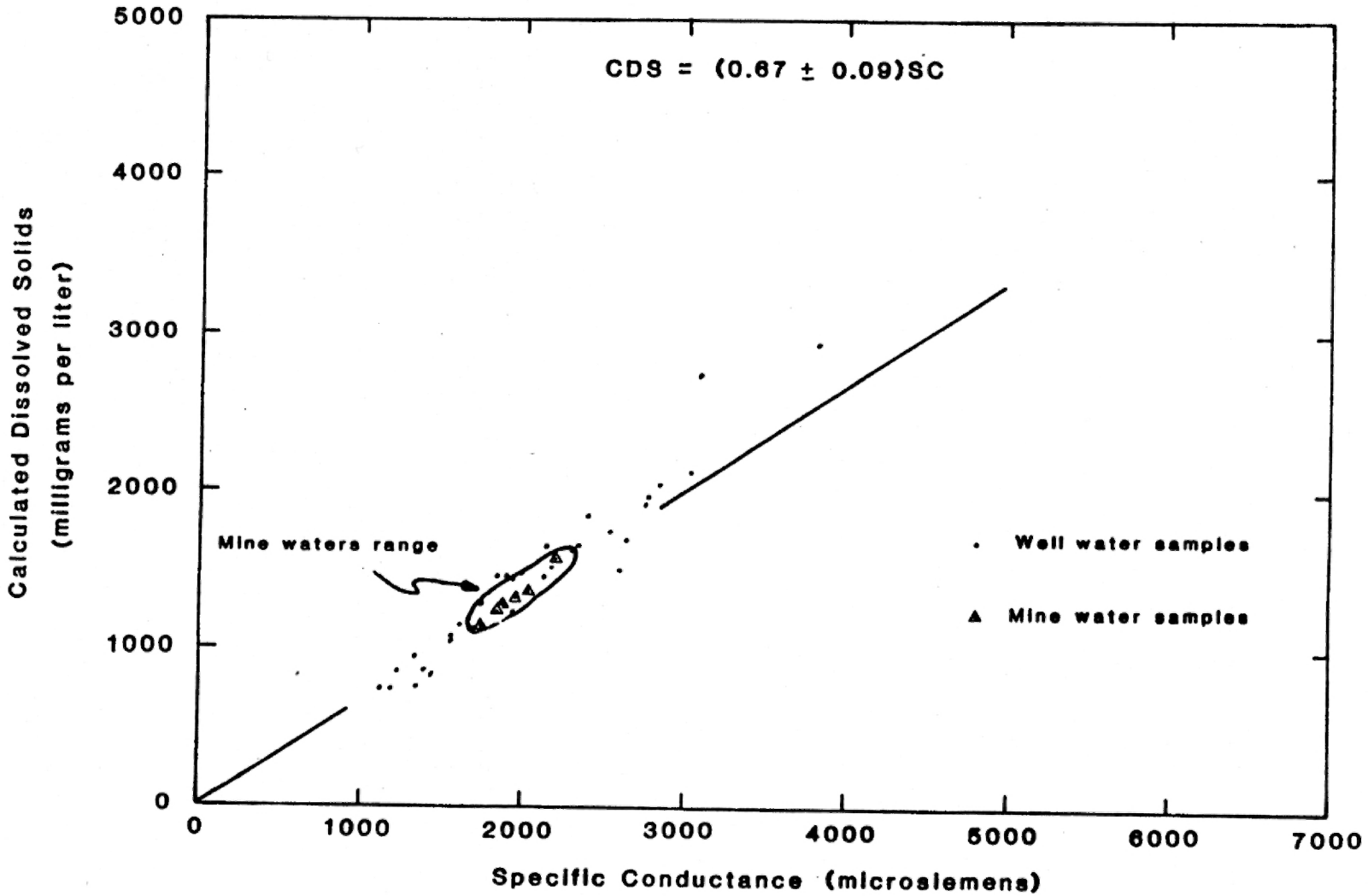


Figure 7. Graph of specific-conductance values vs. calculated-dissolved-solids concentrations.

TABLE 3. WATER-QUALITY DATA FOR SPRINGS IN THE BULL MOUNTAIN AREA

LOCATION	DATE OF SAMPLE	TEMPER-ATURE (DEG C)	pH (LAB)	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	CALCULATED DISSOLVED SOLIDS (MG/L)	SILICA (MG/L)	CALCIUM (MG/L)	MAGNESIUM (MG/L)	SODIUM (MG/L)
06N27E02DCB	04/20/78	12.0	8.2	2100	1981	12.0	120.0	180.0	170.0
06N27E06CAB01	04/13/78	10.5	8.1	2150	1833	9.3	81.0	210.0	110.0
06N27E10BBB01	08/21/72	12.5	8.1	1800	1558	11.0	53.0	150.0	160.0
06N27E17ABAB01	08/25/72	16.5	8.0	1450	1242	17.0	34.0	97.0	150.0
06N27E20BCCC01	08/25/72	10.5	8.0	1400	1211	15.0	71.0	140.0	46.0
06N27E22ABB01	04/14/78	9.0	8.0	500	420	16.0	46.0	30.0	8.6
07N26E27ABA01	04/20/78	8.5	8.0	2000	1486	5.6	73.0	120.0	160.0
07N27E16CCB01	04/13/78	7.0	7.8	1800	1372	14.0	72.0	120.0	130.0
07N27E28BCA01	04/13/78	4.0	8.5	0	4170	4.1	91.0	260.0	900.0
07N26E27ABA01	04/20/78	8.5	8.0	1697	1471	5.6	73.0	115.0	161.0
07N25E20BDBC01	05/11/78	9.0	7.6	1654	1386	8.6	82.5	89.0	176.0

TABLE 3. WATER-QUALITY DATA FOR SPRINGS IN THE BULL MOUNTAIN AREA (CONTINUED)

LOCATION	DATE	POTASSIUM (MG/L)	BICARBONATE (MG/L)	CARBONATE (MG/L)	SULFATE (MG/L)	CHLORIDE (MG/L)	FLUORIDE (MG/L)	NITRATE (NO3 AS N, MG/L)
06N27E02DCB	04/20/78	13.0	650.0		780.0	56.0	0.3	0.10
06N27E06CAB01	04/13/78	9.0	780.0		620.0	13.0	0.2	0.10
06N27E10BBB01	08/21/72	10.0	640.0		520.0	13.0	0.3	1.00
06N27E17ABAB01	08/25/72	7.0	740.0		190.0	4.0	0.0	3.00
06N27E20BCCC01	08/25/72	8.0	480.0		440.0	10.0	0.2	0.90
06N27E22ABB01	04/14/78	3.0	290.0		11.0	13.0	0.7	1.90
07N26E27ABA01	04/20/78	9.0	670.0		430.0	9.5	0.2	8.90
07N27E16CCB01	04/13/78	8.0	550.0		460.0	10.0	0.2	7.50
07N27E28BCA01	04/13/78	12.0	780.0	31.0	2400.0	24.0	0.5	5.30
07N26E27ABA01	04/20/78	8.6	666.0		432.0	9.5	0.2	
07N25E20BDBC01	05/11/78	4.9	526.0		479.0	19.5	0.3	

TABLE 3 WATER-QUALITY DATA FOR SPRINGS IN THE BULL MOUNTAIN AREA (CONTINUED)

LOCATION	DATE	HARDNESS (MG/L AS CaCO3)	ALKALINITY (MG/L AS CaCO3)	SODIUM ADSORPTION RATIO	IRON (MG/L)	MANGANESE (MG/L)	LITHIUM (MG/L)	AQUIFER
NE062702DCB01	04/20/78	1000	540	2.0	0.04	0.03	0.05	125TGRV
NE062706CAB01	04/13/78	1100	640	1.5	0.10			125TGRV
NE062710BBB01	08/21/72	740	520	2.0	0.10	0.00		125TGRV
NE062717ABAB01	08/25/72	490	610	3.0	0.04	0.16		125TGRV
NE062720BCCC01	08/25/72	770	400	0.7	0.01	0.01		125TGRV
NE062722ABB01	04/14/78	240	240	0.2	0.02		0.02	125TGRV
NE072627ABA01	04/20/78	660	550	3.0	0.03			125TGRV
NE072716CCB01	04/13/78	660	450	2.0				110ALVM
NE072728BCA01	04/13/78	1300	700	11.0	0.02			125TGRV
NE072627ABA01	04/20/78	655	546	2.7	0.03		0.02	125TGRV
NE072520BDBC01	05/11/78	572	431	3.2			0.01	

concentrations in samples from springs. Because springs are so highly exposed and often represent very shallow ground-water flow, spring water is more susceptible to contamination by nitrate from stock and human waste and from fertilizer.

Surface-Water Quality

Streams in the Bull Mountains have reaches that are perennial, ephemeral, and intermittent. Knapton (1982) reported concurrent measurements of streamflow and water quality along several of the tributary streams in the area. He noted little variability in the water chemistry during the annual flow cycle in comparison to other eastern Montana streams. Water from tributary streams is chemically similar to ground water from Tongue River Member aquifers. This implies that perennial reaches of most streams are dominated by base flow from ground-water discharge.

Water in the Musselshell River exhibits a wider range of seasonal fluctuations in chemistry than its tributary streams. Streamflow in late spring has lower concentrations of dissolved solids than streamflow during baseflow periods, due mainly to a decrease in the concentrations of sodium and sulfate. Dissolved constituents are lowest when snowmelt from the headwaters in the Big Snowy, Crazy, Castle, and Little Belt Mountains dilutes the sodium-sulfate-dominated base flow with water rich in calcium, magnesium, and bicarbonate. Concentrations of dissolved solids typically range from 450 mg/L during spring runoff to over 1800 mg/L during fall and winter base flow (Knapton, 1982). Baseflow

from tributaries contribute less than 1 percent of the total flow in the Musselshell River at Roundup.

Roundup Coal Bed and Mine Workings

South of the Musselshell River, the Roundup coal bed and the mine workings lie almost entirely below river level (Plate 3), and in all likelihood the workings are flooded. Most of the mined-out area is between 80 and 260 feet below the river level at Roundup. Water levels in the entrances to the Jeffries mine workings are within a few feet of the Musselshell River level.

Aquifer Properties

The Roundup coal bed is discussed as an aquifer in this report, but such a characterization is problematic. Coal beds in southeastern Montana are widely used and highly dependable aquifers. Their broad areas of occurrence, shallow depths, and fractured nature make them easy targets for drilling. A majority of water wells in that corner of the State are completed in coal. In the Bull Mountain area, however, very few well logs indicate well completion in coal; as very fine-grained sandstone beds of the Tongue River Member appear to be the most utilized sources of ground water.

The Roundup coal and mine workings have a bimodal distribution of hydrologic characteristics. Areas of mined-out coal unquestionably have effective porosities greater than 50

percent; unmined areas likely have very low effective porosities that are typical of coal (less than 5%). Hydraulic conductivity of the Roundup bed has not been tested but probably falls within a range of values similar to that of the stratigraphically higher Mammoth coal (0.03 ft/day to 2.9 ft/day) reported by Thompson (1982). Assuming a similar lognormal hydraulic-conductivity value of 0.1 ft/day and an aquifer thickness of 5.5 feet, the unmined Roundup coal has an estimated mean transmissivity of 0.55 square feet per day. The transmissivity of the mine workings is theoretically an infinitely large value. Blockages of rooms by collapsed rubble from the mine roof and reported squeezing off of rooms and slopes could reduce the actual transmissivity within the workings. According to local residents with mine experience, squeezing off of incompetent clay or shale beds into areas of mined-out coal may have occurred. There is little evidence for either roof collapse or clay expansion; furthermore, such evidence would be difficult to obtain. Monitoring water-level fluctuations in different areas of the mine workings during pumping could be a method to assess the existence of such barriers.

Water in the Roundup coal in most locations occurs under confined conditions. Water levels in air shafts and other mine openings rise above the top of the workings, except at a few structurally high outcrops. Two water-level recorders, JEFF-01 (8N26E18DCBC) and JEFF-02 (8N26E18DCDC), set up on air shafts into the Jeffries Mine have given direct readings of water levels since July 1986. There is a good correlation between barometric changes recorded at the SCS office in Roundup and water-level

fluctuations in the Jeffries Mine. This correlation between water-level and barometric fluctuations is consistent with confined-aquifer behavior. The barometric efficiency of wells JEFF-01 and JEFF-02 is calculated to be 50 percent.

Surface-Water Connection

Ground water in the mine workings can be connected closely, in a leaky fashion, or not at all to the Musselshell River. The most likely locations for a hydraulic connection are at the base of the alluvium along the coal subcrop in the valley bottom. Although obscured by alluvium, some degree of connection there is evidenced by the large water flows that interfered with opening of the No. 1 mine.

In September 1986, water levels in the Musselshell River near the No. 1 mine opening were 3 1/2 feet higher than water levels in the mine workings. Near the Jeffries Mine opening, river level was about 1-foot lower than in the mine workings. The reversed hydraulic gradients indicate complex flow relationships between water in the Roundup coal aquifer and the river. Since the coal and the alluvium exhibit a wide range of aquifer properties, it is suggested that hydraulic connection between alluvium and flooded mines is localized. There is historical evidence for a direct connection during high flows between the river and some of the mine workings, however. Several local residents recall a large volume of water discharging from the Jeffries mine opening at 08N26E18CADA during a flood in the late 1960's. The location of flood-water inflows into the mine workings is unknown.

Halfbreed Creek is the only tributary stream directly overlying mined-out portions of the Roundup coal. Effective hydraulic connection between this stream and the aquifer is unlikely because of thick intervening Tongue River Member deposits. A similar relationship probably exists here as that documented in the Fort Union coal fields near Decker, where potentiometric declines in coal aquifers pass beneath perennial streams without affecting water levels in the streams or alluvial deposits (Van Voast and Reiten, 1988).

