Controls on ground-water availability and quality, the Bridger Canyon area, Bozeman, Montana
by Bonnie K Moore

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University
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Abstract:
Residential expansion into the Bridger Canyon area of Bozeman, Montana has encountered localized areas of restricted ground-water availability. In some instances water wells were drilled after houses were built, but no water was found or wells did not produce sufficient water for the household. Within the canyon, water quality varies. Some domestic wells encountered hydrogen sulfide and excess fluoride. Areas where water is available and of good quality include alluvium and some springs at or near the toes of landslides. Water is not readily available or is of poor quality within thick sequences of shales of the Livingston Group. Variations in the Livingston Group deposits cause subsequent variations in ground-water availability and quality.

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Bonnie K. Moore

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Date August 28, 1984

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TABLE OF CONTENTS

	Page
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF PLATES	ix
ABSTRACT	x
INTRODUCTION	1
Statement of Problem	1
General Setting	3
Geographic Setting	3
Stratigraphic Setting	4
Structural Setting	11
METHODS	15
Field Methods	15
Site Numbering System	16
Methods of Chemical Analysis	18
RESULTS AND DISCUSSION	21
Water Availability	21
Results	21
Discussion	23
Summary of Water Availability	30
Water Quality	33
Introduction	33
Calculated Water Quality Parameters	35
Total Dissolved Solids	35
Total Alkalinity	36
Total Hardness	37
Piper Trilinear Plot	37
Measured Water Quality Parameters	39
Introduction	39
Parameters Without Standards	42
Boron	42
Hydrogen Sulfide	42
Ph	44
Temperature	45
Specific Conductance	51

TABLE OF CONTENTS -- Continued

Page

Parameters With Exceeded Standards..... 51
Nitrate..... 51
Fluoride..... 52
Iron..... 53
Discussion of Water Quality..... 54

CONCLUSIONS..... 60

REFERENCES CITED..... 63

APPENDICES..... 66

Appendix A
Methods of Well Measurement..... 67
Appendix B
Methods of Spring Measurement..... 70
Appendix C
Methods of Stream Discharge Measurement..... 72
Appendix D
Water Sampling Method..... 74
Appendix E
Well-Logs..... 76
Appendix F
Drawdown and Recovery Curves..... 133
Appendix G
Chemical Analytical Results..... 173

LIST OF TABLES

Table		Page
1.	Water availability and general aquifer characteristics.....	5
2.	Methods of laboratory analysis.....	19
3.	Domestic well measurements.....	24
4.	Abandoned well measurements.....	26
5.	Location of sample sites for water chemistry.....	34
6.	Chemical constituents represented as calculated values.....	36
7.	Chemical constituents not exceeding standards.....	40
8.	Chemical constituents not exceeding standards.....	41
9.	Secondary standards for drinking water.....	42
10.	Chemical constituents not having standards.....	43
11.	Water quality data for domestic wells.....	46
12.	Water quality data for stream sites.....	48
13.	Water quality data for spring sites.....	49
14.	Water quality data for pond sites.....	49
15.	Primary standards for drinking water.....	52
16.	Chemical constituents exceeding standards.....	53
17.	Primary standards for fluroide.....	54
18.	Comparison of water quality parameters from Bozeman Hot Springs, Bridger Canyon, and the fish Cultural Development Center.....	56
19.	Comparison of surface water chemistry.....	59

LIST OF FIGURES

Figure		Page
1.	Location of study area	2
2.	Schematic representation of cross-section through study area	8
3.	General structural setting of study area	13
4.	Method of numbering sites	17
5.	Drawdown and recovery curves	22
6.	Schematic diagram of Livingston Group deposits and well-siting locations	32
7.	Piper trilinear plot	38

LIST OF PLATES

Plate

1. Geologic Bedrock Map of Bridger Canyon, Bozeman, Montana.
2. Geomorphic Map of Bridger Canyon, Bozeman, Montana.
3. Measured Site Location Map of Bridger Canyon, Bozeman, Montana.

ABSTRACT

Residential expansion into the Bridger Canyon area of Bozeman, Montana has encountered localized areas of restricted ground-water availability. In some instances water wells were drilled after houses were built, but no water was found or wells did not produce sufficient water for the household. Within the canyon, water quality varies. Some domestic wells encountered hydrogen sulfide and excess fluoride. Areas where water is available and of good quality include alluvium and some springs at or near the toes of landslides. Water is not readily available or is of poor quality within thick sequences of shales of the Livingston Group. Variations in the Livingston Group deposits cause subsequent variations in ground-water availability and quality.

INTRODUCTION

Statement of Problem

The Bridger Canyon area is experiencing development associated with residential expansion near Bozeman, Montana and growth related to the Bridger Bowl Ski area to the north (Figure 1). This development has encountered localized areas of restricted groundwater availability. In some instances water wells were drilled after houses were built, but no water was found or wells did not produce sufficient domestic water supplies. Some wells once developed for use have gone dry or began to pump sand and were rendered unfit for use. It is not unusual for homeowners in the canyon to need to have two or even three wells drilled before sufficient supplies are located for domestic use.

In addition to restricted water availability in the canyon, there is also a problem with localized areas of poor water quality. Some domestic wells have encountered hydrogen sulfide gases and excessive fluoride. Also, some water supplies are iron-rich and cause severe staining of fixtures and an adverse water taste.

Knowledge of these water availability and quality problems and their most probable locations within areas under development would be useful to a landowner planning to develop property in the canyon and to government agencies overseeing such development. This study examines the possibility that geology can be used to better understand where problem areas are located. The question was assessed through

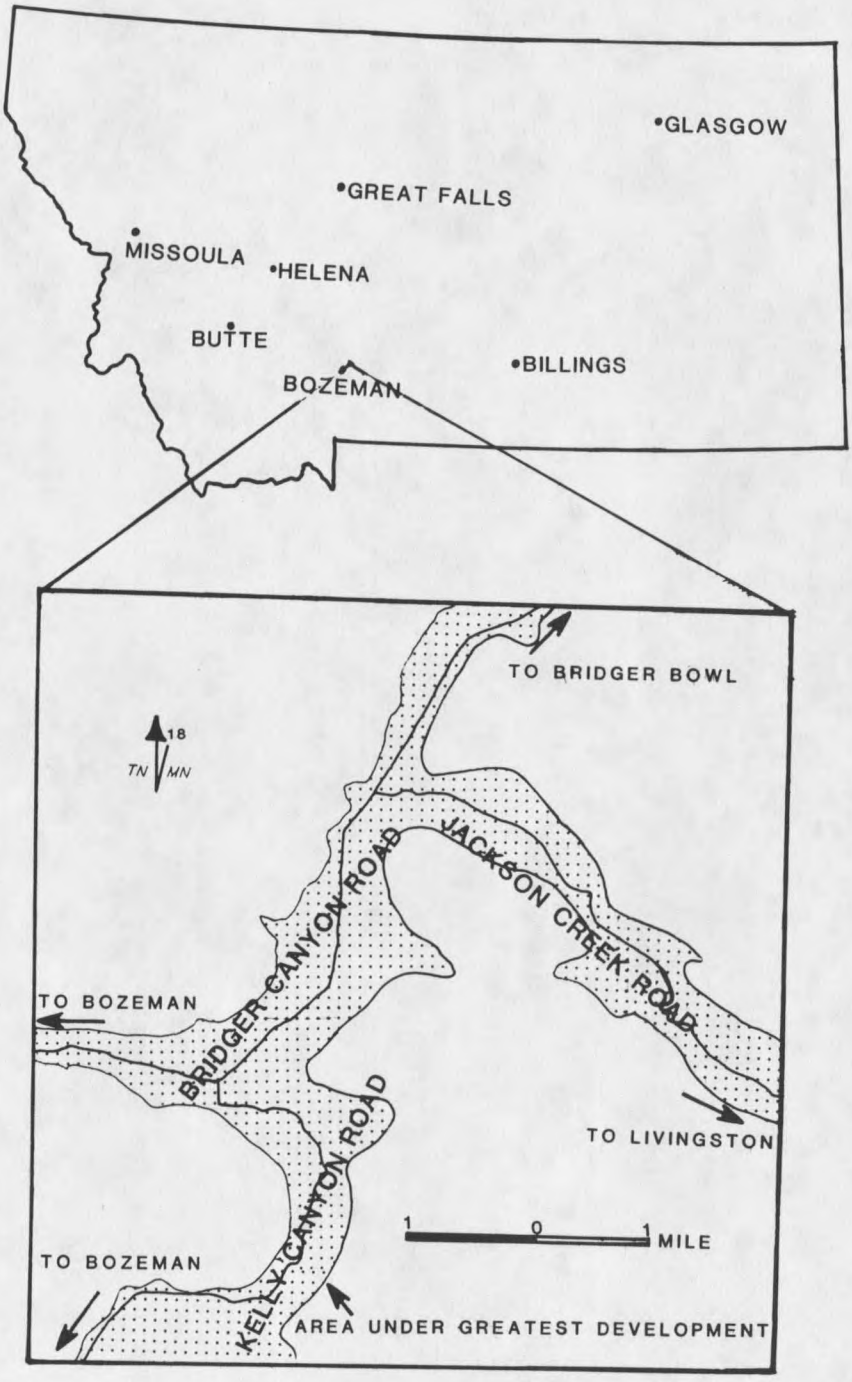


Figure 1. Location of study area indicating area of current development.

evaluation of known water supplies, evaluating the geologic framework in which water is found, and production of a composite water resource map of the area based on this data. Published water studies involving the Bridger Canyon area are scarce. Bridger Creek, which is the main stream in the valley, was included as part of a surface water study for the Gallatin Valley (Hackett and others, 1960) but no groundwater studies have been conducted. A surface water study of Bridger Creek is currently being conducted by the Montana Department of Health and Environmental Sciences Division of the Water Quality Bureau, but no data are as yet published (Montana Department of Health and Environmental Sciences).

General Setting

Geographic Setting

The setting of the study area is important because it establishes the framework in which water is found. Figure 1 shows the area in which people live and are developing homes. The study area boundary was defined on 1982 U.S.G.S. orthophotoquads by enclosing all recognized homes on the photos. At this time (1984) no development is occurring on the steepest slopes on the west side of the valley. These slopes are greater than 15 degrees as measured on topographic maps and are not readily accessible to development.

The study area is located between two National Oceanic and Atmospheric Administration (NOAA) climatological data collection sites. Climate data is collected at the base of the Bridger Bowl Ski area. This station is at an elevation of 5950 feet and records

average annual precipitation of 34.81 inches. Average annual temperatures are 51.4°F maximum, 24.4°F minimum, and 37.9 overall average (National Oceanic and Atmospheric Administration, 1982). Much of the valley is at lower elevations and may experience climate more like that measured at the Montana State University data collection site at Bozeman. This station is at an elevation of 4856 feet and records an average annual precipitation of 18.63 inches. Average annual temperatures are 55.7°F maximum, 31.6°F minimum, and 43.7°F overall average. Elevations of areas within the study area currently under development range from 5040 feet to 6250 feet.

Stratigraphic Setting

Compositional variations within and between the rock units control ground water movement and storage. Table 1 lists the formations found in the study area, their age in chronological order beginning with the oldest unit, composition, and expected water bearing properties estimated from this study. The formations bounding the study area are also listed in Table 1 because development may some day occur on these units. All of these rock units are mapped on the geologic map (Plate 1). The rock descriptions are from Roberts (1964) and McMannis (1955). The oldest unit in the study area is the Cretaceous Telegraph Creek Formation (Ktc). No wells are developed in this formation so specific data are not available. However, the water-bearing characteristics should vary from poor availability and storage in the siltstones to good availability and storage in the sandstones. Above this unit is the Eagle Sandstone (Ke) which is

Table 1. Water availability and general aquifer characteristics.

UNIT NAME	AGE	COMPOSITION	SPECIFIC CAPACITY	WATER-BEARING CHARACTERISTICS
Telegraph Creek Fm.	Upper Cretaceous	siltstone, thin-bedded sandstone	unknown	variable from poor to good
Eagle Sandstone	Upper Cretaceous	sandstone, some siltstone ,some coal	unknown	generally good
LIVINGSTON GROUP				
Cokedale Formation	Upper Cretaceous	siltstone, some sandstone, some claystone, some bentonite, minor coal, minor conglomerate	unknown*	variable from poor to good
Miner Creek Formation	Upper Cretaceous	siltstone, sandstone, some bentonite, lower massive sandstone: Sulphur Flats, Sandstone Member	unknown*	good in Sulphur Flats Member, variable in upper beds
Billman Creek Formation	Upper Cretaceous	alternating olive-green, gray, red to purple shales, very minor sands, some claystone, some freshwater mollusks	0.17 to 5.88	generally very poor

Table 1. (continued)

UNIT NAME	AGE	COMPOSITION	SPECIFIC CAPACITY	WATER-BEARING CHARACTERISTICS
Hoppers Formation	Upper Creataceous	greenish sandstone, claystone, and siltstone, conglomerate beds throughout	unknown*	generally good where thickness is adequate
Fort Union Formation	Paleocene	conglomerate, sandstone, siltstone	unknown	variable, but generally good
Terrace-Alluvium	Quaternary	gravel	unknown*	very poor
Stream-Alluvium	Quaternary	gravel	-6.02 to 6.76	very good
Colluvium	Quaternary	mixed clay, sand, gravel, boulders	unknown*	very poor
Landslides	Quaternary	mixed clay, sand, boulders, rock masses	2.19	variable poor to good in springs and ponds

*Indicates that no wells were completed in these units although some were begun in these. Other unknown specific capacities indicate no known wells completed in these units.

composed of interbedded sandstone and siltstone and should be a good source of water where the sandstones are thickest. There is no data for this unit. The next four formations are grouped together as the Livingston Group. This group of formations comprises the majority of the bedrock currently being developed for groundwater.

The key to understanding the geologic control of water availability in the study area is an understanding of the variations within the rock units. Roberts (1972,p. C36) describes the formations of the Livingston Group as a "thick alternating series of coarse- and fine-grained rocks that are characterized by rapid vertical and lateral variations...(that)...probably were deposited in fluvial channel systems or on associated extensive floodplains, near sea level." The Billman Creek Formation (Kbc) is the most widely developed unit for groundwater due to its location. The stratigraphic setting is illustrated diagrammatically in Figure 2 which shows rapid lateral variations in the rocks formed in such an environment. Notice that in the lower part of the figure the gravel and sand lenses are scattered and if missed by a well, thick sequences of shales will be encountered. Shale thickness can reach nearly 2,500 feet if a drill site is chosen which encounters no sand lenses. Although water can move well through a porous sandstone or conglomerate in the Billman Creek Formation, it cannot move well through a tightly compacted, fine-grained silt or clay between the lenses. Where there are few pore spaces in the fine-grained rock, there cannot be much retrievable water stored. Also, when pore spaces are not well connected water cannot move through the rock. As a result, sandstone lenses found at

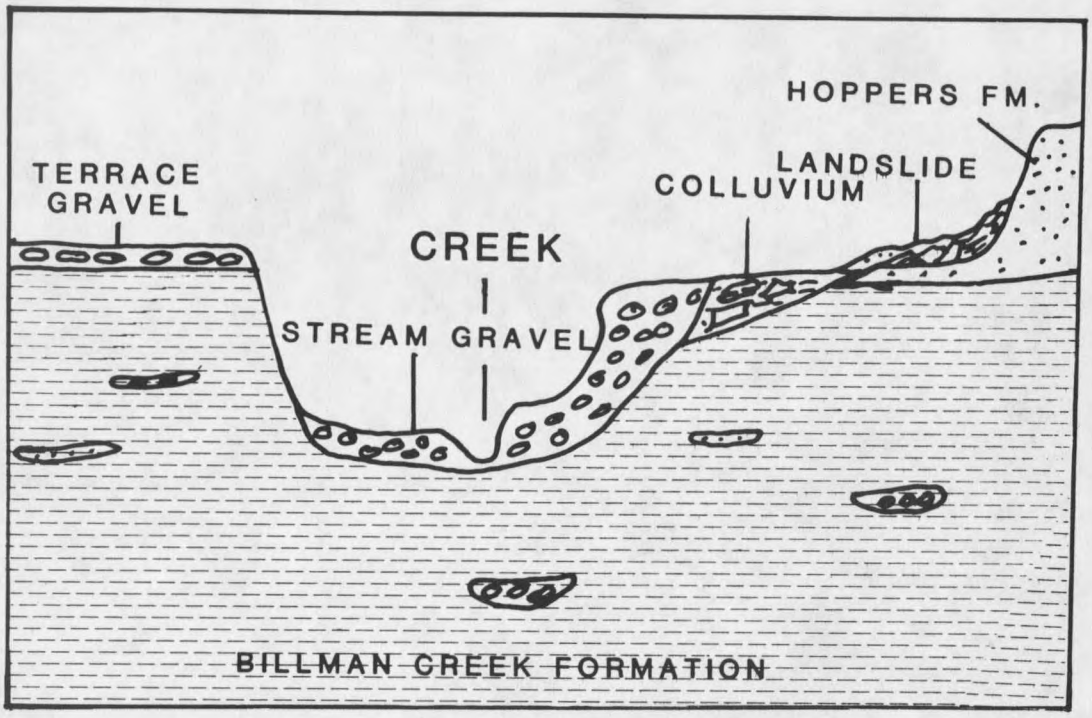


Figure 2. Schematic diagram of the study area showing thick Cretaceous-age Billman Creek Formation dominated by floodplain deposits overlain by Quaternary age sediments.

depth may not be recharged because the sands are isolated from percolating water. There are many areas of poor water availability where the less porous and less permeable zones are encountered.

Below the Billman Creek Formation are the Cokedale Formation (Kc) and the Miner Creek Formation (Km) (Table 1). The Cokedale Formation varies from siltstone and claystone, which should be poor aquifers, to sandstone which should be better. No wells are available in this area to test this hypothesis. Similarly the Miner Creek Formation is much like the Cokedale Formation except for the Sulphur Flats Member (Kms) which is a porous sandstone and should yield water. Both of these lower formations of the Livingston Group lack data for more complete descriptions.

Above the highly variable Billman Creek Formation is the Hoppers Formation (Figure 2). This rock unit should yield much water because it is made up of sandstones and conglomerates which would hold and transmit water. The intermittent claystones and siltstones not shown in Figure 2 should be the only poor water-bearing zones within the formation. The expected water-bearing nature of this rock based on rock type is poorly supported by drill data. The formation should contain much water but does not. When tested in the field, the unit absorbs water poured onto it. The contradiction between the expected and observed natures of the formation is paradoxical. Specific drill data relating to this paradox is discussed later in the text.

The next formation above the Livingston Group is the Fort Union Formation (TKF). No wells in the study area are completed in this

rock unit. However, the conglomerates and sandstones of the formation should be good water-bearing units.

The Cretaceous units are not the only aquifers in the study area. Some quaternary deposits are also aquifers. Quaternary deposits in the study area are either terrace-alluvium, stream-alluvium, colluvium, or landslides (Table 1). These units are shown on the geomorphic map (Plate 2). These deposits are differentiated on the basis of morphology, clast angularity and sorting, and degree of stream development on their surfaces.

Stream-alluvium and terrace-alluvium are both composed of deposits of well-rounded gravel clasts. The stream-alluvium is found on a flat surface at and below present stream level. Terrace-alluvium is found on gently-dipping slopes above the present stream level. As described in Table 1, these gravel deposits should be good water-bearing units, but thickness controls the extent to which this is true. Notice in Figure 2 that where the stream-alluvium is thin (10-20 feet) water quantities may not be adequate for domestic supplies. The same is true for terrace-alluvium which is thin and well-drained. Where stream-alluvium is thicker (20 to 60 feet) water quantities should be sufficient for domestic supplies.

Topographically above the stream-alluvium and on slopes grading into the stream-alluvium is the colluvium. This material occurs on steep slopes and in fan-shaped deposits at the mouths of gullies. Colluvium is debris from the rock units forming the slopes and is angular material which is poorly-sorted. Stream development on colluvial deposits is poor, often consisting of tiny rills but no

discrete channels. No wells are completed in colluvium to establish its water-bearing properties, but because it is usually only a few feet thick it could yield only minor water quantities if any. It is mapped only where found in thickness greater than a few feet.

Landslides are limited to the slopes of Green Mountain. The landslides are lobate features which have moved downhill as a large mass. The upper edges of the landslides are still in motion as indicated by rotated blocks with fresh scarps, scarps with water seeps, rotated fences, and interrupted drainages. Internally drained ponds of varying dimensions formed by land movement are located at the upper parts of rotated blocks within the landslides. Springs are often located at the toes of the landslides where water drains from the landslide mass along the surface of movement. These springs can be developed as sources of domestic water supplies if they are observed to flow consistently year-round.

Structural Setting

The structural setting of the study area is important because it controls the locations and orientations of the rocks in which water is found. The Bridger Range is at the east margin of the disturbed Belt (Woodward, 1981). This margin is a transitional zone where thrust faults and folds merge with basins and uplifts of the Rocky Mountain Foreland. The importance of this transitional zone to water availability is that it mixes the effects of two different types of faults, both thrust faults and normal faults. The older thrust faults in the valley are currently inactive and are unlikely to be

reactivated. However, they may be areas in which rocks are highly broken-up and either enhance water storage and movement because they are coarse and fractured or inhibit water movement and store little water because fault movement broke up material to a fine powder which fills pores and fractures. The thrust faults are not seen at the surface and no wells are known to intersect them so no conclusions can be drawn about their water availability. Younger normal faults in the Bridger Range may be reactivated, but in general are outside the study area. Fold geometry is also important to water availability because folding will change the thickness of rock units with respect to drilling depths. The broad, open folds in the study area differ little from horizontally oriented rock units in that thicknesses are still predictable.

Figure 3 shows the overall structural setting of the Bridger Range. Deformational intensity decreases eastward. As one proceeds from west to east overturned folds become upright and more open and thrust displacement decreases from several miles to less than a mile. The study area is located at the transitional zone and includes both overturned folds and the more upright and open ones. Notice in Figure 3 that in the southeast corner of the map there are fewer faults and folds than to the north and west. Also, in this figure folds to the east of center are less commonly overturned. The more open folds will allow groundwater movement to be less obstructed by structures.

The cross-sections on Plate 1 illustrate this changing orientation of structures. East-west cross-section A-A' is located near the center of the study area. This cross-section shows steeply

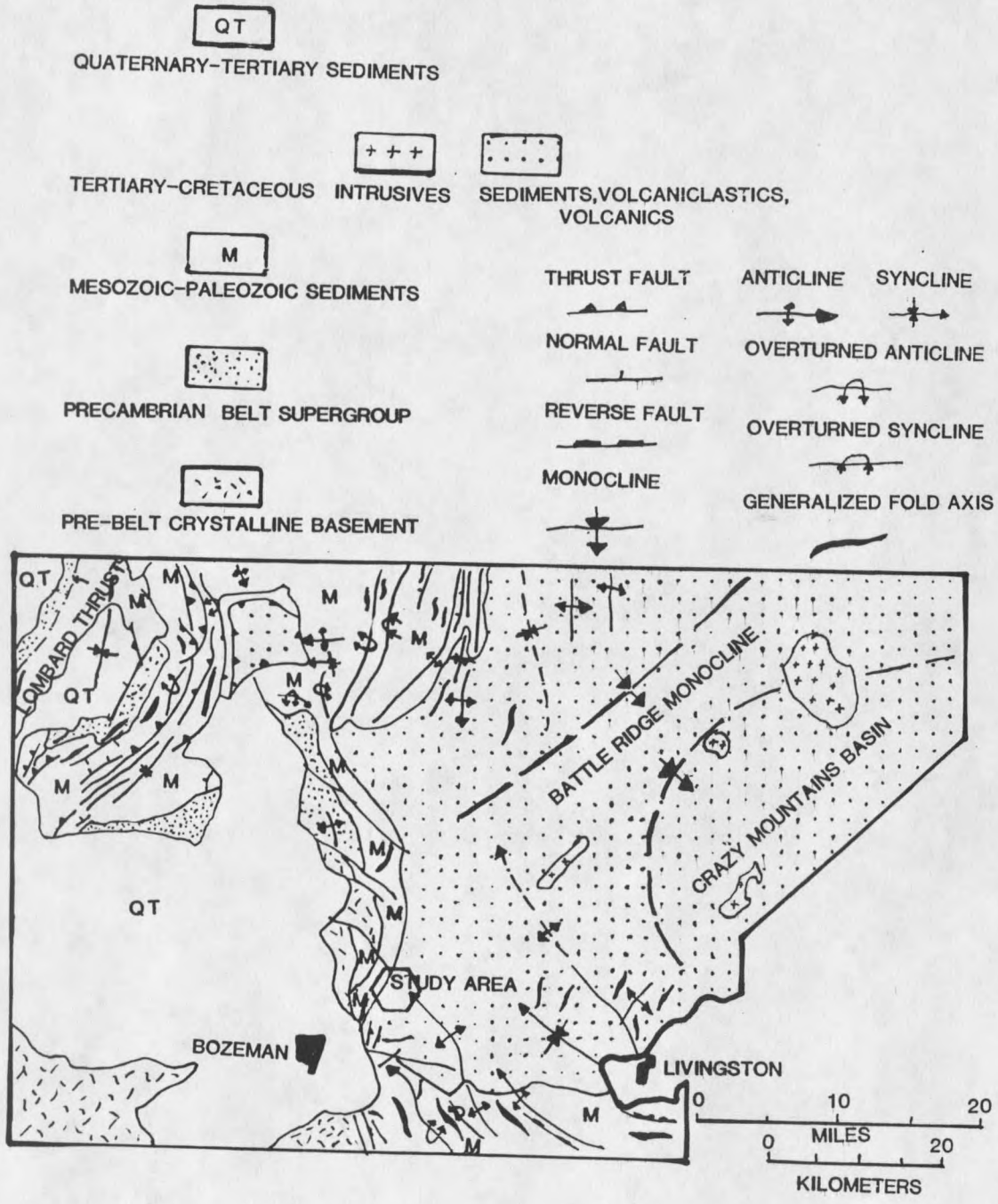


Figure 3. General structural setting of the Bridger Range. (After Woodward, 1981.)

oriented rock units in an overturned limb of an anticline becoming upright, open folds in the Livingston Group to the east with minor offset by a thrust fault. The thrust fault has raised older Cretaceous rocks above younger Cretaceous rocks. This cross-section shows the thick Billman Creek Formation (Kbc) of the Livingston Group gently folded. Resting above the Billman Creek Formation is the Hoppers Formation (Kh), which is a potential aquifer.

Cross-section B-B' crosses the study area from the southwest to the northeast. This cross-section shows the gentle folds within the Billman Creek and Hoppers Formations. Because these units are only mildly deformed, drilling depths in them are nearly the same as if they were horizontal. The absence of overturned folds prevents repetition of rock units or structural zones which might restrict water flow. The absence of faults avoids the possibility of fault-zone restrictions or conduits for flow.

The geologic map (Plate 1) differs from Roberts (1964) in a few details. The Quaternary deposits are not included because they are shown on the geomorphic map (Plate 2). More strikes and dips are added resulting in clarification of fault locations where sudden changes occur. An example of this clarification is seen on the west side of the valley in sections 24 and 25 where rapid changes in dip of the beds suggest a fault may be present. Recent unpublished seismic and gravity data further support the presence of a fault (Lageson and Kelly, 1984). In section 20 along Jackson Creek Road a fault is present in a road cut in the Billman Creek Formation.

METHODS

Field Methods

Domestic and stock wells were inventoried to determine the hydrogeologic properties of the Bridger Canyon aquifers. Plate 3 shows the location of all measured sites within the study area. Where wells are abandoned only their depths are recorded. One well was drilled to be sure water was available on the property, but has never been used, and is included in the abandoned well list. Appendix A explains field methods employed in well measurements in more detail. The most pertinent data include well-logs (Appendix E), water-levels, and specific capacity. Specific capacity is a calculated value obtained by dividing water-flow rate in gallons per minute by the number of feet water level is drawndown with pumping. The value is important because it indicates rate of flow of water into the well from the aquifer. For example, a high flow rate with little drawdown (high specific capacity) indicates fast flow into the well and a good aquifer. A good domestic well with a specific capacity of 10 would allow a homeowner to operate several water-consuming appliances at once. Values smaller than 5 indicate that fewer appliances should be operated at one time. The specific capacity measurements indirectly reflect transmissibilities (Walton, 1970).

In addition to well measurements, springs and ponds were inventoried because they are used as water supplies for both domestic

and stock use and because springs represent groundwater discharge. The ponds are storage areas for water used by people or are used as direct supplies for watering stock. Springs and ponds were located, discharge was measured where possible, and specific conductance was measured. Specific conductance is a measure of electrical conductivity which reflects the amount of dissolved solids in the water. Appendix B explains field methods used in spring and pond measurements in more detail.

One other water source in the study area is streams. Streams were measured because base flow conditions represent groundwater flow and not runoff. Although no known cases of domestic water supplies coming from the main streams were found, a few water supplies come from smaller tributaries in the valley. Where possible, stream discharge and specific conductance were measured. Appendix C describes field methods employed in stream measurement in more detail.

Site Numbering System

The system for numbering wells, springs, ponds, and stream sites is shown in Figure 4. These sites are numbered according to geographic position within the rectangular grid pattern used by the U.S. Bureau of Land Management. All location numbers consist of ten or eleven characters. An example location number is 2S7E06ABCD. The first two characters indicate the township and its position relative to the Montana Base Line. In the example the 2S indicates Township 2 South. The next two characters indicate the range and its position relative to the Montana Principal Meridian. In the example, 7E

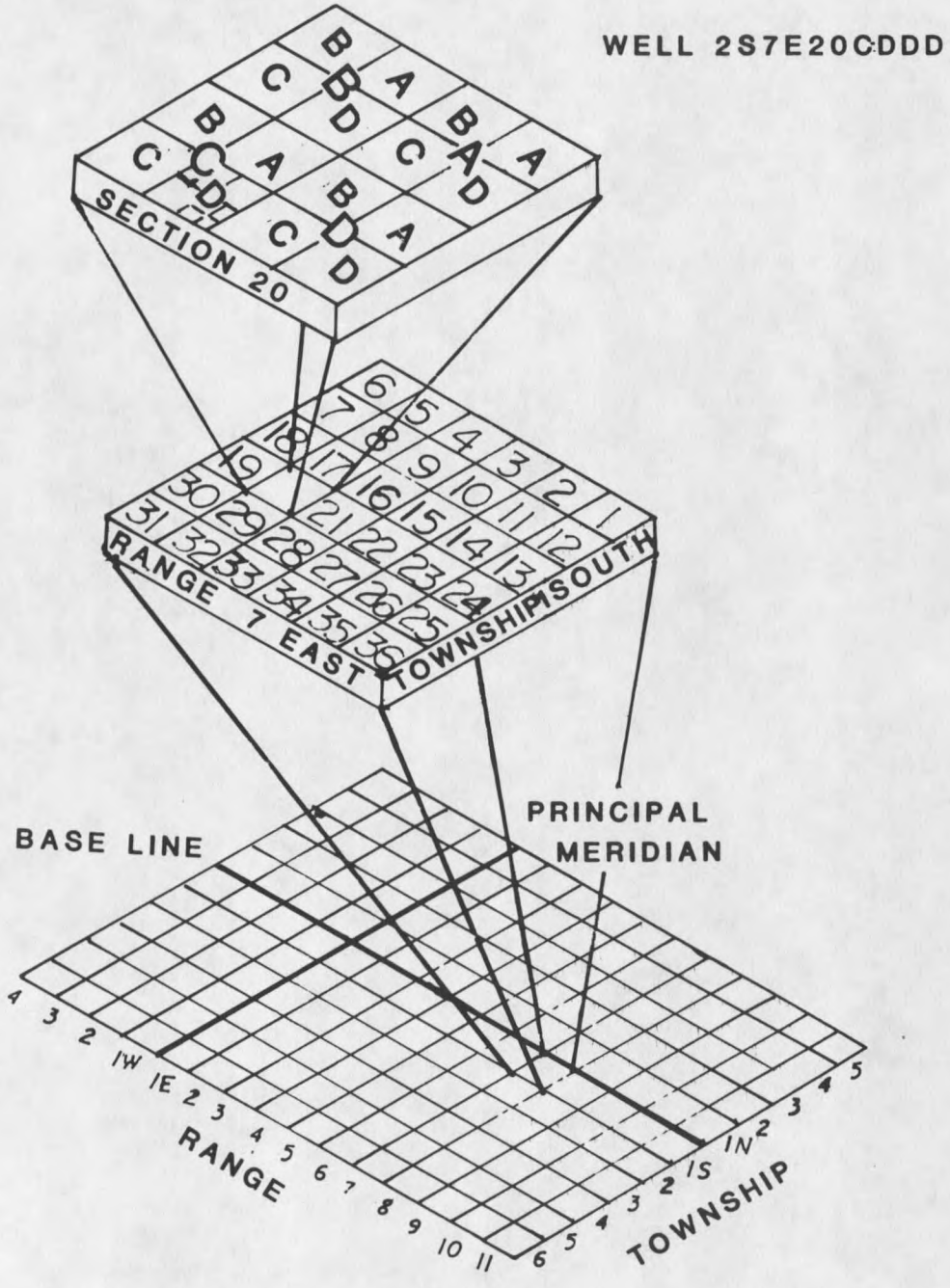


Figure 4. SE 1/4 (D) of SE 1/4 (D) of SE 1/4 (D) of SW 1/4 (C) of SEC 20, T 25, R 7 E. (After Wilke, 1983.)

indicates Range 7 East. The next two characters indicate the section within the township and range indicated. The characters 06 in the example are for Section 6. The last four characters designate the quarter section, the quarter-quarter section, the quarter-quarter-quarter section, and the quarter-quarter-quarter-quarter section. Section subdivisions are labelled A,B,C, or D in a counter-clockwise direction starting in the northeast quarter section. Locations which are in sections not a square mile in area due to surveying irregularities are indicated by an asterisk (*) at the end of the location number. The convention used for location within one of these irregular sections is to superimpose a standard grid over the section with the southeast corner fixed. The result is to change the area along the north and west sides of the section.

Methods of Chemical Analysis

Water quality may restrict development of water supplies. Water samples were collected from fourteen sites for the purpose of determining overall groundwater quality and identifying any possible areas of poor quality. The sites were chosen so as to be randomly scattered throughout the study area, and to sample a variety of lithologic units. Ten sites are wells, two are springs, and two are streams (Plate 3). The method for collecting water samples is described in Appendix D. Water samples were analyzed by the Water Analytic Lab at the Montana Bureau of Mines and Geology using standard techniques (Table 2). Temperature, pH, and specific conductance measurements were also taken in the field (Appendix D). Results of

Table 2. Method of laboratory analysis. Analyses performed by the Montana Bureau of Mines and Geology. Information on analytical methods is from Frank Abercrombie, director of analytical laboratory.

CONSTITUENTS			METHOD
Calcium	Boron	Titanium	Induction-Coupled Argon Plasma, Atomic Emission
Magnesium	Cadmium	Vanadium	
Sodium	Chromium	Zinc	
Potassium	Copper	Zirconium	
Iron	Lithium		
Manganese	Molybdenum		
Silica	Nickel		
Aluminum	Lead		
Silver	Strontium		
Bicarbonate			Potentiometric Titration
Carbonate			
Chloride	Nitrate		Anion Chromatography (Dionex)
Sulfate	Fluoride		
Lab Conductivity			Wheatstone Bridge Conductivity Meter
Lab pH			Glass pH electrode-pH meter
Calculated Dissolved Solids			Computed from cations and anions
Sum of Dissolved Solids			
Total Alkalinity			
Total Hardness			
Sodium Adsorption Ratio			
Piper Plot Percentages			

the analyses are compared to the U.S. Environmental Protection Agency Primary and Secondary drinking water standards established in 1977 and 1979 respectively.

RESULTS AND DISCUSSION

Water Availability

Results

Using the previously described methods, water availability data were collected and evaluated. Difficulties were encountered during some specific capacity tests which made the data difficult to interpret. As a result of these problems in determining specific capacities values should be considered approximate. Appendix F contains graphs of the drawdown and recovery curves from the measured wells. These graphs show the motion of the water level up and down with pumping and after pumping ceased. Sample graphs are shown in Figure 5. Notice that in the upper graph the water level fell with pumping until pumping ceased at the zero point and then rose again. This is the expected pattern. In the lower graph the water level fell with pumping, but began to recover its pre-pumping level before pumping ceased. This pattern is unexpected because the well should drain as long as water is being discharged. The unexpected recovery probably occurred due to the draining of adjacent fractures before draining of the aquifer began. These fractures were formed at the time of drilling and may allow water to run through them into the well at its base. A longer pumping time than the twenty minutes used in this study would likely eliminate the problem, but is impractical when measuring household water supplies because homeowners want to be free

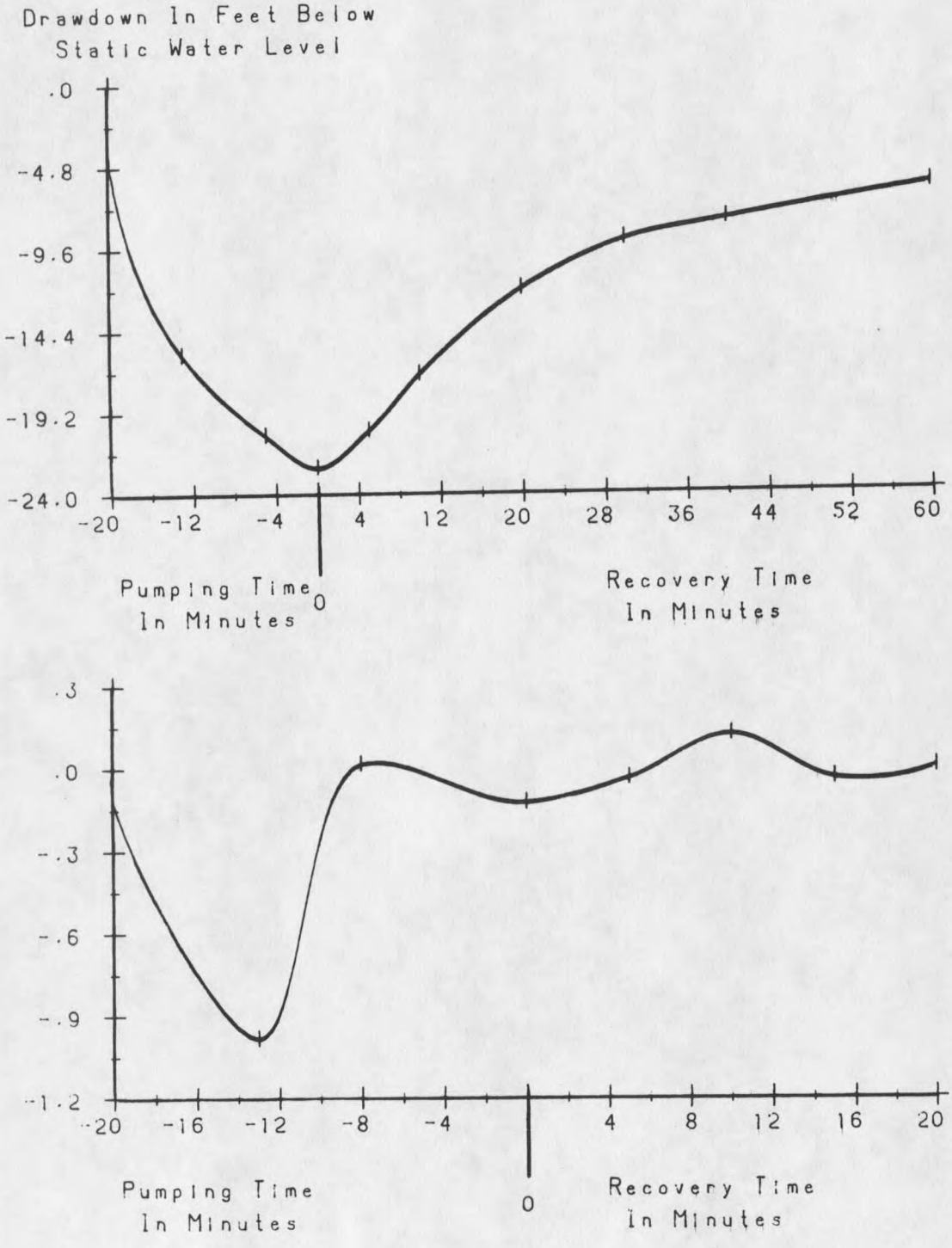


Figure 5. Drawdown and recovery curves showing water level response to pumping.

to use their water at will. Well drillers typically perform specific capacity tests at the time of drilling, but their information cannot be used because they either do not record all the necessary information or are inconsistent in their methods. Specific capacity values are reported here but must be recognized as approximate (Table 3).

Well yield is an important value to know because it reveals how much water can be produced from a well at a given rate. The average yield of wells as measured by drillers and field checked in this study 9 gallons per minute (Table 3). A yield of 15 to 20 gallons per minute is good for a domestic water supply because it allows the homeowner to run most water-consuming appliances at one time. For well yields below the average the use of appliances may need to be spaced to allow water levels to rise in the wells.

All well data which pertain to water availability are found in Table 3 for wells in use and in Table 4 for abandoned wells. Well depths, geologic source of water, static water levels and well yields are included for each well. Considered together, these factors allow one to determine the general water-bearing characteristics of the measured wells.

Discussion

The Billman Creek Formation is the most widely used aquifer because it is the most extensive rock unit in the developed part of the valley. Most homes are built on it because it is where the gentlest slopes are located. The formation is recognized in drillers'

Table 3. Domestic wells measured and in use.

LOCATION	DATE MEASURED (month/day/year)	WELL DEPTH (feet)	GEOLOGIC SOURCE	SPECIFIC CAPACITY** (gpm/feet drawdown)	ELEVATION (feet above sea level)	SWL-(FEET BELOW SURFACE)	YIELD gpm
1S6E25DABD*	8/26/83	74	Qal	0.46	5270	7	10
1S6E35DBBC*	8/20/83	88	Qal	5.10	5040	42	8
1S6C36ADBA*	6/23/83	72	Kbc	—	5170	8	8
1S6E36DCBB*	1/28/84	48	Qal	—	5040	7	-
1S6E36DCDC*	8/12/83	69	Kbc	0.36	5160	11	8
1S7E17AAAD*	8/18/83	107	Kbc,Qal	0.43	5540	29	5
1S7E17AACD*	8/29/83	54	Kbc,Qal	2.89	5410	31	6
1S7E17AACD*	8/25/83	200	Kbc	4.55	5440	25	5
1S7E17ADBA*	8/24/83	65	Kbc	3.88	5420	32	7
1S7E17ADBB*	8/26/83	153	Kbc	0.57	5430	31	7
1S7E17BDBD*	8/20/83	90	Kbc,Qal	0.85	5360	13	9
1S7E17BDDD*	8/18/83	81	Kbc,Qal	0.35	5270	9	5
1S7E17CACC*	6/25/83	48	Kbc,Qal	--	5330	11	8
1S7E17CBBD*	8/24/83	120	Kbc	4.17	5380	82	5
1S7E17CCBA*	8/24/83	85	Kbc	1.27	5320	40	21
1S7E17CCDA*	6/25/83	40	Kbc,Qal	6.76	5260	3	8
1S7E20BBCD*	8/18/83	39	Kbc,Qal	3.57	5220	4	5
1S7E20CABB*	8/29/83	55	Kbc,Qal	5.88	5300	21	5
1S7E21CBCB*	8/16/83	200	Kbc,Kh	0.27	5530	108	13
1S7E28ADBC*	1/28/84	148	Kbc,Qal	0.42	5640	25	12
1S7E29DCCA*	6/25/83	45	Qls	2.19	5500	18	8
1S7E30BAAA*	6/24/83	68	Kbc,Km	—	5240	55	8
1S7E30BADD*	6/24/83	65	Kbc	—	5220	8	-
1S7E30BCDA*	10/8/83	125	Kbc	—	5260	53	-
1S7E30CADD*	8/24/83	71	Qal	0.50	5180	6	10
1S7E30CDAB*	8/16/83	52	Qal	0.86	5190	9	5
1S7E30DAAA*	8/24/83	65	Kbc,Qal	0.45***	5190	8	10

Table 3. (continued)

LOCATION	DATE MEASURED (month/day/year)	WELL DEPTH (feet)	GEOLOGIC SOURCE	SPECIFIC CAPACITY** (gpm/feet drawdown)	ELEVATION (feet above sea level)	SWL-(FEET BELOW SURFACE)	YIELD gpm
1S7E30DDCB*	8/19/83	49	Kbc,Qal	-6.02	5160	34	8
1S7E31CADA*	8/12/83	290	Kbc,Kh	0.70	5275	96	10
1S7E31CDBA*	8/23/83	142	Kbc,Kh	--	5210	53	4
1S7E31CDCC*	8/11/83	250	Kbc,Kh	0.28	5150	64	7
1S7E31DBAC*	8/12/83	135	Kbc,Kh	0.85	5360	78	15
1S7E31DCBC*	6/24/83	110	Kbc,Kh	—	5320	54	-
1S7E31DDCD*	8/12/83	179	Kbc,Kh	0.10	5600	100	7
1S7E33AABA*	8/16/83	72	Kbc	1.62	5720	27	9
1S7E33AACB*	8/16/83	180	Kbc	0.46	5780	40	7
1S7E33CAAB*	8/19/83	265	Kbc,Kh	0.15	6150	84	13
1S7E33CDAD*	8/19/83	41	Kbc	1.98	6250	23	5
1S7E34BBBD*	11/4/83	80	Kbc,Kh	0.21	5700	11	10
1S7E34BBBD*	8/19/83	82	Kbc,Kh	1.41	5720	58	8
2S6E01ABBB	6/27/83	122	Kbc	—	5130	40	12
2S7E06AADC	8/10/83	488	Kbc,Kh	--	6170	298	-
2S7E06ABDA	8/10/83	250	Kbc,Kh	7.50	5500	68	4
2S7E06ACDB	8/15/83	196	Kbc,Kh	0.22	5580	120	20
2S7E06BBAB	8/12/83	74	Kbc	0.17	5210	26	10
2S7E06BCAD	8/21/83	97	Kbc,Qal	0.68	5270	42	7
2S7E06BCBC	6/27/83	299	Kbc	0.19	5320	158	5
2S7E06CCDC	8/15/83	80	Kbc	1.18	5320	27	12
2S7E06CDAB	8/30/83	490	Kbc	0.20	5400	139	10
2S7E12CCBD	8/09/83	400	Kbc,Kh	--	5100	47	10
Average		134		1.48	—	-48	9
Standard Deviation (σ_{n-1})		108		2.35	—	51	4

*means area of section is not equal to one square mile
**means specific capacity calculated from maximum drawdown
***indicates wells which did not drawdown with pumping when negative

Table 4. Domestic wells abandoned

LOCATION	DATE MEASURED (month/day/year)	WELL DEPTH (feet)
1S7E1&CCBA*	8/24/83	72
1S7E20ADBB*	6/23/83	46
1S7E30DDDB*	8/31/83	210
1S7E30DDDB*	8/19/83	162
1S7E06BCBC	8/21/83	230
1S7E12CEEB$	8/09/83	133

*means area of section is not equal to one square mile
$well never developed for use

well-logs by the varying green, gray, red, and purple shales. In the Billman Creek Formation, which reaches 2500 feet in thickness, wells range in depth from 55 to 490 feet. Specific capacities range from 0.17 to 5.88 gallons per minute per foot drawdown and suggest very low transmissibilities (Walton, 1970). The mean specific capacity for all wells measured is 1.48 gpm/foot drawdown with a standard deviation of 2.35 gpm/foot drawdown. The Billman Creek mean value is 1.42 gpm/foot drawdown with a standard deviation of 2.42 gpm/foot drawdown. Eighty-eight percent of all wells measured are completed in the Billman Creek Formation.

