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Role of the groundwater system in controlling nutrient loading of a pristine trout stream western Montana

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The Role of the Groundwater System in

Controlling Nutrient Loading of a

Pristine Trout Stream, Western Montana

by

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presented in partial fulfillment of the requirements

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Director: William W. Woessner

The Rock Creek drainage is becoming increasingly popular as a place to fish and live. Rural living requires each residence to have a domestic well and septic system. Rock Creek residents have become concerned about the potential effects of septic-system nutrients, especially nitrate, on groundwater and surface-water resources. Background nitrate-N concentrations are 0.08 mg/l in the groundwater and 0.003 to 0.009 mg/l in the surface water. Nitrate-N levels in the groundwater increase down valley as water flows through the developed areas. Each septic system is estimated to add between 18 and 27 lbs of nitrate-N to the groundwater each year. Therefore, the increase in the nitrate-N concentration of the groundwater is attributed to the release of septic-system wastes to the aquifer. Before the groundwater discharges into Rock Creek, it flows through a discharge-area wetland with a shallow water table and riparian vegetation. During high water, the water table rises into the root zone causing seasonal saturation of the soils. This near surface zone appears to reduce the nitrate concentration of discharging groundwater through denitrification; thus limiting the impact of nitrate loading for part of the year. As the water table falls during the summer, the ability of this system to attenuate nitrate decreases. An observed increase in nitrate-N concentrations over the summer may be due to a decrease in available organic carbon as the water table falls below the root zone. Both groundwater and surface water in the Rock Creek Valley are of high quality.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

The population of Western Montana is growing rapidly and the demand for vacation homes and property in the scenic mountainous areas in this region is increasing. In these rapidly changing areas, many of which depend on their pristine state to attract tourists and fishermen, the protection of groundwater and surface water quality has become a concern of land owners. Traditionally, homes and recreation cabins constructed in these rural areas depend upon either septic systems or pit toilets for sewage disposal. Waters with elevated nitrate concentrations in such areas are most often viewed as impacted by household sewage. However, most studies involving septic-system related nitrate contamination have been performed in heavily populated areas or regions where nitrate is used as a fertilizer by the agriculture industry (Keeney, 1986; DeWalle and Schaff, 1980; Denver, 1989; Sinton, 1982; Cox, 1980). Few studies address the effect of septic-system waste originating from sparse rural development (Robertson et al., 1991). Interaction of septic system influenced groundwater with nutrient limited surface water has only been addressed in a few papers (Robertson et al., 1991; Duff and Triska, 1990).

Rock Creek is a blue ribbon trout stream that flows into the Clark Fork River 20 mi east of Missoula, Montana. The water of Rock Creek is considered to be of the highest quality and contains concentrations of the nutrients, nitrate and phosphate, in the part per billion range (Watts and Watson, 1993). However, in 1991, residents and recreational users reported a growth of the filamentous alga, Cladophora, in the lower twenty miles of the creek (Watts and Watson, 1993). Long term residents of Rock Creek note that the growth of algae has increased in recent years, and that the 1991 growth exceeded previously observed growths. This apparent increase in algal growth also coincided with a period of expansion of low density housing development in portions of the Rock Creek Valley.

Watts and Watson (1993) studied the surface water and algae at several points along Rock Creek. They found nitrate and phosphate concentrations to be below 0.010 mg/l in the surface water throughout most of the year. However, no previous research has been conducted that examines the exchange of nutrients between groundwater and surface water in the Rock Creek Valley. This project was undertaken to determine if septic system effluent is impacting the groundwater adjacent to Rock Creek, and the degree to which impacted groundwater exchanges with Rock Creek.

GOALS AND OBJECTIVES

The goal of this project was to evaluate the source, behavior, and fate of nitrate within a selected portion of the Rock Creek Valley. This work establishes the relationship between ground-water nitrate-N levels and creek chemistry, and examines how hyporheic processes (near-channel groundwater-surface-water interaction) affect nitrate concentrations. This study was focused on the area between Spring Creek and Ranch Creek, 5 to 12 mi from the mouth of Rock Creek. The following are specific objectives of the project:

1. Determine the thickness and extent of the floodplain material;
2. Develop water-table position and groundwater flow maps;
3. Determine the interaction of the surface water with the groundwater by defining gaining and losing reaches of Rock Creek;
4. Establish background groundwater quality and examine the effect of existing sewage disposal practices on ground-water quality;
5. Characterize the physical and chemical fate of the ground-water nitrates.

BACKGROUND

Physiography

Rock Creek is a north flowing stream that discharges into the Clark Fork River about 20 miles east of Missoula. Rock Creek is bounded to the west by the Sapphire Mountains and by the John Long Mountains to the east. Headwaters are in the Sapphire and Anaconda Ranges. Elevations range from 3,500 ft at the confluence with the Clark Fork River to over 10,000 ft at its headwater in the Anaconda Range (Figure 1).

The study area is located between Ranch Creek and the confluence of Spring Creek and Rock Creek, between 5 and 12 mi upstream from the confluence of Rock Creek and the Clark Fork River (Figure 2). Figure 3 is a simplified map showing the major geographic features. Elevation of the valley floor in the study area ranges from 3,660 to 3,840 ft. Rock Creek flows to the north, along the west side of the valley throughout the study area. Tributaries located in the study area include Ranch Creek, Brewster Creek, Sawmill Creek and Spring Creek. This area was chosen for the study because it is the most densely populated portion of the Rock Creek Valley. About 70 permanent residences and summer homes are located in the study area.

Hydrology

Rock Creek drains an area of 900 square miles. The main stem of the creek flows 50 miles from the confluence of the East, West, and Ross forks of Rock Creek before joining the Clark Fork River 20 mi east of Missoula. Individual drainages along the main stem of Rock Creek are much smaller than the headwater drainages. Ranch Creek is the largest tributary along the main stem of Rock Creek.

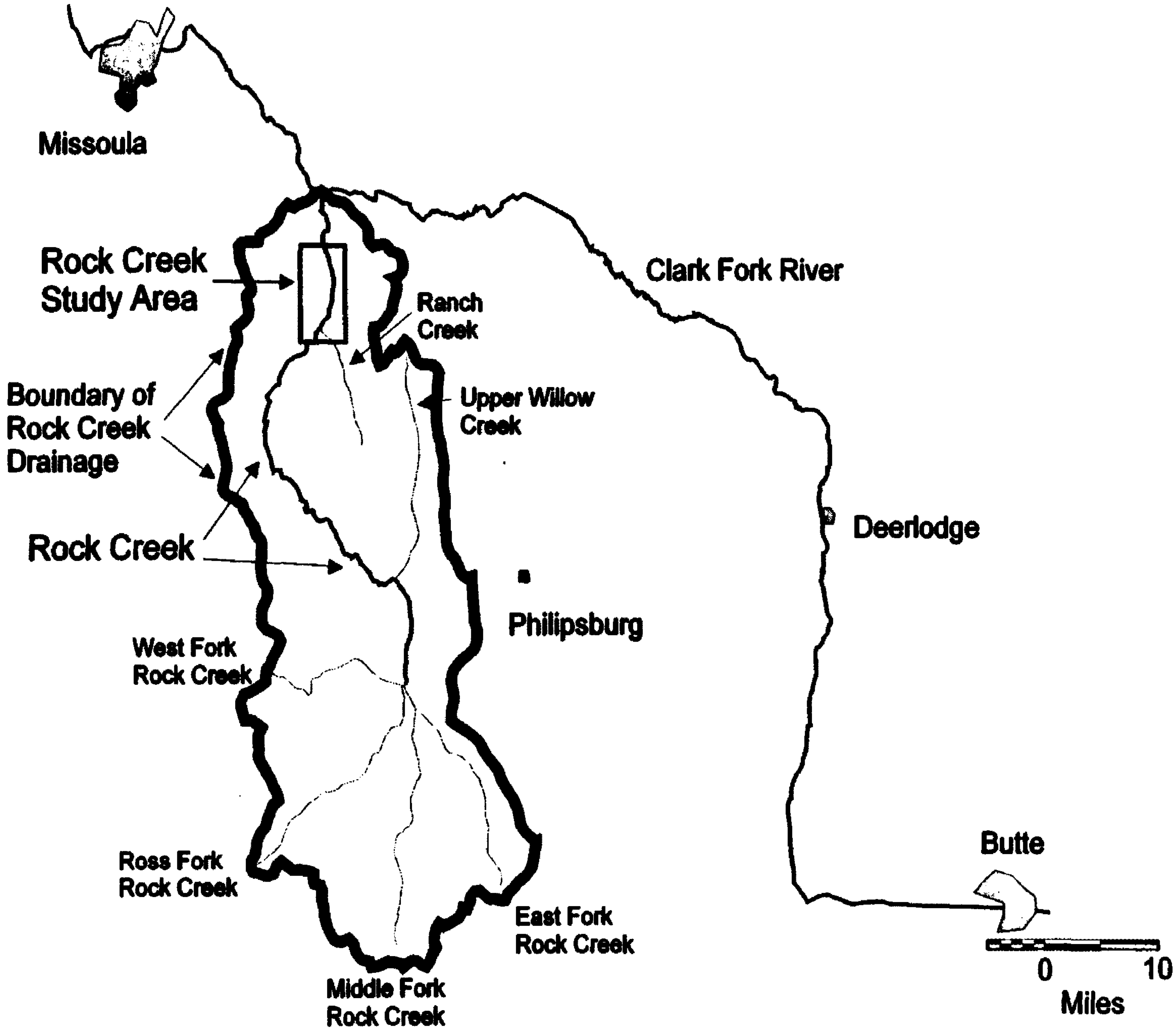


Figure 1: Rock Creek study area location map.

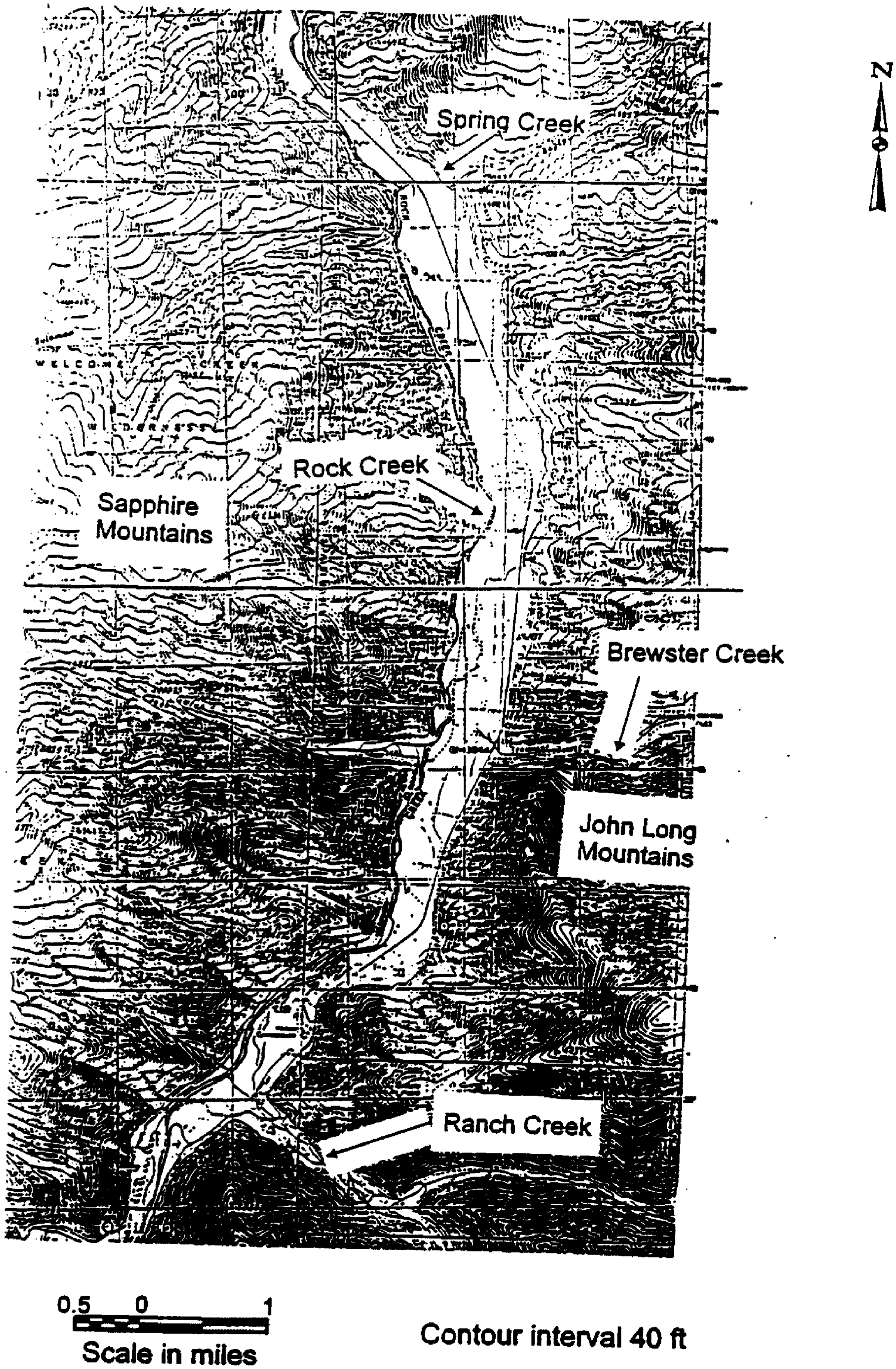


Figure 2: Topographic map of the study area.

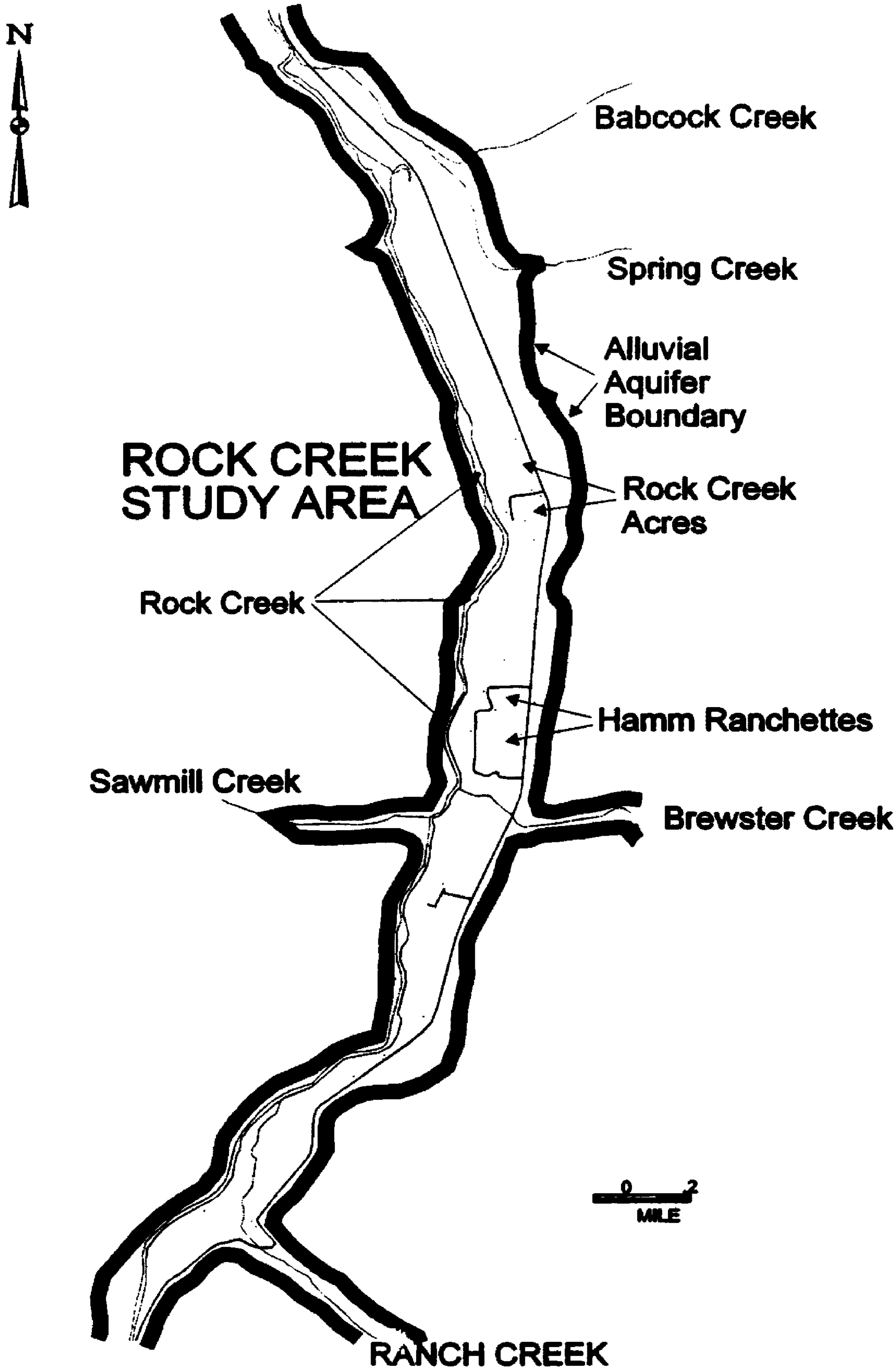


Figure 3: Simplified Diagram of the Study Area.

Average peak flows in Rock Creek occur in May (1500 cfs) and June (1700 cfs). Average base flow is about 200 cfs during the winter. Base flow conditions typically persist from August through March.

Geology

Both the Sapphire Range and the John Long Mountains are composed primarily of quartzites and argilites of the Belt Supergroup. In the Spring Creek drainage, limestone of the Wallace Formation is exposed.

Before the last ice age, about 35,000 years b.p., Rock Creek had carved a canyon in the study area about 180 ft deeper than the present valley floor. With the melting ice, the discharge of Rock Creek was much larger than today, carrying with it large volumes of sediment. These sediments were deposited on the valley floor, raising the valley to its present level. The high benches in the vicinity of Hamm Ranchettes and on either side of Ranch Creek may approximate the maximum level of the valley bottom. After the period of sediment deposition, the creek began to cut down through the gravel deposits until its current level was reached.

Glacial Lake Missoula (15,000 b.p.) rose to an elevation of 4350 ft (Alt and Hyndman, 1986) putting the study area under as much as 700 ft of water. In the southern part of the study area, several well logs record a layer of red or tan clay up to 5 ft thick at 30 to 40 ft below the ground surface. This clay layer may be a remnant of the fine grained lacustrine sediments.

Sediments in the valley are composed primarily of sand, gravel, and cobbles of Belt Group quartzites derived from the surrounding mountains. These sediments comprise the aquifer from which all but a few wells in the valley extract their water. Water flows readily through these coarse sediments, allowing for productive wells.

NITROGEN BEHAVIOR IN SEPTIC SYSTEMS

Septic systems consist of two parts, the septic tank and the drainfield. Household waste water flows into the septic tank and undergoes anaerobic treatment. Nitrogen from organic matter contained in the waste water is converted to ammonium (NH_4^+) in the septic tank.

Ammonium concentrations found in septic tank fluids vary considerably. Keeney (1986) reports a value of total nitrogen between 50 and 70 mg/l, approximately 75% ammonium and 25% organic nitrogen. Two septic systems located in the Missoula, Montana area were sampled by Ver Hey (1987) and contained total nitrogen levels of 41 and 76 mg/l. Canter and Knox (1985) report an average of 45 mg/l total nitrogen from sampling of 99 septic systems, with a range between 9 and 125 mg/l. A septic tank has no nitrogen removal capabilities, therefore the nitrogen found in the effluent will be delivered to the drainfield. Septic tanks produce anaerobic and dissolved constituents in their reduced form. These conditions generally persist as the fluid leaves the drainfield and percolates through the biological mat beneath the typical drainfield.

Between the base of the biological mat and the water table, waste water percolates through an oxygen rich vadose zone which creates aerobic conditions. As the fluid moves through this zone, ammonium is converted to nitrate by the process of nitrification:

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$$

As septic-system effluent migrates through the vadose zone, all or part of the ammonium may be converted to nitrate. When nitrate-rich effluent reaches the water table, the underlying groundwater flow system begins to transport and disperse the nitrate, thus nitrate concentrations are initially reduced by dilution.

NITROGEN BEHAVIOR IN GROUNDWATER

Generally, nitrate is considered to be unreactive in oxygenated groundwater, i.e., it acts conservatively. However, nitrate can be reduced to ammonium by microbial action, plants may take up nitrate for biological uses, or nitrate may be reduced to nitrogen gas (N_2, or N_2O) through denitrification (Keeney, 1986). Denitrification is the only reaction that permanently removes nitrate from the system. Reduction of nitrate typically occurs through microbial action, where nitrogen is the electron acceptor. Organic carbon is usually considered to be the electron donor (Keeney, 1986). However, Fe^{2+} has been shown to be the electron donor in some circumstances (Korom, 1992; Postma et al., 1991). There are two paths that nitrate reduction can take, ending either with NH_4^+ or N_2 gas. Reduction to ammonium is merely the reverse reaction of nitrification:

$$NO_3^- + 2H^+ + H_2O \rightarrow NH_4^+ + 2O_2$$

Reduction of nitrate to ammonium does not remove nitrogen, as the ammonia can easily be converted back to nitrate if oxygen-rich groundwater is encountered.

The denitrification path from nitrate to N_2 gas is shown by the following sequence:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Most denitrifying bacteria are capable of completing the entire reaction, however, some can only complete a portion of the path (Korom, 1992). A balanced net reaction can be written in many different ways and usually omits the middle three steps. The following equation is from Korom (1992):

$$5C + 4NO_3^- + 2H_2O \rightarrow 2N_2 + 4HCO_3 + CO_2$$

Where C represents an arbitrary organic compound with an oxidation state of zero. Labile organic carbon may also play a role in the development of anaerobic conditions in an aquifer.

Under similar conditions, the endpoint of nitrate reduction can be either N_2 gas or ammonium. Robertson and Kuenen (1984) point out that many species of denitrifying bacteria are capable of using both oxygen and nitrate simultaneously, and suggest that denitrification takes place when some oxygen is still present. Knowles (1982) states that under complete anaerobiosis, reduction of nitrate proceeds towards ammonium. Tiedje et al. (1982) looked at energy yields for both reactions. They found when energy yield per electron donor was evaluated, denitrification provides more energy. Reduction to ammonium was favored when energy available per nitrate consumed was evaluated. From these data, Tiedje et al. (1982) suggest that the availability of electron donors to electron acceptors determines the direction of the reaction. When the limiting factor is electron donors, denitrification takes place. Reduction to ammonium is favored when electron acceptors are limiting.

CHAPTER 2

METHODS

The methods used to characterize the physical and geochemical hydrogeology of the Rock Creek study area are described herein.

PHYSICAL HYDROGEOLOGY

In order to develop an understanding of the stratigraphy of the study area, well logs from the Montana Bureau of Mines and Geology were analyzed. Specific capacity data from the well logs were used to estimate hydrologic properties of the valley fill material (Driscoll, 1986). Geological maps were used, in conjunction with well logs, to estimate the depth of the alluvium in the tributary valleys of Rock Creek. The depth of the alluvium in the Rock Creek Valley was inferred from these data.

A network of domestic wells was selected for water level measurement such that data would be representative of: 1) groundwater conditions in the more populated areas of Hamm Ranchettes and Rock Creek Acres; and 2) the regional valley-wide conditions. Permission was obtained from land owners to monitor water levels and water quality from domestic wells. Water levels were measured on a monthly basis from August 1993 to July 1994. Groups of wells were surveyed to a common datum using standard techniques, then elevations of the groups were connected to a common datum using a standard altimeter survey. Water-level maps were then constructed and groundwater flow directions determined.

In areas where a group of domestic wells were being monitored, staff gages were constructed in Rock Creek by driving a fence post into the creek bottom. By comparing the surveyed creek stage to the position of the water table in nearby domestic wells it was possible to determine where the creek recharges the groundwater system and where groundwater discharges to the creek. The distribution of selected water quality parameters was also used to determine the extent and amount of surface water-groundwater interaction.

Hydraulic conductivity was calculated using two different methods. Specific capacity data from well logs were used with Jacob's equation (Driscoll, 1986), then corrected for partial penetration of the aquifer using the Kozeny equation (Driscoll, 1986). The Jacob equation was designed for confined aquifers, however, drawdown of the wells was small compared to the thickness of the aquifer, a requirement for using this method on an unconfined aquifer. The second method was an estimate using Darcy's law and the known amount of groundwater that comes to the surface in Spring Creek. Variables that affect the calculation are the saturated thickness, the quantity of groundwater that comes to the surface at Spring Creek, and the groundwater gradients. All calculations for both methods are shown in Appendix A.

GEOCHEMISTRY

Chemical analysis was performed on water from domestic wells that were being monitored. Water was taken from a hose bib or frost free hydrant. Water samples were passed through a sampling apparatus that included inline pH and dissolved oxygen probes. Water was flushed through the sampling apparatus until temperature, pH, and dissolved oxygen stabilized. Samples were filtered through an inline 0.45 micron filter, filling two 120 ml bottles, one each for anion and cation analyses. Bottles were rinsed with filtered sample water prior to filling for analysis. Samples for cation analysis were immediately acidified with concentrated nitric acid as a preservative. One bottle was filled with an unfiltered sample from which alkalinity was measured. Parameters examined and laboratory methodologies are presented in Table 1. These data were used to establish baseline groundwater chemistry data and to understand the evolution of the groundwater chemistry.

In order to determine the fate of the septic-system wastes in the aquifer, a system of shallow monitoring wells was installed in the groundwater discharge area near the confluence of Spring Creek and Rock Creek. These wells were used to determine the water-table position and to characterize the groundwater chemistry before it enters the surface-water

Specifications of Analyses
Analytical Laboratory

University of Montana, Geology

Parameter	Units	Method	EP A method #	Detection Limit (mg/L)
Ammonia (as N)	mg/L	Electrode	350.3	0.01
Alkalinity (as CaCO3)	mg/L	Manual colorimetric utration to pH 4.5	310.1	0.001
Hydrogen Ion (pH)	pH units	Electrometric	150.1	0-14 pH units
Oxygen, dissolved	mg/L	Electrode	360.1	N/A
Anions				
Bromide	mg/L	Ion Chromatography	301.0	0.5
Chloride	mg/L	Ion Chromatography	300.0	0.3
Nitrate (as N)	mg/L	Ion Chromatography	300.0	0.05
Nitrate (as N)	mg/L	Cadmium Reduction	353.3	0.001
Nitrite (as N)	mg/L	Ion Chromatography	300.0	0.4
Nitrate/Nitrite (as N)	mg/L	Ion Chromatography	300.0	N/A
Phosphate (as P)	mg/L	Ion Chromatography	300.0	0.5
Sulfate (as SO4)	mg/L	Ion Chromatography	300.0	0.6
Cations				
Al	mg/L	ICP-ES	200.7	0.07
As	mg/L	ICP-ES	200.7	0.07
B	mg/L	ICP-ES	200.7	0.04
Be	mg/L	ICP-ES	200.7	0.0003
Ca	mg/L	ICP-ES	200.7	0.1
Cd	mg/L	ICP-ES	200.7	0.01
Co	mg/L	ICP-ES	200.7	0.03
Cr	mg/L	ICP-ES	200.7	0.008
Cu	mg/L	ICP-ES	200.7	0.01
Fe	mg/L	ICP-ES	200.7	0.03
Mg	mg/L	ICP-ES	200.7	0.1
Mn	mg/L	ICP-ES	200.7	.005
Mo	mg/L	ICP-ES	200.7	0.01
Na	mg/L	ICP-ES	200.7	0.1
Ni	mg/L	ICP-ES	200.7	0.02
P	mg/L	ICP-ES	200.7	0.2
Pb	mg/L	ICP-ES	200.7	0.1
Si	mg/L	ICP-ES	200.7	0.1
Sr	mg/L	ICP-ES	200.7	0.05
Ti	mg/L	ICP-ES	200.7	0.05
Zn	mg/L	ICP-ES	200.7	0.005
K	mg/L	ICP-ES	200.7	1.5

Note: The values for detection limits listed are conservative. Individual analyses may yield values "BDL" that are justifiab

Table 1: Methods of analysis and detection limits for all ions analyzed.

system. A total of 16 wells was installed in the shallow groundwater system on both sides of the Rock Creek road above the confluence of Rock Creek and Spring Creek. The installation method started by digging a hole and finished by pounding a PVC well point as far as possible into the ground. The water table in this area is within 2 ft of land surface. Initially 10 wells were installed on the west side of the Rock Creek Road. Then 6 more wells were installed, four in the pasture east of the road and two just west of the road next to the channel that parallels the road. Wells consisted of schedule 80 PVC with a slotted well point. Next to each well was a length of 0.5 inch polyethylene tubing, slotted for six inches and wrapped with nylon screen (Figure 4). Water samples were extracted from the ground through the polyethylene tubing using a peristaltic pump, then sampled using the same apparatus and methods as used with domestic wells.

Surface water samples were collected by grab sampling with a 500 ml beaker. Water was extracted from the beaker with a 60 ml syringe. A filter was attached to the syringe and the water filtered into two 120 ml bottles, one each for anions and cations. The cation sample was acidified with concentrated nitric acid. A third 120 ml unfiltered sample was collected for alkalinity analysis. Samples were analyzed using the same methods as for groundwater shown in Table 1.

Beginning in May, 1994, an additional sample bottle was filled with filtered water from surface water and monitoring

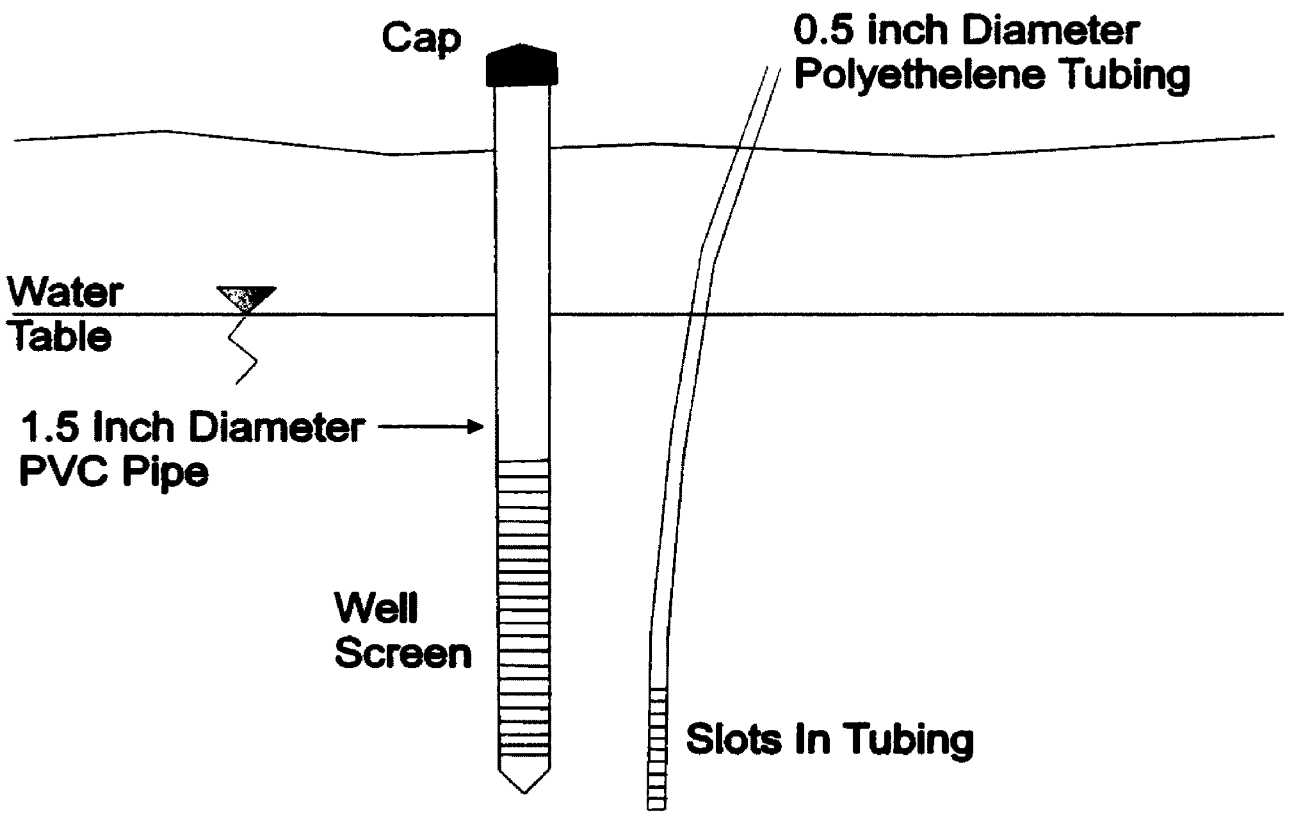


Figure 4: Monitoring well design.

well sampling points. This water was analyzed for nitrate-N using the cadmium reduction method, which has a detection limit of 0.001 mg/l (Table 1).

CHAPTER 3

RESULTS

This chapter examines the nature and configuration of the aquifer, groundwater system, groundwater quality, and the nature and degree of surface water-groundwater interaction.

PHYSICAL HYDROGEOLOGIC SETTING

Twenty one domestic wells were selected to be monitored for this study. Seven staff gages were installed in the surface water near selected domestic wells. Five of the staff gages were located in Rock Creek and the remaining two were in ponds fed by groundwater. Domestic well, monitoring well, and staff gage locations, along with the number assigned each location are shown on Figures 5, 6, and 7. Figure 5 shows the southern part of the study area between Ranch Creek and Brewster Creek. The central part of the study area, between Brewster Creek and the northern most house at Rock Creek Acres is shown on Figure 6. The area in the northern most part of the study area (Figure 7) is referred to as the discharge area, as a portion of the groundwater appears to discharge into Spring Creek.

Well logs were used to determine the stratigraphy of the alluvial aquifer. Most of the wells in the valley are 60 ft deep, but vary from 35 ft to 100 ft. The well logs record very

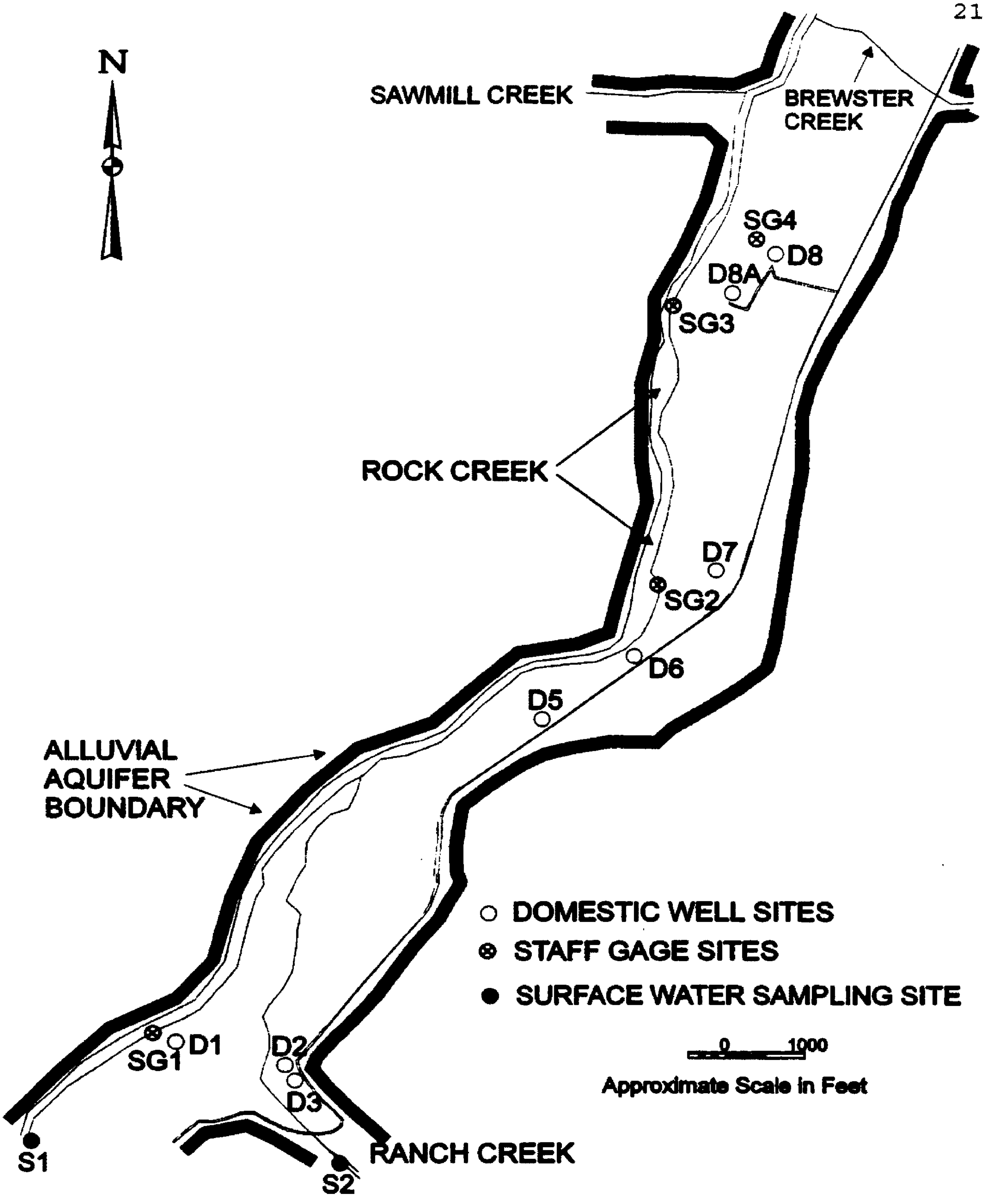


Figure 5: Domestic well and staff gage locations, and surface water sampling sites in the southern part of the study area.

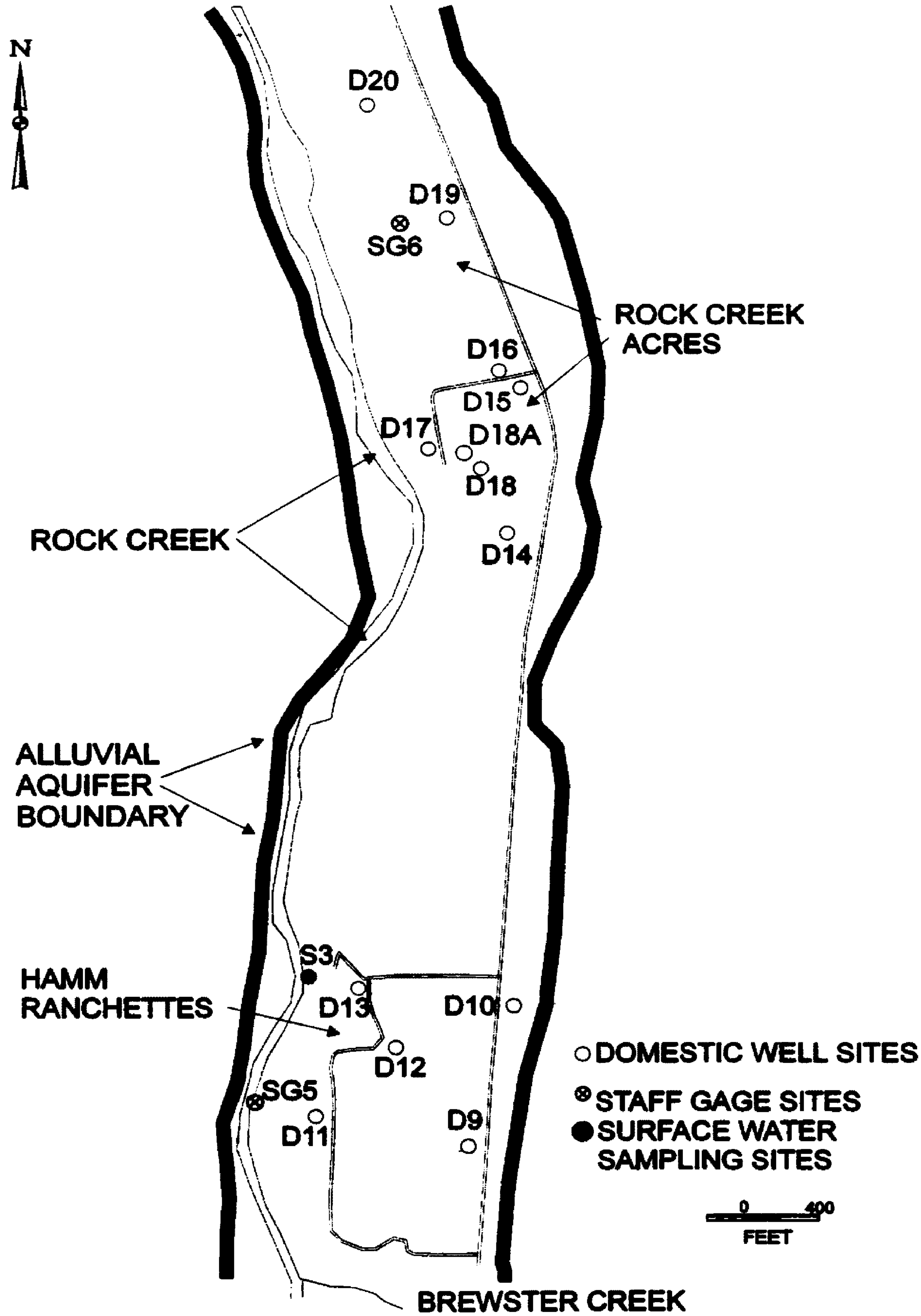


Figure 6: Domestic well, staff gage, and surface water sampling sites in the central part of the study area.

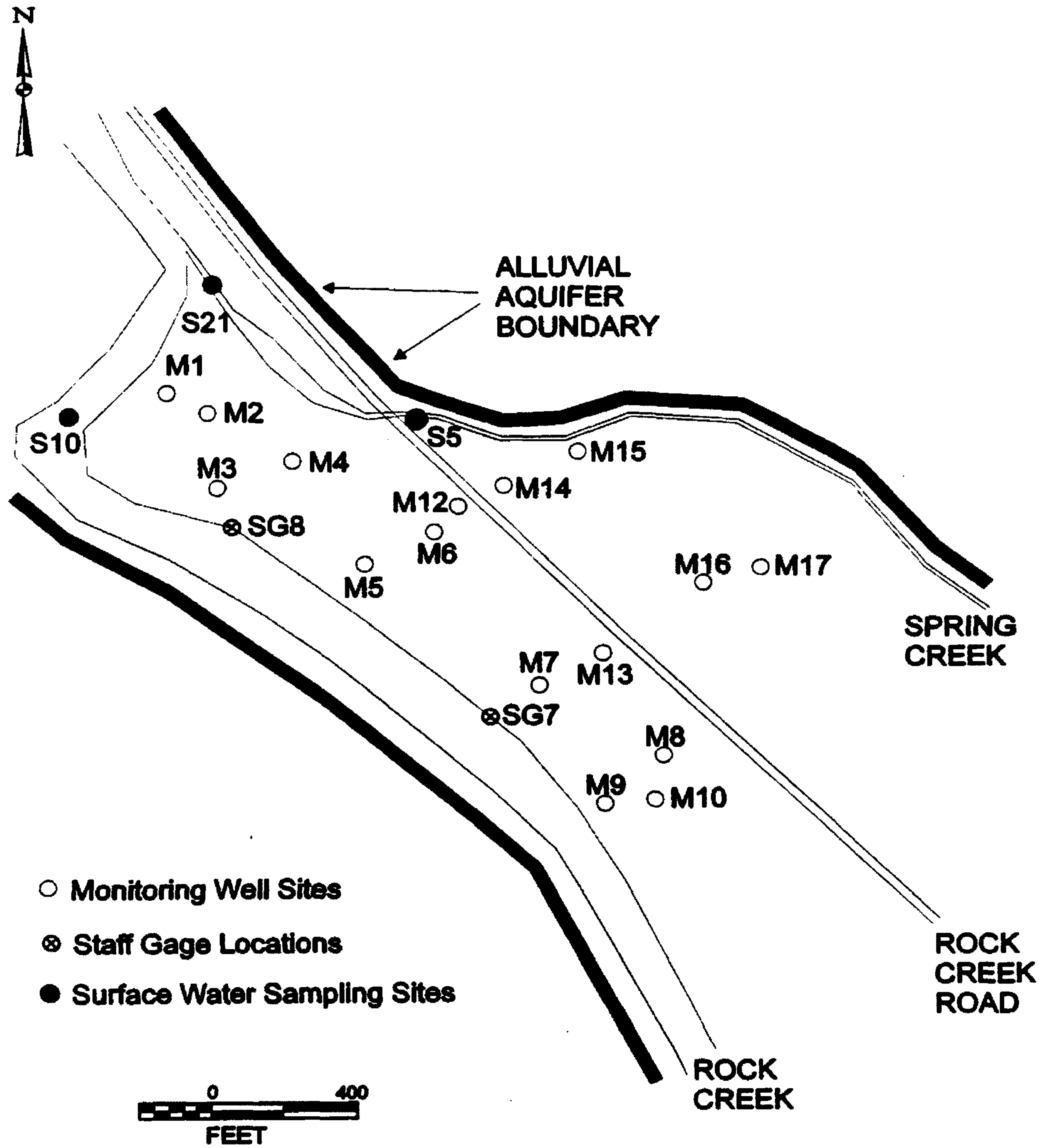


Figure 7: Discharge area monitoring well, staff gage and surface water sampling sites.

few changes in the stratigraphy and often show a uniform sand and gravel for the length of the well. Typically the sediments are reported to consist of sand, gravel, cobbles and boulders with a few clay lenses. Figure 8 shows a schematic cross section of the Rock Creek valley looking south. Since no wells penetrate to bedrock, the shape of the bedrock valley is inferred. Appendix E contains copies of the well logs for the Rock Creek Valley and those used in the construction of the cross section shown in Figure 8.

With one exception, all available well logs examined from the study area show finished wells completed in the alluvial aquifer. The exception, well D2 is 100 ft deep and the lithology is listed as broken rocks and clay from 56 ft to 97 ft. This may represent the presence of colluvium that covered the edge of the valley before the alluvial valley fill was deposited.