Water-Level Monitoring

Water-level recorders have monitored the potentiometric surface in the mines since July 1986 (Figure 8). Water level trends in the Jeffries Mine and the Republic No. 1 Mine are similar, exhibiting both natural fluctuations and changes caused by pumping. The nearly identical responses of water levels in JEFF-01 and JEFF-02 implies strong hydraulic connection over a large area of the Jeffries Mine workings. There is a general, but less close correspondence between water level fluctuations in the Jeffries and Republic No. 1 Mines. Shorter frequency fluctuations in the Republic are absent in the Jeffries, particularly during August and from mid-September to mid-October.

Water Quality

Chemical analyses of mine water have been conducted occasionally since 1910 (Table 4), particularly for the Republic No. 1 Mine because of its use for Roundup's municipal supply.

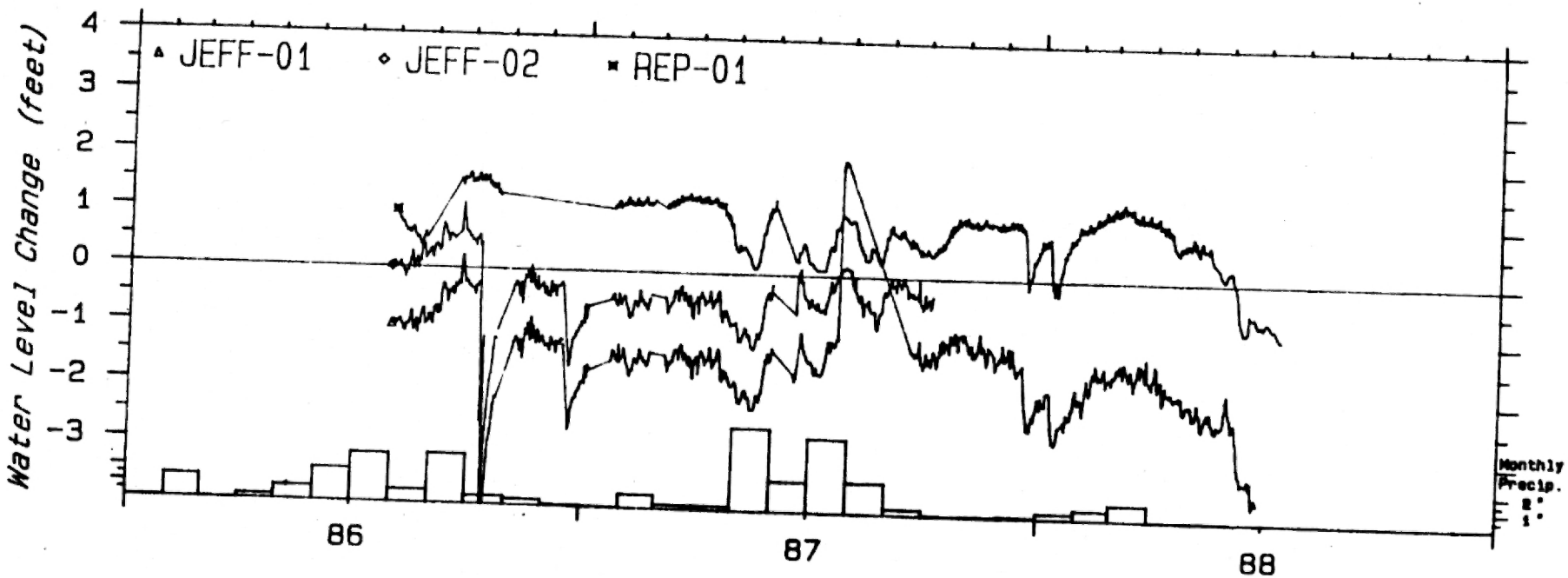


Figure 8. Hydrographs of water levels in mine workings.

TABLE 4 WATER-QUALITY DATA FOR UNDERGROUND MINE WORKINGS

MINE	LOCATION	DATE OF SAMPLE	pH (LAB)	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	CALCULATED DISSOLVED SOLIDS (MG/L)	CALCIUM (MG/L)	MAGNESIUM (MG/L)	SODIUM (MG/L)
REPUBLIC 1	08N25E24AB	12/16/13			793	99.0	41.0	
REPUBLIC 1	08N25E24AB	04/01/59			1200	120.0	80.0	
REPUBLIC 1	08N25E24AB	03/19/75	7.5	1730	1150	112.0	70.0	175.0
REPUBLIC 1	08N25E24AB	07/14/86	7.2		2530	212.0	117.0	455.0
REPUBLIC 2	08N25E36	01/22/10			853	37.0	36.0	
ROUNDUP 3	08N25E25AD	07/30/56	8.0	2010	1340	87.0	46.0	293.0
ROUNDUP 3	08N25E22	03/12/81	7.5	2200	1590	63.0	39.0	414.0
JEFFRIES (JEFF-01)	08N26E18DCBC01	07/29/86	7.7	1890	1280	86.0	43.0	298.0
JEFFRIES (JEFF-02)	08N26E18DCBC01	07/29/86	8.2	1810	1260	96.0	41.0	297.0
JEFFRIES (JEFF-02)	08N26E18DCDC01	07/30/86	7.6	1930	1320	88.0	44.0	301.0
JEFFRIES (JEFF-02)	08N26E18DCDC01	07/30/86	8.1	1820	1280	100.0	42.0	303.0
JEFFRIES (SLOPE)	08N26E18CADA01	12/18/86	7.6	1880	1290	86.0	42.0	301.0

DISSOLVED SOLIDS WERE CALCULATED FROM THE MAJOR CONSTITUENTS.

TABLE 4 WATER-QUALITY DATA FOR UNDERGROUND MINE WORKINGS (CONTINUED)

MINE	DATE	POTASSIUM (MG/L)	SODIUM PLUS POTASSIUM (MG/L)	BICARBONATE (MG/L)	SULFATE (MG/L)	CHLORIDE (MG/L)	SODIUM ADSORPTION RATIO	LABORATORY	LAB NUMBER
REPUBLIC 1	12/16/13		115.0	334.0	359.0	15.0	2.4	MILWAUKEE RAILROAD	
REPUBLIC 1	04/01/59		165.0	323.0	669.0	12.0	2.9	DEPT OF HEALTH	
REPUBLIC 1	03/19/75	4.0		349.0	600.0	23.0	3.3	DEPT OF HEALTH	75W0422
REPUBLIC 1	07/14/86	6.0		538.0	1436.0	24.0	6.2	MBMG	860669
REPUBLIC 2	01/22/10		221.0	415.0	339.0	16.0	6.2	MILWAUKEE RAILROAD	
ROUNDUP 3	07/30/56	5.0		347.0	715.0	21.0	6.3	USGS	N-2466
ROUNDUP 3	03/12/81	8.0		483.0	809.0	20.0	10.0	ENERGY LABS	81-1006
JEFFRIES (JEFF-01)	07/29/86	4.0		464.0	589.0	27.0	6.6	MBMG	8600820
JEFFRIES (JEFF-02)	07/29/86	6.0		420.0	579.0	32.0	6.4	NORTHERN ENGINEERING	85733
JEFFRIES (JEFF-02)	07/30/86	4.0		465.0	624.0	29.0	6.6	MBMG	8600821
JEFFRIES (JEFF-02)	07/30/86	6.0		425.0	592.0	31.0	6.4	NORTHERN ENGINEERING	85734
JEFFRIES (SLOPE)	12/18/86	6.0		471.0	592.0	27.0	6.7	MBMG	8700001

The latest analysis for the Republic No. 1 (July 1986) found substantially higher concentrations of all dissolved constituents, suggesting a deterioration of water quality. The one sample should not be considered definitive but shows a need for further sampling. With the exception of the anomalous 1986 sample, quality of the mine water is about average for Bull Mountain area ground water but is far more uniform (Figure 7).

Three water samples from the Jeffries Mine were analyzed in 1986. Water in this mine has significantly lower concentrations of dissolved solids than samples from the Republic No. 1 Mine collected during the same period. Samples from JEFF-01 and JEFF-02 were collected on 07/29/86 and 07/30/86 respectively, prior to test pumping. The sample from JEFF-03 was collected on 12/18/86 from discharge water during the second period of preliminary pumping. All three samples have similar quality. Concentrations of sulfates and dissolved solids are above drinking water standards, but the water may be adequate for irrigation on suitable soils. The mean specific conductance values (1903 microsiemens/cm) and SAR (6.6) from water in the Jeffries mine indicate the water should be adequate for irrigating well-drained fine sandy loam or coarser soils.

Experimental Pumping

High-capacity pump tests were attempted in a Jeffries Mine slope entry at 08N26E18CADA to evaluate the feasibility of using the slopes for accessing water stored in the underground

workings and to obtain rough estimates of productivity. A 75-horsepower, trailer-mounted, Crissofulli pump capable of producing 6000 gpm (gallons per minute) was employed during the first test. Drawdown was monitored with recorders at sites JEFF-01, JEFF-02, REP-01. A parshall flume system was used at the Jeffries adit to measure the pumping rate. Discharge was ditched to the river.

The first test was started on October 9, 1986, but was plagued by operational problems. Maintaining a constant pumping rate was impossible, and the pump was too large to fit through constrictions in the mine. The pump could not be pushed far enough down the entry slope to maintain hydraulic head, so the pumping rate declined from an initial rate of 5500 gpm to less than 300 gpm. The average rate during the three days of noncontinuous pumping was 500 gpm. The total volume of water pumped was about 360,000 gallons. Drawdown was observed immediately at the mine entrance and at JEFF-01 and JEFF-02, which are about 1200 feet and 2200 feet respectively south of the mine opening. Total drawdown was about 4 feet at both JEFF-01 and JEFF-02. After the pump was shut off, water levels recovered rapidly at first, and later more slowly. Water levels were within 2-feet of the original static water level three days after pumping ceased. Water levels in the No. 1 Mine did not show any immediate response to the pumping (Figure 9). Gradual water-level declines did occur following the preliminary test but it is not known if these were due to natural fluctuations or to pumping.

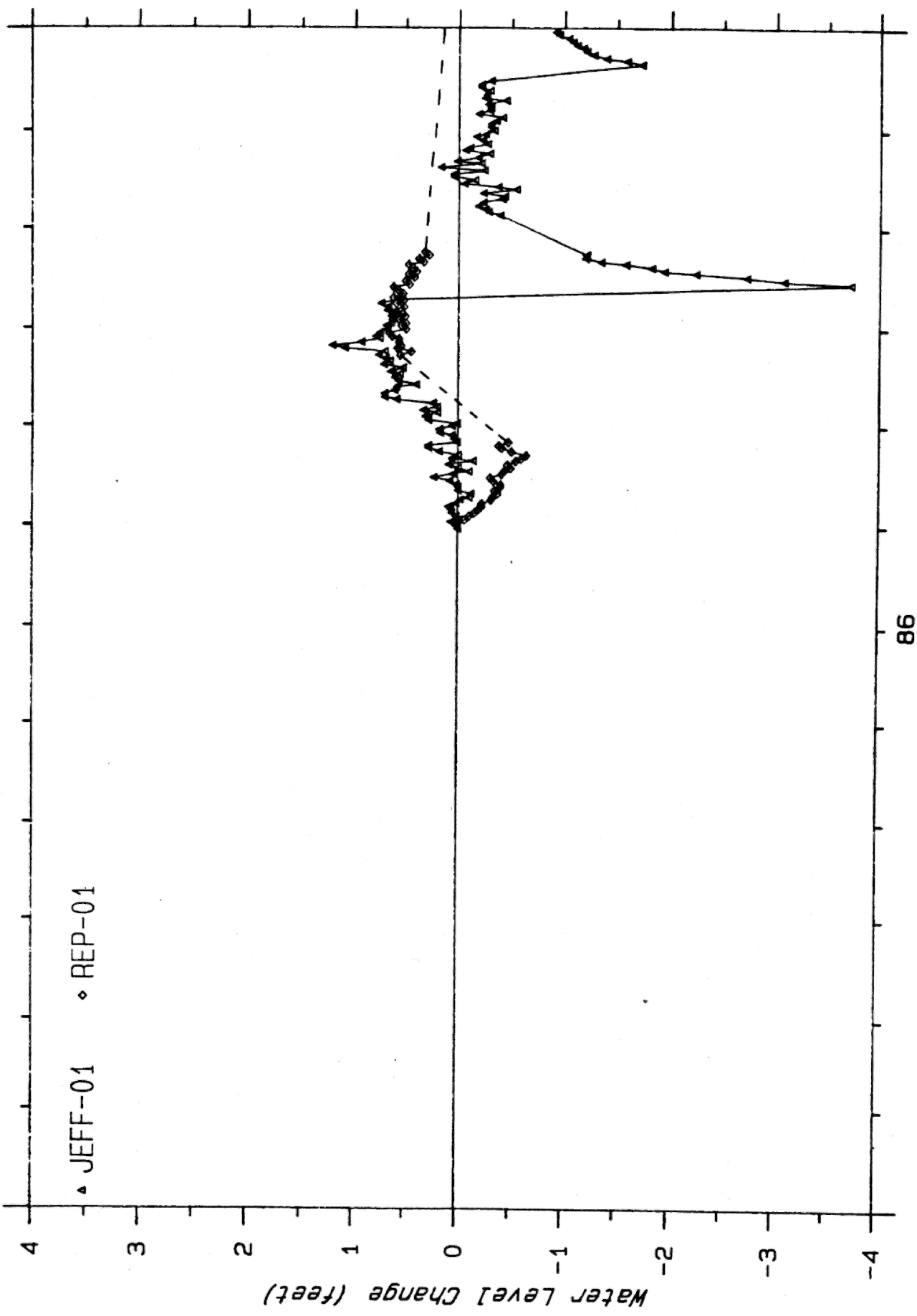


Figure 9. Hydrographs of mine-water levels during pumping experiments.

A second test was run at the same site on December 18, 1986, using a smaller (30 hp) trailer-mounted Crissofulli pump rated at 3000 gpm. The pump was operated for 4 hours over a 5-hour period. Again, constrictions in the mine slope forced abandonment of the test. The pumping rate averaged 750 gpm during this test; total discharge was about 180,000 gallons. Maximum drawdown was 2.42 feet at the mine slope, 2.2 feet at JEFF-01, and 1.98 feet at JEFF-02. Water-level recovery trends were similar to those of the first test period.