Five wells were abandoned in this formation due to lack of adequate water supply or the influx of "sand" into the well. The "sand" influx most probably comes from loose sand lenses within the formation or less likely from the breakdown of small shale chips. No specific descriptions of the sands are available. Much of the sand influx might be eliminated with screens and good well development. Screens would act as filters keeping out sand-sized particles and

packing around the well would keep water from running down the outside of the casing and effectively eroding the rocks surrounding it.

The water availability of an aquifer or the location of water-bearing zones within it is reflected in the water levels. The water levels within the Billman Creek Formation are largely controlled by sand lenses or stringers, and fractures. Because the sand bodies and fractures are discontinuous, their extent and interconnection is unpredictable. Because in localized areas the water level follows general trends of topography the water-bearing zones appear to be inter-connected. In some locations at the highest elevations it is deeper to water than it is at lower elevations. For example, the wells at 1S7E33AABA* and 1S7E33AACB* are both completed in the Billman Creek Formation, were measured on the same day, and are 60 feet different in elevation (Table 3). The well at the higher elevation (5780 feet) is 180 feet deep with static water level at 40 feet, while the well at the lower elevation (5720 feet) is only 72 feet deep with static water level at 27 feet. Because the shales and sands of this formation vary rapidly both vertically and laterally, and the unit is dominantly shale, prediction of water availability at any specific location is nearly impossible because no true water table exists.

The Hoppers Formation rests on top of the Billman Creek Formation and, as seen on well-logs, wells begun in the Hoppers usually cross the contact with the Billman Creek before sufficient water supplies are reached. The contact between the two formations is clearly seen on drillers' well-logs by the appearance of the red or purple shales of the Billman Creek Formation. Wells begun in the Hoppers Formation

are usually completed in the Billman Creek Formation. Depths range from 80 to 488 feet. The average depth of such wells is 220 feet with a standard deviation of 122 feet. Throughout the study area the thickness of the Hoppers ranges from zero to 1500 feet based on cross-sections.

The water-bearing properties of the Hoppers Formation should be good due to the high porosity of most of the unit. If enough thickness of Hoppers Formation could be drilled for water, sufficient supplies might be found. To reach water, drilling depths of the order of 300 feet may be necessary based on known well depths passing through the Hoppers Formation to reach water. An estimated 300 feet drilling depth to water is very deep for a unit expected to be a good aquifer. As discussed earlier, this is a paradox. At the surface, the unit absorbs water readily, but at depth this does not appear to be the case. Examination of the well-logs (Appendix E) shows that water may be found at shallower depths, but at flows of 2 to 3 gpm which is not sufficient for domestic water supplies. A greater thickness of this unit may store more water. However, if at depth the rock unit is highly cemented or if siltstone or mudstone layers prevent recharge of the unit, there may not be enough water available for domestic use.

The slopes of Green Mountain contain many springs flowing directly from the Hoppers Formation. This spring water is draining from the base of the landslides where a shear layer prevents it from infiltrating into the undisturbed Hoppers Formation substrate. Also, springs are found within the landslides at the scarps, and where the

Hoppers is in contact with the Billman Creek Formation in the Kelly Canyon Road area in Section 6 of Township 2 South, Range 7 east. These springs could be developed for domestic or stock water supplies where they flow adequately all year. Where the springs are flowing due to recharge by surface water the potential exists for contamination.

The third source of water in the study area is stream-alluvium. Alluvium depths are determined from drillers' well-logs by the presence of gravel. At the northern end of the study area the alluvium ranges from 10 to 40 feet in depth and yields adequate water for homes spaced at intervals of 0.1 to 0.25 miles. At the southern end of the study area the alluvium thickens to about 60 feet and is also an adequate water supply for domestic use because the alluvium is thicker homes could be built closer together here to a density matching that of the northern end of the valley, if zoning permitted it. Stream-alluvium contains the most easily accessible water supplies with specific capacities from -6.02 to 6.76 with an average 1.54 gpm/foot drawdown. The negative value of specific capacity indicates that no water level drawdown occurred with pumping of the well. this is a very good well. If specific capacities are low positive values (10 gpm/foot), or less transmissibilities and permeabilities are also low. High positive values (10 to 1000 gpm/foot) suggest higher transmissibilities and permeabilities. Most measured wells in the study area have low specific capacities.

The person or government agency considering ground-water development in the study area for domestic or stock use should

consider all water availability factors. Plate 4 is a composite map taking into account the stratigraphy, the geomorphology, and the known water availability factors such as well depths, static water levels, elevation, topography, springs and ponds, and water-quality. The water quality portion of this map is discussed below. The map was made by overlaying maps of individual factors to create the composite picture. Boundaries are not absolute, but rather reflect the intersections of at least two factors. The water availability factors on the map are divided into five categories designated A, B, C, D, or E. While each letter represents an estimated maximum drilling depth it should be recognized that the depth estimate is based on known drilling in the area and that some deeper or shallower water may be encountered. Areas which are designated as having water which is category A should yield adequate domestic water supplies from a single drilled well at depths less than 100 feet. Category B should require drilling depths less than 199 feet. A well drilled in category C may need to be as deep as 399 feet. The deepest known wells are in category D where wells over 400 feet have been required. Category E is reserved for areas in which known abandoned wells are located. These areas do not necessarily represent locations of deepest wells. There may also be other areas where abandoned wells may occur.

Summary of Water Availability

Water availability in the study area is dependent upon the lithologies of the rock units. Variations within the units cause variations in water-yielding characteristics of the rocks. Water is

found in the Billman Creek Formation with variable success. The Hoppers Formation is expected to be a potentially good water-yielding unit, but drilling data contradict the expectation for unknown reasons. Wells drilled in the Hoppers Formation yield very little water. This may be due to cementation of the rock or siltstone zones preventing recharge and transmission of water. The Quaternary stream-alluvium deposits are the best sources of water. In general, however, the thin alluvium in the northern end of the study area, especially north of Jackson Creek Road, is not sufficiently thick to be a good aquifer. All other units within the study area are not developed so information on their water-yielding characteristics is not well defined. A lack of correlation between elevation and depth (r=0.6039) to water supports the hypothesis that no true water table exists throughout the valley. Rather, water availability is controlled by occurrence of water-bearing lithologies.

The general water availability scheme is summarized by the diagrammatic cross-section in Figure 6. Well site A would be a poor availability site because the gravel veneer on the terrace is so thin (10 feet or less) that it drains readily and remains dry. Well site B would be a poor availability site because the stream alluvium is very thin (less than 20 feet) and may not contain enough water for domestic use. The alluvium is thicker at well site C and may contain enough water to be a good availability site without extending into the Billman Creek Formation. At well site D the alluvium thickness is the same as C, but would likely drain its water to site C. At well site E the surface deposit is colluvium which is too thin to supply adequate

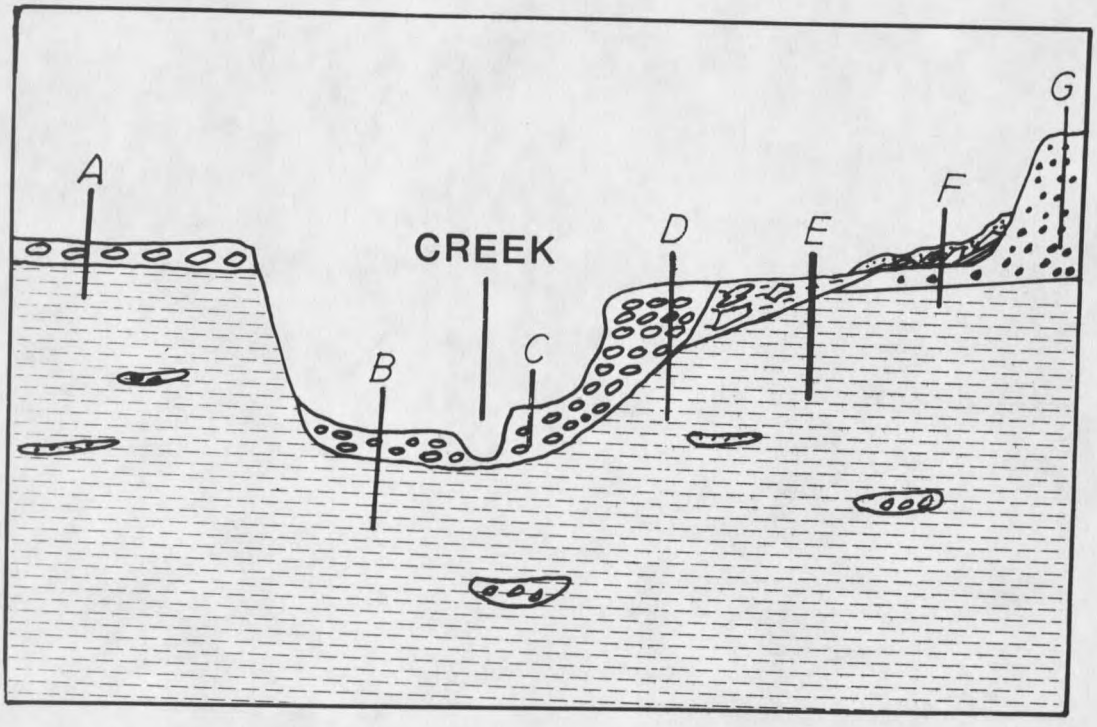


Figure 6. Schematic diagram of thick floodplain deposits of the Livingston Group in their setting at Bridger Canyon. Possible well sites are indicated at locations A to G and are discussed in the text in the water availability section. The thickest unit with gravel or sand lenses represents the Billman Creek Formation. The sandy unit at G represents the Hoppers Formation, but actually contains fine-grained zones not shown . Above the Hoppers Formation at F is a landslide. Well site E encounters thin colluvium at the surface. Well sites A to D encounter alluvium at the surface. Well site G is in thick Hoppers Formation and should encounter good water supplies.

water. The landslide at site F would prohibit building at this location for safety reasons. Development at site G is potentially good for water availability if fine-grained zones are not encountered. At any of the locations where wells pass into the Billman Creek shales, water availability may be poor unless a good channel is encountered close to the surface.

Water Quality

Introduction

When developing water supplies for domestic or stock use, water availability is only part of the consideration. Water quality is as important because large volumes of water which contain problematic chemicals can constrain water use. Water quality is discussed here in the following categories: calculated values, pollutants without standards, and pollutants with standards. Table 5 lists the location of sampled sites, the date samples were collected, the type of water source, well depth where applicable, and the major aquifer complete, original analyses are found in Appendix G.

The chemistry of water strongly influences how it can be used. The U.S. Environmental Protection Agency (EPA) has set standards for drinking water (U.S. Environmental Protection Agency, 1977, 1979). Because most water is used for human consumption, these standards provide a method of evaluating water chemistry in the study area. Different standards exist for irrigation and stock water. A summary of these standards can be found in Freeze and Cherry (1979).

There is considerable confusion in the literature regarding the use of the words contaminant and pollutant. The U.S. Environmental Protection Agency defines a contaminant as "any physical, chemical, biological, or radiological substance or matter in water" (1977). Because this definition suggests that all but deionized water is contaminated, other definitions are more practical. Fetter (1980) defines a contaminant as any solute that enters the hydrologic cycle through human action. Pollution is a contaminant that renders the water objectionable or unfit for use. In the study area, humans are not known to be introducing chemicals into the system. Most ionic constituents are present naturally. For this reason the words pollution or contaminant will not be used and the water quality will be referred to the standards developed by the U.S. Environmental

Table 5. Water Chemistry. Location of sampled sites.

LOCATION	DATE MEASURED (month/day/year)	WELL DEPTH (feet)	MAJOR AQUIFER
1S6E36ADBA*	6/23/83	72	Kbc
1S6E36CDDA*	6/38/82	stream	---
1S7E17CACC*	6/25/83	48	Qal/Kbc
1S7E17CCDA*	6/25/83	40	Qal/Kbc
1S7E29CBDD*	6/25/83	spring	Kh
1S7E29CDDA*	6/25/83	45	Qal
1S7E30BAAA*	6/24/83	68	Kbc
1S7E30BADD*	6/24/83	65	Kbc
1S7E30DABA*	6/28/83	stream	---
1S7E31DCBC*	6/24/83	110	Kbc
1S7E31CDBA*	6/23/84	142	Kbc
2S6E01ABBB	6/27/83	112	Kbc
2S7E06ABBB	6/24/83	spring	Kh
2S7E06BCBC	6/27/83	299	Kbc

*means area of section is not equal to one square mile

Protection Agency for contaminants. Throughout the rest of this paper the word standard will be used.

Calculated Water Quality Parameters

Total Dissolved Solids. The value for total dissolved solids is usually determined as the weight of the solid residue for a filtered sample after evaporation of the water. Not included in this expression are amounts of dissolved gasses, suspended sediments, and colloids. Highly mineralized water may deteriorate plumbing and appliances, and cause adverse taste effects. The U.S. Environmental Protection Agency standard for total dissolved solids is 500 milligrams per liter (mg/l). Laboratory tested waters in the study area range from 144 to 690 mg/l (Table 6). Another method of estimating total dissolved solids is to calculate it from the specific conductance as discussed below.

The specific conductance of the water is a general indication of the total dissolved solids in the water (Freeze and Cherry, 1979). Normally the relationship between total dissolved solids and specific conductance can be written as an equation, but the equation varies from region to region. The actual relationship for sampled waters is in Bridger Canyon dissolved solids equals 0.94 (lab specific conductance) minus 11, (r=.997). The values resulting from the equation range from 153 to 891 mg/l for wells, 158 to 468 mg/l for streams, 181 to 610 mg/l for springs, and 242 to 571 mg/l for ponds. Two wells, one spring, and one pond have values exceeding the standard. Dissolved solids vary linearly with bicarbonate content

Table 6. Chemical constituents in sampled waters represented as calculated values.

SAMPLE NUMBER	LOCATION	DISSOLVED SOLIDS-SUM OF CONSTITUENTS mg/1	ALKALINITY mg/1	HARDNESS TOTAL AS $CaCO_3$
1	1S6E36ADBA*	288.70	151.08	148.82
2	1S6E36CDDA*	282.46	164.67	163.35
3	1S7E17CAAC*	403.93	230.14	223.38
4	1S7E17CCDA*	455.18	263.27	250.68
5	1S7E29CBDD*	610.43	337.91	292.27
6	1S7E29DCCA*	690.27	383.20	309.01
7	1S7E30BAAA*	414.32	192.90	215.17
8	1S7E30BADD*	478.08	229.73	245.24
9	1S7E30DABA*	305.90	175.11	167.74
10	1S7E31DCBC*	272.88	140.25	129.41
11	1S7E31CDBA*	308.45	148.12	60.14
12	2S6E01ABBB	333.16	173.71	38.43
13	2S7E06ABBB	426.77	235.72	211.49
14	2S7E06BCBC	144.82	71.06	8.74

*means area of section is not equal to one square mile

(total dissolved solids = 1.38 (bicarbonate) + 41) with a correlation coefficient of 0.97 for laboratory tested samples. This relationship is expected with the weathering of volcaniclastic rocks such as those in the Livingston group because as the rocks weather the bicarbonate ion and cations are released into solution in the water resulting in increased total dissolved solids (Berner, 1971).

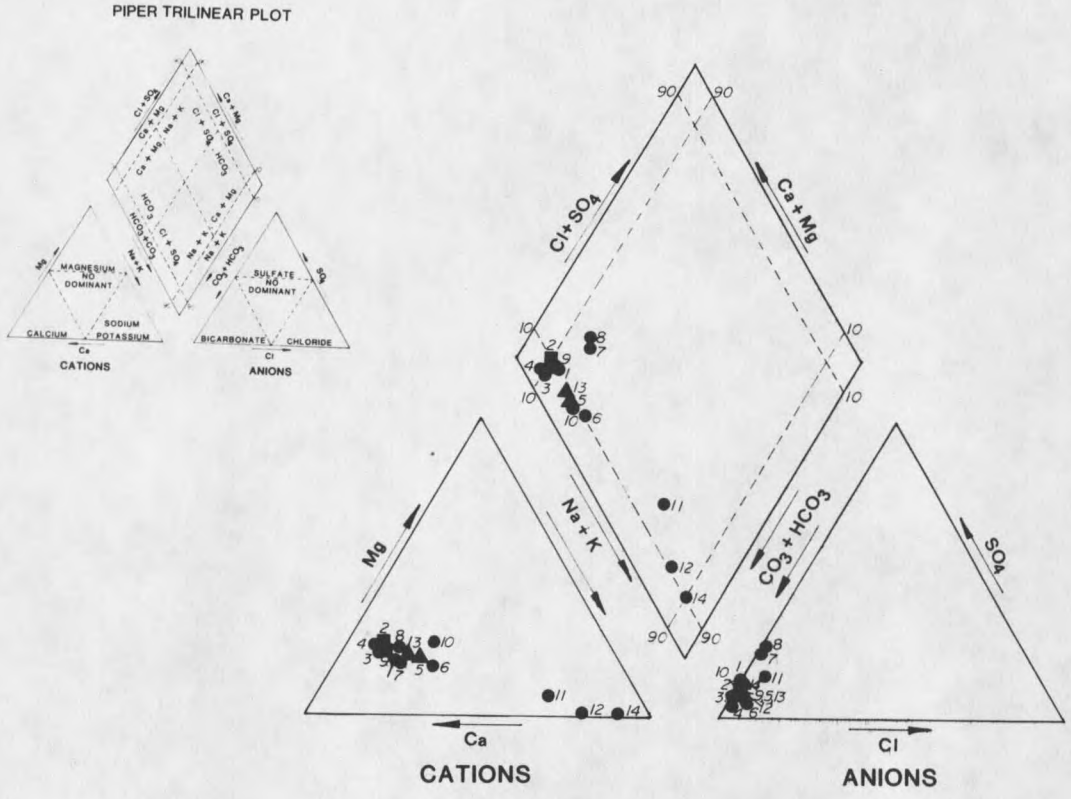
Total Alkalinity. The U.S. Environmental Protection Agency defines alkalinity as the "sum total of components in water that tend to elevate the pH of the water above a value of about 4.5". Substances in natural waters that increase alkalinity are carbonates, bicarbonates, phosphates, hydroxides, and some cations such as calcium, sodium, and barium. The U.S. Environmental Protection Agency

drinking water standard is 20 mg/l expressed as $CaCO_3$. The measure is an indication of the buffering capacity of the water. In freshwater systems aquatic life requires 20 mg/l or more alkalinity. The U.S. Environmental Protection Agency (1979) reports that values lower than 400 mg/l expressed as $CaCO_3$ are not considered a problem to human health. Alkalinity of sampled waters range from 71 to 383 mg/l (Table 6). These values do not present any health problems.

Total Hardness. Water hardness is a measure of the concentrations of polyvalent metallic ions dissolved in the water. It is reported as equivalent concentration of calcium carbonate ($CaCO_3$). Waters are typically classed as soft (0 to 75 mg/l $CaCO_3$), to very hard (300 or more mg/l $CaCO_3$). These terms refer to soap requirements for lather formation and to the potential for hot water systems to develop scale formation in hot water heaters and boilers. Sampled waters range in hardness from 8.74 to 309 mg/l $CaCO_3$ (Table 6). The values in the study area represent all hardness types from soft to very hard. A water softener is recommended for domestic water supplies with hard water that leaves scale on appliances. Only when scale is visible on appliances is this necessary. Water softeners may also benefit water which is causing problems with soap during washing.

Piper Trilinear Plot.

The Piper (1944) trilinear plot is a graphical method of depicting water quality. Figure 7 is a plot of the water sampled in the study area. Readers unfamiliar with reading such diagrams are referred to Fetter (1980, page 336). The inset in the upper left



SAMPLE NUMBER	LOCATION	GEOLOGIC SOURCE	DEPTH
1	1S6E36ADBA*	Kbc	72
2	1S6E36CDDA*	stream site	--
3	1S7E17CACC*	Kbc, Qal	48
4	1S7E17CCDA*	Kbc, Qal	40
5	1S7E29CBDD*	Kh, spring site	--
6	1S7E29DCCA*	Qls	45
7	1S7E30BAAA*	Kbc, Km	68
8	1S7E30BADD*	Kbc	65
9	1S7E30DABA*	stream site	--
10	1S7E31DCBC*	Kbc, Kh	110
11	1S7E31CDBA*	Kbc, Kh	142
12	2S6E01ABBB	Kbc	122
13	2S7E06ABBB	Kh, spring site	--
14	2S7E06BCBC	Kbc	299

● well site
▲ spring site
■ stream site

Figure 7. Chemical characteristics of ground and surface water. Percentages are in milliequivalents per liter.

corner shows the classification of water types by plotted location on the diagram. Three points (11, 12, and 14) are sodium-potassium water types. The remaining eleven points are calcium carbonate waters.

The overall volcanic mineral content of Livingston Group rocks provides numerous sources for mineral dissolution to supply cations and anions through oxidation and reduction reactions. As groundwater reacts with minerals in the rocks such as pyrite and the zeolite minerals some SO_4 is produced (Roberts, 1972, p. 46-48), calcium and sodium are released as cations. As the system is leached through groundwater movement, calcium dominates over sodium. Where the sodium is higher, zones of less leaching are indicated. Points higher in sodium on the Piper trilinear plot are also high in H_2S, a product of sulfate reduction.

Measured Water Quality Parameters

Introduction. Water quality is also dependent upon ionic composition, factors influencing the activity of ions in water such as temperature, and factors affecting the esthetic qualities of water. Esthetic qualities include taste and temperature. Considered together these parameters characterize the chemical quality of the water in the study area. Most measured water quality parameters in the study area do not exceed the U.S. Environmental Protection Agency (EPA) standards. Parameters below the (EPA) standards are considered safe and are listed in Tables 7 and 8. Other parameters exceed EPA standards and are discussed. The U.S. Environmental Protection Agency has not established standards for every possible constituent or

Table 7. Chemical constituents of sampled waters not exceeding standards (E.P.A. Standard is in parenthesis).

SAMPLE NUMBER	LOCATION	SOURCE mg/l	CALCIUM mg/l	MAGNESIUM mg/l	SODIUM	SAR	POTASSIUM mg/l	BICARBONATE mg/l
1	1S6E36ADBA*	well	44.6	9.1	11.9	0.42	.5	184.2
2	1S6E36CDDA*	stream	49.1	9.9	7.7	0.26	.8	190.0
3	1S7E17CAAC*	well	67.7	13.2	11.5	0.33	.5	280.6
4	1S7E17CCDA*	well	75.5	15.1	10.0	0.27	.3	321.0
5	1S7E29CBDD*	spring	88.2	17.5	42.5	1.08	.3	412.0
6	1S7E29DCCA*	well	95.4	17.2	55.1	1.36	.1	466.0
7	1S7E30BAAA*	well	68.7	10.6	22.6	0.67	.1	235.2
8	1S7E30BADD*	well	78.6	11.9	27.2	0.77	.5	280.1
9	1S7E30DABA*	stream	50.2	10.3	8.9	0.30	.5	213.5
10	1S7E31DCBC*	well	36.0	9.6	20.0	0.77	.1	171.0
11	1S7E31CDBA*	well	19.8	2.6	57.4	3.22	.1	180.6
12	2S6E01ABBB	well	14.4	.6	70.4	4.94	.1	211.8
13	2S7E06ABBB	spring	63.6	12.8	22.6	0.68	.5	287.4
14	2S7E06BCBC	well	3.5	.1	36.3	—	.1	72.0

*means area of section is not equal to one square mile

SAMPLE NUMBER	LOCATION	CARBONATE mg/l	MANGANESE mg/l (50)	SULFATE mg/l	CHLORIDE mg/l (250)	SILICA mg/l
1	1S6E36ADBA*	.0	.001	17.8	.7	18.0
2	1S6E36CDDA*	5.3	.015	9.8	.6	8.8
3	1S7E17CAAC*	.0	.20	14.1	1.6	10.1
4	1S7E17CCDA*	.0	.079	13.4	2.6	10.7
5	1S7E29CBDD*	.0	.001	28.2	4.9	16.0
6	1S7E29DCCA*	.0	.009	26.0	16.6	12.3
7	1S7E30BAAA*	.0	.001	56.1	2.2	17.7
8	1S7E30BADD*	.0	.001	57.9	4.0	15.7
9	1S7E30DABA*	.0	.013	12.0	.9	9.2
10	1S7E31DCBC*	.0	.009	11.3	.6	22.5
11	1S7E31CDBA*	.0	.24	22.6	8.3	12.1
12	2S6E01ABBB	.0	.005	17.8	3.8	12.3
13	2S7E06ABBB	.0	.001	16.3	1.9	21.1
14	2S7E06BCBC	7.2	.004	7.0	1.7	13.0

*means area of section is not equal to one square mile

Table 8. Chemical constituents of sampled waters not exceeding standards (E.P.A.) Standard).

SAMPLE NUMBER	LOCATION	ALUMINUM ug/l	SILVER ug/l (50)	MOLYBDENUM ug/l	NICKEL ug/l	TITANIUM ug/l	VANDIUM ug/l	ZIRCONIUM ug/l
1	1S6E36ADBA*	30	2	20	10	1	1	4
2	1S6E36CDDA*	160	2	20	10	5	1	4
3	1S7E17CAAC*	50	5	20	10	10	11	12
4	1S7E17CCDA*	30	2	20	10	6	1	4
5	1S7E29CBDD*	30	2	20	10	9	1	4
6	1S7E29DCCA*	30	2	20	10	10	10	4
7	1S7E30BAAA*	2	2	20	10	3	1	4
8	1S7E30BADD*	30	2	20	10	5	1	4
9	1S7E30DABA*	380	23	20	20	18	24	28
10	1S7E31DCBC*	50	2	20	10	1	8	4
11	1S7E31CDBA*	30	2	20	10	1	1	4
12	2S6E01ABBB	70	2	20	10	1	1	4
13	2S7E06ABBB	30	2	20	10	4	6	4
14	2S7E06BCBC	30	2	20	10	1	3	4

*means area of section is not equal to one square mile

SAMPLE NUMBER	LOCATION	CADMIUM ug/l (10)	CHROMIUM ug/l (50)	COPPER ug/l (100)	LEAD ug/l (50)	LITHIUM ug/l	STRONTIUM ug/l (500)	ZINC ug/l
1	1S6E36ADBA*	2	2	27	40	2	180	3
2	1S6E36CDDA*	2	2	2	40	2	94	15
3	1S7E17CAAC*	6	3	20	40	9	190	280
4	1S7E17CCDA*	2	2	14	40	2	160	470
5	1S7E29CBDD*	2	2	2	40	9	260	3
6	1S7E29DCCA*	2	2	31	40	11	290	140
7	1S7E30BAAA*	2	2	8	40	3	100	3
8	1S7E30BADD*	2	2	4	40	2	230	3
9	1S7E30DABA*	9	11	30	40	17	110	8
10	1S7E31DCBC*	2	2	6	40	4	64	27
11	1S7E31CDBA*	2	2	6	40	11	40	470
12	2S6E01ABBB	2	2	8	40	3	73	98
13	2S7E06ABBB	3	2	18	40	9	200	10
14	2S7E06BCBC	2	2	12	40	4	11	30

*means area of section is not equal to one square mile

chemical property of water. In this text, parameters which contribute to water quality problems are divided into two categories: parameters without standards and parameters with standards. Table 9 lists parameters with U.S. Environmental Protection agency standards.

Parameters Without Standards

Boron. Boron is essential for plant growth and the U.S. Environmental Protection Agency criterion for long-term irrigation on sensitive crops is 750 micrograms per liter (ug/l). Sampled waters range from less than 2 ug/l to 470 ug/l (Table 10). The levels can be

Table 9. Secondary standards for drinking water. (from U.S. Environmental Protection Agency, 1979)

ION	STANDARD (units as indicated)
Chloride	250 mg/l
Copper	1 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
pH	6.5 to 8.5
Sulfate	250 mg/l
Dissolved Solids	500 mg/l
Zinc	5 mg/l

mg/l, milligrams per liter

considered safe. These values vary with fluoride so that locations with high fluoride also have high boron as expected because boron is inert to all chemical reagents except very strong oxidizing agents such as fluoride (Moeller and others, 1980, p. 826).

Hydrogen Sulfide. Hydrogen sulfide is a soluble, highly poisonous gas which smells characteristically like rotten eggs (U.S. Environmental Protection Agency, 1976). In the study area, a few

Table 10. Chemical constituents contributing to water quality but not having drinking water standards.

SAMPLE NUMBER	LOCATION	BORON ug/1	HYDROGEN SULFIDE	PH (units)		WATER TEMPERATURE FIELD ('C)	LABORATORY SPECIFIC CONDUCTANCE (micromhos)/centimeter	
				Laboratory	Field		Laboratory	Field
1	1S6E36ADBA*	50	---	7.11	6.5	9.0	326	353
2	1S6E36CDDA*	20	---	8.34	7.75	10.5	311	414
3	1S7E17CAAC*	80	---	7.79	6.55	9.0	447	523
4	1S7E17CCDA*	60	---	7.78	7.25	9.5	473	569
5	1S7E29CBDD*	50	---	7.62	7.9	7.5	659	844
6	1S7E29DCCA*	100	---	7.61	7.35	8.5	750	900
7	1S7E30BAAA*	2	---	7.57	6.0	9.8	437	406
8	1S7E30BADD*	60	---	7.56	6.45	9.0	542	503
9	1S7E30DABA*	60	---	8.29	7.82	12.0	332	431
10	1S7E31DCBC*	60	---	7.83	6.85	9.5	313	294
11	1S7E31CDBA*	240	Yes	8.09	7.7	10.2	344	354
12	2S6E01ABBB	50	Yes	8.15	7.25	9.2	365	418
13	2S7E06ABBB	50	---	7.34	6.4	9.7	459	398
14	2S7E06BCBC	470	Yes	9.10	8.25	11.0	167	223

*means section is not equal to one square mile

homeowners report water supplies which have this characteristic smell and a grayish color until the dissolved gas bubbles away. Hydrogen sulfide is reported only in water from the Cretaceous Billman Creek Formation. Because the Billman Creek Formation formed as a fresh-water deposit and is locally high in hydrogen sulfide (H_2S), dissolved sulfate is the most probable source of the gas (Berner, 1971). Biological activity in the water which contains sulfate will produce hydrogen sulfide when there is no oxygen present (reducing conditions).

Water supplies which contain the dissolved H_2S gas are unpleasant to taste and smell. As reported by homeowners if the water is allowed to stand in open air for a short time, however, the gas bubbles away, oxidizes, and the water is free of the taste and smell.

PH. Hydrogen ion concentration is usually expressed as pH and controls pipe corrosion and may be important as a health consideration. PH is expressed as the reciprocal value of the base ten logarithm of the hydrogen ion concentration in moles per liter. An equal number of H^+ and OH^- ions is indicated by a pH value of 7.0 and is found in pure water. Waters less than pH 7 are acid. Waters more than pH 7 are basic. The Environmental Protection Agency (1979) suggests that pH values ranging from 6.5 to 8.5 are safe waters to drink. Values outside this range may still be safe to drink, but personal preference of taste may cause some people to reject the water.

Lab pH and pH measured in the field are dissimilar (Table 10). Values for laboratory pH range from 7.11 to 9.10 with only one value

outside the safe water range. Field pH values range from 6.0 to 8.25 with three sites falling below the safe water lower limit (Table 9). Differences between laboratory and field values vary roughly by the following relationship: field pH = 1.03 (lab pH)-1, (r=.75). Some possibilities for the differences include temperature differences from the field and the laboratory, calibration of the pH meter in the field, and variation in the ionization of the sample dependent upon temperature and alkalinity (Rand and others, eds., 1976). There can also be changes in water chemistry as water is stored which would cause differences between field and laboratory measurements. One chemical change which is common is the degassing of CO_2. In groundwater under pressure, CO_2 is dissolved in the water. When the water is no longer under pressure, the CO_2 will escape. The result of this escape is an increased pH.

Temperature. Temperature is another parameter which may influence the perception of water quality. The measured temperatures range from 7 to 19°C. There is no significant difference statistically between temperatures in wells springs, streams or ponds (Tables 11, 12, 13, and 14). This result is somewhat surprising because surface water should be heated by solar radiation and might be expected to be warmer. The lack of difference may be explained in a variety of ways. The time of year might be important. Because the water temperature was measured in June, perhaps the surface water had not yet been heated. Alternatively, the surface water may be strongly related to groundwater, and so be similar in temperature. The average water

Table 11. Water Quality data for domestic wells.

LOCATION	DATE MEASURED (month/day/year)	TEMP °C	SPECIFIC CONDUCTANCE (micrombos/ centimeter)	CALCULATED TOTAL DISSOLVED SOLIDS
1S6E25DABD*	8/26/83	9	342	310.48
1S6E35DBBC*	8/20/83	8	325	294.50
1S6E36ADBA*	6/23/83	9	353	288.70**
1S6E36DCBB*	1/28/84	10	480	440.20
1S6E36DCDC*	8/12/83	18	430	393.20
1S7E17AAAD*	8/18/83	8	213	189.22
1S7E17AACD*	8/29/83	9	320	289.80
1S7E17AACD*	8/25/83	12	318	287.92
1S7E17ADBA*	8/24/83	9	320	289.80
1S7E17ADBB*	8/26/83	9	342	310.48
1S7E17BDBD*	8/20/83	10	345	313.30
1S7E17BDDD*	8/18/83	9	232	207.08
1S7E17CAAC*	6/25/83	9	523	403.93**
1S7E17CBBD*	8/24/83	12	320	289.80
1S7E17CCBA*	8/24/83	8	342	310.48
1S7E17CCDA*	6/25/83	10	569	455.18**
1S7E20BBCD*	8/18/83	8	392	357.48
1S7E20CABB*	8/29/83	12	520	477.80
1S7E21CBCB*	8/16/83	12	458	419.52
1S7E28ADBC*	1/28/84	7	220	195.80
1S7E29DCCA*	6/25/83	9	900	835.00
1S7E30BAAA*	6/24/83	10	406	414.32
1S7E30BADD*	6/24/83	9	503	478.08
1S7E30BCDA*	10/8/83	10	960	891.40
1S7E30CADD*	8/24/83	19	390	355.60
1S7E30CDAB*	8/16/83	9	420	383.80
1S7E30DAAA*	8/24/83	9	510	468.40

*indicates section not one square mile in area
**indicates laboratory tested sample

Table 11. (continued)

LOCATION	DATE MEASURED (month/day/year)	TEMP °C	SPECIFIC CONDUCTANCE (micrombos/ centimeter)	CALCULATED TOTAL DISSOLVED SOLIDS
1S7E30DDCB*	8/19/83	11	482	442.08
1S7E31CACA*	8/12/83	10	175	153.50
1S7E31CDBA*	8/23/83	10	354	308.45**
1S7E31CDCC*	8/11/83	12	352	319.88
1S7E31DBAC*	8/12/83	10	290	261.60
1S7E31DCBC*	6/24/83	10	294	272.88**
1S7E31DDCD*	8/12/83	19	260	233.40
1S7E33AABA*	8/16/83	9	430	393.20
1S7E33AACB*	8/16/83	10	285	256.90
1S7E33CAAB*	8/19/83	7	272	244.68
1S7E33CDAD*	8/19/83	7	445	407.30
1S7E34BBBD*	11/4/83	7	310	280.40
1S7E34BBBD*	8/19/83	9	490	449.60
2S6E01ABBB	6/27/83	10	418	333.16**
2S7E06AADC	8/10/83	14	205	181.70
2S7E06ABDA	8/10/83	12	340	308.60
2S7E06ACDB	8/15/83	11	270	242.80
2S7E06BBAB	8/12/83	13	470	430.80
2S7E06BCAD	8/21/83	11	190	167.60
2S7E06BCBC	6/27/83	11	223	144.82**
2S7E06CCDC	8/15/83	--	---	
2S7E06CDAB	8/30/83	--	---	
2S7E12CCBD	8/09/83	--	---	
Average		10	383	
Standard Deviation		3	153	

Table 12. Stream sites measured.

NAME (creek)	LOCATION	DATE MEASURED (month day/year)	ELEVATION (feet)	TEMP (°Celsius)	FLOW gpm	SPECIFIC CONDUCTANCE (micromhos/ centimeter)	CALCULATED TOTAL DISSOLVED SOLIDS mg/l
Beasley	1S6E25DADA*	9/16/83	5280	13	30	320	289.80
Bridger	1S6E36CDDA*	6/08/83	5020	11	25035	414	282.46*
Unnamed	1S7E16CCAB*	10/19/83	5530	4	---	510	468.40
Stone	1S7E17AAAD*	10/19/83	5530	6	28	240	214.60
Bridger	1S7E20BCCC*	9/12/83	5230	7	---	285	256.90
Spring	1S7E27CDAA*	9/12/83	5720	7	14	235	209.90
Bridger	1S7E30DABA*	6/28/83	5130	12	15062	431	305.90
Unnamed	1S7E32CADD*	10/08/83	5840	7	2	325	294.50
Unnamed	1S7E32DACD*	10/08/83	6230	6	1	305	275.70
Unnamed	2S6E11ABDA	10/08/83	5160	13	1	180	158.20
Unnamed	2S6E12BBCA	10/08/83	5180	8	1	212	188.28
Unnamed	2S7E06ACAC	10/12/83	5550	6		280	252.20

*indicates sections not equal to one square mile in area

Table 13. Measured spring sites.

LOCATION	DATE MEASURED (month/ day/year)	TEMPERATURE (°Celcius)	SPECIFIC CONDUCTANCE (micromhos/ centimeter)	CALCULATED TOTAL DISSOLVED SOLIDS mg/l	FLOW (gallons per minute)	ELEVATION (feet)
1S7E29CBDD*	6/25/83	8	844	610.43**	---	5230
1S7E29DBCD*	9/06/83	9	480	440.20	3.5	5440
1S7E29DDBA*	9/11/83	9	372	338.68	2.3	5500
1S7E32DDDD*	10/12/83	5	370	336.80	---	6480
1S7E33CDAD*	9/06/83	9	410	374.40	0.5	6230
2S7E05AABA	10/12/83	5	385	350.90	---	6400
2S7E06ABBB	6/24/83	10	398	426.77**	8.0	5280
2S7E06ADBD	10/12/83	7	205	181.70	---	5840

*indicates sections not equal to one square mile in area
**indicates laboratory tested sample

Table 14. Measured pond sites. Dashed values of flow represent flow too low to measure.

LOCATION	DATE MEASURED (month/ day/year)	TEMPERATURE (°Celcius)	FLOW gpm	SPECIFIC CONDUCTANCE (micromhos/ centimeter)	CALCULATED TOTAL DISSOLVED SOLIDS mg/l	ELEVATION (feet)
1S6E25DADA*	9/16/83	15	---	378	344.32	5260
1S7E20CBDA*	9/06/83	10	---	270	242.80	5240
1S7E20DDDC*	9/06/83	9	---	285	256.90	5400
1S7E29CAAB*	9/11/83	18	---	395	360.30	5290
1S7E29CBAB*	9/12/83	15	---	487	446.78	5215
1S7E29CBBA*	9/12/83	16	---	460	421.40	5200
1S7E29CBBA*	9/12/83	13	---	500	459.00	5230
1S7E29CDCB*	9/06/83	13	0.4	442	404.48	5360
1S7E29DCCB*	9/06/83	15	---	343	311.42	5460
1S7E30AADD*	9/12/83	17	---	620	571.80	5190
1S7E32ADCA*	10/08/83	15	---	310	280.40	6000
1S7E32CDAD*	10/08/83	6	---	360	327.40	5900
1S7E32CDDB*	10/08/83	4	---	390	355.60	5920
1S7E32DDCD*	10/08/83	5	---	370	336.80	6300
1S7E33CBCA*	9/06/83	8	---	310	280.40	6220
2S6E06BACD	10/08/83	7	---	400	365.00	5280

*indicates sections not equal to one square mile in area
**indicates laboratory tested sample

temperature is 10 degrees celcius. This value compares favorably with the expected temperature. The air temperature at Bridger Bowl (elevation 5950 feet) is 3.3°C (37.9°F). The temperature at Bozeman is 6.5°C (43.7°F) at an elevation of 4856 feet. If one assumes a mean air temperature for Bridger Canyon of 4.9°C (40.8°F), the groundwater temperature is about 5°C above the air temperature. This difference is expected. According to Walton (1970) groundwater temperatures at depths of 30 to 60 feet normally exceed the mean annual air temperature by 2 or 3 degrees Fahrenheit. The geothermal gradient increases temperatures by about 1°C for each 100 feet of additional depth.

The average temperatures not withstanding, there are several warm groundwater wells. The standard deviation for all water temperatures 3.3°C. The water temperatures above 13°C are clearly more than one standard deviation above the mean and are classified as warm. The wells were pumped at 5 gallons per minute before temperatures were measured in the field. Thus the high temperatures are probably not related to equilibrium with the atmosphere. The warmest waters appear to be near the proposed thrust fault running along the edge of the Bridger Range (Plate 1). Further testing of this relationship might define a zone of low temperature geothermal potential. If after long pumpage, the wells remain warm, some consideration might be given to space heating through a heat exchange system. More work is needed before such a project is implemented, however.

Specific Conductance. Specific electrical conductance is the ability (measured in micromhos per centimeter) of water to conduct an electrical current. Specific conductance is the ability of a cube one centimeter on a side to conduct electrical current. This ability is dependent upon its temperature and the types and concentrations of ions present in the water. Measurements are adjusted to 25°C so that variations are due to the dissolved constituents only. Walton (1970) reports that at 25°C, pure water has a specific conductance of 0.5 to 5.0 micromhos/centimeter while normal groundwater has a specific conductance of 30 to 2,000 micromhos/centimeter. Laboratory specific conductances on sampled waters range from 167 to 750 micromhos/centimeter (Table 9). Field values range from 180 to 960 micromhos/centimeter (Tables 11 to 14). These values are within the range of normal groundwater. The Environmental Protection Agency does not list standards for specific conductance.

As discussed above the main advantage of knowing the specific conductance of the water is that it is a general indication of the total dissolved solids. Because the relationship between specific conductance and total dissolved solids in Bridger Canyon is so well-defined, any values of specific conductance greater than 550 micromhos/centimeter will be above the standard for total dissolved solids.

Parameters With Exceeded Standards

Nitrate. The Environmental Protection Agency water standard for nitrate is 10 milligrams per liter (mg/l) as nitrogen (Table 15).