The tributary valleys of Gilbert Creek, Brewster Creek, and Ranch Creek are all of similar width. By assuming that they were V-shaped valleys before the recent sediments were deposited, and that the slopes on both sides of the valley are constant to the bottom of the V, the depth of the alluvium can be inferred. Figure 9 shows cross sections of Ranch, Brewster, and Gilbert Creeks taken from topographic maps. The maximum depths of the unconsolidated sediments filling these valleys are estimated to be 170 ft on Ranch Creek, 150 ft on Brewster Creek, and 170 ft on Gilbert Creek. Thus, the probable maximum

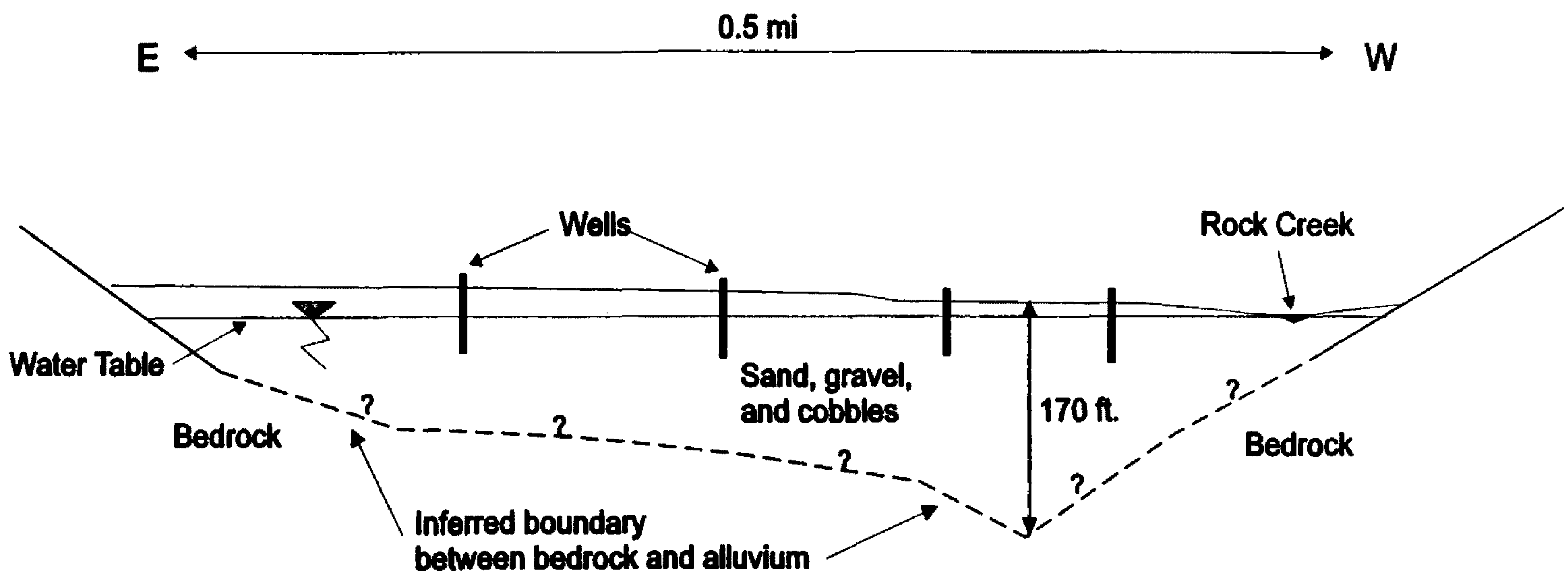
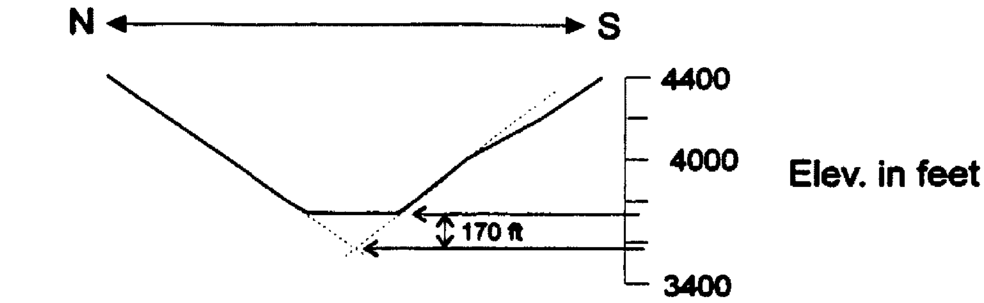
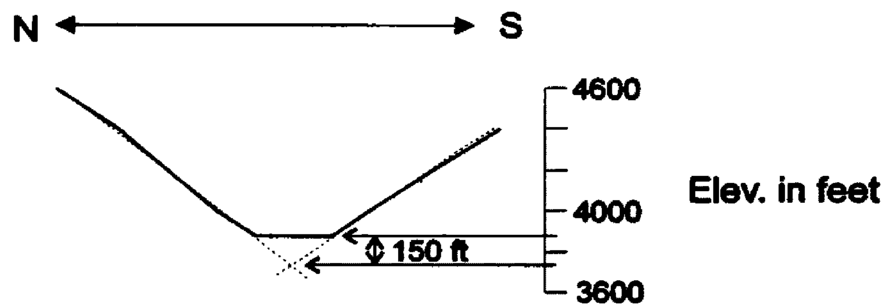


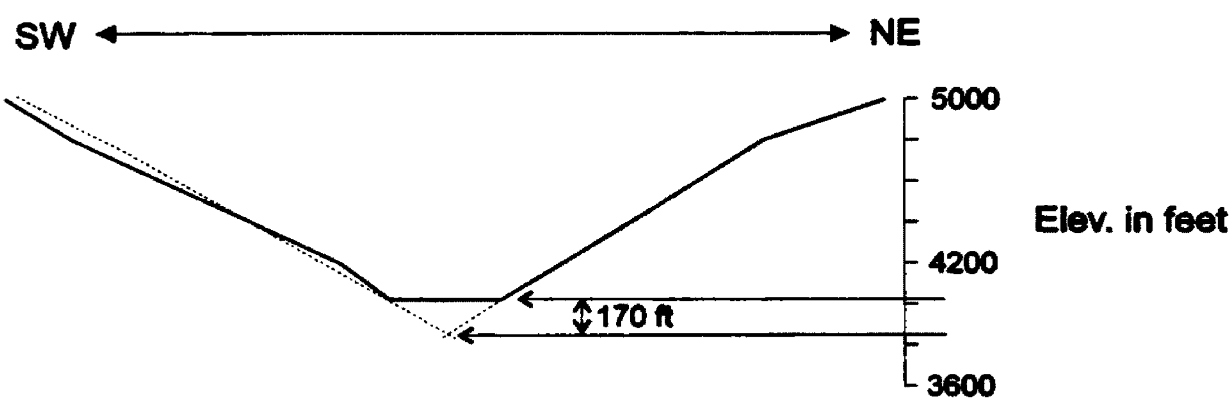
Figure 8: Schematic east-west cross-section of the Rock Creek Valley at Hamm Ranchettes.



Gilbert Creek Valley, 4000 ft from confluence with Rock Creek.



Brewster Creek Valley, 1500 ft from Rock Creek Road.



Ranch Creek Valley, 4500 feet from confluence with Rock Creek.

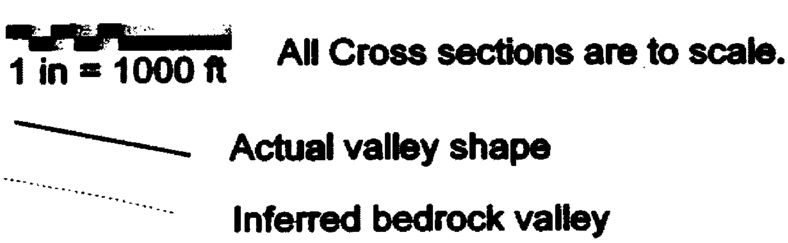


Figure 9: Cross sections from topographic maps to estimate sediment thickness.

depth of alluvium in the Rock Creek valley is between 150 ft and 170 ft.

THE GROUNDWATER SYSTEM

The water table in the valley-fill aquifer varies from less than 10 ft below ground surface near Rock Creek to 50 ft below ground surface near Ranch Creek. In the discharge area, near the confluence of Spring Creek and Rock Creek, depth to groundwater is less than three feet. Spring Creek and some of its feeder channels intersect the water table creating the marshy areas on the banks. Typically the water table is less than 10 ft below land surface adjacent to Rock Creek. Depth to the water table increases as the distance perpendicular to the creek increases. At Rock Creek Acres (Figure 3), maximum depth to water is about 20 ft. Near Hamm Ranchettes (Figure 3), the water table is 40 to 45 ft below land surface. The high river terraces at the Hamm Ranchettes and areas north of Ranch Creek result in the deeper observed water table.

A map of the water table in the southern part of the study area on April 25, 1994, is shown in Figure 10. Groundwater and surface water are at about the same elevation in the vicinity of well D1 and SG1. Groundwater flow in this part of the valley appears to be slightly toward Rock Creek. Most likely, groundwater discharging to the Rock Creek Valley from the Ranch Creek valley contributes to the shallow water table in this portion of the valley. As the valley constricts,

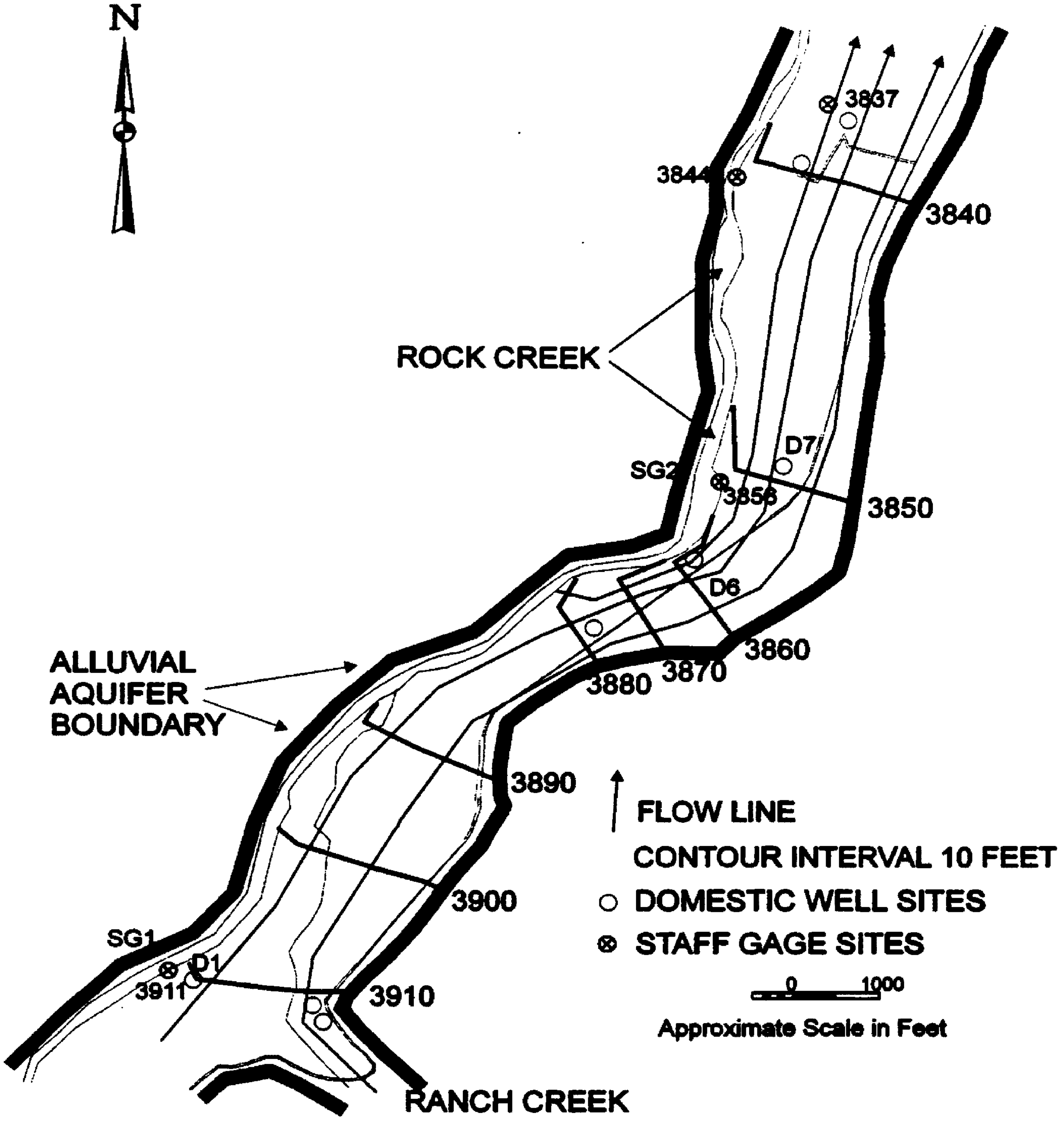


Figure 10: Water table map of southern part of the study area on April 25, 1994.

the groundwater gradient increases and the channel of Rock Creek becomes elevated above the valley groundwater system. Where the valley widens again to the north, the gradient decreases, bringing the water table elevation closer to that of the surface water. At the constriction in the valley south of Ranch Creek, Rock Creek becomes a losing stream (Figure 10).

The fluctuations in water levels over the course of the study at well D1 and SG1 are shown on Figure 11. SG1 is located slightly upgradient from well D1. The groundwater and surface water levels are very close at this station. Water level trends in this well and staff gage are almost identical. Figure 12 shows the water levels at wells D6, D7, and SG2. Water level trends in the groundwater and surface water are similar, however, groundwater levels declined more than the surface water stage during the summer of 1994. This is the case for most wells in the study area. Again the Rock Creek stage is above the water table.

Figure 13 shows the flow system in the central part of the study area on April 25, 1994. The gradient is relatively constant in this part of the valley, increasing slightly where the valley narrows. Flow through this part of the study area appears to parallel Rock Creek or be slightly away from the creek. At each location, Rock Creek is losing water to the groundwater system.

Hydrographs of wells D9, D11, and SG5, in the vicinity of

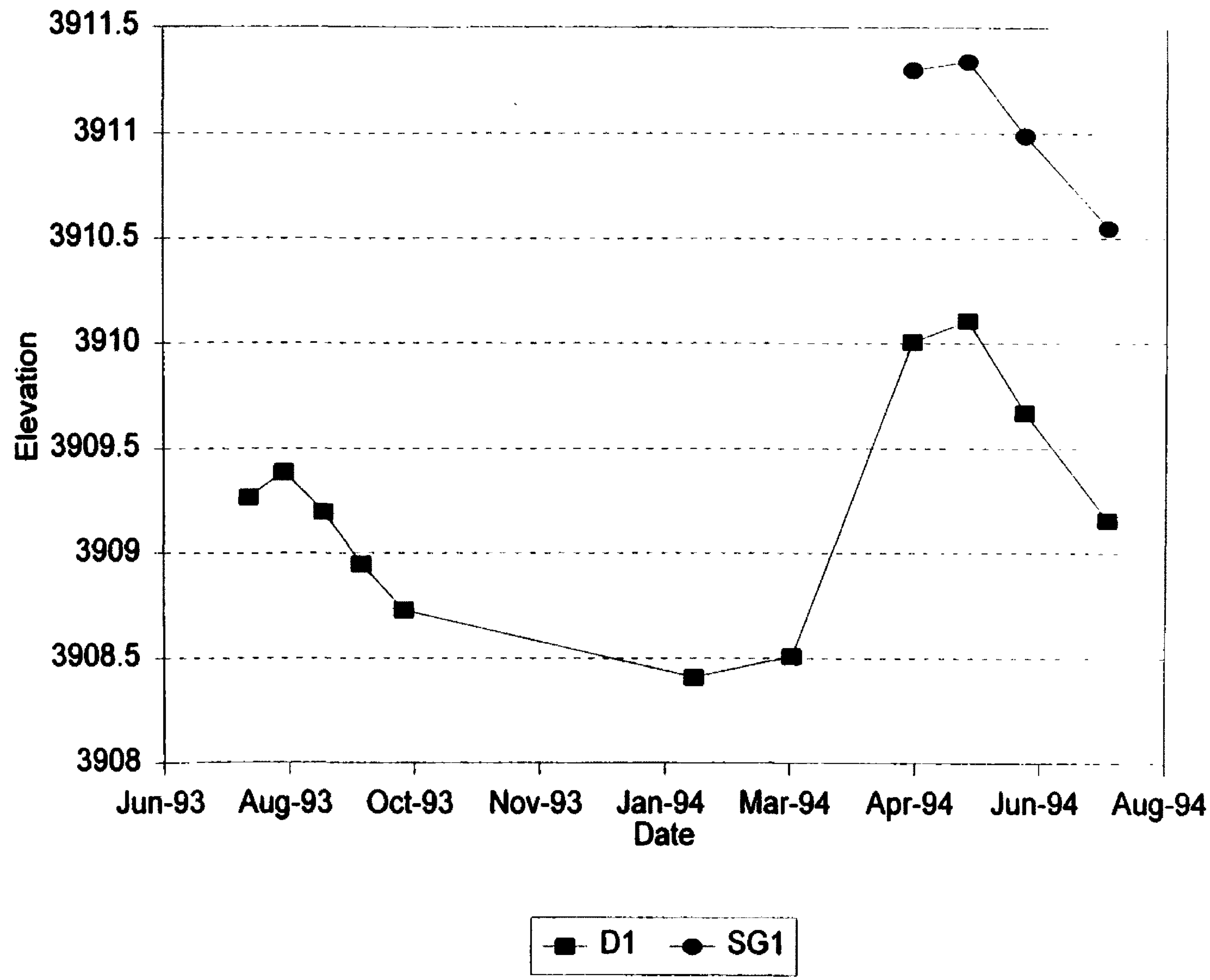


Figure 11: Hydrograph of SG1 and well D1.

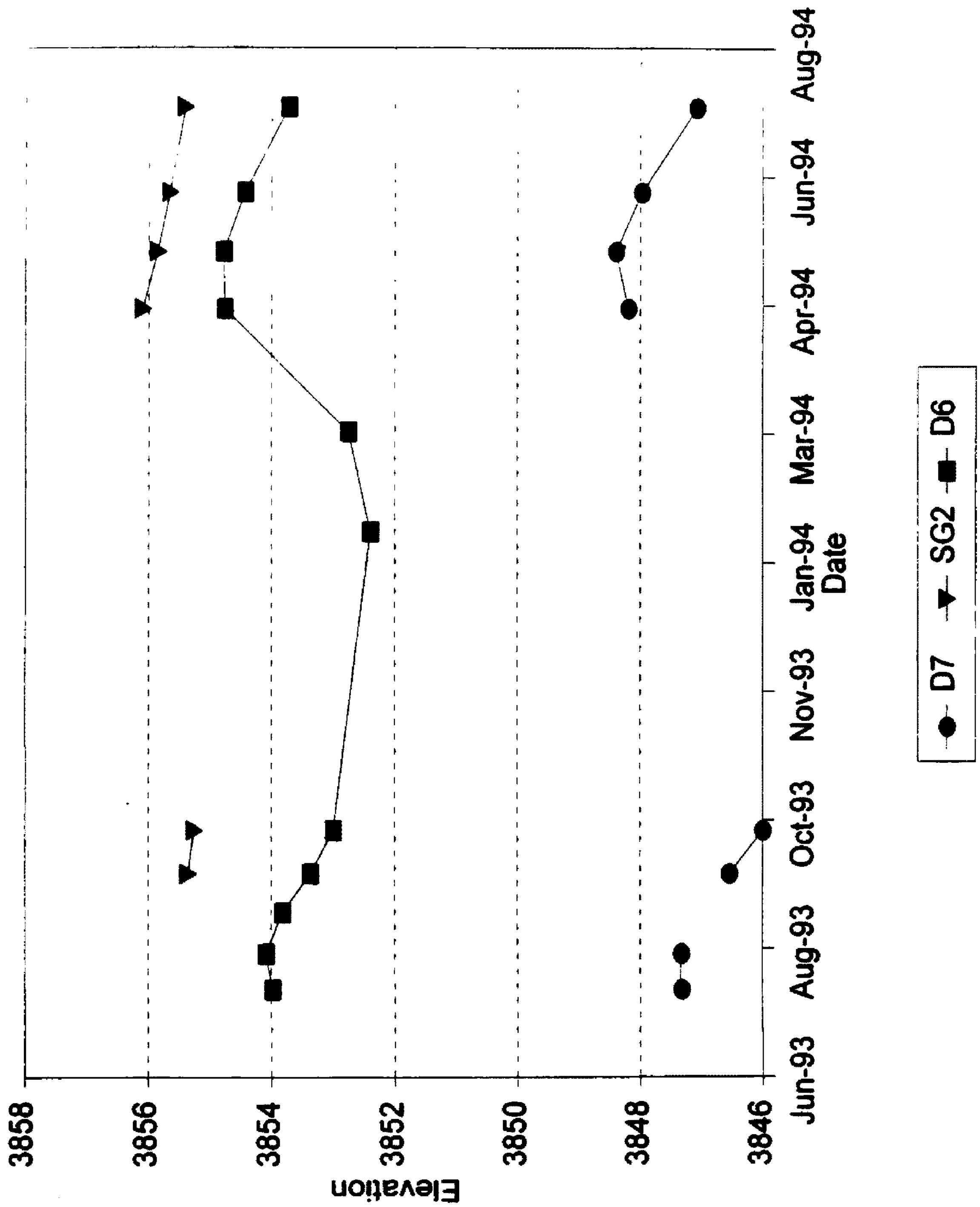


Figure 12: Hydrograph of SG2, and wells D6 and D7.

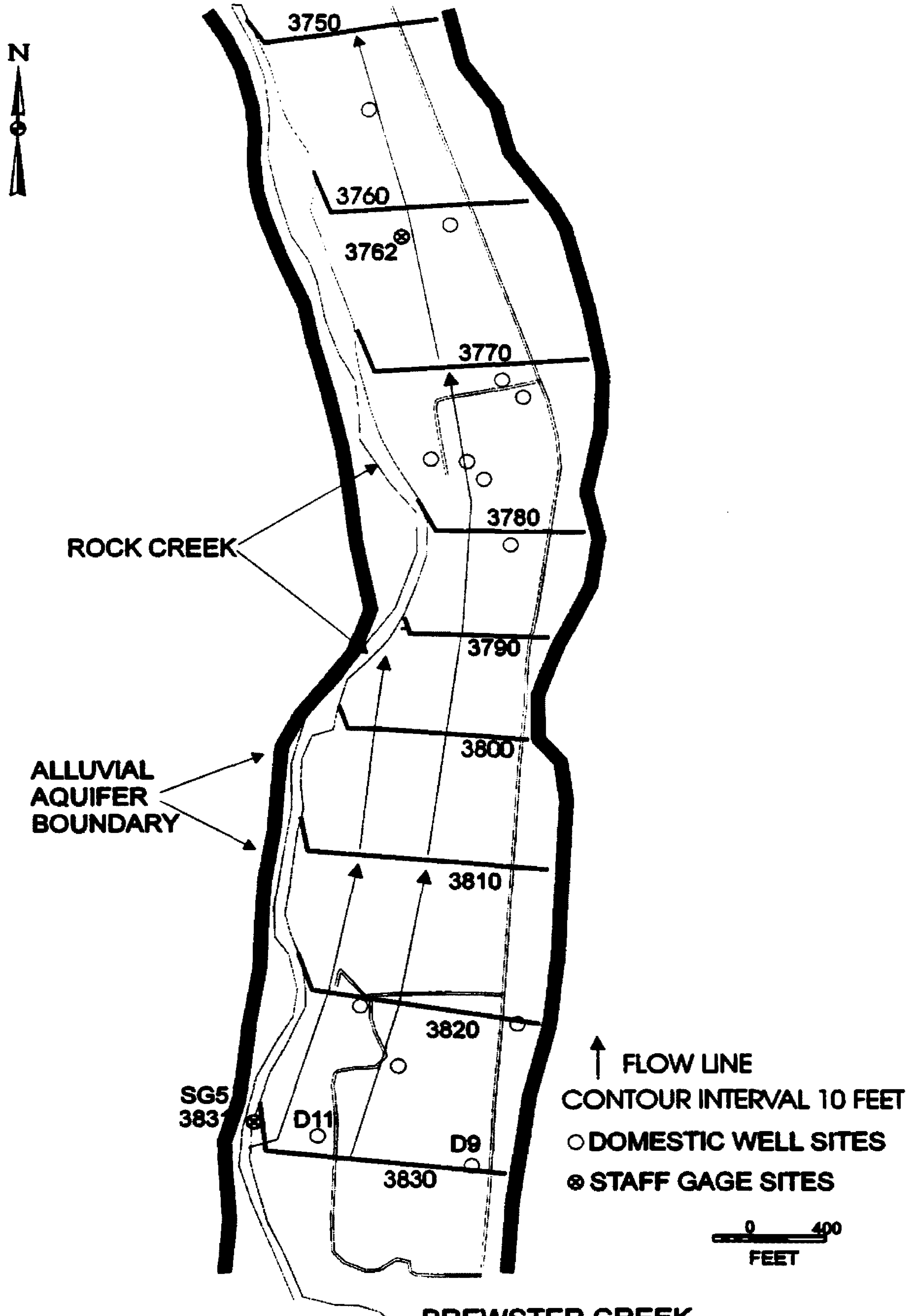


Figure 13: Water table map of the central part of the study area on April 25, 1994.

Hamm Ranchettes, are shown on Figure 14. The surface water stage in Rock Creek is higher than the water table. SG5 is located in Rock Creek slightly upgradient from well D11, and well D9 is on the opposite side of the valley. Water levels in well D11 show similar trends as at SG5. Surface-water levels are elevated two to three feet above the water table. Water level trends in well D9 diverged from those of Rock Creek in the early summer of 1994. Groundwater entering the valley from the Brewster Creek drainage (Figure 3) may be responsible for this trend.

Flow in the area of the confluence of Spring Creek and Rock Creek, the discharge area, generally parallels Rock Creek. Figure 15 shows a map of the water table on July 11, 1994. Immediately adjacent to Rock Creek, flow is away from the creek. In the center of the valley, flow is parallel to Rock Creek, but turns away slightly towards Spring Creek on the east side of the valley, indicating that groundwater is flowing into Spring Creek. Rock Creek is losing water to the groundwater system in this reach of stream. Surface water in Rock Creek is elevated one to three feet above groundwater. Lower Spring Creek, where the valley constricts (Figure 7), has a lower stage than does Rock Creek.

Heads in monitoring wells near Spring Creek varied little as groundwater levels declined during the summer compared with wells away from the creek. Figure 16 shows a hydrograph of wells M2, M3, and M4 in the northern part of the discharge

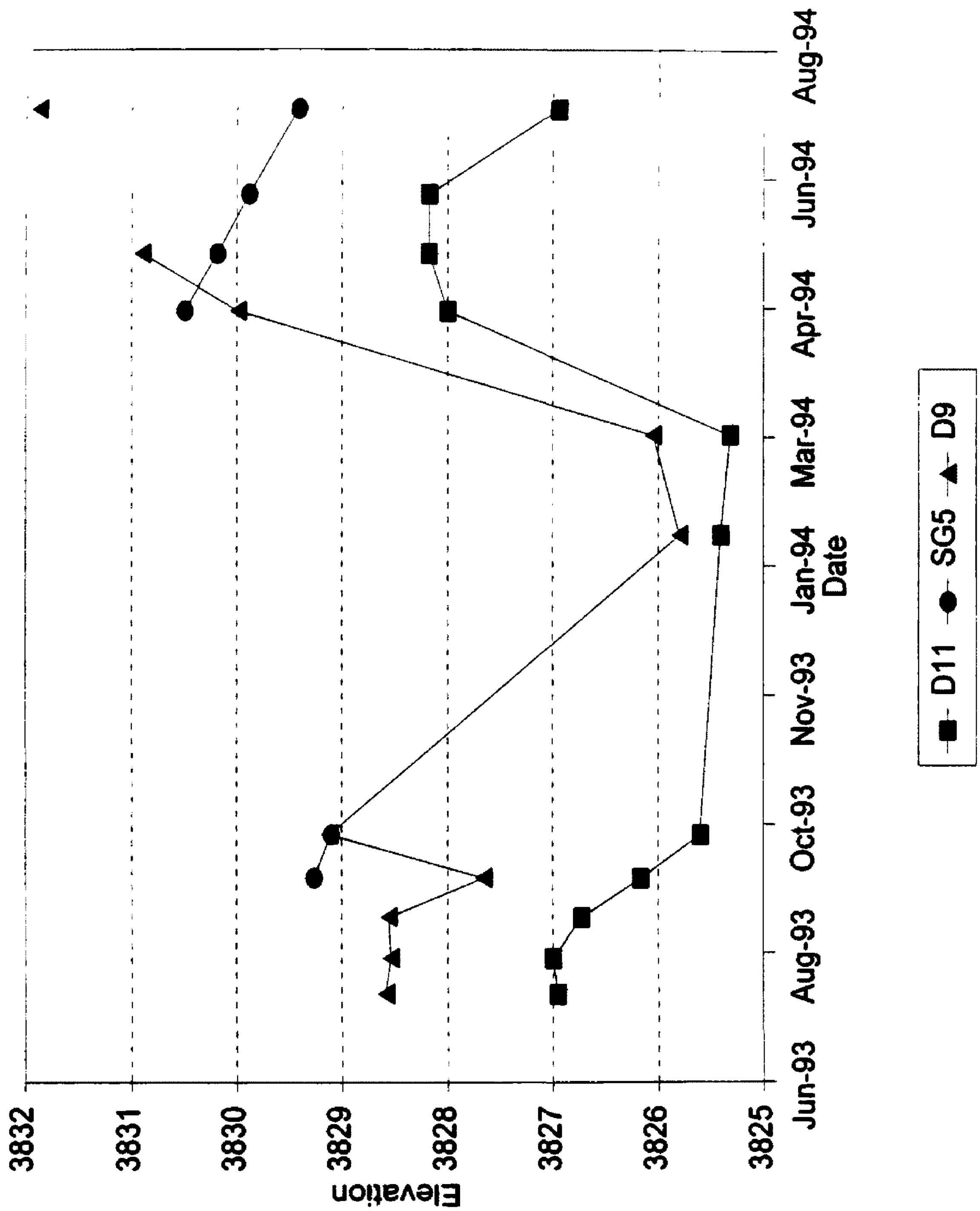


Figure 14: Hydrograph of SG5, and wells D9 and D11.

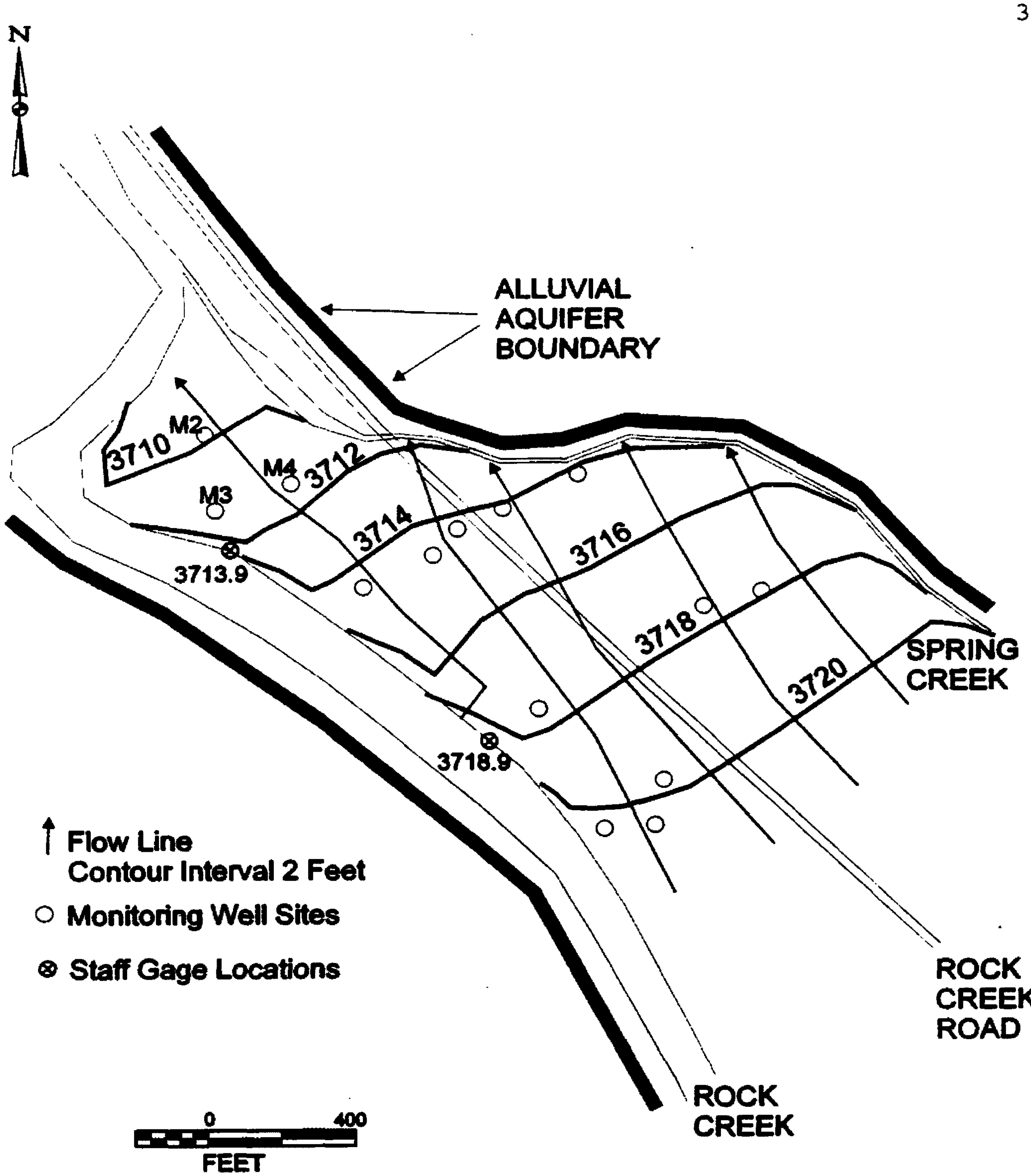


Figure 15: Water table map of the discharge area, July 11, 1994.

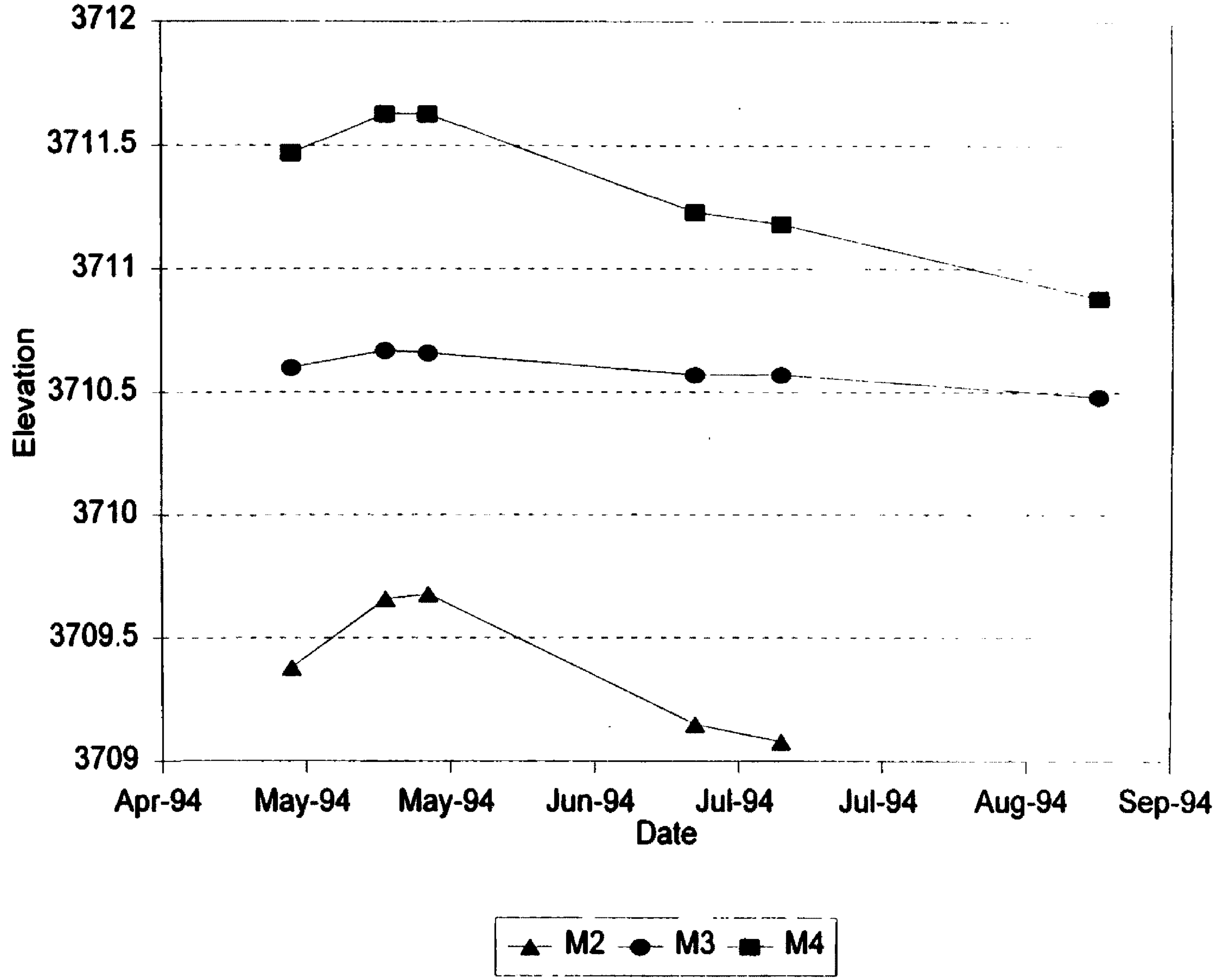


Figure 16: Hydrograph of monitoring wells M2, M3, and M4.

area. Well M3, which is immediately adjacent to Spring Creek and probably reflects the Spring Creek stage, declined 0.18 ft from May to August compared with a change of 0.7 ft in M4. Spring Creek appeared to maintain a more constant water level than other surface waters or than groundwater in the study area.

Aquifer Properties

Aquifer hydraulic conductivity can be viewed as the ease which with water can move through an aquifer. Two methods were used to calculate the average hydraulic conductivity in the study area. The first method used specific capacity data from well logs (Appendix A). Results from this method gave a hydraulic conductivity between 2,100 and 2,700 ft/d. The second method used Darcy's law and the estimated amount of groundwater flowing to the surface in Spring Creek (Appendix A). This method gave a range between 1,600 and 2,500 ft/d. A likely average value that characterizes the Rock Creek sediments most in the range of overlap between the two methods. This compares with values given in the literature for glacial outwash deposits between 2.8 to 2,800 ft/d (Fetter, 1988), with the lower values belonging to aquifers that contain a large percentage of fine material. The Rock Creek alluvium is relatively coarse and should have values in the upper end.

Groundwater velocity is estimated to range between 50 and

150 ft/d in the study area. The range is large because of the variability of the gradients between the wide and narrow portions of the valley. The highest velocities are encountered where the gradients increase at the constrictions in the valley. A value of 50 to 75 ft/d is probably reasonable for most parts of the valley. A porosity of 20-25% was used in the velocity calculations. This compares with literature values for porosity of sand and gravel mixtures of 10-35% (Driscoll, 1986), and 20-35% (Fetter, 1988). A value in the lower end of literature values was used because of the poorly sorted nature of the sediments in the Rock Creek valley.

The groundwater system in the study area at any given time contains considerably less flow than Rock Creek. Using a calculated value of 2,100 ft/day for hydraulic conductivity and a gradient of 0.006 ft/ft measured in the Rock Acres subdivision, there is approximately 22 cfs of groundwater flowing through the Rock Acres area. This compares with at least 200 cfs of stream flow that occurs most of the year. In the area of the confluence of Spring Creek and Rock Creek an estimated nine cfs of groundwater discharges to Spring Creek, which then flows into Rock Creek. This is estimated to be about 40% of the groundwater that is flowing through the aquifer.

Summary

Rock Creek appears to be a losing stream through most of the study area. Its stage is elevated above the groundwater at staff gages 2, 3, 5, 7, and 8 (Figures 5-7). Visual inspection of the stream bank shows very few places where the groundwater seeps into the stream from the bank. The relationship between the hydraulic conductivity and the rate of infiltration from Rock Creek may be responsible for the difference in water elevation between the creek and groundwater. The rate at which groundwater flows down valley generally exceeds the rate at which stream channel water in Rock Creek leaks to the groundwater system. All observable discharge of groundwater is into the springs and seeps in the discharge area, which flow into Spring Creek and then into Rock Creek.

GEOCHEMISTRY

All surface water and most groundwater from the alluvial aquifer are of calcium-bicarbonate type, though concentrations vary considerably within the study area.

Three sources of water to the aquifer in the study area are indicated by groundwater chemistry. First, Rock Creek is the major source of recharge to the aquifer. Second, Ranch Creek is the main source of water in the southern part of the study area. Third, Brewster Creek is a minor source. Calcium concentration in water from domestic wells is the distinguishing component in source determination for Rock Creek and Ranch Creek waters. Increased magnesium concentration distinguishes a Brewster Creek source. Figure 17

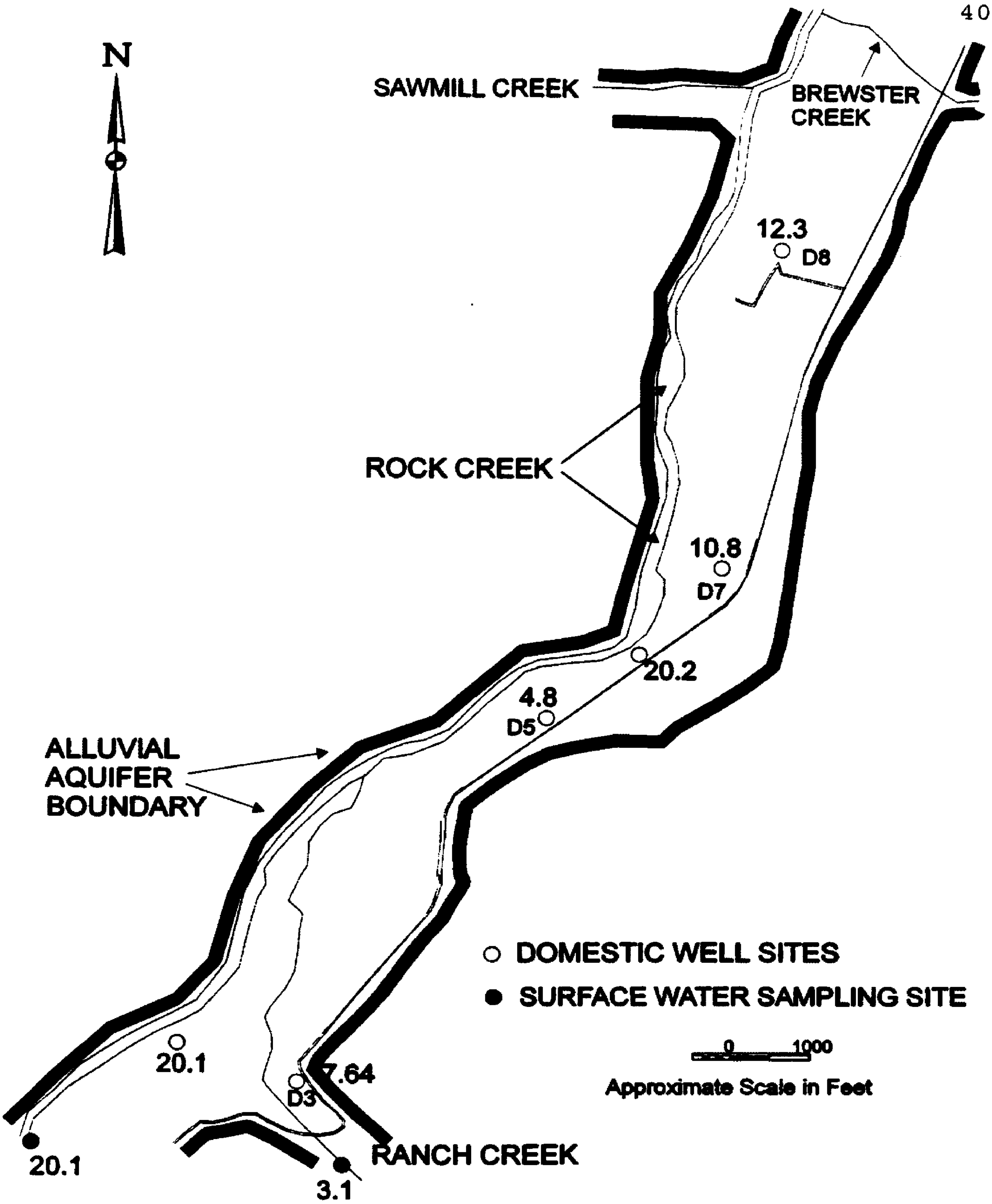


Figure 17: Domestic well calcium concentrations in the northern part of the study area on July 12, 1994.

shows the calcium concentration found in groundwater from domestic wells in the southern part of the study area on July 12, 1994. Ranch Creek (3.1 mg/l) has significantly less calcium than Rock Creek (20.1 mg/l). Wells D3, D5, D7, and D8 are in the part of the aquifer fed by Ranch Creek. However, this signal is lost down gradient from well D8 because of mixing which occurs as groundwater moves down valley. Below Brewster Creek the groundwater is well mixed and, water from Ranch Creek loses its identity as seen in calcium concentrations (Figure 18). Wells D9 and D10, located north of the Brewster Creek valley, consistently had the highest magnesium concentrations (Figure 19). Groundwater from the Brewster Creek drainage is the likely source of this water.