The pumping experiments showed that enough head loss can be expected to prohibit use of suction-lift or Crissofulli-type pumps to obtain large discharges from slope entries. Combined effect of substantial drawdown and gradual slopes of the entries would require such pumps to be progressively moved farther into the workings, perhaps dangerously. Further, during production pumping, the necessary moving of pumps would be a serious operational problem. Clearly, positive-submergence pumps installed under the greatest possible hydraulic head would provide the greatest continuous discharge.

Because the pumping experiments were very short term with low average discharge, the mine workings and any associated aquifers were not stressed enough to provide important information on the degree of interconnection of the workings, the area that could potentially be affected by drawdown, or the potential effects on wells and springs of the area. The results do indicate a good

hydraulic connection between monitoring points within the Jeffries Mine, but a poor connection between the Jeffries and the Republic No. 1 Mines. Slow recovery trends indicate a low recharge rate to the Jeffries Mine. To address potential production and impacts of production, tests that further stress the ground-water system must be conducted.

DISCUSSION

This report has presented an overview of hydrogeology of the Bull Mountain area and the underground mine workings near Roundup. Hydrogeologic conclusions from available data are: (1) about 17,000 acre-feet of ground-water are probably stored in the mines; (2) most of the workings lie more than 400 feet below land surface; (3) quality of water in the workings appears satisfactory for irrigation; (4) positive-submergence pumps in locales with the greatest hydraulic heads would be needed to provide the greatest continuous discharge; and (5) numerous stock and domestic wells rely upon Fort Union Formation aquifers (primarily sandstone) for water supply.

There are numerous questions that this reconnaissance-level study cannot answer. These questions can be addressed through a logical progression of future steps. The critical first element to be assessed is a determination of the degree of hydraulic interconnection of the mine workings. The other questions that must ultimately be addressed are the effects on wells and surface

water in the area, potential subsidence, natural recharge and economic feasibility. At each step, potential problems must be evaluated to determine if a solution is available either through an engineering approach or through mitigation. Serious problems at any of these steps would likely cause the project to be terminated. Even so, some limited use of the resource would be possible.

At the present time, the next logical step in this appraisal would be careful, low-volume pumping of the mine workings under prudent monitoring of observation wells and water wells completed in and near the various mines. With this minor stress of the system, interconnection could be evaluated while insuring protection to existing water supplies. If, through additional studies this question and the others can be favorably addressed, then a longer term demonstration of the resource potential could be undertaken.

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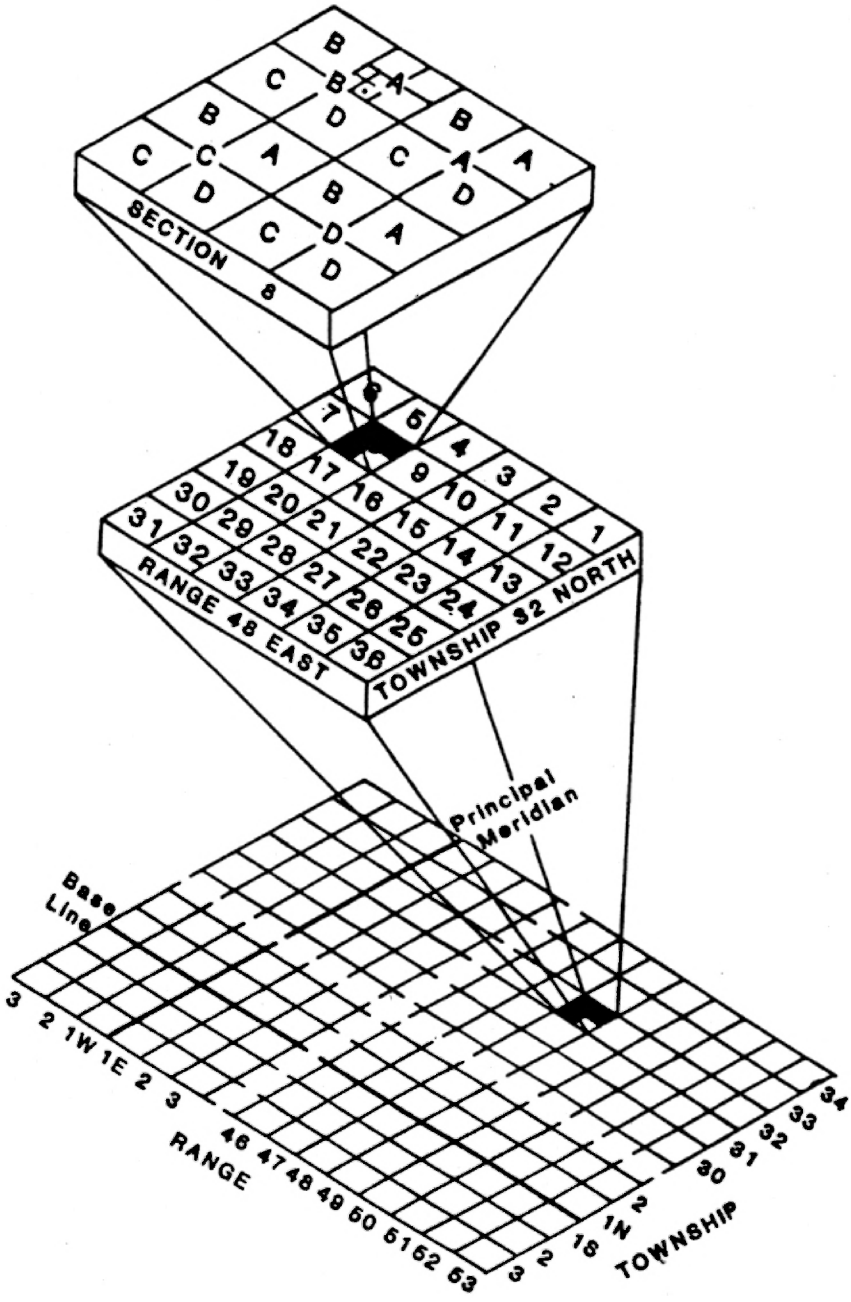
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APPENDIX A

Site-Location System

The system used for identifying or describing locations of wells, springs, or other sites is derived from the U.S. Bureau of Land Management system for surveying public lands. A 36-square mile township, a 1-square mile section and quarters of that section are the primary elements of the system. A site location identifier consists of up to 14 characters assigned according to the site's location within a given township, range, and section. The example shown on the following figure is for the site designation 32N48E08BACD02. This indicates the second well ("02") found in Township 32 North, Range 48 East, section 8, tract BACD. Here, "32N" represents the township north (or south) of the Montana Base Line; "48E" represents the range east (or west) of the Montana Prime Meridian; "08" represents the section within 32N48E; and "BACD" represents the tract within section 8. The tract designation ("BACD") indicates the position of the tract of section 8.

Finally, the last two digits "02" are the sequence number, indicating that this is the second well located within this 2.5 acre tract (BACD). If only one site is found in a tract, the sequence number is either "01" or is left off completely.



Site location system map.

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S

LOCATION	DATE COMPLETED	USE OF WATER	DEPTH OF WELL (FEET)	CASING DIAMETER (INCHES)	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	MEASURE-MENT METHOD	DATE WATER LEVEL MEASURED
06N25E01CBAB01	08/26/73	H	250	5.50	3700.00	150.00	R	08/26/73
06N25E03BBBA01	06/25/75	H	205	5.00	3470.00	117.12	M	08/08/80
06N26E01CDC 01		S	163	6.00	3840.00			
06N26E02BD 01		S	237	7.00	3820.00	152.00	R	
06N26E02BD 02		H	125	6.00	3840.00	88.80	M	09/09/77
06N26E02DCDA01		S	70		3790.00	50.00		
06N26E02DD 01		H		6.00	3790.00			
06N26E03BCBC01		S		4.00	3670.00	30.10	M	09/12/77
06N26E04AB 01		H	60	6.00	3630.00	30.00		
06N26E06CBBC01	11/30/74	H	380	4.00	3960.00	210.00	R	11/30/74
06N26E06CCAD01	07/17/75	S	340	5.50	3850.00	130.00	R	07/17/75
06N26E10AAD 01		S	97	5.00	3730.00	47.00		
06N26E10AADA01		S	50	6.00	3750.00	35.00	M	09/12/77
06N26E11CCAD01		S	68	8.00	3790.00	34.50	M	09/12/77
06N26E12ACDC01		S	132	8.00	3850.00	71.10	M	09/12/77
06N26E13CCAC01		S	200	6.00	3890.00	75.00		
06N26E14BBAB01		S	96	6.00	3800.00	48.60	M	09/12/77
06N26E16ABAB01		S	35	8.00	3780.00			
06N26E22BBBD01		H	245	6.00	3920.00			
06N26E22CBAB01		H	430	5.00	4050.00			
06N26E22CBAB01	01/05/72	H	530	4.50	4050.00	250.00	R	01/05/72
06N26E23ACCA01	06/27/75	H	430	5.00	4020.00	200.00	R	06/30/75
06N26E23ACCA01			430		4020.00			
06N26E23BBCB01	09/06/75		460	4.00	4030.00	390.00	R	09/08/75
06N26E23BDDC01			410		3980.00			
06N26E23BDDC01	08/11/75	H	410	4.00	4020.00	260.00	R	08/11/75
06N26E24DCAB01			170		4065.00	167.34	M	12/01/81
06N26E24DCAB02			142		4065.00	Dry	M	12/01/81
06N27E01CCAA01		S	72	4.00	3860.00	51.70	M	09/14/77
06N27E02DABC01		U	130	6.00	3790.00			
06N27E07ACBC01		S		6.00	3940.00	47.30		
06N27E07CCDC01		H	190	8.00	3970.00	146.00	M	11/14/77
06N27E07CCDC01			190		3970.00			
06N27E10BBBD01			277		4035.00	221.61	M	12/08/81
06N27E10BBBD02			160		4035.00	123.67	M	12/08/81
06N27E11ACCD01		S	100	6.00	3900.00	63.00		
06N27E11DBCC01	08/12/56	S	200	6.00	3910.00	59.05	M	08/15/80
06N27E12AABA01		S	130	5.00	3980.00	119.60	M	09/14/77
06N27E14BBAA01		U	443	6.00	4080.00	115.00		
06N27E14DDAA01			456		4310.00	422.70	M	12/04/81
06N27E14DDAA02			291		4310.00	288.22	M	12/04/81
06N27E14DDAA03			75		4310.00			
06N27E18BBAB01	04/26/54	U	204	8.00	3980.00	143.20	M	08/19/80
06N27E18BBAB01	04/26/54	U	204	6.00	3980.00	143.20	M	08/19/80
06N27E18DDAD01								
06N27E19CBBB01		S	350	5.00	4030.00	173.50	M	11/14/77
06N27E19CBBB01			350		4030.00			
06N28E06BAAA01		S	120		3830.00	20.00		
06N28E17BACB01		S	325	7.00	3990.00	123.10		
06N28E17CCD 01		S	304	6.00	3820.00	108.70		
06N28E18CADD01		S	242	7.00	3960.00	164.00		
06N28E19B 01	06/01/64	S	435	6.60	4000.00	288.00	M	10/03/78
07N25E01BABB01	09/10/75	H	88	4.00	3370.00	42.00	R	09/10/75

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S (CONTINUED)

LOCATION	DISCHARGE (GALLONS PER MINUTE)	DRAWDOWN (FEET)	SPECIFIC CAPACITY (GPM/FT)	PRINCIPAL AQUIFER	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	DATE OF CONDUCTIVITY MEASUREMENT	SOURCE OF DATE
06N25E01CBAB01	3.0	70.00	0.04	125TGRV	1060	08/08/80	USGS
06N25E03BBBA01	10.0	57.88	0.17	125TGRV	1320	08/08/80	USGS
06N26E01CDC 01	20.0		.	125TGRV	2290	11/14/77	MBMG
06N26E02BD 01	7.0	43.00	0.16	125TGRV	4110	09/12/77	MBMG
06N26E02BD 02	5.0			125TGRV	2600	09/09/77	MBMG
06N26E02DCDA01	3.0			125TGRV	2000	04/03/73	USGS
06N26E02DD 01					1700	09/12/77	MBMG
06N26E03BCBC01					2140	09/12/77	MBMG
06N26E04AB 01	10.0						USGS
06N26E06CBBC01	3.0	155.00	0.02	125TGRV	1480	08/08/80	USGS
06N26E06CCAD01	2.0	190.00	0.01	125TGRV	2000	08/08/80	USGS
06N26E10AAD 01	20.0			125TGRV			USGS
06N26E10AADA01				125TGRV	1780	09/12/77	MBMG
06N26E11CCAD01				125TGRV	1700	09/12/77	MBMG
06N26E12ACDC01	5.0			125TGRV	1640	09/12/77	MBMG
06N26E13CCAC01	12.0			125TGRV			USGS
06N26E14BBAB01				125TGRV	2480	09/09/77	MBMG
06N26E16ABAB01				110ALVM	2040	09/07/77	MBMG
06N26E22BBBD01				125TGRV	2530	09/07/77	MBMG
06N26E22CBAB01				125TGRV	1240	09/07/77	MBMG
06N26E22CBAB01	10.0			125FRUN			USGS
06N26E23ACCA01	4.0	210.00	0.02	125TGRV	2050	08/19/80	USGS
06N26E23ACCA01							USGS
06N26E23BBCB01	4.0	65.00	0.06	125FRUN			USGS
06N26E23BDDC01							USGS
06N26E23BDDC01	4.0	135.00	0.03	125TGRV	1930	08/19/80	USGS
06N26E24DCAB01				125TGRV			MBMG
06N26E24DCAB02				125TGRV			MBMG
06N27E01CCAA01				125TGRV			MBMG
06N27E02DABC01	15.0			125TGRV	2280	07/19/72	USGS
06N27E07ACBC01				125TGRV			USGS
06N27E07CCDC01	15.0	26.00	0.58	125TGRV	2460	11/14/77	MBMG
06N27E07CCDC01							USGS
06N27E10BBBD01				125TGRV			MBMG
06N27E10BBBD02				125TGRV			MBMG
06N27E11ACCD01	5.0			125TGRV			USGS
06N27E11DBCC01	5.0			125TGRV			USGS
06N27E12AABA01				125TGRV	1900	09/14/77	MBMG
06N27E14BBAA01	4.0			125TGRV			USGS
06N27E14DDAA01				125TGRV			MBMG
06N27E14DDAA02				125TGRV			MBMG
06N27E14DDAA03				125TGRV			MBMG
06N27E18BBAB01	15.0	31.80	0.47	125TGRV			USGS
06N27E18BBAB01							USGS
06N27E18DDAD01							USGS
06N27E19CBBB01				125TGRV	2180	11/14/77	MBMG
06N27E19CBBB01							USGS
06N28E06BAAA01	5.0			125TGRV	2100	02/16/73	USGS
06N28E17BACB01	6.0						USGS
06N28E17CCD 01	4.0			125TGRV			USGS
06N28E18CADD01	1.0						USGS
06N28E19B 01	3.6	107.00	0.03	125FRUN	2570	10/03/78	USGS
07N25E01BABB01	7.2			125TGRV	1300	08/19/80	USGS