This level is established due to a number of fatal poisonings of

Table 15. Primary standards for drinking water. (from U.S. Environmental Protection Agency, 1977)

CONTAMINANT	STANDARD (milligrams per liter)
Cadmium	0.010
Chromium	0.05
Lead	0.05
Nitrate (as N)	10.00
Silver	0.05

infants at nitrate levels greater than 10 mg/l. Within the infant body, nitrate ion (NO_3) is converted to nitrite (NO_2) which converts the blood pigment hemoglobin to methemoglobin. This conversion prevents the hemoglobin pigment from transporting oxygen and effectively suffocates the infant. Waters with nitrite nitrogen concentrations over 1 mg/l should not be used for infant feeding (Environmental Protection Agency, 1977). Waters sampled for this study have nitrate ranging from 0.02 mg/l to 1.55 mg/l (Table 16). Water users at locations where the values exceed 1 mg/l should consider the water a potential risk for infants. The values are so close to the standard, however, that they may be of little note. These concerned should contact a health official or physician.

Fluoride. Fluoride is a normal constituent of all diets and is an essential nutrient (Environmental Protection Agency, 1977). Fluoride in drinking water will prevent dental caries unless present in excessive amounts. Excessive fluoride in drinking water produces dental fluorosis, usually seen as mottling of the teeth. Optimal

Table 16. Chemical constituents contributing to poor water quality and having drinking water standards. U.S. Environmental Protection Agency standards are found in parentheses.

SAMPLE NUMBER	LOCATION	NITRATE mg/l (10)	FLUORIDE mg/l (2.4)	IRON mg/l (0.3)
1	1S6E36ADBA*	1.37	.2	.38
2	1S6E36CDDA*	.03	.2	.21
3	1S7E17CAAC*	.71	.2	3.52
4	1S7E17CCDA*	.85	.2	5.45
5	1S7E29CBDD*	.53	.3	.002
6	1S7E29DCCA*	.16	.2	1.20
7	1S7E30BAAA*	.70	.4	.016
8	1S7E30BADD*	1.20	.6	.061
9	1S7E30DABA*	.02	.2	.17
10	1S7E31DCBC*	1.55	.2	.12
11	1S7E31CDBA*	.46	1.2	3.05
12	2S6E01ABBB	1.12	.4	.53
13	2S7E06ABBB	.27	.3	.002
14	2S7E06BCBC	.35	3.4	.37

*means area of section is not equal to one square mile

fluoride levels are dependent upon climatic conditions (Environmental Protection Agency, 1977). The Environmental Protection Agency has established levels based upon the annual average maximum daily temperature (Table 17). Values of fluoride from waters sampled in the study area range from 0.2 mg/l to 3.4 mg/l (Table 16). At a mean maximum annual daily temperature of 53.55 degrees Fahrenheit for the Canyon, two sites exceed the U.S. Environmental Protection Agency standard. These sites also have elevated hydrogen sulfide. The waters may be cause for concern when children are drinking the water, because their teeth may become mottled. A dentist should be consulted where concern exists.

Iron. At concentrations greater than 0.05 mg/l iron water becomes colored and begins to stain fixtures. Approximately 1 mg/l of

Table 17. Primary standards for drinking water for fluoride, dependent upon the annual average of the maximum daily air temperature. (from U.S. Environmental Protection Agency, 1977)

TEMPERATURE IN DEGREES FAHRENHEIT	TEMPERATURE IN DEGREES CELSIUS	MAXIMUM RECOMMENDED FLUORIDE LEVEL (milligrams per liter)
53.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.4	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

iron in water is detectable as a bitter taste. The Environmental Protection Agency maximum contaminant level is 0.3 mg/l (Table 10). Waters sampled in the study area range in iron concentrations from less than 0.002 mg/l to 5.45 mg/l (Table 16). At these concentrations some domestic water supplies cause staining, discoloration, and a bitter taste. Some residents reported problems with staining but not with taste. Normal weathering of minerals in the rocks may be causing oxidation which contributes iron to the water. The method for dealing with the iron stain is to use strong iron solvents in cleaning. The problem of taste may only be resolved by consulting an expert in water treatment.

Discussion of Water Quality

With the exceptions of fluoride, hydrogen sulfide, iron, and nitrate no water quality parameters distinguish the Bridger Canyon waters as objectionable. The Piper Trilinear Plot shows that most of

the waters sampled are calcium carbonate waters. The three exceptions are sodium, potassium, and bicarbonate waters. Associated with these sodium and potassium waters are higher fluoride concentrations. Fluoride and boron are expected to occur together because boron is inert to all chemical reagents except very strong oxidizing agents like fluoride. A Pearson Correlation coefficient of 0.9561 calculated by the methods of Nie and others (1975) between fluoride and boron supports this expectation. The fluoride-rich waters are also rich in hydrogen sulfide gas, an indication of reducing conditions. The overall poor quality waters are probably reducing waters from the Billman Creek Formation and are generally located at Township 2 South, Range 7 East, Section 6, and T1S, R7E, Section 31. The lower fluoride and boron waters are oxidizing waters from both the Billman Creek Formation and the Quaternary alluvium. Homeowners report problems in water taste and staining of fixtures due to iron. Individual problems should be referred to a water treatment expert for removal of iron from the water. While the potential exists for problems with nitrate concentrations, each case should be discussed with a health official or physician.

There may be a relationship between water chemistry and thermal water. The U.S. Fish and Wildlife Fish Cultural Development Center (FCDC) water supplies located at the mouth of Bridger Canyon are warm waters. Hydrothermally altered rock is found in place at 1S6E24DDAB* proving hydrothermal influence further north than the fish hatcheries in the geologic past. The nearby Bozeman Hot Springs waters were analyzed in 1979 by the U.S. Geological Survey. Table 18 is an

Table 18. Comparison of chemical analyses of water from Bozeman Hot Springs well (from Leonard, 1980) Bridger Canyon sampled waters, and the Fish Cultural Development Center (FCDC).

LOCATION	DATE OF SAMPLE	FLOW RATE gpm	SPECIFIC CONDUCTANCE micromhos/centimeter	pH (LAB)	TEMPERATURE DEGREES C	HARDNESS AS $CaCO_3$
2S4E13CCB-Hot Sprs.	11/30/79	2.6	588	9.4	46.0	12
1S7E31CDBA*	6/23/83	4	344	8.1	10.2	60
2S6E01ABBB	6/27/83	12	365	8.15	9.2	38.43
2S7E06BCBC	6/27/83	5	167	9.10	11.0	8.74
mean of others	to 6/28/83	8*	374	7.71	9.5	214.23
FCDC (1S6E34BCCC)	7/77	warm waters	448	7.7	21.0	230
		cold waters	385	7.6	8.0	207

*wells only

LOCATION	CALCIUM mg/1	MAGNESIUM mg/1	SODIUM mg/1	SAR	POTASSIUM mg/1	ALKALINITY mg/1	SULFATE mg/1
2S4E13CCB	4.7	0.1	120	15	1.2	57	120
1S7E31CDBA*	19.8	2.6	57.4	3.22	.1	148.12	22.6
2S6E01ABBB	14.4	0.6	70.4	4.94	.1	173.71	17.8
2S7E06BCBC	3.5	.1	36.3		.1	71.06	7.0
mean of others	65.2	12.4	21.8	0.63	.4	227.63	23.9
FCDC - warm	54.8	22.7	4.26	---	1.40	171.2	80
cold	50.1	20.0	1.41	---	.77	148.6	30

*wells only

LOCATION	CHLORIDE mg/1	FLUORIDE mg/1	SILICA mg/1	TOTAL DISSOLVED SOLIDS mg/1	BORON ug/1	IRON mg/1	LITHIUM ug/1	MANGANESE ug/1
2S4E13CCB	49	2.9	34	367.45	240	0.02	30.4	2
1S7E31CDBA*	8.3	1.2	12.1	308.45	240	3.05	11	.24
2S6E01ABBB	3.8	.4	12.3	333.16	50	.53	3	.005
2S7E06BCBC	1.7	3.4	13.0	144.82	470	.37	4	.004
mean of others	3.3	.3	13.8	420.81	54	1.01	6.4	.03
1S7E34BCCC	.19	.47	8	263.7	--	.025	--	.0015
	.23	.23	3	192.9	--	.025	--	.0012

*wells only

analysis of water from a well located at the hot springs at 2S4E13CCB, and at the Fish Cultural Development Center at 1S6E34BCCC.

Fluoride and boron concentrations at the hot springs are similar to those higher values in the study area. The fish hatcheries values are lower. Other chemical parameters are similar except for the higher hardness at the fish hatcheries. The warm water at the fish hatcheries has the highest values of magnesium and potassium. The warmer waters at the hot springs and the fish hatcheries are highest in sulfate. On a Piper Trilinear Plot the Bozeman Hot Springs waters are plotted in the same classification (sodium, potassium) as are the Bridger Canyon samples 11, 12, and 14, but are higher in chloride. The FCDC waters are classified as calcium waters. Sonderegger and Miller (1984) report that at Three Forks, Montana groundwater is contaminated with arsenic which is in turn strongly correlated with high levels of fluoride. Arsenic concentrations were not analyzed in this study, but the Three Forks analyses indicate a high fluoride concentration which may relate the two areas. A geological connection may exist between Three Forks, the Bozeman Hot Springs, the fish hatcheries, and Bridger Canyon which produces similar water qualities. However, the warmest waters in the canyon are not the ones with the highest values of fluoride, boron, or hydrogen sulfide. More research is needed to determine whether or not the waters discussed are in any way connected. Such research might include more detailed chemical analyses. More well temperatures should be measured after substantial pumpage has taken place. Detailed structural analysis, computer image

enhancement and field work to search for a fracture should be performed to test potential a geological connection.

After spring run-off is finished, water flowing in streams is base flow fed by groundwater. At these times surface water is representative of groundwater. Hackett and others (1960) analyzed surface water quality from Bridger Creek at the mouth of the canyon (1S6E34BD). Table 19 compares the September 21, 1951 analysis with two samples taken from Bridger Creek on June 28, 1983 as part of this study. Differences in discharge and temperature are explained by location along the stream with respect to tributaries, and time of year water was sampled. The 1951 sample was taken later in the year than the end of June samples, and represents base flow. Either little chemical interaction between sediment and water is taking place so that water chemistry at base flow and higher discharges is the same, or different discharges of base flow at different times of the year are the same. In either case the only significant differences are an increase in iron and in temperature. The increased iron may be due to an accumulated increase in oxidation of surface outcrops since 1951. The temperature differences may be due to difference in measuring methods and times between the two studies. This suggests an error which could be corrected by more measurements.

Table 19. Chemical analysis of surface water compared from literature and analysis from this study. (Site #1S6E34BD from Hackett, et al, 1960.)

LOCATION CREEK	DISCHARGE (cfs)	DATE OF COLLECTION	TEMPERATURE (degrees F)
Bridger 1S6E34BD	11	9/21/51	44 (7°C)
Bridger 1S6E36CDDA*	56	6/28/83	52 (11°C)
Bridger 1S7E30DABA*	34	6/28/83	54 (12°C)

LOCATION	SILICA mg/1	IRON mg/1	CALCIUM mg/1	MAGNESIUM mg/1	SODIUM mg/1
1S6E34BD	9.0	.04	57	9.2	11
1S6E36CDDA*	8.8	.21	49	9.9	7.7
1S7E30DABA*	9.2	.17	50	10.3	8.9

LOCATION	POTASSIUM mg/1	BICARBONATE mg/1	CARBONATE mg/1	SULFATE mg/1	CHLORIDE mg/1
1S6E34BD	.8	231	0	15	2.0
1S6E36CDDA*	.8	190	5.3	9.8	.6
1S7E30DABA*	.5	213	0	12	.9

LOCATION	FLUORIDE mg/1	NITRATE mg/1	BORON mg/1	DISSOLVED SOLIDS mg/1	HARDNESS mg/1
1S6E34BD	.2	.5	.03	236	180
1S6E36CDDA*	.2	.03	.02	282	163
1S7E30DABA*	.2	.02	.06	306	168

LOCATION	SPECIFIC CONDUCTANCE (micromhos/cm)	pH
1S6E34BD	379	7.5
1S6E36CDDA*	311	8.3
1S7E30DABA*	331	8.3

*means section is not equal to one square mile

CONCLUSIONS

Bridger Canyon is developing in response to growth at the Bridger Bowl Ski area and residential expansion from Bozeman. People building homes in this area need to obtain water, but some areas in the canyon produce little groundwater and/or have water quality problems. Water availability and quality in the canyon are geologically controlled. Plate 4 summarizes the ground water resources based upon both water availability and water quality. Although boundaries are general, this map should allow someone developing groundwater resources to obtain a general picture of groundwater availability and quality. This map was developed by overlaying data on rock type, drilling depth, water levels, and water quality. Water is generally available and of good quality in the Quaternary alluvium where thickness is adequate. Water is sporadically available in the Billman Creek Formation and locally may be of poor quality and may require drilling depths of a few hundred feet. Where the Hoppers Formation is about 300 feet thick, water should be available for domestic water supplies and should be of good quality. Although no data exist for other rock units in the area, where there are sandstones several feet thick, water should be available in the Telegraph Creek and Eagle Sandstone Formations. On the map (Plate 4) water availability is divided into five categories. Categories A to D represent increasing depths to water. Category E represents known water availability problems (abandoned wells). The water quality classification is a simple add-on to the A to E water availability classification. A number (1 or 2) is added to the letter

to indicate water quality. The number 1 indicates that no known water quality problems were encountered in the chemical analysis. This does not indicate that problems as yet undetected will not be found. Generally water in the alluvium will be of good quality unless man-induced pollutants are introduced such as seeping septic tanks. The number 2 indicates that known water quality problems exist in the area. In this case, it is not suggested that all water supplies in this area will be of poor quality and unfit for use, but wells drilled in these areas may encounter problems. Problems include high total dissolved solids, fluoride, hydrogen sulfide gas, excessive iron, and potentially excessive nitrate.

Because there are areas of limited water availability, homeowners should develop an adequate water supply before a home is built. In areas where water supplies are inadequate neighbors may be able to work together to develop water supplies for a few families based on wells drilled into Quaternary alluvium or thick Hoppers or Eagle Sandstone Formations for improved availability and quality. This water would be piped to each home from a central well. Such an approach would lower the cost of well development for all concerned because only a single well would be drilled with water lines to each home and the cost would be divided by the homeowners with a weighting factor for the water line. For households with children it is recommended that water be tested for fluoride. If levels are higher than recommended standards, a dentist should be consulted regarding the potential for fluorosis and how to deal with the problem and a physician should be consulted regarding the potential nitrate

problems. If a severe problem exists, use of bottled water or ion removal through ion exchange might be considered.

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REFERENCES CITED

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APPENDICES

APPENDIX A

METHODS OF WELL MEASUREMENT

APPENDIX A

Water Level Measurements

A steel measuring tape was lowered into the well below the water level and a mark point is noted where the tape intersects the top of the casing. The height of the casing above ground surface is also noted. When the tape is removed from the well, the wet-mark indicating water level is noted.

Water level is determined by the following equation:

water level below land surface = mark point -

wet mark - height of casing above ground

Yield

Yield from the wells was measured with a five-gallon bucket marked in gallons. A single water source is turned on at full flow into the bucket. A stop watch is used to time how long it takes to fill the bucket. A rate is determined in gallons per second and converted to gallons per minute by multiplying by 60.

Water Temperature

Temperature was measured directly from the flowing source after twenty minutes of flow with a Taylor Pocket Thermometer.

Specific Conductance

Specific conductances was measured with a temperature compensated Myron L-DS Meter, Model EP. The meter was rinsed a minimum of three times in the water to be measured before taking a reading. Readings are in micromhos per centimeter.

Specific Capacity

Each well was pumped at 5 gallons per minute for twenty minutes and its water level drawdown measured periodically. If total yield of the well was less than 5 gallons per minute, the well was pumped at its maximum yield. Specific capacity is calculated by dividing pumping rate by the drawdown in feet at the end of pumping or the maximum drawdown before pumping stopped.

Well Logs

Well logs used in this study were obtained in a standard form from the Montana Bureau of Mines and Geology. The last date of issue of the form was September, 1979. A copy of this form (Number 182) is included in Appendix E.

APPENDIX B

METHODS OF SPRING MEASUREMENT

APPENDIX B

Temperature and specific conductance in springs were measured by the same methods as described for wells. Spring discharge was measured either by direct flow into a bucket as for wells or by the floating stick method (Gardiner and Dackombe, 1983). The floating stick method involves floating a small stick in the stream between two points of known distance. The time is recorded for the stick to pass between the two points to give a velocity. A cross-sectional area is found by measuring the actual dimensions of the stream channel at regular points across the stream. Flow is calculated as follows:

Flow (discharge) = cross-sectional area X velocity

APPENDIX C

METHODS OF STREAM DISCHARGE MEASUREMENT

APPENDIX C

Discharge is measured in a stream with a pygmie model current meter which measures velocity and depth allowing construction of a cross-section when measured at regular spacings across the stream, and solving the discharge equation:

$$\text{Discharge} = \text{area} \times \text{velocity}$$

APPENDIX D

WATER SAMPLING METHOD

APPENDIX D

Water samples were collected using the technique of the Montana Bureau of Mines and Geology. A copy of their instructions is included. It is dated March, 1982.

MONTANA BUREAU OF MINES AND GEOLOGY
COLLECTION OF WATER SAMPLES FOR CHEMICAL ANALYSES

To assure meaningful analytical data, proper collection techniques while obtaining samples are of utmost importance. Some collection techniques are outlined below that will improve the validity of the analytical data. It must be kept in mind the analyses are only as reliable as the sample. Fill all bottles <u>full</u> with no air space.

Samples for Standard Chemical Analysis:

A. Rinse a 500 ml bottle three times with 50 to 100 ml amounts of the untreated sample water. Fill it with untreated water, label it with your identification information and circle the words <u>Untreated Raw</u> on the label. This sample will be used to determine pH, specific conductance, and alkalinity.

B. Clean the filtering apparatus and collection flask by filtering three separate 50 to 100 ml amounts of distilled or deionized water. Each filtrate should be used to completely rinse the collection flask. Repeat the process a second time with sample water. Filter 0.5 liter of sample water through a 0.45u membrane into the collection flask, and use it to rinse the 250 and 500 ml sample bottles three times. Filter an additional 0.8 liter (nearly full flask) through a new 0.45u membrane for samples. Fill the 250 ml bottle, and circle the words <u>Filtered Only</u> on the label. Fill the second bottle (500 mls) 3/4 full with filtrate and add 5 ml of HNO_3. Fill the still empty portion of the bottle with filtrate, and circle the words <u>Filtered and Acidified 1% HNO_3</u> on the label.

C. Samples requiring determination for total dissolved or total recoverable nutrients (phosphates-nitrates) require special handling and preservatives. The MBMG analytical laboratory should be contacted for instructions prior to sample collection.

APPENDIX E

WELL-LOGS

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1XX N or S R. 6 E or W XX SEC. 25 TRACT DABD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Robert and Sherrill Steliga ADDRESS 8093 Bridger Canyon Rd.

Bozeman, MT PHONE NUMBER 587-3692 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5270 ft.
TOTAL DEPTH BELOW LSD 70 ft.
PUMPING LEVEL BELOW LSD 70 ft.
STATIC WATER LEVEL* BELOW LSD 20 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED air TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium

CASING DIA. 6 in. FROM 0 ft. TO 32 ft.
in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 6-18-79
HOW DRILLED ____
BY WHOM Hillman Drilling IC. 361
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-26-83

			DATE
MEAS. POINT ABOVE LSD	1.8	ft.	
TOTAL DEPTH BELOW LSD	74	ft.	8/26/83
PUMPING LEVEL BELOW LSD	15.8	ft.	8/26/83
SWL* BELOW LSD	7	ft.	8/26/83
YIELD IN GPM	10		8/26/83
WATER TEMP. °C	9		9/16/83
SPECIFIC COND. at 25°C	342		9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: pumping level test:
60 ft. after 1 hr.@ 4gpm
70 ft. after 1 hr.@ 5gpm

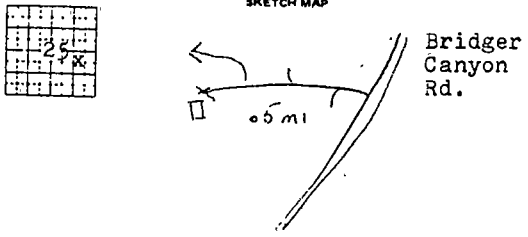
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	topsoil and clay
3	28	gravel
28	70	shale with a little clay

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1XX N or S R. 6 XX E or W SEC. 35 TRACT DBBC*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Jake Mast ADDRESS 6140 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-6488 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5040 ft.
TOTAL DEPTH BELOW LSD 88 ft.
PUMPING LEVEL BELOW LSD 50 ft.
STATIC WATER LEVEL* BELOW LSD 40 ft.
YIELD IN GALLONS PER MIN. 25
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium

CASING DIA. 6 in. FROM 0 ft. TO 88 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Nov. 12, 1968
HOW DRILLED cable
BY WHOM VanDyken LIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 20, 1983

			DATE
MEAS. POINT ABOVE LSD	1.1	ft.	
TOTAL DEPTH BELOW LSD	91	ft.	8/20/83
PUMPING LEVEL BELOW LSD	42	ft.	8/20/83
SWL* BELOW LSD	42	ft.	8/20/83
YIELD IN GPM	8		8/20/83
WATER TEMP.°C	8		10/8/83
SPECIFIC COND. at 25°C	325		10/8/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

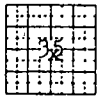
*F = FLOWING

MBMG Form 182 (9/79)

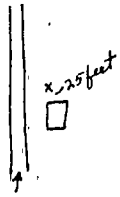
LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	63	clays-dry
63	64	broken, sharp mountain rock
		dry
64	87	sandy clays, little water
87	88	sharp mountain broken
		rock, water

SKETCH MAP



Bridger Canyon Rd. mile 5.8



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ S R. 6 ~~XX~~ E SEC. 36 TRACT DCBB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME George Christie ADDRESS 6800 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-2829 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5040 ft.
TOTAL DEPTH BELOW LSD ____ ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium

CASING DIA. 6 in. FROM ____ ft. TO ____ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED more than 30 yrs.
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE domestic and stock
SOURCE OF INFO: WELL ABPROP. ____
DRILLER ____ OWNER XX USGS ____ SCS ____
OTHER ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Jan. 28, 1984
MEAS. POINT ABOVE LSD 0.1 ft. DATE
TOTAL DEPTH BELOW LSD 48 ft. 1/28/84
PUMPING LEVEL BELOW LSD ____ ft. ____
SWL* BELOW LSD 7 ft. ____
YIELD IN GPM ____ ____
WATER TEMP °C 10 1/28/84
SPECIFIC COND at 25°C 480 1/28/84
MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB NUMBER ____
SYS 2000 NUMBER ____
OTHER ____

REMARKS. well used continuously for 3 homes and stock- cannot shut-off

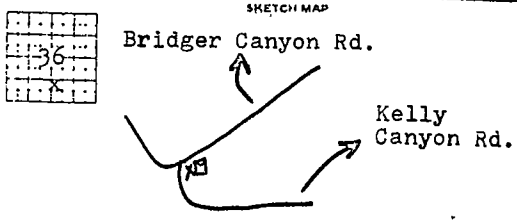
*F = FLOWING

MBMG Form 102 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none AVAILABLE

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 6 E or ~~XX~~ W SEC. 36 TRACT ADbA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME John Harkin ADDRESS 7237 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-9574 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5170 ft.
TOTAL DEPTH BELOW LSD 72 ft.
PUMPING LEVEL BELOW LSD 56 ft.
STATIC WATER LEVEL* BELOW LSD 25 ft.
YIELD IN GALLONS PER MIN. 16
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 39½ ft.
4 in. FROM 12 ft. TO 72 ft.
CASING TYPE steel and plastic
PERFORATED INTERVAL 32 ft. TO 33 ft.
25 feet of ft. TO ft.
the plastic ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Oct. 26, 1977
HOW DRILLED cable
BY WHOM VanDyken Drilling LIC. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 23, 1983
MEAS. POINT ABOVE LSD 1.3 ft. DATE
TOTAL DEPTH BELOW LSD 72 ft. 6/23/83
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 10 ft. 6/23/83
YIELD IN GPM 8 6/23/83
WATER TEMP. °C 9 6/23/83
SPECIFIC COND. at 25°C 353 6/23/83
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER: pH: 6.5

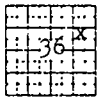
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	10	clay
10	30	soft shale
30	32½	harder shale
32½	36	water: soft shale
36	40	hard shale
40	50	softer shale
50	55	hard shale
55	63	soft shale
63	72	hard shale

SKETCH MAP



Bridger Canyon Rd.
.2mi
past mile marker 7

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ ~~N or S~~ R. 6 E ~~or W~~ SEC. 36 TRACT DCDC*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Lawrence Christie ADDRESS 15416 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-6439 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5160 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 12, 1983

			DATE
MEAS. POINT ABOVE LSD	1.66	ft.	
TOTAL DEPTH BELOW LSD	69	ft.	8/12/83
PUMPING LEVEL BELOW LSD	25	ft.	8/12/83
SWL* BELOW LSD	11	ft.	8/12/83
YIELD IN GPM	8		8/12/83
WATER TEMP. °C	18		10/8/83
SPECIFIC COND at 25°C	430		10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

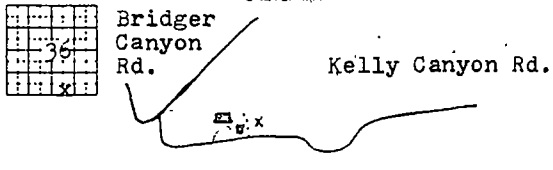
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 17 TRACT AAAD*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME George and Katherine Rice ADDRESS 11330 Bridger Canyon R

Bozeman, MT 59715 PHONE NUMBER 586-6453 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5540 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8/18/83

		ft.	DATE
MEAS. POINT ABOVE LSD			
TOTAL DEPTH BELOW LSD	107	ft.	8/18/83
PUMPING LEVEL BELOW LSD	41	ft.	8/18/83
SWL* BELOW LSD	29	ft.	8/18/83
YIELD IN GPM	5		8/18/83
WATER TEMP. °C	8		9/16/83
SPECIFIC COND. at 25°C	213		9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

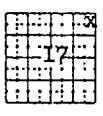
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP



Bridger Canyon Rd.

whale on post

well off front porch

1.8 mi. Jackson Creek Rd.

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XXX~~ W SEC. 17 TRACT AACD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME John E. Drumheller ADDRESS 11284 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-6876 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5410 ft.
TOTAL DEPTH BELOW LSD 54 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 52 ft.
YIELD IN GALLONS PER MIN. 35
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation - alluvium
CASING DIA. 6 in. FROM 0 ft. TO 54 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE Steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE Johnston Water
DATE WELL COMPLETED Oct. 11, 1961
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE domestic and irrigation
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER ____ USGS ____ SCS ____
OTHER: MBMG

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 29, 1983

		DATE
MEAS. POINT ABOVE LSD	-4.5 ft.	
TOTAL DEPTH BELOW LSD	54 ft.	8/29/83
PUMPING LEVEL BELOW LSD	32 ft.	8/29/83
SWL* BELOW LSD	31 ft.	8/29/83
YIELD IN GPM	6	8/29/83
WATER TEMP. °C	9	9/16/83
SPECIFIC COND at 25°C	320	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS. ____

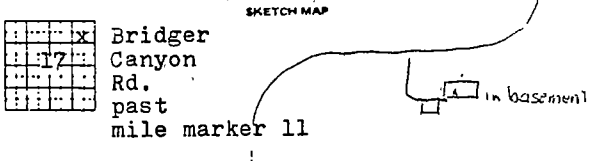
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0-	2	topsoil
2	52	dirty gravel
52	54	gravel

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 ~~XX~~ E or W SEC. 17 TRACT ADBA*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Clarence Serfoss ADDRESS 11260 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-2877 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5440 ft.
TOTAL DEPTH BELOW LSD 200 ft.
PUMPING LEVEL BELOW LSD 18½ ft.
STATIC WATER LEVEL* BELOW LSD 17½ ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 90½ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL 48 ft. TO 51 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED May 1, 1980
HOW DRILLED cable
BY WHOM Potts Drilling LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 25, 1983

		DATE
MEAS. POINT ABOVE LSD	1.5 ft.	
TOTAL DEPTH BELOW LSD	200 ft.	8/25/83
PUMPING LEVEL BELOW LSD	26 ft.	8/25/83
SWL* BELOW LSD	25 ft.	8/25/83
YIELD IN GPM	5	8/25/83
WATER TEMP. °C	12	9/16/83
SPECIFIC COND. at 25°C	318	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

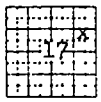
REMARKS: ____

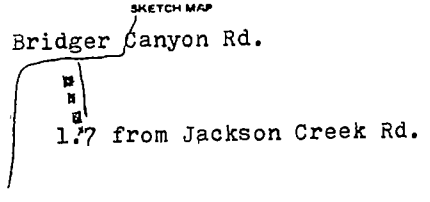
*F = FLOWING.
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		upper portion information
		not available
		lower portion is from
		a second drilling
50	65	firm shales
65	87	sticky formation
87	120	very firm
120	125	very hard
125	200	very hard

SKETCH MAP





MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 17 TRACT ADBA*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Jim Tanhoff ADDRESS 11258 Bridger Canyon RD.

Bozeman, MT 59715 PHONE NUMBER 587-2053 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5420 ft.
TOTAL DEPTH BELOW LSD 68½ ft.
PUMPING LEVEL BELOW LSD 45 ft.
STATIC WATER LEVEL* BELOW LSD 38 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED pump TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 70 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL 54 ft. TO 57 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ½ by 2 inches
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Nov. 19, 1974
HOW DRILLED cable
BY WHOM Potts Drilling LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 24, 1983

		DATE
MEAS. POINT ABOVE LSD	0.9 ft.	
TOTAL DEPTH BELOW LSD	65 ft.	8/24/83
PUMPING LEVEL BELOW LSD	32 ft.	8/24/83
SWL* BELOW LSD	32 ft.	8/24/83
YIELD IN GPM	7	8/24/83
WATER TEMP. °C	9	9/16/83
SPECIFIC COND. at 25°C	320.	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

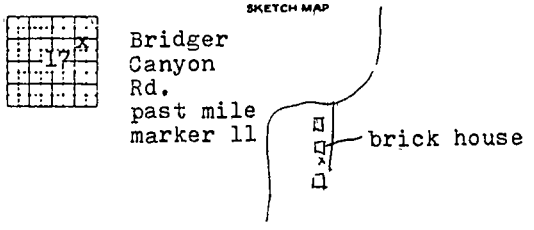
REMARKS: ____

*F = FLOWING
MBMG Form 182 (8/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	black top
2	10	rocky clay
10	42	very dirty gravel and rock
42	54	dirty sand and gravel
54	56	sand and gravel
56	60	brown clay, sandy
60	68½	shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ ~~or~~ S R. 7 ~~E~~ ~~or~~ ~~W~~ SEC. 17 TRACT ADBB*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Douglas and Luelia Polette ADDRESS 11110 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-5768 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5430 ft.
TOTAL DEPTH BELOW LSD ____ ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation
CASING DIA. 6 in. FROM ____ ft. TO ____ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 26, 1983

			DATE
MEAS. POINT ABOVE LSD	____	ft.	
TOTAL DEPTH BELOW LSD	153	ft.	8/26/83
PUMPING LEVEL BELOW LSD	39	ft.	8/26/83
SWL* BELOW LSD	31	ft.	8/26/83
YIELD IN GPM	7		8/26/83
WATER TEMP. °C	9		9/16/83
SPECIFIC COND. at 25°C	342		9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

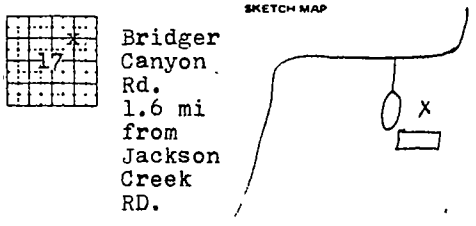
REMARKS: ____

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ ~~S~~ XX R. 7 ~~E~~ ~~W~~ XX SEC. 17 TRACT BDBD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Evan & Rosalyn White ADDRESS 10735 Bridger Canyon Rd.

c/o Mary Buck, Bozeman, MT 59715 PHONE NUMBER 587-7268 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5360 ft.
TOTAL DEPTH BELOW LSD 90 ft.
PUMPING LEVEL BELOW LSD 30 ft.
STATIC WATER LEVEL* BELOW LSD 15 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 35½ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Nov. 20, 1964
HOW DRILLED cable
BY WHOM VanDyken Drilling DIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 20, 1983

			DATE
MEAS. POINT ABOVE LSD	1.4	ft.	
TOTAL DEPTH BELOW LSD	90	ft.	8/20/83
PUMPING LEVEL BELOW LSD	18	ft.	8/20/83
SWL* BELOW LSD	13	ft.	8/20/83
YIELD IN GPM	9		8/20/83
WATER TEMP. °C	10		9/8/83
SPECIFIC COND. at 25°C	345		9/8/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

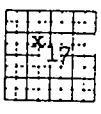
REMARKS: ____

*F = FLOWING

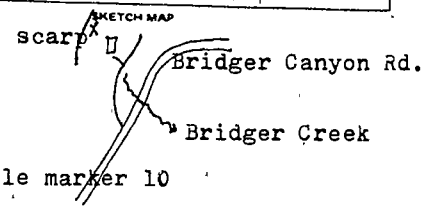
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	5	topsoil
5	11	clays-dry
11	12	sands-wet
12	21	claybound gravels and sand wet
21	28	fine sands-wet
28	30½	brown shales-dry
30½	32	fractured rock-water
32	79	hard blue shale-dry
79	90	hard gray shales-dry



SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1XXX N or S R. 7 XXX E or W SEC. 17 TRACT BDDD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME John and Rosemary Bashor ADDRESS 10680 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-5741 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5270 ft.
TOTAL DEPTH BELOW LSD 80 ft.
PUMPING LEVEL BELOW LSD 60 ft.
STATIC WATER LEVEL* BELOW LSD 8 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED pump/bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 80 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE Steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Aug. 24, 1973
HOW DRILLED cable
BY WHOM Potts Drilling LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 18, 1983

		DATE
MEAS. POINT ABOVE LSD	1.2 ft.	
TOTAL DEPTH BELOW LSD	81 ft.	8/18/83
PUMPING LEVEL BELOW LSD	23 ft.	8/18/83
SWL* BELOW LSD	9 ft.	8/18/83
YIELD IN GPM	5	8/18/83
WATER TEMP. °C	9	9/16/83
SPECIFIC COND at 25°C	232	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

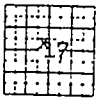
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	12	clay and rocks
12	55	shale
55	75	sandstone
75	80	sandstone

SKETCH MAP



Bridger Canyon Rd.
past mile marker 10

1.2 miles from
Jackson Creek Rd.



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 N/S R. 7 E/W SEC. 17 TRACT CACC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Ray and Diana Martin ADDRESS 10384 Bridger Canyon Rd.

Bozeman, MT PHONE NUMBER 587-2535 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5330 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE domestic, garden, lawn
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 25, 1983

			DATE
MEAS. POINT ABOVE LSD	1.4	ft.	
TOTAL DEPTH BELOW LSD	48.2	ft.	6/25/83
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	10.6	ft.	6/25/83
YIELD IN GPM	8		6/25/83
WATER TEMP. °C	9		6/25/83
SPECIFIC COND at 25°C	523		6/25/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH: 6.55

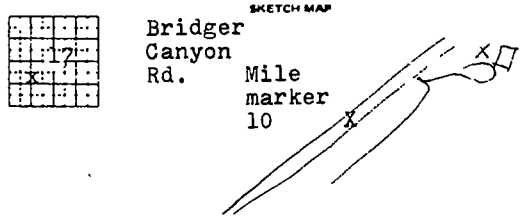
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ or S R. 7 E ~~or W~~ SEC. 17 TRACT CBBD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Robert Orton Smith ADDRESS 10659 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-1394 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5380 ft.
TOTAL DEPTH BELOW LSD 120 ft.
PUMPING LEVEL BELOW LSD 80 ft.
STATIC WATER LEVEL* BELOW LSD 77 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 20 ft.
4 in. FROM 10 ft. TO 120 ft.
CASING TYPE welded steel
PERFORATED INTERVAL 80 ft. TO 120 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ¼ inch slots
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED July 7, 1978
HOW DRILLED ____
BY WHOM ____ LIC. 268
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 24, 1983

		DATE
MEAS. POINT ABOVE LSD	0.95 ft.	
TOTAL DEPTH BELOW LSD	120 ft.	8/24/83
PUMPING LEVEL BELOW LSD	82 ft.	8/24/83
SWL* BELOW LSD	82 ft.	8/24/83
YIELD IN GPM	5	8/24/83
WATER TEMP. °C	12	9/16/83
SPECIFIC COND at 25°C	320	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

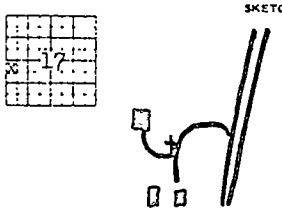
REMARKS: ____

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	15	dirt and shale mix
15	65	clay (pebbly)
65	76	clay, some sandstone
76	84	sandstone
84	120	limestone rock



SKETCH MAP

Bridger Canyon Rd.
1.2 miles from
Jackson Creek Rd.

.3 miles along
driveway

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ S R. 7 ~~XX~~ E SEC. 17 TRACT CCBA *

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION Alpenhauser BLOCK 1 LOT 9

OWNER'S NAME Jerry Perkins ADDRESS 10281 Bridger Canyon RD.

Bozeman, MT PHONE NUMBER 586-2730 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5320 ft.
TOTAL DEPTH BELOW LSD 85 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 43 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 5 ft.
4½ in. FROM 55 ft. TO 85 ft.
CASING TYPE steel and PVC
PERFORATED INTERVAL 55 ft. TO 85 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 9-2-82
HOW DRILLED cable
BY WHOM Bennetts Drilling 383
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 24, 1983

		DATE
MEAS. POINT ABOVE LSD	1.8 ft.	
TOTAL DEPTH BELOW LSD	85 ft.	8/24/83
PUMPING LEVEL BELOW LSD	42.7 ft.	8/24/83
SWL* BELOW LSO	39.7 ft.	8/24/83
YIELD IN GPM	21	8/24/83
WATER TEMP. °C	8	9/16/83
SPECIFIC COND. at 25° C	342	9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: abandoned well 10 feet away

*F = FLOWING

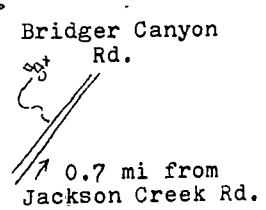
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	15	topsoil
15	40	sandy clay
40	55	sand
55	85	broken rock and shell

SKETCH MAP





MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or ~~S~~ R. 7 E or ~~W~~ SEC. 17 TRACT CCDA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Glen and Virginia Loomis ADDRESS 10380 Bridger Canyon Rd.

Bozeman, MT PHONE NUMBER 587-7938 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5260 ft.
TOTAL DEPTH BELOW LSD 42 ft.
PUMPING LEVEL BELOW LSD 40 ft.
STATIC WATER LEVEL* BELOW LSD 4 ft.
YIELD IN GALLONS PER MIN. 40
HOW TESTED pump TIME (HR.) 1.5
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 37 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE steel
PERFORATED INTERVAL ___ ft. TO ___ ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC.
PUMP SIZE (HP.) ___ TYPE
DATE WELL COMPLETED Aug. 30, 1970
HOW DRILLED churn drill
BY WHOM Donald C. Jones LIC. 17
WELL USE domestic w/ garden, lawn
SOURCE OF INFO: WELL APPROP. ___
DRILLER X OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 25, 1983

		DATE
MEAS. POINT ABOVE LSD	1.1 ft.	
TOTAL DEPTH BELOW LSD	40.4 ft.	6/25/83
PUMPING LEVEL BELOW LSD	3.7 ft.	6/25/83
SWL* BELOW LSD	2.9 ft.	6/25/83
YIELD IN GPM	8	6/25/83
WATER TEMP. °C	9.5	6/25/83
SPECIFIC COND at 25°C	569	6/25/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH: 7.25

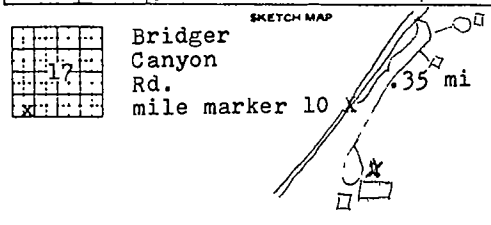
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	topsoil and clay
3	8	gravel with clay
8	14	gravel bound in clay
14	35	clay
35	42	shale



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XXX SEC. 20 TRACT BBCD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Edward F. Rye ADDRESS 9900 Bridger Canyon RD.

Bozeman MT 59715 PHONE NUMBER 586-1356 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5220 ft.
TOTAL DEPTH BELOW LSD ____ ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM ____ ft. TO ____ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.

PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8/18/83

			DATE
MEAS. POINT ABOVE LSD	1.32	ft.	
TOTAL DEPTH BELOW LSD	39	ft.	8/18/83
PUMPING LEVEL BELOW LSD	5	ft.	8/18/83
SWL* BELOW LSD	4	ft.	8/18/83
YIELD IN GPM	5		8/18/83
WATER TEMP. °C	8		9/16/83
SPECIFIC COND. at 25° C	392		9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ.LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

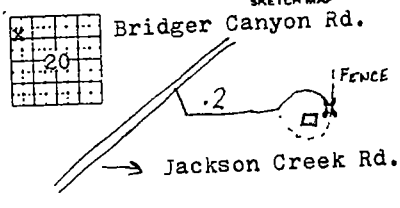
REMARKS: ____

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 20 TRACT CABB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Roger and Betsy Cruwys ADDRESS 7211 Jackson Creek Rd.

Bozeman, MT PHONE NUMBER 586-1830 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5300 ft.
TOTAL DEPTH BELOW LSD 55 ft.
PUMPING LEVEL BELOW LSD 60 ft.
STATIC WATER LEVEL* BELOW LSD 20 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 55 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE ____
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 5-4-82
HOW DRILLED cable
BY WHOM Van Dyken Drilling Inc. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-29-83

		DATE
MEAS. POINT ABOVE LSD	1.7 ft.	
TOTAL DEPTH BELOW LSD	55 ft.	8/29/83
PUMPING LEVEL BELOW LSD	21.5 ft.	8/29/83
SWL* BELOW LSD	21.1 ft.	8/29/83
YIELD IN GPM	5	8/29/83
WATER TEMP. °C	12	9/16/83
SPECIFIC COND. at 25°C	520	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

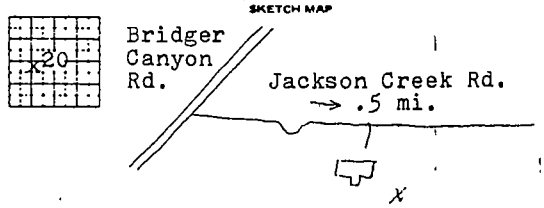
REMARKS: ____

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	25	shale
25	30	hard shale
30	32	soft shale
32	55	shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~S R. 7 E or ~~W~~ SEC. 21 TRACT CBCB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION Lazy Y BLOCK LOT

OWNER'S NAME John McKenna ADDRESS 6474 Jackson Creek Rd.

Bozeman, MT PHONE NUMBER 587-4746 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5530 ft.
TOTAL DEPTH BELOW LSD 200 ft.
PUMPING LEVEL BELOW LSD 170 ft.
STATIC WATER LEVEL* BELOW LSD 120 ft.
YIELD IN GALLONS PER MIN.
HOW TESTED bailer TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek
CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 12-11-77
HOW DRILLED
BY WHOM Herbert Potts LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-16-83

			DATE
MEAS. POINT ABOVE LSD	1.8	ft.	
TOTAL DEPTH BELOW LSD	200	ft.	8/16/83
PUMPING LEVEL BELOW LSD	109.7	ft.	8/16/83
SWL* BELOW LSD	107.6	ft.	8/16/83
YIELD IN GPM	12.5		8/16/83
WATER TEMP. °C	12		9/16/83
SPECIFIC COND. at 25°C	458		9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: clay on inside of well at 55 feet

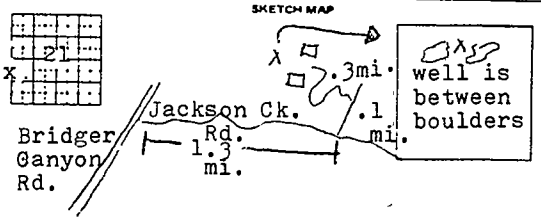
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	7	fractured rock
7	14	brown rock
14	132	hard blue shale
132	174	small fracture
174	196	brown sandstone
196	198	brown sandstone
198	200	blue shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 28 TRACT ADBC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Richard Moats ADDRESS 5730 Jackson Creek Rd.