Groundwater in the study area is of high quality. Table 2 shows the EPA drinking water standards. All water examined from the alluvial aquifer was well below the drinking water standards for the ions analyzed. Iron was near the recommended limit in some samples, but this may be a result of incomplete purging of some wells prior to sampling. The detection limits of the instrument used for analysis of water samples were higher than the drinking water standards for lead, arsenic, and cadmium. However, these compounds were below measured detection limits for all samples and they are not expected to exceed drinking water standards. No analysis for organic compounds were performed.

The EPA recommends that the pH of drinking water systems

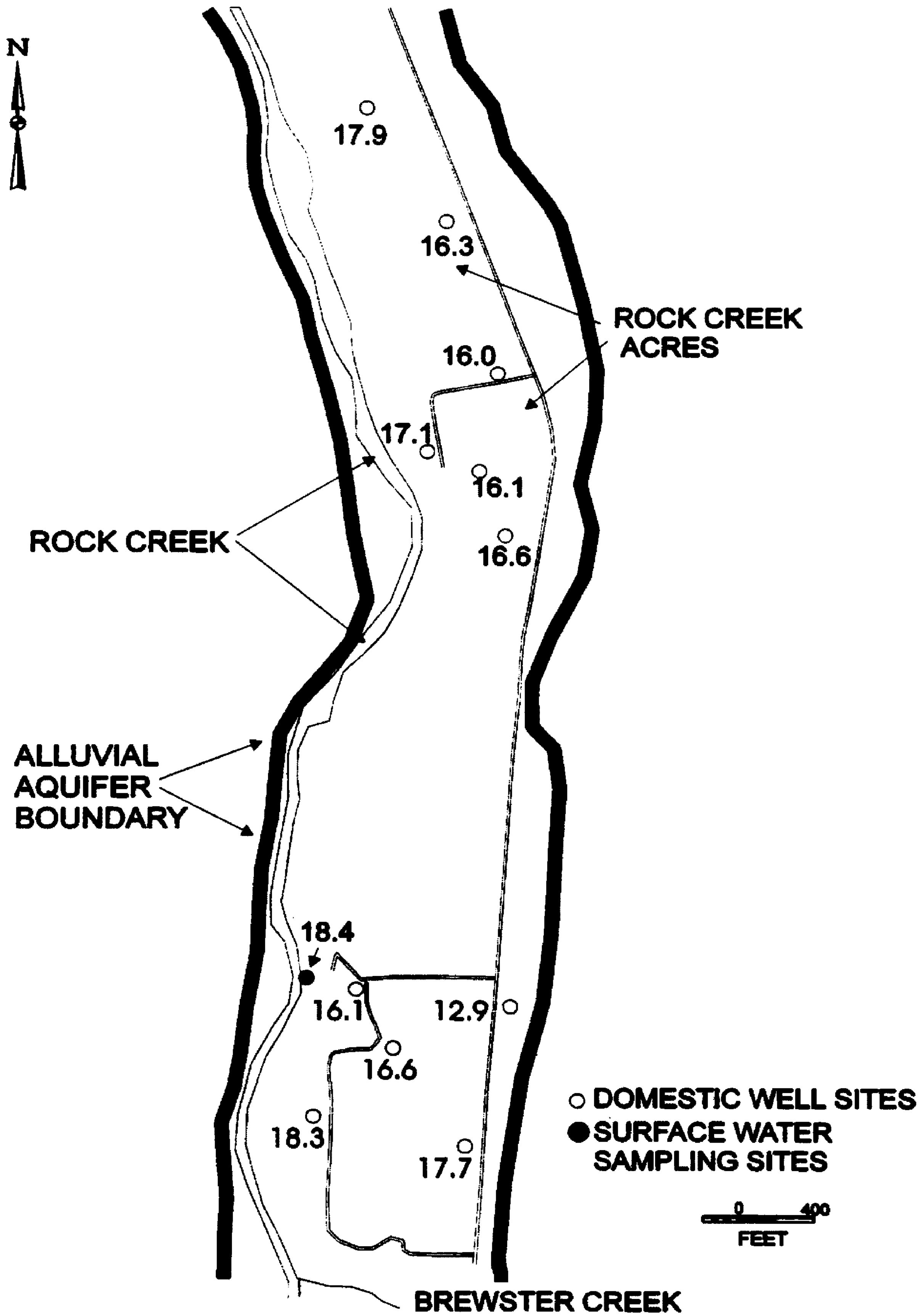


Figure 18: Domestic well calcium concentrations (mg/l) in the central part of the study area, July 12, 1994.

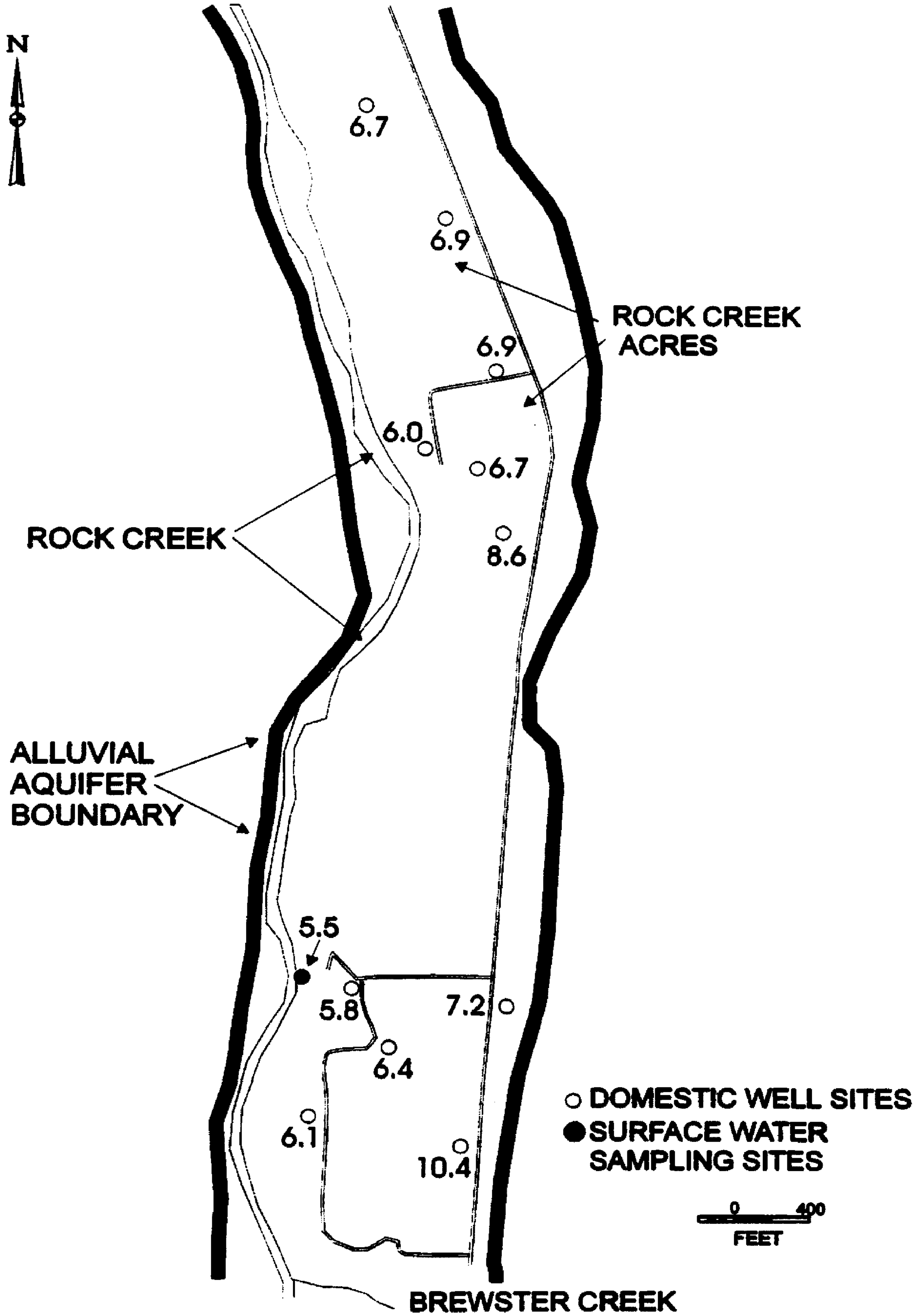


Figure 19: Domestic well magnesium concentrations (mg/l) from the central part of the study area on July 12, 1994.

Parameter	Status Reg *	MCL/(SMCL) (mg/L)	MCLG (mg/L)	ACCEPTANCE LIMIT	Status
Ammonia (as N)	L				
Alkalinity (as CaCO3)	N/A	——	——		
Hydrogen Ion (pH)		6.5-8.5(6.5-8.5)			F
Oxygen, dissolved					
Anions					
Bromide					
Chloride		(250)			F
Nitrate (as N)	F	10	10	+/- 10%	
Nitrite (as N)	F	1	1	+/- 15%	
Nitrate/Nitrite (as N)		10	10		
Phosphate (as P)		——	——		
Sulfate (as SO4)		deferred(250)	deferred(250)		F
Cations					
Al	L	(0.05-0.2)		+/- 30%	F
As	*	0.05	——		
B					
Be	P	0.001	0		
Ca		——	——		
Cd	F	0.005	0.005		
Co					
Cr	F	0.1	0.1	+/- 15%	
Cu	P	1.3**(1.0)	1.3		F
Fe		(0.3)	——		F
Mg					
Mn		(0.05)	——		F
Mo					
Na		20*			
Ni	P	0.1	0.1	+/- 15%	
P					
Pb	F	0.015**4	zero	+/- 30%	
Si		(0.1)			
Sr					
Ti					
Zn		(5)			F
K					

MCL = Maximum Contaminant Level	F = Final
SMCL = Suggested Maximum Contaminant Level	L = listed for regulation
MCLG = Maximum Contaminant Limit Goal	P = proposed (Phase II and V proposals)
** = Action Level	NA = Not Applicable
* = Under review	

Table 2: EPA drinking water standards (April 1992) for ions of interest.

be maintained above a pH of 7. The pH of drinking water in the study area is below 7 in most wells, and below 6 in some wells in the southern part of the study area where Ranch Creek water dominates the aquifer. Recommended levels for iron, manganese and pH are set for aesthetic and taste characteristics, rather than for health reasons (Driscoll, 1986).

Groundwater nitrate-N concentrations from domestic wells are very low. Concentrations range from 0.06 mg/l to 0.26 mg/l during the course of the study. This compares with the drinking water standard of 10 mg/l nitrate-N.

Most ions in the groundwater show a mixing of Ranch Creek water that has low concentrations of various ions, with other water that has higher concentrations. Then concentrations appear to level off at an intermediate value as shown with calcium and magnesium concentrations from domestic wells in Figure 20. The behavior of nitrate is more erratic than other ions.

Figures 21 and 22 show nitrate concentrations from domestic wells on October 4,1993. Nitrate concentrations in groundwater increase down valley, reaching a peak at Rock Creek Acres. The lowest concentrations are observed in wells closest to Rock Creek. Concentrations near Ranch Creek (0.08 mg/l) are considered background concentration.

Nitrate concentrations increase as groundwater flows through the study area. This, along with the difference in behavior of nitrate compared to the other ions, suggest that

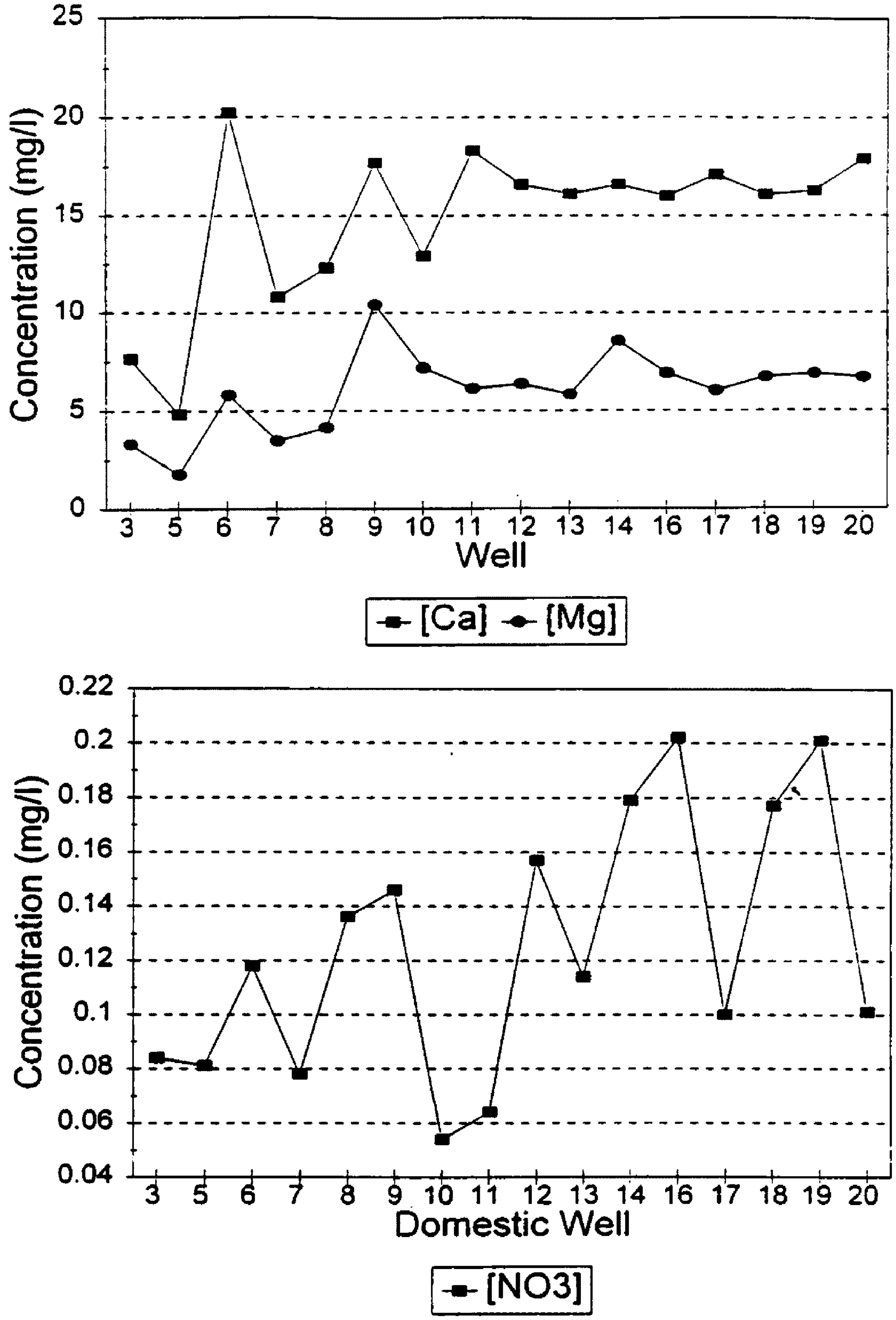


Figure 20: Calcium, magnesium (upper), and nitrate (lower) concentrations from south to north (down valley) in the Rock Creek groundwater system.

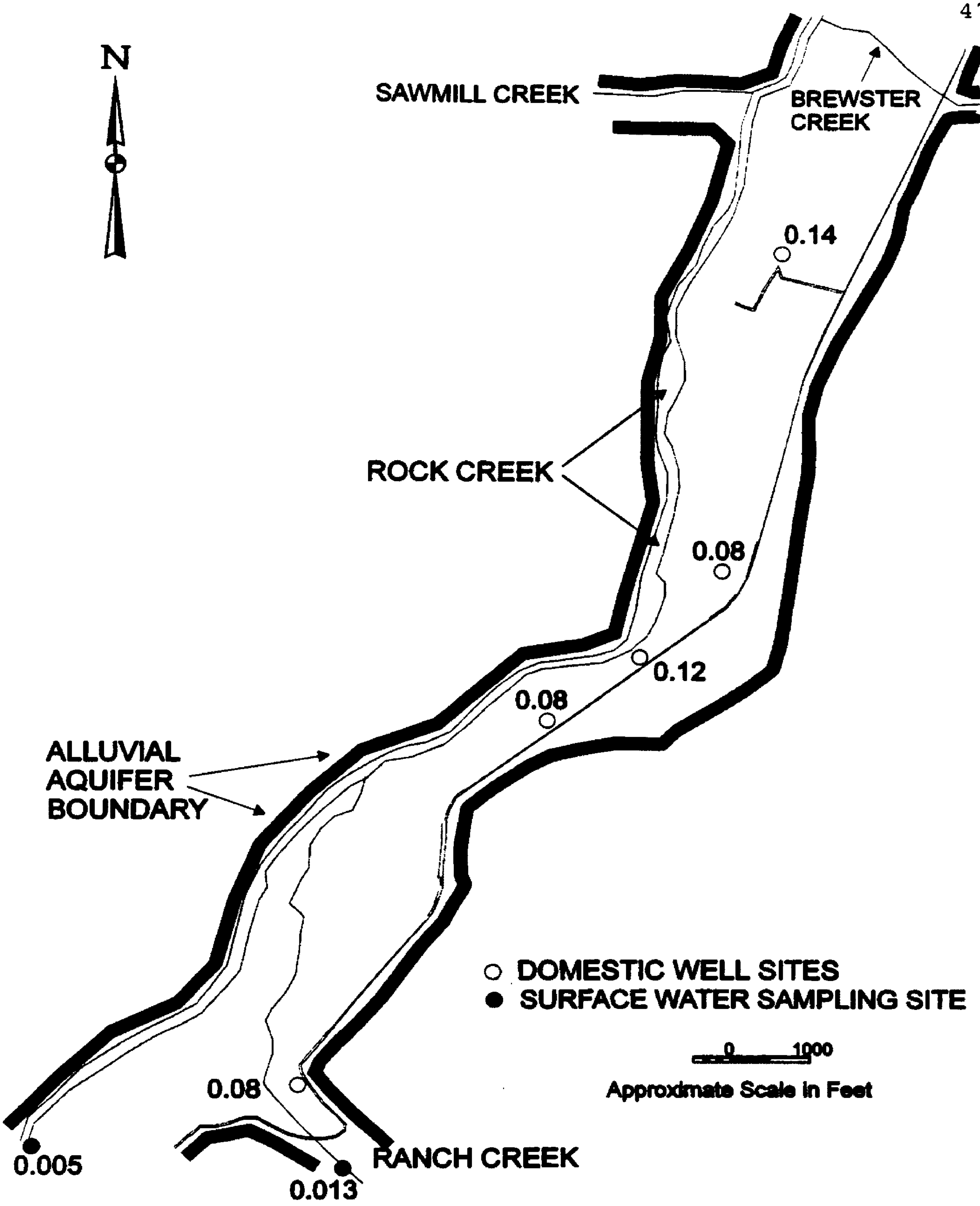


Figure 21: Domestic well nitrate-N concentrations (mg/l) in the southern part of the study area, July 12, 1994.

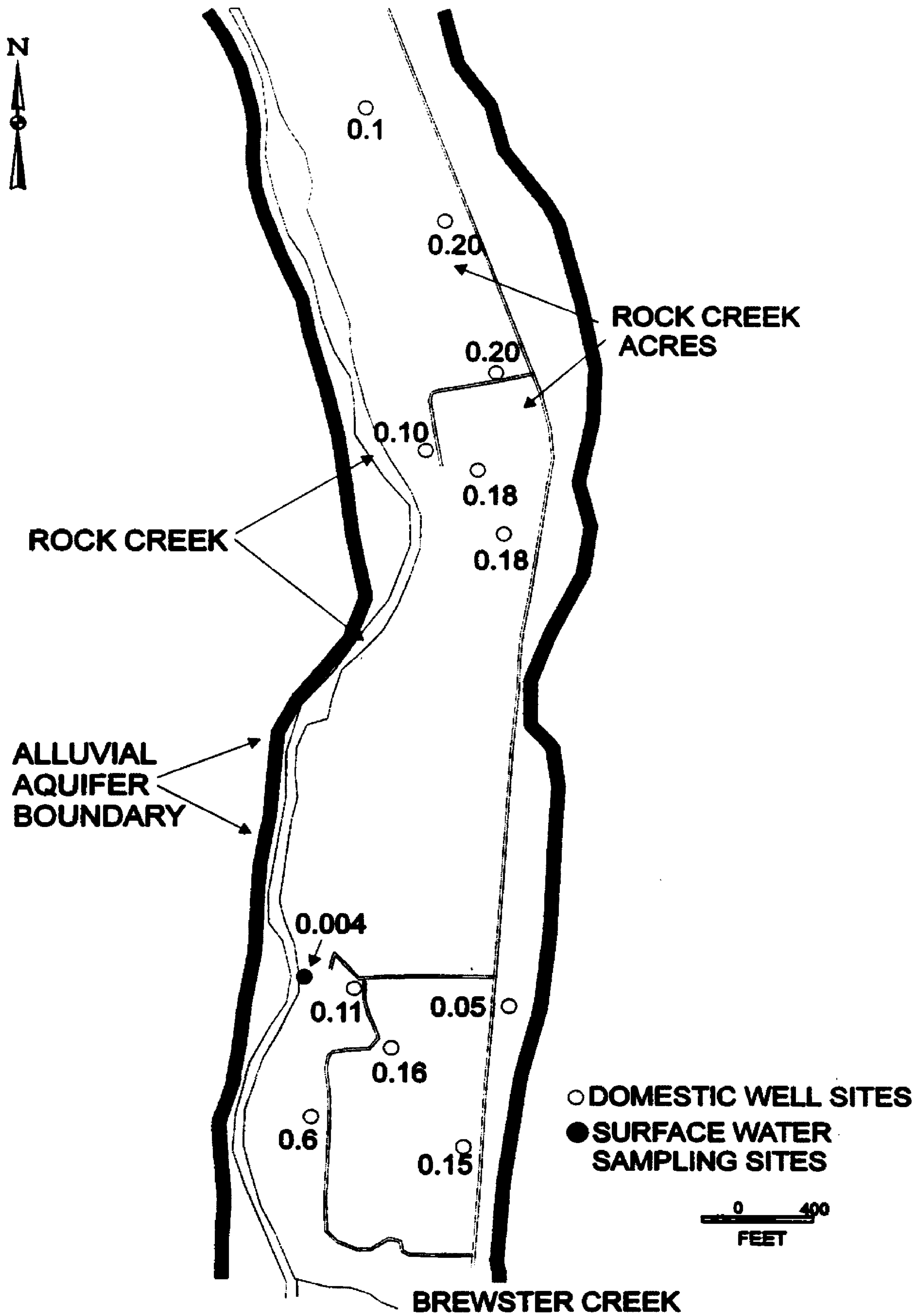


Figure 22: Domestic well nitrate-N concentrations (mg/l) in the central part of the study area, July 12, 1994.

septic systems are the likely source of the increase in nitrates above background concentrations. Water taken from the domestic wells was extracted from between 20 and 50 ft below the water table. Septic effluent percolates down to the water table, then apparently disperses into a larger volume of the aquifer. Nitrate concentrations at a given well may not reflect an immediately adjacent source. Thus, the increase in concentrations between the Hamm Ranchettes and Rock Creek Acres may be from a source in the vicinity of the Hamm Ranchettes. Although no well consistently has the highest nitrate concentration, the highest values were consistently in the Rock Creek Acres area.

General groundwater chemistry varied little during the year at most locations. However, nitrate concentrations showed some seasonal variation. Concentrations were lowest in early spring and highest in the fall. Factors that may have seasonal effects on groundwater nitrate concentrations include seasonal use of homes, uptake of nitrate by plants, and seasonal saturation of soils in riparian zones and areas with a shallow water table (Fustec et al., 1991).

GEOCHEMICAL EVIDENCE OF SURFACE WATER-GROUNDWATER INTERACTION

Surface water and groundwater have the greatest contrast in chemical composition during spring runoff. As snowmelt becomes a larger part of streamflow, concentrations of the major ions decrease. During spring runoff, it is possible to define areas that readily interact with Rock Creek by using calcium concentration as an indicator. Figure 23 shows the calcium concentration of Rock Creek and nearby well D11 over the course of the study. Calcium concentrations in Rock Creek drop by 50% to a low of 9 mg/l during spring runoff, a decrease which should be reflected in groundwater which interacts to a large extent with surface water. Well D11 shows a more constant calcium concentration than is seen in the surface water. This well is close to Rock Creek, but extracts water from 45 ft below the water table. The calcium concentration declines slightly during spring runoff, indicating that there is a little mixing taking place at depth. All samples from domestic wells near the Rock Creek showed similar results.

Concentrations of major ions in groundwater from domestic wells near Rock Creek are intermediate to those found in the surface water and in the groundwater farther from the creek. Figures 18 and 19 show the calcium concentrations in groundwater from domestic wells on July 12, 1994. At this time of year, calcium concentrations are higher in surface water of Rock Creek than in the groundwater. Groundwater with the highest calcium concentrations are from wells near the creek, while calcium concentrations tend to decrease slightly away from the creek. Chemistry of the deep groundwater near Rock Creek tends to represent the baseflow chemistry of the creek.

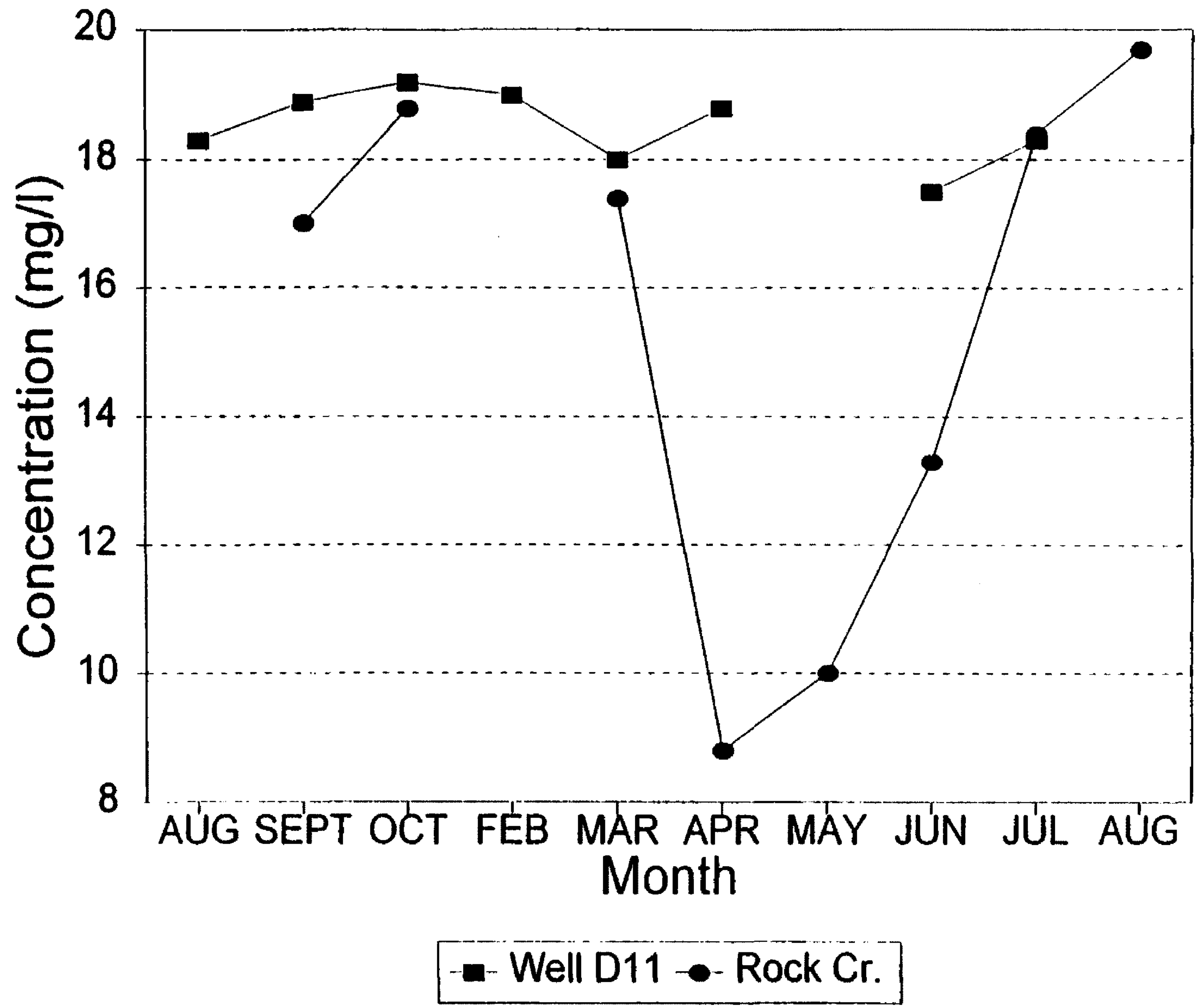


Figure 23: Rock Creek and well D11 calcium concentrations.

Figures 21 and 22 show the nitrate-N concentrations in groundwater from domestic wells on Oct. 4, 1993. Groundwater with the lowest concentrations are from wells close to Rock Creek. Although deep groundwater near the creek resembles baseflow creek water, the nitrate-N concentrations are much higher than found in Rock Creek. Nitrate-N concentrations increase in the groundwater as it flows down valley. However, the increase is much greater in groundwater farther from the creek than near the creek. One possible explanation for the lower nitrate-N concentrations near Rock Creek is that the water flowing out of the creek forces groundwater impacted by septic effluents to flow parallel to the creek, thus keeping the nitrate-N concentrations in groundwater near the creek low.

Water chemistry of Spring Creek is relatively constant during the summer. Calcium concentrations drop slightly in June (Figure 24). If a surface-water source had contributed to Spring Creek, then the chemistry of the creek should fluctuate more than it does. Chemical data confirms visual observation that most of the water in Spring Creek has a groundwater source.

Figure 25 shows the calcium concentration in groundwater from discharge area monitoring wells on June 13, 1995. Calcium concentrations in shallow groundwater from wells M7 (19.6 mg/l), M8 (20.2 mg/l), and M9 (19.9 mg/l) resemble groundwater. Wells M1 (12.2 mg/l), M2 (10.8 mg/l), M3 (10.1

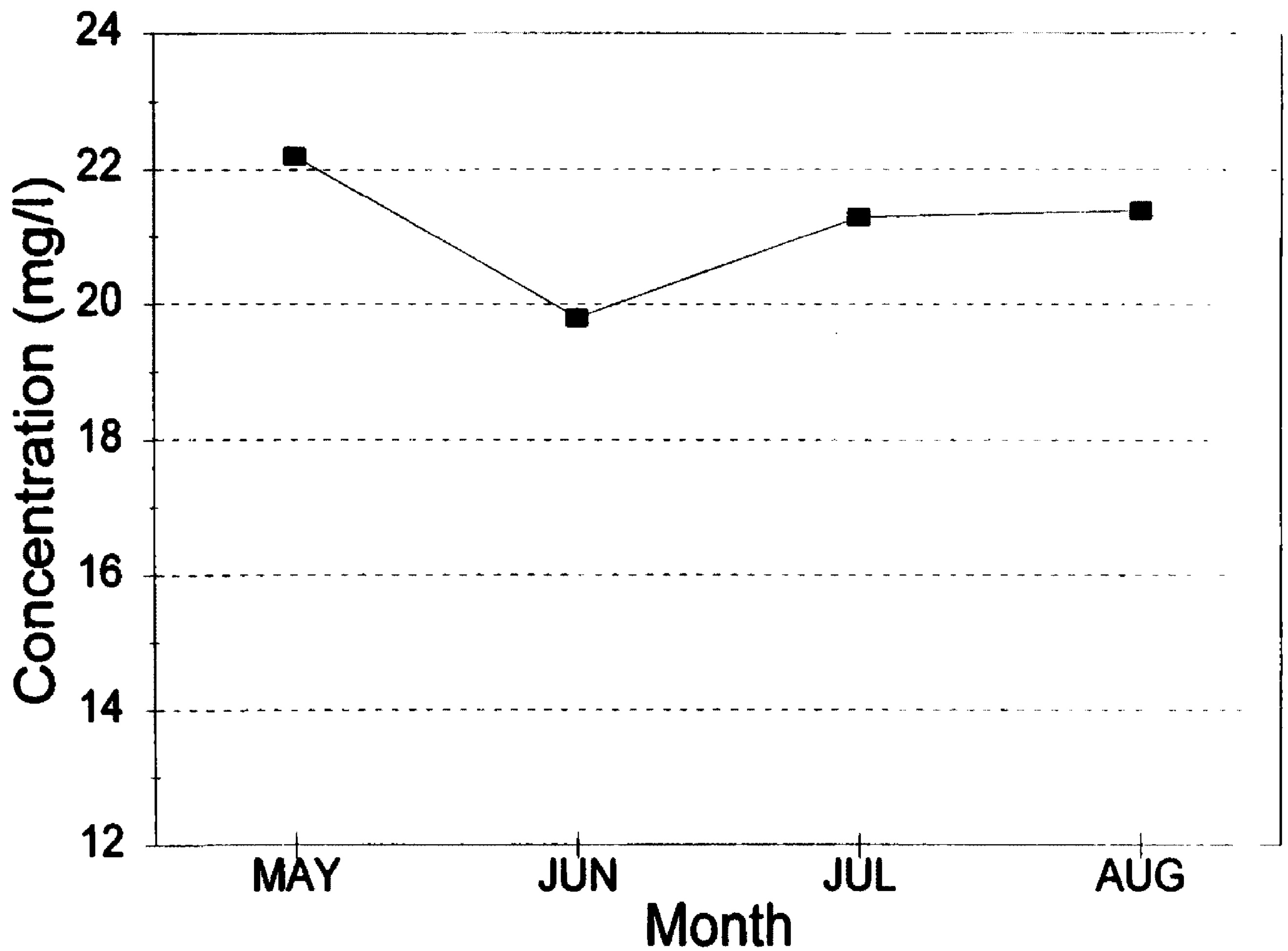


Figure 24. Spring Creek Calcium Concentrations, Summer 1994.

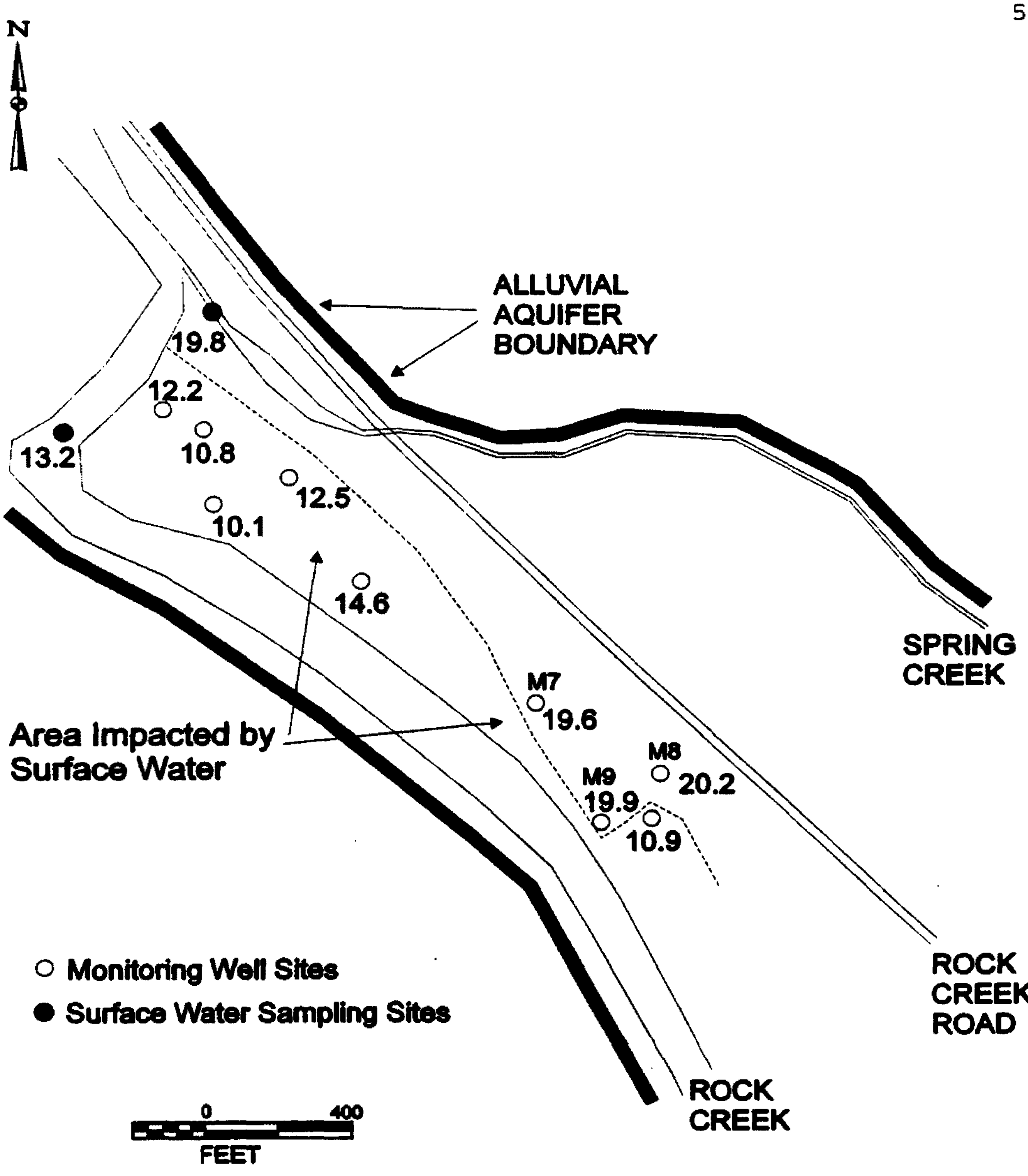


Figure 25: Discharge area monitoring well calcium concentrations, June 13, 1994

mg/l), M4 (12.5 mg/l), M5 (14.6 mg/l), and M10 (10.9 mg/l) are all heavily influenced by Rock Creek (13.2 mg/l).

Figure 26 shows calcium concentrations on July 11, 1994. Groundwater with a Rock Creek source was detected in the same wells as in June. Well M8 (16.6 mg/l) now reveals some influence from Rock Creek, compared with 18.7 mg/l in Rock Creek. Groundwater chemistry east of Rock Creek Road has little influence from Rock Creek. It is interesting to note that well M14 has a significantly lower calcium concentration (15.5 mg/l) than does well M12 (21.2 mg/l), which is west of M14 and closer to Rock Creek. This may caused by the presence of an old stream channel with a higher hydraulic conductivity along which water leaking from Rock Creek is directed to this well.

Shallow groundwater from well M8 had a different pattern of calcium concentrations over time than did the other wells. Calcium concentrations declined during the summer from 20 mg/l in June to 14 mg/l in August. This decline most likely reflects the length of the flow path from Rock Creek to this well. Groundwater in well M8 at this time probably flowed out of Rock Creek during spring runoff three months earlier. In May and June water from well M8 resembled groundwater with its higher magnesium (7.1 mg/l) and nitrate-N (0.10 mg/l) concentrations.

Zones of influence of the surface water on the shallow groundwater of the discharge area are shown on Figure 27.

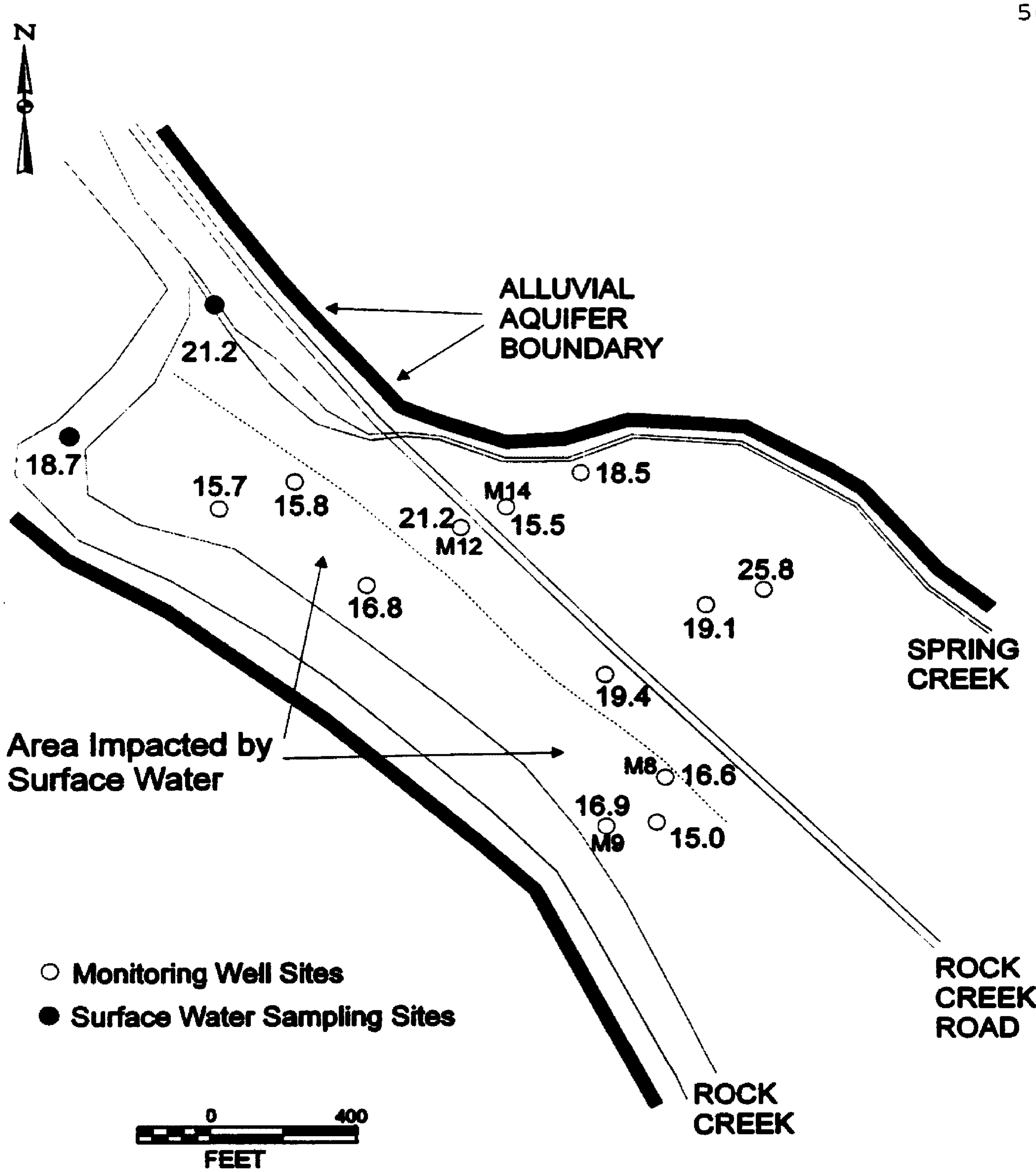


Figure 26: Discharge area monitoring well calcium concentrations, July 11, 1994.

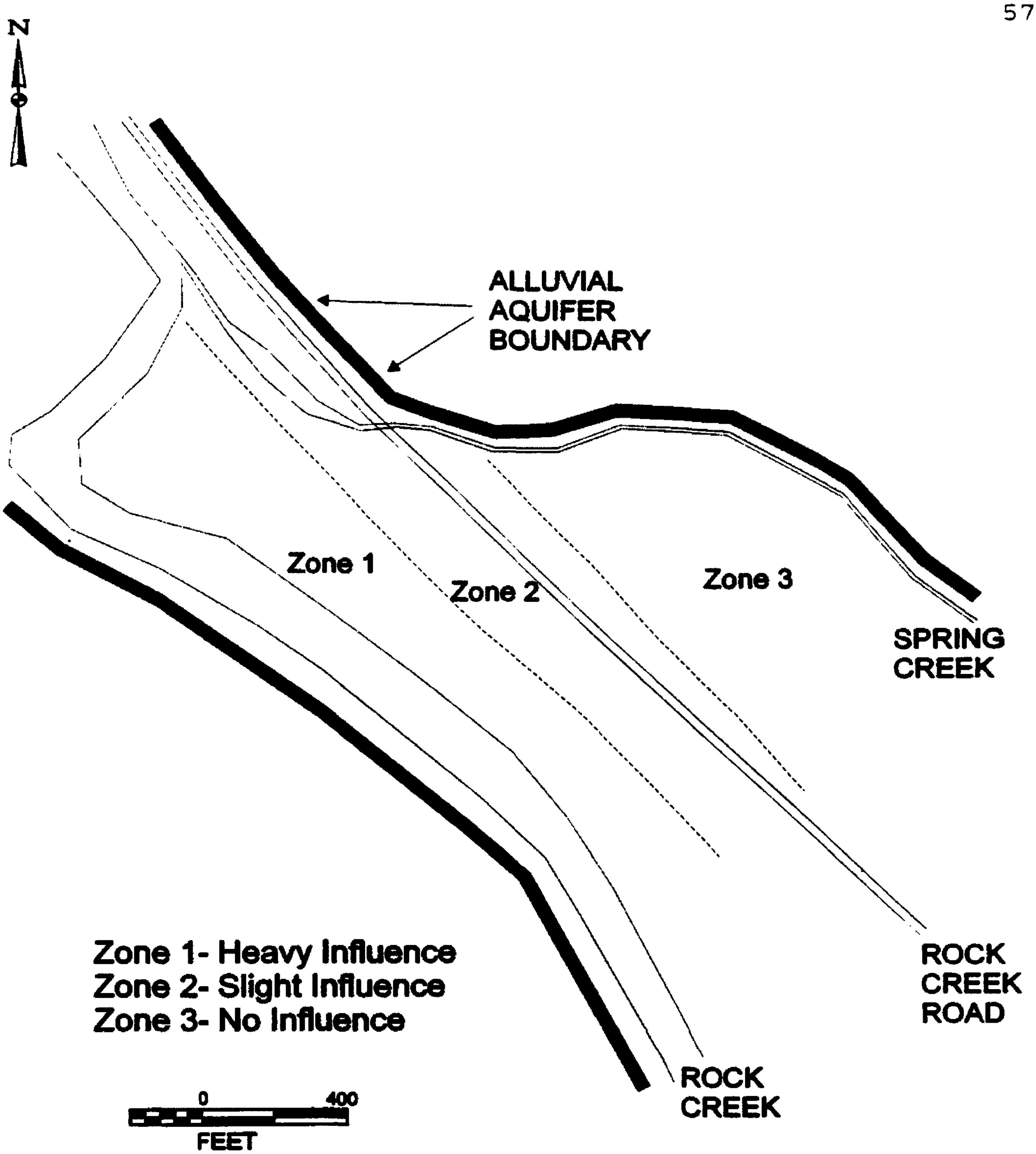


Figure 27: Zones of influence of surface water from Rock Creek on the ground water in the discharge area.