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S
(Continued)

LOCATION	DATE COMPLETED	USE OF WATER	DEPTH OF WELL (FEET)	CASING DIAMETER (INCHES)	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	MEASURE-MENT METHOD	DATE WATER LEVEL MEASURED
07N25E03DBBA01	09/15/66	S	80	5.00	3420.00	28.48	M	08/14/80
07N25E15CCDC01	09/15/56	S	280	6.00	3530.00	138.20	M	08/21/80
07N25E16BDCD01	09/15/50	S	108	6.00	3381.00	44.85	M	08/21/80
07N25E27ADDC01	12/15/73	U	110	6.00	3540.00	64.50	M	08/24/80
07N25E27BACA01	02/18/74	H	360	5.00	3670.00	180.00	R	02/18/74
07N26E02ADCB01		S	12	60.0	3460.00	5.50	M	10/07/77
07N26E03DADA01	11/08/74	S	160	6.00	3560.00	20.00	R	11/08/74
07N26E03DBDA01		U	128	6.00	3620.00	25.50	M	10/07/77
07N26E04AABC01		S	176	8.00	3620.00			
07N26E04CDBA01	01/01/52	S	138	5.00	3640.00	100.00	R	
07N26E08BACB01		H		4.00	3460.00			
07N26E08CBCA01		U	55	5.00	3420.00	16.30	M	09/09/77
07N26E08CBCD01		H	18		3410.00	7.40	M	09/09/77
07N26E08CBD 01		H	25	72.0	3420.00	23.00	R	
07N26E08CBD 02		H	80	4.00	3440.00			
07N26E08DDAB01		S	60	6.00	3500.00	24.70	M	09/02/80
07N26E09ADDB01	06/10/58	S	134	6.00	3700.00			
07N26E10BCCC01		S	300	5.00	3730.00	150.00		
07N26E10DDB 01		H	341	5.00	3710.00	250.00		
07N26E12CBAB01		S	122	6.00	3590.00	84.00		
07N26E14AAC 01	01/01/48	S	40	6.00	3700.00	23.50		02/22/73
07N26E14BAD 01	01/01/50	S	114	6.00	3840.00	59.03		02/21/73
07N26E14BCDD01			180		3830.00	150.91	M	12/03/81
07N26E14BCDD02			152		3830.00	142.30	M	12/03/81
07N26E15BBCA01		S	209	6.00	3620.00	73.50		02/21/73
07N26E17DAAD01	07/13/73	H	137	5.50	3470.00	37.82	M	08/13/80
07N26E20DABB01	07/11/73	H	137	5.50	3540.00	60.00	R	07/11/73
07N26E20DADC01	11/16/72	H	95	5.50	3540.00	53.95	M	08/09/80
07N26E20DCBD01	08/21/72	H	150	5.00	3560.00	101.03	M	08/23/80
07N26E23ACDB01	07/01/59	S	365	6.00	4030.00	260.00	R	07/01/59
07N26E25ACDB01		U	230	8.00	3960.00	200.00	M	11/15/77
07N26E25ACDB01		U	230	6.00	3960.00	200.00	M	11/15/77
07N26E29BCAA01	07/18/74	U	100	5.00	3620.00	49.92	M	08/17/80
07N26E29CDCA01	11/10/74	H	360	5.00	3770.00	300.00	R	11/10/74
07N26E31CBAD01	09/19/74	H	515		3890.00	350.00		09/19/74
07N26E32AA 01		H	31	6.00	3580.00	22.80	M	09/09/77
07N26E32AA 02		S	34	6.00	3590.00	24.00	M	09/09/77
07N26E32BCAB01	06/01/48	S	300	6.00	3660.00	43.16	M	09/08/80
07N26E32CCDC01	07/21/74	H	240	4.00	3700.00	129.78	M	08/09/80
07N26E32DACC01	05/28/75	H	140	5.00	3620.00	105.00	R	05/28/75
07N26E33BBAC01	10/02/65	H	70	7.00	3570.00	23.00	M	08/21/80
07N26E33CDD 01		U	3		3610.00	18.70	M	09/12/77
07N26E35BBAC01		S	115	8.00	3840.00	59.40	M	09/09/77
07N26E36CCCC01		S	194	6.00	4010.00	149.20	M	09/09/77
07N27E01DADD01	12/10/63	S	472	6.00	3486.00	12.58	M	07/07/79
07N27E03CBB 01		U	90	6.00	3460.00	24.30		10/03/77
07N27E06CBBB01		H	110	5.00	3460.00			
07N27E06CCB 01		H	145	5.00	3500.00			
07N27E06DCBC01	12/28/74	U	100	5.00	3500.00	33.82	M	08/13/80
07N27E06DDDD01		S	120	6.00	3570.00	97.20		
07N27E07CA 01		H	31	6.00	3540.00	29.50		
07N27E07CA 02		S	32		3540.00	30.48		02/20/73
07N27E08CCDB01		U	80	5.50	3540.00	18.00	M	10/03/77

LOCATION	DISCHARGE (GALLONS PER MINUTE)	DRAWDOWN (FEET)	SPECIFIC CAPACITY (GPM/FT)	PRINCIPAL AQUIFER	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	DATE OF CONDUCTIVITY MEASUREMENT	SOURCE OF DATE
O7N25E03DBBA01	25.0	41.52	0.60	125TGRV			USGS
O7N25E15CCDC01	8.0			125TGRV	1470	08/21/80	USGS
O7N25E16BDCD01	8.0			125TGRV	1630	08/21/80	USGS
O7N25E27ADDC01	5.0			125TGRV			USGS
O7N25E27BACA01	5.0	120.00	0.04	125TLCK	825	08/21/80	USGS
O7N26E02ADCB01	60.0			110ALVM	2540	10/07/77	MBMG
O7N26E03DADA01	2.0	100.00	0.02	125TGRV	1890	10/07/77	USGS
O7N26E03DBDA01				125TGRV			MBMG
O7N26E04AABC01	60.0			125TGRV	2660	10/07/77	MBMG
O7N26E04CDBA01	2.7			125TGRV	2700	08/15/80	USGS
O7N26E08BACB01				125TGRV	1830	09/09/77	MBMG
O7N26E08CBCA01				110ALVM	1570	09/09/77	MBMG
O7N26E08CBCD01	8.0	7.60	1.05	110ALVM			MBMG
O7N26E08CBD 01	20.0	2.00	10.00	125TGRV	1310	09/09/77	MBMG
O7N26E08CBD 02				125TGRV	1440	09/09/77	MBMG
O7N26E08DDAB01	30.0	25.30	1.19	125TGRV			USGS
O7N26E09ADDB01	30.0			125TGRV			USGS
O7N26E10BCCC01	10.0			125TGRV			USGS
O7N26E10DDB 01	4.0			125TGRV	2150	03/30/73	USGS
O7N26E12CBAB01	6.0			125TGRV			USGS
O7N26E14AAC 01	15.0			125TGRV			USGS
O7N26E14BAD 01	4.0			125TGRV	1400	05/31/73	USGS
O7N26E14BCDD01				125TGRV			MBMG
O7N26E14BCDD02				125TGRV			MBMG
O7N26E15BBCA01	5.0			125TGRV	2200	05/31/73	USGS
O7N26E17DAAD01	17.0	27.18	0.63	125TGRV	1110	08/13/80	USGS
O7N26E20DABB01	15.0	15.00	1.00	125TLCK	1290	08/09/80	USGS
O7N26E20DADC01	12.0	1.75	6.86	125TGRV	1330	08/09/80	USGS
O7N26E20DCBD01	3.0	38.97	0.08	125TGRV	1520	08/23/80	USGS
O7N26E23ACDB01	5.0			125TGRV			USGS
O7N26E25ACDB01	3.0			125TGRV			MBMG
O7N26E25ACDB01							MBMG
O7N26E29BCAA01	6.0	40.08	0.15	125TGRV	1320	08/17/80	USGS
O7N26E29CDCA01	5.0	50.00	0.10	125TGRV	1750	08/13/80	USGS
O7N26E31CBAD01	2.0	90.00	0.02	125FRUN	1420	06/27/79	USGS
O7N26E32AA 01				110ALVM	1380	09/09/77	MBMG
O7N26E32AA 02				110ALVM	1090	09/12/77	MBMG
O7N26E32BCAB01	25.0	56.84	0.44	125TGRV	1870	09/08/80	USGS
O7N26E32CCDC01	3.0	95.22	0.03	125TGRV	1020	08/09/80	USGS
O7N26E32DACC01	2.0	30.00	0.07	125TGRV	1370	08/09/80	USGS
O7N26E33BBAC01	35.0	22.00	1.59	125TGRV	1440	08/21/80	USGS
O7N26E33CDD 01				125TGRV	1090	09/12/77	MBMG
O7N26E35BBAC01	10.0			125TGRV			MBMG
O7N26E36CCCC01				125TGRV	2530	09/09/77	MBMG
O7N27E01DADD01	6.9	3.42	2.02	125FRUN	1720	07/07/79	USGS
O7N27E03CBB 01				125TGRV			MBMG
O7N27E06CBBB01				125TGRV	1510	10/04/77	MBMG
O7N27E06CCB 01				125TGRV	1480	10/04/77	MBMG
O7N27E06DCBC01	7.0	56.18	0.12	125TGRV			USGS
O7N27E06DDDD01	4.5			125TGRV	1200	03/08/73	USGS
O7N27E07CA 01							USGS
O7N27E07CA 02	4.0			125TGRV	2000	02/20/73	USGS
O7N27E08CCDB01	3.0			125TGRV			MBMG

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S
(Continued)

LOCATION	DATE COMPLETED	USE OF WATER	DEPTH OF WELL (FEET)	CASING DIAMETER (INCHES)	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	MEASURE-MENT METHOD	DATE WATER LEVEL MEASURED
07N27E08DDDB01		S	80	5.50	3660.00			
07N27E09ACCC01		U	75	5.00	3590.00	30.00	R	
07N27E10BBAD01		S	80	6.0	3480.00			
07N27E13ADDD01	07/22/66	U	172	6.00	3530.00	30.00	R	07/22/66
07N27E14ADCD01	11/26/62	S	138	6.00	3840.00	50.00	R	11/26/62
07N27E15ABBB01		S	66	5.00	3600.00	42.00	R	
07N27E15ABCB01		H	95	5.00	3590.00	33.00	R	
07N27E15ABCB01			95		3590.00			
07N27E15ABCB02		U	59	6.00	3600.00	30.20	M	11/15/77
07N27E18CCDB01		U	61	6.00	3700.00	18.00	M	10/03/77
07N27E19DBBD01			59		3825.00			
07N27E19DBBD01	01/01/61	S	59		3830.00	45.00	R	01/01/61
07N27E19DBBD01	01/01/61	S	59		3830.00	45.00	R	01/01/61
07N27E20ABBD01		S	27	36.0	3730.00	12.00	R	
07N27E22DBDD01		U	95	4.00	3780.00	40.60	M	11/15/77
07N27E23DBBB01		S	157	6.00	3650.00	60.00		
07N27E24AACB01	11/09/73	U	400	4.00	3530.00	30.81	M	08/11/80
07N27E24ABDA01		U	177	5.00	3540.00	29.60	M	09/15/77
07N27E25BABD01		H	74	6.00	3580.00	25.10	M	09/13/77
07N27E25BABD02			23		3582.00			
07N27E25BDBB01		U	22	6.00	3580.00	1.40	M	09/13/77
07N27E26CCCA01		S	140	4.00	3770.00			
07N27E30AAAC01		U	22	48.0	3880.00	16.00	M	11/15/77
07N27E33CDAC01			378		4060.00	273.19	M	12/03/81
07N27E33CDAC02			59		4060.00	56.02	M	12/03/81
07N27E34ACDA01		H	36		3780.00	31.00		
07N27E35BDAC01	01/01/50	S	100	4.00	3700.00	27.16	M	04/02/73
07N28E07ACCB01	10/12/64	S	165	6.00	3450.00	75.00	R	10/12/64
07N28E18ABDB01	10/03/64	S	86	6.00	3460.00	28.25	M	08/08/80
07N28E30ADBC01	07/15/55	S	187	6.00	3660.00	150.00	R	07/15/55
07N28E30DAAC01		U	167		3680.00	64.00	M	09/14/77
08N25E01DDDD01	01/01/78	S	220	5.00	3350.00			
08N25E02ABBD01	05/01/57	S	410		3312.00	25.00	R	05/01/57
08N25E10ACDB01	01/01/69	H	185	5.00	3450.00	50.00	R	01/01/69
08N25E10ACDB02	01/01/51	S	210	4.50	3450.00	58.61	M	07/24/80
08N25E12CDBA01	01/20/57	U	155	6.00	3280.00	26.09	M	09/08/80
08N25E13D 01		P	30					
08N25E14CCAD01	04/01/77	H	177	5.00	3250.00	47.48	M	08/05/80
08N25E14CCBB01	12/15/73	H	126	8.62	3270.00	47.32	M	07/28/80
08N25E15BDCC01	02/14/67	H	180	5.00	3360.00	77.40	M	09/09/80
08N25E15BDDB01	11/24/74	S	135	4.00	3380.00	97.57	M	08/06/80
08N25E15DDDA01	08/08/75	H	160	5.00	3300.00	65.00	R	08/08/75
08N25E22DABB01	01/17/73	H	142	5.00	3220.00	30.50	M	09/02/80
08N25E22DACA01	06/25/73	H	125	5.00	3210.00	12.20	M	09/02/80
08N25E22DADA01	02/21/72	H	123	5.00	3200.00	15.00	R	02/21/72
08N25E22DADA02	12/13/65	H	158	4.50	3200.00	38.65	M	08/07/80
08N25E23ABBB01	07/02/75	H	114	4.00	3190.00	20.00	R	07/02/75
08N25E23BACC01	04/21/62	H	325	5.00	3200.00	16.00	R	04/21/62
08N25E23BBDC01	02/23/77	H	220	5.00	3230.00	23.14	M	07/28/80
08N25E24CAC 01	10/30/73	S	280	5.00	3300.00	85.39	M	09/09/78
08N25E32ABBD01	07/24/65	S	170	6.12	3430.00	146.29	M	08/14/80
08N25E35DDAC01	05/08/76	H	194	5.00	3360.00	63.66	M	07/29/80
08N25E35DDAC02	05/23/74	H	165	5.50	3330.00	40.00	R	05/23/74