Bozeman, MT 59715 PHONE NUMBER 586-2784 YEAR 1984

ALT. LAND SURF. AT WELL MSL 5640 ft.
TOTAL DEPTH BELOW LSD 148 ft.
PUMPING LEVEL BELOW LSD 143 ft.
STATIC WATER LEVEL* BELOW LSD 42 ft.
YIELD IN GALLONS PER MIN. 3
HOW TESTED bailer TIME (HR.) 3
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 148 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE welded steel
PERFORATED INTERVAL 69 ft. TO 70 ft.
85 ft. TO 90 ft.
___ ft. TO ___ ft.
PERFORATION DESC. ¼ inch slots
PUMP SIZE (HP.) ___ TYPE ___
DATE WELL COMPLETED Sept. 28, 1973
HOW DRILLED cable
BY WHOM VanDyken LIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ___
DRILLER X OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Jan. 28, 1984

		DATE
MEAS. POINT ABOVE LSD	0.5 ft.	
TOTAL DEPTH BELOW LSD	148 ft.	1/28/84
PUMPING LEVEL BELOW LSD	37 ft.	1/28/84
SWL* BELOW LSD	25 ft.	1/28/84
YIELD IN GPM	12	1/28/84
WATER TEMP. °C	7	1/28/84
SPECIFIC COND. at 25°C	220	

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

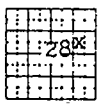
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

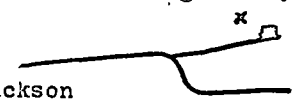
LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	1	soils
1	19	clay bound gravels
19	69	blue shales
69	70	pink shales, water
70	148	gray shales, water at 85 to 90 feet and wet at 148 feet



SKETCH MAP

2.1 miles along Jackson Creek Road from Bridger Canyon Road



Jackson Creek Rd.

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~S R. 7 E ~~or W~~ SEC. 29 TRACT DCCA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Robert A. Chadwick ADDRESS 1920 Spring Cr. Dr.

Bozeman, MT 59715 PHONE NUMBER 586-6518 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5500 ft.
TOTAL DEPTH BELOW LSD 45 ft.
PUMPING LEVEL BELOW LSD 30 ft.
STATIC WATER LEVEL* BELOW LSD 20 ft.
YIELD IN GALLONS PER MIN. 60
HOW TESTED bailer TIME (HR.) 1½
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O landslide on Hoppers Formation

CASING DIA. 6 in. FROM 0 ft. TO 44½ ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. slots over 30 ft length
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Sept. 16, 1974
HOW DRILLED cable
BY WHOM Potts LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 25, 1983

			DATE
MEAS. POINT ABOVE LSD	1.4	ft.	
TOTAL DEPTH BELOW LSD	45	ft.	6/25/83
PUMPING LEVEL BELOW LSD	20	ft.	6/25/83
SWL* BELOW LSD	18	ft.	6/25/83
YIELD IN GPM	8		6/25/83
WATER TEMP. °C	9		6/25/83
SPECIFIC COND at 25°C	900		6/25/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH 7.35

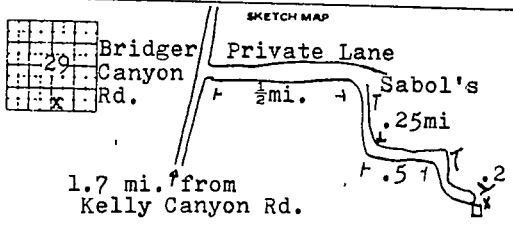
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
0	45	clay

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W SEC. 30 TRACT BAAA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Don Reichmuth ADDRESS 622 6th Avenue South

Bozeman, MT 59715 PHONE NUMBER 586-0730 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5240 ft.
TOTAL DEPTH BELOW LSD 68 ft.
PUMPING LEVEL BELOW LSD 68 ft.
STATIC WATER LEVEL* BELOW LSD 53 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED pump TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Miner Creek Formation may reach Billman Creek Fm.
CASING DIA. 6 in. FROM 0 ft. TO 59 ft.
5 in. FROM 58 ft. TO 68 ft.
CASING TYPE steel with 5" liner
PERFORATED INTERVAL 58 ft. TO 68 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. 1/16 X 1½ inches
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED June 24, 1965
HOW DRILLED churn drill
BY WHOM Donald C. Jones LIC. 17
WELL USE domestic
SOURCE OF INFO WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 24, 1983

		DATE
MEAS. POINT ABOVE LSD	3.0 ft.	
TOTAL DEPTH BELOW LSD	68 ft.	6/24/83
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	55 ft.	6/24/83
YIELD IN GPM	8	6/24/83
WATER TEMP. °C	10	6/24/83
SPECIFIC COND. at 25°C	406	6/24/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER pH: 6.0

REMARKS:

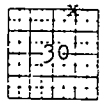
*F = FLOWING

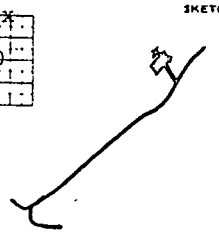
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	57	clay
57	60	sand and fine gravel
60	68	shale

SKETCH MAP





Bridger Canyon Rd.

2.2 miles from Kelly Canyon Rd.

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 30 TRACT BADD*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME George and Dorothy Ripley ADDRESS 8791 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-6408 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5220 ft.
TOTAL DEPTH BELOW LSD 65 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 52 ft.
YIELD IN GALLONS PER MIN. 35
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 52 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel-open in ss to 65 ft
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE Dapm wall jet
DATE WELL COMPLETED May 2, 1963
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE domestic, lawn, garden
SOURCE OF INFO: WELL APPROP. ____
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: DNRC

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 24, 1983

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	8 ft.	6/24/83
YIELD IN GPM	____	____
WATER TEMP. °C	9	6/24/83
SPECIFIC COND. at 25°C	503	6/24/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: pH 6.45

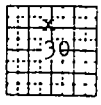
REMARKS: well enclosed by porch steps; inaccessible

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	1½	loam
1½	30	clay
30	52	sandy clay
52	65	sandstone, coarse

SKETCH MAP



under back steps

Bridger Canyon Rd.
past mile marker 8

private lane

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ XX ~~S~~ R. 7 ~~E~~ XX ~~W~~ SEC. 30 TRACT BCDA

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Bruce Patterson ADDRESS 8653 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-8016 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5260 ft.
TOTAL DEPTH BELOW LSD 125 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 53 ft.
YIELD IN GALLONS PER MIN. 12
HOW TESTED pump and bailer TIME (HR.) 1½
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 41 ft.
5 in. FROM 40 ft. TO 125 ft.
CASING TYPE steel and PVC
PERFORATED INTERVAL 45 ft. TO 125 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. 1/8 X 6 inch slots
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Jan. 21, 1978
HOW DRILLED cable
BY WHOM Wilton E. Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Oct. 8, 1983

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	10	10/8/83
SPECIFIC COND. at 25°C	960	10/8/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: well-head buried 40 feet behind house

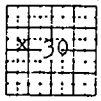
*F = FLOWING

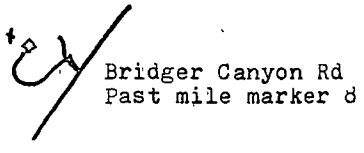
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	12	topsoil
12	125	shale

SKETCH MAP





MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 ~~XX~~ E or W SEC. 30 TRACT CADD*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Roland Ortmayer ADDRESS 8191 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-2741 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5180 ft.
TOTAL DEPTH BELOW LSD 74 ft.
PUMPING LEVEL BELOW LSD 74 ft.
STATIC WATER LEVEL* BELOW LSD 9 ft.
YIELD IN GALLONS PER MIN. 22
HOW TESTED pump TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium

CASING DIA. 6 in. FROM 0 ft. TO 29 ft.
5 in. FROM 10 ft. TO 73 ft.
CASING TYPE steel
PERFORATED INTERVAL 10 ft. TO 73 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. 3/8 inch slots x 3
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Aug. 28, 1967
HOW DRILLED churn drill
BY WHOM Donald Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug 24, 1983

		DATE
MEAS. POINT ABOVE LSD	1.4 ft.	
TOTAL DEPTH BELOW LSD	71 ft.	8/24/83
PUMPING LEVEL BELOW LSD	16 ft.	8/24/83
SWL* BELOW LSD	6 ft.	8/24/83
YIELD IN GPM	10	8/24/83
WATER TEMP. °C	19	10/8/83
SPECIFIC COND. at 25°C	390	10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

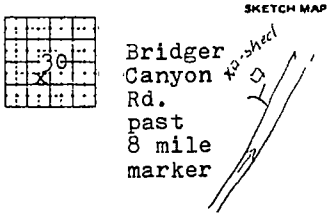
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	30	gravel and clay
30	43	clay
43	45	shale
45	73	layered shale and clay
73	74	gray clay

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 30 TRACT CDAB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME R. Williamson ADDRESS 8131 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-0500 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5190 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN. 40
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 16, 1983

			DATE
MEAS. POINT ABOVE LSD	0.9	ft.	
TOTAL DEPTH BELOW LSD	52	ft.	8/16/83
PUMPING LEVEL BELOW LSD	15	ft.	8/16/83
SWL* BELOW LSD	9	ft.	8/16/83
YIELD IN GPM	5		8/16/83
WATER TEMP. °C	9		10/8/83
SPECIFIC COND at 25°C	420		10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: indoor faucet must run to activate pump in well other water is from stream

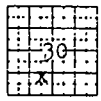
*F = FLOWING

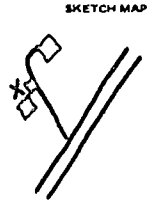
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP





Bridger Canyon Rd. past mile marker 8

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 30 TRACT DAAA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Richard and Joyce Grover ADDRESS* 7892 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-3709 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5190 ft.
TOTAL DEPTH BELOW LSD 65 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 25 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED pump TIME (HR.) 1½
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 38½ ft.
4 in. FROM 35 ft. TO 65 ft.
CASING TYPE steel and plastic
PERFORATED INTERVAL 39 ft. TO 65 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. ½ inch slots
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED July 1, 1978
HOW DRILLED cable
BY WHOM Jones Welding LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 24, 1983

		DATE
MEAS. POINT ABOVE LSD	1.6 ft.	
TOTAL DEPTH BELOW LSD	65 ft.	8/24/83
PUMPING LEVEL BELOW LSD	19 ft.	8/24/83
SWL* BELOW LSD	8 ft.	8/24/83
YIELD IN GPM	10	8/24/83
WATER TEMP. °C	9	11/4/83
SPECIFIC COND at 25°C	510	11/4/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

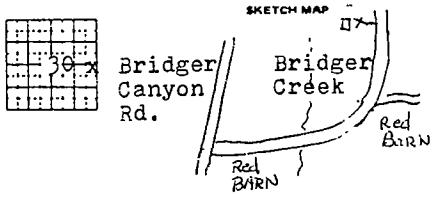
REMARKS: *Missoula address:
2635 West Central
Missoula, MT
543-8428

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	topsoil
10	25	clay
25	28	sandstone
28	30	clay
30	65	red sandstone



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 XX E or W SEC. 30 TRACT DDCB*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Richard and Mickey Rosa ADDRESS 7900 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-5215 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5160 ft.
TOTAL DEPTH BELOW LSD 46 ft.
PUMPING LEVEL BELOW LSD 35 ft.
STATIC WATER LEVEL* BELOW LSD 29 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O alluvium along Bridger Creek and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 46 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. 8 @ 38 ft., ¼ in. slots
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED Sept. 12, 1979
HOW DRILLED cable
BY WHOM VanDyken Drilling LIC. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Sept. 19, 1983

			DATE
MEAS. POINT ABOVE LSD	1.1	ft.	
TOTAL DEPTH BELOW LSD	49	ft.	8/19/83
PUMPING LEVEL BELOW LSD	33	ft.	8/19/83
SWL* BELOW LSD	34	ft.	8/19/83
YIELD IN GPM	8		8/19/83
WATER TEMP. °C	11		10/8/83
SPECIFIC COND. at 25°C	482		10/8/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

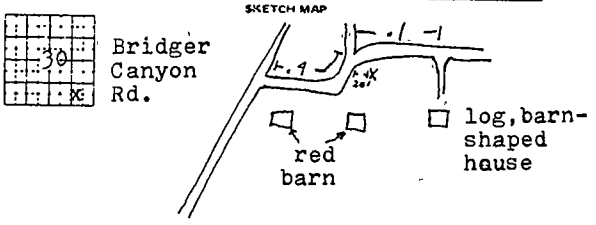
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	top soil
2	16	soft shale
16	27	sandstone-dry
27	38	sand and claybound gravel
38	38½	sand & gravel-water
38½	44	claybound gravel
44	46	shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 XX E or W SEC. 31 TRACT CADA*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Dale Nuss ADDRESS 15038 Kelly Canyon Rd.

Bozeman, MT PHONE NUMBER 586-3639 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5275 ft.
TOTAL DEPTH BELOW LSD 290 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN. 10
HOW TESTED bailer TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek
CASING DIA. in. FROM ft. TO ft.
5 in. FROM 190 ft. TO 290 ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Jan 3, 1979
HOW DRILLED cable
BY WHOM Herbert Potts LIC. 150
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-12-83

		DATE
MEAS. POINT ABOVE LSD	1.4 ft.	
TOTAL DEPTH BELOW LSD	290 ft.	8/12/83
PUMPING LEVEL BELOW LSD	149.7 ft.	8/12/83
SWL* BELOW LSD	96.1 ft.	8/12/83
YIELD IN GPM	10	8/12/83
WATER TEMP. °C	10	10/8/83
SPECIFIC COND. at 25°C	175	10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: water held in reservoir 2400-2600 gallons

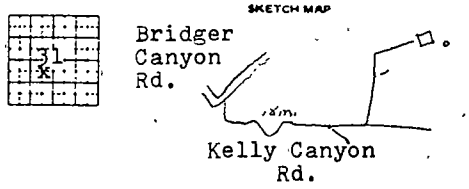
*F = FLOWING

MBMG Form 192 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
190	197	red shale, rock (hard)
197	225	hard, blue-black shale
225	230	softer black shale
230	255	soft blue-black shale
255	290	hard, red shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 31 TRACT CDBA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Robert Pipinich ADDRESS 15034 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-1613 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5210 ft.
TOTAL DEPTH BELOW LSD 140 ft.
PUMPING LEVEL BELOW LSD 140 ft.
STATIC WATER LEVEL* BELOW LSD 65 ft.
YIELD IN GALLONS PER MIN. 18
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL 43 ft. TO 135 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. slots, ¼ X 3 inches
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Feb. 14, 1972
HOW DRILLED churn drill
BY WHOM Donald Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 23, 1983

			DATE
MEAS. POINT ABOVE LSD	1.2	ft.	
TOTAL DEPTH BELOW LSD	142	ft.	6/23/83
PUMPING LEVEL BELOW LSD		ft.	6/23/83
SWL* BELOW LSD	53	ft.	6/23/83
YIELD IN GPM	4		6/23/83
WATER TEMP. °C	10		6/23/83
SPECIFIC COND. at 25°C	354		6/23/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH: 7.7

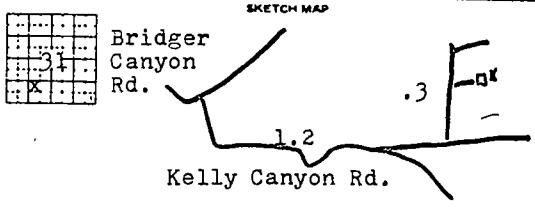
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	14	clay
14	45	red shale
45	80	gray clay and shale
80	105	red shale and clay
105	140	shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1XX N or S R. 7 E or W XX SEC. 31 TRACT CDCC*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Carol Gord ADDRESS 15030 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-9432 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5150 ft.
TOTAL DEPTH BELOW LSD 250 ft.
PUMPING LEVEL BELOW LSD 210 ft.
STATIC WATER LEVEL* BELOW LSD 57 ft.
YIELD IN GALLONS PER MIN. 7
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 49 ft.
4 in. FROM 30 ft. TO 250 ft.
CASING TYPE welded steel and plastic
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. slots every 6 inches
PUMP SIZE (HP.) XXXX in plastic
DATE WELL COMPLETED Nov. 11, 1977
HOW DRILLED cable
BY WHOM VanDyken Drilling. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 11, 1983

		DATE
MEAS. POINT ABOVE LSD	1.1 ft.	
TOTAL DEPTH BELOW LSD	250 ft.	8/11/83
PUMPING LEVEL BELOW LSD	82 ft.	8/11/83
SWL* BELOW LSD	64 ft.	8/11/83
YIELD IN GPM	7	8/11/83
WATER TEMP. °C	12	10/8/83
SPECIFIC COND. at 25°C	352	10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

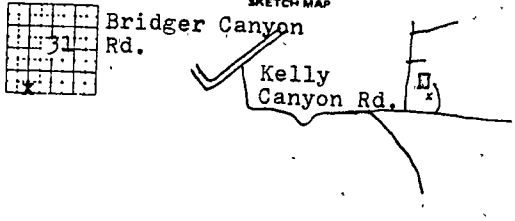
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	topsoil
3	10	dry clay
10	33	soft red shale
33	35	hard gray shale
35	45	hard red shale
45	50	some softer shale
50	62	sandstone-some water
62	74	hard gray shale
74	98	softer gray shale
98	103	red shale
103	106	red sand
106	157	soft shale
157	164	hard sandstone
164	176	softer sandstone
176	192	gray shale
192	198	blue shale
198	207	soft red shale
207	212	hard sandstone
212	220	some softer gray shale
220	250	red shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 ~~XX~~ E or W SEC. 31 TRACT DBAC*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Philip and Nancy Davis ADDRESS 15037 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-1311 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5360 ft.
TOTAL DEPTH BELOW LSD 135 ft.
PUMPING LEVEL BELOW LSD 112 ft.
STATIC WATER LEVEL* BELOW LSD 77 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 135 ft.
4 in. FROM 115 ft. TO 135 ft.
CASING TYPE steel
PERFORATED INTERVAL 115 ft. TO 135 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. 4inch plastic XXXX w/ 1/16 in
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED June 16, 1980
HOW DRILLED cable
BY WHOM VanDyken LIC. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 12, 1983

		DATE
MEAS. POINT ABOVE LSD	2.1 ft.	
TOTAL DEPTH BELOW LSD	135 ft.	8/12/83
PUMPING LEVEL BELOW LSD	85 ft.	8/12/83
SWL* BELOW LSD	78 ft.	8/12/83
YIELD IN GPM	15	8/12/83
WATER TEMP. °C	10	10/8/83
SPECIFIC COND. at 25°C	290	10/8/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

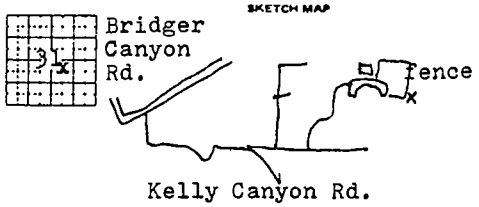
*F = FLOWING

MBMG Form 132 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	topsoil
3	12	soft clay
12	31	soft red shale with hard broken-up shale in places
31	43	soft grey shale with hard broken-up layers
43	57	med. hard broken-up shale
57	77	med. hard shale
77	90	red shale- sandy shale-hard
90	105	very hard shale
105	112	hard shale
112	135	very hard shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 31 TRACT DCBC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Gary and Pat Brown ADDRESS 15035 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-2818 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5320 ft.
TOTAL DEPTH BELOW LSD 110 ft.
PUMPING LEVEL BELOW LSD 65 ft.
STATIC WATER LEVEL* BELOW LSD 54 ft.
YIELD IN GALLONS PER MIN. 25
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 18 ft.
5 in. FROM 18 ft. TO 110 ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Nov. 3, 1980
HOW DRILLED cable
BY WHOM Haggerty Drilling LIC. 353
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 24, 1983

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	10	6/24/83
SPECIFIC COND. at 25°C	294	6/24/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH: 6.85

REMARKS: owner will not permit well opening

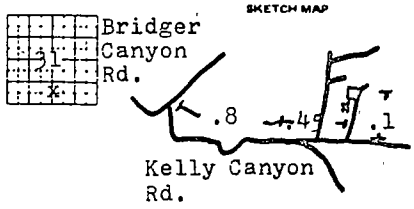
*F = FLOWING

MBMG Form 182 (S/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	clay
20	55	clay rock mix
55	110	Livingston Formation

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 31 TRACT DDCD*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Ron and Judy Burgess ADDRESS 10532 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-0917 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5600 ft.
TOTAL DEPTH BELOW LSD 179 ft.
PUMPING LEVEL BELOW LSD 104 ft.
STATIC WATER LEVEL* BELOW LSD 94 ft.
YIELD IN GALLONS PER MIN. 25
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 79 ft.
4 in. FROM 0 ft. TO 179 ft.
CASING TYPE steel and plastic
PERFORATED INTERVAL 160 ft. TO 179 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. 1/16 inch slots
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED April 12, 1969
HOW DRILLED cable
BY WHOM VanDyken LIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 12, 1983

			DATE
MEAS. POINT ABOVE LSD	0.4	ft.	
TOTAL DEPTH BELOW LSD	179	ft.	8/12/83
PUMPING LEVEL BELOW LSD	145	ft.	8/12/83
SWL* BELOW LSD	100	ft.	8/12/83
YIELD IN GPM	7		8/12/83
WATER TEMP. °C	19		10/12/83
SPECIFIC COND. at 25°C	260		10/12/83

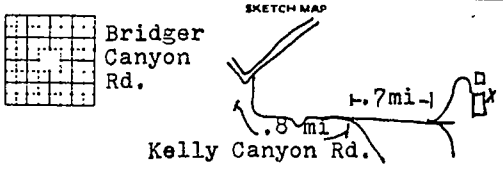
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DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	boulders and clays
20	74	dark red shales and boulders
74	97	dark red shales-dry
97	131	dark grey shales-dry
131	178	dark red shales-dry
178	179	soft sandstone-water



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ XX S R. 7 E ~~or W~~ XX SEC. 33 TRACT AABA*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION Aspen Meadow BLOCK ____ LOT ____

OWNER'S NAME Jerry Coffey ADDRESS Jackson Creek Road

Bozeman, MT 59715 PHONE NUMBER 587-9494 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5720 ft.
TOTAL DEPTH BELOW LSD 72 ft.
PUMPING LEVEL BELOW LSD 30 ft.
STATIC WATER LEVEL* BELOW LSD 30 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 60 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED May 24, 1978
HOW DRILLED forward rotary
BY WHOM Hillman Drilling LIC. 258
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 16, 1983

			DATE
MEAS. POINT ABOVE LSD	1.7	ft.	
TOTAL DEPTH BELOW LSD	72	ft.	8/16/83
PUMPING LEVEL BELOW LSD	30	ft.	8/16/83
SWL* BELOW LSD	27	ft.	8/16/83
YIELD IN GPM	9		8/16/83
WATER TEMP. °C	9		9/16/83
SPECIFIC COND. at 25° C	430		9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

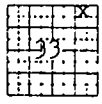
*F = FLOWING

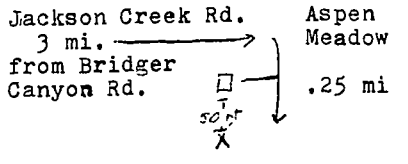
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	clay
20	60	blue shale
60	72	red shale

SKETCH MAP





MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 ~~XX~~ E or W SEC. 33 TRACT AACB*

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION Aspen Meadows BLOCK ____ LOT ____

OWNER'S NAME James and Sue Brown ADDRESS 4738 Meadow Lane

Bozeman, MT 59715 PHONE NUMBER 587-3092 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5780 ft.
TOTAL DEPTH BELOW LSD 180 ft.
PUMPING LEVEL BELOW LSD 160 ft.
STATIC WATER LEVEL* BELOW LSD 24 ft.
YIELD IN GALLONS PER MIN. 9
HOW TESTED air TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 60 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED June 27.1978
HOW DRILLED forward rotary
BY WHOM Hillman Drilling LIC. 258
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 16, 1983

		DATE
MEAS. POINT ABOVE LSD	1.6 ft.	
TOTAL DEPTH BELOW LSD	180 ft.	8/16/83
PUMPING LEVEL BELOW LSD	49 ft.	8/16/83
SWL* BELOW LSD	40 ft.	8/16/83
YIELD IN GPM	7	8/16/83
WATER TEMP. °C	10	9/16/83
SPECIFIC COND. at 25°C	285	9/16/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

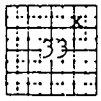
REMARKS ____

*F = FLOWING
MBMG Form 182 (9/79)

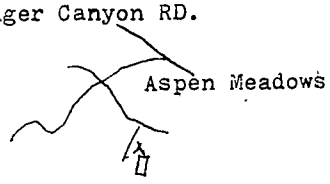
LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	50	clay
50	90	shale-blue
90	95	red shale
95	160	blue shale
160	170	red shale
170	175	blue clay
175	180	blue shale

SKETCH MAP



Jackson Creek Rd. 3 mi from Bridger Canyon RD.



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ S R. 7 E ~~W~~ SEC. 33 TRACT CAAB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION Aspen Meadows BLOCK LOT

OWNER'S NAME Warren D. Bellcour ADDRESS 4774 Aspen Lane

Bozeman, MT 59715 PHONE NUMBER 587-5652 YEAR 1983

ALT. LAND SURF. AT WELL MSL 6150 ft.
TOTAL DEPTH BELOW LSD 265 ft.
PUMPING LEVEL BELOW LSD 260 ft.
STATIC WATER LEVEL* BELOW LSD 60 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED air TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 75 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP) TYPE
DATE WELL COMPLETED June 26, 1979
HOW DRILLED forward rotary
BY WHOM Hillman Drilling LIC. 361
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 19, 1983

		DATE
MEAS. POINT ABOVE LSD	1.9 ft.	
TOTAL DEPTH BELOW LSD	265 ft.	8/19/83
PUMPING LEVEL BELOW LSD	117 ft.	8/19/83
SWL* BELOW LSD	84 ft.	8/19/83
YIELD IN GPM	13	8/19/83
WATER TEMP. °C	7	9/16/83
SPECIFIC COND. at 25°C	272	9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

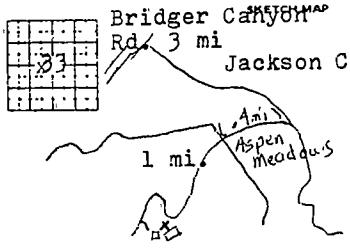
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	74	shale and sandstone layers
74	85	hard sandstone
85	165	clay varies soft to hard- different colors, changed rapidly
165	183	soft sandstone
183	188	sandstone-a little harder
188	201	soft sandstone-almost clay-like
201	265	shale-clay

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 33 TRACT CDAD*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Robert and Mary Jacobs ADDRESS 4762 Aspen Lane

Bozeman, MT. 59715 PHONE NUMBER 586-5780 YEAR 1983

ALT. LAND SURF. AT WELL MSL 6250 ft.
TOTAL DEPTH BELOW LSD * 183 ft.
PUMPING LEVEL BELOW LSD 35 ft.
STATIC WATER LEVEL* BELOW LSD 22 ft.
YIELD IN GALLONS PER MIN. 8
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O landslide on Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 183 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL 39½ ft. TO 41 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. ¼ inch slots
PUMP SIZE (HP.) ½ TYPE
DATE WELL COMPLETED Oct. 2, 1980
HOW DRILLED cable
BY WHOM VanDyken Drilling LIC. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 19, 1983

		DATE
MEAS. POINT ABOVE LSD	1.2 ft.	
TOTAL DEPTH BELOW LSD	41 ft.	8/19/83
PUMPING LEVEL BELOW LSD	25 ft.	8/19/83
SWL* BELOW LSD	23 ft.	8/19/83
YIELD IN GPM	5	8/19/83
WATER TEMP. °C	7	9/16/83
SPECIFIC COND. at 25°C	445	9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

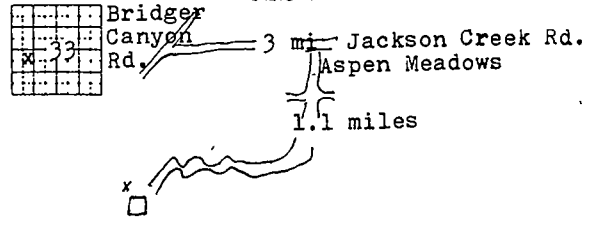
REMARKS: * well plugged from 41 to 183 feet

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	top soil
10	29	hard broken-up shale & clay
29	31	hard rock
31	39	soft shale & clay
39	41	hard broken-up shale
		30 gpm water-dirty
41	43	sandy shale-some hard shale
43	56	soft grey shale
56	59	hard grey shale
59	78	med hard grey shale
78	88	hard grey shale
88	95	broken-up hard shale
95	103	med hard shale
103	106	soft sticky shale
106	123	hard shale
123	125	med hard grey shale
125	129	hard shale-grey
129	183	med shale-grey

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ S R. 7 E ~~or W~~ SEC. 34 TRACT BBBD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME R. J. Johnson ADDRESS 4646 Jackson Creek Rd.

Bozeman, MT 59715 PHONE NUMBER 587-0556 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5700 ft.
TOTAL DEPTH BELOW LSD 80 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 5 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 20 ft.
4 in. FROM 17 ft. TO 80 ft.
CASING TYPE welded steel and plastic
PERFORATED INTERVAL 55 ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. 55feet
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED June 12, 1976
HOW DRILLED cable
BY WHOM Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Nov. 4, 1983

		DATE
MEAS. POINT ABOVE LSD	2.4 ft.	
TOTAL DEPTH BELOW LSD	80 ft.	11/4/83
PUMPING LEVEL BELOW LSD	35 ft.	11/4/83
SWL* BELOW LSD	11 ft.	11/4/83
YIELD IN GPM	10	11/4/83
WATER TEMP. °C	7	11/4/83
SPECIFIC COND. at 25°C	310	11/4/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: H_2S smell

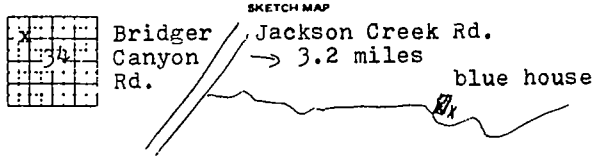
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	13	topsoil
13	21	brown clay
21	80	shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 34 TRACT BBBD*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Jane VanAlstyne ADDRESS 4424 Jackson Creek Rd.

Bozeman, MT 59715 PHONE NUMBER 586-5751 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5720 ft.
TOTAL DEPTH BELOW LSD 82 ft.
PUMPING LEVEL BELOW LSD 82 ft.
STATIC WATER LEVEL* BELOW LSD 60 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED pump TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 82 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE welded steel
PERFORATED INTERVAL ___ ft. TO ___ ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC.
PUMP SIZE (HP.) ___ TYPE
DATE WELL COMPLETED Sept. 22, 1973
HOW DRILLED cable
BY WHOM Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ___
DRILLER X OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 19, 1983

			DATE
MEAS. POINT ABOVE LSD	1.7	ft.	
TOTAL DEPTH BELOW LSD	82	ft.	8/19/83
PUMPING LEVEL BELOW LSD	61	ft.	8/19/83
SWL* BELOW LSD	58	ft.	8/19/83
YIELD IN GPM	8		8/19/83
WATER TEMP. °C	9		9/16/83
SPECIFIC COND. at 25°C	490		9/16/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

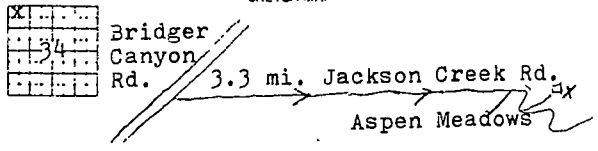
REMARKS:

*F = FLOWING

MBMG Form 182 (9/70)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 XX N or S R. 6 E or W XX SEC. 1 TRACT ABBB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Rod and Nore Brunner ADDRESS 15507 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-2823 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5130 ft.
TOTAL DEPTH BELOW LSD 122 ft.
PUMPING LEVEL BELOW LSD 122 ft.
STATIC WATER LEVEL* BELOW LSD 40 ft.
YIELD IN GALLONS PER MIN. 10
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 35 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. 1/16 X 1 inch slots
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED July 14, 1964
HOW DRILLED churn drill
BY WHOM Wilton E. Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 27, 1983

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM	12	6/27/83
WATER TEMP. °C	10	6/27/83
SPECIFIC COND. at 25°C	418	6/27/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER: pH: 7.25

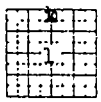
REMARKS: well is completely buried behind back porch

*F = FLOWING

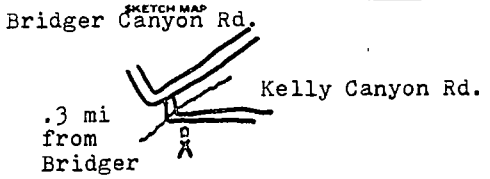
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	64	clay
64	122	shale



SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 N R. 6 E SEC. 12 TRACT CCBD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Bruce Rea ADDRESS 2255 Sawmill Rd.

Bozeman, MT PHONE NUMBER 587-4753 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5100 ft.
TOTAL DEPTH BELOW LSD 400 ft.
PUMPING LEVEL BELOW LSD 400 ft.
STATIC WATER LEVEL* BELOW LSD 110 ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 60 ft.
4½ in. FROM 40 ft. TO 400 ft.
CASING TYPE steel to 60', PVC 40-400
PERFORATED INTERVAL 340 ft. TO 400 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. ½inch
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Oct. 17, 1981
HOW DRILLED forward rotary
BY WHOM Hillman Drilling LIC. 258
WELL USE domestic/stock
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-9-83
MEAS. POINT ABOVE LSD 2.7 ft. DATE
TOTAL DEPTH BELOW LSD 400 ft.
PUMPING LEVEL BELOW LSD 77.1 ft. 8/9/83
SWL* BELOW LSD 46.9 ft. 8/9/83
YIELD IN GPM 9.7 8/9/83
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: crooked hole (word of mouth)

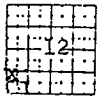
*F = FLOWING

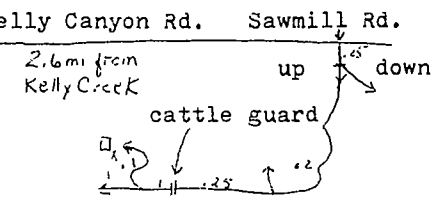
MBMG Form 192 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	50	hard shale
50	400	hard blue shale
		water at 160 feet
		dry at 400 feet

SKETCH MAP





MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N ~~OR S~~ R. 7 E ~~OR W~~ SEC. 6 TRACT AADC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT 7

OWNER'S NAME Tim McKubbins ADDRESS 15047 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-9443 YEAR 1983

ALT. LAND SURF. AT WELL MSL 6170 ft.
TOTAL DEPTH BELOW LSD 488 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 200 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED air TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 74 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Aug., 1979
HOW DRILLED forward rotary
BY WHOM Hillman Drilling LIC. 258
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug.10, 1983
MEAS. POINT ABOVE LSD 0.2 ft. DATE
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD ft.
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

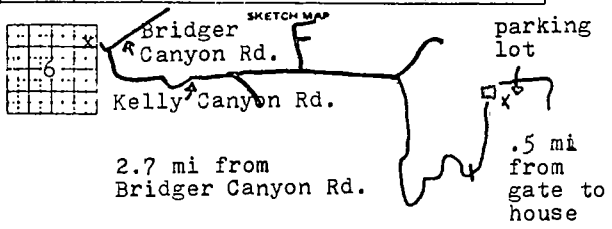
REMARKS: water level below tape length-297.7

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	36	sandstone and clay
36	42	sandstone
42	70	clay
70	110	Sandy-siltstone-hard
110	130	clay and shale-blue
130	147	sandstone-hard
147	153	clay-grey
153	194	gray sandstone with clay
194	226	brittle sandstone and clay
226	350	gray sandstone and clay
350	362	red sandstone - hard
362	367	red clay
367	375	blue sandstone and clay
375	396	red sandstone and clay
396	407	blue shale with clay traces
407	412	blue clay with a little rock
412	417	gray shale-brittler dulls-fine
417	422	red shale with clay-wet
422	488	gray shale-hard
		this well was originally drilled to 600 feet, the lower part caved-in and was left closed by the driller

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 XX N or S R. 7 E or W XX SEC. 6 TRACT ABDA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME William and Jean Terry ADDRESS 15040 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-0975 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5500 ft.
TOTAL DEPTH BELOW LSD 250 ft.
PUMPING LEVEL BELOW LSD 240 ft.
STATIC WATER LEVEL* BELOW LSD 140 ft.
YIELD IN GALLONS PER MIN. 7
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 250 ft.
— in. FROM — ft. TO — ft.
CASING TYPE steel and plastic
PERFORATED INTERVAL — ft. TO — ft.
— ft. TO — ft.
— ft. TO — ft.
PERFORATION DESC. slots
PUMP SIZE (HP.) — TYPE
DATE WELL COMPLETED Sept. 17, 1976
HOW DRILLED cable
BY WHOM VanDyken LIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP. —
DRILLER X OWNER — USGS — SCS —
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 10, 1983

		DATE
MEAS. POINT ABOVE LSD	1.6 ft.	
TOTAL DEPTH BELOW LSD	250 ft.	8/10/83
PUMPING LEVEL BELOW LSD	69 ft.	8/10/83
SWL* BELOW LSD	68 ft.	8/10/83
YIELD IN GPM	4	8/10/83
WATER TEMP. °C	12	10/12/83
SPECIFIC COND. at 25°C	340	10/12/83

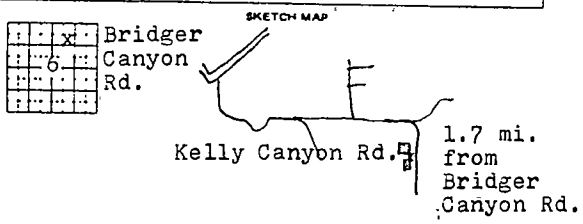
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER.

REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	35	clay
35	45	red clay
45	47	hard red shale
47	59	softer red shale
59	65	hard red shale
65	70	very hard red shale
70	95	soft red shale-2gpm @ 70 ft
95	123	grey shale
123	125	red sandy shale
125	130	gray shale
130	142	shale
142	172	tight sand
172	177	clay and sand
177	226	red shale 5gpm @ 197 ft.
226	250	grey shale 7gpm @ 222 ft.



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 6 TRACT ACDB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Emily Stonington ADDRESS 15042 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-1713 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5580 ft.
TOTAL DEPTH BELOW LSD 210 ft.
PUMPING LEVEL BELOW LSD 202 ft.
STATIC WATER LEVEL* BELOW LSD 130 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 210 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL 170 ft. TO 210 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. 1/16 inch slots
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED July 3, 1979
HOW DRILLED cable
BY WHOM VanDyken LIC. 306
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 15, 1983

		DATE
MEAS. POINT ABOVE LSD	1.1 ft.	
TOTAL DEPTH BELOW LSD	196 ft.	8/15/83
PUMPING LEVEL BELOW LSD	142 ft.	8/15/83
SWL* BELOW LSD	120 ft.	8/15/83
YIELD IN GPM	20	8/15/83
WATER TEMP. °C	11	10/12/83
SPECIFIC COND at 25°C	270	10/12/83

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

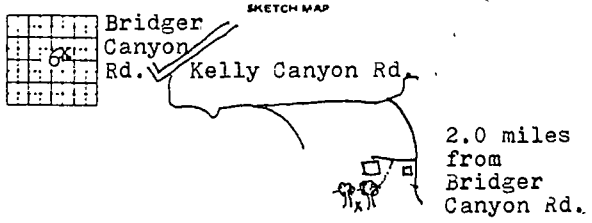
REMARKS: ____

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	32	soft brown shale
32	83	hard shale
83	90	some softer shale, little water
90	112	soft shale
112	121	shale-some harder
121	125	hard shale
125	140	softer shale
140	155	hard shale
155	168	very hard shale
168	185	hard shale
185	191	very hard shale, water
191	210	medium hard shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 6 TRACT BBAB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Stan Bambauer ADDRESS 15044 Kelly Canyon Rd.

Bozeman, MT PHONE NUMBER 587-5069 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5210 ft.
TOTAL DEPTH BELOW LSD 70 ft.
PUMPING LEVEL BELOW LSD 30 ft.
STATIC WATER LEVEL* BELOW LSD 28 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 25 ft.
4 in. FROM 10 ft. TO 70 ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 8-31-79
HOW DRILLED cable
BY WHOM Haggerty Drilling LIC. 353
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED 8-12-83

			DATE
MEAS. POINT ABOVE LSD	1.25	ft.	
TOTAL DEPTH BELOW LSD	74.2	ft.	8/12/83
PUMPING LEVEL BELOW LSD	55.4	ft.	8/12/83
SWL* BELOW LSD	25.7	ft.	8/12/83
YIELD IN GPM	10		8/12/83
WATER TEMP. °C	13		10/ 8/83
SPECIFIC COND at 25°C	470		10/ 8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: originally drilled for Authority Builders

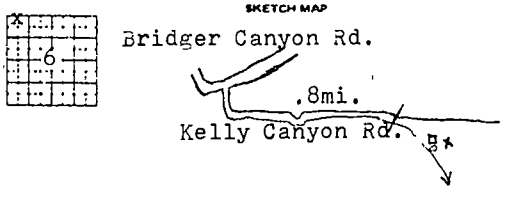
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	7	overburden
7	12	consolidated(shale w/ ss)*
12	29	shale
29	70	shale with sandstone
		*ss means sandstone

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 XX N&S R. 7 E&W XX SEC. 6 TRACT BCAD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Ladd and Bonnie Rutherford ADDRESS 14541 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 587-9053 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5270 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O alluvium and Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 21, 1983

		DATE
MEAS POINT ABOVE LSD	1.63 ft.	
TOTAL DEPTH BELOW LSD	97 ft.	8/21/83
PUMPING LEVEL BELOW LSD	49 ft.	8/21/83
SWL* BELOW LSD	42 ft.	8/21/83
YIELD IN GPM	7	8/21/83
WATER TEMP. °C	11	10/8/83
SPECIFIC COND. at 25°C	190	10/8/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

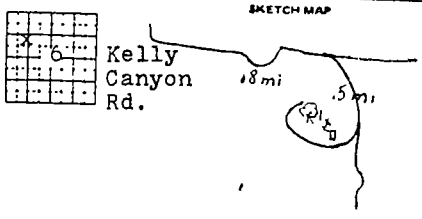
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		none available

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N or S R. 7 E ~~XX~~ W SEC. 6 TRACT BCBC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Henry VanderVos ADDRESS 14543 Kelly Canyon Rd.

Bozeman, MT PHONE NUMBER 587-1307 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5320 ft.
TOTAL DEPTH BELOW LSD 299 ft.
PUMPING LEVEL BELOW LSD 275 ft.
STATIC WATER LEVEL* BELOW LSD 180 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED Air TIME (HR.) 2
IF F, SHUT-IN PRESS IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL 220 ft. TO 282 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC. ¼ X 6 slots
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED November 3, 1971
HOW DRILLED Rotary
BY WHOM VanDyken LIC. 1
WELL USE domestic
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 27, 1983

		DATE
MEAS. POINT ABOVE LSD	1.1 ft.	
TOTAL DEPTH BELOW LSD	299 ft.	6/27/83
PUMPING LEVEL BELOW LSD	185 ft.	6/27/83
SWL* BELOW LSD	158 ft.	6/27/83
YIELD IN GPM	5	6/27/83
WATER TEMP. °C	11	6/27/83
SPECIFIC COND. at 25° C	223	6/27/83

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER: pH: 8.25

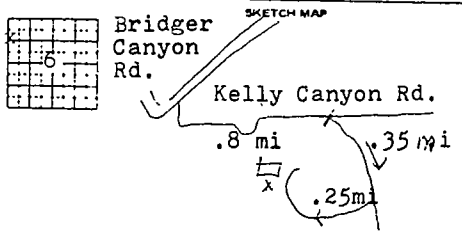
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	6	clays
6	9	hard black rock
9	33	hard red shales
33	67	hard gray shale
67	85	hard red shales
85	89	hard gray shales
89	220	Hard and soft lenses gray and red shales
220	221	hard gray shale-3gpm water
221	280	red hard shales-2gpm water at 280
280	299	lt. green quartzite rock-dry



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 XX N or S R. 7 E or W XX SEC. 6 TRACT CCDC

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN Bozeman SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME A.F. Geis ADDRESS 13870 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-2878 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5320 ft.
TOTAL DEPTH BELOW LSD 80 ft.
PUMPING LEVEL BELOW LSD 80 ft.
STATIC WATER LEVEL* BELOW LSD 32 ft.
YIELD IN GALLONS PER MIN. 8
HOW TESTED bailer TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM -5.8 ft. TO 80 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE steel
PERFORATED INTERVAL 20 ft. TO 75 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ½ x 4 inch slots
PUMP SIZE (HP.) ____ TYPE Johnston Water
DATE WELL COMPLETED Dec. 3, 1964
HOW DRILLED churn drill
BY WHOM M.E. Jones LIC. 17
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ____
DRILLER X OWNER ____ USGS ____ SCS ____
OTHER. ____

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 15, 1983

		DATE
MEAS. POINT ABOVE LSD	-5.8 ft.	
TOTAL DEPTH BELOW LSD	80 ft.	8/15/83
PUMPING LEVEL BELOW LSD	31 ft.	8/15/83
SWL* BELOW LSD	27 ft.	8/15/83
YIELD IN GPM	12	8/15/83
WATER TEMP. °C		
SPECIFIC COND at 25°C		

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

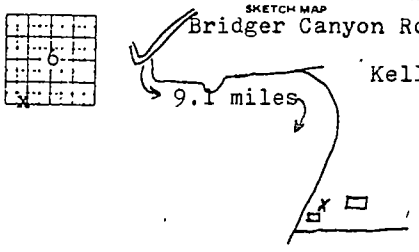
REMARKS: well located in well house below ground

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	1	topsoil
1	21	clay
21	80	shale



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N ~~or~~ S R. 7 E ~~or~~ W SEC. 6 TRACT CDAB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME John and Harriett Tamminga ADDRESS 14178 Kelly Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-1864 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5400 ft.
TOTAL DEPTH BELOW LSD 490 ft.
PUMPING LEVEL BELOW LSD 410 ft.
STATIC WATER LEVEL* BELOW LSD 120 ft.
YIELD IN GALLONS PER MIN. 12
HOW TESTED bailer TIME (HR.) 4
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation
CASING DIA. 5 in. FROM 0 ft. TO 490 ft.
— in. FROM — ft. TO — ft.
CASING TYPE steel
PERFORATED INTERVAL 425 ft. TO 485 ft.
casing torch 430 ft. TO 435 ft.
— ft. TO — ft.
PERFORATION DESC.
PUMP SIZE (HP.) 3 TYPE submersible
DATE WELL COMPLETED Oct. 9, 1978
HOW DRILLED cable
BY WHOM Herbert Potts LIC. 130
WELL USE domestic and stock
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER — USGS — SCS —
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 30, 1983

		DATE
MEAS. POINT ABOVE LSD	2.1 ft.	
TOTAL DEPTH BELOW LSD	490 ft.	8/30/83
PUMPING LEVEL BELOW LSD	184 ft.	8/30/83
SWL* BELOW LSD	139 ft.	8/30/83
YIELD IN GPM	10	8/30/83
WATER TEMP. °C		
SPECIFIC COND at 25°C		

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

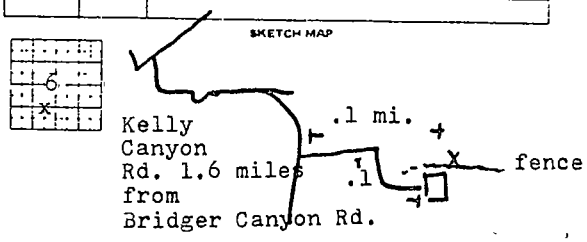
REMARKS:

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	clay
10	20	red shale
20	25	blue shale
25	30	red shale
30	40	blue shale
40	205	red shale
205	208	blue shale
208	250	red shale
250	253	blue shale
253	335	intermittent green and red shales
335	340	sandstones
340	375	shales
375	450	sandy shale
450	480	sandstone
480	490	sandy shales

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 XX E or W SEC. 17 TRACT CCBA*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Jerry Perkins ADDRESS 10281 Bridger Canyon R.