Wells in zone 1 near Rock Creek always reflect surface water chemistry. Wells located in zone 2 also show the influence of the surface water, however, they are affected after peak runoff occurs in the late summer. Chemical data indicate that water in zone 2 appears to be a mixture of surface water and groundwater in late summer. During most of the year shallow groundwater in zone 2 is uninfluenced by surface water. Zone 3 shows no influence from Rock Creek. These zones only reflect shallow groundwater. Chemistry of deeper groundwater is probably not affected by surface water.

SUMMARY

Rock Creek is losing water to the groundwater system at all locations where there are data. Surface water leaves Rock Creek and flows in the upper-most portion of the aquifer near the water table, but apparently does not mix to the depths penetrated by domestic wells. Although Rock Creek is a losing stream, there is significant interaction between the groundwater and Rock Creek. An estimated 40% of the groundwater available at Rock Creek Acres discharges into Spring Creek, which then flows into Rock Creek. The extent of surface water-groundwater interaction is similar to what Stanford and Gaufin (1974) found on the Tobacco River where groundwater with a surface-water source extended up to 600 ft away from the river and up to 12.5 ft below the water table. Thus large volumes of surface water may be present in the upper portion of the valley floor aquifer during some times of the year.

CHAPTER 4

FATE OF THE WASTES AND THEIR INFLUENCE ON ROCK CREEK

INTRODUCTION

Generally, nitrate is considered to be unreactive in oxygenated groundwater and thus to act conservatively. However, nitrate can be reduced to ammonium by microbial action, plants may take up nitrate for biological uses, or nitrate may be reduced to nitrogen gas (N_2, or N_2O) through denitrification (Keeney, 1986). Denitrification is the only reaction that permanently removes nitrate from the system. Ammonium may be oxidized back to nitrate when it encounters oxygenated water. Nitrate that is used by plants is only temporarily removed because, when the plant dies and decays, the nitrogen is released back into the system. However, this process may account for nitrate loss over short time frames, such as seasonal periods.

Figure 28 shows the concentration of nitrate-N in groundwater from the domestic wells, moving down-valley through the study area on October 4, 1993 and June 9, 1994. The final data point is Spring Creek immediately before the confluence with Rock Creek. Although the concentration of nitrate-N in Spring Creek was considerably lower than values found in the nearest domestic wells on October 4,1993, it was much higher than 0.07 mg/l found in well D2, which is

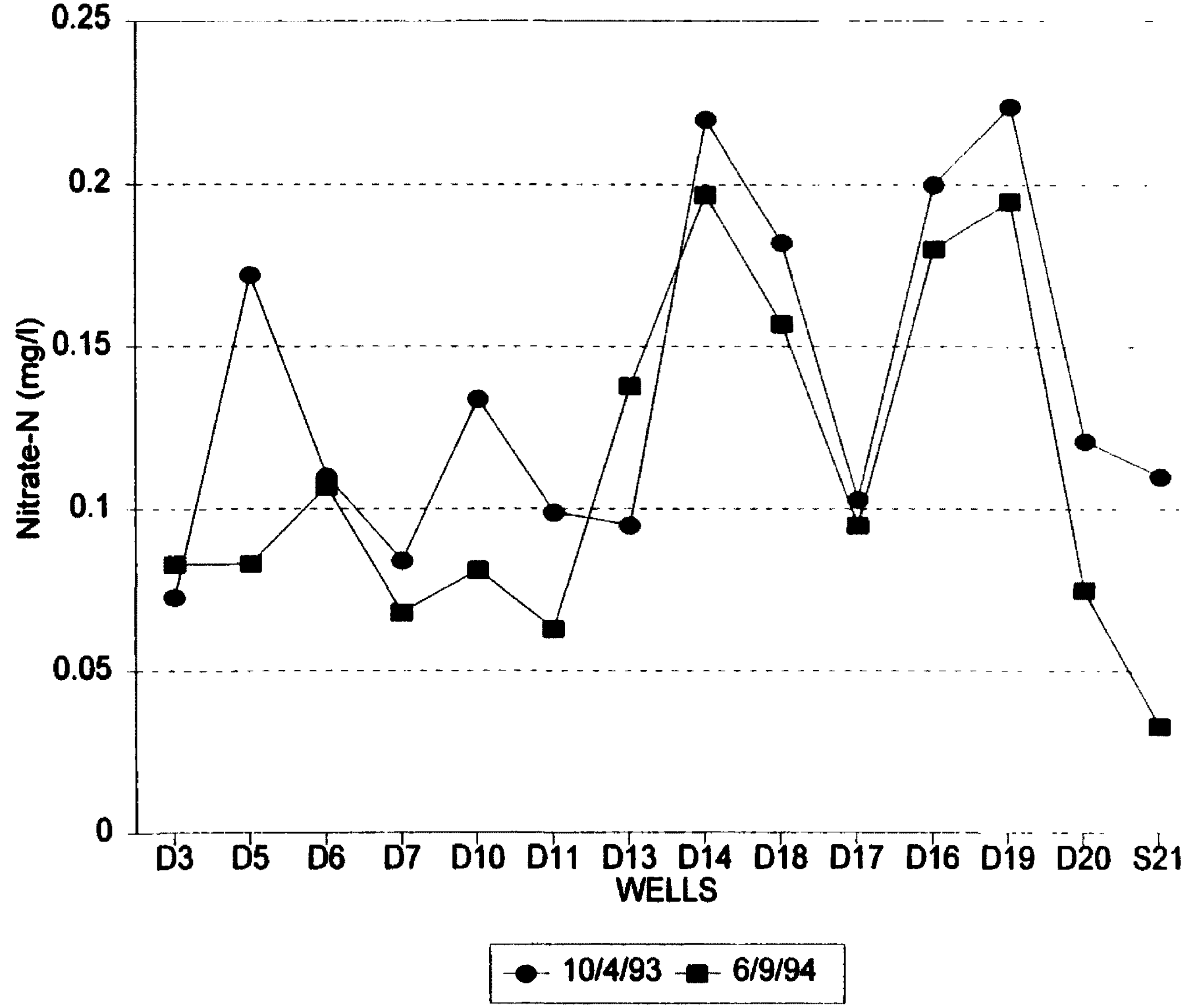


Figure 28: Nitrate-N concentrations from domestic wells and Spring Creek, Oct. 4, 1993 and June 9,1994.

considered background concentration. Input of nitrate into Rock Creek from Spring Creek at that time amounted to about 3 kg per day. On June 9, 1994, nitrate-N concentrations in general were lower than the previous October, but still increase to 2.5 times background. However, Spring Creek nitrate-N concentrations are now less than half of background concentration. This portion of the study focused on understanding the relationship between the concentration of nitrate in the groundwater and the concentration found in Spring Creek.

CHEMISTRY OF SHALLOW GROUNDWATER OF THE DISCHARGE AREA

Shallow groundwater found in the discharge area is distinguished from the deeper groundwater from domestic wells by its low dissolved oxygen, high iron and manganese concentrations, and the presence of ammonium in some locations (Table 3). The presence of these ions indicate that reducing conditions occur in areas with a shallow water table.

Nitrate-N concentrations in the discharge area tend to be lower than those found in the domestic wells throughout the study area. Figure 29 shows the nitrate-N concentrations in shallow groundwater from monitoring wells in the discharge area on July 11, 1994. Concentrations are below 0.1 mg/l in all parts of the discharge area. Nitrate-N concentrations are lowest in groundwater near Rock Creek, due to the influence of surface water from the creek. Nitrate-N values east of Rock

Well	Date	Ca	Fe	Mn	NO3	Cl	Na	pH	D.O.
D10	07/12/94	12.9	<0.03	<0.005	0.054	0.649	2.41	6.36	10.4
D11	07/12/94	18.3	<0.03	<0.005	0.064	0.636	3.43	6.53	2.9
D12	07/12/94	16.6	<0.03	<0.005	0.157	0.975	3.52	6.46	4.8
D13	07/12/94	16.1	<0.03	<0.005	0.114	0.806	3.3	6.25	4.6
D14	07/12/94	16.6	<0.03	<0.005	0.179	0.846	3.39	6.77	6.4
D16	07/12/94	16	<0.03	<0.005	0.202	0.882	3.51	6.59	5.7
D17	07/12/94	17.1	<0.03	0.011	0.1	0.724	3.37	6.72	3.4
D18	07/12/94	16.1	0.06	0.014	0.177	0.853	3.39	6.37	4.7
D19	07/12/94	16.3	<0.03	<0.005	0.201	1.051	3.64	6.61	5.7
D20	07/12/94	17.9	<0.03	<0.005	0.101	0.73	3.61	6.75	4.1
M3	07/11/94	15.7	1.15	0.281	0.018	0.376	2.58	6.54	0.6
M4	07/11/94	15.8	0.11	0.005	0.006	0.568	2.93	6.73	0.8
M5	07/11/94	16.8	1.13	0.065	0.018	0.519	2.95	6.52	
M8	07/11/94	16.6	10.50	0.419	0.099	0.777	4.53	6.51	0.2
M9	07/11/94	16.9	0.61	0.102	0.011	0.592	3.02	6.61	0.1
M10	07/11/94	14.9	0.25	0.084	0.009	0.599	2.9	6.58	0.7
M12	07/11/94	21.2	0.35	0.685	0.049	1.318	3.54	6.95	2.2
M13	07/11/94	19.4	1.53	0.197	0.021	0.879	3.32	6.58	2
M14	07/11/94	15.5	1.70	0.175	0.051	1.126	3.38	6.66	0.8
M15	07/11/94	18.5	<0.03	0.007	0.063	0.898	3.53	6.59	2.9
M16	07/11/94	19.1	4.44	0.148	0.075	1.248	3.99	6.2	0.7
M17	07/11/94	25.8	2.50	0.151	0.024	0.797	4.09	6.47	0.4

Table 3: Comparison of groundwater from domestic wells with shallow groundwater of the discharge area.

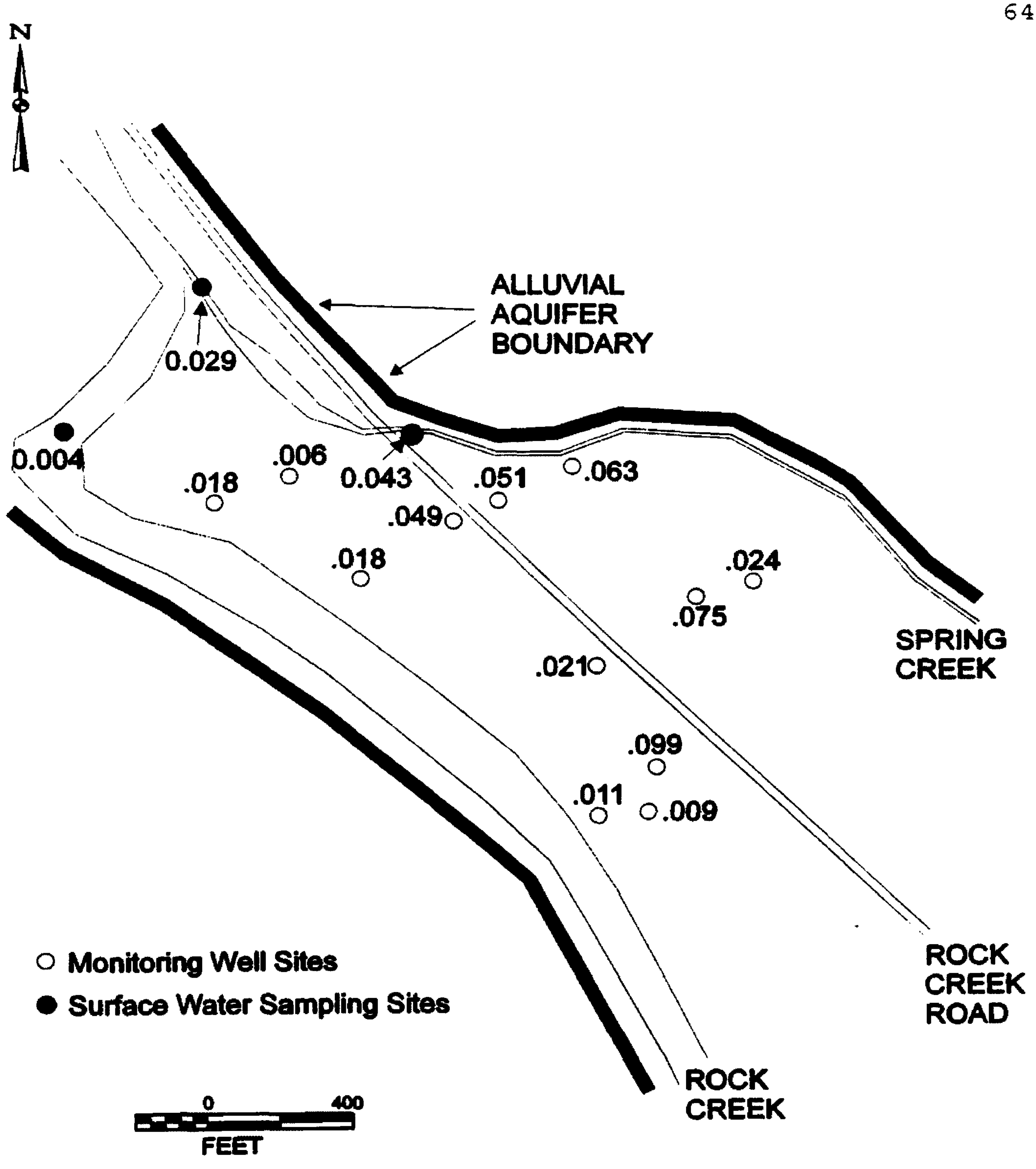


Figure 29: Discharge area nitrate-N concentrations (mg/l) on July 11, 1994.

Creek Road varied from 0.024 mg/l to 0.075 mg/l, which is at or below what is considered to be background concentrations of 0.07 mg/l to 0.09 mg/l in the southern part of the study area. Concentrations of nitrate-N from domestic wells in the Rock Creek Acres area in July ranged from 0.10 mg/l to 0.20 mg/l with an average of 0.16 mg/l.

Nitrate-N concentrations for the discharge area on August 24, 1994, are shown in Figure 30. Concentrations are higher than in July, ranging from 0.043 mg/l to 0.087 mg/l in the wells east of the road. Most of the wells near Rock Creek had gone dry as the water table dropped by the time of this sampling, but wells M3 (0.017 mg/l) and M9 (0.003 mg/l) still showed very low nitrate-N values.

Water chemistry data along with visual inspection of Spring Creek indicate that groundwater contributes most of the flow to Spring Creek. Surface water samples were taken at the mouth of Spring Creek immediately before its confluence with Rock Creek during the course of the discharge area study. Nitrate-N concentrations varied from 0.029 mg/l to 0.045 mg/l. This compares with 0.003 mg/l to 0.009 mg/l found in Rock Creek above the confluence with Spring Creek.

Shallow groundwater from the discharge area has much less dissolved oxygen than is found in the water of the deep aquifer. The highest concentration was 2.9 mg/l, however, most concentrations are below 1.0 mg/l. There is little difference between the dissolved oxygen in the shallow groundwater east

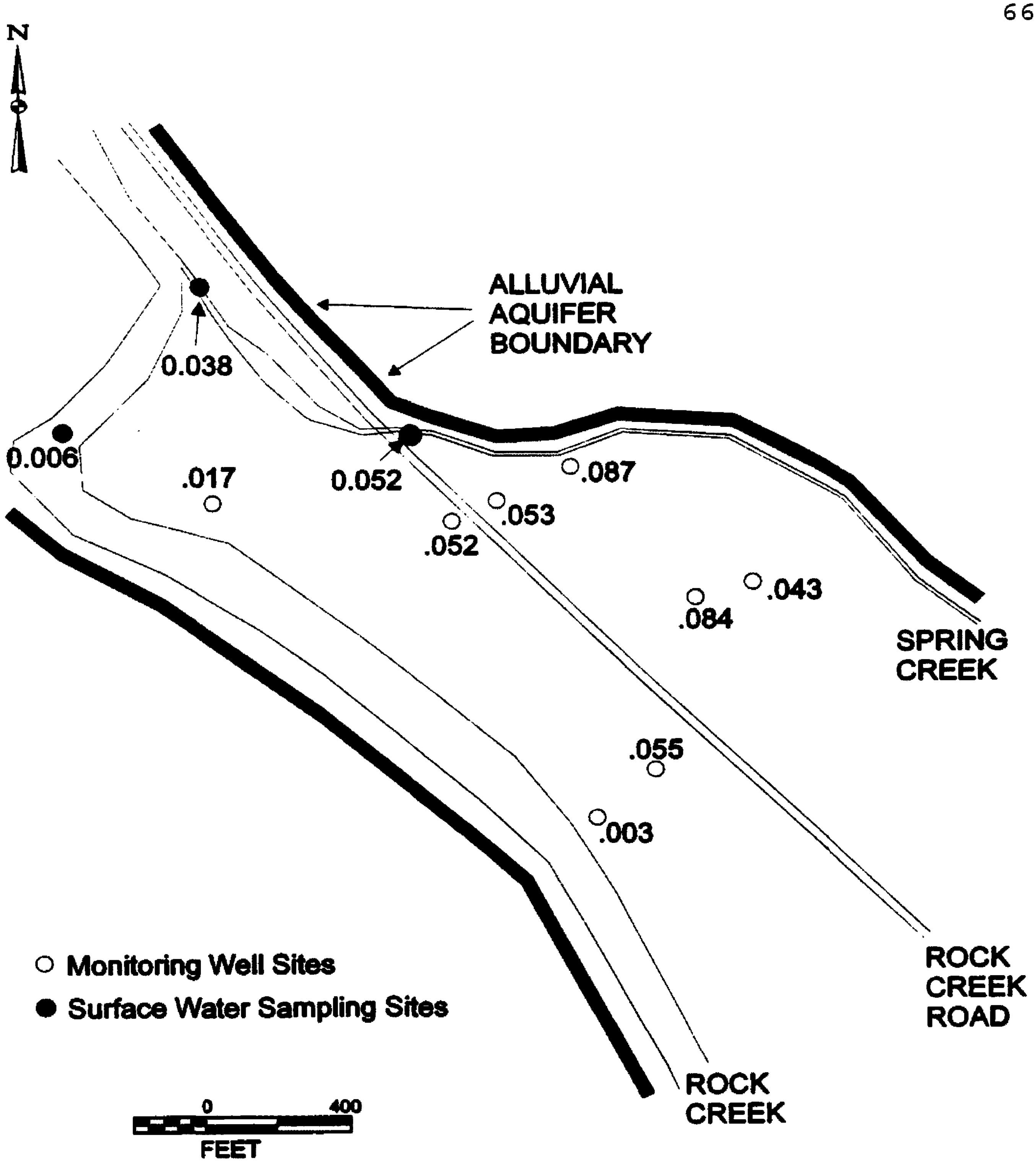


Figure 30: Discharge area nitrate-N concentrations (mg/l) on August 24, 1994.

of the road and in the area influenced by surface water from Rock Creek.

Groundwater in the discharge area contains considerably more iron than is found in domestic wells. All wells show elevated iron concentrations except well M15, which had a higher dissolved oxygen concentration. Iron is thought to be Fe^{2+} as only samples that have dissolved oxygen concentrations less than 2.5 mg/l have iron concentrations greater than 0.05 mg/l. Water that contained high iron concentrations also had nitrate and sulfate indicating the water is not in chemical equilibrium, as reduced iron and oxidized nitrogen and sulfur were both present.

Anomalous ammonium-N concentrations were detected in the August 24, 1994 sampling. Ammonium-N concentrations of 0.4 mg/l and 1.3 mg/l were found in wells M12 and M16 respectively. Possible sources of ammonium include ammonium released by anaerobic decay of organic matter or reduction of nitrate to ammonium. One possible explanation for the high ammonium concentrations is retardation of the flow of ammonium from the area where it is being formed (Richey et al., 1985; Ceazan et al., 1989). Some reduction of nitrate to ammonium may have occurred while the sample was awaiting analysis.

Sulfate concentrations in the shallow groundwater of the discharge area are more variable than in groundwater from other parts of the study area. Sulfate concentrations in groundwater from domestic wells in the central part of the study area were consistently between 5 and 6 mg/l. In the discharge area, shallow groundwater from well M8 was less than 0.6 mg/l, the detection limit, in all samples. Sulfate concentrations in groundwater from well M15 was similar to that found in groundwater at Rock Creek Acres, 5 to 5.5 mg/l. At all other locations in the discharge area, groundwater sulfate concentrations were intermediate to those of M8 and M15. The low sulfate concentrations in shallow groundwater at some monitoring wells in the discharge area suggest that sulfate reduction is taking place near those locations. No sulfide measurements were made to confirm this.

DISAPPEARANCE OF NITRATE

There are three possible explanations for the decrease in the nitrate concentrations found between Rock Creek Acres and the mouth of Spring Creek: 1) the groundwater is diluted by water that has much lower nitrate concentrations; 2) plants are using the nitrate; 3) denitrification is taking place, whereby nitrate is converted to nitrogen-containing gases. It is possible that all three scenarios are contributing to the disappearance of the nitrate in the groundwater.

Rock Creek is a losing stream throughout the study area. Water that flows out of the creek has very low concentrations of nitrate. This water flows away from the creek at the water table. However, geochemical evidence indicates that surface water from Rock Creek impacts a discrete zone near the creek.

While mixing of surface water with groundwater accounts for the low nitrate-N concentrations near the creek, decreases seen farther from the creek do not appear to be related to surface water.

Nitrate is an essential nutrient for plants. Where roots extend down to the groundwater, they will absorb nitrate. Riparian vegetation found in the discharge area is using nitrate. Once the groundwater enters Spring Creek, aquatic plants also are using nitrate. Quantifying the nitrate uptake of plants in the discharge area was beyond the scope of the study. However, groundwater at well M8 has a long flowpath through riparian vegetation but has relatively high nitrate-N concentrations. Therefore the absorption of nitrate by plants is not considered to play a major role in the removal of nitrate.

Conditions required for denitrification are the presence of: (1) nitrate; (2) labile organic carbon; (3) denitrifying bacteria; and (4) reducing conditions (Starr and Gillham, 1993). Nitrate was present in all the groundwater analyzed in the study area. Organic carbon is readily available in areas with a shallow water table (Starr and Gillham, 1993) and in riparian zones (Fustec et al., 1991). Denitrifying bacteria have been shown to be prevalent in most environments (Tiedje et al., 1982) and are likely to be found in the discharge area. Reducing conditions have been shown to be present in the shallow groundwater of the discharge area. During spring runoff the rising water table brings the groundwater into the root zone in areas with a shallow water table, thus providing the organic carbon necessary to drive the reactions leading to denitrification.

Chloride is usually a conservative ion, and decreases in the concentration of nitrate relative to chloride indicate that nitrate is disappearing. Changes in nitrate-chloride ratios have been used to infer that denitrification is taking place (Robertson et al., 1991; Keeney, 1986). Chloride concentrations are relatively constant throughout the study area. If nitrate concentrations are falling relative to chloride concentrations, the value of Cl/NO_3 will increase. Values for Cl/NO_3 on July 12, 1994, for groundwater from Rock Creek Acres (Figure 31) vary from 4.4 to 7.2 with an average of 5.6. The higher numbers are from the wells closest to Rock Creek. At Hamm Ranchettes values from domestic well water range between 3.7 and 12.0, with an average of 7.8. This compares with values of Cl/NO_3 from 8 to 42, with an average of 20, in shallow groundwater of the discharge area that is not influenced by Rock Creek (Figure 32). Variations in the ratios may reflect differences in the ability of different parts of the aquifer to reduce nitrate. Ratios in groundwater adjacent to Rock Creek range from 21 to 95, reflecting the influence of the creek with its very low nitrate concentration. Surface water in Spring Creek immediately before it enters Rock Creek, has a chloride-nitrate ratio of

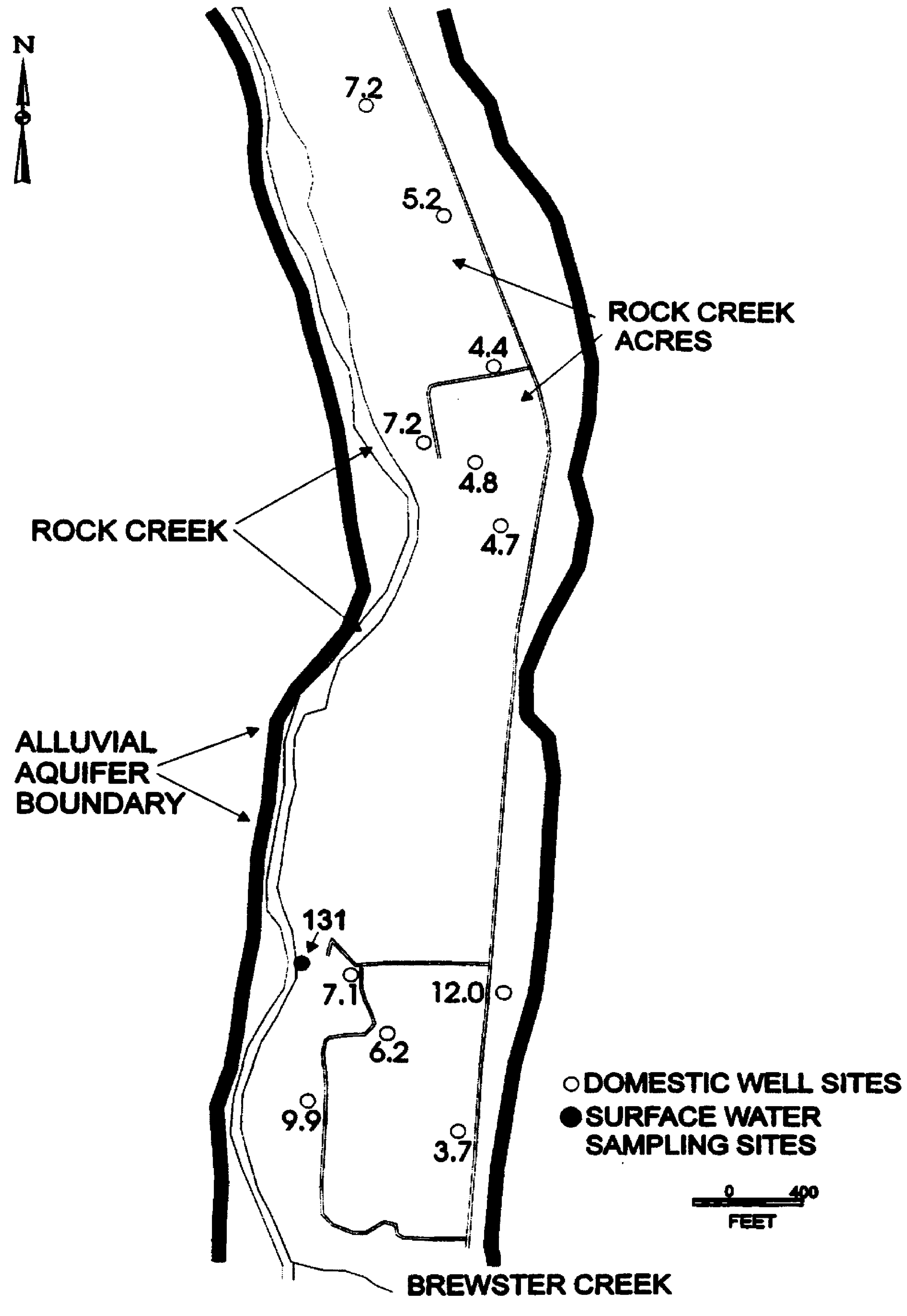


Figure 31: Cl/NO3 in the central part of the study area on July 12, 1994.

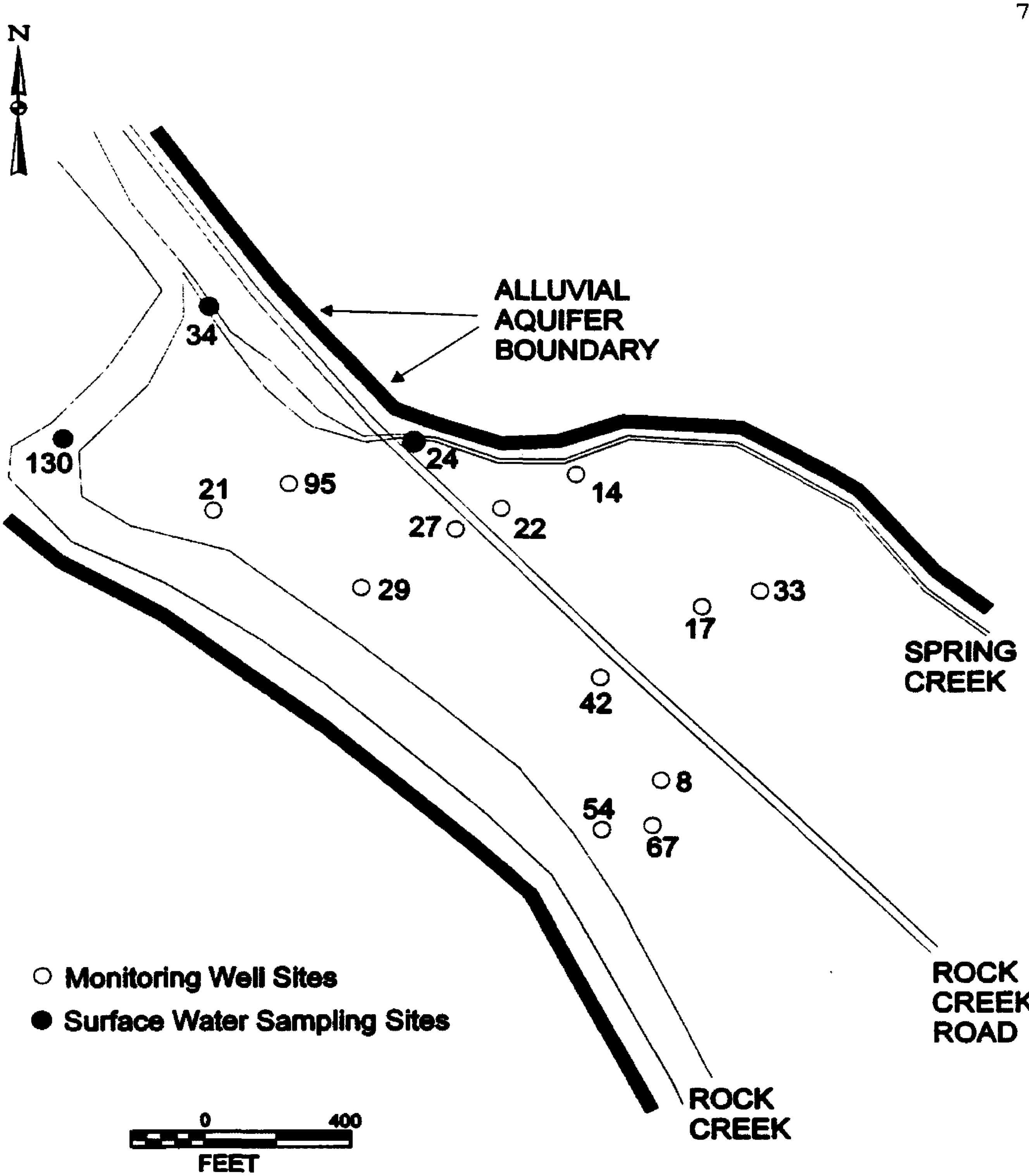


Figure 32: Cl/NO3 in the discharge area on July 11, 1994.

34, indicating still lower concentrations of nitrate relative to chloride than in the monitoring wells. On August 24, 1994, values for Cl/NO_3 declined from the July numbers (Figure 33), reflecting higher nitrate concentrations. Decreases in the chloride-nitrate ratio from Rock Creek Acres to Spring Creek indicate that denitrification is probably taking place.

MASS BALANCE

Mass balances are another tool used to infer that denitrification is taking place. A discrepancy in the mass balance may indicate that denitrification is taking place. Septic systems in the Missoula valley are reported to contribute between 18 and 27 pounds of nitrate-N to the groundwater each year (Ver Hey, 1987). With approximately 70 dwellings in the study area this amounts to an estimated input of between 1200 and 1900 pounds of nitrate-N per year added to the groundwater in the study area. If this amount of nitrate-N is completely mixed with the 22 cfs of groundwater that is estimated to be flowing through the valley at Rock Creek Acres, it would raise the nitrate-N concentration between 0.029 and 0.043 mg/l. When this is added to background concentrations of 0.07 to 0.09 mg/l, final concentrations before discharging into Spring Creek should be between 0.10 and 0.13 mg/l. Values similar to these were found in Spring Creek on October 4, 1993 (0.11 mg/l) and in well M8 on July 11, 1994 (0.10 mg/l). Concentrations exceeding this level in

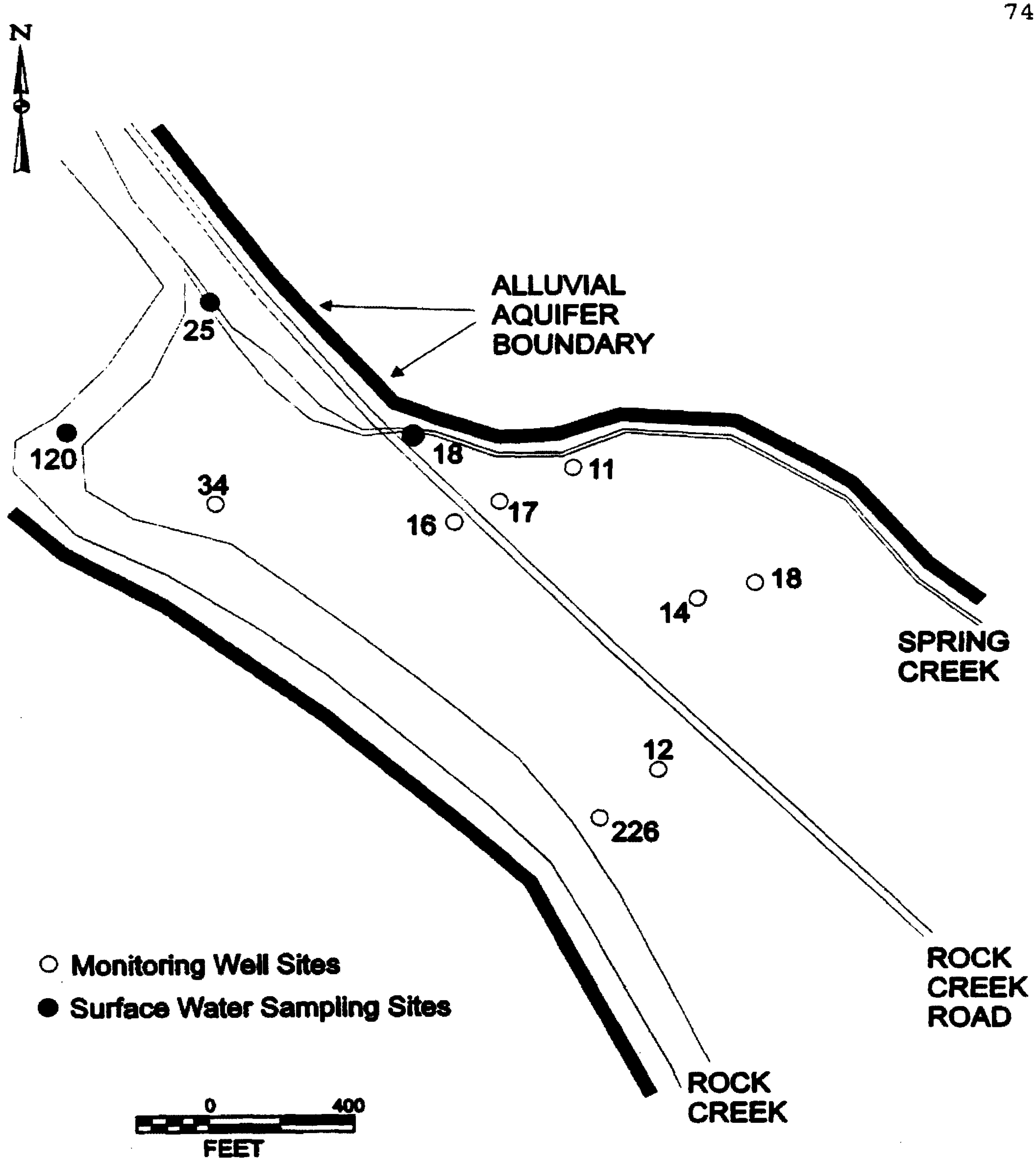


Figure 33: Cl/NO3 in the discharge area on August 25, 1994.

the Rock Creek Acres area may be from mixing of septic effluent with a smaller volume of groundwater. Since septic system effluent enters the groundwater at the water table, it is doubtful that there would be complete mixing. Nitrate-N concentrations are probably higher in the upper portion of the aquifer than at depth. Most domestic wells that were sampled extract groundwater from between 20 and 40 ft below the water table.

A steady-state mass balance of nitrate in Spring Creek shows considerable loss of nitrate during the summer. On Oct. 1, 1993, Spring Creek had a measured flow of 11 cfs. This probably represents base flow for most of the year. Using 11 cfs for the flow and 0.029 mg/l nitrate from July 1994, 780 grams nitrate are entering Rock Creek through Spring Creek each day at this time. Using a concentration of 0.12 mg/l nitrate-N for the groundwater flowing into the discharge area, 3,200 grams of nitrate per day should be entering Spring Creek. This leaves a difference of 2,420 grams of nitrate per day that is unaccounted for.

LITERATURE REVIEW

Loss of nitrate in areas of shallow groundwater has been documented in the literature. Trudell et al. (1986) studied a shallow, sandy aquifer (3 ft to water) at Rodney, Ontario. A chemical profile of the site showed that nitrate decreased with depth, as did dissolved oxygen. Alkalinity increased in the zone where the denitrification was inferred to be taking place. They found adequate organic carbon in the soil and aquifer material to drive the denitrification reaction. An injection experiment (Trudell et al, 1986) confirmed that denitrification was taking place in the saturated zone.

Starr and Gillham (1993) working on the Rodney site and another site at Alliston, Ontario, proposed that the depth to the water table affects denitrification activity in the saturated zone. Both sites have a similar lithology of fine to medium sand, however, the water table at the Alliston site is 12 ft deep. Starr and Gillham (1993) concluded that the thickness of the vadose zone affected the infiltration of organic carbon to the saturated zone. Thus, denitrification is unlikely to occur in aquifers where the water table is greater than 6 to 9 ft deep.

Korom (1992) performed a tracer test in shallow groundwater in Utah. He found an increase in both HCO_3 and SO_4 in the zone where nitrate decreased. It appeared that both organic carbon and sulfide were the electron donors for the reduction of nitrate. A similar mechanism for denitrification was seen in a sandy aquifer in Denmark (Postma et al., 1991). There sediments contained both coal fragments and pyrite. Although organic matter was much more abundant, pyrite was thought to be the major electron donor using the reaction:

$$2FeS_2 + 6NO_3^- + 2H_20 \rightarrow 3N_2 + 2FeOOH + 4SO_4^{2-} + 2H^+$$

Fustec et al. (1991) studied the role of a former channel of the Garonne River, France in the removal of nitrate by denitrification. Groundwater from nearby, intensively-cultivated areas flows into the former river channel. Depth to the water table varied between nine and 17 ft below ground level in the agricultural areas and between 0.5 ft above ground level to five feet below ground level in the former channel. The primary difference between the groundwater chemistry of the former channel and the agricultural areas involved nitrate and dissolved Mn^{2+} and Fe^{2+}. No dissolved iron and manganese were found in the wells on the higher ground. These wells had very high nitrate-N concentrations (average 10.5 mg/l). Groundwater from the former channel had high concentrations of iron (average 12.4 mg/l) and manganese (average 0.42 mg/l), while nitrate-N concentrations were very low (average 0.50 mg/l). There was considerable seasonal variation in the nitrate-N concentrations in the former channel. During the summer concentrations approached zero, rising over the winter and peaking in the spring. Fustec et al (1991) were able to determine a denitrification rate by measuring in situ gaseous nitrogen losses.

The above studies support a model for the discharge area in which denitrification is taking place in the saturated zone. Rock Creek shares some similarities in that the chemical conditions necessary for denitrification are present and depth to water in the discharge area is less than 6 ft. Further support for the model is given by the discrepency in the mass balance and the changes in the chloride-nitrate ratios. However, all the above studies were conducted in areas with nitrate contamination from agricultural sources. None of the studies address denitrification in groundwater with nitrate concentrations as low as those found in the Rock Creek aquifer.

SUMMARY

During the summer, the shallow groundwater areas along with the riparian zones are able to substantially reduce the quantity of nitrate that is entering Rock Creek through Spring Creek. The study did not continue into the fall, but data from the previous year indicate that this ability to reduce the nitrate levels decreases late in the summer. On October 1, 1993, the concentration of nitrate-N in Spring Creek was 0.11 mg/l. It is possible that as the level of the groundwater falls during the summer, there is less organic carbon available to drive the denitrification reactions. This results in the higher concentrations seen later in the fall. The result is that there was approximately three times as much nitrate flowing into Rock Creek from Spring Creek in October 1993 than there was during the summer of 1994. Nitrate that enters Rock Creek late in the growing season is more likely to pass down the creek without growing algae than if it were to be put in the creek during the summer.

CHAPTER 5

CONCLUSION

From this study, the data suggest that protection of riparian areas, wetlands, and seasonal wetlands are extremely important in maintaining the water quality of Rock Creek. If these areas are degraded, the water quality of Rock Creek may deteriorate. There appears to be a direct relationship between intact wetlands and riparian zones and water quality.

Groundwater of the study area is high quality with respect to all criteria except pH. Most of the groundwater in the study area has a pH of 6.3 to 6.7. The EPA recommends that the pH of drinking water be above 7. Water with a pH below 7 is not harmful, as the standard for pH is set for aesthetic purposes. Domestic well water is below drinking water standards for all ions analyzed.

Water flowing through the aquifer in the study area receives an estimated input of between 1,200 and 1,900 lbs of nitrate-N from the septic systems each year (Ver Hey, 1986). Nitrate concentrations increase by 2.5 times in domestic wells between the Ranch Creek area and Rock Creek Acres from 0.08 mg/l to 0.20 mg/l. This compares with nitrate concentrations in Rock Creek of 0.004 mg/l. Rock Creek is a losing stream throughout the study area. Groundwater that is affected by the septic systems flows parallel to Rock Creek, not interacting with the creek until it reaches Spring Creek. Before entering Spring Creek, the groundwater flows through an area with a shallow water table and riparian vegetation. Much of the groundwater nitrate appears to be lost through denitrification in this shallow groundwater zone. Uptake of nitrate by vegetation in the riparian zone and by aquatic plants in Spring Creek are the final buffer between the groundwater and Rock Creek. However, the loss of nitrate appears to be seasonal. The ability of this system to attenuate nitrate appears to decrease over the summer. In the fall, Spring Creek is a larger source of nitrate to Rock Creek than in the summer.

In the summer of 1991, there was a growth of the filamentous alga Cladophora in Rock Creek. Watts and Watson (1993) studied nutrient levels in the surface water of Rock Creek and in the algae. Data from the Rock Creek Cladophora Study (Watts and Watson, 1993) indicate that Cladophora was most prevalent near the confluence of the East and West Forks of Rock Creek. In the lower reaches of Rock Creek, the location that had the most Cladophora was near the Norton Fishing Access. This site is in the southern part of the groundwater study area, below the confluence of Ranch Creek and Rock Creek. Along the main stem of Rock Creek, Stations four and nine had the most growth of Cladophora. These two stations also had the highest average nitrate-N concentrations. The source of the nitrate at the Norton

Fishing Access is probably Ranch Creek. Ranch Creek consistently had higher concentrations on nitrate-N than Rock Creek (0.007-0.04 mg/l vs 0.003-0.009mg/l). The nitrate in Ranch Creek is probably natural. There is only one dwelling and a campground upstream from the sampling location and the headwaters are pristine. It is doubtful that these two inputs could account for the concentrations found in the creek.

There was no sampling station near the confluence of Rock Creek and Spring Creek in the Rock Creek Chladophora Study (Watts and Watson, 1993). Water samples were taken approximately 0.5 mi below the confluence of Rock Creek and Spring Creek during the discharge area study. Surface water samples taken at this location had approximately the same concentrations of nitrate-N as did surface water from Rock Creek immediately above its confluence with Spring Creek. If Chladophora grows near inputs of nitrate, then there should be some growth below the confluence of Spring Creek and Rock Creek.

RECOMMENDATIONS

Water quality monitoring in this study covered a period of one year, from August 1993, to August 1994. The summer of 1993 was very wet, while the summer of 1994 was very dry. Yearly changes in weather patterns probably have little effect on the chemistry of the deeper groundwater. Changes in precipitation and temperature may influence the reactions taking place in the shallow groundwater of the discharge area. These factors may play a role in the timing and quantity of nitrate inputs into Rock Creek through Spring Creek. The summer of 1994 was a hot, dry year and may not accurately reflect conditions found in a normal year. I recommend that water chemistry of Spring Creek be monitored seasonally. Periodic monitoring of water chemistry in Spring Creek will show the annual variations in the water entering Spring Creek as well as document changes in groundwater quality that may occur over time. It is possible that a change in water quality of Spring Creek would be reflected in increased growth of algae in Rock Creek below its confluence with Spring Creek.

This study shows that there is evidence that denitrification is taking place in the areas of shallow groundwater of the discharge area. Further research is necessary in order to prove conclusively that denitrification is taking place. We do not know the limits of the discharge area to attenuate nitrate. Further study could focus on denitrification rates, the availability of organic carbon in the shallow groundwater, the quantities of nitrate that the discharge area is capable of denitrifying before Rock Creek is impacted, and why some areas appear to be more effective at reducing nitrate that others. Answering these issues would be of value in understanding the amount of development that is possible without negative impacts to Rock Creek.