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S (CONTINUED)

LOCATION	DISCHARGE (GALLONS PER MINUTE)	DRAWDOWN (FEET)	SPECIFIC CAPACITY (GPM/FT)	PRINCIPAL AQUIFER	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	DATE OF CONDUCTIVITY MEASUREMENT	SOURCE OF DATE
07N27E08DDDB01	5.0		.	125TGRV	1620	10/03/77	MBMG
07N27E09ACCC01	5.0		.	125TGRV	1100	11/15/77	MBMG
07N27E10BBAD01			.	125TGRV	1050	10/03/77	MBMG
07N27E13ADDD01			.	125TGRV			USGS
07N27E14ADCD01	1.0	15.00	0.07	125TGRV			USGS
07N27E15ABBB01	5.0		.	110ALVM	1260	11/15/77	MBMG
07N27E15ABCB01	20.0		.	110ALVM	1250	11/15/77	MBMG
07N27E15ABCB01			.				USGS
07N27E15ABCB02			.	110ALVM			MBMG
07N27E18CCDB01			.	125TGRV	2080	10/03/77	MBMG
07N27E19DBBD01	20.0		.	125TGRV	1790	11/15/77	MBMG
07N27E19DBBD01			.		2300	09/06/80	MBMG
07N27E19DBBD01			.				USGS
07N27E20ABBD01	10.0		.	110ALVM	1650	11/15/77	MBMG
07N27E22DBDD01			.	125TGRV			MBMG
07N27E23DBBB01	2.0		.	125TGRV	1900	02/16/73	USGS
07N27E24AACB01	10.0	44.19	0.23	125TGRV			USGS
07N27E24ABDA01			.	125TGRV	1840	09/15/77	MBMG
07N27E25BABD01			.	125TGRV	2160	09/13/77	MBMG
07N27E25BABD02			.				USGS
07N27E25BDBB01			.	110ALVM			MBMG
07N27E26CCCA01	20.0		.	125TGRV	2350	09/23/77	MBMG
07N27E30AAAC01	10.0		.	110ALVM			MBMG
07N27E33CDAC01			.	125TGRV			MBMG
07N27E33CDAC02			.	125TGRV			MBMG
07N27E34ACDA01	10.0		.				USGS
07N27E35BDAC01	10.0		.	125TGRV			USGS
07N28E07ACCB01	4.3		.	125TGRV	1400	08/08/80	USGS
07N28E18ABDB01	6.0		.	125TGRV	2150	08/08/80	USGS
07N28E30ADBC01	15.0	10.00	1.50	125TGRV			USGS
07N28E30DAAC01			.	125TGRV			MBMG
08N25E01DDDD01			.	125TLCK	7000	08/11/80	USGS
08N25E02ABBD01	7.0	25.00	0.28	211HLCK			USGS
08N25E10ACDB01	4.0		.	125TLCK	4050	07/24/80	USGS
08N25E10ACDB02	7.2		.	125TLCK	3900	07/24/80	USGS
08N25E12CDBA01	2.5	113.91	0.02	125TLCK			USGS
08N25E13D 01			.	111ALVM			USGS
08N25E14CCAD01	12.0	92.52	0.13	125TGRV	2350	08/05/80	USGS
08N25E14CCBB01	2.0	52.68	0.04	125TGRV	2050	07/28/80	USGS
08N25E15BDCC01	20.0		.	125TGRV	1390	09/09/80	USGS
08N25E15BDDB01	5.0	32.43	0.15	125TGRV			USGS
08N25E15DDDA01	10.0	55.00	0.18	125TGRV	1230	07/28/80	USGS
08N25E22DABB01	7.8	2.90	2.69	125TGRV	2800	09/02/80	USGS
08N25E22DACA01	11.0	17.30	0.64	125TGRV	2420	09/02/80	USGS
08N25E22DADA01	10.0	15.00	0.67	125TGRV	3500	09/09/80	USGS
08N25E22DADA02	1.0		.	125TGRV	1750	08/07/80	USGS
08N25E23ABBB01	8.0	80.00	0.10	125TGRV	3430	09/09/80	USGS
08N25E23BACC01	7.0	234.00	0.03	125TGRV	2800	08/01/80	USGS
08N25E23BBDC01	12.0	156.86	0.08	125TGRV	2800	07/28/80	USGS
08N25E24CAC 01	16.0	154.61	0.10	125FRUN	1850	09/09/78	USGS
08N25E32ABBD01	7.7	13.71	0.56	125TGRV	1820	08/14/80	USGS
08N25E35DDAC01	8.0	111.34	0.07	125TGRV	1530	07/29/80	USGS
08N25E35DDAC02	12.0	25.00	0.48	125TGRV	1540	09/06/80	USGS

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S

LOCATION	DATE COMPLETED	USE OF WATER	DEPTH OF WELL (FEET)	CASING DIAMETER (INCHES)	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	MEASURE-MENT METHOD	DATE WATER LEVEL MEASURED
08N26E05CBBB01	08/26/74	S	340	5.50	3410.00	120.00	R	08/26/74
08N26E10BBBB01	09/24/75	H	400	5.50	3210.00	51.23	M	07/06/79
08N26E25BACC01	12/17/73	S	60	5.00	3280.00	20.38	M	07/31/80
08N26E25BBDA01		S	50	8.00	3260.00	17.21	M	08/01/74
08N26E25DB 01		H	16	36.0	3310.00	11.00	M	10/04/77
08N26E26DBAD01	10/12/65	S	48	7.00	3330.00	30.00	R	10/12/65
08N26E27BA 01		U		6.00	3380.00			
08N26E28CD 01		S	46	10.0	3460.00	8.00	M	10/07/77
08N26E28CDCA01		U	60	10.0	3460.00	15.00		
08N26E31CC 01		S		6.00	3390.00	33.51	M	10/07/77
08N26E32AAAA01	06/04/62	S	149	6.00	3520.00	67.51	M	07/30/80
08N26E34ADB 01		S	80	8.00	3420.00	39.00		
08N26E34CAA 01		S		10.0	3490.00			
08N26E34DDC 01		S	86	8.00	3540.00	42.00	M	10/07/77
08N27E12CACD01	10/25/63	U	238	5.50	3290.00	120.00	R	10/25/63
08N27E15DCBA01	03/28/64	U	171	5.50	3300.00	145.00	R	03/28/64
08N27E15DCBA01	03/28/64	U	171	8.62	3300.00	145.00	R	03/28/64
08N27E22ACBC01	01/01/53	S	392	6.00	3400.00	158.49	M	09/15/78
08N27E23ACBA01	12/30/65	S	202	5.50	3350.00	122.00	M	07/30/80
08N27E25BDBC01	05/03/62	U	335	6.00	3454.00	220.14	M	07/31/80
08N27E25BDBC01	05/03/62	U	335	8.00	3454.00	220.14	M	07/31/80
08N27E27AACC01	12/09/55		480	6.00	3624.00	332.49	M	09/15/78
08N27E27AACC01	12/09/55		480		3624.00	332.49	M	09/15/78
08N27E28CCCA01	06/05/53	U	64	6.00	3340.00	27.97	M	07/31/80
08N27E28CCCB01		H	60	10.0	3350.00	26.50	M	10/15/77
08N27E29ACBB01	09/30/63	U	105	6.00	3280.00	7.94	M	07/31/80
08N27E29ADBD01		S	140	6.00	3310.00	35.00	M	10/15/77
08N27E31CCBD01	01/01/52	S	90	8.00	3380.00	36.77	M	05/16/73
08N27E33ABBC01		S	41	8.00	3370.00	29.50	M	10/15/77
08N27E33ADDC01		H	75		3400.00			
08N27E34BABC01	08/29/63	S	180	6.00	3460.00	93.99	M	07/31/80
08N28E06BBAA01	06/01/57	H	150	6.00	3075.00	22.17	M	07/30/80
08N28E18DABB01	06/01/54	H	158	6.00	3220.00	125.00	R	06/01/54
08N28E19BAAD01	05/18/72	S	358	5.50	3270.00	25.00	R	05/18/72
09N25E32ADAC01	05/24/55	S	152	6.00	3390.00			
09N25E32CCCD01	06/24/65	S	100	6.12	3525.00	35.00	R	06/24/65
09N27E32C 01		H	75					
09N27E35CACD01	06/06/75	H	115	7.00	3080.00	12.70	M	08/18/80
09N27E35DCBA01	11/01/45	S	315	7.00	3080.00	-22.00	M	09/14/78

APPENDIX B. DATA FROM FIELD INVENTORIES OF WELLS DURING THE 1970'S AND 1980'S (CONTINUED)

LOCATION	DISCHARGE (GALLONS PER MINUTE)	DRAWDOWN (FEET)	SPECIFIC CAPACITY (GPM/FT)	PRINCIPAL AQUIFER	SPECIFIC CONDUCTANCE (MICROSIEMENS PER CM AT 25 C)	DATE OF CONDUCTIVITY MEASUREMENT	SOURCE OF DATE
O8N26E05CBBB01	5.0	205.00	0.02	125TLCK	8000	07/06/79	USGS
O8N26E10BBBB01	4.4	23.17	0.19	211HLCK	1600	07/06/79	USGS
O8N26E25BACC01	18.0	29.62	0.61	125TGRV			USGS
O8N26E25BBDA01	25.0			110ALVM			USGS
O8N26E25DB 01				110ALVM	1250	10/04/77	MBMG
O8N26E26DBAD01	80.0	13.00	6.15	125TGRV	1800	07/31/80	USGS
O8N26E27BA 01							MBMG
O8N26E28CD 01				125TGRV	1640	10/07/77	MBMG
O8N26E28CDCA01	10.0						USGS
O8N26E31CC 01					1240	10/07/77	MBMG
O8N26E32AAAA01	20.0			125TGRV			USGS
O8N26E34ADB 01	9.0			125TGRV			USGS
O8N26E34CAA 01							MBMG
O8N26E34DDC 01				125TGRV	1550	10/07/77	MBMG
O8N27E12CACD01	6.0	80.00	0.07	125TGRV			USGS
O8N27E15DCBA01	10.0	15.00	0.67	125TGRV			USGS
O8N27E15DCBA01							USGS
O8N27E22ACBC01	2.0	141.51	0.01	125FRUN	1650	09/15/78	USGS
O8N27E23ACBA01	13.0			125TGRV	1160	07/30/80	USGS
O8N27E25BDBC01				125TGRV			USGS
O8N27E25BDBC01							USGS
O8N27E27AACC01				125FRUN			USGS
O8N27E27AACC01							USGS
O8N27E28CCCA01				125TGRV			USGS
O8N27E28CCCB01	30.0	6.00	5.00	110ALVM	1200	10/15/77	MBMG
O8N27E29ACBB01	50.0			110ALVM			USGS
O8N27E29ADBD01	6.0			125TGRV	1450	10/15/77	MBMG
O8N27E31CCBD01				125TGRV			USGS
O8N27E33ABBC01				110ALVM	1950	10/15/77	MBMG
O8N27E33ADDC01				125FRUN	1260	07/31/79	USGS
O8N27E34BABC01	7.0			125TGRV	1190	07/31/80	USGS
O8N28E06BBAA01	10.0	2.83	3.53	125TLCK	1120	07/31/80	USGS
O8N28E18DABB01	9.0			125TGRV	2300	07/30/80	USGS
O8N28E19BAAD01	8.0	205.00	0.04	125FRUN	1770	07/07/79	USGS
O9N25E32ADAC01	5.0			125TLCK	9500	08/12/80	USGS
O9N25E32CCCD01	3.5			211HLCK	2600	08/12/80	USGS
O9N27E32C 01				125FRUN			USGS
O9N27E35CACD01	9.0			125LEBO	5170	08/18/80	USGS
O9N27E35DCBA01	0.1			125TLCK	1500	09/14/78	USGS

USE OF WATER: S, STOCK; U, NOT IN USE; H, DOMESTIC; P, PUBLIC;
SWL MEASUREMENT METHOD: R, REPORTED; M, MEASURED;