Bozeman, MT 59715 PHONE NUMBER 586-2730 YEAR 1983

ALT. LAND SURF AT WELL MSL 5320 ft.
TOTAL DEPTH BELOW LSD 72 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation- through Miner Creek Formation
CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 24, 1983
MEAS. POINT ABOVE LSD 1.4 ft. DATE
TOTAL DEPTH BELOW LSD 72 ft. 8/24/83
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 37 ft. 8/24/83
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

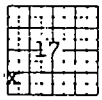
REMARKS: ABANDONED AND NEW WELL DRILLED TEN FEET AWAY, BUT DEEPER

*F = FLOWING

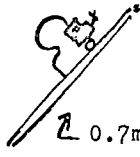
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	15	topsoil
15	40	sandy clay
40	55	sand
55	72	broken rock and shell



SKETCH MAP



Bridger Canyoln Rd.

0.7mi Jackson Creek Rd.

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 XX N or S R. 7 E or W XX SEC. 20 TRACT ADBB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Jane Newhall ADDRESS 7120 Jackson Creek Rd.

Bozeman, MT 59715 PHONE NUMBER 587-0218 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5450 ft.
TOTAL DEPTH BELOW LSD 46 ft.
PUMPING LEVEL BELOW LSD 42 ft.
STATIC WATER LEVEL* BELOW LSD 8.5 ft.
YIELD IN GALLONS PER MIN. 30
HOW TESTED pump TIME (HR.) 4
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O colluvium developed over Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 42 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED April 22, 1970
HOW DRILLED churn drill
BY WHOM Donald Jones LIC. 17
WELL USE domestic and stock
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED June 23, 1983
MEAS. POINT ABOVE LSD 1.2 ft. DATE
TOTAL DEPTH BELOW LSD ft. 6/23/83
PUMPING LEVEL BELOW LSD ft. 6/23/83
SWL* BELOW LSD ft. 6/23/83
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

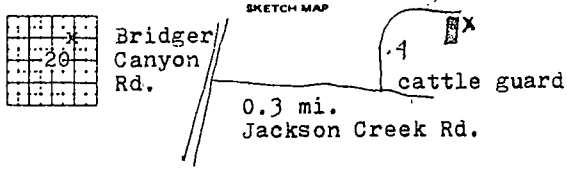
REMARKS: ABANDONED

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	26	clay
26	27	shale sand in clay
27	42 2/3	clay
42 2/3	46	shale gravel



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~N~~ S R. 7 E ~~W~~ SEC. 30 TRACT DDDB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Richard and Mickey Rosa ADDRESS 7900 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-5215 YEAR 1983

ALT. LAND SURF AT WELL MSL 5220 ft.
TOTAL DEPTH BELOW LSD 163 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 75 ft.
YIELD IN GALLONS PER MIN. 0.5
HOW TESTED bailer TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM 0 ft. TO 162 ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Sept. 24, 1979
HOW DRILLED cable
BY WHOM VanDyken LIC.
WELL USE Domestic
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 19, 1983
MEAS. POINT ABOVE LSD 1.7 ft. DATE
TOTAL DEPTH BELOW LSD 162 ft. 8/19/83
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 26 ft. 8/19/83
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: abandoned

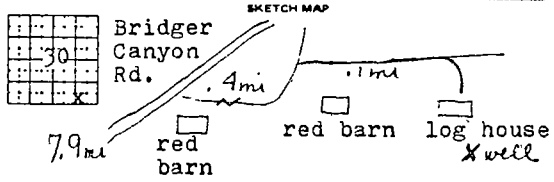
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	topsoil
2	45	shale
45	50	hard gray shale
50	68	firm shale-trace of water
68	69	gray color shale
69	87	hard purple shale
87	91	rust color shale
91	96	purple shale
96	98	hard gray ahale-tr. of water
98	112	firm purple shale
112	116	soft shale
116	143	firm purple shale
143	145	gray shale
145	163	purple shale

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 1 ~~XX~~ N or S R. 7 E or ~~XX~~ W SEC. 30 TRACT DDDB*

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Peter French and Carol Borden ADDRESS 7890 Bridger Canyon Rd.

Bozeman, MT 59715 PHONE NUMBER 586-1271 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5200 ft.
TOTAL DEPTH BELOW LSD 210 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 65 ft.
YIELD IN GALLONS PER MIN. 2
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFOPATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 31, 1983

		DATE
MEAS. POINT ABOVE LSD	2.03 ft.	
TOTAL DEPTH BELOW LSD	210 ft.	
PUMPING LEVEL BELOW LSD	ft.	8/31/83
SWL* BELOW LSD	21 ft.	8/31/83
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25°C		

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

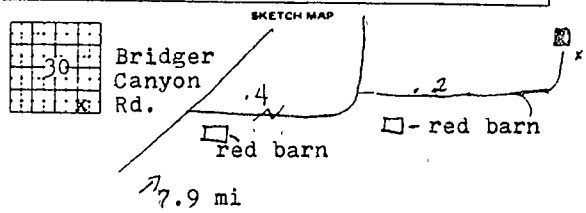
REMARKS: ABANDONED

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	topsoil
3	25	clay
25	65	overburden
65	210	Colorado Shale (driller misidentified Formation)

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 XX N or S R. 6 E or XX W SEC. 12 TRACT CDDB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Richard O. Dean (new? Bilyeu?) ADDRESS 1804 W. Babcock

Bozeman, MT 59715 PHONE NUMBER 587-3748 YEAR 1983

ALT. LAND SURF. AT WELL MSL 5150 ft.
TOTAL DEPTH BELOW LSD 133 ft.
PUMPING LEVEL BELOW LSD 123 ft.
STATIC WATER LEVEL* BELOW LSD 12 ft.
YIELD IN GALLONS PER MIN. 8
HOW TESTED bailer TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Hoppers Formation and Billman Creek Formation
CASING DIA. 6 in. FROM 0 ft. TO 20 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE welded steel
PERFORATED INTERVAL 20 ft. TO 133 ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC. ¼ inch slots
PUMP SIZE (HP.) ___ TYPE
DATE WELL COMPLETED July 25, 1978
HOW DRILLED cable
BY WHOM ___ LIC. 268
WELL USE domestic
SOURCE OF INFO: WELL APPROP. ___
DRILLER X OWNER ___ USGS ___ SCS ___
OTHER:

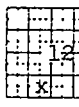
HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 9, 1983
MEAS. POINT ABOVE LSD 1.8 ft. DATE
TOTAL DEPTH BELOW LSD 133 ft. 8/9/83
PUMPING LEVEL BELOW LSD ___ ft.
SWL* BELOW LSD 14 ft. 8/9/83
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: not developed with pump

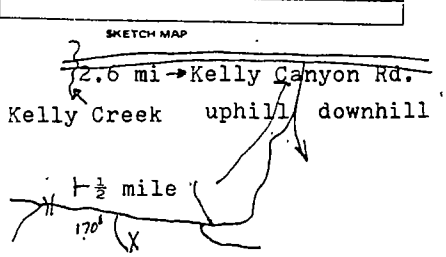
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	topsoil
4	33	loose shale and dirt mix
33	133	black shale



SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Gallatin T. 2 ~~XX~~ N ~~OR~~ S R. 7 E ~~OR~~ W SEC. 6 TRACT BCBC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN Bozeman SUBDIVISION BLOCK LOT

OWNER'S NAME Ladd and Bonnie Rutherford ADDRESS 14541 Kelly Canyon RD.

Bozeman, MT 59715 PHONE NUMBER 587-9053 YEAR 1983

ALT. LAND SURF. AT WELL MSL ~~5350~~ ft.
TOTAL DEPTH BELOW LSD 230 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Billman Creek Formation

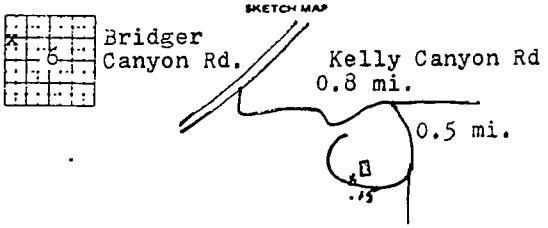
CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED yes
BY WHOM Bonnie Moore AGENCY MSU
DATE VERIFIED Aug. 21, 1983
MEAS. POINT ABOVE LSD 1.5 ft. DATE
TOTAL DEPTH BELOW LSD 195 ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 66 ft.
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS. ABANDONED

*F = FLOWING
MBMG Form 182 (9/79)

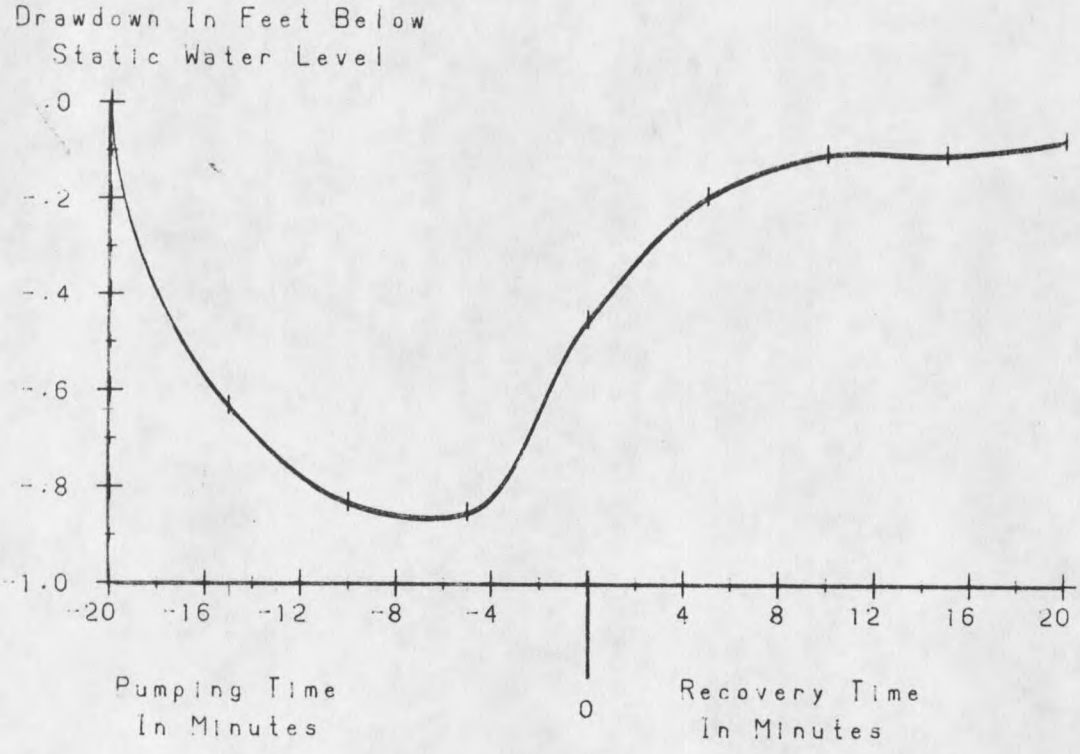
LITHOLOGIC LOG		
INTERVAL (FT.)		
FROM	TO	DESCRIPTION
		none available