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APPENDIX A

HYDRAULIC CONDUCTIVITY CALCULATIONS

Hydraulic conductivity was determined using two methods. Specific capacity data taken from well logs in the study area were used in equation 1 (Domenico and Schwartz, 1990). Equation 1 is used to determine the theoretical specific capacity of a well or the transmissivity of the formation in which the well is finished in (Driscoll, 1986). Hydraulic conductivity is then estimated by dividing T by aquifer thickness.

$$Q/s = T/(264\ \log(Tt/1.87r^2S) - 65.5) \qquad (1)$$

Where Q/s = the specific capacity in gallons per minute per foot

T = the transmisivity in gallons per day per foot

t = the pumping period in days

r = the effective radius of the well

All wells in the study area are finished with an open ended casing rather than a screened interval. A perforated length of 1 ft was used to represent the open ended casing. In order to correct for the partial penetration of the aquifer, the Kozeny equation (Equation 2) was used (Driscoll, 1986). The equation is solved for Q/s. Q/s_p is given on the well logs.

$$(Q/s_p)/(Q/s) = L(1+7*(r/2bL)^{.5}*\cos(3.14*L/2)) \qquad (2)$$

Where Q/s_p = specific capacity of a partially penetrating well in gpm/ft.

Q/s = maximum possible specific capacity of a fully penetrating well in gpm/ft.

r = radius of the well, in ft

b = aquifer thickness, in ft

L = well screen length as a fraction of the aquifer thickness

In choosing well logs for analysis, logs where the drawdown of the well was to the bottom of the well were avoided, however nine were included. Results from a few wells showed hydraulic conductivity values as high as 30,000 ft/day. These high values were statistical outliers that had a large effect on the average. Therefore those wells having hydraulic conductivities over 10,000 ft/day were eliminated.

Estimated thickness of valley fill sediments is from 180 to 190 ft. Maximum saturated thickness of the aquifer is estimated to be 140 to 150 ft. In a V-shaped valley the average saturated thickness is 0.5 times the maximum thickness. Therefore an average saturated thickness of 70 to 90 ft was used in the calculations. Resulting values of hydraulic conductivity for individual wells ranged from 290 to 8,950 ft/day. Average values from all wells varied from 2,100 ft/day to 2,700 ft/day depending on the saturated thickness used. Results are shown on Table A1.

The second method used to estimate a large scale value of hydraulic conductivity employed Darcy's law and the known amount of groundwater that comes to the surface in Spring Creek compared to the estimated groundwater flow at Rock Creek Acres. It is assumed that groundwater flow at Rock Creek Acres is equal to groundwater flow near Spring Creek plus the groundwater that flows into Spring Creek. Uncertain parameters used in this method are the amount of groundwater flowing into Spring Creek and the saturated thickness of the aquifer. Equation 3 is derived from Darcy's Law to solve for average hydraulic conductivity.

$$K*A_1*i_1 = K*A_2*i_2 + Q \tag{3}$$

Where
- K = average hydraulic conductivity
- A_1 = area of saturation at Rock Creek Acres
- i_1 = groundwater gradient at Rock Creek Acres
- A_2 = area of saturation at mouth of Spring Creek
- i_2 = groundwater gradient at mouth of Spring Creek
- Q = amount of groundwater coming to the surface in Spring Creek

The groundwater gradients were calculated from known water elevations in monitoring wells in the discharge area and from domestic wells in Rock Creek Acres. Area was determined using widths of the valley taken from topographic maps. Average saturated thickness was estimated to be between 70 and 90 feet. Flow in Spring Creek was measured at 11 cfs on Oct. 1, 1993 immediately before it enters Rock Creek. There are small inputs of surface water from upper Spring Creek, before it enters the Rock Creek Valley, and from Babcock Creek. Because of the small inputs of surface water, the flow of groundwater into Spring Creek is estimated to be between eight cfs and 10 cfs. Calculations were made using the range of variables to give a range for hydraulic conductivity. Using the above parameters, average hydraulic conductivity was calculated to be between 1,600 and 2,500 ft/day. Calculations are shown on Table A2.

WELL OWNER	FLOW Q (GPM)	DRAW DOWN s	Q/s	TIME hours	DIAMETER OF WELL	AQUIFER THICKNESS	T	K	CORRECT FOR PARTIAL PENETRATION	CORRECT T	CORRECT K
Aquifer Thickness = 70 ft.											
Kennedy	8	12	0.67	1	0.5	70	256	0	300	194332	371
Holtby	100	32	3.13	1	0.5	70	1198	2	1406	910930	1740
Gray	50	12	4.17	1.5	0.5	70	1791	3	1875	1301730	2486
Gomme	50	24	2.08	4	0.5	70	1130	2	937	756282	1444
Engebretson	40	21	1.90	1	0.5	70	730	1	857	555233	1060
Ackerlund	40	10	4.00	3	0.42	70	1877	4	1683	1234981	2359
Olson	50	41	1.22	1.5	0.5	70	524	1	549	380994	728
Olson	100	38	2.63	1	0.5	70	1009	2	1184	767099	1465
Olson	100	14	7.14	1	0.5	70	2738	5	3214	2082125	3977
Olson, Alton	100	32	3.13	1	0.5	70	1198	2	1406	910930	1740
Gendrow (35')	65	8	8.13	2	0.5	70	3760	7	3656	2658958	5078
Mackie	100	11	9.09	1	0.5	70	3485	7	4091	2649977	5061
Peterson	40	12	3.33	1	0.5	70	1278	2	1500	971658	1856
Larum	60	4	15.00	1.5	0.5	70	6447	12	6749	4686226	8950
Fried	40	14	2.86	1.5	0.5	70	1228	2	1286	892615	1705
Kane	100	18	5.56	1	0.5	70	2130	4	2500	1619430	3093
Wolff	40	12	3.33	2.5	0.5	70	1628	3	1500	1129227	2157
Soltes	69	5	13.80	0.5	0.5	70	4193	8	6209	3529192	6740
Persico	40	5	8.00	1	0.5	70	3067	6	3600	2331980	4454
Page	30	19	1.58	2	0.5	70	731	1	710	516721	987

Data continues on next page.

Table A1: Calculation of hydraulic conductivity using specific capacity data from domestic wells.

WELL OWNER	FLOW Q (GPM)	DRAW DOWN s	Q/s	TIME hours	DIAMETER OF WELL	AQUIFER THICKNESS	T	K	CORRECT FOR PARTIAL PENETRATION	CORRECT T	CORRECT K
Aquifer Thickness = 90 ft.											
Kennedy	8	12	0.67	1	0.5	90	256	0	300	194332	289
Holtby	100	32	3.13	1	0.5	90	1198	2	1406	910930	1353
Gray	50	12	4.17	1.5	0.5	90	1791	3	1875	1301730	1934
Gomme	50	24	2.08	4	0.5	90	1130	2	937	756282	1123
Engebretson	40	21	1.90	1	0.5	90	730	1	857	555233	825
Ackerlund	40	10	4.00	3	0.42	90	1877	3	1683	1234981	1834
Olson	50	41	1.22	1.5	0.5	90	524	1	549	380994	566
Olson	100	38	2.63	1	0.5	90	1009	1	1184	767099	1139
Olson	100	14	7.14	1	0.5	90	2738	4	3214	2082125	3093
Olson, Alton	100	32	3.13	1	0.5	90	1198	2	1406	910930	1353
Gendrow (35')	65	8	8.13	2	0.5	90	3760	6	3656	2658958	3950
Mackie	100	11	9.09	1	0.5	90	3485	5	4091	2649977	3936
Peterson	40	12	3.33	1	0.5	90	1278	2	1500	971658	1443
Larum	60	4	15.00	1.5	0.5	90	6447	10	6749	4686226	6961
Fried	40	14	2.86	1.5	0.5	90	1228	2	1286	892615	1326
Kane	100	18	5.56	1	0.5	90	2130	3	2500	1619430	2406
Wolff	40	12	3.33	2.5	0.5	90	1628	2	1500	1129227	1677
Soltes	69	5	13.80	0.5	0.5	90	4193	6	6209	3529192	5242
Persico	40	5	8.00	1	0.5	90	3067	5	3600	2331980	3464
Page	30	19	1.58	2	0.5	90	731	1	710	516721	768

Data continues on next page.

Table A1: Cont.

WELL OWNER	FLOW Q (GPM)	DRAW DOWN s	Q/s	TIME hours	DIAMETER OF WELL	AQUIFER THICKNESS	T	K	CORRECT FOR PARTIAL PENETRATION	CORRECT T	CORRECT K
Aquifer Thickness = 70 ft.											
Alexander	40	10	4.00	1.5	0.5	70	1719	3	1800	1249660	2387
Msla managemen	50	27	1.85	5.5	0.5	70	1072	2	833	702674	1342
Baker	25	2	12.50	2	0.5	70	5785	11	5624	4090705	7813
Gilbert	30	2	15.00	1	0.5	70	5750	11	6749	4372462	8351
Davico	75	32.5	2.31	2	0.5	70	1068	2	1038	755207	1442
Benton	60	15	4.00	5	0.5	70	2271	4	1800	1498109	2861
Swank	75	5.5	13.64	2	0.5	70	6311	12	6136	4462587	8523
Chamberlain	75	36	2.08	1.5	0.5	70	895	2	937	650865	1243
Tettman	35	32	1.09	1	0.5	70	419	1	492	318825	609
Jelletich	30	13	2.31	1	0.5	70	885	2	1038	672686	1285
Hammer	75	36	2.08	2	0.5	70	964	2	937	681784	1302
Peltier	100	16	6.25	1	0.5	70	2396	5	2812	1821859	3479
Brown	100	46	2.17	1	0.5	70	833	2	978	633690	1210
Ryan	100	48	2.08	1	0.5	70	799	2	937	607286	1160
Erp	50	16	3.13	1	0.5	70	1198	2	1406	910930	1740
Schneider	70	28	2.50	1	0.5	70	958	2	1125	728744	1392
Rehfus	40	20	2.00	1	0.5	70	767	1	900	582995	1113
Armstrong	50	29	1.72	1	0.5	70	661	1	776	502582	960
Socha	50	26	1.92	1	0.5	70	737	1	865	560572	1071
										Average K	2603

Table A1: Cont.

WELL OWNER	FLOW Q (GPM)	DRAW DOWN s	Q/s	TIME hours	DIAMETER OF WELL	AQUIFER THICKNESS	T	K	CORRECT FOR PARTIAL PENETRATION	CORRECT T	CORRECT K
Aquifer Thickness = 90 ft.											
Alexander	40	10	4.00	1.5	0.5	90	1719	3	1800	1249660	1856
Msla managemen	50	27	1.85	5.5	0.5	90	1072	2	833	702674	1044
Baker	25	2	12.50	2	0.5	90	5785	9	5624	4090705	6077
Gilbert	30	2	15.00	1	0.5	90	5750	9	6749	4372462	6495
Davico	75	32.5	2.31	2	0.5	90	1068	2	1038	755207	1122
Benton	60	15	4.00	5	0.5	90	2271	3	1800	1498109	2225
Swank	75	5.5	13.64	2	0.5	90	6311	9	6136	4462587	6629
Chamberlain	75	36	2.08	1.5	0.5	90	895	1	937	650865	967
Tettman	35	32	1.09	1	0.5	90	419	1	492	318825	474
Jelletich	30	13	2.31	1	0.5	90	885	1	1038	672686	999
Hammer	75	36	2.08	2	0.5	90	964	1	937	681784	1013
Peltier	100	16	6.25	1	0.5	90	2396	4	2812	1821859	2706
Brown	100	46	2.17	1	0.5	90	833	1	978	633690	941
Ryan	100	48	2.08	1	0.5	90	799	1	937	607286	902
Erp	50	16	3.13	1	0.5	90	1198	2	1406	910930	1353
Schneider	70	28	2.50	1	0.5	90	958	1	1125	728744	1083
Rehfus	40	20	2.00	1	0.5	90	767	1	900	582995	866
Armstrong	50	29	1.72	1	0.5	90	661	1	776	502582	747
Socha	50	26	1.92	1	0.5	90	737	1	865	560572	833
										AVE K	2025

Table A1: Cont.

WIDTH 1	DEPTH 1	WIDTH 2	DEPTH 2	AREA 1	AREA 2	i1	i2	K	K FT/DAY
Q= 10 cfs									
2200	70	700	70	154000	49000	0.006	0.012	0.0298	2571
2200	80	700	80	176000	56000	0.006	0.012	0.0260	2250
2200	90	700	90	198000	63000	0.006	0.012	0.0231	2000
Q= 8 cfs									
2200	70	700	70	154000	49000	0.006	0.012	0.0238	2057
2200	80	700	80	176000	56000	0.006	0.012	0.0208	1800
2200	90	700	90	198000	63000	0.006	0.012	0.0185	1600

Table A2. Hydraulic conductivity calculations using Darcy's law and the estimated flow of groundwater in Spring Creek.

APPENDIX B

SURFACE WATER FLOW AND WATER QUALITY DATA AND MASS BALANCE

On October 1, 1993, stream flow measurements were made on Rock Creek, above and below the study area, and on all the major tributaries. Stream measurements were made using a Marsh-McBirney meter. Flow velocity and water depth were measured every 1.0 ft in Rock Creek, except near shore in slow water where measurements were taken every 2 ft. On the smaller tributaries, measurements were taken every 0.5 ft. Margin of error on the water flow measurements are estimated to be ± 10%. All flow data are shown in Table B1

Water samples were taken at all the stream gaging locations and analyzed using the same methods as for domestic well water (Table 1). Data from the analysis is shown in Table B2. Tributaries that were gaged and sampled include: Ranch Creek, Sawmill Creek, Brewster Creek and Spring Creek. Soloman Creek was sampled; however, the flow was too small to measure.

Table B3 shows a written equation for the mass balance of the surface water and groundwater in the study area. A calculated mass balance applying numbers to the inputs and outputs is shown in Table B4. Since an estimated 90% of Spring Creek is composed of groundwater, one cfs was used for the surface water input from that source. For the surface water the balance shows 281 cfs input from Rock Creek and the tributaries. Output is in Rock Creek, and is measured at 280 cfs. When the estimated groundwater flows are added to the surface water the mass balance shows 307 cfs flowing in and 300 cfs flowing out.

In calculating the groundwater flow of the tributary valleys, a gradient of .006 ft/ft was used since this is the gradient found in the areas of Rock Creek where the valley is a uniform width. Saturated thickness was estimated to be 0.5 times the maximum saturated thickness of 140 ft. A hydraulic conductivity of 2100 ft/day was used in all calculations (Appendix A). As the hydraulic conductivity is increased from 2100 ft/day, the mass balance begins to diverge. Therefore a value from the lower end of the calculated range was used.

Gradient used for the Rock Creek calculations was .012 ft/ft, since the measurements were made where the valley constricts, and the measured gradient in the discharge area was 0.012 ft/ft.

SITE ONE AT PUT IN .5MI ABOVE RANCH CREEK

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
2	2	0.45	0.11	0.9	0.10
4	2	0.7	1.15	1.4	1.61
6	2	0.8	2.18	1.6	3.49
8	2	0.8	3.02	1.6	4.83
10	2	1.4	2.69	2.8	7.53
12	2	1.4	2.67	2.8	7.48
14	2	1.5	2.83	3	8.49
16	2	1.8	2.4	3.6	8.64
18	2	1.5	2.02	3	6.06
19	1	1.2	2.89	1.2	3.47
20	1	1.4	2.69	1.4	3.77
21	1	1.4	2.5	1.4	3.50
22	1	1.4	2.52	1.4	3.53
23	1	1.8	2.79	1.8	5.02
24	1	1.9	2.25	1.9	4.28
25	1	2	2.02	2	4.04
26	1	2.1	2.67	2.1	5.61
27	1	2.1	2.33	2.1	4.89
28	1	1.9	2.72	1.9	5.17
29	1	2	2.83	2	5.66
30	1	1.5	3.18	1.5	4.77
31	1	1.8	3.04	1.8	5.47
32	1	2	3.02	2	6.04
33	1	1.9	3.15	1.9	5.99
34	1	1.8	2.82	1.8	5.08
35	1	1.9	2.58	1.9	4.90
36	1	1.9	2.93	1.9	5.57
37	1	2	2.84	2	5.68
38	1	1.9	2.76	1.9	5.24
39	1	1.4	3.28	1.4	4.59
40	1	1.5	2.72	1.5	4.08
41	1	1.5	3.02	1.5	4.53
42	1	1.5	3.14	1.5	4.71
43	1	1.5	2.44	1.5	3.66
44	1	1.6	2.66	1.6	4.26
45	1	1.5	2.38	1.5	3.57
46	1	1.8	3.22	1.8	5.80

Table B1: Stream gage flow data.

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
47	1	1.4	2.76	1.4	3.86
48	1	1.3	2.76	1.3	3.59
49	1	1.1	2.4	1.1	2.64
50	1	1.1	2.85	1.1	3.14
51	1	1.1	1.6	1.1	1.76
52	1	1.3	3.15	1.3	4.10
53	1	1.5	2.89	1.5	4.34
54	1	1.5	2.98	1.5	4.47
55	1	1.5	2.6	1.5	3.90
56	1	1.3	2.75	1.3	3.58
57	1	1.2	2.8	1.2	3.36
58	1	1.1	2.79	1.1	3.07
59	1	1.2	2.4	1.2	2.88
60	1	1.1	2.66	1.1	2.93
61	1	1.1	2.28	1.1	2.51
62	1	1.1	2.75	1.1	3.03
63	1	1.1	2.9	1.1	3.19
64	1	1.1	2.25	1.1	2.48
65	1	1.1	2.36	1.1	2.60
66	1	1	2.02	1	2.02
67	1	0.9	2.4	0.9	2.16
68	1	1	1.8	1	1.80
69	1	1	2.12	1	2.12
70	1	1	1.38	1	1.38
71	1	0.9	1.41	0.9	1.27
73	2	0.6	2.12	1.2	2.54
75	2	0.7	1.46	1.4	2.04
77	2	0.7	0.99	1.4	1.39
79	2	0.5	0.52	1	0.52
81	2	0.5	0.22	1	0.22
83	2	0.4	0.19	0.8	0.15
84	1	0.4	0.01	0.4	0.00
TOTAL FLOW 0.5 MI ABOVE RANCH CREEK					260.09

Table B1: cont.

DISCHARGE OF ROCK CREEK AT TAKEOUT .5MI BELOW SPRIN

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
2	2	0.2	0.18	0.4	0.07
4	2	0.6	0.9	1.2	1.08
6	2	0.6	1.16	1.2	1.39
8	2	0.8	0.65	1.6	1.04
10	2	0.6	0.31	1.2	0.37
12	2	0.7	1.06	1.4	1.48
14	2	0.9	1.69	1.8	3.04
16	2	0.9	1.99	1.8	3.58
18	2	0.9	2.18	1.8	3.92
20	2	1.1	2.48	2.2	5.46
22	2	1.2	2.58	2.4	6.19
24	2	1.3	2.38	2.6	6.19
26	2	1.1	2.96	2.2	6.51
28	2	1.3	2.91	2.6	7.57
29	1	1.4	3.2	1.4	4.48
30	1	1.5	2.08	1.5	3.12
31	1	1.5	2.83	1.5	4.25
32	1	1.6	2.63	1.6	4.21
33	1	1.7	2.61	1.7	4.44
34	1	1.8	2.58	1.8	4.64
35	1	1.7	2.7	1.7	4.59
36	1	1.7	2.93	1.7	4.98
37	1	1.7	2.75	1.7	4.68
38	1	1.6	2.96	1.6	4.74
39	1	1.5	2.86	1.5	4.29
40	1	1.5	2.96	1.5	4.44
41	1	1.6	3.18	1.6	5.09
42	1	1.6	2.8	1.6	4.48
43	1	1.6	2.53	1.6	4.05
44	1	1.5	2.86	1.5	4.29
45	1	1.5	2.91	1.5	4.37
46	1	1.3	2.62	1.3	3.41
47	1	1.3	2.89	1.3	3.76
48	1	1.4	2.85	1.4	3.99
49	1	1.4	2.86	1.4	4.00
50	1	1.6	3.05	1.6	4.88
51	1	1.6	2.76	1.6	4.42

Table B1: cont.

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
52	1	1.4	3.22	1.4	4.51
53	1	1.5	3.49	1.5	5.24
54	1	1.6	2.91	1.6	4.66
55	1	1.8	3.5	1.8	6.30
56	1	1.7	3.3	1.7	5.61
57	1	1.7	3.45	1.7	5.87
58	1	1.8	3.67	1.8	6.61
59	1	1.8	3.67	1.8	6.61
60	1	1.5	4.21	1.5	6.32
62	2	1.5	3.96	3	11.88
63	1	1.7	4.04	1.7	6.87
64	1	1.3	4.32	1.3	5.62
65	1	1.6	4.02	1.6	6.43
66	1	1.5	4.05	1.5	6.08
67	1	1.5	4.54	1.5	6.81
68	1	1.4	4.27	1.4	5.98
69	1	1.6	3.4	1.6	5.44
70	1	1.5	3.25	1.5	4.88
71	1	1.4	3.14	1.4	4.40
72	1	1.4	3.02	1.4	4.23
73	1	1.5	2.48	1.5	3.72
74	1	1.1	2.58	1.1	2.84
75	1	1.4	1.58	1.4	2.21
76	1	1.1	1.34	1.1	1.47
77	1	1.1	0.98	1.1	1.08
78	1	0.8	0.73	0.8	0.58
79	1	0.7	0.59	0.7	0.41
80	1	0.4	0.48	0.4	0.19
81	1	0.2	0.34	0.2	0.07
TOTAL FLOW .5 MI BELOW SPRING CREEK					280.35

Table B1: cont.

RANCH CREEK

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
1	1	0.3	0.55	0.3	0.17
2	1	0.4	0.27	0.4	0.11
3	1	0.5	0.8	0.5	0.40
4	1	0.6	0.82	0.6	0.49
4.5	0.5	0.7	0.44	0.35	0.15
5	0.5	0.7	0.5	0.35	0.18
5.5	0.5	0.5	0.77	0.25	0.19
6	0.5	0.6	0.22	0.3	0.07
6.5	0.5	0.6	0.63	0.3	0.19
7	0.5	0.8	0.6	0.4	0.24
7.5	0.5	0.7	1.59	0.35	0.56
8	0.5	0.8	1.35	0.4	0.54
8.5	0.5	1.1	0.47	0.55	0.26
9	0.5	0.9	2.04	0.45	0.92
9.5	0.5	1.2	1.48	0.6	0.89
10	0.5	1.2	1.43	0.6	0.86
10.5	0.5	1.3	1.02	0.65	0.66
11	0.5	1.3	0.81	0.65	0.53
11.5	0.5	1.2	0.81	0.6	0.49
12	0.5	1.2	0.69	0.6	0.41
12.5	0.5	1.2	0.69	0.6	0.41
13	0.5	1.1	0.9	0.55	0.50
13.5	0.5	0.9	1.08	0.45	0.49
14	0.5	1	1.2	0.5	0.60
14.5	0.5	0.9	1.47	0.45	0.66
15	0.5	0.9	1.89	0.45	0.85
15.5	0.5	1	1.87	0.5	0.94
16	0.5	1	1.72	0.5	0.86
16.5	0.5	0.4	1.86	0.2	0.37
17	0.5	0.5	1.8	0.25	0.45
18	1	0.6	1.29	0.6	0.77
19	1	0.5	0.74	0.5	0.37
20	1	0.6	0.53	0.6	0.32
21	1	0.4	0.37	0.4	0.15
22	1	0.3	0.21	0.3	0.06
TOTAL FLOW IN RANCH CREEK					16.09

Table B1: cont.

SAWMILL CREEK

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
0.5	0.5	0.2	2.5	0.1	0.25
1	0.5	0.3	1.97	0.15	0.30
1.5	0.5	0.4	1.4	0.2	0.28
2	0.5	0.3	1.95	0.15	0.29
2.5	0.5	0.3	1.63	0.15	0.24
3	0.5	0.3	1.81	0.15	0.27
3.5	0.5	0.2	1.73	0.1	0.17
4	0.5	0.2	0.78	0.1	0.08
TOTAL FLOW IN SAWMILL CREEK					1.89

BREWSTER CREEK

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
1	1	0.3	0	0.3	0.00
2	1	0.2	0	0.2	0.00
2.5	0.5	0.4	0.12	0.2	0.02
3	0.5	0.4	0.31	0.2	0.06
3.5	0.5	0.5	0.6	0.25	0.15
4	0.5	0.6	0.58	0.3	0.17
4.5	0.5	0.6	0.59	0.3	0.18
5	0.5	0.6	0.6	0.3	0.18
5.5	0.5	0.6	0.63	0.3	0.19
6	0.5	0.6	0.55	0.3	0.17
6.5	0.5	0.6	0.6	0.3	0.18
7	0.5	0.6	0.56	0.3	0.17
7.5	0.5	0.5	0.62	0.25	0.16
8	0.5	0.5	0.54	0.25	0.14
8.5	0.5	0.4	0.45	0.2	0.09
9	0.5	0.3	0.18	0.15	0.03
9.5	0.5	0.2	0.07	0.1	0.01
TOTAL FLOW IN BREWSTER CREEK					1.88

Table B1: cont.

SPRING CREEK

DISTANCE FROM BANK	WIDTH	DEPTH	VELOCITY	AREA	DISCHARGE (CFS)
0.5	0.5	0.2	0.18	0.1	0.02
1.5	1	0.2	0	0.2	0.00
2	0.5	0.3	0.74	0.15	0.11
2.5	0.5	0.3	0.96	0.15	0.14
3	0.5	0.3	0.55	0.15	0.08
3.5	0.5	0.3	1.49	0.15	0.22
4	0.5	0.2	0.99	0.1	0.10
4.5	0.5	0.5	1.86	0.25	0.47
5	0.5	0.4	1.36	0.2	0.27
5.5	0.5	0.4	1.36	0.2	0.27
6	0.5	0.5	1.52	0.25	0.38
6.5	0.5	0.4	1.45	0.2	0.29
7	0.5	0.6	1.59	0.3	0.48
7.5	0.5	0.5	0.79	0.25	0.20
8	0.5	0.5	1.25	0.25	0.31
8.5	0.5	0.5	1.24	0.25	0.31
9	0.5	0.4	0.72	0.2	0.14
9.5	0.5	0.7	0.93	0.35	0.33
10	0.5	0.8	1.54	0.4	0.62
10.5	0.5	0.6	2.05	0.3	0.61
11	0.5	0.4	2.47	0.2	0.49
11.5	0.5	0.7	2.69	0.35	0.94
12	0.5	0.6	1.71	0.3	0.51
12.5	0.5	0.9	1.76	0.45	0.79
13	0.5	0.7	0.49	0.35	0.17
13.5	0.5	0.5	0.6	0.25	0.15
14	0.5	0.6	2.26	0.3	0.68
14.5	0.5	0.6	2.26	0.3	0.68
15	0.5	0.6	1.98	0.3	0.59
15.5	0.5	0.5	1.07	0.25	0.27
16	0.5	0.3	0.59	0.15	0.09
16.5	0.5	0.3	1.62	0.15	0.24
17	0.5	0.2	1.68	0.1	0.17
17.5	0.5	0.2	0.27	0.1	0.03
TOTAL FLOW IN SPRING CREEK					11.16

Table B1: cont.

Oct. 1, 1994

Sample Name	Ca	Fe	Mg	Mn	Mo
Rock Creek at S1	20.9	0.066	6.93	0.0051	<0.01
Rock Creek at S1	20.5	0.065	6.76	<0.005	<0.01
Rock Creek at S1	22.2	0.068	7.01	0.0054	<0.01
Ranch Creek	3.7	0.022	1.61	<0.005	<0.01
Ranch Creek	3.74	0.024	1.62	<0.005	<0.01
Rock Creek above Ranch Cr.	20.7	0.068	6.72	<0.005	<0.01
Sawmill Creek	10.7	0.026	4.48	<0.005	<0.01
Sawmill Creek	11	0.026	4.6	<0.005	<0.01
Rock Creek above Sawmill Cr.	19	0.058	6.29	<0.005	<0.01
Brewster Creek	17	0.056	9.29	<0.005	<0.01
Rock Creek at Sawmill F.A.	18.7	0.053	6.19	<0.005	<0.01
Soloman Creek	9.3	0.067	5.04	<0.005	<0.01
Rock Cr. above Soloman Cr.	19.2	0.057	6.27	<0.005	<0.01
Spring Creek	22.6	0.019	10.1	<0.005	<0.01
Rock Cr. above Spring Cr.	19.4	0.059	6.36	<0.005	<0.01
Rock Cr. 0.5 mi below Spring C	19.1	0.058	6.54	<0.005	<0.01
Rock Cr. 0.5 mi below Spring C	19.3	0.054	6.43	<0.005	<0.01

Oct. 1, 1994

Sample Name	Na	Si	Sr	Zn	K
Rock Creek at S1	3.84	5.48	0.0396	0.0199	2.017
Rock Creek at S1	3.24	5.63	0.0403	0.0218	2.451
Rock Creek at S1	3.57	5.34	0.0385	0.0204	2.244
Ranch Creek	1.77	5.27	0.0116	0.0221	1.736
Ranch Creek	1.73	5.27	0.0117	0.0234	1.923
Rock Creek above Ranch Cr.	3.51	5.36	0.0386	0.0187	2.036
Sawmill Creek	2.63	6.38	0.0163	0.0203	1.514
Sawmill Creek	2.72	6.48	0.0168	0.0205	1.726
Rock Creek above Sawmill Cr.	3.37	5.25	0.0362	0.0182	2.125
Brewster Creek	2.48	6.91	0.0226	0.0238	1.997
Rock Creek at Sawmill F.A.	3.5	5.23	0.0354	0.0195	1.963
Soloman Creek	3.08	6.89	0.0201	0.0175	1.405
Rock Cr. above Soloman Cr.	3.26	5.19	0.0359	0.0203	2.258
Spring Creek	3.96	6.67	0.0419	0.0214	2.155
Rock Cr. above Spring Cr.	3.42	5.31	0.0365	0.02	2.106
Rock Cr. 0.5 mi below Spring C	3.71	5.3	0.0366	0.021	2.017
Rock Cr. 0.5 mi below Spring C	3.34	5.23	0.0362	0.0226	2.253

Table B2: Chemical data for Rock Creek tributaries.

Oct. 1, 1994

Sample Name	Cl	NO3-N	SO4
Rock Creek at S1	0.899	<0.05	4.153
Rock Creek at S1	1.085	0.126	4.087
Ranch Creek	0.454	<0.05	3.703
Ranch Creek	0.412	<0.05	3.76
Rock Creek above Ranch Cr.	0.897	<0.05	4.152
Sawmill Creek	0.496	<0.05	2.81
Sawmill Creek	0.821	0.071	2.872
Rock Creek above Sawmill Cr.	1.548	<0.05	4.246
Brewster Creek	0.581	<0.05	5.506
Rock Creek at Sawmill F.A.	0.698	<0.05	4.135
Soloman Creek	0.526	<0.05	2.803
Rock Cr. above Soloman Cr.	0.924	<0.05	4.421
Spring Creek	1.32	0.113	5.804
Rock Cr. above Spring Cr.	0.947	<0.05	4.155
Rock Cr. 0.5 mi below Spring C	0.715	<0.05	4.215
Rock Cr. 0.5 mi below Spring C	1.324	<0.05	4.095

Table B2: Cont.

WATER BALANCE EQUATION

Water included in the water balance equation is surface water and the associated groundwater. All water flows out as surface water in Rock Creek or groundwater in the alluvial aquifer beneath the creek.

In	=	Out
Rock Creek surface water		Rock Creek surface water
Rock Creek groundwater		Rock Creek groundwater
Ranch Creek surface water		
Ranch Creek groundwater		
Sawmill Creek surface water		
Brewster Creek surface water		
Brewster Creek groundwater		
Spring Creek surface water		

Table B3: Written water balance equation.

Total Water Flowing Into the Study Area

SOURCE IN	SW IN (CFS)	GW IN (CFS)
ROCK CREEK	260	16
RANCH CREEK	16	6
SAWMILLCREEK	2	
BREWSTER CREE	2	4
SPRING CREEK	1	
	281	26

TOTAL WATER IN SW + GW	307

Total Water Leaving the Study Area.

	SW OU (CFS)	GW OUT (CFS)
ROCK CREEK	280	20

TOTAL WATER OUT SW + GW	300

GROUND WATER FLOW CALCULATIONS

Ground Water In

	WIDTH	THICKNESS	AREA	K	GRADIENT	Q
ROCK CREEK	800	70	56000	0.0243	0.012	16.33
RANCH CREEK	600	70	42000	0.0243	0.006	6.13
SAWMILLCREEK						
BREWSTER CREE	400	70	28000	0.0243	0.006	4.08

Ground Water Out

	WIDTH	THICKNESS	AREA	K	GRADIENT	Q
ROCK CREEK	1000	70	70000	0.0243	0.012	20.42

Table B4: Groundwater and surface water mass balance calculations.

APPENDIX C

WATER LEVEL MEASUREMENTS FOR DOMESTIC WELLS, MONITORING WELLS AND SURFACE WATER

This appendix presents the water level measurements. Those from the domestic wells and staff gages 1-6 comprise the first part (Table C1). The second part (Table C2) contains water level measurements for the monitoring wells and staff gages 7 and 8 in the discharge area. Locations of wells and staff gages are shown on Figures 6, 7, and 8. Well location discriptions are given in Table C3, along with names of well owners. Figure C1 shows the lettering scheme used for designating location within the section. Letters go from largest to smallest tract. The first letter being the 1/4 section.

Water Levels, July 12, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	7/12/94	3921	15	3.16	3909.16
S1	7/12/94	3910.09		0.46	3910.55
D2	7/12/94	3960.56	60	1.1	3901.66
D3	7/12/94	3956.82	43	1.3	3915.12
D5	7/12/94	3904	28	2.01	3878.01
D6	7/12/94	3864.82	12	0.91	3853.73
D7	7/12/94	3857	11	1.08	3847.08
S2	7/12/94	3854.86		0.56	3855.42
D8	7/12/94	3855.67	23	0.78	3833.45
D8A	7/12/94	3849	12	2.34	3839.34
S3	7/12/94	3834.83		1.2	3836.03
S4	7/12/94	3842.16		0.875	3843.035
D9	7/12/94	3866.7	38	3.18	3831.88
D10	7/12/94	3858.84	40	1.46	3820.3
D11	7/12/94	3840.51	15	1.44	3826.95
S5	7/12/94	3828.61		0.81	3829.42
D12	7/12/94	3838			
D13	7/12/94	3850.38	32	1.64	3820.02
D14	7/12/94	3801.43	25	6.15	3782.58
D15	7/12/94	3790.55			
D16	7/12/94	3783.8	14	0.49	3770.29
D17	7/12/94	3782.76	10	1.23	3773.99
D18	7/12/94	3788.24	14	1.18	3775.42
D18A	7/12/94	3783.38	9	0.26	3774.64
D19	7/12/94	3781.68	21	0.23	3760.91
S6	7/12/94	3760.21		0.67	3760.88
D20	7/12/94	3766.64	13.5	1.4	3754.54

Table C1: Domestic well water level measurements.

Water Levels, June 9, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	6/9/94	3921	12	0.67	3909.67
S1	6/9/94	3910.09		0.9	3910.99
D2	6/9/94	3960.56	60.5	2.07	3902.13
D3	6/9/94	3956.82	44	3.23	3916.05
D5	6/9/94	3904	27	1.94	3878.94
D6	6/9/94	3864.82	12	1.62	3854.44
D7	6/9/94	3857	10	0.98	3847.98
S2	6/9/94	3854.86		0.81	3855.67
D8	6/9/94	3855.67			
D8A	6/9/94	3849			
S3	6/9/94	3834.83			
S4	6/9/94	3842.16			
D9	6/9/94	3866.7			
D10	6/9/94	3858.84			
D11	6/9/94	3840.51	14	1.67	3828.18
S5	6/9/94	3828.61		1.28	3829.89
D12	6/9/94	3838	17	2.94	3823.94
D13	6/9/94	3850.38	31	1.35	3820.73
D14	6/9/94	3801.43	18	2.04	3785.47
D15	6/9/94	3790.55			
D16	6/9/94	3783.8	14	1.69	3771.49
D17	6/9/94	3782.76	9	1.42	3775.18
D18	6/9/94	3788.24	14	2.29	3776.53
D18A	6/9/94	3783.38	9	1.43	3775.81
D19	6/9/94	3781.68	21	1.93	3762.61
S6	6/9/94	3760.21		1.9	3762.11
D20	6/9/94	3766.64	12	0.99	3755.63

Water Levels, May 17, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	5/17/94	3921	12	1.11	3910.11
S1	5/17/94	3910.09		1.25	3911.34
D2	5/17/94	3960.56	60	2.08	3902.64
D3	5/17/94	3956.82	43	3.39	3917.21
D5	5/17/94	3904	28	3.25	3879.25
D6	5/17/94	3864.82	12	1.97	3854.79
D7	5/17/94	3857	10	1.4	3848.4
S2	5/17/94	3854.86		1	3855.86
D8	5/17/94	3855.67	22	1.2	3834.87
D8A	5/17/94	3849	10	1.42	3840.42
S3	5/17/94	3834.83		2.18	3837.01
S4	5/17/94	3842.16		2.19	3844.35
D9	5/17/94	3866.7	38	2.2	3830.9
D10	5/17/94	3858.84	41	2.9	3820.74
D11	5/17/94	3840.51	14	1.67	3828.18
S5	5/17/94	3828.61		1.58	3830.19
D12	5/17/94	3838	16	1.67	3823.67
D13	5/17/94	3850.38	31	1.6	3820.98
D14	5/17/94	3801.43	20	2.46	3783.89
D15	5/17/94	3790.55	20	2.95	3773.5
D16	5/17/94	3783.8	14	2.15	3771.95
D17	5/17/94	3782.76	9	1.9	3775.66
D18	5/17/94	3788.24	13	1.67	3776.91
D18A	5/17/94	3783.38	9	1.85	3776.23
D19	5/17/94	3781.68	20	1.46	3763.14
S6	5/17/94	3760.21		2.47	3762.68
D20	5/17/94	3766.64	12	1.57	3756.21

Water Levels April 25, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	4/25/94	3921	12	1.01	3910.01
S1	4/25/94	3910.09		1.21	3911.3
D2	4/25/94	3960.56	60	2.1	3902.66
D3	4/25/94	3956.82			
D5	4/25/94	3904	26	0.99	3878.99
D6	4/25/94	3864.82	12	1.95	3854.77
D7	4/25/94	3857	10.1	1.3	3848.2
S2	4/25/94	3854.86		1.25	3856.11
D8	4/25/94	3855.67	23	2.2	3834.87
D8A	4/25/94	3849	11	2.33	3840.33
S3	4/25/94	3834.83		2	3836.83
S4	4/25/94	3842.16		2.17	3844.33
D9	4/25/94	3866.7	40	3.29	3829.99
D10	4/25/94	3858.84	41	2.15	3819.99
D11	4/25/94	3840.51	15	2.49	3828
S5	4/25/94	3828.61		1.89	3830.5
D12	4/25/94	3838	17	2.3	3823.3
D13	4/25/94	3850.38	31	1.44	3820.82
D14	4/25/94	3801.43	20	1.4	3782.83
D15	4/25/94	3790.55			
D16	4/25/94	3783.8	14	1.78	3771.58
D17	4/25/94	3782.76	9	1.9	3775.66
D18	4/25/94	3788.24	13	1.39	3776.63
D18A	4/25/94	3783.38	9	1.61	3775.99
D19	4/25/94	3781.68	20	1.2	3762.88
S6	4/25/94	3760.21		2.25	3762.46
D20	4/25/94	3766.64	12	1.62	3756.26

Water Levels March 8, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	3/8/94	3921	14	1.51	3908.51
S1	3/8/94	3910.09			
D2	3/8/94	3960.56	62	2.5	3901.06
D3	3/8/94	3956.82			
D5	3/8/94	3904	28	1.39	3877.39
D6	3/8/94	3864.82	14	1.93	3852.75
D7	3/8/94	3857			
S2	3/8/94	3854.86			
D8	3/8/94	3855.67			
D8A	3/8/94	3849			
S3	3/8/94	3834.83			
S4	3/8/94	3842.16			
D9	3/8/94	3866.7	43	2.35	3826.05
D10	3/8/94	3858.84	43	1.7	3817.54
D11	3/8/94	3840.51	17	1.81	3825.32
S5	3/8/94	3828.61			
D12	3/8/94	3838	19	1.8	3820.8
D13	3/8/94	3850.38	34	2.19	3818.57
D14	3/8/94	3801.43	21	1.72	3782.15
D15	3/8/94	3790.55	21	2.22	3771.77
D16	3/8/94	3783.8	16	2.35	3770.15
D17	3/8/94	3782.76	11	1.99	3773.75
D18	3/8/94	3788.24	15	1.59	3774.83
D18A	3/8/94	3783.38	11	2.05	3774.43
D19	3/8/94	3781.68	22.1	1.8	3761.38
S6	3/8/94	3760.21			
D20	3/8/94	3766.64	14	2.12	3754.76

Water Levels January 28, 1994

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	1/28/94	3921	14	1.41	3908.41
S1	1/28/94	3910.09			
D2	1/28/94	3960.56	62	2.32	3900.88
D3	1/28/94	3956.82			
D5	1/28/94	3904	28	1.2	3877.2
D6	1/28/94	3864.82	14	1.58	3852.4
D7	1/28/94	3857			
S2	1/28/94	3854.86			
D8	1/28/94	3855.67			
D8A	1/28/94	3849			
S3	1/28/94	3834.83			
S4	1/28/94	3842.16			
D9	1/28/94	3866.7	42	1.1	3825.8
D10	1/28/94	3858.84	43	1.33	3817.17
D11	1/28/94	3840.51	16	0.9	3825.41
S5	1/28/94	3828.61			
D12	1/28/94	3838	18	0.67	3820.67
D13	1/28/94	3850.38			
D14	1/28/94	3801.43	21	1.16	3781.59
D15	1/28/94	3790.55	21	1.4	3770.95
D16	1/28/94	3783.8	16	1.51	3769.31
D17	1/28/94	3782.76	11	1.36	3773.12
D18	1/28/94	3788.24	15	1.26	3774.5
D18A	1/28/94	3783.38	11	1.37	3773.75
D19	1/28/94	3781.68	22	0.65	3760.33
S6	1/28/94	3760.21			
D20	1/28/94	3766.64	15	1.98	3753.62

Water Levels October 4, 1993

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	10/4/93	3921	14	1.73	3908.73
S1	10/4/93	3910.09			
D2	10/4/93	3960.56	62	2.72	3901.28
D3	10/4/93	3956.82	44	0.84	3913.66
D5	10/4/93	3904	28	2.14	3878.14
D6	10/4/93	3864.82	14	2.18	3853
D7	10/4/93	3857	12	1	3846
S2	10/4/93	3854.86		0.41	3855.27
D8	10/4/93	3855.67	26	3.03	3832.7
D8A	10/4/93	3849	12	1.69	3838.69
S3	10/4/93	3834.83		0.53	3835.36
S4	10/4/93	3842.16		0.35	3842.51
D9	10/4/93	3866.7	45.01	7.43	3829.12
D10	10/4/93	3858.84	42	1.41	3818.25
D11	10/4/93	3840.51	16	1.09	3825.6
S5	10/4/93	3828.61		0.5	3829.11
D12	10/4/93	3838	18	1.3	3821.3
D13	10/4/93	3850.38	34	2.62	3819
D14	10/4/93	3801.43	22	2.58	3782.01
D15	10/4/93	3790.55	22.1	2.73	3771.18
D16	10/4/93	3783.8	19.4	5.36	3769.76
D17	10/4/93	3782.76	12	2.77	3773.53
D18	10/4/93	3788.24	15	1.66	3774.9
D18A	10/4/93	3783.38	11	1.77	3774.15
D19	10/4/93	3781.68	22	1.19	3760.87
S6	10/4/93	3760.21		0.2	3760.41
D20	10/4/93	3766.64	14	1.47	3754.11

Water Levels August 17, 1993

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	8/17/93	3921	14	2.39	3909.39
S1	8/17/93	3910.09			
D2	8/17/93	3960.56	62	3.24	3901.8
D3	8/17/93	3956.82	43	1.38	3915.2
D5	8/17/93	3904	28	2.53	3878.53
D6	8/17/93	3864.82	14	3.27	3854.09
D7	8/17/93	3857	10	0.33	3847.33
S2	8/17/93	3854.86			
D8	8/17/93	3855.67	25	2.93	3833.6
D8A	8/17/93	3849	14	4.6	3839.6
S3	8/17/93	3834.83			
S4	8/17/93	3842.16			
D9	8/17/93	3866.7	42	3.84	3828.54
D10	8/17/93	3858.84	42	2.5	3819.34
D11	8/17/93	3840.51	15	1.5	3827.01
S5	8/17/93	3828.61			
D12	8/17/93	3838	18	2.42	3822.42
D13	8/17/93	3850.38	34	3.62	3820
D14	8/17/93	3801.43	20.01	1.31	3782.73
D15	8/17/93	3790.55	20	1.61	3772.16
D16	8/17/93	3783.8	15	1.77	3770.57
D17	8/17/93	3782.76	12	3.64	3774.4
D18	8/17/93	3788.24	15	2.45	3775.69
D18A	8/17/93	3783.38	10.01	1.59	3774.96
D19	8/17/93	3781.68	22	2.03	3761.71
S6	8/17/93	3760.21			
D20	8/17/93	3766.64	13	1.34	3754.98

Water Levels September 17, 1993

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	9/17/93	3921	14	1.95	3908.95
S1	9/17/93	3910.09			
D2	9/17/93	3960.56	63	3.88	3901.44
D3	9/17/93	3956.82	43	0.68	3914.5
D5	9/17/93	3904	28	1.83	3877.83
D6	9/17/93	3864.82	14	2.55	3853.37
D7	9/17/93	3857	12	1.55	3846.55
S2	9/17/93	3854.86		0.51	3855.37
D8	9/17/93	3855.67	25	2.36	3833.03
D8A	9/17/93	3849	14	3.99	3838.99
S3	9/17/93	3834.83		0.86	3835.69
S4	9/17/93	3842.16		0.57	3842.73
D9	9/17/93	3866.7	42	2.96	3827.66
D10	9/17/93	3858.84	42	1.86	3818.7
D11	9/17/93	3840.51	16	1.66	3826.17
S5	9/17/93	3828.61		0.66	3829.27
D12	9/17/93	3838	18	1.69	3821.69
D13	9/17/93	3850.38	34	2.86	3819.24
D14	9/17/93	3801.43			
D15	9/17/93	3790.55	20	1.12	3771.67
D16	9/17/93	3783.8	15	1.26	3770.06
D17	9/17/93	3782.76	12	2.99	3773.75
D18	9/17/93	3788.24	15	1.92	3775.16
D18A	9/17/93	3783.38	10	1.01	3774.39
D19	9/17/93	3781.68	22	1.51	3761.19
S6	9/17/93	3760.21		0.5	3760.71
D20	9/17/93	3766.64	13	0.8	3754.44

Water Levels September 2, 1993

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	9/2/93	3921	14	2.2	3909.2
S1	9/2/93	3910.09			
D2	9/2/93	3960.56	62	3.02	3901.58
D3	9/2/93	3956.82	43	1.2	3915.02
D5	9/2/93	3904	28	2.27	3878.27
D6	9/2/93	3864.82	14	3.01	3853.83
D7	9/2/93	3857			
S2	9/2/93	3854.86			
D8	9/2/93	3855.67	26	3.87	3833.54
D8A	9/2/93	3849	12	2.42	3839.42
S3	9/2/93	3834.83			
S4	9/2/93	3842.16			
D9	9/2/93	3866.7	42	3.86	3828.56
D10	9/2/93	3858.84	42	2.55	3819.39
D11	9/2/93	3840.51	15	1.22	3826.73
S5	9/2/93	3828.61			
D12	9/2/93	3838	18	2.26	3822.26
D13	9/2/93	3850.38	35	4.43	3819.81
D14	9/2/93	3801.43	20	1.09	3782.52
D15	9/2/93	3790.55	20	1.4	3771.95
D16	9/2/93	3783.8	16	2.54	3770.34
D17	9/2/93	3782.76	13	4.26	3774.02
D18	9/2/93	3788.24	15	2.18	3775.42
D18A	9/2/93	3783.38	10	1.09	3774.47
D19	9/2/93	3781.68	22	1.82	3761.5
S6	9/2/93	3760.21			
D20	9/2/93	3766.64	13	0.92	3754.56

Water Levels August 3, 1993

WELL	DATE	ELEV OF WEL	TAPE IN WELL	WATER ON TAPE	ELEV OF WATER
D1	8/3/93	3921	12	0.27	3909.27
S1	8/3/93	3910.09			
D2	8/3/93	3960.56	60	0.37	3900.93
D3	8/3/93	3956.82			
D5	8/3/93	3904	30	4.57	3878.57
D6	8/3/93	3864.82	15	4.16	3853.98
D7	8/3/93	3857	10	0.33	3847.33
S2	8/3/93	3854.86			
D8	8/3/93	3855.67	30	7.93	3833.6
D8A	8/3/93	3849	18	8.54	3839.54
S3	8/3/93	3834.83			
S4	8/3/93	3842.16			
D9	8/3/93	3866.7	42	3.89	3828.59
D10	8/3/93	3858.84	44	4.56	3819.4
D11	8/3/93	3840.51	15	1.45	3826.96
S5	8/3/93	3828.61			
D12	8/3/93	3838	16	0.4	3822.4
D13	8/3/93	3850.38	40	9.55	3819.93
D14	8/3/93	3801.43	20	1.28	3782.71
D15	8/3/93	3790.55	22	3.61	3772.16
D16	8/3/93	3783.8	15	1.74	3770.54
D17	8/3/93	3782.76	12	3.47	3774.23
D18	8/3/93	3788.24	15	1.95	3775.19
D18A	8/3/93	3783.38	10	1.48	3774.86
D19	8/3/93	3781.68	22	2.02	3761.7
S6	8/3/93	3760.21			
D20	8/3/93	3766.64	13	1.3	3754.94

Discharge area water levels.