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE[1] OF WATER	WELL DEPTH[2] (FEET)	WELL BOTTOM[3] ALTITUDE (FEET)	BASE OF COAL[4] ALTITUDE (FEET)	DISTANCE[5] TD TO RU COAL (FEET)	DISTANCE[6] WELL TO MINE (FEET)
065000006	MAHAN, MURIEL	07N25E01BBAA	H	88.0	3272.00	3050.00	222	
065000004	WITCHER, VERN	07N25E01BBBA	Q	45.0	3260.00	3060.00	200	
065000003	EATON, JESSE	07N25E01BBBD	Q			3060.00		
065000002	GAVLYN, FOLDA	07N25E01BBCB	Q			3070.00		400
065000129	JIM NEWTON	07N25E01CACA01	Z	17.0	3313.00	3070.00	243	400
065000007	RAUCH, ANTON	07N25E01CBCD	HS	175.0	3195.00	3090.00	105	1600
065000005	POYNTER, BOB	07N25E01CBDA	Q			3080.00		1000
065000001	SESSIONS, MRS. STEVE	07N25E01DDAD	H	250.0	3130.00	3040.00	90	
065000008	WESTRUM, WILLIAM	07N25E02CDAA	Q	190.0	3240.00	3150.00	90	4600
065000009	ELIASSON, H.	07N25E04BBBC	HS	382.0	2968.00Y			
065000087	MALLOY, JIM	07N25E10DABA	Q	310.0	3230.00	3270.00	-40	18400
065000010	MALLOY, JIM	07N25E11ABCC	S	300.0	3265.00	3180.00	85	5000
065000011	HEWITT, RODGER	07N25E12AABD	H	64.0	3296.00	3060.00	236	600
065000012	WOMELDORF, ALLEN	07N25E12BBAB	Q			3100.00		1600
065000013	RATH, NICHOLAS	07N25E18CCCD	Q		Y			32000
065000014	STEFFANS, JOE	07N26E04AABB	S	176.0	3439.00	2860.00	579	5400
065000015	EVANS, ALLEN	07N26E07BDDB	H	80.0	3310.00	3060.00	250	200
065000018	KUZARA, JOSEPH JR.	07N26E08BACD	S	58.0	3402.00	2990.00	412	200

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN [7] (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE [8] HEAD (FEET)	SPECIFIC [9] CAPACITY (GALLONS PER MINUTE PER FOOT)
065000006	3360.00	48.30	3311.70	8.0		0.2	1500	39.70	
065000004	3305.00	17.80	3287.20	3.5		0.2	2100	27.20	
065000003	3310.00	22.00	3288.00	8.0	2.00	0.2	2200		4.00
065000002	3315.00	22.00	3293.00	4.2		0.1	2300		
065000129	3330.00	9.84	3320.16					7.16	
065000007	3370.00	27.50	3342.50	9.0	15.90	0.2	1500	147.50	0.57
065000005	3360.00	30.00	3330.00		50.00		1400		
065000001	3380.00	74.00	3306.00	6.0	71.60	0.3	2000	176.00	0.08
065000008	3430.00	50.00	3380.00		18.00		1500	140.00	
065000009	3350.00	20.40	3329.60	6.0	0.50	0.2	2400	361.60	12.00
065000087	3540.00	2.50	3537.50					307.50	
065000010	3565.00	133.50	3431.50	3.3		0.2	2800	166.50	
065000011	3360.00	5.70	3354.30	5.0	14.10	0.2	2300	58.30	0.35
065000012	3395.00	43.70	3351.30		23.00				
065000013	3300.00	59.80	3240.20	10.7	19.20	0.2	2800		0.56
065000014	3615.00	3.80	3611.20					172.20	
065000015	3390.00	30.50	3359.50	7.5	0.20	0.2	2100	49.50	37.50
065000018	3460.00	38.00	3422.00	10.0		0.2	2100	20.00	

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000017	KUZARA, SELMA	07N26E08CCAB	Q	97.0	3338.00	3030.00	308	1200
065000113	EVANS, DALE	07N26E08CCCC	Q			3050.00		2200
065000016	YOUNT	07N26E08DDAC	H	117.0	3368.00	2990.00	378	3600
065000020	HERMAN, FRANK	07N26E10CDDC	H	455.0	3370.00	2900.00	470	11800
065000019	UNKNOWN	07N26E10DDCC	Q	235.0	3575.00	2870.00	705	12400
065000021	MOSEMAN, RICHARD	07N26E11DBAA	Q	243.0	3481.00	2910.00	571	16000
065000022	UNKNOWN	07N26E14BBDD	Q			2870.00		14800
065000083	FENTON, THOMAS	07N26E15ACDC	S	530.0	3310.00	2920.00	390	13400
065000084	FRASCA, RAY&ROBERTA	07N26E15BBCD	S	170.0	3454.00	2940.00	514	10200
065000085	MCCAN, REX	07N26E15DBBD	S	400.0GT		2940.00		13400
065000086	SALVESON. DAVID	07N26E16ACCB	S	123.0	3403.00	2990.00	413	8400
065000024	ELIASON, CARL	07N26E17ABCC	H	400.0	3035.00	3030.00	5	4000
065000128	LENHARDT.EDWARD	07N26E17BBBA01	Z	13.0	3402.00	3040.00	362	2600
065000023	MAJERUS,GILBERT	07N26E17DAAD	H	140.0	3335.00	3030.00	305	6800
065000025	LENHARDT, ROBERT	07N26E18AADB	HS	60.0	3395.00	3060.00	335	3500
065000114	LEHMAN, ANN	07N26E20DBBD	HS	137.0	3463.00	3090.00	373	10800
065000115	TULL, RUBY	07N26E29AADA	Q			3090.00		14400
065000116	TURLEY	07N27E03CCDB	Q	125.0	3360.00	3330.00	30	37200

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000017	3435.00	30.60	3404.40	6.3		0.2	2100	66.40	
065000113	3425.00						1300		
065000016	3485.00	44.90	3440.10	15.0		0.2	1600	72.10	
065000020	3825.00	233.00	3592.00	1.2		0.2	2700	222.00	
065000019	3810.00								
065000021	3724.00	129.50	3594.50	4.9	29.50	0.2	2900	113.50	0.17
065000022	3840.00	270.00	3570.00						
065000083	3840.00	243.10	3596.90	4.5		0.2	2800	286.90	
065000084	3624.00	66.20	3557.80	8.3	103.80	0.2	3000	103.80	0.08
065000085	3830.00	248.50	3581.50				2880	151.50	
065000086	3526.00	68.30	3457.70	4.5	1.80	0.3	1900	54.70	2.50
065000024	3435.00	9.20	3425.80	5.3	0.01	0.2	1800	390.80	530.00
065000128	3415.00	5.38	3409.62					7.62	
065000023	3475.00	36.70	3438.30	15.2	13.80	0.2	1300	103.30	1.10
065000025	3455.00			3.0		1.0	1200		
065000114	3600.00	63.20	3536.80	13.0	1.90	0.2	1700	73.80	6.84
065000115	3530.00	30.20	3499.80	13.0	1.50	0.2	1900		8.67
065000116	3485.00	31.00	3454.00	6.0	24.50	0.2	1540	94.00	0.24

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000117	SMITH, GEORGE	07N27E04ADAC01	U	36.0	3424.00	3360.00	64	37600
065000118	SMITH, GEORGE	07N27E04ADAC02	Q			3370.00		37800
065000119	SMITH, JOHN	07N27E06BBAB	Q	175.0	3245.00	3180.00	65	23600
065000120	TURLEY	07N27E10BABC	Q	65.0	3435.00	3320.00	115	39800
065000088	WOLF, NELLIE	08N25E13CCDC	Q		Y			1000
065000029	LOCKHART, CLYDE	08N25E14CCDA	H	160.0	3080.00Y			1000
065000027	FINCO, VIVIAN	08N25E14CDCC01	H		Y			1000
065000028	HALEY, EDNA	08N25E14CDCC02	H	108.0	3122.00Y			1200
065000026	PAULUS, BOB	08N25E14CDCD	H	80.0	3150.00Y			1200
065000033	MANG, ANTHONY	08N25E15DBBC	H		Y			2000
065000032	ELIASON, STANLEY	08N25E15DBDB	Q	225.0	3080.00Y			200
065000030	ORLEY, ARTHUR	08N25E15DDAD01	H	180.0	3075.00Y			600
065000031	ORLEY, ARTHUR	08N25E15DDAD02	H	65.0	3190.00Y			600
065000034	PETRIE, HAROLD	08N25E17DCBB	H	200.0	3145.00Y			5800
065000035	SMETANA, JEAN	08N25E17DCBB	H	282.0	3073.00Y			5400
065000121	WELCH, JACK	08N25E20BBAC	S	60.0	3220.00Y			7400
065000036	HUNT, MERLE	08N25E22ADAB	S	175.0	3115.00	3115.00		
065000091	VOISE, DON & ELLA	08N25E22DABA01	Q			3100.00		

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000117	3460.00	34.30	3425.70					1.70	
065000118	3460.00	25.20	3434.80	6.0	2.30	0.2	1700		2.61
065000119	3420.00	70.20	3349.80	5.5	8.40	0.2	1150	104.80	0.65
065000120	3500.00	23.10	3476.90	8.3		0.2	1750	41.90	
065000088	3195.00	9.00	3186.00	3.8		0.2	4700		
065000029	3240.00	49.80	3190.20	4.0	17.00	0.2	2500	110.20	0.24
065000027	3230.00	10.10	3219.90	6.0		0.1	1450		
065000028	3230.00	51.20	3178.80	7.7	19.40	0.2	2500	56.80	0.40
065000026	3230.00	43.60	3186.40	6.7		0.2	1900	36.40	
065000033	3320.00	6.00	3314.00	20.0		0.2	1200		
065000032	3305.00	71.70	3233.30	10.0	5.20	0.5	1300	153.30	1.92
065000030	3255.00	47.40	3207.60	7.0	20.10	0.2	1100	132.60	0.35
065000031	3255.00	35.20	3219.80					29.80	
065000034	3345.00	75.00	3270.00	3.8	5.00	0.2	2000	125.00	0.76
065000035	3355.00	86.10	3268.90	5.5	13.10	0.2	2000	195.90	0.42
065000121	3280.00	15.00	3265.00	9.8	2.30	0.2	5100	45.00	4.26
065000036	3290.00	77.20	3212.80				3480	97.80	
065000091	3210.00	73.20	3136.80	8.3	0.30	0.2	3900		27.67

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000037	BAKER, EVALIN	08N25E22DABB	H	135.0	3085.00	3100.00	-15	
065000038	STEPHENSON, JOHN O.	08N25E22DABD	HS	80.0	3120.00	3100.00	20	200
065000090	MCTIER, DEBRA	08N25E22DACA	Q			3100.00		600
065000089	HORTON, IVAN	08N25E22DADA01	I		Y	3100.00		800
065000092	UNKNOWN	08N25E22DDBC01	Q			3100.00		1200
065000136	VFW,(CHARLES GUSICK)	08N25E22DDBD01	Z	15.0	3185.00	3100.00	85	1600
065000041	KECSKEMETI, MARGARET	08N25E23ABBC	H	240.0	2955.00Y			1600
065000044	KOZLAKER, JOHN	08N25E23ACBA01	H	21.0	3174.00	3160.00	14	600
065000048	BLACK, DIANE	08N25E23BACC01	I		Y			200
065000049	HUNT, M. & NEIGHBORS	08N25E23BACC02	H	325.0	2873.00Y			400
065000042	HELEDIC, GEORGE	08N25E23BADD01	H	33.7	3161.30Y			1200
065000046	JENSICK, RUDY&SHIRLY	08N25E23BADD02	Q		Y			1400
065000047	HAGSTROM, MARIE	08N25E23BADD03	H	20.0	3175.00Y			600
065000040	STORTZ, LYLE	08N25E23BCCC	H			3110.00		100
065000039	STORTZ, LYLE E.	08N25E23BCDC	H	110.0	3095.00	3110.00	-15	100
065000043	STOUDT, ED	08N25E23BDAA01	H	15.0	3180.00Y			1000
065000138	CITY OF ROUNDUP	08N25E23BDAD01	Z	18.0	3172.00	3200.00	-28	1200
065000045	RACKI, TONY	08N25E23BDBA	Q		Y			800

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000037	3220.00	29.00	3191.00	5.0		0.2	3200	106.00	
065000038	3200.00	6.20	3193.80	6.0	5.90	0.2	2700	73.80	1.02
065000090	3205.00	9.20	3195.80	4.8	20.30	0.2	3200		0.24
065000089	3200.00	10.00	3190.00	6.7	3.80	0.2	3900		1.76
065000092	3205.00	10.00	3195.00	5.4	1.40	0.2	4200		3.86
065000136	3200.00	9.08	3190.92					5.92	
065000041	3195.00	12.00	3183.00	14.0	31.60	0.2	3500	228.00	0.44
065000044	3195.00	13.00	3182.00				1800	8.00	
065000048	3195.00	12.50	3182.50				2300		
065000049	3198.00	24.20	3173.80				2100	300.80	
065000042	3195.00	12.80	3182.20	2.0	3.20	0.2	2100	20.90	0.63
065000046	3195.00	12.30	3182.70	5.0		0.2	2500		
065000047	3195.00	11.50	3183.50	4.5		0.2	1800	8.50	
065000040	3200.00	8.20	3191.80	7.5		0.2			
065000039	3205.00	10.50	3194.50	13.0	21.90	0.2	2700	99.50	0.59
065000043	3195.00	12.00	3183.00	6.4	0.30	0.2	1700	3.00	21.33
065000138	3190.00	11.06	3178.94					6.94	
065000045	3195.00	13.60	3181.40	3.6		0.2	2700		

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000137	STORTZ, LYLE	08N25E23CABA01	Z	18.0	3174.00	3110.00	64	600
065000050	RECH, LOREN	08N25E23DBAA	HS			3110.00		
065000141	MUSS. CO. (L.MINNIE)	08N25E24AABB01	Z	18.0	3157.00	3060.00	97	
065000140	MUSS. CO. (L.MINNIE)	08N25E24ABBD01	Z	19.0	3161.00	3080.00	81	
065000147	CITY OF ROUNDUP	08N25E24BADD	Z			3080.00		
065000052	SIETZ, AL	08N25E24BBCA	HN	75.0	3110.00Y			100
065000139	LEKSE, LARRY	08N25E24BBCB01	Z	11.0	3169.00Y			200
065000051	RECH, LOREN	08N25E24CACC	HS	280.0	2990.00	3030.00	-40	
065000102	BALICH, ROBERT	08N25E26BBCA01	Q	90.0	3140.00	3090.00	50	100
065000134	THAYER, PAUL	08N25E26BBCC01	Z	18.0	3202.00	3100.00	102	400
065000100	DINGER, FRED	08N25E26BCAA01	Q	50.0	3225.00	3090.00	135	
065000101	DINGER, FRED	08N25E26BCAA02	Q	100.0	3175.00	3090.00	85	
065000133	MARSH, DALE	08N25E26BDCB01	Z	13.0	3217.00	3090.00	127	
065000099	BAKER, KIM	08N25E26CADA01	Q			3060.00		
065000098	FISK, GERALD	08N25E26DBBD01	Q	135.0	3150.00	3060.00	90	
065000097	MESTDAGH, GILBERT	08N25E26DCBA01	Q	70.0	3190.00	3060.00	130	
065000095	MCCLEARY, DENNIS	08N25E26DCCA01	Q	70.0	3205.00	3060.00	145	
065000094	RINEHART, NORMAN	08N25E26DCDC01	Q	70.0	3210.00	3060.00	150	