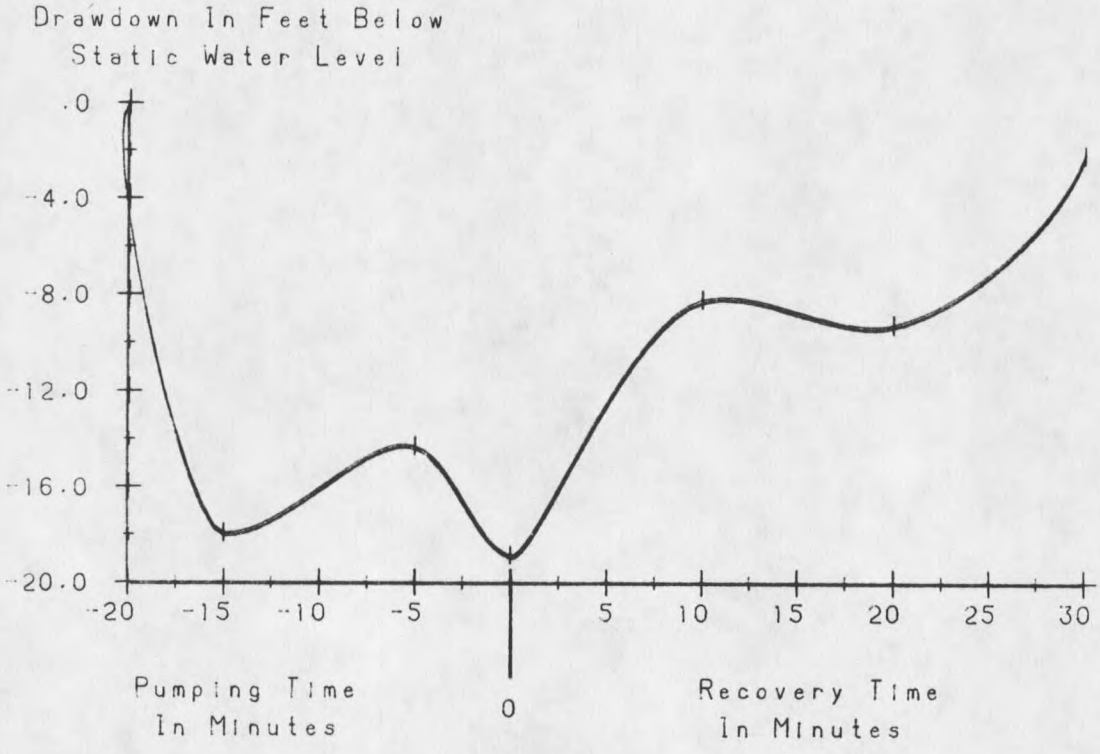
APPENDIX F

DRAWDOWN AND RECOVERY CURVES

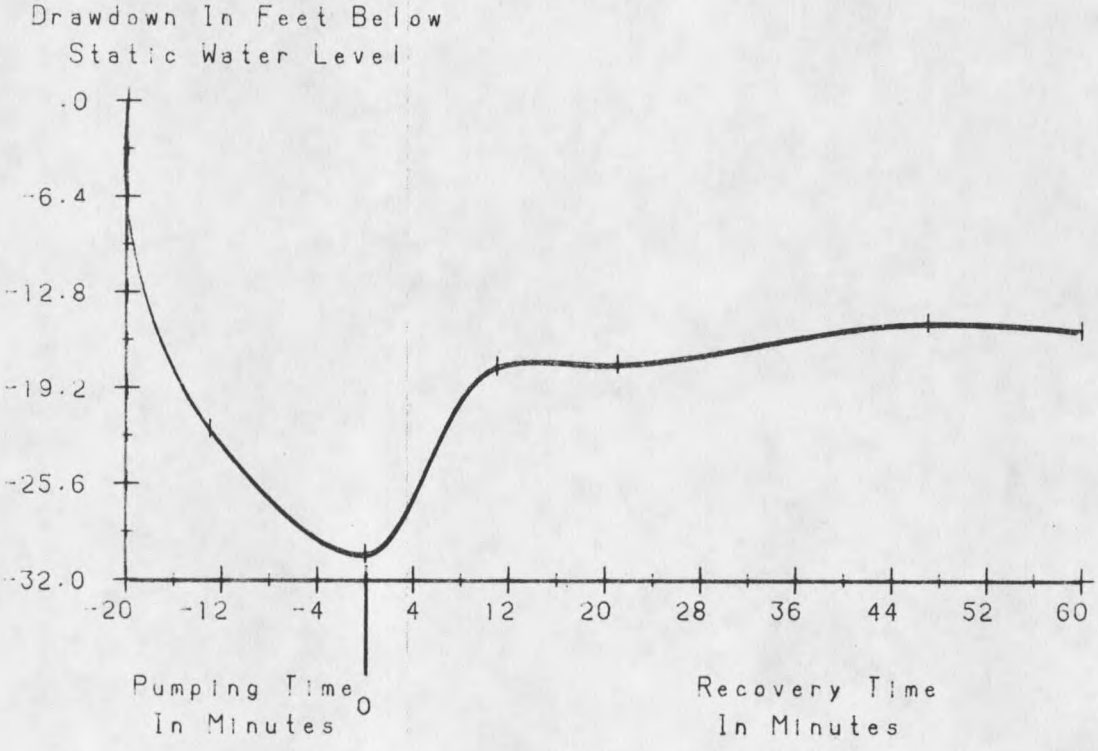
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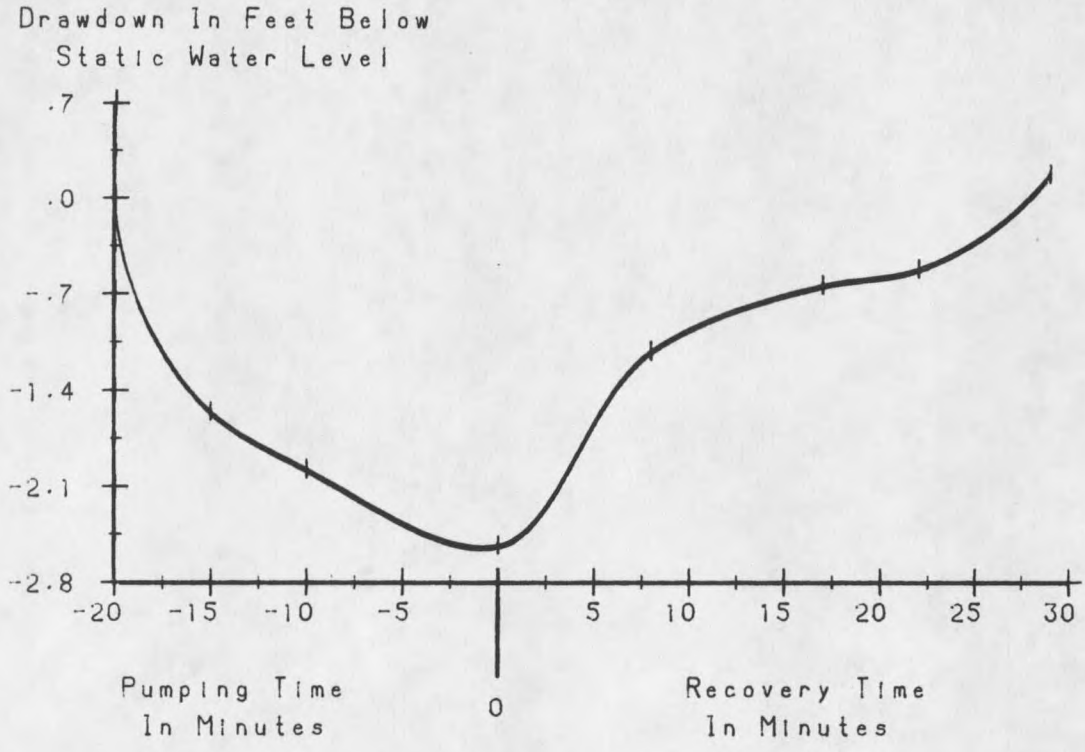
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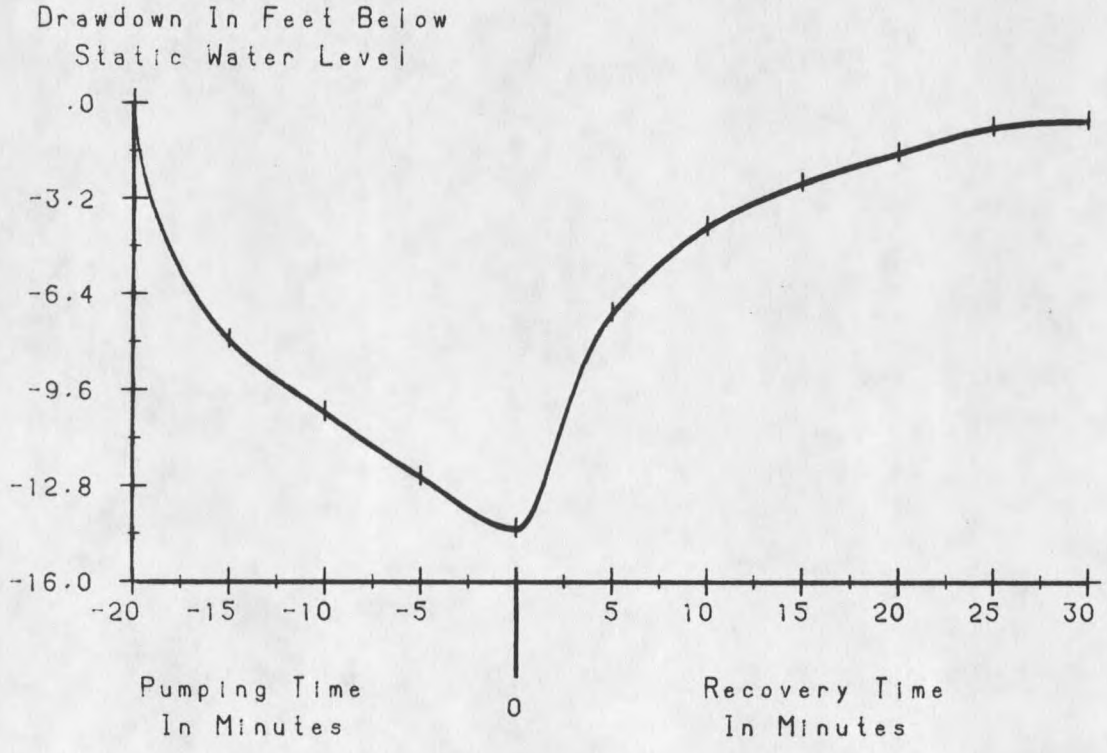
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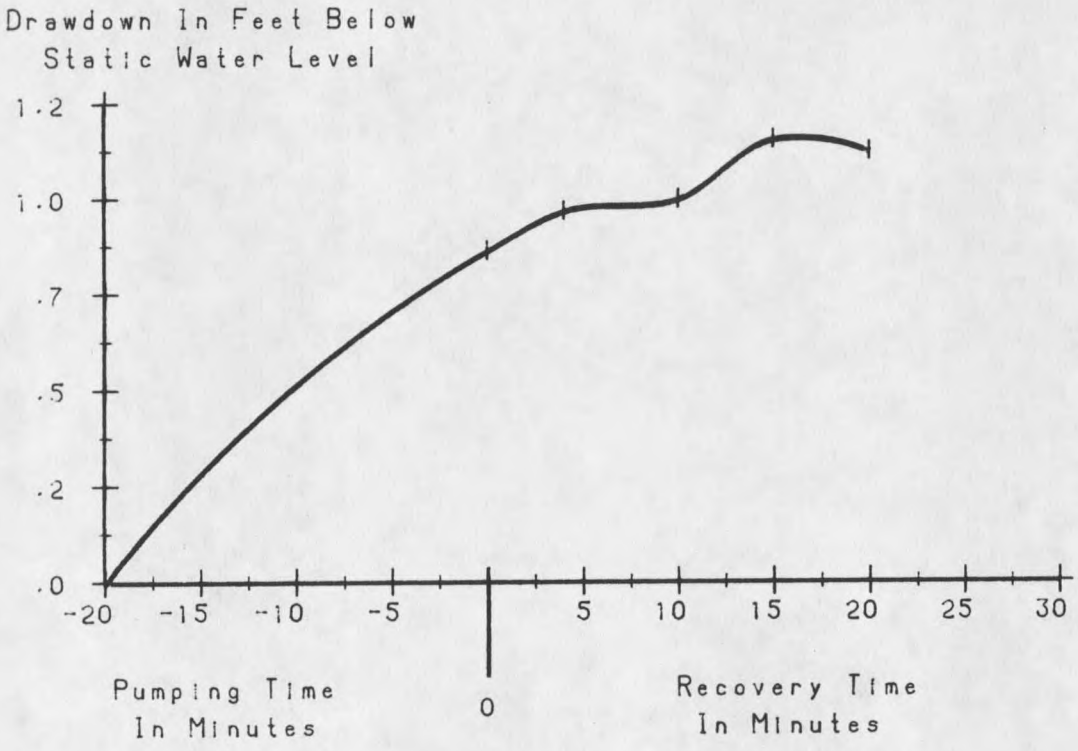
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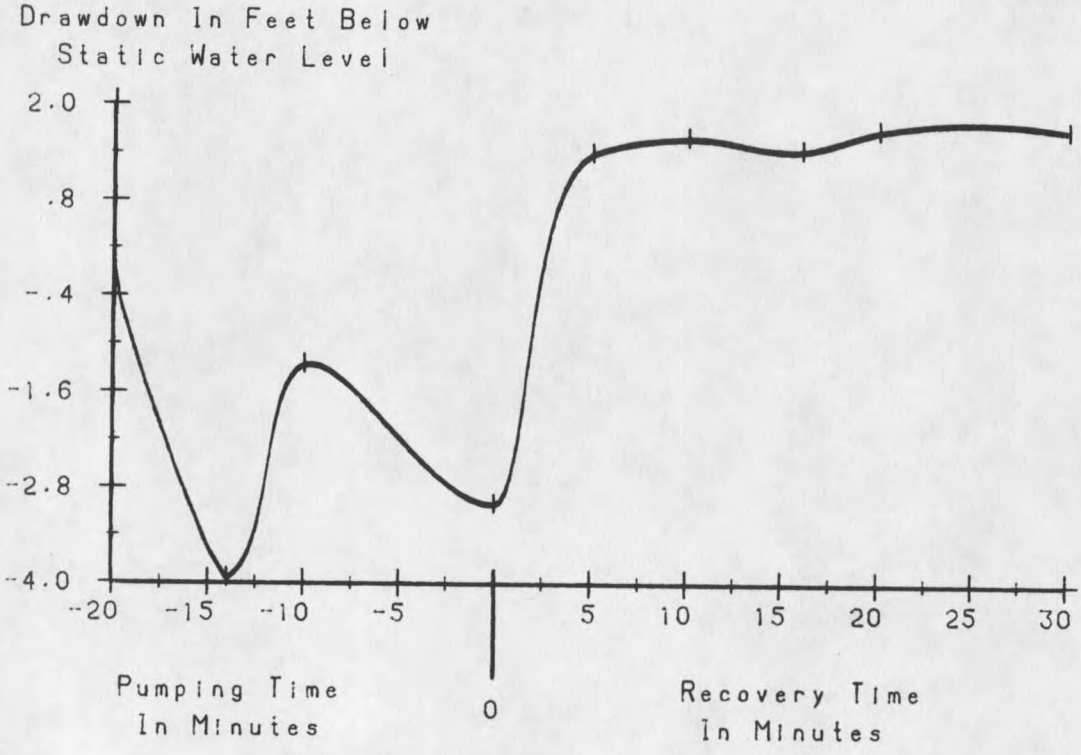
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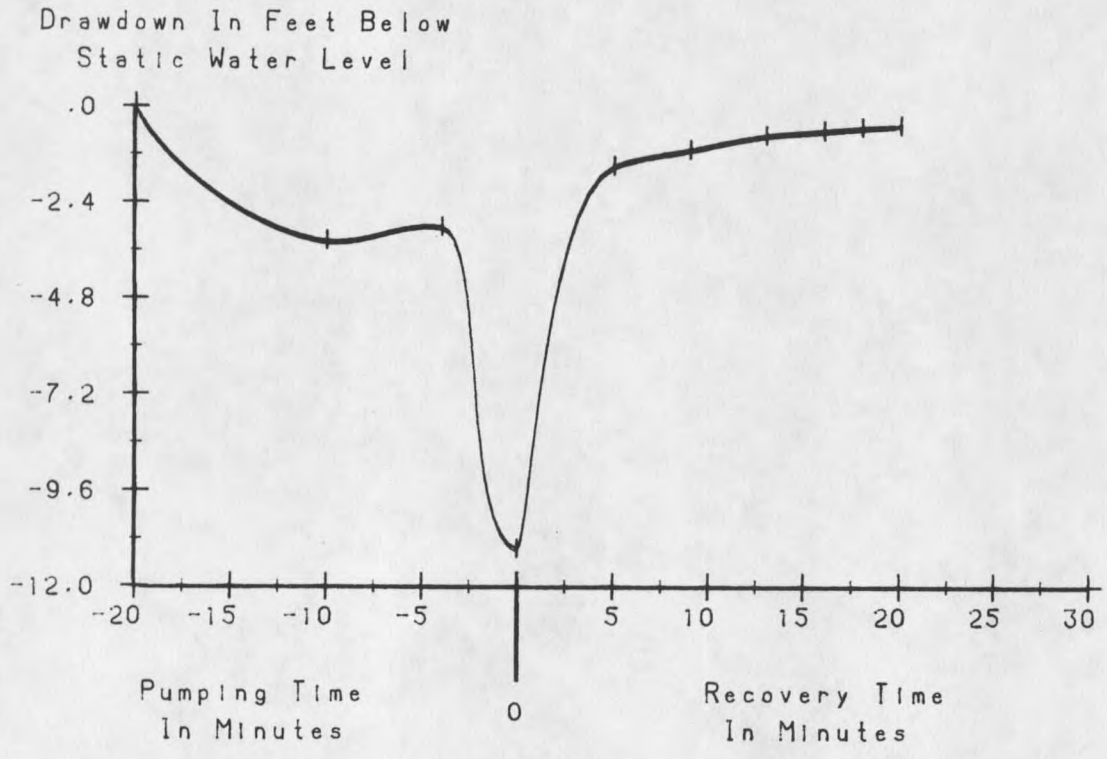
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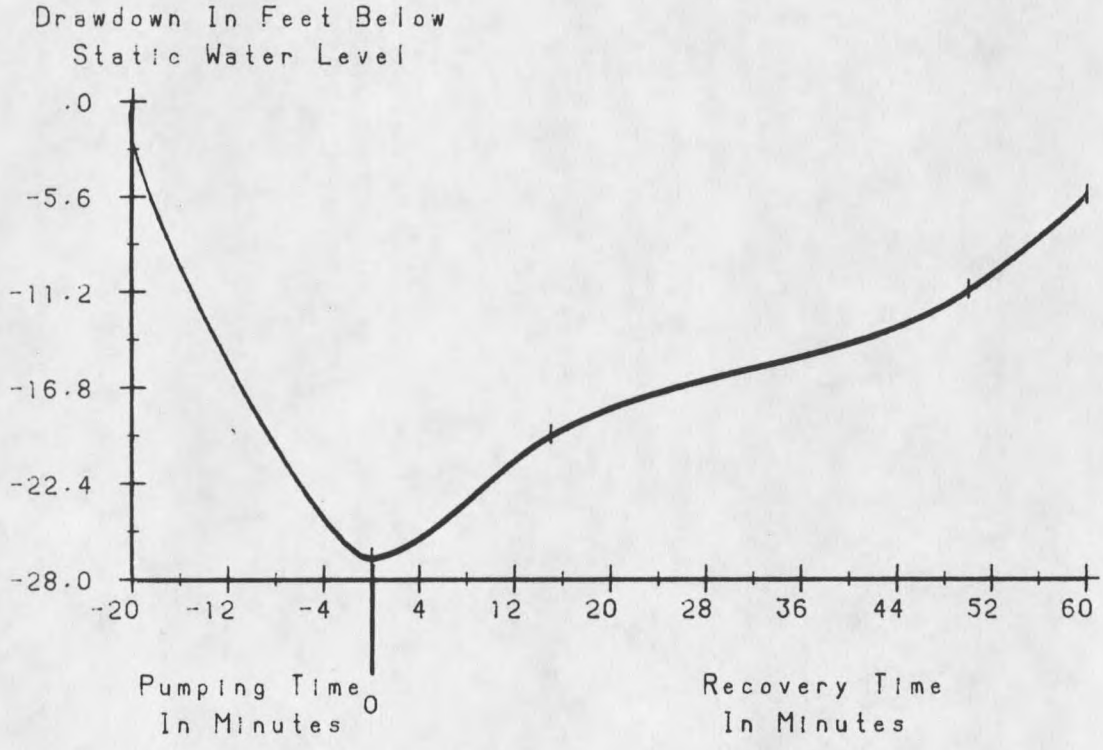
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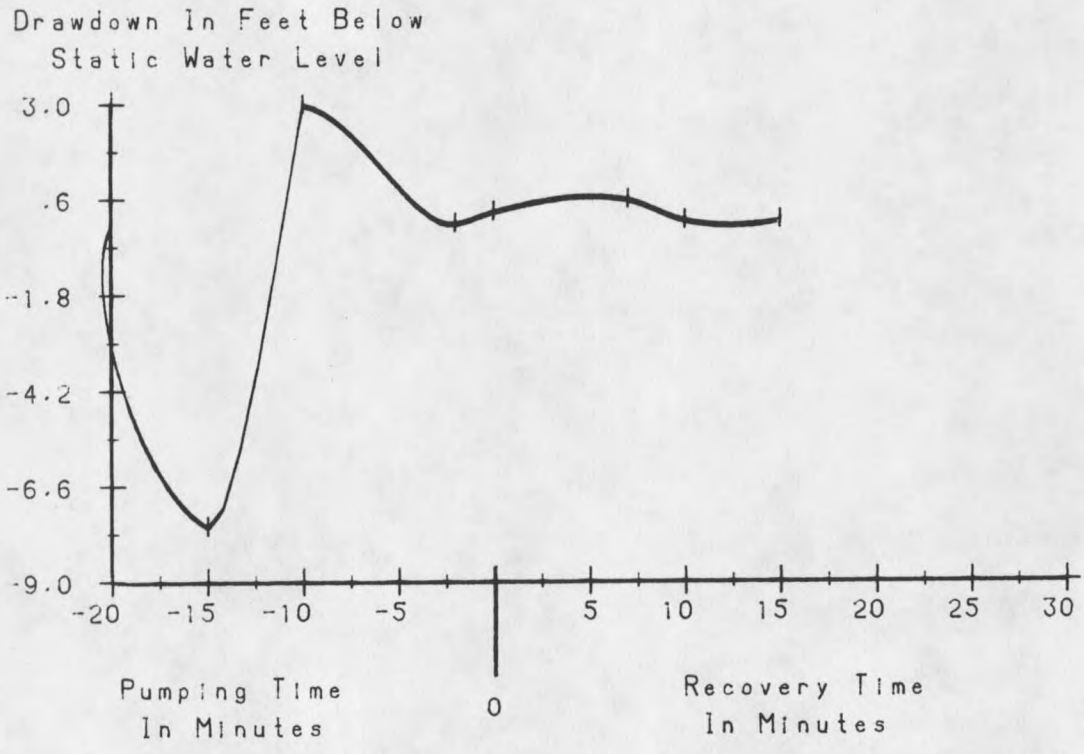
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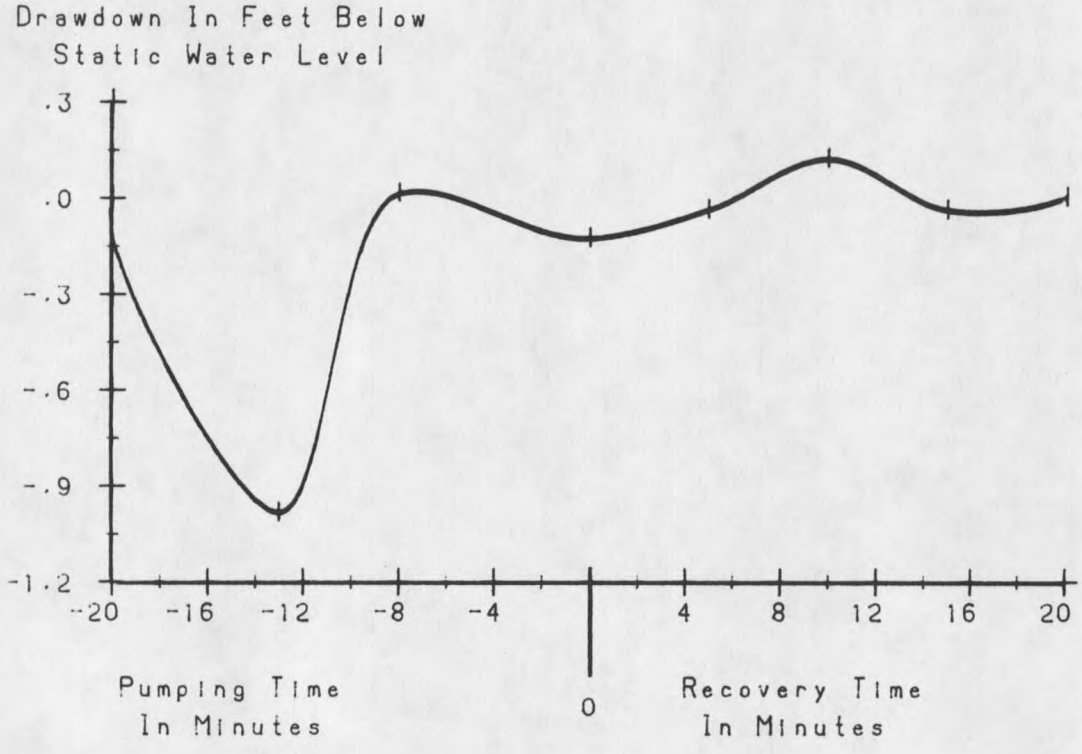
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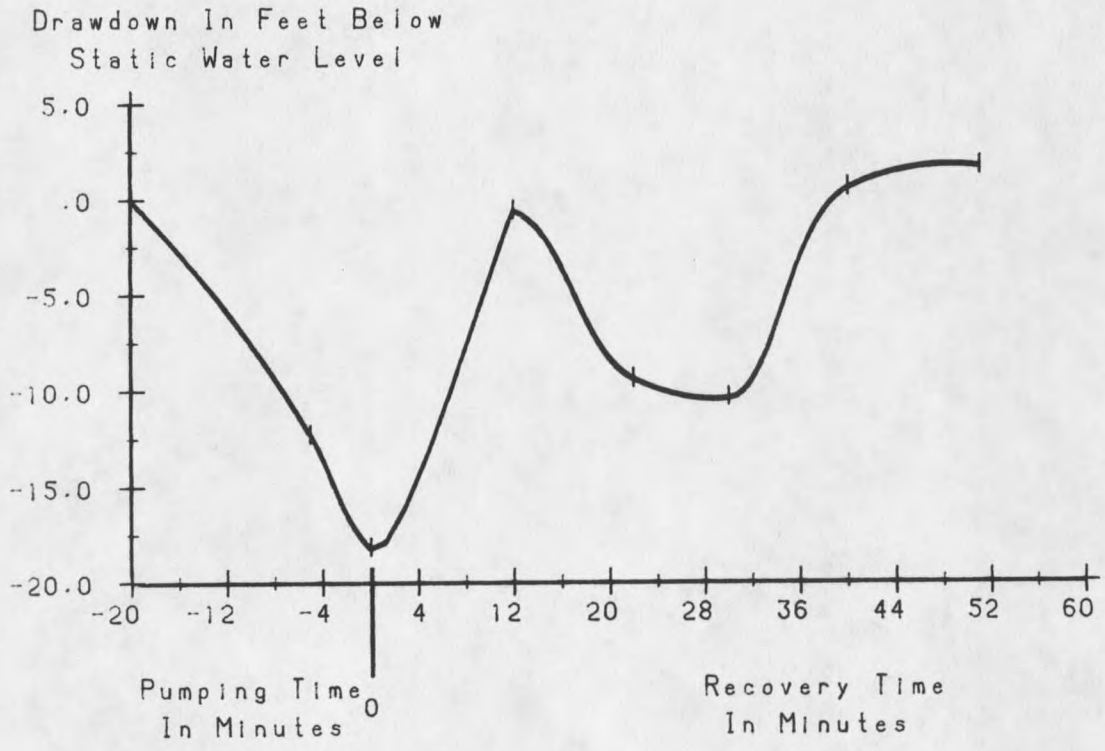
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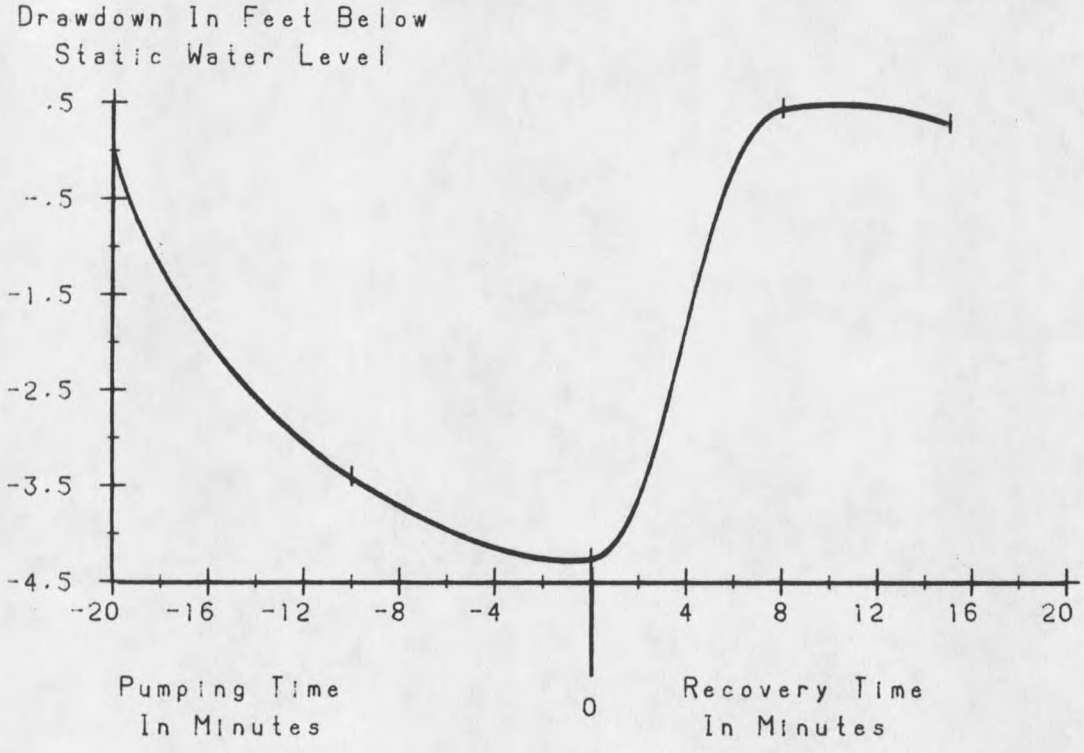
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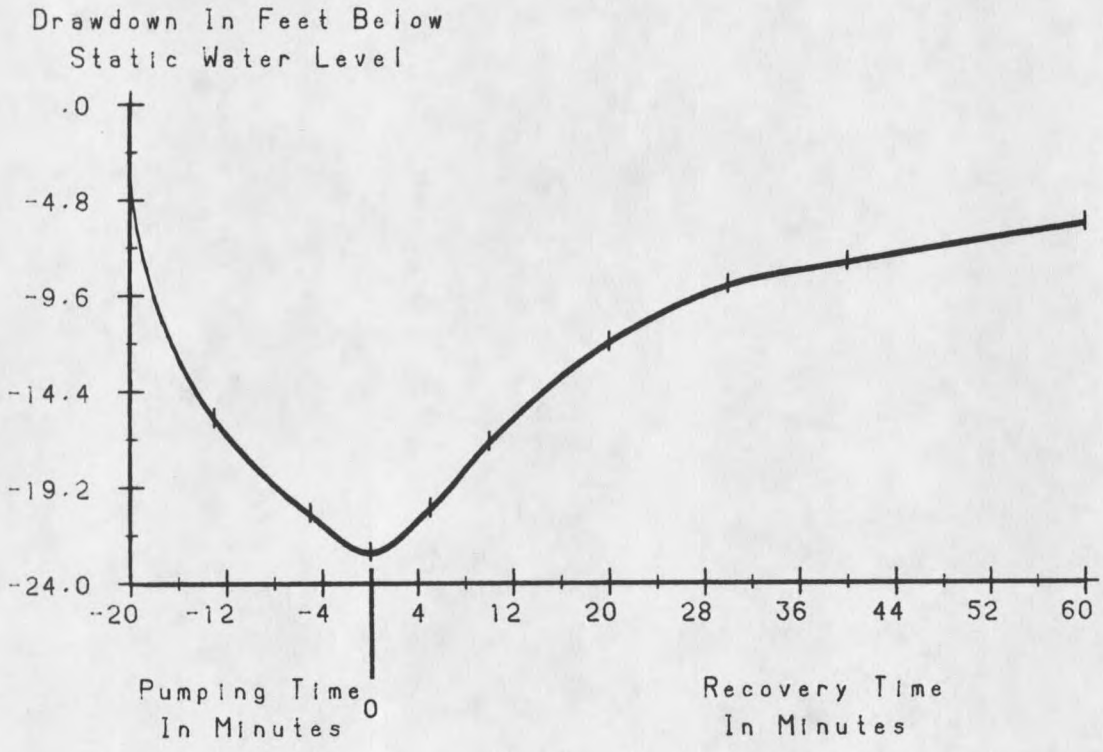
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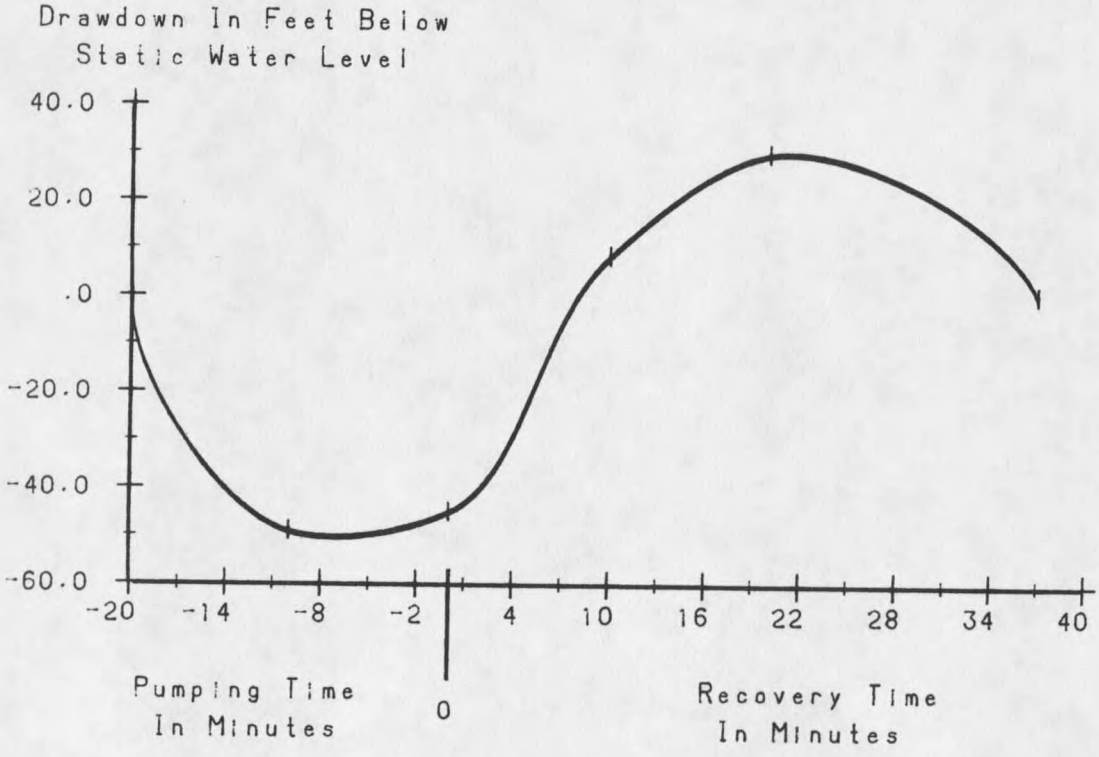
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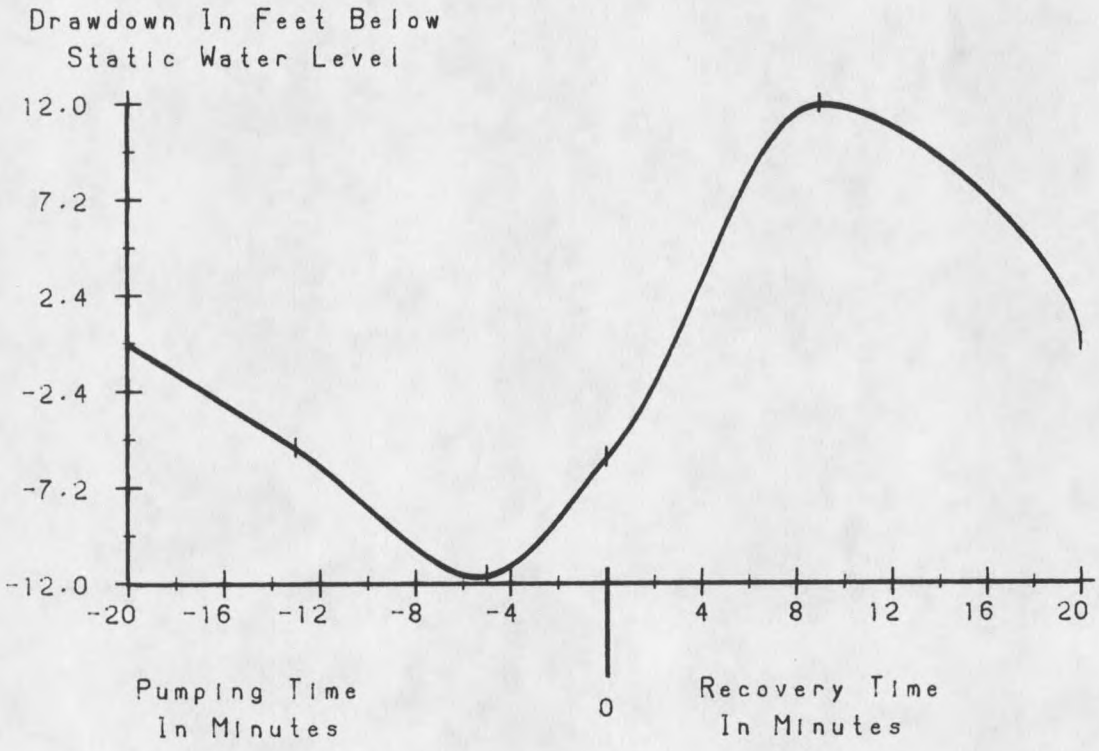
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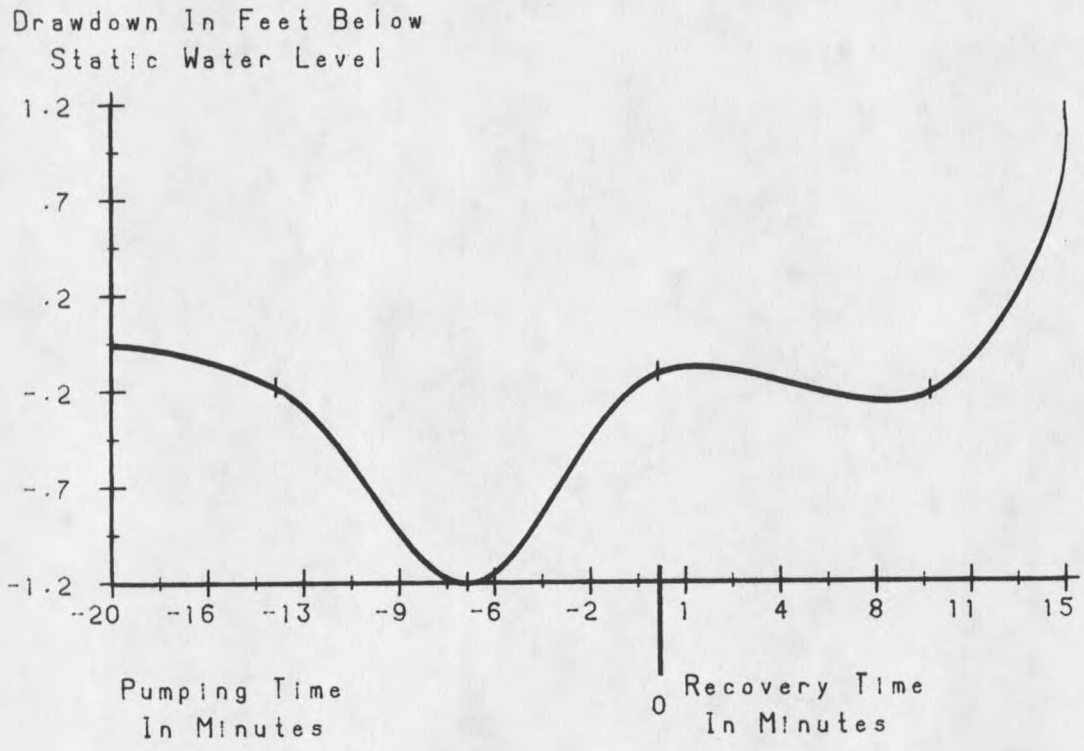
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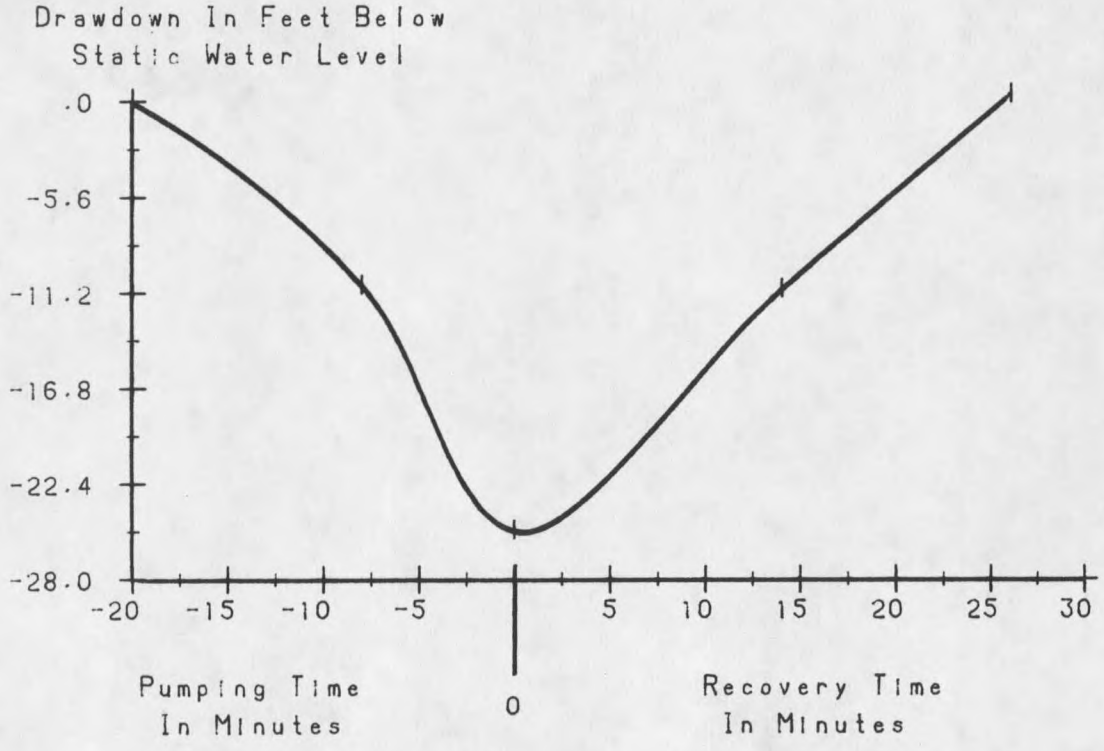
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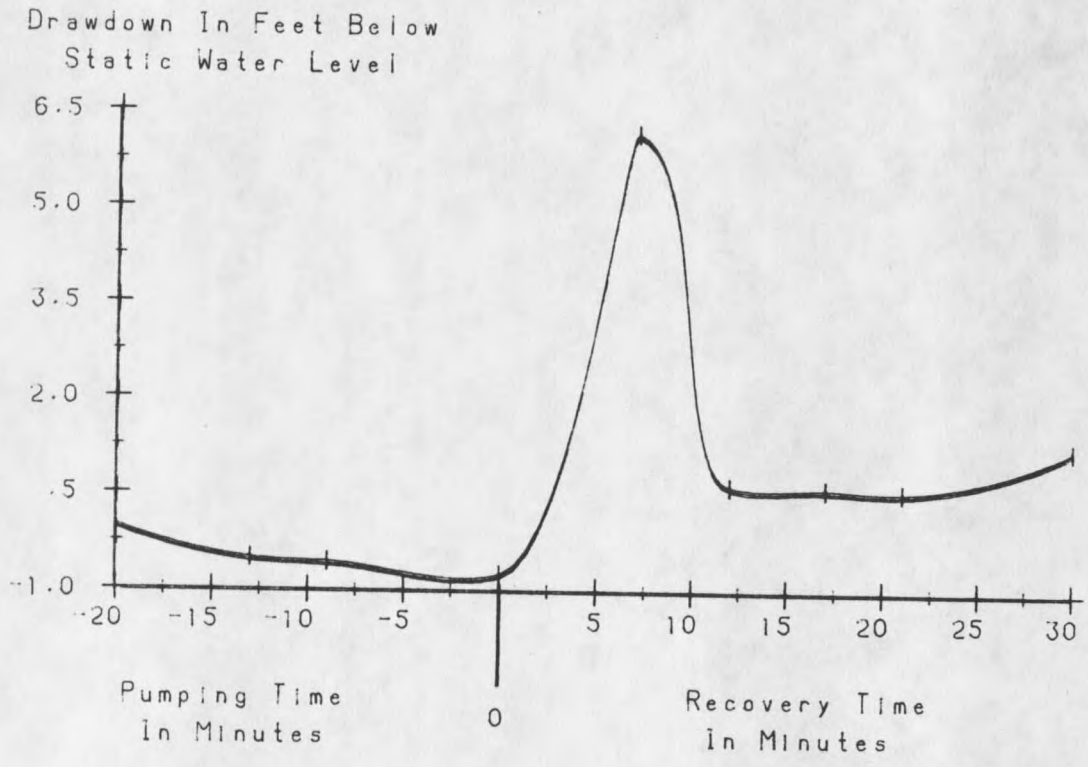
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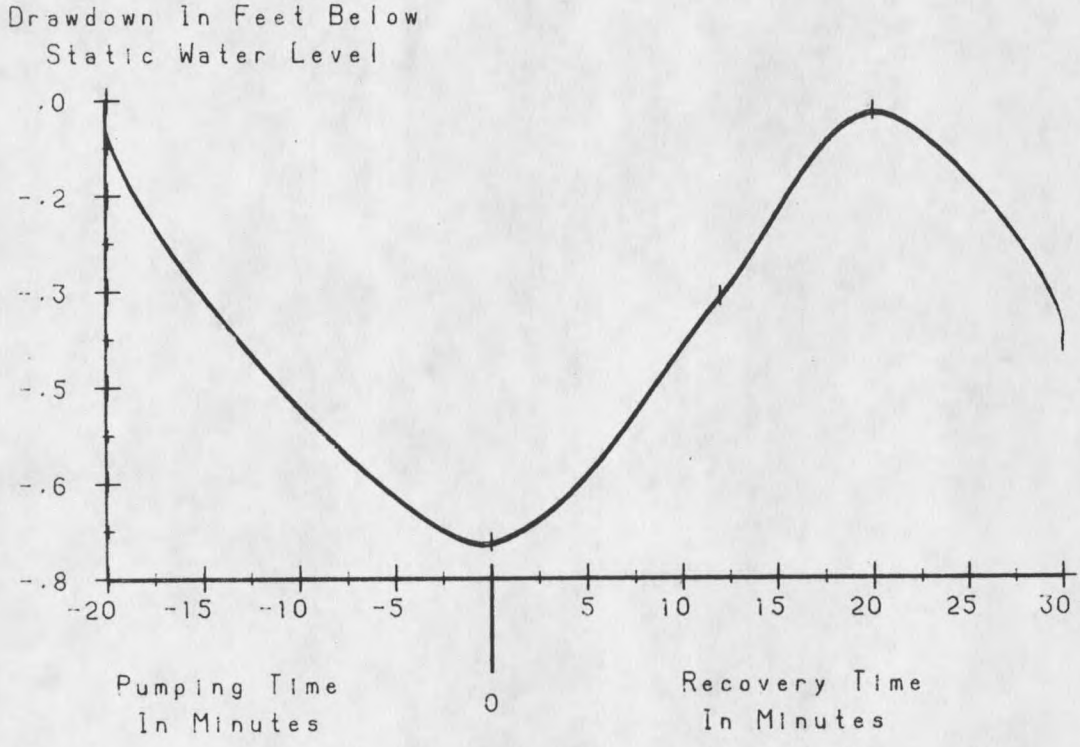
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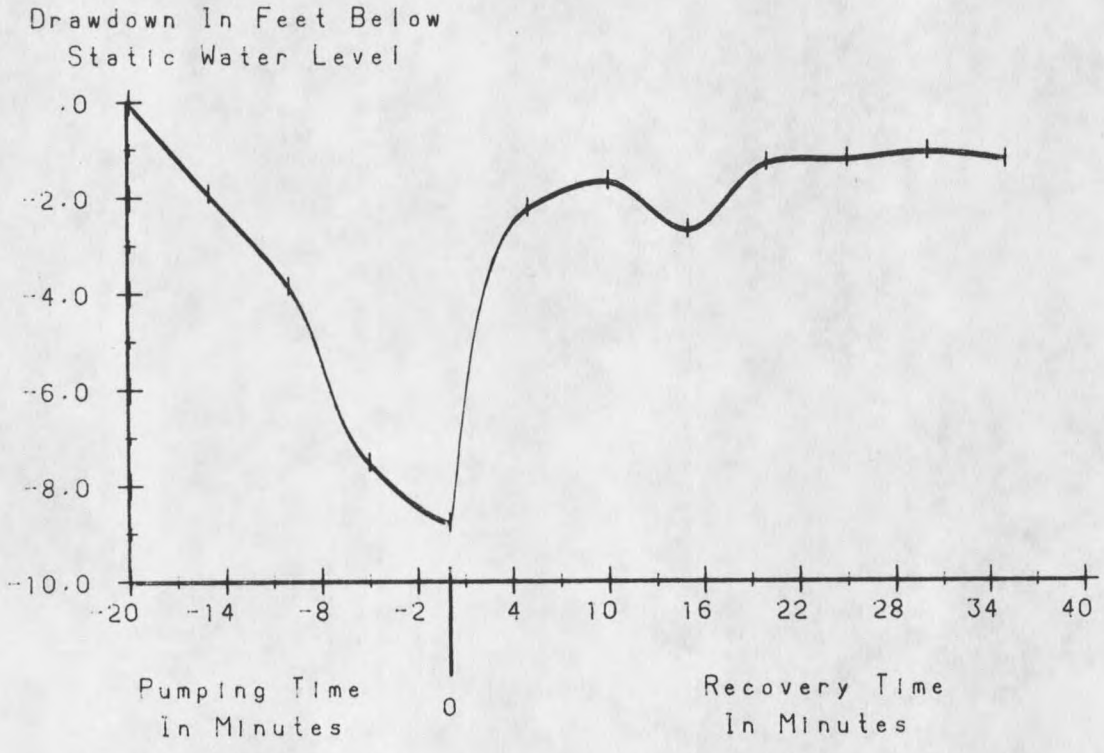
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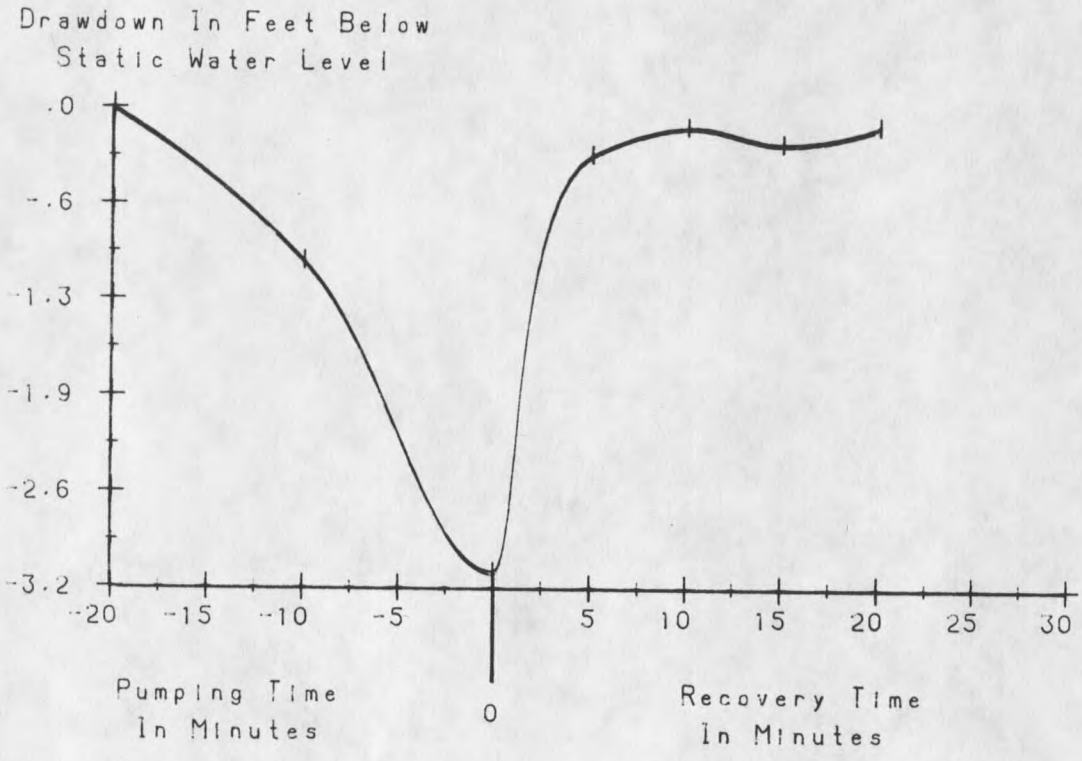
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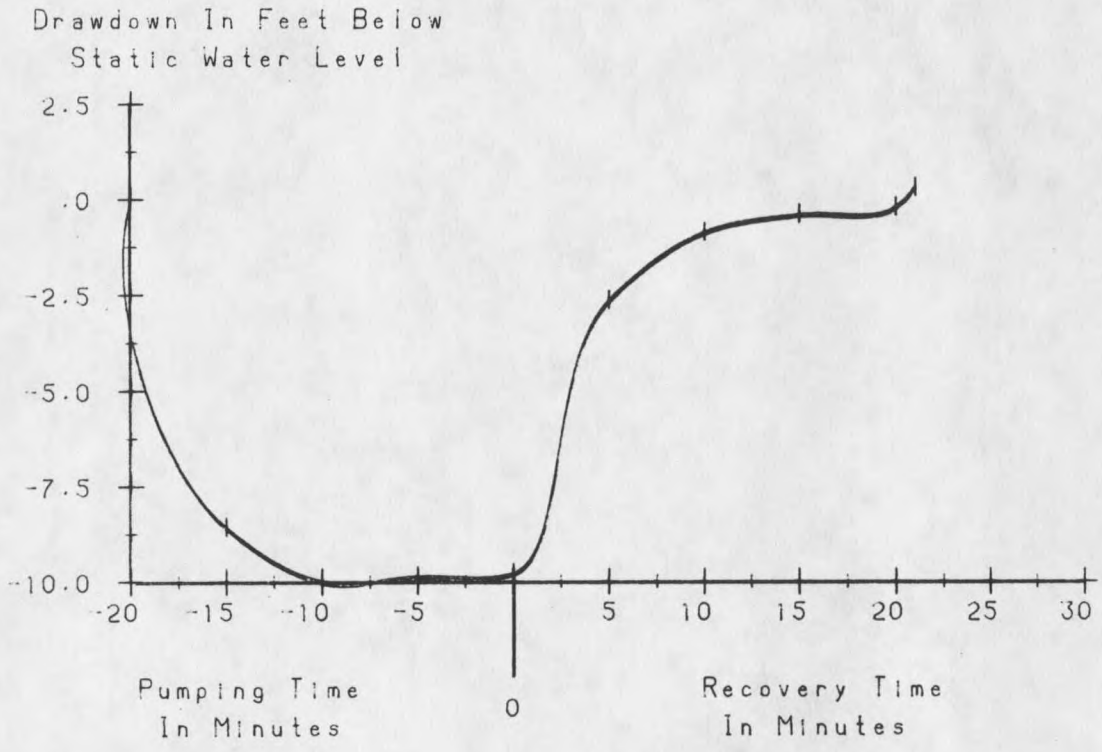
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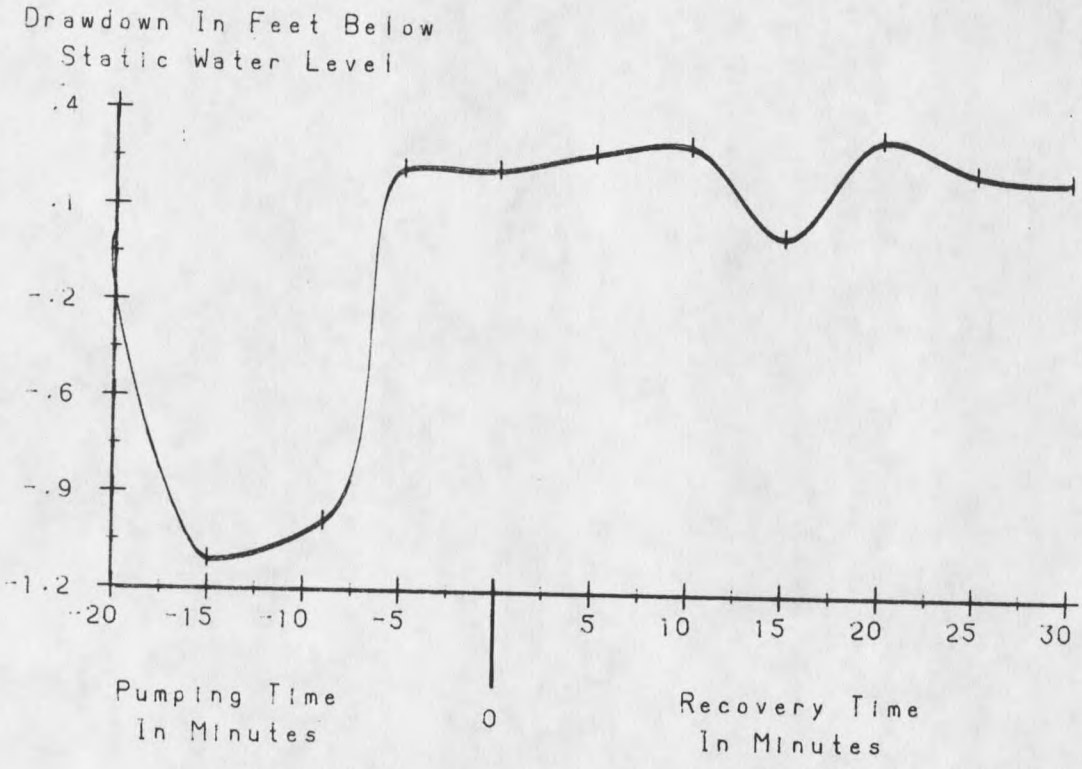
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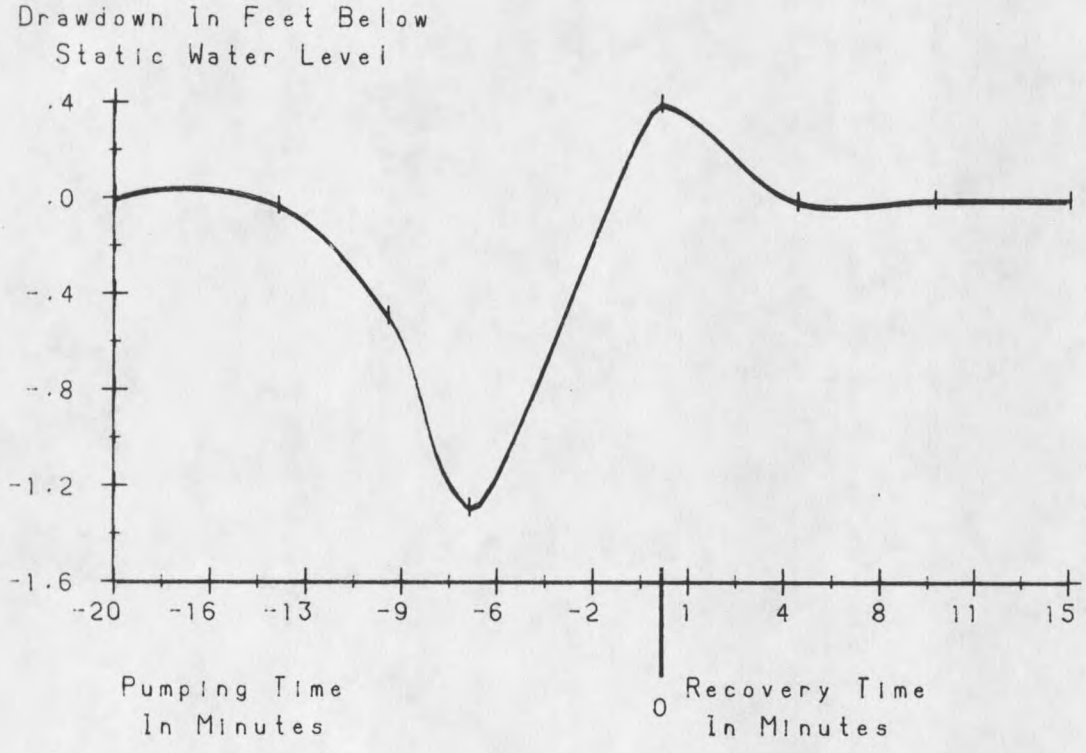
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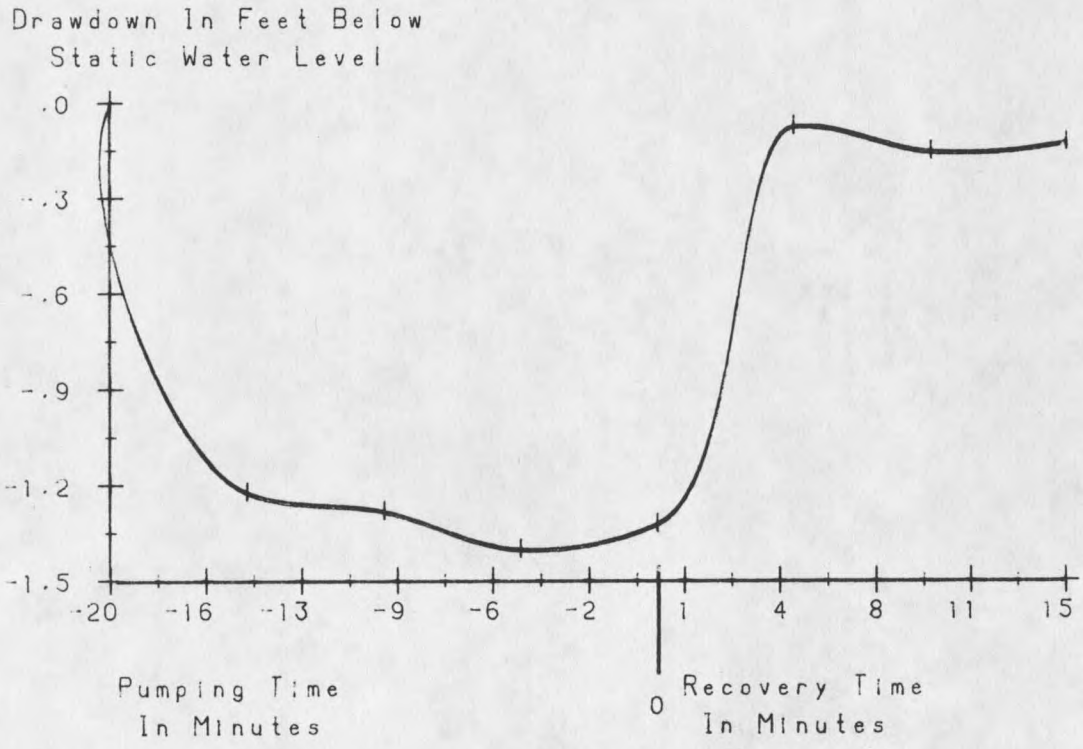
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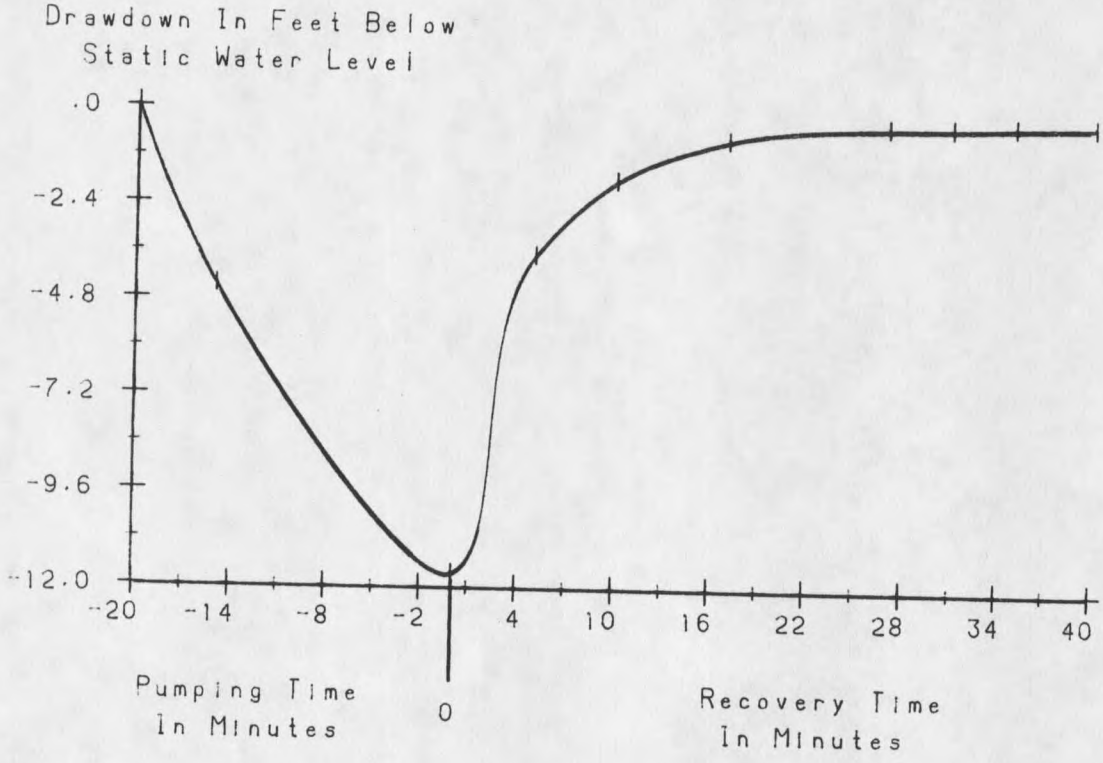
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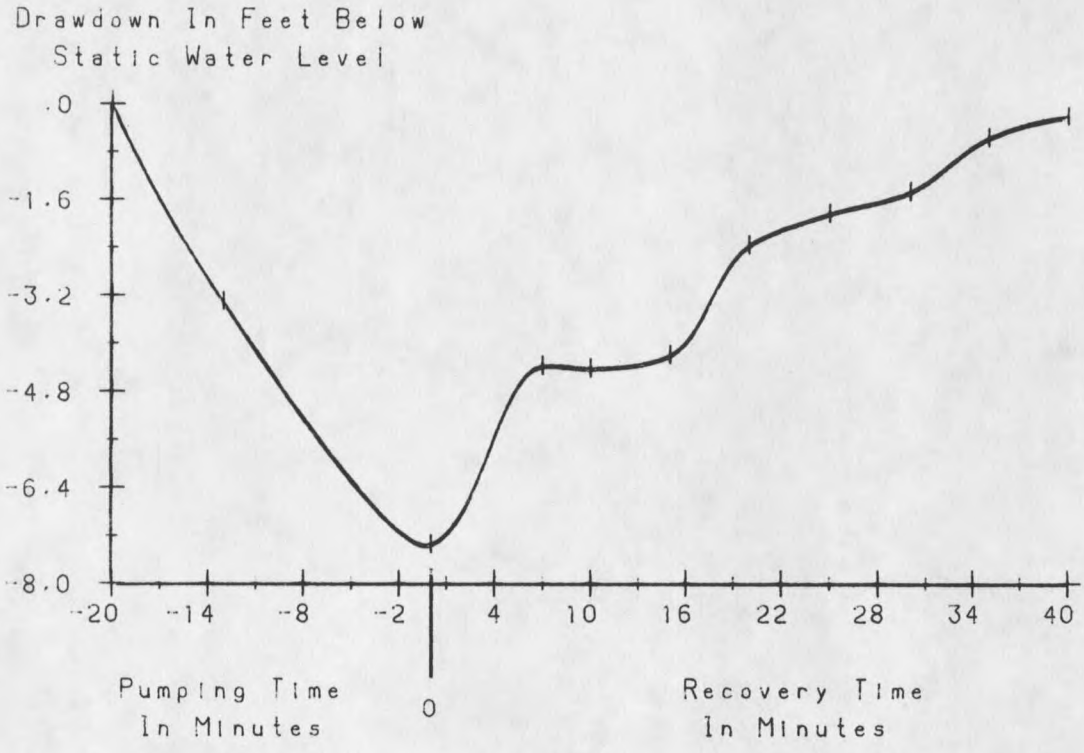
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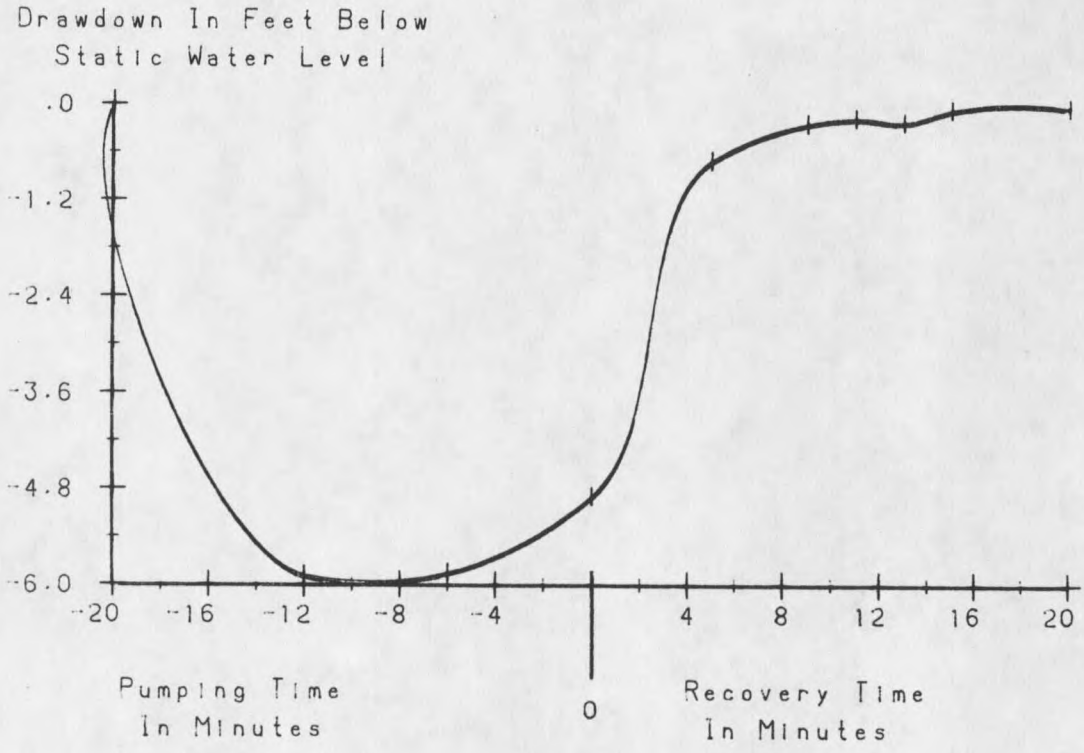
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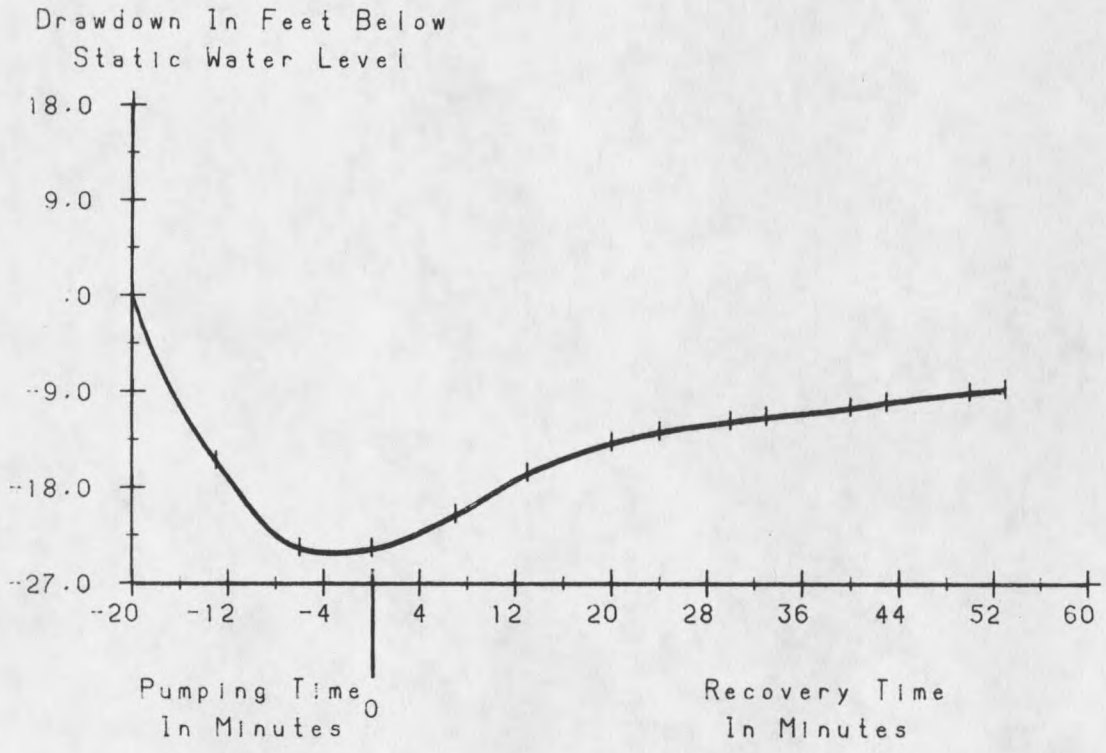
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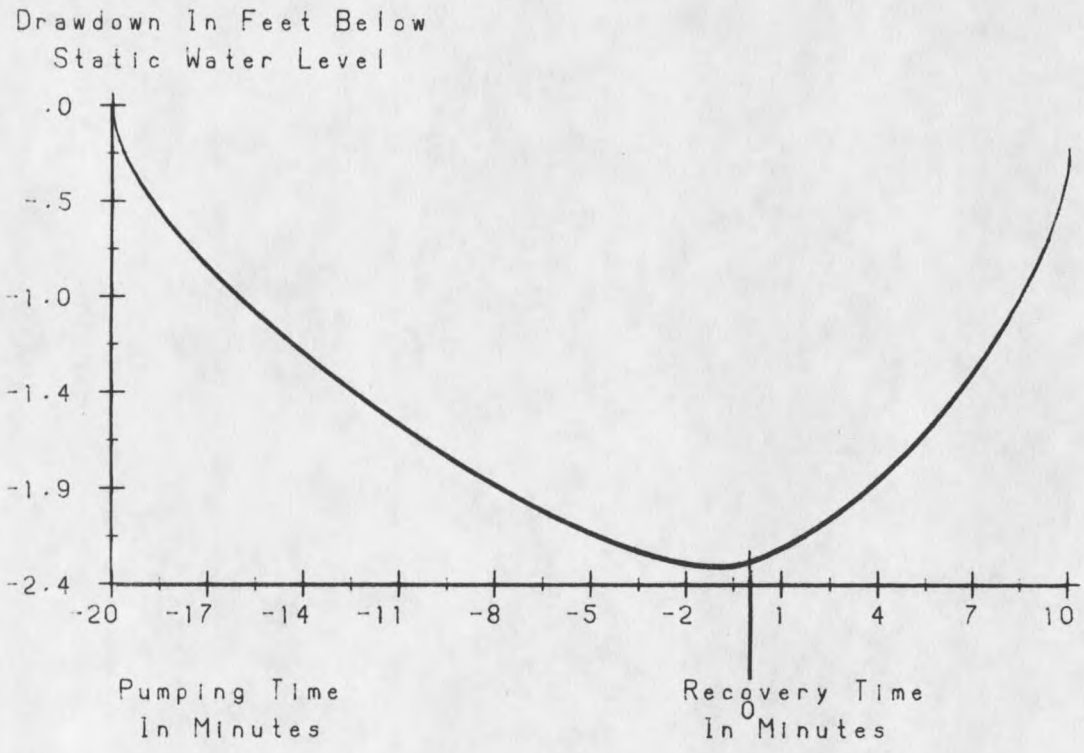
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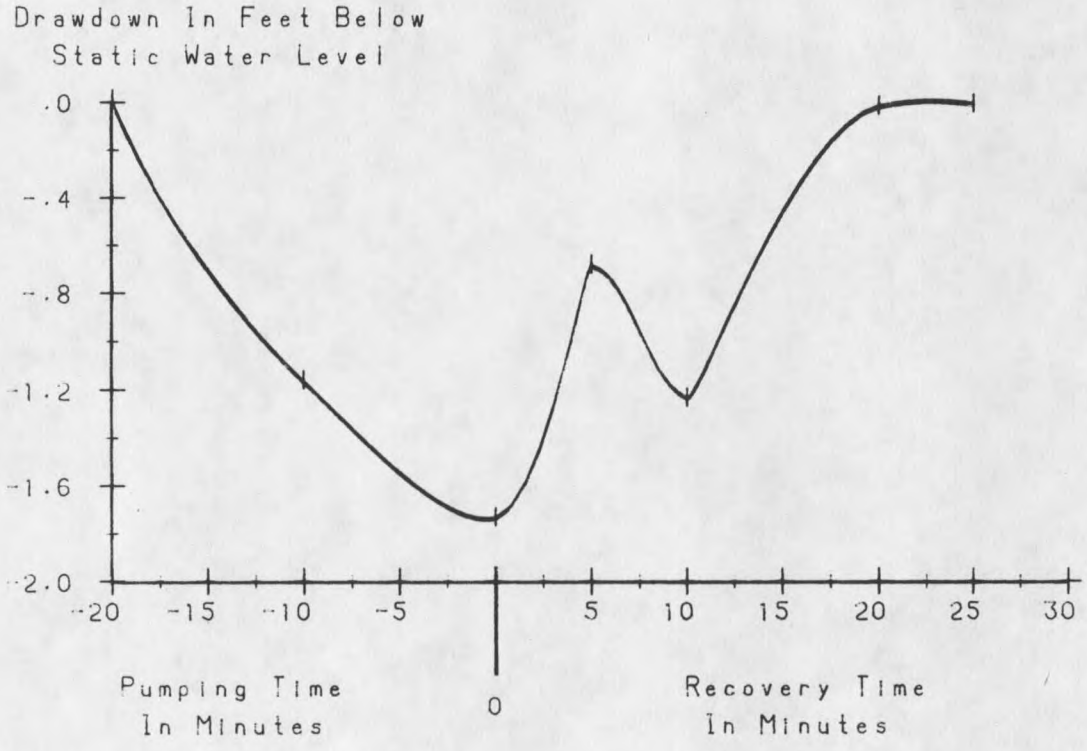
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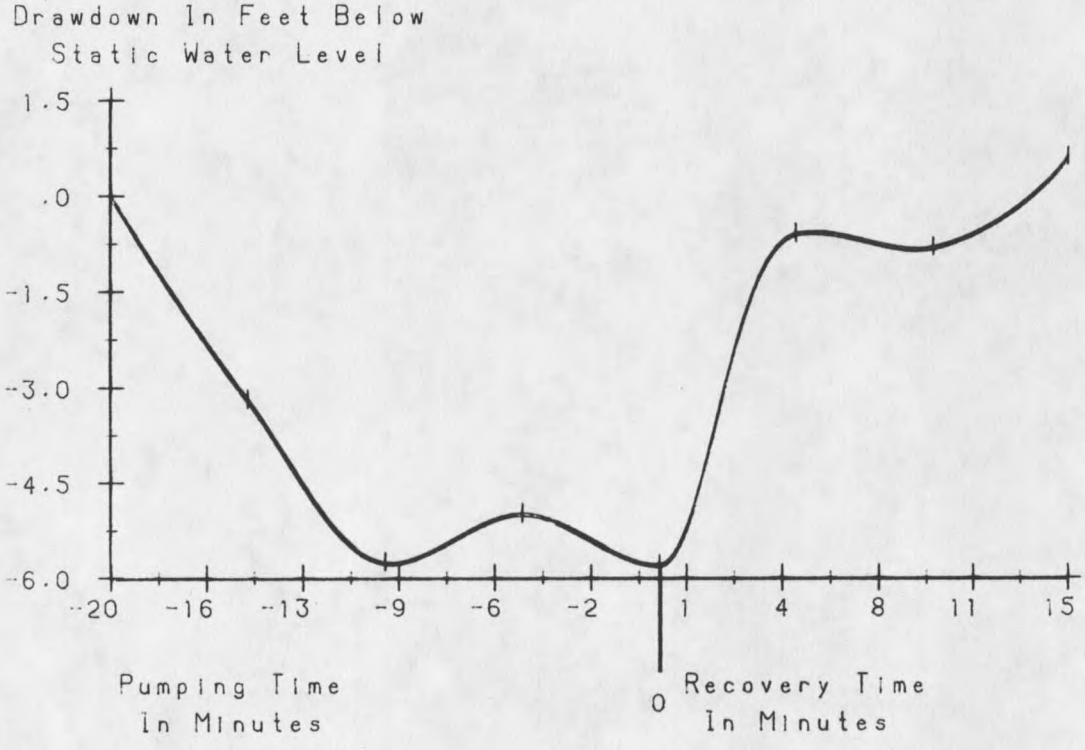
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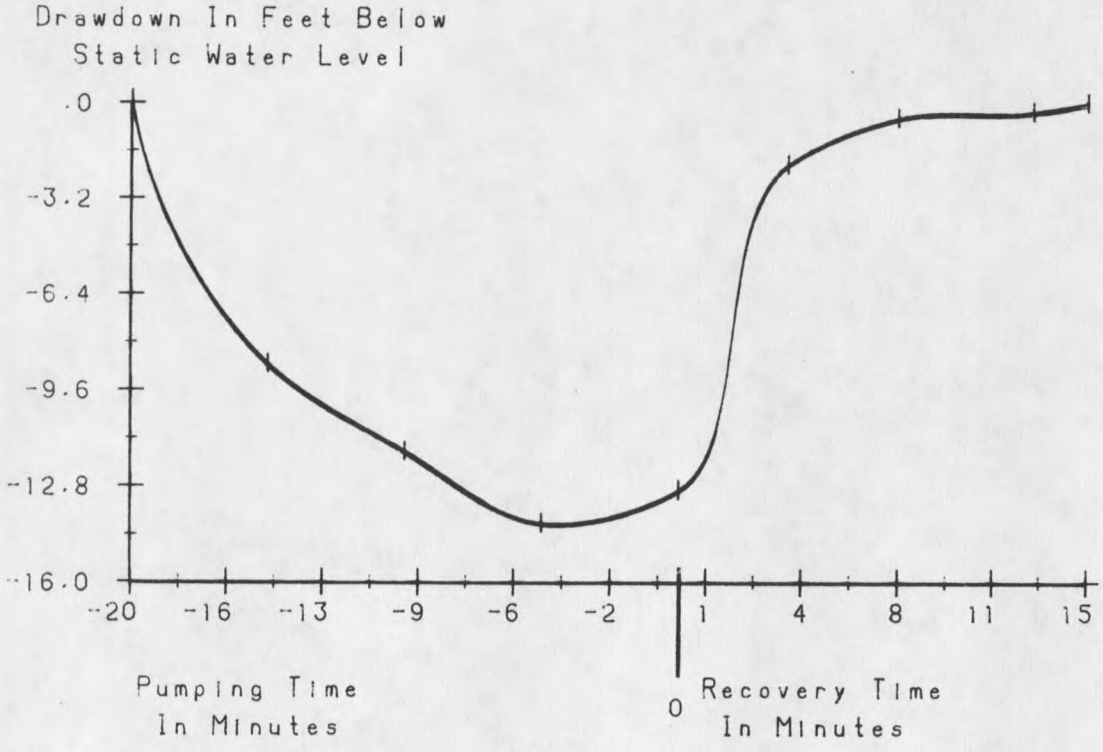
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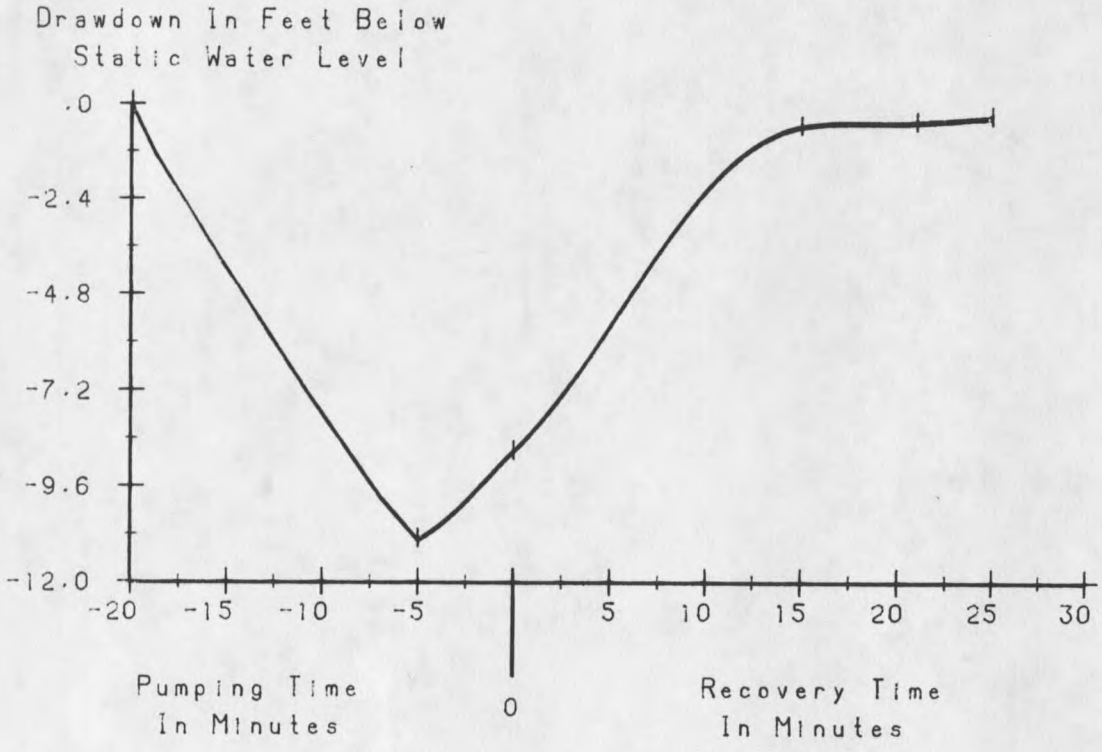
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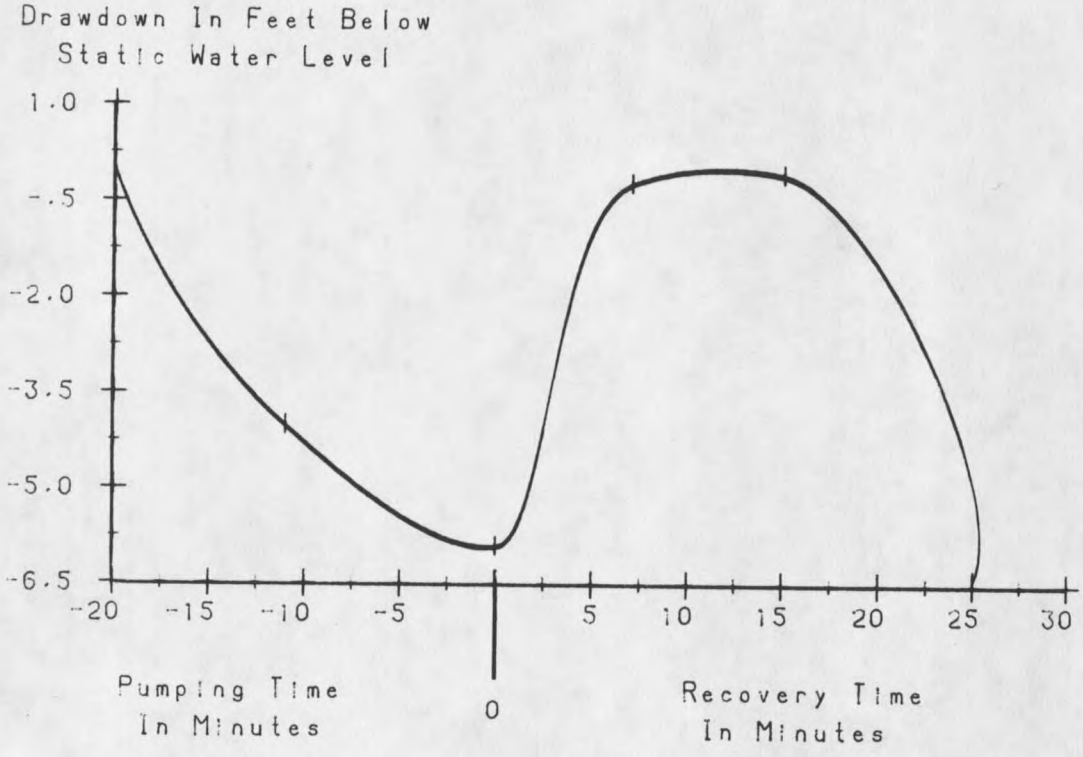
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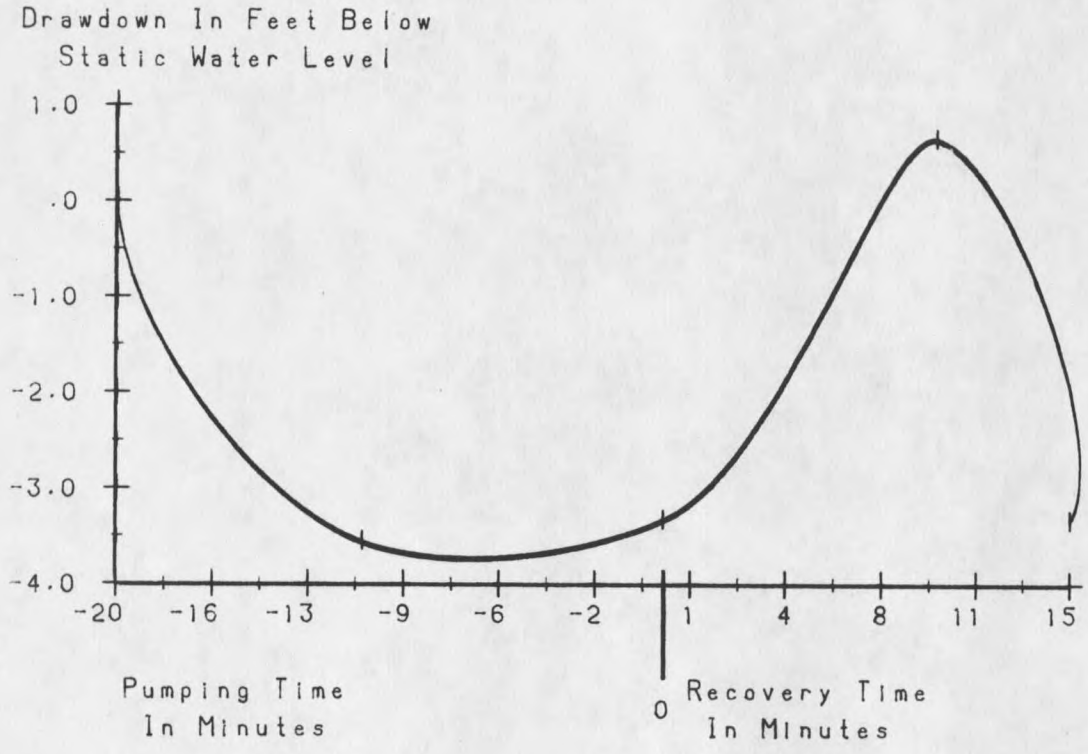
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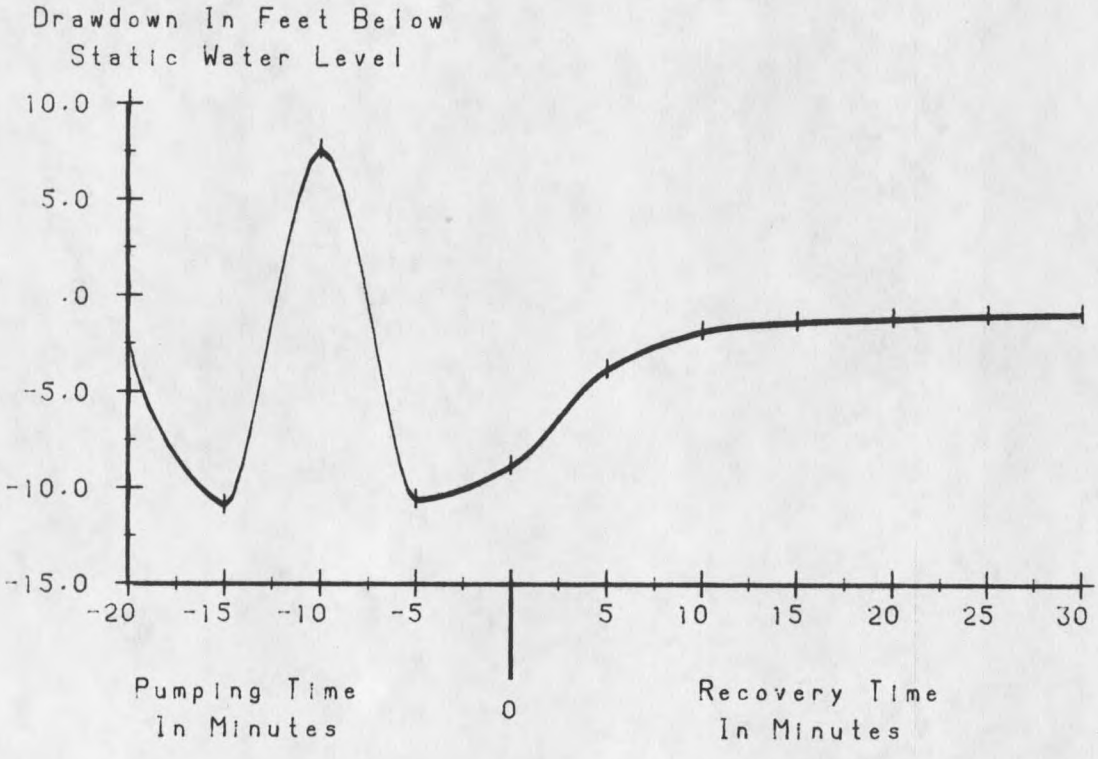
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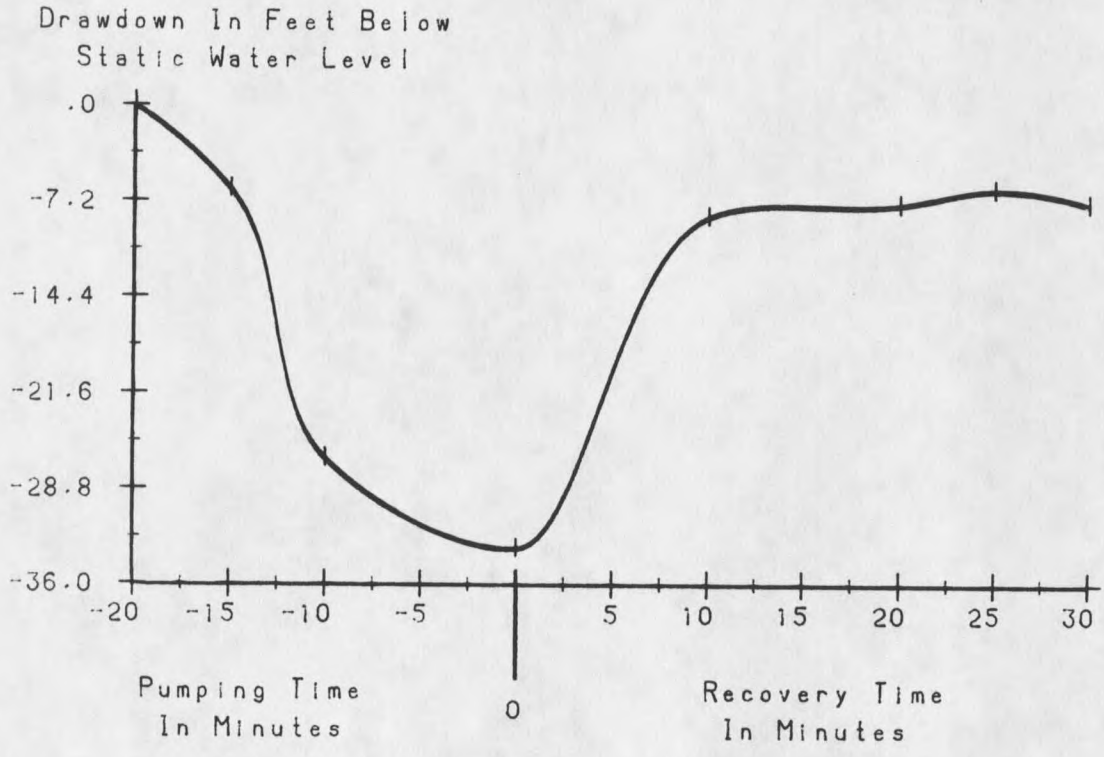
Location 1S7E34BBBD*