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
05/04/94	7M1	3710.37	1.5	0.05	3708.92
05/04/94	7M2	3710.55	1.3	0.13	3709.38
05/04/94	7M3	3711.27	1	0.33	3710.6
05/04/94	7M4	3712	1	0.47	3711.47
05/04/94	7M5	3715.57	1.2	0.14	3714.51
05/04/94	7M6	3716.3	1	0.26	3715.56
05/04/94	7M7	3719.85	1.8	0.27	3718.32
05/04/94	7M8	3720.62	1	0.42	3720.04
05/04/94	7M9	3721.47	1.4	0.75	3720.82
05/04/94	7M10	3721.72			

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
05/17/94	NAIL 1	3710.46	1.4	0.35	3709.41
05/17/94	7M1	3710.37	1.3	0.13	3709.2
05/17/94	7M2	3710.55	1	0.11	3709.66
05/17/94	7M3	3711.27	1	0.4	3710.67
05/17/94	7M4	3712	1	0.63	3711.63
05/17/94	NAIL 2	3717.4	1.4	0.12	3716.12
05/17/94	7M5	3715.57	1	0.11	3714.68
05/17/94	7M6	3716.3	1	0.43	3715.73
05/17/94	7M7	3719.85	2	0.64	3718.49
05/17/94	7M8	3720.62	1	0.54	3720.16
05/17/94	7M9	3721.47	1	0.5	3720.97
05/17/94	7M10	3721.72	1	0.28	3721

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
05/23/94	NAIL 1	3710.46	1.2	0.16	3709.42
05/23/94	7M1	3710.37	1.6	0.5	3709.27
05/23/94	7M2	3710.55	1	0.13	3709.68
05/23/94	7M3	3711.27	1	0.39	3710.66
05/23/94	STAFF 8	3716.64	14.25	1.1875	3714.8275
05/23/94	7M4	3712	1	0.63	3711.63
05/23/94	7M5	3715.57	1	0.21	3714.78
05/23/94	7M6	3716.3	1	0.36	3715.66
05/23/94	STAFF 7	3721.43	13.5	1.125	3719.555
05/23/94	7M7	3719.85	1.5	0.14	3718.49
05/23/94	7M8	3720.62	1	0.52	3720.14
05/23/94	7M9	3721.47	1	0.52	3720.99
05/23/94	7M10	3721.72	1	0.29	3721.01

Table C2: Monitoring well water level measurements.

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
06/29/94	NAIL 1	3710.46	2.1	0	3708.36
06/29/94	7M1	3710.37	1.8	0.08	3708.65
06/29/94	7M2	3710.55	1.53	0.13	3709.15
06/29/94	7M3	3711.27	1	0.3	3710.57
06/29/94	STAFF 8	3716.64		0.33	3713.97
06/29/94	7M4	3712	1	0.23	3711.23
06/29/94	7M5	3715.57	1.6	0.25	3714.22
06/29/94	7M6	3716.3	1.2	0.28	3715.38
06/29/94	STAFF 7	3721.43		0.48	3718.91
06/29/94	7M7	3719.85	2.3	0.25	3717.8
06/29/94	7M8	3720.62	1	0.19	3719.81
06/29/94	7M9	3721.47	1	0.24	3720.71
06/29/94	7M10	3721.72	1.1	0.1	3720.72

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
07/11/94	7M1	3710.37			
07/11/94	7M2	3710.55	1.51	0.04	3709.08
07/11/94	7M3	3711.27	1	0.3	3710.57
07/11/94	STAFF 8	3716.64		0.27	3716.91
07/11/94	7M4	3712	1	0.18	3711.18
07/11/94	7M5	3715.57	1.5	0.12	3714.19
07/11/94	7M6	3716.3	1	0.04	3715.34
07/11/94	STAFF 7	3721.43		0.45	3721.88
07/11/94	7M7	3719.85	2.3	0.12	3717.67
07/11/94	7M8	3720.62	1	0.17	3719.79
07/11/94	7M9	3721.47	1	0.13	3720.6
07/11/94	7M10	3721.72	1.5	0.47	3720.69
07/11/94	7M12	3715.19	1	0.16	3714.35
07/11/94	7M14	3715.4	2	0.83	3714.23
07/11/94	7M15	3714.64	1	0.57	3714.21
07/11/94	7M16	3718.61	2	0.9	3717.51
07/11/94	7M17	3718.95	1	0.12	3718.07

DATE	WELL	WELL ELEV	TAPE IN WELL	READING ON TAPE	WATER ELEV
08/24/95	7M1	3710.37			
08/24/95	7M2	3710.55			
08/24/95	7M3	3711.27	1	0.21	3710.48
08/24/95	STAFF 1	3716.64			
08/24/95	7M4	3712	1.24	0.12	3710.88
08/24/95	7M5	3715.57			
08/24/95	7M6	3716.3	1.31	0.14	3715.13
08/24/95	STAFF 2	3721.43			
08/24/95	7M7	3719.85			
08/24/95	7M8	3720.62	1.2	0.11	3719.53
08/24/95	7M9	3721.47	1.5	0.4	3720.37
08/24/95	7M10	3721.72	1.5	0.26	3720.48
08/24/95	7M12	3715.19	1.1	0.17	3714.26
08/24/95	7M14	3715.4	2	0.69	3714.09
08/24/95	7M15	3714.64	1	0.52	3714.16
08/24/95	7M16	3718.61	2	0.76	3717.37
08/24/95	7M17	3718.95	1.5	0.48	3717.93

Name of Well Owner	Well #	T&R	Section	Quarter Section	Well log
Childers	D1	T10N R17W	36	ABC	No
Larango	D2	T10N R17W	36	AAC	Yes
Siria	D3	T10N R17W	36	AAC	No
Hammer	D5	T10N R16W	30	BCD	Yes
Persico	D6	T10N R16W	30	BDD	Yes
Spearman	D7	T10N R16W	30	ABC	Yes
Michnevich	D8	T10N R16W	19	DBA	No
	D8A	T10N R16W	19	DBB	Yes
Pederson	D9	T10N R16W	17	CCB	Yes
Peltier	D10	T10N R16W	17	CBC	Yes
Erp	D13	T10N R16W	18	DAB	Yes
McNair	D12	T10N R16W	18	DAD	No
Ryan	D11	T10N R16W	18	DDB	Yes
Hatch	D14	T10N R16W	8	CCB	Yes
Fisher	D15	T10N R16W	8	CBB	Yes
Howard	D16	T10N R16W	8	CBB	Yes
Yeager	D17	T10N R16W	7	DAD	Yes
Bethke	D18	T10N R16W	8	CBC	No
	D18A	T10N R16W	8	CBC	Yes
Brabham	D19	T10N R16W	7	ADA	No
Kane	D20	T10N R16W	7	AAD	Yes

Table C3: Well location descriptions.

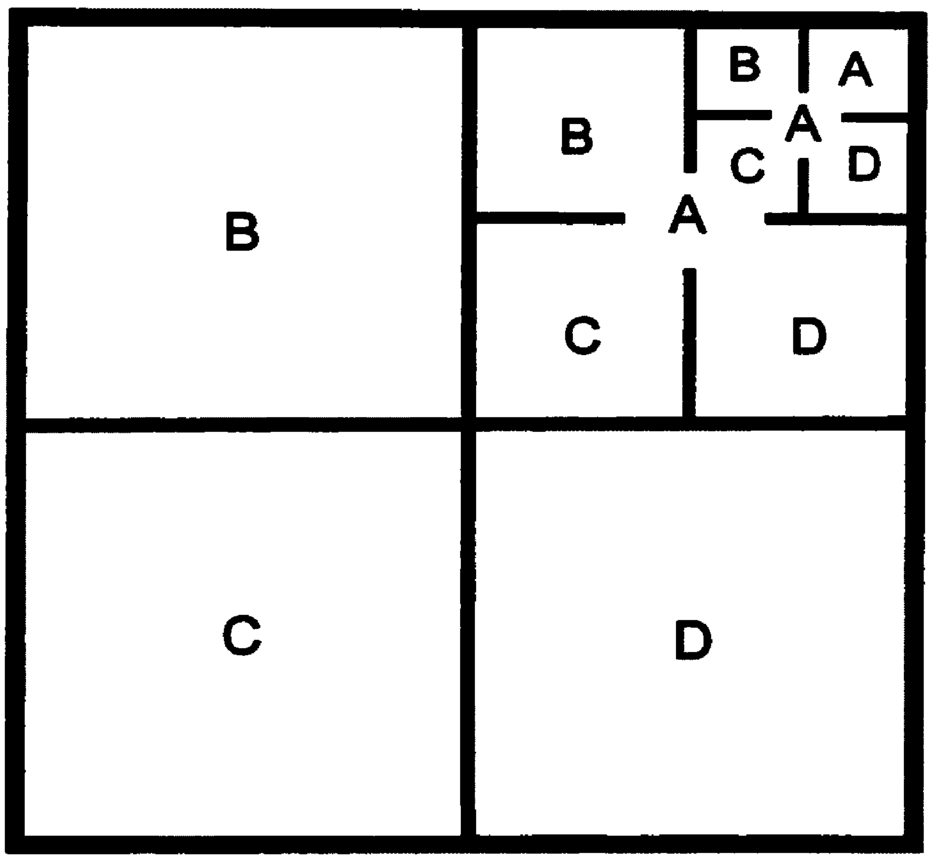


Figure C1: Lettering scheme used for designating location within a section.

APPENDIX D

DOMESTIC WELL AND MONITORING WELL CHEMICAL DATA

The following tables include results from the chemical analysis of groundwater from domestic wells (Table D1) and monitoring wells (Table D2).

August 4, 1993 Sampling

WELL	DATE	Ca	Cd	Cu	Fe	Mg	Mn
D1	08/04/93	20.1	<0.01	<0.01	<0.03	5.72	<0.005
D2	08/04/93	30.7	<0.01	<0.01	4.46	6.92	0.4138
D5	08/04/93	4.95	<0.01	<0.01	0.056	1.88	<0.005
D8	08/04/93	12.9	<0.01	<0.01	0.546	4.62	0.0089
D9	08/04/93	18.1	<0.01	<0.01	<0.03	11.2	<0.005
D10	08/04/93	15.5	<0.01	<0.01	<0.03	8.54	<0.005
D11	08/04/93	18.3	<0.01	<0.01	<0.03	5.86	<0.005
D12	08/04/93	17	<0.01	<0.01	<0.03	6.65	<0.005
D13	08/04/93	17.3	<0.01	<0.01	<0.03	5.95	<0.005
D14	08/04/93	17.6	<0.01	<0.01	<0.03	9.22	<0.005
D15	08/04/93	16.8	<0.01	<0.01	<0.03	8.12	<0.005
D16	08/04/93	16.9	<0.01	<0.01	<0.03	7.17	<0.005
D19	08/04/93	17.1	<0.01	<0.01	0.048	6.97	0.0079
D20	08/04/93	18.3	<0.01	<0.01	<0.03	6.85	<0.005

WELL	DATE	Na	Pb	Si	Zn	K
D1	08/04/93	4.09	<0.1	6.56	0.0743	2.11
D2	08/04/93	17	<0.1	19.1	2.284	4.364
D5	08/04/93	2.23	<0.1	5.88	0.0661	2.472
D8	08/04/93	3.51	<0.1	7.24	0.0695	3.007
D9	08/04/93	3.4	<0.1	6.68	0.1079	2.374
D10	08/04/93	2.8	<0.1	6.79	0.0535	1.71
D11	08/04/93	3.7	<0.1	6.15	0.0524	1.985
D12	08/04/93	3.82	<0.1	6.82	0.1391	2.758
D13	08/04/93	3.63	<0.1	6.46	0.0751	2.224
D14	08/04/93	3.62	<0.1	7.09	0.0964	2.736
D15	08/04/93	3.4	<0.1	6.9	0.0632	1.835
D16	08/04/93	3.7	<0.1	6.95	0.0879	2.385
D19	08/04/93	3.72	<0.1	6.67	0.0475	2.17
D20	08/04/93	3.75	<0.1	6.23	0.1597	1.728

WELL	DATE	pH	D.O.	T	Cl	NO3-N	SO4
D1	08/04/93	7.03	3.1		0.595	0.060	5.435
D2	08/04/93	5.83	0	8.9	1.133	0.000	93.6
D5	08/04/93	6.1	5.7	8.7	0.634	0.122	3.181
D8	08/04/93	6.49	6.3	11.1	1.793	0.105	5.958
D9	08/04/93	6.95	8.7	8	0.636	0.105	5.894
D10	08/04/93	6.36	8.6	8.4	0.741	0.098	4.97
D11	08/04/93	6.81	2.8	9.6	0.749	0.051	5.081
D12	08/04/93	6.58	3.9	8.6	1.123	0.113	6.199
D13	08/04/93	6.32	3.8	8.6	0.867	0.086	5.494
D14	08/04/93	6.76	7.1	8.5	0.912	0.171	5.999
D15	08/04/93	6.29	7.3	8.6	0.939	0.175	5.729
D16	08/04/93	6.55	5.7	8.4	1.03	0.169	5.837
D19	08/04/93	6.29	4.5	8	1.05	0.187	5.602
D20	08/04/93	6.38	3.8	9.7	0.838	0.108	5.296

Table D1: Domestic well chemical data.

August 31, 1993 Sampling

WELL	DATE	Ca	Cd	Cu	Fe	Mg	Mn
D2	08/31/93	38.9	<0.01	<0.01	4.73	7.81	0.4008
D3	08/31/93	7.75	<0.01	<0.01	<0.03	3.4	<0.005
D5	08/31/93	5.51	<0.01	<0.01	0.057	2.03	0.0134
D8	08/31/93	13.1	<0.01	0.0125	0.061	4.59	0.0054
D8 LD	08/31/93	12.8	<0.01	0.0129	0.056	4.51	0.0054
D9	08/31/93	18.8	<0.01	<0.01	<0.03	11.3	<0.005
D10	08/31/93	15.5	<0.01	<0.01	<0.03	8.79	<0.005
D11	08/31/93	18.9	<0.01	<0.01	<0.03	6.37	<0.005
D12	08/31/93	17.3	<0.01	<0.01	0.257	6.53	0.042
D13	08/31/93	17.4	<0.01	<0.01	0.051	6.29	0.0071
D14	08/31/93	17.5	<0.01	<0.01	<0.03	8.88	<0.005
D15	08/31/93	17.1	<0.01	<0.01	<0.03	8.66	<0.005
D16	08/31/93	16.7	<0.01	<0.01	<0.03	7.19	<0.005
D17	08/31/93	17.3	<0.01	0.0117	0.097	6.24	0.0083
D18	08/31/93	17	<0.01	<0.01	<0.03	7	<0.005
D19	08/31/93	17.6	<0.01	<0.01	<0.03	7.38	<0.005
D19 FD	08/31/93	17.9	<0.01	<0.01	<0.03	7.56	<0.005
D19 FD LD	08/31/93	17.5	<0.01	<0.01	<0.03	7.53	<0.005
D20	08/31/93	18.5	<0.01	<0.01	<0.03	7.12	<0.005
S2	08/31/93	3.51	<0.01	<0.01	<0.03	1.53	<0.005
S3	08/31/93	17	<0.01	<0.01	0.066	5.32	0.0051
S4	08/31/93	39.1	<0.01	<0.01	<0.03	18.3	<0.005
S5	08/31/93	22.8	<0.01	<0.01	<0.03	10.4	<0.005
BREWSTER CR		14.6	<0.01	<0.01	<0.03	7.84	<0.005
FB		<0.1	<0.01	<0.01	<0.03	<0.1	<0.005
FILTER BLANK		<0.1	<0.01	<0.01	<0.03	<0.1	<0.005
D8 SPIKE	08/31/93	20.4	1.058	1.051	1.09	13.8	1.066
D19 SPIKE	08/31/93	24.4	1.093	1.078	1.08	16.5	1.099

August 31, 1993 Sampling

WELL	DATE	Na	Pb	Si	Zn	K
D2	08/31/93	19.3	<0.1	24.3	0.7822	4.869
D3	08/31/93	3.17	<0.1	6.31	0.5223	1.844
D5	08/31/93	2.25	<0.1	5.92	0.0741	2.115
D8	08/31/93	3.49	<0.1	7.12	0.0746	2.511
D8 LD	08/31/93	3.47	<0.1	7.01	0.0738	1.984
D9	08/31/93	3.6	<0.1	6.66	0.0939	1.985
D10	08/31/93	2.75	<0.1	6.84	0.0638	1.761
D11	08/31/93	3.76	<0.1	6.34	0.0722	2.287
D12	08/31/93	3.76	<0.1	6.27	0.28	2.494
D13	08/31/93	3.67	<0.1	6.41	0.1409	2.074
D14	08/31/93	3.58	<0.1	6.93	0.1514	2.092
D15	08/31/93	3.5	<0.1	7.11	0.0393	1.956
D16	08/31/93	3.6	<0.1	6.81	0.1009	2.429
D17	08/31/93	3.57	<0.1	6.1	0.2332	2.328
D18	08/31/93	3.7	<0.1	6.67	0.4021	2.257
D19	08/31/93	3.78	<0.1	6.95	0.1376	2.186
D19 FD	08/31/93	3.89	<0.1	7.12	0.1216	2.659
D19 FD LD	08/31/93	3.8	<0.1	6.97	0.118	1.911
D20	08/31/93	3.86	<0.1	6.27	0.0922	2.228
S2	08/31/93	1.63	<0.1	5.13	0.0375	1.649
S3	08/31/93	2.94	<0.1	5.1	0.0428	2.18
S4	08/31/93	4.09	<0.1	7.62	0.0326	2.033
S5	08/31/93	3.82	<0.1	6.49	0.0299	2.18
BREWSTER CR		2.34	<0.1	6.37	0.029	1.755
FB		<0.1	<0.1	<0.1	0.0535	<1.5
FILTER BLANK		<0.1	<0.1	<0.1	0.0304	<1.5
D8 SPIKE	08/31/93	13.3	1.05	6.48	1.134	<1.5
D19 SPIKE	08/31/93	14.1	1.1	6.49	1.202	<1.5

WELL	DATE	pH	D.O.	T	Cl	NO3-N	SO4
D2	08/31/93	5.78	6.5	7.1	0.498	0.092	5.389
D3	08/31/93	5.29	0.3	7	1.596	0	
D5	08/31/93	5.56	5	8.7	0.866	0.162	3.367
D8	08/31/93	6.36	8.4	12.4	1.639	0.15	5.752
D9	08/31/93	6.61	9.5	7	0.743	0.192	5.85
D10	08/31/93	6.47	8.6	6.6	0.86	0.16	4.794
D11	08/31/93	6.68	3	8.6	0.766	0.093	4.968
D12	08/31/93	6.55	2.9	9	1.125	0.111	5.263
D13	08/31/93	6.69	3.6	8.3	0.937	0.115	5.247
D14	08/31/93	6.33	6	8.2	1.102	0.203	6.256
D15	08/31/93	6.31	5.5	8.9	1.166	0.229	5.933
D16	08/31/93	6.63	3.6	8.7	1.12	0.218	5.356
D17	08/31/93	6.49	3.4	9.8	0.92	0.097	4.291
D18	08/31/93	6.41	3.6	9.7	1.115	0.204	5.864
D19	08/31/93	6.44	4	8.6	1.21	0.258	5.741
D20	08/31/93	6.97	3.2	8.7	0.965	0.135	5.338
S2	08/31/93	6.9		7.1	0.565		3.139
S3	08/31/93	8.01		10.5	1.672		3.486
S4	08/31/93	8.32		8.4	2.216	0.208	9.224
S5	08/31/93	7.63		12.3	1.374	0.086	5.971
BREWSTER CR					0.64		4.992

October 4, 1993 Sampling

WELL	DATE	Al	As	B	Ca	Cd	Co
D2	10/04/93	0.234	<0.07	<0.04	33.5	<0.01	<0.03
D3	10/04/93	<0.07	<0.07	<0.04	6.67	<0.01	<0.03
D4	10/04/93	0.129	<0.07	<0.04	5.15	<0.01	<0.03
D5	10/04/93	0.126	<0.07	<0.04	5.49	<0.01	<0.03
D6	10/04/93	<0.07	<0.07	<0.04	20.6	<0.01	<0.03
D6 LD	10/04/93	0.141	<0.07	<0.04	5.3	<0.01	<0.03
D7	10/04/93	<0.07	<0.07	<0.04	11.2	<0.01	<0.03
D8	10/04/93	<0.07	<0.07	<0.04	12.7	<0.01	<0.03
D9	10/04/93	<0.07	<0.07	<0.04	18.5	<0.01	<0.03
D10	10/04/93	<0.07	<0.07	<0.04	16.3	<0.01	<0.03
D11	10/04/93	<0.07	<0.07	<0.04	19.2	<0.01	<0.03
FB	10/04/93	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
D13	10/04/93	<0.07	<0.07	<0.04	17.4	<0.01	<0.03
D14	10/04/93	<0.07	<0.07	<0.04	17.7	<0.01	<0.03
D15	10/04/93	<0.07	<0.07	<0.04	17.3	<0.01	<0.03
D16	10/04/93	<0.07	<0.07	<0.04	16.3	<0.01	<0.03
D17	10/04/93	<0.07	<0.07	<0.04	17.7	<0.01	<0.03
D18	10/04/93	<0.07	<0.07	<0.04	16.8	<0.01	<0.03
D19	10/04/93	<0.07	<0.07	<0.04	16.7	<0.01	<0.03
D20	10/04/93	<0.07	<0.07	<0.04	18.8	<0.01	<0.03
S1	10/04/93	<0.07	<0.07	<0.04	19.6	<0.01	<0.03
S2	10/04/93	<0.07	<0.07	<0.04	3.6	<0.01	<0.03
S3	10/04/93	<0.07	<0.07	<0.04	18.8	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
7D4 10/4/93 SPIKE		0.303	0.134	0.267	38.4	0.0236	0.0558
7D8 10/4/93 SPIKE		0.186	0.125	0.266	44.6	0.0222	0.0541

October 4, 1993 Sampling

WELL	DATE	Cr	Cu	Fe	Mg	Mn	Mo
D2	10/04/93	<0.008	<0.01	4.63	7.31	0.3938	<0.01
D3	10/04/93	<0.008	<0.01	0.508	2.99	0.0426	<0.01
D4	10/04/93	<0.008	<0.01	0.066	1.97	<0.005	<0.01
D5	10/04/93	<0.008	<0.01	0.087	2	<0.005	<0.01
D6	10/04/93	<0.008	0.0472	<0.03	5.95	<0.005	<0.01
D6 LD	10/04/93	<0.008	<0.01	0.071	1.99	<0.005	<0.01
D7	10/04/93	<0.008	0.0118	0.042	3.68	<0.005	<0.01
D8	10/04/93	<0.008	0.0102	0.058	4.29	<0.005	<0.01
D9	10/04/93	<0.008	0.0126	0.079	11	0.0582	<0.01
D10	10/04/93	<0.008	<0.01	<0.03	9.22	<0.005	<0.01
D11	10/04/93	<0.008	<0.01	<0.03	6.29	<0.005	<0.01
FB	10/04/93	<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
D13	10/04/93	<0.008	<0.01	0.031	6.27	<0.005	<0.01
D14	10/04/93	<0.008	<0.01	<0.03	8.96	<0.005	<0.01
D15	10/04/93	<0.008	<0.01	<0.03	8.58	<0.005	<0.01
D16	10/04/93	<0.008	<0.01	0.045	7.12	<0.005	<0.01
D17	10/04/93	<0.008	0.0264	0.051	6.29	<0.005	<0.01
D18	10/04/93	<0.008	<0.01	<0.03	7.01	<0.005	<0.01
D19	10/04/93	<0.008	<0.01	<0.03	7.16	0.0053	<0.01
D20	10/04/93	<0.008	<0.01	<0.03	6.97	<0.005	<0.01
S1	10/04/93	<0.008	<0.01	<0.03	6.11	<0.005	<0.01
S2	10/04/93	<0.008	<0.01	<0.03	1.49	<0.005	<0.01
S3	10/04/93	<0.008	<0.01	<0.03	5.84	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
7D4 10/4/93 SPIKE		0.0106	0.1082	1.18	22.9	1.111	0.059
7D8 10/4/93 SPIKE		0.01	0.1143	1.13	24.6	1.084	0.0553

October 4, 1993 Sampling

WELL	DATE	Na	Ni	P	Pb	Si	Sr
D2	10/04/93	17.8	<0.02	<0.2	<0.1	22.6	0.0928
D3	10/04/93	3.07	<0.02	<0.2	<0.1	5.16	<0.05
D4	10/04/93	2.22	<0.02	<0.2	<0.1	5.99	<0.05
D5	10/04/93	2.24	<0.02	<0.2	<0.1	6.04	<0.05
D6	10/04/93	5.37	<0.02	<0.2	<0.1	7.23	<0.05
D6 LD	10/04/93	2.27	<0.02	0.22	<0.1	6.13	<0.05
D7	10/04/93	3.02	<0.02	<0.2	<0.1	6.3	<0.05
D8	10/04/93	3.38	<0.02	<0.2	<0.1	7.17	<0.05
D9	10/04/93	3.36	<0.02	<0.2	<0.1	6.49	<0.05
D10	10/04/93	2.83	<0.02	<0.2	<0.1	6.83	<0.05
D11	10/04/93	3.86	<0.02	0.23	<0.1	6.78	<0.05
FB	10/04/93	<0.1	<0.02	<0.2	<0.1	<0.1	<0.05
D13	10/04/93	3.7	<0.02	<0.2	<0.1	6.76	<0.05
D14	10/04/93	3.66	<0.02	<0.2	<0.1	7.27	<0.05
D15	10/04/93	3.5	<0.02	0.27	<0.1	7.4	<0.05
D16	10/04/93	3.52	<0.02	<0.2	<0.1	6.8	<0.05
D17	10/04/93	3.58	<0.02	<0.2	<0.1	6.37	<0.05
D18	10/04/93	3.62	<0.02	<0.2	<0.1	6.86	<0.05
D19	10/04/93	3.66	<0.02	<0.2	<0.1	6.91	<0.05
D20	10/04/93	3.8	<0.02	0.23	<0.1	6.58	<0.05
S1	10/04/93	3.4	<0.02	0.22	<0.1	5.4	<0.05
S2	10/04/93	1.68	<0.02	<0.2	<0.1	5.16	<0.05
S3	10/04/93	3.22	<0.02	0.25	<0.1	5.38	<0.05
BLANK		<0.1	<0.02	<0.2	<0.1	<0.1	<0.05
BLANK		<0.1	<0.02	<0.2	<0.1	<0.1	<0.05
7D4 10/4/93 SPIKE		18.3	0.032	0.67	0.127	13.1	0.0697
7D8 10/4/93 SPIKE		19.1	0.032	0.67	<0.1	13.8	0.0788

October 4, 1993 Sampling

WELL	DATE	Ti	Zn	K
D2	10/04/93	<0.05	0.8771	4.723
D3	10/04/93	<0.05	0.9691	1.681
D4	10/04/93	<0.05	0.2554	1.871
D5	10/04/93	<0.05	0.0879	1.785
D6	10/04/93	<0.05	0.0736	2.485
D6 LD	10/04/93	<0.05	0.2636	2.1
D7	10/04/93	<0.05	0.0295	1.923
D8	10/04/93	<0.05	0.0686	2.261
D9	10/04/93	<0.05	0.317	1.716
D10	10/04/93	<0.05	0.0742	1.515
D11	10/04/93	<0.05	0.0442	2.301
FB	10/04/93	<0.05	0.0219	<1.5
D13	10/04/93	<0.05	0.1255	2.221
D14	10/04/93	<0.05	0.1507	2.014
D15	10/04/93	<0.05	0.0323	2.055
D16	10/04/93	<0.05	0.3296	1.848
D17	10/04/93	<0.05	0.2694	2.215
D18	10/04/93	<0.05	0.4329	2.02
D19	10/04/93	<0.05	0.0507	1.991
D20	10/04/93	<0.05	0.0833	2.227
S1	10/04/93	<0.05	0.0052	2.089
S2	10/04/93	<0.05	0.006	1.854
S3	10/04/93	<0.05	<0.005	2.227
BLANK		<0.05	<0.005	<1.5
BLANK		<0.05	<0.005	<1.5
7D4 10/4/93 SPIKE		<0.05	1.403	5.131
7D8 10/4/93 SPIKE		<0.05	1.19	5.211

WELL	DATE	pH	D.O.	T	CL	NO3-N	SO4
D2	10/04/93	5.82	0.1	7.2	2.115	<0.04	124.35
D3	10/04/93	6.28	5.1	9.1	0.627	0.073	4.203
D5	10/04/93	5.99	3.8	8.1	0.874	0.172	0.3907
D6	10/04/93	7.17	3.3	11	1.279	0.11	10.382
D7	10/04/93	6.35	1.5	11.1	0.783	0.084	4.499
D8	10/04/93	6.07	4.9	12.1	1.44	0.132	5.833
D9	10/04/93	6.71	1.9	16	0.851	<0.04	5.564
D10	10/04/93	6.8	6.6	7.6	0.914	0.134	5.027
D11	10/04/93	6.8	1.8	9.4	0.573	0.099	4.915
D13	10/04/93	6.76	1.6	8.9	0.943	0.095	5.077
D14	10/04/93	6.94	4.1	8	1.184	0.22	6.036
D15	10/04/93	6.66	6.2	8.9	1.238	0.24	5.664
D16	10/04/93	6.8	4.6	8.8	1.196	0.2	5.707
D17	10/04/93	6.6	3.3	11.4	0.582	0.103	4.546
D18	10/04/93	6.62	3.7	9.6	0.893	0.182	5.495
D19	10/04/93	6.55	4.7	8.7	1.161	0.224	5.673
D20	10/04/93	6.93	3.1	9.2	0.676	0.121	5.194

March 23, 1994 Sampling

WELL	DATE	Al	As	B	Ca	Cd	Co	Cr
D7	03/23/94	<0.07	<0.07	<0.04	11.6	<0.01	<0.03	<0.008
D8	03/23/94	<0.07	<0.07	<0.04	11.6	<0.01	<0.03	<0.008
D10	03/23/94	<0.07	<0.07	<0.04	17.2	<0.01	<0.03	<0.008
D11	03/23/94	<0.07	<0.07	<0.04	18	<0.01	<0.03	<0.008
D11 FD	03/23/94	<0.07	<0.07	<0.04	18.5	<0.01	<0.03	<0.008
D11DUP LD		<0.07	<0.07	<0.04	18.7	<0.01	<0.03	<0.008
D13	03/23/94	<0.07	<0.07	<0.04	16.7	<0.01	<0.03	<0.008
D16	03/23/94	<0.07	<0.07	<0.04	15.5	<0.01	<0.03	<0.008
D17	03/23/94	<0.07	<0.07	<0.04	16.7	<0.01	<0.03	<0.008
D18	03/23/94	<0.07	<0.07	<0.04	16	<0.01	<0.03	<0.008
D19	03/23/94	<0.07	<0.07	<0.04	16.1	<0.01	<0.03	<0.008
D19 DUP LD		<0.07	<0.07	<0.04	15.9	<0.01	<0.03	<0.008
D22	03/23/94	<0.07	<0.07	<0.04	17.8	<0.01	<0.03	<0.008
S1	03/23/94	<0.07	<0.07	<0.04	18.8	<0.01	<0.03	<0.008
S2	03/23/94	<0.07	<0.07	<0.04	4.21	<0.01	<0.03	<0.008
S3	03/23/94	<0.07	<0.07	<0.04	17.4	<0.01	<0.03	<0.008
S4	03/23/94	<0.07	<0.07	<0.04	21.2	<0.01	<0.03	<0.008
blank		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.008
D11 DUPSPK		0.368	0.233	0.708	77.5	0.0417	0.1019	0.0205
D19 DUP SPK		0.376	0.233	0.715	76.1	0.0423	0.1035	0.0225

WELL	DATE	Cu	Fe	Mg	Mn	Mo	Na	Ni
D7	03/23/94	0.0124	<0.03	4.03	<0.005	<0.01	2.93	<0.02
D8	03/23/94	<0.01	0.068	4.1	<0.005	<0.01	3.22	<0.02
D10	03/23/94	<0.01	<0.03	10.2	<0.005	<0.01	2.97	<0.02
D11	03/23/94	<0.01	<0.03	6.31	<0.005	<0.01	3.53	<0.02
D11 FD	03/23/94	<0.01	<0.03	6.45	<0.005	<0.01	3.52	<0.02
D11DUP LD		<0.01	<0.03	6.59	<0.005	<0.01	3.63	<0.02
D13	03/23/94	<0.01	0.702	6.22	<0.005	<0.01	3.45	<0.02
D16	03/23/94	<0.01	<0.03	6.92	<0.005	<0.01	3.35	<0.02
D17	03/23/94	0.0304	<0.03	6.3	<0.005	<0.01	3.39	<0.02
D18	03/23/94	<0.01	<0.03	6.85	0.0061	<0.01	3.47	<0.02
D19	03/23/94	<0.01	<0.03	7.12	<0.005	<0.01	3.47	<0.02
D19 DUP LD		<0.01	<0.03	7.1	<0.005	<0.01	3.52	<0.02
D22	03/23/94	0.1091	<0.03	6.2	<0.005	<0.01	3.12	<0.02
S1	03/23/94	<0.01	<0.03	6.39	<0.005	<0.01	3.72	<0.02
S2	03/23/94	<0.01	<0.03	1.81	<0.005	<0.01	1.89	<0.02
S3	03/23/94	<0.01	<0.03	5.97	<0.005	<0.01	3.45	<0.02
S4	03/23/94	<0.01	<0.03	10.1	<0.005	<0.01	3.59	<0.02
blank		<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
D11 DUPSPK		0.2041	2.08	47.1	2.018	0.1055	34.4	0.052
D19 DUP SPK		0.2053	2.11	48.2	2.038	0.1061	34.4	0.054

February 14, 1994 Sampling

Well	Date	Al	As	B	Ca	Cd	Co	Cr
D6	02/14/94	<0.07	<0.07	<0.04	20.9	<0.01	<0.03	<0.008
D9	02/14/94	<0.07	<0.07	<0.04	19	<0.01	<0.03	<0.008
D10	02/14/94	<0.07	<0.07	<0.04	18.2	<0.01	<0.03	<0.008
D11	02/14/94	<0.07	<0.07	<0.04	19	<0.01	<0.03	<0.008
D13	02/14/94	<0.07	<0.07	<0.04	18.5	<0.01	<0.03	<0.008
D14	02/14/94	<0.07	<0.07	<0.04	17.1	<0.01	<0.03	<0.008
D14 FD	02/14/94	<0.07	<0.07	<0.04	17	<0.01	<0.03	<0.008
D14 FD LD	02/14/94	<0.07	<0.07	<0.04	16.7	<0.01	<0.03	<0.008
D16	02/14/94	<0.07	<0.07	<0.04	16.7	<0.01	<0.03	<0.008
D16 FD	02/14/94	<0.07	<0.07	<0.04	16.8	<0.01	<0.03	<0.008
D16 FD LD	02/14/94	<0.07	<0.07	<0.04	16.4	<0.01	<0.03	<0.008
D17	02/14/94	<0.07	<0.07	<0.04	17.9	<0.01	<0.03	<0.008
D19	02/14/94	<0.07	<0.07	<0.04	17	<0.01	<0.03	<0.008
Field Blank	02/14/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.008
BLANK	02/14/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.008
BLANK	02/14/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.008
BLANK	02/14/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.008
USGS T115	02/14/94	<0.07	<0.07	0.101	57.1	0.0171	<0.03	0.0371

February 14, 1994 Sampling

Well	Date	Cu	Fe	Mg	Mn	Mo	Na	Ni
D6	02/14/94	0.016	<0.03	6.28	<0.005	<0.01	5.32	<0.02
D9	02/14/94	<0.01	0.03	11.7	<0.005	<0.01	3.4	<0.02
D10	02/14/94	<0.01	<0.03	10.7	<0.005	<0.01	3.06	<0.02
D11	02/14/94	<0.01	<0.03	6.62	<0.005	<0.01	3.6	<0.02
D13	02/14/94	<0.01	0.043	6.75	<0.005	<0.01	3.58	<0.02
D14	02/14/94	<0.01	0.031	8.93	<0.005	<0.01	3.64	<0.02
D14 FD	02/14/94	<0.01	0.06	7.2	<0.005	<0.01	3.72	<0.02
D14 FD LD	02/14/94	<0.01	0.058	7.13	0.0052	<0.01	3.62	<0.02
D16	02/14/94	<0.01	<0.03	7.41	<0.005	<0.01	3.51	<0.02
D16 FD	02/14/94	<0.01	<0.03	7.45	<0.005	<0.01	3.68	<0.02
D16 FD LD	02/14/94	<0.01	<0.03	7.34	<0.005	<0.01	3.55	<0.02
D17	02/14/94	0.0339	<0.03	6.66	<0.005	<0.01	3.6	<0.02
D19	02/14/94	<0.01	<0.03	7.46	<0.005	<0.01	3.59	<0.02
Field Blank	02/14/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
BLANK	02/14/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
BLANK	02/14/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
BLANK	02/14/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
USGS T115	02/14/94	0.0158	1.26	31.2	0.5116	0.0516	154	<0.02

February 14, 1994 Sampling

Well	Date	P	Pb	Si	Sr	Ti	Zn	K
D6	02/14/94	<0.2	<0.1	7.17	<0.05	<0.05	0.0226	2.519
D9	02/14/94	<0.2	<0.1	6.97	<0.05	<0.05	0.1314	1.882
D10	02/14/94	<0.2	<0.1	6.94	<0.05	<0.05	0.0524	1.837
D11	02/14/94	<0.2	<0.1	5.88	<0.05	<0.05	0.0878	2.23
D13	02/14/94	<0.2	<0.1	6.4	<0.05	<0.05	0.1809	2.425
D14	02/14/94	<0.2	<0.1	6.93	<0.05	<0.05	0.1368	2.016
D14 FD	02/14/94	<0.2	<0.1	6.6	<0.05	<0.05	0.7064	2.111
D14 FD LD	02/14/94	<0.2	<0.1	6.49	<0.05	<0.05	0.6968	2.151
D16	02/14/94	<0.2	<0.1	6.9	<0.05	<0.05	0.0764	2.201
D16 FD	02/14/94	<0.2	<0.1	6.9	<0.05	<0.05	0.1394	2.146
D16 FD LD	02/14/94	<0.2	<0.1	6.8	<0.05	<0.05	0.1366	2.056
D17	02/14/94	<0.2	<0.1	6.22	<0.05	<0.05	0.3627	2.22
D19	02/14/94	<0.2	<0.1	6.78	<0.05	<0.05	0.0467	2.225
Field Blank	02/14/94	<0.2	<0.1	0.121	<0.05	<0.05	<0.005	<1.5
BLANK	02/14/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK	02/14/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK	02/14/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T115	02/14/94	<0.2	<0.1	5.52	0.6264	<0.05	0.456	7.498

February 14, 1994 Sampling

Well	Date	pH	D.O.	T	ALK	Cl	NO3	SO4
D6	02/14/94	7.35	2.7	4.6	63	0.881	0.123	10.602
D9	02/14/94	6.7	4.3	3.5	74	0.567	0.136	6.257
D10	02/14/94	6.21	6.6	5.1	70	0.624	0.141	5.82
D11	02/14/94	6.59	5.2	5.7	65	0.5	0.056	5.267
D13	02/14/94	6.3	5.2	8	58	0.506	0.06	5.68
D14	02/14/94	6.32	4.6	7.2	58	0.748	0.152	6.181
D14 FD	02/14/94				56	0.816	0.132	5.678
D16	02/14/94	6.33	4.2	5.4	56	0.655	0.13	5.685
D17	02/14/94	6.42	6.1	2.8	62	0.484	0.061	5.155
D19	02/14/94	6.38	4.8	7.8	58	0.699	0.172	5.566

March 23, 1994 Sampling

WELL	DATE	P	Pb	Si	Sr	Ti	Zn	K
D7	03/23/94	<0.2	<0.1	5.52	<0.05	<0.05	<0.005	2.426
D8	03/23/94	<0.2	<0.1	6.51	<0.05	<0.05	0.0344	2.714
D10	03/23/94	<0.2	<0.1	6.61	<0.05	<0.05	0.051	2.072
D11	03/23/94	<0.2	<0.1	5.63	<0.05	<0.05	0.0654	2.637
D11 FD	03/23/94	<0.2	<0.1	5.82	<0.05	<0.05	0.0654	2.62
D11DUP LD		<0.2	<0.1	5.88	<0.05	<0.05	0.0664	2.732
D13	03/23/94	<0.2	<0.1	5.79	<0.05	<0.05	0.2887	2.661
D16	03/23/94	<0.2	<0.1	6.48	<0.05	<0.05	0.118	2.496
D17	03/23/94	<0.2	<0.1	5.96	<0.05	<0.05	0.1757	2.531
D18	03/23/94	<0.2	<0.1	6.41	<0.05	<0.05	0.4944	2.614
D19	03/23/94	<0.2	<0.1	6.53	<0.05	<0.05	0.0411	2.531
D19 DUP LD		<0.2	<0.1	6.45	<0.05	<0.05	0.0408	2.473
D22	03/23/94	<0.2	<0.1	5.58	<0.05	<0.05	0.0232	2.632
S1	03/23/94	<0.2	<0.1	5.68	<0.05	<0.05	<0.005	2.555
S2	03/23/94	<0.2	<0.1	5.1	<0.05	<0.05	<0.005	2.355
S3	03/23/94	<0.2	<0.1	5.58	<0.05	<0.05	<0.005	2.561
S4	03/23/94	<0.2	<0.1	5.98	<0.05	<0.05	<0.005	2.367
blank		<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
D11 DUPSPK		0.87	0.222	20.5	0.131	<0.05	2.148	8.954
D19 DUP SPK		0.87	0.229	21.4	0.1268	<0.05	2.144	8.996