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000137	3192.00	10.51	3181.49					7.49	
065000050	3280.00	100.10	3179.90	15.0	0.10	0.2	4200		150.00
065000141	3175.00	9.60	3165.40					8.40	
065000140	3180.00	7.83	3172.17					11.17	
065000147	3173.31	3.00	3170.31						
065000052	3185.00	10.30	3174.70	10.0	0.10	0.2	2600	64.70	100.00
065000139	3180.00	7.27	3172.73					3.73	
065000051	3270.00	85.70	3184.30	11.0	9.00	0.2	2100	194.30	1.22
065000102	3230.00	33.30	3196.70	3.9		0.2	2500	56.70	
065000134	3220.00	14.54	3205.46					3.46	
065000100	3275.00	34.00	3241.00					16.00	
065000101	3275.00	42.00	3233.00	5.0	12.00	0.2	2700	58.00	0.42
065000133	3230.00	1.99	3228.01					11.01	
065000099	3270.00	11.10	3258.90			0.2	2500		
065000098	3285.00	40.50	3244.50	4.3		0.2	2700	94.50	
065000097	3260.00	15.40	3244.60	5.4		0.2	2800	54.60	
065000095	3275.00			15.0		0.2	2700		
065000094	3280.00	15.00	3265.00	9.7	0.10	0.2	2500	55.00	97.00

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000132	O'BRIAN, JACK	08N25E26DCDD01	Z	8.0	3242.00	3050.00	192	
065000096	MOORE, LYLE	08N25E26DDCC01	Q	67.0	3208.00	3050.00	158	
065000093	BARNABEI, FRANK	08N25E26DDDB01	Q	100.0	3180.00	3040.00	140	
065000135	RODEGHEIRO, BRUNO	08N25E27BBAD01	Z	16.0	3196.00	3140.00	56	4200
065000053	LOWRY, ALICE	08N25E28ABCD	H	337.0	2943.00	3240.00	-297	6800
065000055	WAGNER, BILL	08N25E28ACAC	I	60.0	3165.00	3240.00	-75	7200
065000054	WAGNER, BILL	08N25E28ACBA	Q			3250.00		7000
065000056	WAGNER, BILL	08N25E28DABC	I		Y			7600
065000057	GILREATH, HOWARD	08N25E28DDBA	H		Y			700
065000058	TOMAC, LLOYD	08N25E33CADD	H	200.0	3030.00Y			11200
065000112	MCCLEARY, CHARLES	08N25E35AAAA01	Q			3040.00		
065000111	FERRIS, MARK	08N25E35AAAD01	Q	50.0	3225.00	3040.00	185	
065000131	SABINS, LOUISE	08N25E35ADDC01	Z	13.0	3272.00	3060.00	212	
065000106	YOUNT, NORMA	08N25E35ADDD01	Q	70.0	3215.00	3050.00	165	
065000110	HAZLETON, VINCE	08N25E35ADDD02	Q	170.0	3120.00	3050.00	70	
065000107	YATES, ROBERT	08N25E35DAAA01	Q			3050.00		
065000108	SCHAFF, JIM	08N25E35DAAC01	Q			3060.00		
065000109	UNKNOWN	08N25E35DABD01	Q			3060.00		

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000132	3250.00	2.06	3247.94					5.94	
065000096	3275.00	8.60	3266.40	5.0		0.2	2500	58.40	
065000093	3280.00	19.70	3260.30	7.5	5.60	0.1	2700	80.30	1.34
065000135	3212.00	9.73	3202.27					6.27	
065000053	3280.00			2.5		0.2	3700		
065000055	3225.00	37.00	3188.00	4.0	0.10	0.2		23.00	40.00
065000054	3240.00	30.70	3209.30	2.4	5.50	0.2	5000		0.44
065000056	3220.00	3.20	3216.80		5.80	0.1			
065000057	3220.00	14.50	3205.50	7.5		0.2	4050		
065000058	3230.00			7.5		0.2	1700		
065000112	3275.00			4.4		8.0	2500		
065000111	3275.00	8.20	3266.80	4.0	1.20	0.2		41.80	3.33
065000131	3285.00	6.66	3278.34					6.34	
065000106	3285.00	13.00	3272.00	7.0	0.30	0.2	2300	57.00	23.33
065000110	3290.00	24.00	3266.00		1.30		2100	146.00	
065000107	3285.00			6.6		0.2	2500		
065000108	3290.00	9.70	3280.30	7.1		0.2	2400		
065000109	3295.00			5.0		0.2	2100		

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000104	SYSUM, TREVOR	08N25E35DDDB01	Q	165.0	3170.00	3060.00	110	
065000105	SYSUM, EMMIT	08N25E35DDDB02	Q	94.0	3236.00	3060.00	176	
065000103	SCHWAB, KEN	08N25E35DDDD01	Q			3060.00		
065000130	FARMER, MURIEL	08N25E36CCBB01	Z	17.0	3273.00	3050.00	223	
065000148	ARMSTRONG, MERRILL	08N25E36DBBA	Z	300.0	3060.00	3020.00	40	
065000059	ADOLPH, ALFRED J.	08N26E17ACDD	Q	180.0	3010.00Y			600
065000063	UNKNOWN	08N26E18ACCC	Q	24.0	3151.00Y			600
065000143	NEWTON, WALTER	08N26E18CACC01	Z	13.0	3159.00Y			400
065000146	NEWTON, WALTER	08N26E18CADA	Z		Y			200
065000065	HOLLIDAY, JIM	08N26E18CDCC	S			3030.00		
065000142	NEWTON, WALTER	08N26E18DABC01	Z	14.0	3154.00Y			600
065000064	NEWTON, WALTER	08N26E18DACB	S		Y			400
065000061	NEWTON, WALTER	08N26E18DBDA01	U	100.0	3080.00	3160.00	-80	
065000062	NEWTON, WALTER	08N26E18DBDA02	H	125.0	3058.00	3120.00	-62	
065000060	NEWTON, WALTER	08N26E18DCAA	U	22.4	3157.60	3080.00	78	
065000144	KOWALSKI, DOREEN	08N26E18DCBC	Z	178.0	3037.36	3037.00		
065000145	TAYLOR, THOMAS R.	08N26E18DCDC	Z	205.0	2993.68	2993.00		
065000066	NEWTON, WALTER	08N26E18DDDD	H	150.0	3050.00	3000.00	50	

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000104	3335.00	44.40	3290.60	15.0	23.80	0.2	2000	120.60	0.63
065000105	3330.00	60.30	3269.70	12.0	23.10	0.2	1700	33.70	0.52
065000103	3310.00	18.70	3291.30	6.0	0.30	0.2	2700		20.00
065000130	3290.00	9.21	3280.79					7.79	
065000148	3360.00	98.47	3261.53					201.53	
065000059	3190.00	44.60	3145.40	7.9	26.80	0.2	2100	135.40	0.29
065000063	3175.00	3.70	3171.30					20.30	
065000143	3172.00	7.29	3164.71					5.71	
065000146	3165.30	0.80	3164.50						
065000065	3210.00	72.80	3137.20	8.3	4.80	0.2	1900		1.73
065000142	3168.00	7.50	3160.50					6.50	
065000064	3175.00	12.60	3162.40	3.8	0.10	0.2	3200		38.00
065000061	3180.00	13.00	3167.00					87.00	
065000062	3183.00	29.70	3153.30	7.1	2.10	0.2	2160	95.30	3.38
065000060	3180.00	21.50	3158.50					0.90	
065000144	3215.36	55.93	3159.43	68.0		1.1	2000	122.07	
065000145	3198.68	39.61	3159.07	79.0		1.0	2000	165.39	
065000066	3200.00	37.10	3162.90					112.90	

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000122	RECH, LOREN	08N26E19AABA	U			2990.00		400
065000067	RECH, LOREN	08N26E19AACB	S	150.0	3070.00	2980.00	90	1000
065000068	RECH, LOREN	08N26E19DDCB	U	300.0GT		2960.00		
065000080	RECH, LOREN	08N26E20BBBB	S			2940.00		600
065000069	RECH, LOREN	08N26E20CBBA	U	100.0	3160.00	2950.00	210	1800
065000070	RECH, LOREN	08N26E20CCAD01	U	300.0GT		2940.00		
065000071	RECH, LOREN	08N26E20CCAD02	Q		3154.00	2940.00		800
065000072	UNKNOWN	08N26E21ABAB	H	250.0	3190.00	3220.00	-30	3400
065000123	TARRANT, PATRICK	08N26E21BDCA	Q			3030.00		2000
065000124	SLATER, GORDON	0826E21DABC	Q	380.0	2980.00	3060.00	-80	4400
065000075	WHITE, CARL	08N26E22ACCD	Q	190.0	3115.00	3180.00	-65	8200
065000073	TULL, BLAIN	08N26E22BCAA	H	198.0	3082.00	3240.00	-158	6000
065000074	GRANBOIS, JOSEPH	08N26E22CDBA	Q			3100.00		7400
065000077	ANDERSON	08N26E23BAAB	H	375.0	3030.00	3360.00	-330	12200
065000076	POTTS, GLEN	08N26E23CBAC	Q	435.0	2965.00	3180.00	-215	11800
065000126	TURLEY	08N26E24CBBA	Q		Y			16800
065000125	UNKNOWN	08N26E25BCBB	Q	195.0	3095.00	3200.00	-105	16800
065000078	BENDER, RODGER	08N26E26DBAD	Q			3100.00		18000

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE PER FOOT)
065000122	3240.00	36.90	3203.10						
065000067	3220.00	55.20	3164.80		3.40	0.1	1700	94.80	
065000068	3420.00	254.00	3166.00					46.00	
065000080	3490.00	13.20	3476.80				2000		
065000069	3260.00	75.50	3184.50					24.50	
065000070	3390.00	227.00	3163.00					73.00	
065000071	3390.00	187.50	3202.50					48.50	
065000072	3440.00	149.00	3291.00	5.7		0.?	2200	101.00	
065000123	3500.00			10.0		0.2	1200		
065000124	3360.00	233.20	3126.80	7.5		0.2	2300	146.80	
065000075	3305.00	156.00	3149.00	8.3		0.2	1400	34.00	
065000073	3280.00	58.00	3222.00	5.3	17.50	0.2	1100	140.00	0.30
065000074	3295.00	31.90	3263.10	5.5		0.2	1900		
065000077	3405.00	164.70	3240.30	7.3	45.30	0.2	1870	210.30	0.16
065000076	3400.00	194.00	3206.00	17.6	42.00	0.2	1200	241.00	0.42
065000126	3240.00	26.70	3213.30	14.0	1.00	0.2	1500		14.00
065000125	3290.00	70.40	3219.60					124.60	
065000078	3355.00	36.00	3319.00	9.7		0.2	2150		

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	OWNER	LOCATION	USE OF WATER	WELL DEPTH (FEET)	WELL BOTTOM ALTITUDE (FEET)	BASE OF COAL ALTITUDE (FEET)	DISTANCE TD TO RU COAL (FEET)	DISTANCE WELL TO MINE (FEET)
065000079	STEFFANS, JOE	08N26E26DBCD	S	48.0	3307.00	3090.00	217	17600
065000081	RODEGHIERO, DOMINICK	08N26E30DBBA	S			2950.00		1000
065000082	STEFFANS, JOE	08N26E34AADC	S			2980.00		13200
065000127	CASEY	08N27E33DAAA	Q	60.0	3360.00	3420.00	-60	37800

APPENDIX C. WATER WELL DATA FROM SITES THAT WERE INVENTORIED IN THE BULL MOUNTAIN AREA DURING SUMMER, 1987. (CONTINUED)

MBMG NUMBER	ALTITUDE OF LAND SURFACE (FEET)	STATIC WATER LEVEL (FEET)	WATER-LEVEL ALTITUDE (FEET)	DISCHARGE (GALLONS) PER MINUTE)	DRAWDOWN (FEET)	DURATION OF DISCHARGE (HOURS)	SPECIFIC CONDUCTANCE (MICROSIEMENS/CM AT 25 C)	AVAILABLE HEAD (FEET)	SPECIFIC CAPACITY (GALLONS PER MINUTE (PER FOOT)
065000079	3355.00	25.00	3330.00	15.0	0.40	0.2	2200	23.00	37.50
065000081	3520.00	16.70	3503.30				0		
065000082	3415.00	14.50	3400.50	10.0	7.00	0.2	2800		1.43
065000127	3420.00	43.30	3376.70	4.0	1.20	0.2	1200	16.70	3.33

1 THE USE OF THE WELL IS DESIGNATED BY THE FOLLOWING CODES: H, HOUSEHOLD; I, IRRIGATION; N, INDUSTRIAL; Q, NOT REPORTED; S, STOCK; U, NOT IN USE; Z, OBSERVATION WELL

2 WELL DEPTH FOLLOWED BY "GT" INDICATES THE WELL IS DEEPER THAN THE REPORTED VALUE BY AN UNKNOWN AMOUNT.

3 WELL BOTTOM ALTITUDE CONTAINS A 'Y' IN THE FIELD IF THE WELL COMPLETION IS STRATIGRAPHICALLY BELOW THE ROUNDUP COAL BED.