Location 1S6E25DABD*



Location 1S7E33CAAB*



APPENDIX G

CHEMICAL ANALYTICAL RESULTS

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0551

STATE MONTANA
LATITUDE-LONGITUDE 45D42'56"N 110D53'09"W
UTM COORDINATES Z N E
TOPOGRAPHIC MAP BOZEMAN PASS 15'
GEOLOGIC SOURCE 211HPRS* *
DRAINAGE BASIN AH
AGENCY + SAMPLER MBMG%RKM
BOTTLE NUMBER CHADWIC
DATE SAMPLED 25-JUN-83
TIME SAMPLED 15:00 HOURS
LAB + ANALYST MBMG%FNA
DATE ANALYZED 15-SEP-83
SAMPLE HANDLING
METHOD SAMPLED PUMPED
WATER USE DOMESTIC

COUNTY GALLATIN
SITE LOCATION 01S 07E 29 DCCA
MBMG SITE
STATION ID 454256110530901
* SAMPLE SOURCE WELL
LAND SURFACE ALTITUDE 5560. FT < 10
SUSTAINED YIELD
YIELD MEAS METHOD
TOTAL DEPTH OF WELL 45. FT (M)
SWL ABOVE(-) OR BELOW GS 18.20 FT (M)
CASING DIAMETER 6 IN (M)
CASING TYPE STEEL
COMPLETION TYPE 02*
PERFORATION INTERVAL

SAMPLING SITE CHADWICK * AT TOE OF LANDSLIDE (QLS)
GEOLOGIC SOURCE HOPPERS FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	95.4	4.76	BICARBONATE	(HCO3)	466.	7.64
MAGNESIUM (MG)	17.2	1.41	CARBONATE	(CO3)	.0	
SODIUM (NA)	53.1	2.30	CHLORIDE	(CL)	16.6	0.47
POTASSIUM (K)	.1	0.00	SULFATE	(SO4)	26.0	0.54
IRON (FE)	1.20	0.06	NITRATE	(AS N)	.16	0.01
MANGANESE (MN)	.009	0.00	FLUORIDE	(F)	.2	0.01
SILICA (SIO2)	12.3		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		8.64	TOTAL ANIONS			8.67

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.13

CALCULATED DISSOLVED SOLIDS	453.83	TOTAL HARDNESS AS CACO3	309.01
SUM OF DISS. CONSTITUENT	690.27	TOTAL ALKALINITY AS CACO3	382.20
FIELD CNDUCTVY, MICROMHOS	900.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	750.3	RYZNAR STABILITY INDEX	6.27
FIELD PH	7.35	LANGLIER SATURATION INDEX	0.67
LABORATORY PH	7.61	SODIUM ADSORPTION RATIO	1.36

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	28.5 C	FIELD TEMP. WATER	8.5 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	100.	STRONTIUM,DISS (UG/L-SR)	290.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	10.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	10.
COPPER,DISS (UG/L AS CU)	31.	ZINC, DISS (UG/L AS ZN)	140.
LITHIUM,DISS(UG/L AS LI)	11.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: RUSTY
NEED WELL LOG - IT IS REGISTERED *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL. BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT:
COST:
LAST EDIT DATE: 17-OCT-83 BY: TP *BCS
PROCESSING PROGRAM: F1730P V3 (09/1/83) PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
55.5	16.5	28.0	0.0	5.4	6.3	88.3	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0551

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300545

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D43'31"N 110D54'32"W	SITE LOCATION	01S 07E 30 BADD
UTM COORDINATES	Z N E	MBMG SITE STATION ID	454331110543201
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	* SAMPLE SOURCE	WELL
GEOLOGIC SOURCE	211BMCN* *	LAND SURFACE ALTITUDE	5440. FT ± 50
DRAINAGE BASIN	AH	SUSTAINED YIELD	
AGENCY + SAMPLER	MBMG*BAM	YIELD MEAS METHOD	
BOTTLE NUMBER	RIPLEY	TOTAL DEPTH OF WELL	65. FT (R)
DATE SAMPLED	21-JUN-83	SWL ABOVE(-) OR BELOW GS	52. FT (R)
TIME SAMPLED	: HOURS	CASING DIAMETER	6 IN (M)
LAB + ANALYST	MBMG*FNA	CASING TYPE	STEEL
DATE ANALYZED	06-SEP-83	COMPLETION TYPE	10*
SAMPLE HANDLING		PERFORATION INTERVAL	52 TO 65 FT (R)
METHOD SAMPLED	PUMPED		
WATER USE	DOMESTIC		

SAMPLING SITE RIPLEY *
GEOLOGIC SOURCE BILLMAN CREEK FORMATION (OF LIVINGSTON GROUP)

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	78.6	3.92	BICARBONATE	(HCO3)	280.1	4.59
MAGNESIUM	(MG)	11.9	0.98	CARBONATE	(CO3)	.0	
SODIUM	(NA)	27.7	1.20	CHLORIDE	(CL)	4.0	0.11
POTASSIUM	(K)	.5	0.01	SULFATE	(SO4)	57.9	1.21
IRON	(FE)	.061	0.00	NITRATE	(AS N)	1.02	0.07
MANGANESE	(MN)	<.001		FLUORIDE	(F)	.6	0.03
SILICA	(SIO2)	15.7		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			6.12	TOTAL ANIONS			6.01

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.56

CALCULATED DISSOLVED SOLIDS	335.96	TOTAL HARDNESS AS CACO3	245.24
SUM OF DISS. CONSTITUENTS	478.08	TOTAL ALKALINITY AS CACO3	229.73
FIELD CNDUCTVY, MICRONHOS	503.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICRONHOS	542.1	RYZNAR STABILITY INDEX	6.93
FIELD PH	6.15	LANGLIER SATURATION INDEX	0.32
LABORATORY PH	7.56	SODIUM ADSORPTION RATIO	0.77

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	30. C	FIELD TEMP. WATER	9.0 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	60.	STRONTIUM,DISS (UG/L-SR)	230.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	5.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	4.	ZINC, DISS (UG/L AS ZN)	<3.
LITHIUM,DISS(UG/L AS LI)	<2.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: VERY CLEAR
WELL IS ENCLOSED BY BACK PORCH STEPS AND INACCESSIBLE WITHOUT REMOVING STEPS *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (N) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL. BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT:
LAST EDIT DATE: 10-JAN-84 COST:
PROCESSING PROGRAM: F1730P V3 (09/1/83) BY: TP *TP
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
64.1	16.0	19.7	0.2	1.9	20.4	77.7	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300545

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300556

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45N41'39"N 110D54'58"W	SITE LOCATION	02S 07E 06 BCBC
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15/	STATION ID	454139110545801
GEOLOGIC SOURCE	211RMCK* *	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5460. FT ; 10
AGENCY + SAMPLER	MBMG%BAM	SUSTAINED YIELD	5. GPM
BOTTLE NUMBER	VANDERV	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED		TOTAL DEPTH OF WELL	299. FT (R)
TIME SAMPLED	: HOURS	SWL ABOVE(-) OR BELOW GS	150.25 FT
LAB + ANALYST	MBMG%FNA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	02-SEP-83	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	03*
METHOD SAMPLED		PERFORATION INTERVAL	220 TO 282 FT (R)
WATER USE	DOMESTIC		

SAMPLING SITE VANDERVOS *
GEOLOGIC SOURCE BILLMAN CREEK FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	3.5	0.17	BICARBONATE (HCO3)	72.0	1.18
MAGNESIUM (MG)	<.1		CARBONATE (CO3)	7.2	0.24
SODIUM (NA)	36.3	1.58	CHLORIDE (CL)	1.7	0.05
POTASSIUM (K)	<.1		SULFATE (SO4)	7.0	0.15
IRON (FE)	.37	0.02	NITRATE (AS N)	.35	0.02
MANGANESE (MN)	.004	0.00	FLUORIDE (F)	3.4	0.18
SILICA (SIO2)	13.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		1.77	TOTAL ANIONS		1.82

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.33

CALCULATED DISSOLVED SOLIDS	108.29	TOTAL HARDNESS AS CACO3	8.74
SUM OF DISS. CONSTITUENT	144.82	TOTAL ALKALINITY AS CACO3	71.06
FIELD CNDUCTVY, MICROMHOS	233.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	167.3	RYZNAR STABILITY INDEX	9.11
FIELD PH	8.25	LANGLIER SATURATION INDEX	-0.00
LABORATORY PH	9.10	SODIUM ADSORPTION RATIO	

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	29.0 C	FIELD TEMP. WATER	11.0 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	470.	STRONTIUM,DISS (UG/L-SR)	11.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	<1.
CHROMIUM, DISS (UG/L-CR)	<3.	VANADIUM,DISS(UG/L AS V)	3.
COPPER,DISS (UG/L AS CU)	12.	ZINC, DISS (UG/L AS ZN)	30.
LITHIUM,DISS(UG/L AS LI)	4.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: H2S GAS; WATER GRAY TO CLEAR *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE. TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
10.0	0.0	90.0	0.0	3.0	9.0	73.1	14.9

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300556
Reaa

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300547

STATE MONTANA
LATITUDE-LONGITUDE 45D44'51"N 110D53'35"W
UTM COORDINATES Z N E
TOPOGRAPHIC MAP BOZEMAN PASS 15'
GEOLOGIC SOURCE 110ALVM* *
DRAINAGE BASIN AH
AGENCY & SAMPLER MBMG*BKM
BOTTLE NUMBER MARTIN
DATE SAMPLED 25-JUN-83
TIME SAMPLED 10:30 HOURS
LAB & ANALYST MBMG*FNA
DATE ANALYZED 15-SEP-83
SAMPLE HANDLING
METHOD SAMPLED PUMPED
WATER USE DOMESTIC

COUNTY GALLATIN
SITE LOCATION 01S 07E 17 CACC
MBMG SITE
STATION ID 454451110533501
& SAMPLE SOURCE WELL
LAND SURFACE ALTITUDE 5318. FT < 10
SUSTAINED YIELD
YIELD MEAS METHOD
TOTAL DEPTH OF WELL 48.2 FT (M)
SWL ABOVE(-) OR BELOW GS 10.6 FT (M)
CASING DIAMETER 6 IN (M)
CASING TYPE STEEL
COMPLETION TYPE *
PERFORATION INTERVAL *

SAMPLING SITE MARTIN *
GEOLOGIC SOURCE ALLUVIUM (QUATERNARY)

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	67.7	3.38	BICARBONATE	(HCO3)	280.6	4.60
MAGNESIUM (MG)	13.2	1.09	CARBONATE	(CO3)	.0	
SODIUM (NA)	11.5	0.50	CHLORIDE	(CL)	1.6	0.05
POTASSIUM (K)	.5	0.01	SULFATE	(SO4)	14.1	0.29
IRON (FE)	3.52	0.19	NITRATE	(AS N)	.71	0.05
MANGANESE (MN)	.20	0.01	FLUORIDE	(F)	.2	0.01
SILICA (SIO2)	10.1		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		5.17	TOTAL ANIONS			5.00

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.97

CALCULATED DISSOLVED SOLIDS	261.56	TOTAL HARDNESS AS CACO3	223.38
SUM OF DISS. CONSTITUENT	403.93	TOTAL ALKALINITY AS CACO3	230.14
FIELD CNDUCTVY, MICROMHOS	523.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	417.0	RYZNAR STABILITY INDEX	6.82
FIELD PH	6.55	LANGLIER SATURATION INDEX	0.48
LABORATORY PH	7.79	SODIUM ADSORPTION RATIO	0.33

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP, AIR	22.0 C	FIELD TEMP. WATER	9.0 C
ALUMINUM, DISS (UG/L-AL)	50.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	5.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	80.	STRONTIUM,DISS (UG/L-SR)	190.
CADMIUM,DISS(UG/L AS CD)	6.	TITANIUM DIS(UG/L AS TI)	10.
CHROMIUM, DISS (UG/L-CR)	3.	VANADIUM,DISS(UG/L AS V)	11.
COPPER,DISS (UG/L AS CU)	20.	ZINC, DISS (UG/L AS ZN)	280.
LITHIUM,DISS(UG/L AS LI)	9.	ZIRCONIUM DIS(UG/L AS ZR	12.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: RUSTY
WELL IN FRONT YARD * NEED WELL LOG *
LAB: RU SAMPLE DECREASING IN ALKALINITY *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

QW WA S2 WI OW PW AT OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 31-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
67.9	21.8	10.1	0.3	0.9	5.9	93.1	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300547

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0555

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D44'41"N 110D53'44"W	SITE LOCATION	01S 07E 17 CCDB
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454441110534401
GEOLOGIC SOURCE	110AI VM* *	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5280. FT (E) 10
AGENCY + SAMPLER	MBMG&BKM	SUSTAINED YIELD	40. GPM
BOTTLE NUMBER	LOOMIS	YIELD MEAS METHOD	REPORTED
DATE SAMPLED	25-JUN-83	TOTAL DEPTH OF WELL	40.4 FT (M)
TIME SAMPLED	06:30 HOURS	SWL ABOVE(-) OR BELOW GS	2.98 FT (M)
LAB + ANALYST	MBMG&FNA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	07-SEP-83	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE LOOMIS *
GEOLOGIC SOURCE ALLUVIUM (QUATERNARY)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	75.5	3.77	BICARBONATE (HCO3)	321.	5.26
MAGNESIUM (MG)	15.1	1.24	CARBONATE (CO3)	.0	
SODIUM (NA)	10.0	0.44	CHLORIDE (CL)	2.6	0.07
POTASSIUM (K)	.3	0.01	SULFATE (SO4)	13.4	0.28
IRON (FE)	5.45	0.39	NITRATE (AS N)	.85	0.06
MANGANESE (MN)	.079	0.00	FLUORIDE (F)	.2	0.01
SILICA (SIO2)	10.7		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		5.75	TOTAL ANIONS		5.68

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.34

CALCULATED DISSOLVED SOLIDS	292.31	TOTAL HARDNESS AS CACO3	250.68
SUM OF DISS. CONSTITUENT	155.18	TOTAL ALKALINITY AS CACO3	263.27
FIELD CNDUCTVY, MICROMHOS	569.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	473.3	RYZNAR STABILITY INDEX	6.62
FIELD PH	7.25	LANGLIER SATURATION INDEX	0.58
LABORATORY PH	7.78	SODIUM ADSORPTION RATIO	0.27

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP, AIR	20.5 C	FIELD TEMP, WATER	9.5 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	60.	STRONTIUM,DISS (UG/L-SR)	160.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	6.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	14.	ZINC, DISS (UG/L AS ZN)	470.
LITHIUM,DISS(UG/L AS LI)	<2.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: VERY RUSTY *
WELL IN FRONT YARD *
LAB: VALUES FOR FE OF 9.92 AND ZN OF.63 MG/L ON 2/9/84 SUGGEST FA CONTAINS
LAB: PARTICULATES *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER; MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.
BIO = BIOLOGICALLY AVAILABLE.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 14-FEB-84
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
69.1	22.8	8.0	0.1	1.3	5.0	93.7	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0555

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0548

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D42'06"N 110D54'30"W	SITE LOCATION	01S 07E 31 CDAD
UTM COORDINATES	Z N E	MBMG SITE	BROWN
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454206110543001
GEOLOGIC SOURCE	21JHPRS* *	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	6280. FT (E)
AGENCY + SAMPLER	MBMG*BKM	SUSTAINED YIELD	25. GPM
BOTTLE NUMBER	BROWN	YIELD MEAS METHOD	REPORTED
DATE SAMPLED	24-JUN-83	TOTAL DEPTH OF WELL	110. FT (R)
TIME SAMPLED	12:30 HOURS	SWL ABOVE(-) OR BELOW GS	54. FT (R)
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	15-SEP-83	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED		PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE BROWN *
GEOLOGIC SOURCE HOPPERS FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	36.0	1.80	BICARBONATE (HCO3)	171.0	2.80
MAGNESIUM (MG)	9.6	0.79	CARBONATE (CO3)	.0	
SODIUM (NA)	20.0	0.87	CHLORIDE (CL)	.6	0.02
POTASSIUM (K)	<.1		SULFATE (SO4)	11.3	0.24
IRON (FE)	.12	0.01	NITRATE (AS N)	1.55	0.11
MANGANESE (MN)	.009	0.00	FLUORIDE (F)	.2	0.01
SILICA (SIO2)	22.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		3.46	TOTAL ANIONS		3.18

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -1.86

CALCULATED DISSOLVED SOLIDS	184.12	TOTAL HARDNESS AS CACO3	129.41
SUM OF DISS. CONSTITUENT	272.88	TOTAL ALKALINITY AS CACO3	140.25
FIELD CNDUCTVY, MICROMHOS	294.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	312.6	RYZNAR STABILITY INDEX	7.76
FIELD PH	6.85	LANGLIER SATURATION INDEX	0.03
LABORATORY PH	7.83	SODIUM ADSORPTION RATIO	0.77

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	29. C	FIELD TEMP. WATER	9.5 C
ALUMINUM, DISS (UG/L-AL)	50.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	60.	STRONTIUM,DISS (UG/L-SR)	64.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	<1.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	8.
COPPER,DISS (UG/L AS CU)	6.	ZINC, DISS (UG/L AS ZN)	27.
LITHIUM,DISS(UG/L AS LI)	4.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: VERY CLEAR
OWNER REFUSED OPENING OF WELL BUT ALLOWED SAMPLING *
LAB: RU SAMPLE DECREASING IN ALKALINITY *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE. TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 17-OCT-83 BY: TP *BCS
PROCESSING PROGRAM: F1730P V3 (09/1/83) PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
52.0	22.9	25.2	0.0	0.6	7.7	91.7	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B3Q0548

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0549

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D42'09"N 110D54'38"W	SITE LOCATION	01S 07E 31 CDBA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454209110543801
GEOLOGIC SOURCE	211HPRS* *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5210. FT < 10
AGENCY + SAMPLER	MBMG*RKM	SUSTAINED YIELD	18. GPM
BOTTLE NUMBER	PIPINIC	YIELD MEAS METHOD	REPORTED
DATE SAMPLED	23-JUN-83	TOTAL DEPTH OF WELL	142. FT (M)
TIME SAMPLED	14:00 HOURS	SWL ABOVE(-) OR BELOW GS	52.9 FT (M)
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	6 IN
DATE ANALYZED	15-SEP-83	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*03
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	42 TO 135 FT (R)
WATER USE	DOMESTIC		

SAMPLING SITE PIPINICH *
GEOLOGIC SOURCE HOPPERS FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	19.8	0.99	BICARBONATE (HCO3)	180.6	2.96
MAGNESIUM (MG)	2.6	0.21	CARBONATE (CO3)	0	
SODIUM (NA)	57.4	2.50	CHLORIDE (CL)	8.3	0.23
POTASSIUM (K)	.1	0.00	SULFATE (SO4)	22.6	0.47
IRON (FE)	3.05	0.16	NITRATE (AS N)	.46	0.03
MANGANESE (MN)	.24	0.01	FLUORIDE (F)	1.2	0.06
SILICA (SIO2)	12.1		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		3.87	TOTAL ANIONS		3.76

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.70

CALCULATED DISSOLVED SOLIDS	216.82	TOTAL HARDNESS AS CACO3	60.14
SUM OF DISS. CONSTITUENT	308.45	TOTAL ALKALINITY AS CACO3	148.12
FIELD CNDUCTVY, MICROMHOS	354.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	344.4	RYZNAR STABILITY INDEX	7.98
FIELD PH	7.7	LANGLIER SATURATION INDEX	0.06
LABORATORY PH	8.09	SODIUM ADSORPTION RATIO	3.22

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	25.0 C	FIELD TEMP. WATER	10.2 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	240.	STRONTIUM,DISS (UG/L-SR)	40.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	<1.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	6.	ZINC, DISS (UG/L AS ZN)	470.
LITHIUM,DISS(UG/L AS LI)	11.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR
NEW OWNER - ROBERT PIPINICH * OLD OWNER - WILLIAM BERNDT
LAB: RU SAMPLE DECREASING IN ALKALINITY *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (N) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT:
LAST EDIT DATE: 17-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
26.7	5.8	67.5	0.1	6.1	12.8	80.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0549

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0553

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D41'56"N 110D55'34"W	SITE LOCATION	02S 06E 01 ABBB
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454156110553401
GEOLOGIC SOURCE	211BMCN* *	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5130. FT < 10
AGENCY + SAMPLER	MBMG*BAM	SUSTAINED YIELD	
BOTTLE NUMBER	BRUNER	YIELD MEAS METHOD	
DATE SAMPLED	27-JUN-83	TOTAL DEPTH OF WELL	122. FT (R)
TIME SAMPLED	10:30 HOURS	SWL ABOVE(-) OR BELOW LS	40. FT (R)
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	6 IN (R)
DATE ANALYZED	06-SEP-83	CASING TYPE	
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE BRUNER *
GEOLOGIC SOURCE BILLMAN CREEK FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	14.4	0.72	BICARBONATE (HCO3)	211.8	3.47
MAGNESIUM (MG)	.6	0.05	CARBONATE (CO3)	.0	
SODIUM (NA)	70.4	3.06	CHLORIDE (CL)	3.8	0.11
POTASSIUM (K)	<.1		SULFATE (SO4)	17.8	0.37
IRON (FE)	.53	0.03	NITRATE (AS N)	1.12	0.08
MANGANESE (MN)	.005	0.00	FLUORIDE (F)	.4	0.02
SILICA (SIO2)	12.3		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		3.86	TOTAL ANIONS		4.05

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 1.17

CALCULATED DISSOLVED SOLIDS	225.69	TOTAL HARDNESS AS CACO3	38.43
SUM OF DISS. CONSTITUENT	333.16	TOTAL ALKALINITY AS CACO3	173.71
FIELD CNDUCTVY, MICROMHOS	418.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	364.7	RYZNAR STABILITY INDEX	8.05
FIELD PH	7.25	LANGLIER SATURATION INDEX	0.05
LABORATORY PH	8.15	SODIUM ABSORPTION RATIO	4.94

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	17.5 C	FIELD TEMP. WATER	9.2 C
ALUMINUM, DISS (UG/L-AL)	70.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	50.	STRONTIUM,DISS (UG/L-SR)	73.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	<1.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	8.	ZINC, DISS (UG/L AS ZN)	98.
LITHIUM,DISS(UG/L AS LI)	3.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: VERY CLEAR
WELL IS BURIED BEHIND PATIO AT BACK OF HOUSE *
LAB: FU NA 73.4 MG/L GIVES 3.99 MEQ CATIONS FOR .36 SIGMA *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL. BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	SD	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT:
LAST EDIT DATE: 01-OCT-83 BY: TP *BCS
PROCESSING PROGRAM: F1730P V3 (09/1/83) PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
18.8	1.3	80.0	0.0	2.7	9.4	87.9	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0553

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0554

STATE MONTANA
LATITUDE-LONGITUDE 45D43'04"N 110D53'38"W
UTM COORDINATES Z N E
TOPOGRAPHIC MAP BOZEMAN PASS 15'
GEOLOGIC SOURCE 21HPRS* *
DRAINAGE BASIN AH
AGENCY + SAMPLER MRMG*BKM
BOTTLE NUMBER SABOL
DATE SAMPLED 29-JUN-83
TIME SAMPLED 13:45 HOURS
LAB + ANALYST MBMG*FNA
DATE ANALYZED 02-SEP-83
SAMPLE HANDLING
METHOD SAMPLED GRAB
WATER USE DOMESTIC AND STOCK