WELL	DATE	T	D.O.	pH	Alk	Cl	NO3	SO4
D7	03/23/94					0.528	0.088	5.589
D8	03/23/94					1.16	0.139	6.157
D10	03/23/94					0.85	1.85	5.922
D11	03/23/94					0.594	0.066	5.295
D11 FD	03/23/94					5.58	0.063	5.234
D13	03/23/94					0.555	0.06	5.557
D16	03/23/94					0.965	0.146	5.663
D17	03/23/94					0.582	0.073	5.156
D18	03/23/94					0.917	0.118	5.598
D19	03/23/94					1.056	0.16	5.649
D22	03/23/94					0.877	0.128	4.931
S1	03/23/94					0.634		5.029
S2	03/23/94					0.27		4.851
S3	03/23/94					0.593		5.044
S4	03/23/94					0.867	0.111	6.109

APRIL 25, 1994 SAMPLING

WELL	DATE	Al	As	B	Ca	Cd	Co
D5	04/27/94	0.073	<0.07	<0.04	7.05	<0.01	<0.03
D6	04/25/94	<0.07	<0.07	<0.04	20.8	<0.01	<0.03
D7	04/25/94	<0.07	<0.07	<0.04	11.8	<0.01	<0.03
D8	04/27/94	<0.07	<0.07	<0.04	12.4	<0.01	<0.03
D9	04/25/94	<0.07	<0.07	<0.04	18.9	<0.01	<0.03
D10	04/25/94	<0.07	<0.07	<0.04	16.5	<0.01	<0.03
D11	04/25/94	<0.07	<0.07	<0.04	18.8	<0.01	<0.03
D11 DUP		<0.07	<0.07	<0.04	19	<0.01	<0.03
D11 LABDUP		<0.07	<0.07	<0.04	18.4	<0.01	<0.03
D12	04/25/94	<0.07	<0.07	<0.04	16.9	<0.01	<0.03
D13	04/25/94	<0.07	<0.07	<0.04	17.6	<0.01	<0.03
D14	04/25/94	<0.07	<0.07	<0.04	17.8	<0.01	<0.03
D16	04/25/94	<0.07	<0.07	<0.04	16.3	<0.01	<0.03
D17	04/25/94	<0.07	<0.07	<0.04	17.3	<0.01	<0.03
D18	04/25/94	<0.07	<0.07	<0.04	16.8	<0.01	<0.03
D19	04/25/94	<0.07	<0.07	<0.04	17.2	<0.01	<0.03
D20	04/25/94	<0.07	<0.07	<0.04	19	<0.01	<0.03
S1	04/27/94	0.159	<0.07	<0.04	9	<0.01	<0.03
S2	04/27/94	0.124	<0.07	<0.04	3.25	<0.01	<0.03
S3	04/27/94	0.162	<0.07	<0.04	8.8	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
blank		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03
USGS T115		<0.07	<0.07	0.1	58	<0.01	<0.03
D11 DUP SPK		0.398	0.222	0.713	79.2	0.0406	0.1041
FB		<0.07	<0.07	<0.04	0.046	<0.01	<0.03

APRIL 25, 1994 SAMPLING

WELL	DATE	Cr	Cu	Fe	Mg	Mn	Mo
D5	04/27/94	<0.008	<0.01	0.059	2.7	0.0057	<0.01
D6	04/25/94	<0.008	<0.01	<0.03	6.26	<0.005	<0.01
D7	04/25/94	<0.008	0.0113	<0.03	4.01	<0.005	<0.01
D8	04/27/94	<0.008	<0.01	0.059	4.38	<0.005	<0.01
D9	04/25/94	<0.008	<0.01	<0.03	11.7	<0.005	<0.01
D10	04/25/94	<0.008	<0.01	<0.03	9.59	<0.005	<0.01
D11	04/25/94	<0.008	<0.01	<0.03	6.52	<0.005	<0.01
D11 DUP		<0.008	<0.01	<0.03	6.58	<0.005	<0.01
D11 LABDUP		<0.008	<0.01	<0.03	6.32	<0.005	<0.01
D12	04/25/94	<0.008	<0.01	0.183	6.48	0.0081	<0.01
D13	04/25/94	<0.008	<0.01	<0.03	6.44	<0.005	<0.01
D14	04/25/94	<0.008	<0.01	<0.03	9.15	<0.005	<0.01
D16	04/25/94	<0.008	<0.01	<0.03	7.24	<0.005	<0.01
D17	04/25/94	<0.008	0.0389	<0.03	6.34	<0.005	<0.01
D18	04/25/94	<0.008	<0.01	<0.03	7.06	<0.005	<0.01
D19	04/25/94	<0.008	<0.01	<0.03	7.52	<0.005	<0.01
D20	04/25/94	<0.008	<0.01	<0.03	7.45	<0.005	<0.01
S1	04/27/94	<0.008	<0.01	0.107	3.01	<0.005	<0.01
S2	04/27/94	<0.008	<0.01	0.058	1.46	<0.005	<0.01
S3	04/27/94	<0.008	<0.01	0.1	3.04	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
BLANK		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
blank		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01
USGS T115		0.036	0.0182	1.29	31.7	0.5215	0.0517
D11 DUP SPK		0.0181	0.1997	2.07	45.2	2.126	0.1071
FB		<0.008	<0.01	<0.03	<0.1	<0.005	<0.01

APRIL 25, 1994 SAMPLING

WELL	DATE	Na	Ni	P	Pb	Si
D5	04/27/94	2.69	<0.02	<0.2	<0.2	5.97
D6	04/25/94	5.6	<0.02	<0.2	<0.2	7.18
D7	04/25/94	3.05	<0.02	<0.2	<0.2	5.98
D8	04/27/94	3.36	<0.02	<0.2	<0.2	6.74
D9	04/25/94	3.49	<0.02	<0.2	<0.2	6.96
D10	04/25/94	2.95	<0.02	<0.2	<0.2	7.07
D11	04/25/94	3.76	<0.02	<0.2	<0.2	6.07
D11 DUP		3.73	<0.02	<0.2	<0.2	6.12
D11 LABDUP		3.55	<0.02	<0.2	<0.2	5.89
D12	04/25/94	3.71	<0.02	<0.2	<0.2	6.23
D13	04/25/94	3.54	<0.02	<0.2	<0.2	6.2
D14	04/25/94	3.65	<0.02	<0.2	<0.2	7.45
D16	04/25/94	3.64	<0.02	<0.2	<0.2	6.62
D17	04/25/94	3.48	<0.02	<0.2	<0.2	6.26
D18	04/25/94	3.57	<0.02	<0.2	<0.2	6.62
D19	04/25/94	3.84	<0.02	<0.2	<0.2	6.78
D20	04/25/94	3.79	<0.02	<0.2	<0.2	6.45
S1	04/27/94	2.25	<0.02	<0.2	<0.2	6.37
S2	04/27/94	1.64	<0.02	<0.2	<0.2	5.49
S3	04/27/94	2.23	<0.02	<0.2	<0.2	6.39
BLANK		<0.1	<0.02	<0.2	<0.2	<0.1
BLANK		<0.1	<0.02	<0.2	<0.2	<0.1
BLANK		<0.1	<0.02	<0.2	<0.2	<0.1
BLANK		<0.1	<0.02	<0.2	<0.2	<0.1
blank		<0.1	<0.02	<0.2	<0.2	<0.1
USGS T115		157	<0.02	<0.2	<0.2	5.66
D11 DUP SPK		35.8	0.067	1	<0.2	20.4
FB		<0.1	<0.02	<0.2	<0.2	<0.1

APRIL 25, 1994 SAMPLING

WELL	DATE	Sr	Ti	Zn	K
D5	04/27/94	<0.05	<0.05	0.0939	1.831
D6	04/25/94	<0.05	<0.05	0.0144	2.096
D7	04/25/94	<0.05	<0.05	<0.005	1.732
D8	04/27/94	<0.05	<0.05	0.0345	2.013
D9	04/25/94	<0.05	<0.05	0.0945	<1.5
D10	04/25/94	<0.05	<0.05	0.0582	<1.5
D11	04/25/94	<0.05	<0.05	0.0403	1.737
D11 DUP		<0.05	<0.05	0.0438	1.831
D11 LABDUP		<0.05	<0.05	0.0422	1.791
D12	04/25/94	<0.05	<0.05	0.1449	1.9
D13	04/25/94	<0.05	<0.05	0.0191	1.89
D14	04/25/94	<0.05	<0.05	0.099	1.964
D16	04/25/94	<0.05	<0.05	0.2448	1.836
D17	04/25/94	<0.05	<0.05	0.1664	2.023
D18	04/25/94	<0.05	<0.05	0.5088	1.988
D19	04/25/94	<0.05	<0.05	0.0444	1.845
D20	04/25/94	<0.05	<0.05	0.0965	2.023
S1	04/27/94	<0.05	<0.05	<0.005	1.585
S2	04/27/94	<0.05	<0.05	<0.005	<1.5
S3	04/27/94	<0.05	<0.05	<0.005	1.506
BLANK		<0.05	<0.05	<0.005	<1.5
BLANK		<0.05	<0.05	<0.005	<1.5
BLANK		<0.05	<0.05	<0.005	<1.5
BLANK		<0.05	<0.05	<0.005	<1.5
blank		<0.05	<0.05	<0.005	<1.5
USGS T115		0.6357	<0.05	0.4686	7.977
D11 DUP SPK		0.134	<0.05	2.166	8.027
FB		<0.05	<0.05	<0.005	<1.5

APRIL 25, 1994 SAMPLING

WELL	DATE	T	D.O.	pH	Alk	Cl	NO3	SO4
D5	04/27/94	6.5	6.1	5.94	26	1.112	0.138	2.79
D6	04/25/94	6.7	3.8	6.96	66	0.836	0.124	10.695
D7	04/25/94	4.8	4.3	6	42	0.68	0.078	5.523
D8	04/27/94	9.1	5.1	6.81	72	0.901	0.164	6.353
D9	04/25/94	6.2	7.4	6.61	80	0.481	0.133	6.301
D10	04/25/94	6.2	9.7	6.57	68	0.95	0.155	5.116
D11	04/25/94	4.7	5.8	6.64	68	0.537	0.065	5.219
D11 DUP	04/27/94				64	0.592		5.262
D12	04/25/94	7.6	4.3	6.34	60	0.924	0.064	5.606
D13	04/25/94	6.9	5.5	6.33	60	0.82	0.087	5.674
D14	04/25/94	7.4	5.3	6.46	68	1.079	0.171	6.47
D16	04/25/94	6.9	5.1	6.5	64	0.851	0.113	5.759
D17	04/25/94	6.3	5.7	6.35	64	0.665	0.07	4.94
D18	04/25/94	7.1	4.8	6.29	62	0.881	0.108	5.582
D19	04/25/94	6.7	5.4	6.33	50	0.805	0.157	5.644
D20	04/25/94	6.9	3.9	6.92	64	0.561	0.087	5.442
S1	04/27/94	3.1		8.29	30	0.406	0	2.822
S2	04/27/94	3.1		7.97	14	0.262	0.044	2.899
S3	04/27/94	4.2		9.14	30	0.422	0	2.895

June 6, 1994 Sampling

WELL		Al	As	B	Ca	Cd	Co	Cu
D1	06/09/94	<0.07	<0.07	<0.04	18.7	<0.01	<0.03	<0.01
D1 FD	06/09/94	<0.07	<0.07	<0.04	20	<0.01	<0.03	<0.01
D1 DUP LD	06/09/94	<0.07	<0.07	<0.04	20	<0.01	<0.03	<0.01
D3	06/09/94	<0.07	<0.07	<0.04	7.13	<0.01	<0.03	<0.01
D4	06/09/94	0.257	<0.07	<0.04	3.47	<0.01	<0.03	<0.01
D4 LD	06/09/94	0.273	<0.07	<0.04	3.45	<0.01	<0.03	<0.01
D5	06/09/94	0.371	<0.07	<0.04	4.16	<0.01	<0.03	<0.01
D6	06/09/94	<0.07	<0.07	<0.04	18.9	<0.01	<0.03	0.0177
D7	06/09/94	<0.07	<0.07	<0.04	9.72	<0.01	<0.03	0.0175
D9	06/06/94	<0.07	<0.07	<0.04	17.4	<0.01	<0.03	<0.01
D10	06/06/94	<0.07	<0.07	<0.04	12.3	<0.01	<0.03	<0.01
D11	06/06/94	<0.07	<0.07	<0.04	17.5	<0.01	<0.03	<0.01
D11 FD	06/06/94	<0.07	<0.07	<0.04	18.1	<0.01	<0.03	<0.01
D12	06/06/94	<0.07	<0.07	<0.04	17	<0.01	<0.03	<0.01
D13	06/06/94	<0.07	<0.07	<0.04	17.2	<0.01	<0.03	<0.01
D14	06/06/94	<0.07	<0.07	<0.04	16.9	<0.01	<0.03	<0.01
D14 LD	06/06/94	<0.07	<0.07	<0.04	16.9	<0.01	<0.03	<0.01
D16	06/06/94	<0.07	<0.07	<0.04	16	<0.01	<0.03	<0.01
D17	06/06/94	<0.07	<0.07	<0.04	16.4	<0.01	<0.03	0.0328
D18	06/06/94	<0.07	<0.07	<0.04	16.6	<0.01	<0.03	<0.01
D19	06/06/94	<0.07	<0.07	<0.04	16.9	<0.01	<0.03	<0.01
D2	06/06/94	0.208	<0.07	<0.04	34.1	<0.01	<0.03	<0.01
D20	06/06/94	<0.07	<0.07	<0.04	17.4	<0.01	<0.03	<0.01
D20 LD	06/06/94	<0.07	<0.07	<0.04	17.5	<0.01	<0.03	<0.01
D21	06/09/94	<0.07	<0.07	<0.04	9.49	<0.01	<0.03	<0.01
FB	06/09/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
S19	06/09/94	<0.07	<0.07	<0.04	14	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
USGS T107		0.228	<0.07	0.138	12.6	0.0167	<0.03	0.0316
USGS T117		0.09	<0.07	0.151	21.6	<0.01	<0.03	<0.01
USGS T117		0.084	<0.07	0.147	22.9	<0.01	<0.03	<0.01
USGS T117		0.086	<0.07	0.161	23.7	<0.01	<0.03	<0.01

July 12, 1994 Sampling

Well	Date	Al	As	B	Be	Ca	Cd	Co
D3	07/12/94	<0.07	<0.07	<0.04	<0.0003	7.64	<0.01	<0.03
D5	07/12/94	0.084	<0.07	<0.04	<0.0003	4.82	<0.01	<0.03
D6	07/12/94	<0.07	<0.07	<0.04	<0.0003	20.2	<0.01	<0.03
D7	07/12/94	<0.07	<0.07	<0.04	<0.0003	10.8	<0.01	<0.03
D8	07/12/94	<0.07	<0.07	<0.04	<0.0003	12.3	<0.01	<0.03
D9	07/12/94	<0.07	<0.07	<0.04	<0.0003	17.7	<0.01	<0.03
D10	07/12/94	<0.07	<0.07	<0.04	<0.0003	12.9	<0.01	<0.03
D11	07/12/94	<0.07	<0.07	<0.04	<0.0003	18.3	<0.01	<0.03
D12	07/12/94	<0.07	<0.07	<0.04	<0.0003	16.6	<0.01	<0.03
D13	07/12/94	<0.07	<0.07	<0.04	<0.0003	16.1	<0.01	<0.03
D14	07/12/94	<0.07	<0.07	<0.04	<0.0003	16.6	<0.01	<0.03
D16	07/12/94	<0.07	<0.07	<0.04	<0.0003	16	<0.01	<0.03
D17	07/12/94	<0.07	<0.07	<0.04	<0.0003	17.1	<0.01	<0.03
D18	07/12/94	<0.07	<0.07	<0.04	<0.0003	16.1	<0.01	<0.03
D19	07/12/94	<0.07	<0.07	<0.04	<0.0003	16.3	<0.01	<0.03
D20	07/12/94	<0.07	<0.07	<0.04	<0.0003	17.9	<0.01	<0.03
D24	07/12/94	<0.07	<0.07	<0.04	<0.0003	15.3	<0.01	<0.03
BLANK	07/12/94	<0.07	<0.07	<0.04	<0.0003	<0.1	<0.01	<0.03
USGS T117		0.093	<0.07	0.147	0.0046	22.7	<0.01	<0.03

Well	Date	Cu	Fe	Mg	Mn	Mo	Na	Ni
D3	07/12/94	<0.01	<0.03	3.31	<0.005	<0.01	3.21	<0.02
D5	07/12/94	<0.01	0.11	1.75	0.011	<0.01	1.98	<0.02
D6	07/12/94	0.0258	<0.03	5.8	<0.005	<0.01	5.31	<0.02
D7	07/12/94	<0.01	<0.03	3.48	<0.005	<0.01	2.94	<0.02
D8	07/12/94	<0.01	0.047	4.16	<0.005	<0.01	3.34	<0.02
D9	07/12/94	<0.01	<0.03	10.4	<0.005	<0.01	3.22	<0.02
D10	07/12/94	<0.01	<0.03	7.18	<0.005	<0.01	2.41	<0.02
D11	07/12/94	<0.01	<0.03	6.11	<0.005	<0.01	3.43	<0.02
D12	07/12/94	<0.01	<0.03	6.37	<0.005	<0.01	3.52	<0.02
D13	07/12/94	<0.01	<0.03	5.81	<0.005	<0.01	3.3	<0.02
D14	07/12/94	<0.01	<0.03	8.57	<0.005	<0.01	3.39	<0.02
D16	07/12/94	<0.01	<0.03	6.87	<0.005	<0.01	3.51	<0.02
D17	07/12/94	0.016	<0.03	6.02	0.0111	<0.01	3.37	<0.02
D18	07/12/94	<0.01	0.059	6.71	0.0142	<0.01	3.39	<0.02
D19	07/12/94	<0.01	<0.03	6.87	<0.005	<0.01	3.64	<0.02
D20	07/12/94	<0.01	<0.03	6.67	<0.005	<0.01	3.61	<0.02
D24	07/12/94	<0.01	<0.03	8.81	<0.005	<0.01	2.96	<0.02
BLANK	07/12/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
USGS T117		<0.01	0.477	10.7	0.2395	0.0106	21.5	<0.02

July 12, 1994 Sampling

Well	Date	P	Pb	Si	Sr	Ti	Zn	K
D3	07/12/94	<0.2	<0.1	6.13	<0.05	<0.05	0.5441	<1.5
D5	07/12/94	<0.2	<0.1	5.52	<0.05	<0.05	0.0316	<1.5
D6	07/12/94	<0.2	<0.1	6.63	<0.05	<0.05	0.0185	1.816
D7	07/12/94	<0.2	<0.1	6.14	<0.05	<0.05	<0.005	<1.5
D8	07/12/94	<0.2	<0.1	6.66	<0.05	<0.05	0.0339	<1.5
D9	07/12/94	<0.2	<0.1	6.56	<0.05	<0.05	0.024	<1.5
D10	07/12/94	<0.2	<0.1	6.37	<0.05	<0.05	0.051	<1.5
D11	07/12/94	<0.2	<0.1	6.01	<0.05	<0.05	0.0415	1.576
D12	07/12/94	<0.2	<0.1	6.56	<0.05	<0.05	0.0377	<1.5
D13	07/12/94	<0.2	<0.1	6.12	<0.05	<0.05	0.0393	<1.5
D14	07/12/94	<0.2	<0.1	6.68	<0.05	<0.05	0.0494	<1.5
D16	07/12/94	<0.2	<0.1	6.54	<0.05	<0.05	0.0838	<1.5
D17	07/12/94	<0.2	<0.1	5.86	<0.05	<0.05	0.2502	1.572
D18	07/12/94	<0.2	<0.1	6.23	<0.05	<0.05	0.557	<1.5
D19	07/12/94	<0.2	<0.1	6.46	<0.05	<0.05	0.0316	<1.5
D20	07/12/94	<0.2	<0.1	6.17	<0.05	<0.05	0.0477	<1.5
D24	07/12/94	<0.2	<0.1	6.96	<0.05	<0.05	0.0763	<1.5
BLANK	07/12/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T117		0.26	<0.1	5.83	0.2464	<0.05	0.1986	2.415

Well	Date	T	pH	D.O.	Alk	Cl	NO3	SO4
D3	07/12/94		6.24	5.6	30	0.504	0.084	5.548
D5	07/12/94		5.43	7.2	18	0.636	0.081	3.423
D6	07/12/94		7.21	4.4	65	1.024	0.118	10.73
D7	07/12/94		6.15	2.8	38	0.584	0.078	4.49
D8	07/12/94		6.12	7.2	42	1.183	0.136	6.022
D9	07/12/94		6.78	8.9	78	0.553	0.146	5.746
D10	07/12/94		6.36	10.4	54	0.649	0.054	4.75
D11	07/12/94		6.53	2.9	64	0.636	0.064	5.082
D12	07/12/94		6.46	4.8	61	0.975	0.157	6.442
D13	07/12/94		6.25	4.6	58	0.806	0.114	5.648
D14	07/12/94		6.77	6.4	70	0.846	0.179	6.131
D16	07/12/94		6.59	5.7	62	0.882	0.202	5.793
D17	07/12/94		6.72	3.4	57	0.724	0.1	4.713
D18	07/12/94		6.37	4.7	62	0.853	0.177	5.79
D19	07/12/94		6.61	5.7	63	1.051	0.201	5.703
D20	07/12/94		6.75	4.1	66	0.73	0.101	5.144
D24	07/12/94		6.6	10	66	0.511	0.153	4.847

June 6, 1994 Sampling

WELL		Fe	Mg	Mn	Mo	Na	Ni	P
D1	06/09/94	<0.03	5.9	<0.005	<0.01	3.94	<0.02	<0.2
D1 FD	06/09/94	<0.03	5.98	<0.005	<0.01	3.77	<0.02	<0.2
D1 DUP LD	06/09/94	<0.03	5.93	<0.005	<0.01	3.87	<0.02	<0.2
D3	06/09/94	0.035	3.28	<0.005	<0.01	3.13	<0.02	<0.2
D4	06/09/94	0.118	1.38	<0.005	<0.01	1.54	<0.02	<0.2
D4 LD	06/09/94	0.118	1.36	<0.005	<0.01	1.52	<0.02	<0.2
D5	06/09/94	0.192	1.6	<0.005	<0.01	1.77	<0.02	<0.2
D6	06/09/94	<0.03	5.82	<0.005	<0.01	5.34	<0.02	<0.2
D7	06/09/94	0.036	3.4	<0.005	<0.01	2.81	<0.02	<0.2
D9	06/06/94	0.045	10.5	<0.005	<0.01	3	<0.02	<0.2
D10	06/06/94	<0.03	7.01	<0.005	<0.01	2.17	<0.02	<0.2
D11	06/06/94	<0.03	5.98	<0.005	<0.01	3.29	<0.02	<0.2
D11 FD	06/06/94	<0.03	6.09	<0.005	<0.01	3.3	<0.02	<0.2
D12	06/06/94	0.074	6.49	<0.005	<0.01	3.45	<0.02	<0.2
D13	06/06/94	<0.03	6.1	<0.005	<0.01	3.26	<0.02	<0.2
D14	06/06/94	<0.03	8.8	<0.005	<0.01	3.34	<0.02	<0.2
D14 LD	06/06/94	<0.03	8.75	<0.005	<0.01	3.41	<0.02	<0.2
D16	06/06/94	<0.03	7.04	<0.005	<0.01	3.35	<0.02	<0.2
D17	06/06/94	<0.03	6.03	0.0065	<0.01	3.15	<0.02	<0.2
D18	06/06/94	0.099	6.88	0.0222	<0.01	3.42	<0.02	<0.2
D19	06/06/94	<0.03	7.23	<0.005	<0.01	3.51	<0.02	<0.2
D2	06/06/94	3.34	7.11	0.3923	<0.01	16.9	<0.02	<0.2
D20	06/06/94	<0.03	6.75	<0.005	<0.01	3.39	<0.02	<0.2
D20 LD	06/06/94	<0.03	6.74	<0.005	<0.01	3.47	<0.02	<0.2
D21	06/09/94	0.301	3.27	0.0159	<0.01	3.05	<0.02	<0.2
FB	06/09/94	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
S19	06/09/94	0.078	4.77	0.007	<0.01	2.64	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
USGS T107		0.049	2.26	0.0508	0.0144	22.1	0.034	<0.2
USGS T117		0.466	10.7	0.2332	0.0102	22.6	<0.02	0.25
USGS T117		0.48	10.8	0.2396	0.0103	21	<0.02	0.29
USGS T117		0.494	11.2	0.247	0.0113	21.6	<0.02	0.28

June 6, 1994 Sampling

WELL		Pb	Si	Sr	Ti	Zn	K
D1	06/09/94	<0.1	6.4	<0.05	<0.05	0.0812	<1.5
D1 FD	06/09/94	<0.1	6.43	<0.05	<0.05	0.025	1.837
D1 DUP LD	06/09/94	<0.1	6.44	<0.05	<0.05	0.0256	1.642
D3	06/09/94	<0.1	6.19	<0.05	<0.05	0.486	<1.5
D4	06/09/94	<0.1	5.66	<0.05	<0.05	0.0725	<1.5
D4 LD	06/09/94	<0.1	5.55	<0.05	<0.05	0.0656	<1.5
D5	06/09/94	<0.1	6.21	<0.05	<0.05	0.0381	<1.5
D6	06/09/94	<0.1	6.88	<0.05	<0.05	0.027	<1.5
D7	06/09/94	<0.1	6.14	<0.05	<0.05	<0.005	<1.5
D9	06/06/94	<0.1	6.5	<0.05	<0.05	0.0774	<1.5
D10	06/06/94	<0.1	6.58	<0.05	<0.05	0.0514	<1.5
D11	06/06/94	<0.1	5.7	<0.05	<0.05	0.0283	<1.5
D11 FD	06/06/94	<0.1	5.79	<0.05	<0.05	0.0362	1.822
D12	06/06/94	<0.1	6.4	<0.05	<0.05	0.0983	1.586
D13	06/06/94	<0.1	6.34	<0.05	<0.05	0.0115	1.898
D14	06/06/94	<0.1	6.74	<0.05	<0.05	0.0557	<1.5
D14 LD	06/06/94	<0.1	6.73	<0.05	<0.05	0.0555	<1.5
D16	06/06/94	<0.1	6.45	<0.05	<0.05	0.0697	<1.5
D17	06/06/94	<0.1	5.84	<0.05	<0.05	0.1529	<1.5
D18	06/06/94	<0.1	6.4	<0.05	<0.05	0.8437	1.678
D19	06/06/94	<0.1	6.46	<0.05	<0.05	0.0362	1.581
D2	06/06/94	<0.1	21	0.0916	<0.05	1.944	4.165
D20	06/06/94	<0.1	5.91	<0.05	<0.05	0.1003	<1.5
D20 LD	06/06/94	<0.1	5.93	<0.05	<0.05	0.1005	<1.5
D21	06/09/94	<0.1	5.76	<0.05	<0.05	0.3411	<1.5
FB	06/09/94	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
S19	06/09/94	<0.1	5.28	<0.05	<0.05	0.006	1.545
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T107		<0.1	3.92	0.0573	<0.05	0.0864	<1.5
USGS T117		<0.1	6.05	0.2486	<0.05	0.1954	2.113
USGS T117		<0.1	5.87	0.2461	<0.05	0.199	2.65
USGS T117		<0.1	6.09	0.2528	<0.05	0.2068	2.963

June 6, 1994 Sampling

WELL		T	pH	D.O.	ALK	Cl	NO3	SO4
D1	06/09/94	8.3	6.78	3.4	58	0.609	0.077	5.349
D1 FD	06/09/94					0.63	0.086	5.589
D1 DUP LD	06/09/94				62	0.605	0.088	5.553
D3	06/09/94	5.5	6.32	6.8	26	0.375	0.083	5.666
D4	06/09/94	6.7	6.69	7.2	14	0.382	0.047	2.903
D4 LD	06/09/94							
D5	06/09/94	6.9	5.47	7.2	14	0.747	0.083	3.133
D6	06/09/94	7.5	7.36	3.9	54	0.948	0.107	10.572
D7	06/09/94	5.5	6.55	3	32	0.512	0.068	4.49
D9	06/06/94	6.4	7.35	8.6	72	0.459	0.127	5.587
D10	06/06/94	6.2	6.72	10.4	47	1.106	0.081	4.537
D11	06/06/94	5.8	6.99	4.6	63	0.613	0.063	5.252
D11 FD	06/06/94				62	0.564	0.061	5.185
D12	06/06/94	8.5	6.6	4.4	62	0.837	0.125	6.098
D13	06/06/94	7.2	6.84	5.6	56	0.796	0.138	5.873
D14	06/06/94	7.9	7	5.5	62	0.852	0.197	6.306
D14 LD	06/06/94							
D16	06/06/94	7.5	6.54	4.8	63	0.86	0.18	5.835
D17	06/06/94	8	6.9	4.5	60	0.627	0.095	4.926
D18	06/06/94	8.2	6.64	4.7	66	0.798	0.157	5.792
D19	06/06/94	6.8	6.5	5	60	1.12	0.195	5.695
D2	06/06/94	6.6	5.8	0.1	9	1.204		
D20	06/06/94	7.4	7	3.8	64	0.654	0.075	5.163
D20 LD	06/06/94							
D21	06/09/94	5.7	6.04	3.6	32	0.516	0.076	5.14
FB	06/09/94				3			
S19	06/09/94	13.1	7.34		50	0.306	bdl	2.186

May 23, 1994 Monitoring Well Sampling

WELL	DATE	Al	As	B	Ca	Cd	Co	Cu
M1	05/23/94	<0.07	<0.07	<0.04	14.1	<0.01	<0.03	<0.01
M2	05/23/94	<0.07	<0.07	<0.04	10.5	<0.01	<0.03	<0.01
M3	05/23/94	<0.07	<0.07	<0.04	11.1	<0.01	<0.03	<0.01
M4	05/23/94	<0.07	<0.07	<0.04	12.2	<0.01	<0.03	<0.01
M5	05/23/94	<0.07	<0.07	<0.04	13.9	<0.01	<0.03	<0.01
M6	05/23/94	<0.07	<0.07	<0.04	18.4	<0.01	<0.03	<0.01
M7	05/23/94	<0.07	<0.07	<0.04	21	<0.01	<0.03	<0.01
M8	05/23/94	<0.07	<0.07	<0.04	18.7	<0.01	<0.03	<0.01
M9	05/23/94	<0.07	<0.07	<0.04	13.3	<0.01	<0.03	<0.01
M10	05/23/94	<0.07	<0.07	<0.04	13.6	<0.01	<0.03	<0.01
M10 FD	05/23/94	<0.07	<0.07	<0.04	13.3	<0.01	<0.03	<0.01
M10 LD	05/23/94	<0.07	<0.07	<0.04	13.2	<0.01	<0.03	<0.01
FB	05/23/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
S10	05/23/94	<0.07	<0.07	<0.04	9.99	<0.01	<0.03	<0.01
S21	05/23/94	<0.07	<0.07	<0.04	22.1	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	0.106	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
USGS T1117		0.081	<0.07	0.148	22.9	<0.01	<0.03	<0.01

WELL	DATE	Fe	Mg	Mn	Mo	Na	Ni	P
M1	05/23/94	0.647	4.46	0.2931	<0.01	2.52	<0.02	<0.2
M2	05/23/94	<0.03	3.53	<0.005	<0.01	2.22	<0.02	<0.2
M3	05/23/94	0.393	3.42	0.2689	<0.01	1.93	<0.02	<0.2
M4	05/23/94	0.139	4	0.0226	<0.01	2.37	<0.02	<0.2
M5	05/23/94	0.478	4.8	0.0712	<0.01	2.55	<0.02	<0.2
M6	05/23/94	12.1	6.16	0.4637	0.0175	4.48	<0.02	0.21
M7	05/23/94	4.03	5.94	1.214	<0.01	2.6	<0.02	0.24
M8	05/23/94	12.3	6.22	0.4702	0.017	4.5	<0.02	0.22
M9	05/23/94	<0.03	4.61	0.0092	<0.01	2.69	<0.02	<0.2
M10	05/23/94	0.104	4.49	0.1246	<0.01	2.38	<0.02	<0.2
M10 FD	05/23/94	0.095	4.46	0.1184	<0.01	2.38	<0.02	<0.2
M10 LD	05/23/94	0.092	4.4	0.1189	<0.01	2.42	<0.02	<0.2
FB	05/23/94	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
S10	05/23/94	0.036	3.13	<0.005	<0.01	1.91	<0.02	<0.2
S21	05/23/94	<0.03	10	<0.005	<0.01	3.58	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
USGS T1117		0.492	10.8	0.2398	0.0102	21	<0.02	0.3

Table D2: Monitoring well chemical data.

May 23, 1994 Monitoring Well Sampling

WELL	DATE	Pb	Si	Sr	Ti	Zn	K
M1	05/23/94	<0.1	7.65	<0.05	<0.05	<0.005	2.026
M2	05/23/94	<0.1	6.22	<0.05	<0.05	<0.005	<1.5
M3	05/23/94	<0.1	6.2	<0.05	<0.05	<0.005	<1.5
M4	05/23/94	<0.1	6.46	<0.05	<0.05	<0.005	1.591
M5	05/23/94	<0.1	7.57	<0.05	<0.05	<0.005	2.349
M6	05/23/94	<0.1	9.2	<0.05	<0.05	<0.005	<1.5
M7	05/23/94	<0.1	9.33	<0.05	<0.05	<0.005	2.896
M8	05/23/94	<0.1	9.31	<0.05	<0.05	<0.005	<1.5
M9	05/23/94	<0.1	6.03	<0.05	<0.05	<0.005	<1.5
M10	05/23/94	<0.1	6.24	<0.05	<0.05	<0.005	1.668
M10 FD	05/23/94	<0.1	6.2	<0.05	<0.05	<0.005	<1.5
M10 LD	05/23/94	<0.1	6.16	<0.05	<0.05	<0.005	<1.5
FB	05/23/94	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
S10	05/23/94	<0.1	5.15	<0.05	<0.05	<0.005	<1.5
S21	05/23/94	<0.1	5.84	<0.05	<0.05	<0.005	1.515
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T1117		<0.1	5.85	0.2454	<0.05	0.199	2.609

WELL	DATE	pH	D.O.	T	Alk	Cl	NO3	SO4	NH4
M1	05/23/94	6.54	0.6	10.4	42	0.215	0.001	1.602	0.01
M2	05/23/94	6.35	1.4	10.4	44	0.283	0.002	2.549	0.006
M3	05/23/94	6.44	0.9	9.9	38	0.15	0.009	1.448	0.06
M4	05/23/94	6.36	0.5	9.8	40	0.505	0.002	2.145	0.02
M5	05/23/94	6.21	1.1	11.1	48	0.41	0.01	0.273	0.06
M7	05/23/94	6.35	0.1	13.5	66	0.378	0.022	1.626	0.06
M8	05/23/94	6.23	0.2	11.3	82	1.102	0.093	0.483	0.08
M9	05/23/94	6.64	1.4	10	48	0.399	0.009	3.264	0.008
M10	05/23/94	6.38	0.2	12.1	46	0.257	0.006	2.142	0.013
M10 FD	05/23/94				52	0.289	0.007	2.093	
FB	05/23/94				<1.0	<0.3	0.008	<0.6	0
S10	05/23/94	7.54		9.7	42	2.58	0.009	2.51	0
S21	05/23/94	7.71		13.5	83	0.897	0.045	5.992	0

June 13, 1994 Monitoring Well Sampling

WELL	DATE	Al	As	B	Ca	Cd	Co	Cu
M1	06/13/94	<0.07	<0.07	<0.04	12.2	<0.01	<0.03	<0.01
M2	06/13/94	<0.07	<0.07	<0.04	10.8	<0.01	<0.03	<0.01
M3	06/13/94	<0.07	<0.07	<0.04	10.1	<0.01	<0.03	<0.01
M4	06/13/94	<0.07	<0.07	<0.04	12.5	<0.01	<0.03	<0.01
M4 LD	06/13/94	<0.07	<0.07	<0.04	12.8	<0.01	<0.03	<0.01
M5	06/13/94	<0.07	<0.07	<0.04	14.6	<0.01	<0.03	<0.01
M6	06/13/94	0.219	<0.07	<0.04	8.24	<0.01	<0.03	<0.01
M7	06/13/94	<0.07	<0.07	<0.04	15.9	<0.01	<0.03	<0.01
M8	06/13/94	<0.07	<0.07	<0.04	20.2	<0.01	<0.03	<0.01
M9	06/13/94	<0.07	<0.07	<0.04	19.9	<0.01	<0.03	<0.01
M10	06/13/94	<0.07	<0.07	<0.04	10.9	<0.01	<0.03	<0.01
M11	06/13/94	<0.07	<0.07	<0.04	19.6	<0.01	<0.03	<0.01
FB	06/13/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
S3	06/13/94	<0.07	<0.07	<0.04	13.3	<0.01	<0.03	<0.01
S3 LD	06/13/94	<0.07	<0.07	<0.04	13.9	<0.01	<0.03	<0.01
S4	06/13/94	<0.07	<0.07	<0.04	34	<0.01	<0.03	<0.01
S10	06/13/94	<0.07	<0.07	<0.04	13.2	<0.01	<0.03	<0.01
S10 DUP	06/13/94	<0.07	<0.07	<0.04	13.6	<0.01	<0.03	<0.01
S10 LD	06/13/94	<0.07	<0.07	<0.04	13.9	<0.01	<0.03	<0.01
S21	06/13/94	<0.07	<0.07	<0.04	19.8	<0.01	<0.03	<0.01
S22	06/13/94	<0.07	<0.07	<0.04	13.7	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.01
USGS T107		0.231	<0.07	0.114	12.1	0.016	<0.03	0.0294
USGS T107		0.236	<0.07	0.155	12.3	0.017	<0.03	0.0331
USGS T117		0.079	<0.07	0.19	22.9	<0.01	<0.03	<0.01
USGS T117		0.084	<0.07	0.153	21.8	<0.01	<0.03	<0.01
USGS T117		0.078	<0.07	0.133	23.3	<0.01	<0.03	<0.01

June 13, 1994 Monitoring Well Sampling

WELL	DATE	Fe	Mg	Mn	Mo	Na	Ni	P
M1	06/13/94	0.803	4.03	0.1418	<0.01	2.45	<0.02	<0.2
M2	06/13/94	<0.03	3.65	<0.005	<0.01	2.11	<0.02	<0.2
M3	06/13/94	0.585	3.27	0.2095	<0.01	1.78	<0.02	<0.2
M4	06/13/94	0.14	4.3	0.0086	<0.01	2.5	<0.02	<0.2
M4 LD	06/13/94	0.128	4.19	0.0079	<0.01	2.36	<0.02	<0.2
M5	06/13/94	0.897	5.02	0.069	<0.01	2.54	<0.02	<0.2
M6	06/13/94	0.63	2.67	0.0665	<0.01	1.36	<0.02	<0.2
M7	06/13/94	2.39	4.88	0.7342	<0.01	2.57	<0.02	<0.2
M8	06/13/94	13.6	7.09	0.5279	0.0203	5.48	<0.02	<0.2
M9	06/13/94	1.15	6.86	0.2933	<0.01	3.01	<0.02	<0.2
M10	06/13/94	0.197	3.75	0.1196	<0.01	2.28	<0.02	<0.2
M11	06/13/94	3.51	5.91	1.032	<0.01	2.71	<0.02	<0.2
FB	06/13/94	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
S3	06/13/94	<0.03	4.21	<0.005	<0.01	2.43	<0.02	<0.2
S3 LD	06/13/94	<0.03	4.16	<0.005	<0.01	2.32	<0.02	<0.2
S4	06/13/94	<0.03	16.3	<0.005	<0.01	4.06	<0.02	<0.2
S10	06/13/94	<0.03	4.23	<0.005	<0.01	2.42	<0.02	<0.2
S10 DUP	06/13/94	<0.03	4.27	<0.005	<0.01	2.44	<0.02	<0.2
S10 LD	06/13/94	<0.03	4.18	<0.005	<0.01	2.3	<0.02	<0.2
S21	06/13/94	<0.03	9.07	<0.005	<0.01	3.61	<0.02	<0.2
S22	06/13/94	<0.03	4.32	<0.005	<0.01	2.43	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
BLANK		<0.03	<0.1	<0.005	<0.01	<0.1	<0.02	<0.2
USGS T107		0.051	2.27	0.049	0.0142	22.7	0.029	<0.2
USGS T107		0.05	2.27	0.0505	0.0147	23.2	0.03	<0.2
USGS T117		0.486	11.3	0.2439	0.0103	22.7	<0.02	0.3
USGS T117		0.475	10.8	0.2359	<0.01	22.7	<0.02	0.23
USGS T117		0.492	11.1	0.2428	0.0119	21.4	<0.02	0.23

June 13, 1994 Monitoring Well Sampling

WELL	DATE	Pb	Si	Sr	Ti	Zn	K
M1	06/13/94	<0.1	7.99	<0.05	<0.05	<0.005	1.508
M2	06/13/94	<0.1	6.76	<0.05	<0.05	<0.005	1.675
M3	06/13/94	<0.1	5.85	<0.05	<0.05	<0.005	<1.5
M4	06/13/94	<0.1	6.76	<0.05	<0.05	<0.005	<1.5
M4 LD	06/13/94	<0.1	6.37	<0.05	<0.05	<0.005	<1.5
M5	06/13/94	<0.1	8.09	<0.05	<0.05	<0.005	2.108
M6	06/13/94	<0.1	7.2	<0.05	<0.05	0.018	3.506
M7	06/13/94	<0.1	10.5	<0.05	<0.05	<0.005	2.291
M8	06/13/94	<0.1	10.8	<0.05	<0.05	<0.005	<1.5
M9	06/13/94	<0.1	7.31	<0.05	<0.05	<0.005	1.618
M10	06/13/94	<0.1	6.98	<0.05	<0.05	<0.005	<1.5
M11	06/13/94	<0.1	10.8	<0.05	<0.05	<0.005	2.525
FB	06/13/94	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
S3	06/13/94	<0.1	5.26	<0.05	<0.05	0.032	<1.5
S3 LD	06/13/94	<0.1	5.06	<0.05	<0.05	0.032	<1.5
S4	06/13/94	<0.1	7.68	0.0943	<0.05	<0.005	<1.5
S10	06/13/94	<0.1	5.19	<0.05	<0.05	0.005	<1.5
S10 DUP	06/13/94	<0.1	5.26	<0.05	<0.05	<0.005	<1.5
S10 LD	06/13/94	<0.1	4.97	<0.05	<0.05	<0.005	<1.5
S21	06/13/94	<0.1	5.95	<0.05	<0.05	0.006	<1.5
S22	06/13/94	<0.1	5.27	<0.05	<0.05	<0.005	<1.5
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T107		<0.1	1.97	0.0562	<0.05	0.085	<1.5
USGS T107		<0.1	4.09	0.0579	<0.05	0.087	<1.5
USGS T117		<0.1	6.37	0.2556	<0.05	0.206	2.797
USGS T117		<0.1	6.11	0.2512	<0.05	0.197	2.212
USGS T117		<0.1	3	0.2514	<0.05	0.202	2.368

June 13, 1994 Monitoring Well Sampling

WELL	DATE	pH	T	D.O.	Alk	Cl	NO3	SO4	NH4
M1	06/13/94	6.8	12.2	0.8	42	0.333	0.013	1.968	0.01
M2	06/13/94	6.94	12.1	5.1	36	0.287	0.003	2.293	0.0036
M3	06/13/94	6.84	11.9	1.4	36	0.197	0.01	1.081	0.03
M4	06/13/94	6.89	10.8	0.5	42	0.339	0.004	2.403	0.01
M4 LD	06/13/94								
M5	06/13/94	6.79	11.8	0.4	53	0.434	0.034	0.334	0.03
M6	06/13/94	6.62	12	2.5	28		0.035		0.08
M7	06/13/94	6.75	13.8	2.5	50	0.856	0.081	4.657	0.03
M8	06/13/94	6.72	11.8	0.4	84	0.9	0.102	0	0.12
M9	06/13/94	7.06	11.7	0.3	64	0.56	0.014	2.252	0.002
M10	06/13/94	6.97	12.4	1.3	38	0.25	0.031	1.514	0.008
M11	06/13/94				60	0.827	0.082	3.961	0.04
FB	06/13/94				0	0	0	0	0.004
S3	06/13/94	8.69	11.6		46	0.553	0.006	2.946	0
S3 LD	06/13/94								
S4	06/13/94	8.53	6.9		126	0.859	0.23	6.377	0
S10	06/13/94	8.6	12.2		44	0.479	0.004	2.895	0
S10 DUP	06/13/94				44	0.473	0.004	2.899	0
S10 LD	06/13/94								
S21	06/13/94	7.8	10		78	0.868	0.033	5.237	0
S22	06/13/94	8.65	12.2		48	0.369	0.006	2.9	0