4 BASE OF COAL ALTITUDE IS THE ELEVATION OF THE BASE OF THE ROUNDUP COAL BED AT THE WELL LOCATION. ACCURACY OF DATA IS 10 FEET WITHIN THE MINE BOUNDARIES AND 20 FEET ELSEWHERE. BLANK VALUES INDICATE THE WELL LOCATION IS BEYOND THE AREAL EXTENT OF THE ROUNDUP COAL BED.

5 DISTANCE, TD TO RU COAL IS THE VERTICAL DISTANCE BETWEEN THE BOTTOM OF THE WELL AND THE BASE OF THE ROUNDUP COAL BED.

6 DISTANCE, WELL TO MINE IS THE HORIZONTAL DISTANCE BETWEEN THE WELL AND THE NEAREST MINE WORKINGS.

7 DRAWDOWN IS THE DRAWDOWN MEASURED IN THE WELL AT THE LISTED DISCHARGE FOR THE LISTED DURATION OF PUMPING.

8 AVAILABLE HEAD IS THE TOTAL DEPTH OF THE COLUMN OF WATER IN THE WELL.

9 SPECIFIC CAPACITY IS THE SPECIFIC CAPACITY OF THE WELL AS MEASURED AT THE LISTED DRAWDOWN, DISCHARGE AND DURATION.

APPENDIX D

WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 7N R. 26E Sec. 17 Tract: BBBA01 Hole name or Number RU-01 (065000128)

Hole location: Near Halfbreed Creek (Lenhardt) Lat 46°21'57" Long. 108°30'18"

Recorded by: JR Date hole Started: 10/06/87 Date hole Comp.: 10/06/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 13 Well diameter: 2" PVC Casing diameter(s) and length (s): 10' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened: PVC 20 slot screen

Interval-perforated or screened: 8-13' 2" #20 slot backfilled with gvl pack then cuttings surface bent. plug

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Altitude = 3415' est. from topo; drilled with solid stem augers, gravel packed, surface bent. plug

3416.72 MP elevation MP = 1.72

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; grayish brown, sandy, silty
1	5	Very fine sand; yellowish brown, silty
5	13	Silt; grayish brown and yellowish brown, sandy, silty, layers of clay, grading to very fine sand; grayish brown, silty

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 7N R. 25E Sec. 01 Tract: CACA01 Hole name or Number RU-02 (065000129)

Hole location: Next to USGS gauge 1 mile south of Klein Lat 46°23'14" Long 108°32'29"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 17 Well diameter: 2" Casing diameter(s) and length (s): 2"-15' 2" 20 slot screen 5'

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 12-17 20 slot PVC

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Next to gauging station on Halfbreed Creek, well sand packed, backfilled with cuttings, surface bentonite seal Elevation = 3330 3332.10 MP elevation

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	4	Silt; yellowish brown, very fine sandy
4	7	Very fine sand; yellowish brown, silty
7	10	Silt; light gray to dark gray, sandy - Interbedded with - silt; yellowish brown, sandy,thin clay layers, wet at about 9-10 feet
10	17	Very fine sand; gray, silty, pebbly, poor returns

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 8N R. 25E Sec. 36 Tract: CCBB01 Hole name or Number RU-03 (065000130)

Hole location: Next to bridge 1/4 mile North of Farralltown Lat 46°24'02" Long 108°32'53"

Recorded by: JR Date hole Started: 10/06/87 Date hole Comp.: 10/06/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 17 Well diameter: 2" Casing diameter(s) and length (s): 14'2", 2'out of hole

Type of casing(s): Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 12-17 sand packed #20 slot screen

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Drilled with solid stem auger, surface bentonite seal

Elevation = 3290 est. 3292 MP elevation MP = 20

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; grayish brown, silty, sandy
1	5	Very fine sand; yellowish brown, silty, coarsens with depth
5	14	Silt; yellowish brown interbedded with grayish brown, sandy
14	17	Fine sand; gray, silty - Interbedded with medium to coarse gravel

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 8N R. 25E Sec. 35 Tract: ADDC01 Hole name or Number RU-04 (065000131)

Hole location: Near bridge at Klein Lat = 46°24'16" Long = 106°33'00"

Recorded by: Date hole Started: 10/06/87 Date hole Comp.: Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 13 Well diameter: 2" Casing diameter(s) and length (s): 10' of 2" PVC

Type of casing(s): Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 8-13 2" #20 slot PVC

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled with solid stem auger, surface bentonite seal

Elevation = 3285 est. 3286.70 MP

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; grayish brown, sandy, silty
1	5	Silt; pale brown, sandy
5	7	
7	13	Silt; light gray interbedded with yellowish brown, a few wet sand layers

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 8N R. 25E Sec. 26 Tract: DCDD01 Hole name or Number RU-05
(065000132)

Hole location: West of Gibbtown next to creek Lat = 46°24'43" Long = 108°33'14"

Recorded by: JR Date hole Comp.: 10/06/87 Date hole Started: 10/06/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 8 Well diameter: 2" Casing diameter(s) and length (s): 5'2" 5' screen 2' PVC out of ground

Type of casing(s): Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 3-8 2" #20 slot PVC

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Right next to creek, drilled with solid stem auger, surface bentonite seal

Elevation = 3250 est 3251.8 MP elevation MP = 1.80

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, sandy
1	3	Fine sand; brownish gray, silty, wet
3	8	Fine to coarse sand; brownish gray, slightly silty, a few gravel fragments, poorly sorted

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 8N R. 25E Sec. 26 Tract: BDCB01 Hole name or Number RU-06 (065000133)

Hole location: By creek NW of cemetery behind Marsh residence Lat = 46°25'12" Long = 108°33'48"

Recorded by: JR Date hole Started: 10/06/87 Date hole Comp.: 10/06/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 13 Well diameter: 2" Casing diameter(s) and length (s):

Type of casing(s): Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 8-13' 2" #20 slot PVC

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Drilled with solid stem auger; surface bentonite seal, gravel packs

Elevation = 3230 est. 3231.70 MP elevation MP = 1.70

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, sandy
1	5	Very fine to fine sand; grayish brown, silty, saturated below 3 feet
5	10	Fine sand; grayish brown, silty - Interbedded with - silt; gray sandy, moderately cohesive, thinly bedded
10	13	Silt; gray, sandy, moderately cohesive, thinly bedded

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 26 Tract: BBCC01 Hole name or Number RU-07 (065000134)

Hole location: On Paul Thayers land, near garden, above Halfbreed Creek, Lat = 46°35'22" Long=108°34'05"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 22 Well diameter: 2" Casing diameter(s) and length (s): 2" PVC, 16'

Type of casing(s): Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: 13.5-18.5 2" #20 slot PVC screen

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Bedrock at 22' drilled with solid stem auger, bentonite seal at surface

Elevation = 3220 est. 3222.05 MP elevation

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; gray brown, silty
1	7	Silt; pale brown to grayish brown, very fine sandy, soft, non-bedded
7	15	Very fine sand; grayish brown to gray, silty, slightly clayey, a few pebbles
15	22	Sandstone and gravel; silty, poorly sorted, wet
22		Sandstone or siltstone, very hard drilling, auger would not penetrate

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 8N R. 25E Sec. 27 Tract: BBAD01 Hole name or Number RU-08 (065000135)

Hole location: On land owned by Bruno Rhodegeiro, towards river from house Lat 46°25'28",Long 108°35'07"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 16 Well diameter: 2" PVC Casing diameter(s) and length (s): 13' of 2" PVC 2' MP

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI = 11'-16', 2" #20 slot PVC screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Bedrock at 19 ft. drilled with solid stem auger, bentonite seal at surface

Elevation = 3212 est. 3214 MP elev. MP=2.00

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; light yellowish brown, silty
1	5	Silt; yellowish brown, very fine sandy
5	9	Very fine sand; yellowish brown, silty
9	19	Sand and gravel; silty, clayey, poorly sorted, coarsens with depth
19		Sandstone?; very hard drilling, bedrock

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 22 Tract: DDBD01 Hole name or Number RU-09 (065000136)

Hole location: Next to USGS gauging station Lat = 46°25'41" Long = 108°34'19"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 14.5' Well diameter: 2" Casing diameter(s) and length (s): 12' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI = 9.5-14.5, 2" #20 slot screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled to 25' hole collapsed could not set screen past 14.5 ft, used solid stem auger bentonite seal at surface, Elevation = 3200 est. 3202.04 MP elevation

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; grayish brown, sandy
1	5	Silt; pale brown to yellowish brown, sandy
5	8	Very fine to fine sand; yellowish brown, silty
8	25	Sand and gravel; silty, slightly clayey, poorly sorted

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 23 Tract: BDAA01 Hole name or Number RU-11 (065000138)

Hole location: End of trail overlooking Musselshell River Lat = 46°26'09" Long=108°33'33"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 18 Well diameter: 2" PVC Casing diameter(s) and length (s): 15' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI = 13'-18', 5' of 2" " #20 slot screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled with hollow stem auger, surface bentonite seal

elevation = 3190 est. 3192.38 MP elevation MP = 2.38

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; grayish brown, silty
1	5	Silt; pale yellow, very fine sandy, loose, dry
5	8	Silt; grayish brown, very fine sandy
8	10	Silt; yellowish brown, sandy, interbedded with very fine sand; grayish brown, silty
10	18	Sand and gravel; silty, poorly sorted

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 23 Tract: CABA01 Hole name or Number RU-10
(065000137)

Hole location: Near Musselshell River east of Lyle Stortz, Lat = 46°25'58", Long = 108°33'42"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 18 Well diameter: 2" PVC Casing diameter(s) and length (s): 15' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=13'-18', 5' of 2" " #20 slot screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled with hollow stem auger, surface bentonite seal

Elevation = 3192 est. 3193.65 MP elevation MP = 1.65

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; pale brown, silty
1	6	Silt; pale yellow, very fine sandy, loose, dry
6	8	Very fine to fine sand; yellowish brown, silty
8	10	Very fine to fine sand; light olive grey
10	15	Sand and gravel; silty, poorly sorted
15	18	Very fine to fine sand; bluish gray, silty

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 23 Tract: BBCB01 Hole name or Number RU-12 (065000139)

Hole location: Above Musselshell River near Locker Plant, Lat = 46°26'18", Long = 108°32'50"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 11 Well diameter: 2" PVC Casing diameter(s) and length (s): 8' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=6'-11', 2" " #20 slot screen

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Drilled with hollow stem auger, surface bentonite seal

Elevation = 3180 est. 3182.36 MP elevation MP = 2.36

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark grayish brown, silty
1	3	Silt; pale brown, sandy, loose
3	5	Silt; pale brown, sandy, pebbly
5	11	Sand and gravel; silty, poorly sorted, hard drilling
11		Sandstone?; hard drilling, auger could not penetrate

APPENDIX D

WELL LOG

MONTANA BUREAU OF MINES AND GEOLOGY

GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 24 Tract: ABBD01 Hole name or Number RU-13 (065000140)

Hole location: West end of fairgrounds, near city well, Lat = 46°26'20", Long = 108°32'10"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 19 Well diameter: 2" PVC Casing diameter(s) and length (s): 16' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=14'-19', 2" " #20 slot screen

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Drilled with hollow stem auger, surface bentonite seal

Elevation = 3180 est. 3181.30 MP elevation MP = 1.30

DRILLING LOG

Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, silty
1	4	Silt; pale brown, sandy, loose
4	10	Silt; grayish brown, sandy, clayey, moist
10	19	Sand and gravel; silty, poorly sorted

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 25E Sec. 24 Tract: ABBD01 Hole name or Number RU-14
(065000141)

Hole location: East of County Fairgrounds, NW side of bridge, Lat = 46°26'23", Long = 108°31'52"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 18 Well diameter: 2" PVC Casing diameter(s) and length (s): 15' of 2" PVC
Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=13'-18', 2" #20 slot screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled with hollow stem auger, surface bentonite seal

Elevation = 3175 est. 3177.15 MP elevation MP = 2.15

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, silty
1	3	Silt; pale brown, sandy, loose
3	5	Silt; grayish brown, sandy, slightly clayey
5	7	clay; bluish gray, silty, slightly sandy
7	19	Sand and gravel; silty, poorly sorted

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 26E Sec. 18 Tract: DABC01 Hole name or Number RU-15
(065000142)

Hole location: NE of Newton Bridge, Lat = 46°26'48", Long = 108°30'42"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 14 Well diameter: 2" PVC Casing diameter(s) and length (s): 10' of 2" PVC

Type of casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=9'-14', 2" #20 slot screen

Has well been test pumped?: No Were material samples taken? No Was a water sample taken?: No

Remarks: Drilled with hollow stem auger, surface bentonite seal

Elevation = 3168 est. 3170.35 MP elevation MP = 2.35

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, silty
1	3	Silt; yellowish brown, sandy
3	5	Fine sand; brownish gray, silty
5	14	Sand and gravel; silty, poorly sorted

APPENDIX D
WELL LOG
MONTANA BUREAU OF MINES AND GEOLOGY
GROUND WATER DIVISION

County: Musselshell Location: T. 08N R. 26E Sec. 18 Tract: CACC01 Hole name or Number RU-16 (065000143)

Hole location: 1/4 mile upstream from Jeffries Mine Slope (pump site), Lat = 46°26'43", Long = 108°31'17"

Recorded by: JR Date hole Started: 10/07/87 Date hole Comp.: 10/07/87 Driller: F. Schmidt Drilling Company MBMG

Total well depth (ft) 13 Well diameter: 2" PVC Casing diameter(s) and length (s): 10' of 2" PVC

Type of Casing(s): Plastic Weight or gage of casing: Method-perforated or screened:

Interval-perforated or screened: SI=3'-13', 2" #20 slot PVC screen

Has well been test pumped?: Were material samples taken? Was a water sample taken?:

Remarks: Drilled to 19', 6 feet collapsed, drilled with solid stem auger, surface bentonite seal

Elevation = 3172 est. 3174.60 MP elevation MP = 2.60

DRILLING LOG
Geological, drilling, and water conditions; remarks and sampling

From	To	
0	1	Topsoil; dark brown, silty
1	4	Coarse gravel
4	10	Silt; interbedded bluish gray and yellowish brown, sandy, clayey, finely bedded
10	19	Sand and gravel; silty, poorly sorted