COUNTY GALLATIN
SITE LOCATION 01S 07E 29*CBDD
MBMG SITE
STATION ID 453043110533801
* SAMPLE SOURCE SPRING
LAND SURFACE ALTITUDE 5230. FT < 10
SUSTAINED YIELD
YIELD MEAS METHOD
TOTAL DEPTH OF WELL
SWL ABOVE(-) OR BELOW GS
CASING DIAMETER
CASING TYPE
COMPLETION TYPE *
PERFORATION INTERVAL

SAMPLING SITE SABOL * SPRING IN FIELD DRAINAGE *
GEOLOGIC SOURCE HOPPERS FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	88.2	4.40	BICARBONATE (HCO3)	412.	6.75
MAGNESIUM (MG)	17.5	1.44	CARBONATE (CO3)	.0	
SODIUM (NA)	42.5	1.85	CHLORIDE (CL)	4.9	0.14
POTASSIUM (K)	.3	0.01	SULFATE (SO4)	28.2	0.59
IRON (FE)	<.002		NITRATE (AS N)	.53	0.04
MANGANESE (MN)	<.001		FLUORIDE (F)	.3	0.02
SILICA (SIO2)	16.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		7.70	TOTAL ANIONS		7.53

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.77

CALCULATED DISSOLVED SOLIDS	401.39	TOTAL HARDNESS AS CACO3	292.27
SUM OF DISS. CONSTITUENT	610.43	TOTAL ALKALINITY AS CACO3	337.91
FIELD CNDUCTVY, MICROMHOS	844.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	658.7	RYZNAR STABILITY INDEX	6.43
FIELD PH	7.9	LANGLIER SATURATION INDEX	0.59
LABORATORY PH	7.62	SODIUM ADSORPTION RATIO	1.08

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	26.5 C	FIELD TEMP. WATER	7.5 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	50.	STRONTIUM,DISS (UG/L-SR)	260.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	9.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	2.	ZINC, DISS (UG/L AS ZN)	<3.
LITHIUM,DISS(UG/L AS LI)	9.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: VERY CLEAR
SPRING IS ENCLOSED BY CONCRETE WITH ACCESS HOLE *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

QW WA S2 WI DW FW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.2	18.7	24.0	0.1	1.8	7.9	90.3	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0554

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0552

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D43'40"N 110D54'32"W	SITE LOCATION	01S 07E 30 BAAA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454340110543201
GEOLOGIC SOURCE	211BNCK* *	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5230. FT < 10
AGENCY + SAMPLER	MBMG*RAM	SUSTAINED YIELD	
BOTTLE NUMBER	REICHMU	YIELD MEAS METHOD	
DATE SAMPLED	21-JUN-83	TOTAL DEPTH OF WELL	65.0 FT (M)
TIME SAMPLED	09:45 HOURS	SWL ABOVE(-) OR BELOW GS	54.68 FT (M)
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	02-SEP-83	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	02*
METHOD SAMPLED		PERFORATION INTERVAL	58 TO 68 FT (R)
WATER USE	DOMESTIC		

SAMPLING SITE REICHMUTH
GEOLOGIC SOURCE BILLMAN CREEK FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	68.7	3.43	BICARBONATE	(HCO3)	235.2	3.85
MAGNESIUM (MG)	10.6	0.87	CARBONATE	(CO3)	.0	
SODIUM (NA)	22.6	0.98	CHLORIDE	(CL)	2.2	0.06
POTASSIUM (K)	.1	0.00	SULFATE	(SO4)	56.1	1.17
IRON (FE)	.016	0.00	NITRATE	(AS N)	.70	0.05
MANGANESE (MN)	<.001		FLUORIDE	(F)	.4	0.02
SILICA (SIO2)	17.7		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		5.29	TOTAL ANIONS			5.16

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.72

CALCULATED DISSOLVED SOLIDS	294.98	TOTAL HARDNESS AS CACO3	215.17
SUM OF DISS. CONSTITUENT	414.32	TOTAL ALKALINITY AS CACO3	192.90
FIELD CNDUCTVY, MICROMHOS	406.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	436.7	RYZNAR STABILITY INDEX	7.19
FIELD PH	6.0	LANGLIER SATURATION INDEX	0.19
LABORATORY PH	7.57	SODIUM ABSORPTION RATIO	0.67

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	21.2 C	FIELD TEMP. WATER	9.8 C
ALUMINUM, DISS (UG/L-AL)	<2.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	<2.	STRONTIUM,DISS (UG/L-SR)	100.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	3.
CHROMIUM, DISS (UG/L-CR)	<5.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	8.	ZINC, DISS (UG/L AS ZN)	<3.
LITHIUM,DISS(UG/L AS LI)	3.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR * FILTER CLEAN *
WELL SET IN RETAINING WALL AT BACK OF HOUSE * RETAINING WALL 3 ' *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI - METERS. (M) = MEASURED, (E) = ESTIMATED, (R) REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	17-NOV-83	BY:	TP *RCS
PROCESSING PROGRAM:	F1730P V3 (09/1/83)	PRINTED:	16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
64.9	16.5	18.6	0.0	1.2	23.0	75.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0552

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0550

STATE MONTANA
COUNTY GALLATIN
LATITUDE-LONGITUDE 45D42'34"N 110D55'13"W
UTM COORDINATES Z N E
TOPOGRAPHIC MAP BOZEMAN PASS 15'
GEOLOGIC SOURCE 211DNCK* *
DRAINAGE BASIN AH
AGENCY + SAMPLER MBMG*BKM
BOTTLE NUMBER HARKIN
DATE SAMPLED 23-JUN-83
TIME SAMPLED 12:00 HOURS
LAB + ANALYST MBMG*FNA
DATE ANALYZED 06-SEP-83
SAMPLE HANDLING
METHOD SAMPLED PUMPED
WATER USE DOMESTIC

SITE LOCATION 01S 06E 36 ADBA
MBMG SITE HARKIN
STATION ID 454234110551301
* SAMPLE SOURCE WELL
LAND SURFACE ALTITUDE 5180. FT < 10
SUSTAINED YIELD
YIELD MEAS METHOD
TOTAL DEPTH OF WELL 72. FT (R)
SWL ABOVE(-) OR BELOW GS 9.9 FT (R)
CASING DIAMETER 6 IN (M)
CASING TYPE STEEL
COMPLETION TYPE 01*03
PERFORATION INTERVAL 32 TO 33 FT (R)

SAMPLING SITE HARKIN *
GEOLOGIC SOURCE BILLMAN CREEK FORMATION (OF LIVINGSTON GROUP)

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	44.6	2.23	BICARBONATE	(HCO3)	184.2	3.02
MAGNESIUM	(MG)	9.1	0.75	CARBONATE	(CO3)	.0	
SODIUM	(NA)	11.9	0.52	CHLORIDE	(CL)	.7	0.02
POTASSIUM	(K)	.5	0.01	SULFATE	(SO4)	17.8	0.37
IRON	(FE)	.38	0.02	NITRATE	(AS N)	1.37	0.10
MANGANESE	(MN)	<.001		FLUORIDE	(F)	.2	0.01
SILICA	(SIO2)	18.0		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			3.53	TOTAL ANIONS			3.52

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.05

CALCULATED DISSOLVED SOLIDS	195.29	TOTAL HARDNESS AS CACO3	148.82
SUM OF DISS. CONSTITUENT	288.75	TOTAL ALKALINITY AS CACO3	151.08
FIELD CNDUCTVY, MICROMHOS	453.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	326.1	RYZNAR STABILITY INDEX	8.23
FIELD PH	6.5	LANGLIER SATURATION INDEX	-0.56
LABORATORY PH	7.11	SODIUM ADSORPTION RATIO	0.42

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	25.0 C	FIELD TEMP. WATER	9.0 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	50.	STRONTIUM,DISS (UG/L-SR)	180.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	<1.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	27.	ZINC, DISS (UG/L AS ZN)	<3.
LITHIUM,DISS(UG/L AS LI)	2.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR
WELL AT BACK DOOR; 25 FEET OF PERFORATED PLASTIC LINER IN WELL * EXACT DEPTHS NOT NOTED ON LOG *
LAB: FU CA 45.8 MG/L GIVES 3.59 MEQ CATIONS FOR -.41 SIGMA *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 31-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TF *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
63.5	21.4	14.8	0.4	0.6	10.9	88.6	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0550

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0543

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D41'19"N 110D55'39"W	SITE LOCATION	01S 06E 36 CDDA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	
GEOLOGIC SOURCE	* *	* SAMPLE SOURCE	STREAM
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5020. FT < 10
AGENCY + SAMPLER	MBMG:BKM	WATER FLOW RATE	55.6 CFS
BOTTLE NUMBER	BRIDGE1	FLOW MEAS METHOD	CURRENT METER
DATE SAMPLED	28-JUN-83	STAFF GAGE	
TIME SAMPLED	10:30 HOURS	STREAM STAGE	FALLING
LAB + ANALYST	MBMG:KENA	DEPTH TO SAMPLE	0.6 FT (M)
DATE ANALYZED	02 SEP-83	TOTAL DEPTH OF WATER	1.1 FT (M)
SAMPLE HANDLING		STREAM WIDTH	37. FT (M)
METHOD SAMPLED			
WATER USE	IRRIGATION		

SAMPLING SITE LOWER BRIDGER CR AT KELLY CANYON RD BRIDGE
DRAINAGE BASIN GALLATIN RIVER

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	49.1	2.45	BICARBONATE (HCO3)	190.	3.11
MAGNESIUM (MG)	9.9	0.81	CARBONATE (CO3)	5.3	0.18
SODIUM (NA)	7.7	0.33	CHLORIDE (CL)	.6	0.02
POTASSIUM (K)	.8	0.02	SULFATE (SO4)	9.8	0.20
IRON (FE)	.21	0.01	NITRATE (AS N)	.03	0.00
MANGANESE (MN)	.015	0.00	FLUORIDE (F)	.2	0.01
SILICA (SIO2)	8.8		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		3.63	TOTAL ANIONS		3.52

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.68

CALCULATED DISSOLVED SOLIDS	186.05	TOTAL HARDNESS AS CACO3	163.35
SUM OF DISS. CONSTITUENT	282.46	TOTAL ALKALINITY AS CACO3	164.67
FIELD CNDUCTVY, MICROMHOS	414.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	411.5	RYZNAR STABILITY INDEX	6.84
FIELD PH	7.75	LANGLIER SATURATION INDEX	0.75
LABORATORY PH	8.34	SODIUM ADSORPTION RATIO	0.26

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP, AIR	14.0 C	FIELD TEMP, WATER	10.5 C
ALUMINUM, DISS (UG/L-AL)	160.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	<20.	STRONTIUM,DISS (UG/L-SR)	94.
CADMIUM,DISS(UG/L AS CD)	<2.	TITANIUM DIS(UG/L AS TI)	5.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	<1.
COPPER,DISS (UG/L AS CU)	<2.	ZINC, DISS (UG/L AS ZN)	15.
LITHIUM,DISS(UG/L AS LI)	<2.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVLENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (F) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL, BIO = BIOLOGICALLY AVAILABLE.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04-OCT-83
PROCESSING PROGRAM: P1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
67.7	22.5	9.3	0.6	0.5	3.8	88.7	5.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0543

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 83Q0546

STATE	MONTANA	COUNTY	GALLATIN
LATITUDE-LONGITUDE	45D43'15"N 110D54'07"W	SITE LOCATION	01S 07E 30*DABA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'	STATION ID	454315110540701
GEOLOGIC SOURCE	* *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	AH	LAND SURFACE ALTITUDE	5130. FT (E) 10
AGENCY + SAMPLER	MBMG&BKM	WATER FLOW RATE	33.6 CFS
BOTTLE NUMBER	BRIDGE2	FLOW MEAS METHOD	CURRENT METER
DATE SAMPLED	28-JUN-83	STAFF GAGE	
TIME SAMPLED	13:20 HOURS	STREAM STAGE	FALLING
LAB + ANALYST	MBMG&FNA	DEPTH TO SAMPLE	0.6 FT (M)
DATE ANALYZED	02-SEP-83	TOTAL DEPTH OF WATER	1.5 FT (M)
SAMPLE HANDLING		STREAM WIDTH	24. FT (M)
METHOD SAMPLED	GRAB		
WATER USE	IRRIGATION		

SAMPLING SITE BRIDGER CREEK AT SAROL ROAD* WOODEN BRIDGE
DRAINAGE BASIN GALLATIN RIVER

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	50.2	2.50	BICARBONATE (HCO3)	213.5	3.50
MAGNESIUM (MG)	10.3	0.85	CARBONATE (CO3)	.0	
SODIUM (NA)	8.9	0.39	CHLORIDE (CL)	.9	0.03
POTASSIUM (K)	.5	0.01	SULFATE (SO4)	12.0	0.25
IRON (FE)	.17	0.01	NITRATE (AS N)	.02	0.00
MANGANESE (MN)	.013	0.00	FLUORIDE (F)	.2	0.01
SILICA (SIO2)	9.2		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		3.76	TOTAL ANIONS		3.79

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.15

CALCULATED DISSOLVED SOLIDS	197.58	TOTAL HARDNESS AS CACO3	167.74
SUM OF DISS. CONSTITUENT	305.90	TOTAL ALKALINITY AS CACO3	175.11
FIELD CNDUCTVY, MICROMHOS	431.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	331.7	RYZNAR STABILITY INDEX	6.82
FIELD PH	7.82	LANGLIER SATURATION INDEX	0.73
LABORATORY PH	8.29	SODIUM ADSORPTION RATIO	0.30

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP. AIR	20.0 C	FIELD TEMP. WATER	12.0 C
ALUMINUM, DISS (UG/L-AL)	380.	NICKEL,DISS (UG/L AS NI)	20.
SILVER, DISS(UG/L AS AG)	23.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	60.	STRONTIUM,DISS (UG/L-SR)	<10.
CADMIUM,DISS(UG/L AS CD)	9.	TITANIUM DIS(UG/L AS TI)	18.
CHROMIUM, DISS (UG/L-CR)	11.	VANADIUM,DISS(UG/L AS V)	24.
COPPER,DISS (UG/L AS CU)	30.	ZINC, DISS (UG/L AS ZN)	8.
LITHIUM,DISS(UG/L AS LI)	17.	ZIRCONIUM DIS(UG/L AS ZR	28.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL. BIO - BIOLOGICALLY AVAILABLE.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04-OCT-83
PROCESSING PROGRAM: F1730P V3 (09/1/83)

COST:
BY: TP *BCS
PRINTED: 16-FEB-84

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
66.8	22.6	10.3	0.3	0.7	6.6	92.7	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 83Q0546

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300544

STATE	MONTANA
LATITUDE-LONGITUDE	45D41'51"N 110D54'18"W
UTM COORDINATES Z N E	
TOPOGRAPHIC MAP	BOZEMAN PASS 15'
GEOLOGIC SOURCE	211HPRS* *
DRAINAGE BASIN	AH
AGENCY + SAMPLER	MBMG*BLM
BOTTLE NUMBER	LANDERD
DATE SAMPLED	21-JUN-83
TIME SAMPLED	11:00 HOURS
LAB + ANALYST	MBMG*FNA
DATE ANALYZED	02-SEP-83
SAMPLE HANDLING	
METHOD SAMPLED	PUMPED
WATER USE	DOMESTIC

COUNTY	GALLATIN
SITE LOCATION	02S 07E 06 ABBB
MBMG SITE STATION ID	454151110541801
* SAMPLE SOURCE	SPRING
LAND SURFACE ALTITUDE	5780. FT < 10
SUSTAINED YIELD	
YIELD MEAS METHOD	
TOTAL DEPTH OF WELL	
SWL ABOVE(-) OR BELOW GS	
CASING DIAMETER	
CASING TYPE	
COMPLETION TYPE	*
PERFORATION INTERVAL	

SAMPLING SITE LANDERDAHL * 15035 KELLY CANYON ROAD
GEOLOGIC SOURCE HOPPERS FORMATION (OF LIVINGSTON GROUP)

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	63.6	3.17	BICARBONATE (HCO3)	287.4	4.71
MAGNESIUM (MG)	12.8	1.05	CARBONATE (CO3)	.0	
SODIUM (NA)	22.6	0.98	CHLORIDE (CL)	1.9	0.05
POTASSIUM (K)	.5	0.01	SULFATE (SO4)	16.3	0.34
IRON (FE)	<.002		NITRATE (AS N)	.27	0.02
MANGANESE (MN)	<.001		FLUORIDE (F)	.3	0.02
SILICA (SIO2)	21.1		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		5.22	TOTAL ANIONS		5.14

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.46

CALCULATED DISSOLVED SOLIDS	280.95	TOTAL HARDNESS AS CACO3	211.49
SUM OF DISS. CONSTITUENT	426.77	TOTAL ALKALINITY AS CACO3	235.72
FIELD CNDUCTVY, MICROMHOS	398.	FIELD ALKALINITY AS CACO3	
LAB CNDUCTVY, MICROMHOS	459.1	RYZNAR STABILITY INDEX	7.31
FIELD PH	6.4	LANGLIER SATURATION INDEX	0.02
LABORATORY PH	7.34	SODIUM ADSORPTION RATIO	0.68

PARAMETER	VALUE	PARAMETER	VALUE
FIELD TEMP, AIR	24. C	FIELD TEMP, WATER	9.7 C
ALUMINUM, DISS (UG/L-AL)	<30.	NICKEL,DISS (UG/L AS NI)	<10.
SILVER, DISS(UG/L AS AG)	<2.	LEAD,DISS(UG/L AS PB)	<40.
BORON,DISS (UG/L AS B)	50.	STRONTIUM,DISS (UG/L-SR)	200.
CADMIUM,DISS(UG/L AS CD)	3.	TITANIUM DIS(UG/L AS TI)	4.
CHROMIUM, DISS (UG/L-CR)	<2.	VANADIUM,DISS(UG/L AS V)	6.
COPPER,DISS (UG/L AS CU)	18.	ZINC, DISS (UG/L AS ZN)	10.
LITHIUM,DISS(UG/L AS LI)	9.	ZIRCONIUM DIS(UG/L AS ZR	<4.
MOLYBDENUM,DISS(UG/L-MO)	<20.		

REMARKS: CLEAR
SPRING SAMPLE AT HOUSE * SPRING COVERED IN CONCRETE AND INACCESSIBLE *
2 GPM FROM SPIGOT *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL. BIO = BIOLOGICALLY AVAILABLE.

OTHER AVAILABLE DATA: QW WA SO WI OW PW AT OTHER
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04-OCT-83 COST:
PROCESSING PROGRAM: F1730F V3 (09/1/83) BY: TP *BCS
PRINTED: 16-FEB-84

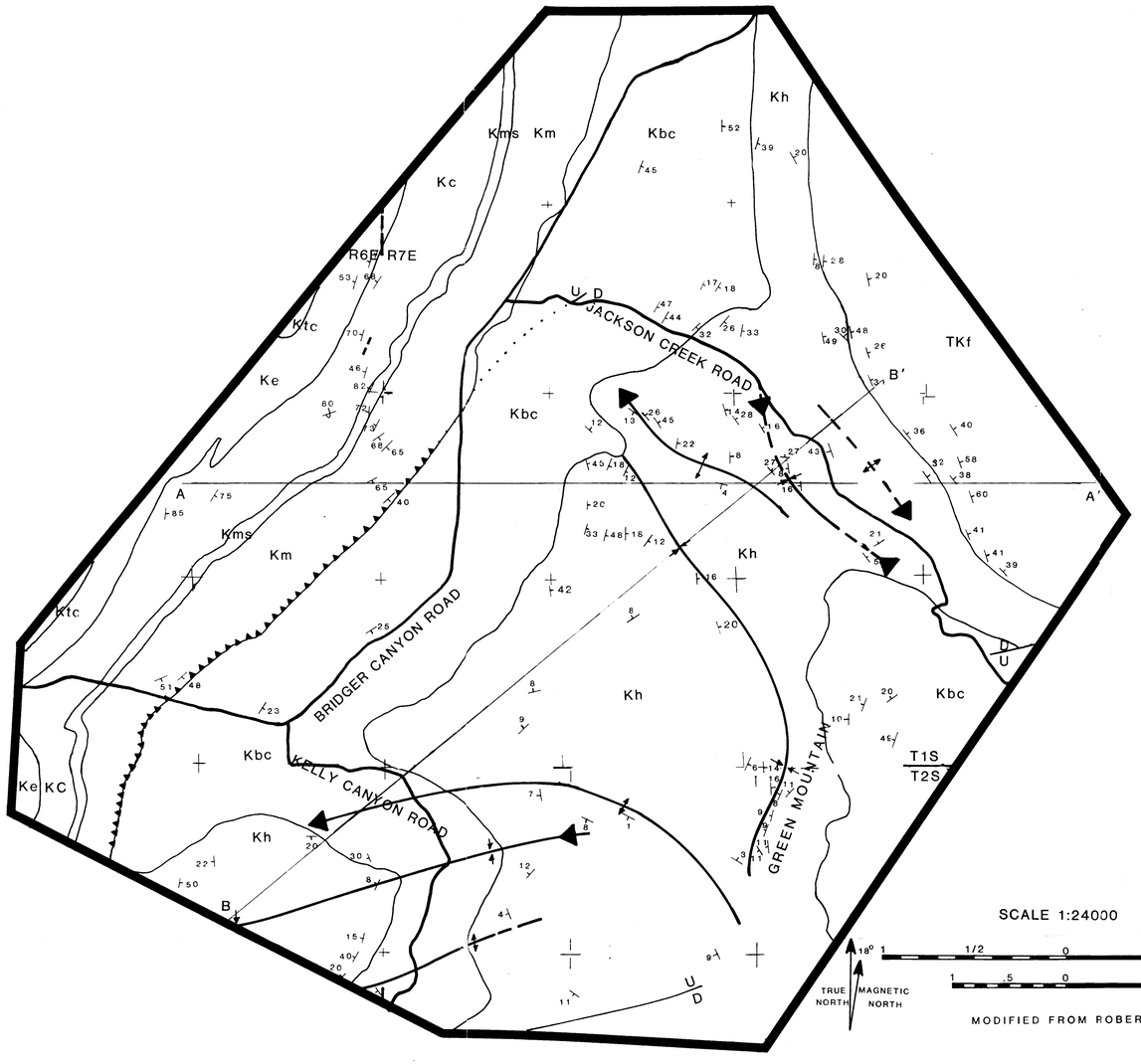
PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
60.8	20.2	18.8	0.2	1.1	6.7	92.3	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300544

GEOLOGIC BEDROCK MAP OF BRIDGER CANYON, BOZEMAN, MONTANA

PLATE 1



EXPLANATION

TERTIARY

TKf — FORT UNION FORMATION
MIXED CONGLOMERATE, SANDSTONE, AND SILTSTONE, PRE-CRETACEOUS CLASTS IN CONGLOMERATES.

CRETACEOUS

Kh — HOPPERS FORMATION
ANDESITIC SANDSTONE INTERBEDDED WITH CLAYSTONE AND SILTSTONE, BASAL YELLOWISH-GRAY MASSIVE CROSS-BEDDED SANDSTONE

Kbc — BILLMAN CREEK FORMATION
VARYING GRAY, RED AND PURPLE CLAYSTONE INTERBEDDED WITH SANDSTONE, SILTSTONE, AND MINOR CONGLOMERATE ZONES OF FRESH-WATER MOLLUSKS AND DINOSAUR BONES.

Km — MINER CREEK FORMATION
ANDESITIC SILTSTONE AND SANDSTONE WITH TUFF AND BENTONITE IN LOWER PARTS CONTAINS PLANT FOSSILS AND DINOSAUR BONES.

Kms — KMS, SULPHUR FLATS SANDSTONE MEMBER MASSIVE YELLOWISH-GRAY MOTTLED SANDSTONE

Kc — COKEDALE FORMATION
ANDESITIC SILTSTONE, SANDSTONE, MINOR CONGLOMERATE, TUFF, BENTONITE, AND COAL, CARBONACEOUS LOWER PART, LOCALLY CONGLOMERATIC SANDSTONE, CONTAINS FOSSIL PLANTS, DINOSAUR BONES, AND FRESH-WATER MOLLUSKS

Ke — EAGLE SANDSTONE FORMATION
SANDSTONE AND SILTSTONE WITH INTERCALATED COAL AND SHALE IN UPPER PART, MASSIVE CROSS-BEDDED SANDSTONE WITH MINOR COAL, SILTSTONE, AND SHALE IN LOWER PART

Ktc — TELEGRAPH CREEK FORMATION
SILTSTONE WITH THIN-BEDDED SANDSTONE, WITH CALCAREOUS CONCRETIONS

- CONTACT
- FAULT — U, UPTHROWN SIDE; D, DOWNTHROWN SIDE
- INFERRED FAULT
- THRUST FAULT, SAWTEETH ON UPPER PLATE, DOTTED WHERE INFERRED
- ANTICLINE, DASHED WHERE APPROXIMATELY LOCATED, ARROWS IN DIRECTION OF PLUNGE
- SYNCLINE, DASHED WHERE APPROXIMATELY LOCATED
- STRIKE AND DIP OF BEDS
- STRIKE AND DIP OF OVERTURNED BEDS
- ZONE OF HYDROTHERMAL ALTERATION
- FORM LINE
- THRUST FAULT
- A — A' LINE OF CROSS-SECTION

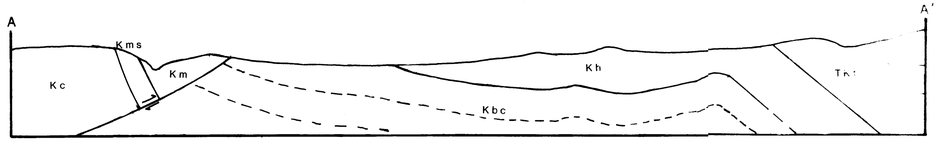
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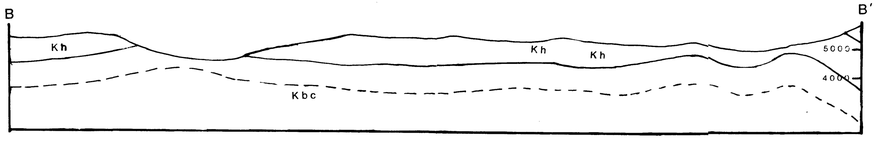
1 1/2 0 1 MILE

1 .5 0 1 KILOMETER

18° TRUE NORTH, MAGNETIC NORTH

MODIFIED FROM ROBERTS, 1964



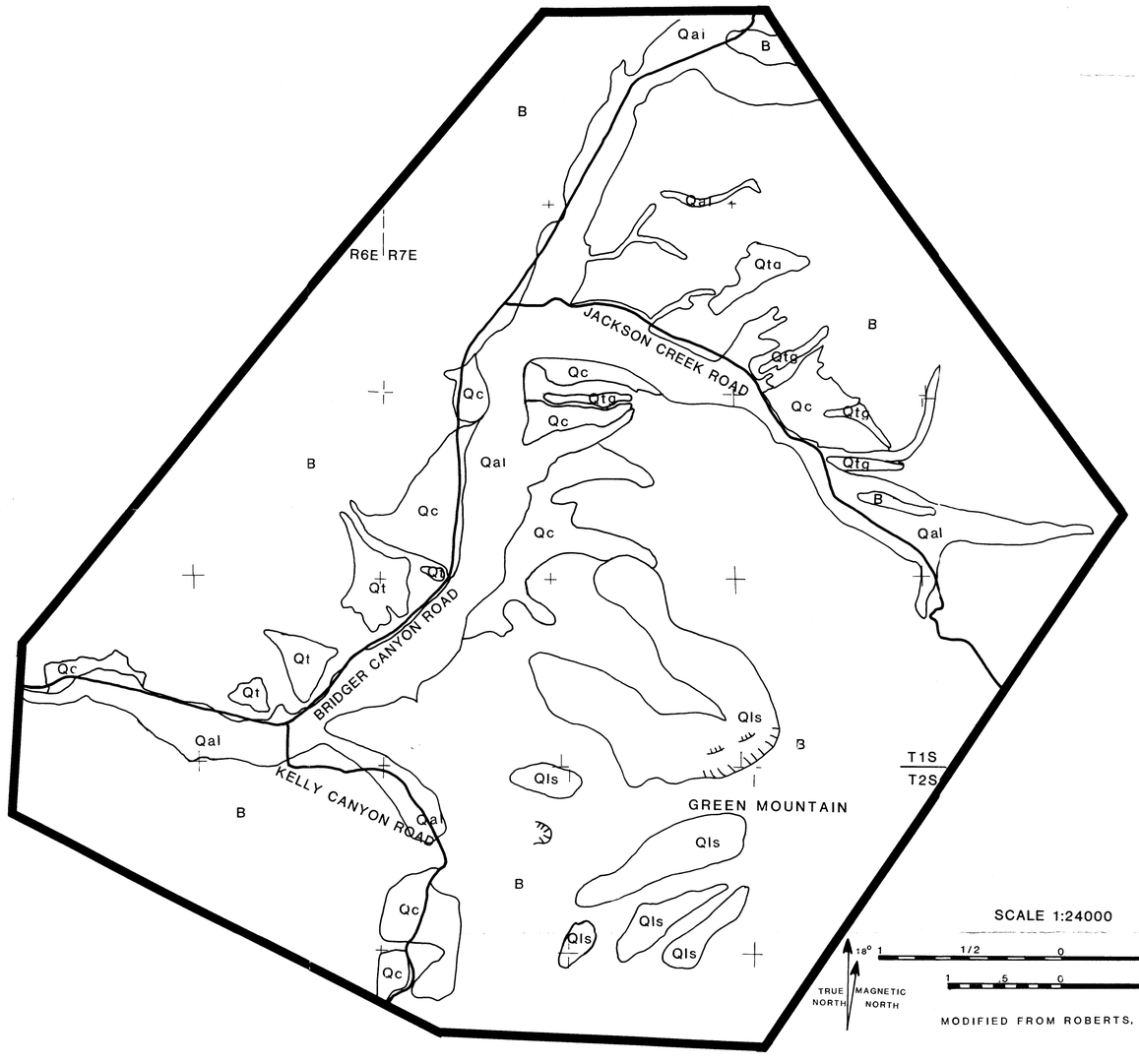


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PLATE 2

GEOMORPHIC MAP OF BRIDGER CANYON, BOZEMAN, MONTANA



EXPLANATION

SEE PLATE 4 FOR WATER AVAILABILITY

- **Qal** — QUATERNARY STREAM-ALLUVIUM: WELL-SORTED ROUNDED GRAVELS AT LEVEL OF PRESENT STREAMS
- **Qc** — QUATERNARY COLLUVIUM: UNSORTED POORLY -SORTED, ANGULAR DEBRIS AT LEAST 3 FEET THICK ON SLOPES GRADING TO STREAMS
- **Qt** — QUATERNARY CUT-TERRACE: GENTLY SLOPING SURFACE TRUNCATING BEDROCK
- **Qtg** — QUATERNARY GRAVEL-VENEERED TERRACE: GRAVEL-VENEERED , GENTLY SLOPING SURFACE TRUNCATING BEDROCK
- **Qls** — QUATERNARY LANDSLIDE: UNSORTED BLOCKS OF BEDROCK AND SOIL, LOBATE SHAPE
- **B** — BEDROCK
- SLUMP SCARP

SCALE 1:24000

18° TRUE NORTH / MAGNETIC NORTH

1 0 1/2 1 MILE

1 0 .5 1 KILOMETER

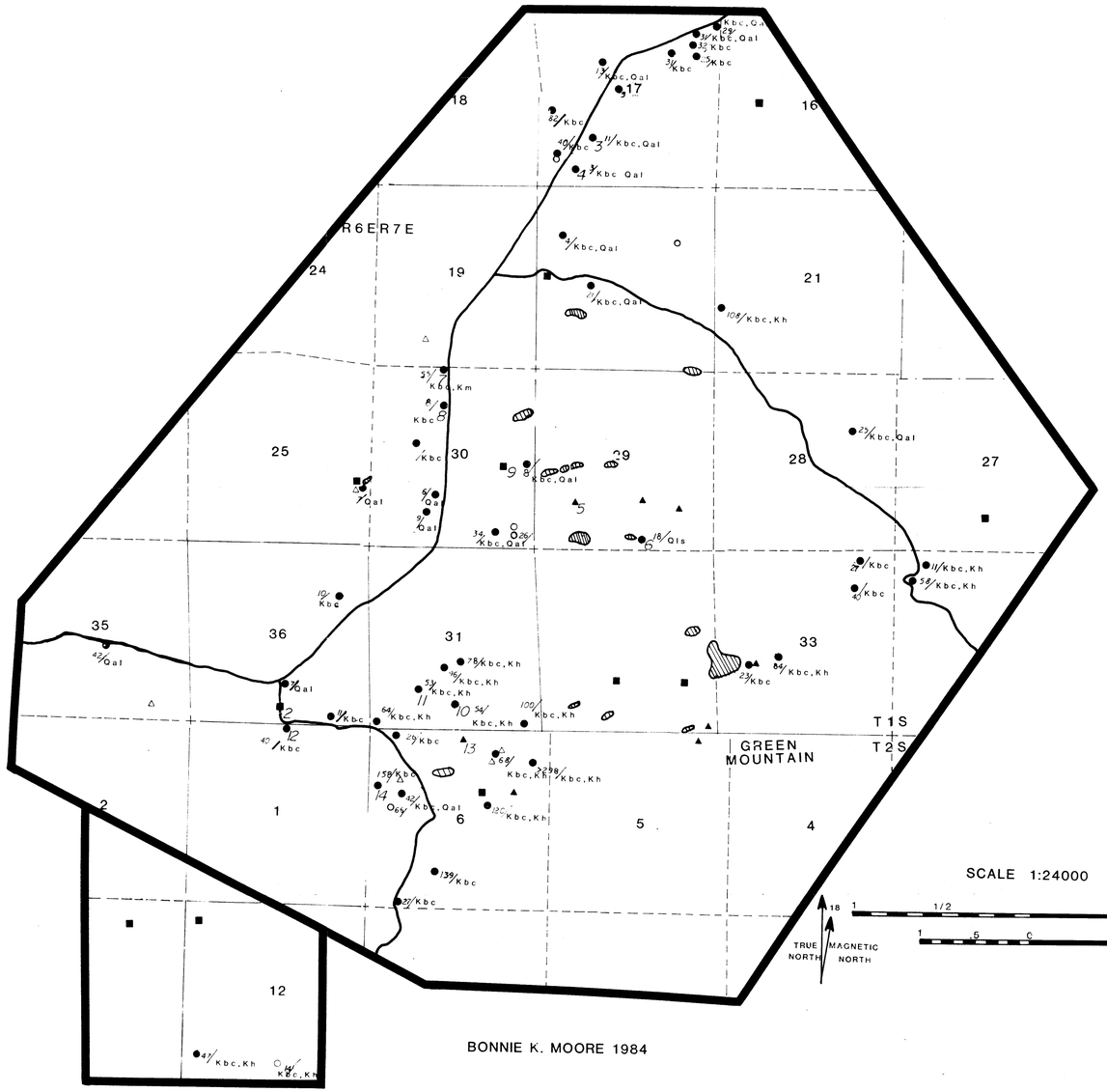
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PLATE 3

MEASURED SITE LOCATION MAP OF BRIDGER CANYON , BOZEMAN, MONTANA



EXPLANATION

- MEASURED WELL
- ABANDONED WELL
- MEASURED SPRING
- SPRING NOT MEASURED
- MEASURED STREAM SITE
- MEASURED POND
- 12 SAMPLED SITE
  NUMBER INDICATES WATER QUALITY SAMPLE NUMBER IN TEXT
- 23/Kbc DEPTH TO STATIC WATER LEVEL/SOURCE
  SEE TEXT FOR DETAILS

SCALE 1:24000

1 1/2 1 MILE

1 .5 0 1 KILOMETER

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AREA WHERE SUPPLEMENTAL MEASUREMENTS TAKEN
DATA INCLUDED WITH ALL OTHERS IN TEXT

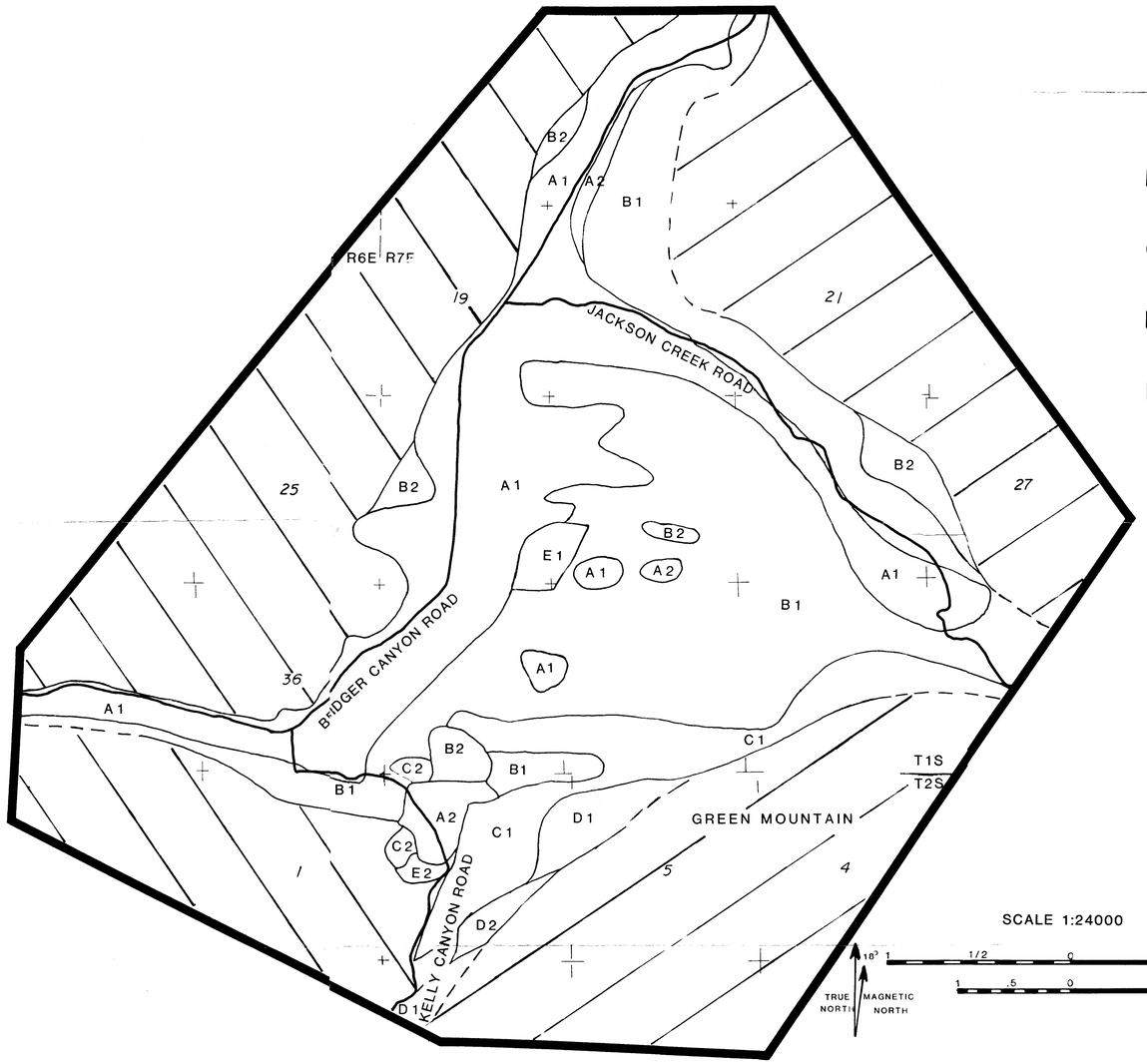
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PLATE 4

GROUND WATER RESOURCE MAP OF BRIDGER CANYON, BOZEMAN, MONTANA

THIS MAP IS A GENERALIZED EVALUATION OF WATER AVAILABILITY AND WATER QUALITY. BOUNDARIES ARE APPROXIMATE.

BASED UPON GEOMORPHOLOGY AND WELL MEASUREMENTS OF DEPTH AND QUALITY



EXPLANATION

FAIR CHANCE OF FINDING WATER AT DRILLING DEPTHS OF: (INDICATED BY THE FIRST LETTER:)

- **A** 100 FEET OR LESS.
- **B** 101 TO 199 FEET
- **C** 200 TO 399 FEET
- **D** 400 OR MORE FEET
- **E** INDICATES KNOWN WATER AVAILABILITY PROBLEMS SUCH AS ABANDONED WELLS

- **1** IN SECOND POSITION INDICATES NO KNOWN WATER QUALITY PROBLEMS. DOES NOT SUGGEST THAT NO QUALITY PROBLEMS WILL BE ENCOUNTERED
- **2** IN SECOND POSITION INDICATES KNOWN WATER QUALITY PROBLEMS SUCH AS HYDROGEN SULFIDE GAS, EXCESSIVE FLUORIDE, IRON STAINING, OR EXCESSIVE NITRATE, AND/OR HIGH TOTAL DISSOLVED SOLIDS

CONTACT BETWEEN WATER RESOURCE TYPES

SECTION CORNERS

21 SECTION NUMBERS

AREA NOT STUDIED

SCALE 1:24000

1 1/2 0 1 MILE

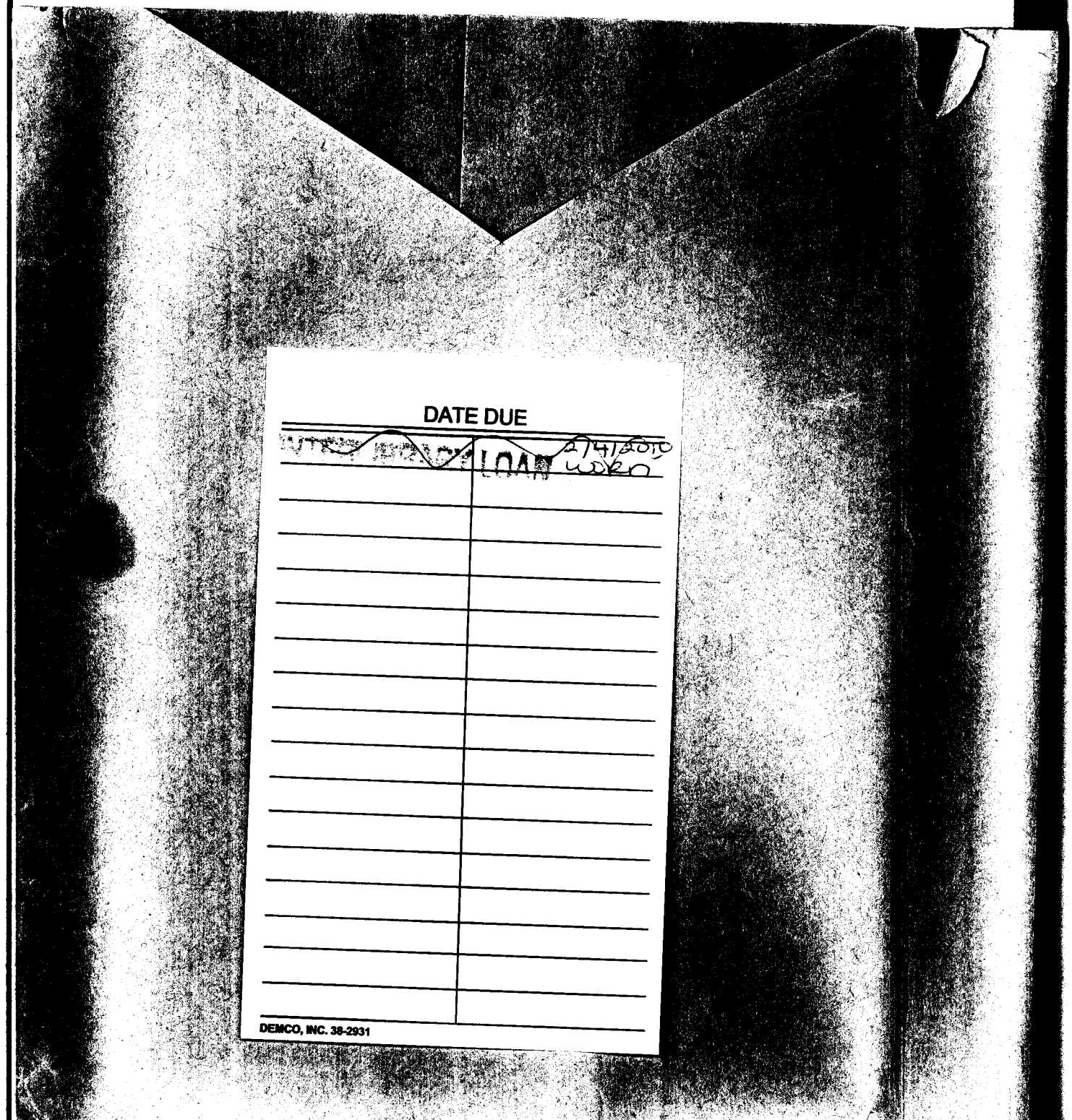
1 .5 0 1

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