July 11, 1994 Monitoring Well Sampling

Well	Date	Al	As	B	Be	Ca	Cd	Co
M3	07/11/94	<0.07	<0.07	<0.04	<0.0003	15.7	<0.01	<0.03
M4	07/11/94	<0.07	<0.07	<0.04	<0.0003	15.8	<0.01	<0.03
M5	07/11/94	<0.07	<0.07	<0.04	<0.0003	16.8	<0.01	<0.03
M5 LD	07/11/94	<0.07	<0.07	<0.04	<0.0003	16.5	<0.01	<0.03
M8	07/11/94	<0.07	<0.07	<0.04	<0.0003	16.6	<0.01	<0.03
M9	07/11/94	<0.07	<0.07	<0.04	<0.0003	16.9	<0.01	<0.03
M10	07/11/94	<0.07	<0.07	<0.04	<0.0003	15	<0.01	<0.03
M11	07/11/94	<0.07	<0.07	<0.04	<0.0003	14.9	<0.01	<0.03
M12	07/11/94	<0.07	<0.07	<0.04	<0.0003	21.2	<0.01	<0.03
M13	07/11/94	<0.07	<0.07	<0.04	<0.0003	19.4	<0.01	<0.03
M14	07/11/94	<0.07	<0.07	<0.04	<0.0003	15.5	<0.01	<0.03
M15	07/11/94	<0.07	<0.07	<0.04	<0.0003	18.5	<0.01	<0.03
M16	07/11/94	<0.07	<0.07	<0.04	<0.0003	19.1	<0.01	<0.03
M17	07/11/94	<0.07	<0.07	<0.04	<0.0003	25.8	<0.01	<0.03
M18	07/11/94	<0.07	<0.07	<0.04	<0.0003	<0.1	<0.01	<0.03
S1	07/11/94	<0.07	<0.07	<0.04	<0.0003	20.1	<0.01	<0.03
S2	07/11/94	<0.07	<0.07	<0.04	<0.0003	3.13	<0.01	<0.03
S3	07/11/94	<0.07	<0.07	<0.04	<0.0003	18.4	<0.01	<0.03
S5	07/11/94	<0.07	<0.07	<0.04	<0.0003	21.4	<0.01	<0.03
S10	07/11/94	<0.07	<0.07	<0.04	<0.0003	18.7	<0.01	<0.03
S21	07/11/94	<0.07	<0.07	<0.04	<0.0003	21.2	<0.01	<0.03
S22	07/11/94	<0.07	<0.07	<0.04	<0.0003	18.4	<0.01	<0.03
BLANK	07/11/94	<0.07	<0.07	<0.04	<0.0003	<0.1	<0.01	<0.03
USGS T1	07/11/94	0.088	<0.07	0.149	0.0046	23	<0.01	<0.03

July 11, 1994 Monitoring Well Sampling

Well	Date	Cu	Fe	Mg	Mn	Mo	Na	Ni
M3	07/11/94	<0.01	1.15	4.86	0.2809	<0.01	2.58	<0.02
M4	07/11/94	<0.01	0.111	5.19	0.0052	<0.01	2.93	<0.02
M5	07/11/94	<0.01	1.13	5.53	0.0654	<0.01	2.95	<0.02
M5 LD	07/11/94	<0.01	1.1	5.52	0.0652	<0.01	2.98	<0.02
M8	07/11/94	<0.01	10.5	5.5	0.4194	0.014	4.53	<0.02
M9	07/11/94	<0.01	0.612	5.71	0.1022	<0.01	3.02	<0.02
M10	07/11/94	<0.01	0.252	5.06	0.0821	<0.01	2.9	<0.02
M11	07/11/94	<0.01	0.251	5.03	0.084	<0.01	2.9	<0.02
M12	07/11/94	<0.01	0.35	7.19	0.6848	<0.01	3.54	<0.02
M13	07/11/94	<0.01	1.53	6.48	0.1969	<0.01	3.32	<0.02
M14	07/11/94	<0.01	1.7	5.53	0.1746	<0.01	3.38	<0.02
M15	07/11/94	<0.01	<0.03	7.64	0.0074	<0.01	3.53	<0.02
M16	07/11/94	<0.01	4.44	7.25	0.1475	<0.01	3.99	<0.02
M17	07/11/94	<0.01	2.5	10.4	0.1513	<0.01	4.09	<0.02
M18	07/11/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
S1	07/11/94	<0.01	<0.03	5.89	<0.005	<0.01	3.04	<0.02
S2	07/11/94	<0.01	<0.03	1.33	<0.005	<0.01	1.44	<0.02
S3	07/11/94	<0.01	<0.03	5.49	<0.005	<0.01	2.9	<0.02
S5	07/11/94	<0.01	<0.03	9.8	<0.005	<0.01	3.59	<0.02
S10	07/11/94	<0.01	<0.03	5.54	<0.005	<0.01	2.96	<0.02
S21	07/11/94	<0.01	<0.03	9.29	<0.005	<0.01	3.53	<0.02
S22	07/11/94	<0.01	<0.03	5.57	<0.005	<0.01	2.96	<0.02
BLANK	07/11/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
USGS T1	07/11/94	<0.01	0.487	10.7	0.2409	0.012	21.2	<0.02

July 11, 1994 Monitoring Well Sampling

Well	Date	P	Pb	Si	Sr	Ti	Zn	K
M3	07/11/94	<0.2	<0.1	6.3	<0.05	<0.05	<0.005	1.545
M4	07/11/94	<0.2	<0.1	6.26	<0.05	<0.05	<0.005	<1.5
M5	07/11/94	<0.2	<0.1	7.4	<0.05	<0.05	<0.005	2.205
M5 LD	07/11/94	<0.2	<0.1	7.34	<0.05	<0.05	<0.005	1.914
M8	07/11/94	0.23	<0.1	9.63	<0.05	<0.05	<0.005	<1.5
M9	07/11/94	<0.2	<0.1	6.37	<0.05	<0.05	<0.005	<1.5
M10	07/11/94	<0.2	<0.1	6.66	<0.05	<0.05	<0.005	<1.5
M11	07/11/94	<0.2	<0.1	6.62	<0.05	<0.05	<0.005	<1.5
M12	07/11/94	<0.2	<0.1	6.96	<0.05	<0.05	<0.005	2.62
M13	07/11/94	<0.2	<0.1	7.35	<0.05	<0.05	<0.005	1.699
M14	07/11/94	<0.2	<0.1	6.44	<0.05	<0.05	<0.005	2.272
M15	07/11/94	<0.2	<0.1	6.73	<0.05	<0.05	<0.005	1.525
M16	07/11/94	<0.2	<0.1	7.47	<0.05	<0.05	<0.005	1.96
M17	07/11/94	<0.2	<0.1	7.65	0.0535	<0.05	<0.005	<1.5
M18	07/11/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
S1	07/11/94	<0.2	<0.1	4.86	<0.05	<0.05	<0.005	1.53
S2	07/11/94	<0.2	<0.1	4.65	<0.05	<0.05	0.0052	<1.5
S3	07/11/94	<0.2	<0.1	4.61	<0.05	<0.05	0.0054	<1.5
S5	07/11/94	<0.2	<0.1	5.57	<0.05	<0.05	0.0069	<1.5
S10	07/11/94	<0.2	<0.1	4.56	<0.05	<0.05	<0.005	1.586
S21	07/11/94	<0.2	<0.1	5.63	<0.05	<0.05	<0.005	1.525
S22	07/11/94	<0.2	<0.1	4.52	<0.05	<0.05	<0.005	<1.5
BLANK	07/11/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T1	07/11/94	0.29	<0.1	5.85	0.2459	<0.05	0.2002	2.584

July 11, 1994 Monitoring Well Sampling

Well	Date	T	D.O.	pH	ALK	Cl	NO3	SO4	NH4
M3	07/11/94	14.2	0.6	6.54	56	0.376	0.018	2.31	0.035
M4	07/11/94	13.3	0.8	6.73	57	0.568	0.006	3.278	<0.01
M5	07/11/94	15.9		6.52	62	0.519	0.018	0.375	0.1
M8	07/11/94	13.7	0.2	6.51	75	0.777	0.099	<0.6	0.11
M9	07/11/94	12.6	0.1	6.61	61	0.592	0.011	3.241	<0.01
M10	07/11/94	13.9	0.7	6.58	54	0.599	0.009	3.5	<0.01
M11	07/11/94				55	0.537	0.01	3.434	0.01
M12	07/11/94	11	2.2	6.95	75	1.318	0.049	4.148	0.02
M13	07/11/94	12.3	2	6.58	71	0.879	0.021	1.863	0.1
M14	07/11/94	10.8	0.8	6.66	59	1.126	0.051	4.404	0.04
M15	07/11/94	10.6	2.9	6.59	67	0.898	0.063	5.051	<0.01
M16	07/11/94	11.2	0.7	6.2	80	1.248	0.075	3.253	0.04
M17	07/11/94	12.5	0.4	6.47	105	0.797	0.024	2.893	<0.01
S1	07/11/94	18.3		8.77	67	0.609	0.005	3.463	
S2	07/11/94	13.9		7.26	14	0.375	0.013	3.178	
S3	07/11/94	18		9.11	64	0.525	0.004	3.463	
S5	07/11/94	15		7.9	83	1.039	0.043	5.909	
S10	07/11/94	17.8		8.55	62	0.519	0.004	3.384	
S21	07/11/94	15.2		7.76	81	0.977	0.029	5.713	
S22	07/11/94	18.8		8.6	64	0.496	0.006	3.447	

August 24, 1994 Monitoring Well Sampling

WELL	DATE	Al	As	B	Ca	Cd	Co	Cr
M3	08/24/94	<0.07	<0.07	<0.04	17.3	<0.01	<0.03	<0.08
M8	08/24/94	<0.07	<0.07	<0.04	14.1	<0.01	<0.03	<0.08
M9	08/24/94	<0.07	<0.07	<0.04	17.7	<0.01	<0.03	<0.08
M11	08/24/94	<0.07	<0.07	<0.04	17.6	<0.01	<0.03	<0.08
M12	08/24/94	<0.07	<0.07	<0.04	18.9	<0.01	<0.03	<0.08
M14	08/24/94	<0.07	<0.07	<0.04	16.2	<0.01	<0.03	<0.08
M15	08/24/94	<0.07	<0.07	<0.04	18.8	<0.01	<0.03	<0.08
M16	08/24/94	<0.07	<0.07	<0.04	18.4	<0.01	<0.03	<0.08
M17	08/24/94	<0.07	<0.07	<0.04	32.8	<0.01	<0.03	<0.08
S1	08/24/94	<0.07	<0.07	<0.04	22.8	<0.01	<0.03	<0.08
S2	08/24/94	<0.07	<0.07	<0.04	3.49	<0.01	<0.03	<0.08
S3	08/24/94	<0.07	<0.07	<0.04	19.7	<0.01	<0.03	<0.08
S5	08/24/94	<0.07	<0.07	<0.04	22.4	<0.01	<0.03	<0.08
S10	08/24/94	<0.07	<0.07	<0.04	19.2	<0.01	<0.03	<0.08
S21	08/24/94	<0.07	<0.07	<0.04	21.3	<0.01	<0.03	<0.08
S22	08/24/94	<0.07	<0.07	<0.04	20	<0.01	<0.03	<0.08
FB	08/24/94	<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.08
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.08
BLANK		<0.07	<0.07	<0.04	<0.1	<0.01	<0.03	<0.08
USGS T107		0.256	<0.07	0.135	12.6	0.017	<0.03	<0.08
USGS T117		0.099	<0.07	0.144	21.9	<0.01	<0.03	<0.08
USGS T117		0.111	<0.07	0.146	22.6	<0.01	<0.03	<0.08

WELL	DATE	Cu	Fe	Mg	Mn	Mo	Na	Ni
M3	08/24/94	<0.01	1.06	5.4	0.2358	<0.01	3.37	<0.02
M8	08/24/94	<0.01	8.15	4.67	0.3581	0.011	3.77	<0.02
M9	08/24/94	<0.01	0.414	5.93	0.0629	<0.01	3.36	<0.02
M11	08/24/94	<0.01	0.497	5.94	0.0748	<0.01	3.39	<0.02
M12	08/24/94	<0.01	0.702	6.61	0.3981	<0.01	3.59	<0.02
M14	08/24/94	<0.01	1.24	6	0.096	<0.01	3.56	<0.02
M15	08/24/94	<0.01	<0.03	7.67	<0.005	<0.01	3.76	<0.02
M16	08/24/94	<0.01	4.23	7.01	0.0976	<0.01	3.98	<0.02
M17	08/24/94	<0.01	5.17	12.7	0.1718	<0.01	4.31	<0.02
S1	08/24/94	<0.01	<0.03	7	<0.005	<0.01	4.17	<0.02
S2	08/24/94	<0.01	<0.03	1.43	<0.005	<0.01	1.69	<0.02
S3	08/24/94	<0.01	<0.03	6.14	<0.005	<0.01	3.77	<0.02
S5	08/24/94	<0.01	<0.03	10.2	<0.005	<0.01	3.87	<0.02
S10	08/24/94	<0.01	<0.03	6.06	<0.005	<0.01	3.69	<0.02
S21	08/24/94	<0.01	<0.03	9.45	<0.005	<0.01	3.82	<0.02
S22	08/24/94	<0.01	<0.03	6.34	<0.005	<0.01	3.78	<0.02
FB	08/24/94	<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
BLANK		<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
BLANK		<0.01	<0.03	<0.1	<0.005	<0.01	<0.1	<0.02
USGS T107		0.0308	0.05	2.18	0.0522	0.016	22.7	0.038
USGS T117		<0.01	0.47	10.3	0.2367	0.012	22	<0.02
USGS T117		<0.01	0.484	10.5	0.2437	<0.01	22.1	<0.02

August 24, 1994 Monitoring Well Sampling

WELL	DATE	P	Pb	Si	Sr	Ti	Zn	K
M3	08/24/94	<0.2	<0.1	6.52	<0.05	<0.05	<0.005	<1.5
M8	08/24/94	0.24	<0.1	8.77	<0.05	<0.05	<0.005	<1.5
M9	08/24/94	<0.2	<0.1	6.29	<0.05	<0.05	<0.005	<1.5
M11	08/24/94	<0.2	<0.1	6.33	<0.05	<0.05	<0.005	<1.5
M12	08/24/94	<0.2	<0.1	6.72	<0.05	<0.05	<0.005	<1.5
M14	08/24/94	<0.2	<0.1	6.53	<0.05	<0.05	<0.005	<1.5
M15	08/24/94	<0.2	<0.1	6.82	<0.05	<0.05	<0.005	<1.5
M16	08/24/94	0.29	<0.1	7.34	<0.05	<0.05	<0.005	1.86
M17	08/24/94	<0.2	<0.1	9.85	0.0701	<0.05	<0.005	<1.5
S1	08/24/94	<0.2	<0.1	4.94	<0.05	<0.05	<0.005	<1.5
S2	08/24/94	<0.2	<0.1	4.87	<0.05	<0.05	<0.005	<1.5
S3	08/24/94	<0.2	<0.1	4.63	<0.05	<0.05	<0.005	<1.5
S5	08/24/94	<0.2	<0.1	6.04	<0.05	<0.05	<0.005	<1.5
S10	08/24/94	<0.2	<0.1	4.38	<0.05	<0.05	<0.005	<1.5
S21	08/24/94	<0.2	<0.1	5.9	<0.05	<0.05	<0.005	<1.5
S22	08/24/94	<0.2	<0.1	4.61	<0.05	<0.05	<0.005	<1.5
FB	08/24/94	<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
BLANK		<0.2	<0.1	<0.1	<0.05	<0.05	<0.005	<1.5
USGS T107		<0.2	<0.1	3.91	0.0589	<0.05	0.0854	<1.5
USGS T117		0.25	<0.1	5.8	0.2504	<0.05	0.1906	1.841
USGS T117		0.34	<0.1	5.91	0.2542	<0.05	0.195	2.004

WELL	DATE	T	D.O.	pH	ALK	Cl	NO3	SO4
M3	08/24/94	15.5	0.6	6.48	64	0.587	0.017	3.763
M8	08/24/94	14.8	4.1	6.52	72	0.674	0.055	<0.6
M9	08/24/94	12.1	0.2	6.72	72	0.68	0.003	3.876
M11	08/24/94				76	0.728	0.006	3.912
M12	08/24/94	12.3	1.1	6.8	74	0.847	0.052	4.431
M14	08/24/94	12.1	0.8	6.33	70	0.884	0.053	4.67
M15	08/24/94	11.4	2.6	6.53	84	0.976	0.087	5.522
M16	08/24/94	12.9	0.7	6.39	78	1.146	0.084	3.815
M17	08/24/94	12.8	0.9	6.48	152	0.756	0.043	0.712
S1	08/24/94	17.5		8.93	88	0.593	0.008	4.656
S2	08/24/94	12.9		7.27	14	0.354	0.007	3.618
S3	08/24/94	11.3		7.53	100	0.958	0.052	6.031
S5	08/24/94	13.7		8.06	68	0.72	0.006	4.565
S10	08/24/94	18.3		8.97	80	0.612	0.003	4.574
S21	08/24/94	11.5		7.42	82	0.937	0.038	5.785
S22	08/24/94	18.3		8.89	74	0.636	0.003	4.592

APPENDIX E

WELL LOGS

This appendix contains the available domestic well logs for wells used in this study.

039- 10N 17W 36 A

Form No. 603 (Rev. 7/76)

STATE OF MONTANA

File No. 19321-s 76E

GRANITE

White-Department

Department of Natural Resources and Conservation

039 WELL LOG REPORT D2

Gold-Driller

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name [illegible]

2. CURRENT MAILING ADDRESS
[illegible]
Missoula, Mt. [illegible]

3. PROPOSED USE X domestic (includes lawn and garden); ___ stock; ___ municipal; ___ industrial; ___ irrigation; ___ other (specify)

4. WELL LOCATION

NW NE SW SE

¼ ___ ¼ ___ ¼ NE ¼ Section 36
T. 10 (N) or S R. 17 E or (W)
OR, Lot ___ Block ___
Subdivision [illegible] Hip. Wds.
City ___ County Granite
Elevation ___ Accuracy: ___ ±10'; ___ ±50'; ___ ±100';

5. DRILLING METHOD ___ cable, ___ bored, ✓ forward rotary, ___ reverse rotary, ___ jetted, ___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
5"	6" I.D. 17 lb per ft.	+2½	98			

Was casing left open end? X Yes, ___ No
Was a packer or seal used? ___ Yes, X No
If so, what material
Was the well gravel packed? ___ Yes, X No
Was the well grouted? ___ Yes, X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter ___
12 in. above grade ___ other ___
(if other, specify)
Pump horsepower ___, pump type ___
Pump intake level ___ feet below land surface
Power (electric, diesel, etc.)

7. WATER LEVEL
Static water level ___ feet below land surface
If flowing, closed-in pressure ___ psi
___ gpm flow through ___ inch pipe
Controlled by: ___ valve, ___ reducers, ___ other
(if other, specify)

8. WELL TEST DATA ___ pump ___ bailer ✓ other
(if other, specify) [illegible]
Pumping level below land surface:
___ ft. after ___ hrs. pumping ___ gpm
___ ft. after ___ hrs. pumping ___ gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes ✓ No
If yes, how?

10. DATE STARTED [illegible]
DATE COMPLETED [illegible]

11. WELL LOG
Depth (ft.)

From	To	Formation
0	19	Clay & Gravel
19	56	Clay, Gravel & Boulders
56	97	Clay, Gravel, Broken Rock (small seams of water)
97	100	Broken Rock & Water

(use separate sheet if necessary)

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

5/21/78
Date

[illegible] Drilling & Pump Supply
Firm Name

1522 S. 14th [illegible], Missoula, Mt. 59801
Address

Phil Balke
Signature

License No.

Well D2

Form No. 603 R10/79 RECEIVED 039 10N 16W 30 GRANITE C3A File No. 081598

D5 CODED JUN 12 1980

MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name: Louis W. Hammer

2. CURRENT MAILING ADDRESS
Rt. 1 Box 1458 Rock Cr. Rd
Clinton, Montana 59825

3. WELL LOCATION

¼ ¼ ¼ Section 30
Township 10 N N/S Range 16 W E/W
County Granite
Lot ____ Block ____
Subdivision Cert. Survey # 35
Well Elevation ____
Accuracy: ____ ±10'; ____ ±50'; ____ ±100';

4. DRILLING METHOD ____ cable, ____ bored, x forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
6"	6"ID 17 lb per ft.	+1½	59			

Was casing left open end? x Yes ____ No
Was a packer or seal used? ____ Yes x No
If so, what material ____
Was the well gravel packed? ____ Yes x No
Was the well grouted? ____ Yes x No
To what depth? ____
Material used in grouting ____
Well head completion: Pitless adapter ____
12 in. above grade x, other ____
(if other, specify) ____
Pump horsepower ____, pump type ____
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.) ____

6. WATER LEVEL
Static water level 23 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify) ____

7. WELL TEST DATA ____ pump ____ bailer x other
(if other, specify) Air Compressor
Pumping level below land surface:
59 ft. after 2 hrs. pumping 75 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If yes, how? ____

9. DATE STARTED April 30, 1980
DATE COMPLETED April 30, 1980

10. WELL LOG

Depth (ft.) From	To	Formation
0	8	Clay, Gravel, Boulders
		Concrete (fill)
8	26	Clay, Gravel & Boulders
26	35	Sand, Gravel & Cobblestones
35	59	Sand, Gravel, Cobblestones & Water

PB

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

June 9, 1980
Date

Camp Well Drilling & Pump Supply
Firm Name

1522 S. 14th W., Missoula, Montana 59801
Address

[signature] 7
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

M: 63400
WL - 52

DEPARTMENT COPY

Well D5

Form No. 603 (R 6-84)

039 JUN 30 1986

10N 16W 30 File No. Granite

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comple

028281

1. WELL OWNER
Name [illegible]

2. CURRENT MAILING ADDRESS
Box 792
[illegible] 59[illegible]

3. WELL LOCATION
County Granite
Township ____ N/S Range ____ E/W
___ ¼ ___ ¼ ___ ¼ Section ____
Lot 4 Block 1
Subdivision [illegible]

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ____

5. DRILLING METHOD ____ cable, ____ bored,
X forward rotary, ____ reverse rotary, ____ jetted,
____ other (specify) ____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
[illegible]	[illegible]	-1	51			

Was casing left open end? ✓ Yes ____ No
Was a packer or seal used? ____ Yes ✓ No
If so, what material ____
Was the well gravel packed? ____ Yes ✓ No
Was the well grouted? ____ Yes ✓ No
To what depth? ____
Material used in grouting ____
Well head completion: Pitless adapter ____ Yes ✓ No
Top of casing 12 in. or greater above grade X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
42 Degrees Fahrenheit
☐ Measured ☒ Estimated

8. WATER LEVEL
Static water level 15 feet below land surface
If flowing; closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers,
____ other, (specify) ____

9. WELL TEST DATA ____ pump ____ bailer
X other, (specify) Air
Pumping water level below land surface:
20 ft. after 1 hrs. pumping 50 gpm
____ ft. after ____ hrs. pumping ____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes ✓ No
If yes, how? ____

11. DATE COMPLETED 11-5-85

12. WELL LOG

Depth (ft.) From	To	Formation
0	15	[illegible]
15	51	[illegible] sand gravel

PB

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
11-5-85
Date
[illegible] Well Drilling Service
Firm Name
[illegible] Box [illegible]
Address
[illegible] 23
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING *HELENA, MONTANA 59620* *444-6610*

M: 63403

Well D6

D7

GW 2 Revised 1969

CODED

RECEIVED

039 T10N R16W-30 DAA

County Missoula Granite

(?)

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

— Developed after January 1, 1962 —

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller. Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner Frank Seitel

Address Rock Creek Lot # 2

For Administrator's Use
File
GW 1

Date well started Sept. 11, 1970

completed Sept. 11, 1970

Type of well Drilled (Dug, driven, bored or drilled)

Equipment used Churn Drill (Churn drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	Perforations: Slot Size	From (Feet)	To (Feet)
6" ID	6" ID	[illegible]	31			
	17# [illegible]	above				
	[illegible]					

Static water level [illegible] ft.*

Pumping water level [illegible] ft.*

at [illegible] gallons per minute,

measured 5 minutes after pumping began.

*Measured from ground level.

Well developed by Compressor

for 1 hours.

Power _____ Pump _____ HP

Remarks: (Gravel packing, cementing, packers, type of shutoff)

LOT 2 - BLOCK 1

___ ¼ ___ ¼ Sec. 30

T. 10 N R. 16 W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature CAMP WELL DRILLING & PUMP SUPPLY

Driller's Address 1522 S. 14th W., Missoula, Montana

Glenn Camp LICENSE NO. 7

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground _____ (Elev. above sea level)

From (Feet)	To (Feet)	
0	1	Sand and Gravel
1	18	Clay, Gravel & Cobblestones
18	31	Sand, Gravel & Water

31 Show exact depth of bottom

Well D7

D8A

039 T10N R14W-19DB

CODED

GW 1 Revised 1969 STATE PUBLISHING COMPANY

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner Adam Mishnevich

Address P. O. Box 129

Clinton, Montana

Date well started March 27, 1972

completed March 27, 1972

For Administrator's Use
File
GW 1

Type of well Drilled (Dug, driven, bored or drilled)

Equipment used Churn Drill (Cable drill, rotary or other)

Water Use: Domestic [X] Municipal [ ] Stock [ ] Irrigation [ ]

Industrial [ ] Drainage [ ] Other [ ]* Garden/Lawn [ ]

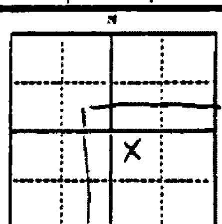
*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	Perforations: Kind Size	From (Feet)	To (Feet)
6" I.D.	6" I.D. 17 lb per ft.	1'5" above g.l.	39'		none	

N



W E

Lot 6 of HES291
NW¼ SE¼ Sec. 19
T. 10N N/S R. 14W E/W

Static water level 17 ft.*
Pumping water level 27 ft.*
at 100 gallons per minute,
measured 1 minutes after pumping began.
*Measured from ground level.
Well developed by [illegible]
for 1 hours.
Power Does not Pump apply HP
Remarks: (Gravel packing, cementing, packers, type of shutoff)

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature [signature] ~~[illegible] Drilling & Pump Supply~~

Driller's Address 1522 S. 14th W., Missoula, Montana 59801

LICENSE NO. 7

County Missoula
GRANITE

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level) 3840

From (Feet)	To (Feet)	
0	10	Sandy Clay & Cobblestones
10	18	Clay & Gravel
18	34	Clay, Gravel & Water
34	39	Sand Gravel & Water

39' Show exact depth of bottom

Well D8A

D9

Form No. 603 (Rev. 7/76)

BUTTE 039

STATE OF MONTANA

File No. Granite

Department of Natural Resources and Conservation

WELL LOG REPORT

028279

Gold-Driller

State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name Ronald Baker

2. CURRENT MAILING ADDRESS
Missoula, Montana 5980

3. PROPOSED USE: domestic (includes lawn and garden), stock, municipal, industrial, irrigation, other (specify)

4. WELL LOCATION

Subdivision Hanson Ranchettes

County Granite

5. DRILLING METHOD

6. WELL CONSTRUCTION AND COMPLETION

Was casing left open end? Yes No
Was a packer or seal used? Yes XX No
If so, what material?
Was the well gravel packed? Yes XX No
Was the well grouted? Yes XX No
To what depth?
Material used in grouting
Well head completion: Pitless adapter, 12 in. above grade, other
(If other, specify)
Pump horsepower, pump type
Pump intake level feet below land surface
Power (electric, diesel, etc.)

7. WATER LEVEL
Static water level 40 feet below land surface
If flowing, closed-in pressure psi
gpm flow through inch pipe
Controlled by: valve, reducers, other
(If other, specify)

8. WELL TEST DATA: pump, bailer XX other
(If other, specify) compressor
Pumping level below land surface:
142 ft. after 3 hrs. pumping 25 gpm
ft. after hrs. pumping gpm

9. WAS WELL PLUGGED OR ABANDONED? Yes XX No
If yes, how?

10. DATE STARTED March 16, 1978
DATE COMPLETED March 18, 1978

11. WELL LOG

From	To	Formation
0	1	Topsoil
1	42	Sand, gravel and clay
42	157	Sand, gravel, clay and
		water

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge. March 20, 1978

C.K.C. Drilling
Firm Name

P.O. Box 118, Frenchtown, MT 598
Address

135
Signature / License No.

Well D9

Form No. 603 (R 2-85)

WELL LOG REPORT

File No. ______

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

D10

1. WELL OWNER
Name JOSEPH P. PELTIER

2. CURRENT MAILING ADDRESS
Box 1363
Clinton, MT 59825

3. WELL LOCATION
NW ¼ NE ¼ ____ ¼ Section 17
Township 10 N N/S Range 16 W E/W County Granite
Gov't Lot ______, or Lot ______ Block ______
Subdivision Name ______
Tract Number ______

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ______

5. TYPE OF WORK:
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☒
Reconditioned ☐ Rotary ☒ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from g.l. ft. to 60'8" ft.
Dia. ______ in. from ______ ft. to ______ ft.
Dia. ______ in. from ______ ft. to ______ ft.

7. CONSTRUCTION DETAILS:
Casing: Steel Dia. 6" ID from +1½ ft. to 60'8" ft.
Threaded ☐ Welded ☒ Dia. ______ from ______ ft. to ______ ft.
Type ______ Wall Thickness .250
Casing: Plastic Dia. ______ from ______ ft. to ______ ft.
Weight ______ Dia. ______ from ______ ft. to ______ ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used ______
Size of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
SCREENS: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Dia. ______ Slot size ______ from ______ ft. to ______ ft.
Dia. ______ Slot size ______ from ______ ft. to ______ ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.
GROUTED: To what depth? 20 ft.
Material used in grouting bentonite surface seal

8. WELL HEAD COMPLETION:
Pitless Adapter ☐ Yes ☐ No

9. PUMP (If installed)
Manufacturer's name ______
Type ______ Model No. ______ HP. ______

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air x Pump ______ Bailer ______
b) Static water level immediately before testing 34 ft. If flowing; closed-in pressure ______ psi. ______ gpm.
Flow controlled by: ______ valve, ______ reducers, other (specify) ______
c) Depth at which pump is set for test 50
d) The pumping rate: 100 * gpm.
e) Pumping water level 50 ft. at 1 hrs. after pumping began.
f) Duration of test: Pumping time 1 hrs.
g) Recovery time ______ hrs.
h) Recovery water level 34 ft. at ______ hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

12. WELL LOG

Depth (ft.) From	To	Formation
0	36	Clay, Sand, Gravel & Boulders
36	65	Clay, Sand, Gravel , Boulders & Water
		* anticipated yield! under 100 gpm

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED June 15, 1990

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

June 19, 1990
Date

CAMP WELL DRILLING & PUMP SUPPLY
Firm Name

1522 S. 14th W., Missoula, MT 59801
Address

[signature] 7
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

Well D10

Form No. 603 (R 8-84)

File No. ____

WELL LOG REPORT D11

State law requires that this form be filed by the water well driller within 60 days after completion.

028278

1. WELL OWNER
Name: PATRICIA RYAN

2. CURRENT MAILING ADDRESS
69 W 37th Ave.
San Mateo, CA 94403

3. WELL LOCATION
County: Granite
Township: 10 N/S Range: 16 E/W
¼ ¼ ¼ Section
Lot: 13-17 Block
Subdivision: Lan Ranchetts

4. PROPOSED USE Domestic ☐ Stock ☐ Irrigation ☐
Other ☐ specify

5. DRILLING METHOD ____ cable, ____ bored, X forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) Driven

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen: Kind Size	From (feet)	To (feet)
6"	6"ID 17 lb per ft.	+2'3"	60'6"	none		

Was casing left open end? X Yes ____ No
Was a packer or seal used? ____ Yes X No
If so, what material X
Was the well gravel packed? ____ Yes ____ No
Was the well grouted? X Yes ____ No
To what depth? 20
Material used in grouting: bentonite surface seal
Well head completion: Pitless adapter ____ Yes ____ No
Top of casing 12 in. or greater above grade X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
45 Degrees Fahrenheit
☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level 12 feet below land surface
If flowing; closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers, ____ other, (specify)

9. WELL TEST DATA ____ pump ____ bailer
✓ other, (specify) Air Compressor
Pumping water level below land surface:
50 ft. after 1 hrs. pumping 100 gpm
____ ft. after ____ hrs. pumping ____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If yes, how?

11. DATE COMPLETED August 31, 1987

12. WELL LOG ANTICIPATED YIELD LESS THAN 100

Depth (ft.) From	To	Formation
0	3	Black Dirt & Gravel
3	17	Clay, Sand & Gravel
17	25	Sand, Gravel & Water
25	27	Clay & Gravel
27	44	Sand, Gravel & Water
44	49	Sand & Water
49	59	Brown Sand, Gravel & Water
59	60	Gravel & Water

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
September 2, 1987
Date
CAMP WELL DRILLING & PUMP SUPPLY
Firm Name
1522 S. 14th W., Missoula, MT 59801
Address
[signature] 7
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

Well D11

Butte 10N16W18 D13 GRANITE

Form No. 603 (R 2-85)

WELL LOG REPORT

File No. ____

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name [illegible]

2. CURRENT MAILING ADDRESS
P.O. Box [illegible]
[illegible]

3. WELL LOCATION
___ ¼ ___ ¼ ___ ¼ Section ___
Township ___ N/S Range ___ E/W County [illegible]
Gov't Lot ___ or Lot [illegible] Block ___
Subdivision Name [illegible]
Tract Number ___

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ___

5. TYPE OF WORK:
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☒
Reconditioned ☐ Rotary ☒ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. [illegible] in. from [illegible] ft. to [illegible] ft.
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.

7. CONSTRUCTION DETAILS:
Casing: Steel Dia. [illegible] from [illegible] ft. to [illegible] ft.
Threaded ☐ Welded ☒ Dia. ___ from ___ ft. to ___ ft.
Type ___ Wall Thickness [illegible]
Casing: Plastic Dia. ___ from ___ ft. to ___ ft.
Weight ___ Dia. ___ from ___ ft. to ___ ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used ___
Size of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
SCREENS: Yes ☐ No ☐
Manufacturer's Name ___
Type ___ Model No. ___
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel ___
Gravel placed from ___ ft. to ___ ft.
GROUTED: To what depth? 20 ft.
Material used in grouting [illegible]

8. WELL HEAD COMPLETION:
Pitless Adapter ☐ Yes ☐ No

9. PUMP (if installed)
Manufacturer's name ___
Type ___ Model No. ___ HP ___

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air ___ Pump ___ Bailer ___
b) Static water level immediately before testing ___ ft. If flowing; closed-in pressure ___ psi. ___ gpm.
Flow controlled by: ___ valve, ___ reducers, other. (specify) ___
c) Depth at which pump is set for test ___
d) The pumping rate: [illegible] gpm.
e) Pumping water level ___ ft. at ___ hrs. after pumping began.
f) Duration of test: Pumping time ___ hrs.
g) Recovery time ___ hrs.
h) Recovery water level ___ ft. at ___ hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes [illegible] No
If yes, how? ___

12. WELL LOG

Depth (ft.) From	To	Formation
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
		[illegible]
[illegible]	[illegible]	[illegible]
		[illegible]

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED [illegible]

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

[illegible]
Date

[illegible]
Firm Name

[illegible]
Address

[signature]
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

Well D13

Butte 10 N 16 W 08 B D14 GRANITE

Form No. 603 (R 2/87)

WELL LOG REPORT

File No. 055516

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name: ALTON OLSON

2. CURRENT MAILING ADDRESS
Rt 1 Box 1330
Clinton, MT 59825

3. WELL LOCATION
NW ¼ ___ ¼ ___ ¼ Section 8
Township 10 N N/S Range 16 W E/W County Granite
Gov't Lot ___ or Lot ___ Block ___
Subdivision Name ___
Tract Number ___

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify ___

5. TYPE OF WORK:
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from 0 ft. to 63 ft.
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.

7. CONSTRUCTION DETAILS:
Casing: Steel Dia. 6" ID from +1½ ft. to 59'2 ft.
Threaded ☐ Welded ☒ Dia. ___ from ___ ft. to ___ ft.
Type ___ Wall Thickness .250
Casing: Plastic Dia. ___ from ___ ft. to ___ ft.
Weight ___ Dia. ___ from ___ ft. to ___ ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used ___
Size of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
SCREENS: Yes ☐ No ☒
Manufacturer's Name ___
Type ___ Model No. ___
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel ___
Gravel placed from ___ ft. to ___ ft.
GROUTED: To what depth? 20 ft.
Material used in grouting: bentonite surface seal

8. WELL HEAD COMPLETION:
Pitless Adapter ☐ Yes ☐ No

9. PUMP (if installed)
Manufacturer's name ___
Type ___ Model No. ___ HP ___

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air X Pump ___ Bailer ___
b) Static water level immediately before testing 18 ft. If flowing; closed-in pressure ___ psi ___ gpm.
Flow controlled by: ___ valve, ___ reducers, other (specify) ___
c) Depth at which pump is set for test 50
d) The pumping rate 100* gpm.
e) Pumping water level 50 ft. at 1 hrs. after pumping began.
f) Duration of test: Pumping time 1 hrs.
g) Recovery time ___ hrs.
h) Recovery water level 18 ft. at ___ hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how? ___

12. WELL LOG

From (ft)	To (ft)	Formation
0	23	Clay, Sand & Gravel
23	39	Clay, Sand, Gravel & Water
39	42	Clay
42	63*	Clay, Sand, Gravel & Water
		* anticipated yield under 100 gpm

PB

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED August 21, 1991

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Date: August 22, 1991
Firm name: CAMP WELL DRILLING & PUMP SUPPLY
Address: 1522 S. 14th W. Missoula, MT 59801
Signature: Phil Bohlke License No. 7

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

Well D14

GW 2 Revised 1966 CODED D15 RECEIVED AUG 30 1971 Montana Bureau ... 9T 10N R16W - 8CB

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner [illegible]

Address 1739 - PHILLIPS

MISSOULA, MONT 59801

For Administrator's Use
File
GW 1

Date well started JUNE 24, 1971

completed JUNE 25, 1971

Type of well DRILLED (Dug, driven, bored or drilled)

Equipment used CABLE (Cable drill, rotary or other)

Water Use: Domestic [X] Municipal [ ] Stock [ ] Irrigation [ ] Industrial [ ] Drainage [ ] Other [ ]* Garden/Lawn [ ]

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	Perforations: Size	From (Feet)	To (Feet)
6" I.D.	6-5/8" OD 17 lbs. 1/4" side wall	ground level	37 ft.	none	none	none

Static water level 18 ft.*
Pumping water level 30 ft.*
at 40 gallons per minute,
measured 90 minutes after pumping began.
*Measured from ground level.
Well developed by test pump
for 3 hours.
Power gas Pump 1½ HP
Remarks: (Gravel packing, cementing, packers, type of shutoff)

ROCK CREEK
LOT 1 of LOT 10

Location of well: N W¼ SW¼ Sec. 8
T. 10 N N/S R. 16 W E/W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature Kenneth L. Williams

Driller's Address 1258 So. 5th W., MISSOULA, MONT.

LICENSE NO. 151

County GRANITE

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
0'	5'	tan sandy clay & silt
5'	16'	tan clay, gravel, sand & boulders
16'	29'	surface water, sand & gravel
29'	33'	tan clay, sand & gravel
33'	37'	sand, gravel & water

37 ft. Show exact depth of bottom

Well D15

D16

GW 2 Revised 1969

CODED

RECEIVED FEB 28 1972 Montana Bureau of Mines and Geology

039 T10N R16W-7

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located; last copy to be retained by driller. Please answer all questions; if not applicable, so state; otherwise the form may be returned.

Owner [illegible]

Address Box 474 Milltown, [illegible] Montana

For Administrator's Use: File [illegible] GW [illegible]

Date well started Nov. 6, 1971

completed Nov. 13, 1971

Type of well Drilled (Dug, driven, bored or drilled)

Equipment used Churn drill (Churn drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Other ☐ Garden/Lawn ☐

*Describe USE: If used for irrigation, industrial, drainage or other: Explain, state number of acres and location or other data (i.e. Lot, Block and Addition) [illegible]

ESTIMATED ANNUAL WITHDRAWAL [illegible] gallons

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Static water level [illegible]

Pumping water level 20 ft.

at 25 [illegible] gallons per minute

measured 20 minutes after pumping began [illegible]

*Measured from ground level.

Well developed by Compressor for [illegible] hours.

Power [illegible] Pump [illegible] HP

Remarks: (Gravel packing, cementing, packers, type of shutoff) [illegible]

Lot 10 [illegible]
SE¼ SE¼ Sec. 7
T 10 (N) R 16 (W)

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature Charles [illegible]

Driller's Address C.K.C. Drilling, P.O. Box 670, Missoula, Montana

LICENSE NO 185

County Granite

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground [illegible] (Elev. above sea level)

From (Feet)	To (Feet)	
0	12	Cobblestones, gravel and clay
12	16	Sand, gravel and clay
16	20	Sand, gravel and water
20	32	Sand, gravel and clay
32	36	Sand, gravel and water

36 ft. Show exact depth of bottom

Well D16

uHe D18A 039 10N 16W 08 CBC

RECEIVED
Granite

Form No. 603 (R 2-89)

WELL LOG REPORT

File No: JUL 12 1990

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion of 075570 MISSL

1. WELL OWNER
Name William G. & Joyce L. Bethke

2. CURRENT MAILING ADDRESS
H.C. 85 Box 1310
Clinton, Montana 59825

3. WELL LOCATION
SW ¼ NW ¼ SW ¼ Section 8
Township 10 N/S Range 16 W E/W County Granite
Gov't Lot ES000176 or Lot 15 of 19 Block
Subdivision Name Rock Creek Acres
Tract Number

4. PROPOSED USE: Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify

5. TYPE OF WORK:
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from 8 ft. to 29 ft.
Dia. in. from ft. to ft.
Dia. in. from ft. to ft.

7. CONSTRUCTION DETAILS:
Casing: Steel Dia. 6" from 1½up ft. to 29 ft.
Threaded ☐ Welded ☒ Dia. from ft. to ft.
Type A-53B Wall Thickness .250
Casing: Plastic Dia. from ft. to ft.
Weight Dia. from ft. to ft.
PERFORATIONS: Yes ☐ No ☒
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
SCREENS: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Dia. Slot size from ft. to ft.
Dia. Slot size from ft. to ft.
GRAVEL PACKED: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.
GROUTED: To what depth? 18 ft.
Material used in grouting bentonite filled to G/L

8. WELL HEAD COMPLETION:
Pitless Adapter: ☐ Yes ☒ No

9. PUMP (if installed)
Manufacturer's name
Type Model No. HP

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air Pump XX Bailer
b) Static water level immediately before testing 5½ ft. If flowing; closed-in pressure psi. gpm.
Flow controlled by: valve, reducers,
other. (specify)
c) Depth at which pump is set for test 20
d) The pumping rate 65 gpm.
e) Pumping water level 11 ft. at 2 hrs. after pumping began.
f) Duration of test: Pumping time 2 hrs.
g) Recovery time 1 hrs.
h) Recovery water level 5½ ft. at 1 hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.
NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? Yes X No
If yes, how?

12. WELL LOG

From (ft.)	To (ft.)	Formation
0	8	Old 12" hole
8	29	Sand, gravel, boulders and water

PE

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED April 6, 1990

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

April 30, 1990
Date
C.K.C. Drilling
Firm Name
10475 Hiway 10 W., Missoula, MT
Address
Charles F Hellenstein 185
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

Well D18A

Butte 039 10N 16W 07 DAD

D17

RECEIVED Granite

JUL 12 1990

MISSOULA

Form No. 603 (R 7-88)

WELL LOG REPORT

File No. 075567

State law requires that the Bureau's copy be filed by the water well driller within 60 days after completion.

1. WELL OWNER
Name Henry Childers

2. CURRENT MAILING ADDRESS
800 Kensington, Suite 109
Missoula, Montana 59801

3. WELL LOCATION
SE ¼ NE ¼ SE ¼ Section 7
Township 10 N/S Range 16 W E/W County Granite
Gov't Lot ___ or Lot 19 of 10 Block ___
Subdivision Name Rock Creek Acres
Tract Number ___

4. PROPOSED USE: Domestic X Stock ☐ Irrigation ☐
Other ☐ specify ___

5. TYPE OF WORK:
New well X Method: Dug ☐ Bored ☐
Deepened ☐ Cable X Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

6. DIMENSIONS: Diameter of Hole
Dia. 6 in. from 0 ft. to 39 ft.
Dia. ___ in. from ___ ft. to ___ ft.
Dia. ___ in. from ___ ft. to ___ ft.

7. CONSTRUCTION DETAILS:
Casing: Steel Dia. 6" from 1½ up to 39½ ft.
Threaded ☐ Welded X Dia. ___ from ___ ft. to ___ ft.
Type A-53B Wall Thickness .250
Casing: Plastic Dia. ___ from ___ ft. to ___ ft.
Weight ___ Dia. ___ from ___ ft. to ___ ft.
PERFORATIONS: Yes ☐ No X
Type of perforator used ___
Size of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
SCREENS: Yes ☐ No X
Manufacturer's Name ___
Type ___ Model No. ___
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
Dia. ___ Slot size ___ from ___ ft. to ___ ft.
GRAVEL PACKED: Yes ☐ No X Size of gravel ___
Gravel placed from ___ ft. to ___ ft.
GROUTED: To what depth? 18 ft.
Material used in grouting bentonite

8. WELL HEAD COMPLETION:
Pitless Adapter X Yes ☐ No

9. PUMP (if installed)
Manufacturer's name ___
Type ___ Model No. ___ HP ___

10. WELL TEST DATA
The information requested in this section is required for all wells. All depth measurements shall be from the top of the well casing.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air ___ Pump XX Bailer ___
b) Static water level immediately before testing 9 ft. If flowing: closed-in pressure ___ psi, ___ gpm.
Flow controlled by: ___ valve, ___ reducers, other (specify) ___
c) Depth at which pump is set for test 20'
d) The pumping rate: 35 gpm.
e) Pumping water level 10 ft. at 2 hrs. after pumping began.
f) Duration of test: Pumping time 2 hrs.
g) Recovery time 1 hrs.
h) Recovery water level 9 ft. at 1 hrs. after pumping stopped.

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes XX No
If yes, how? ___

12. WELL LOG

Depth (ft.) From	To	Formation
0	2	Topsoil
2	12	Sand, gravel and clay
12	39	Sand, gravels, boulders, and water

ATTACH ADDITIONAL SHEETS IF NECESSARY

13. DATE COMPLETED April 3, 1990

14. DRILLER/CONTRACTOR'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

April 30, 1990
Date

C.K.C. Drilling
Firm Name

10475 Hiway 10 W., Missoula, MT
Address

Charles J. Hollenstein 185
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610
DNRC

Well D17

D20

WELL LOG REPORT

File No. ____________

State law requires that this form be filed by the water well driller within 60 days after completion

031448

1. WELL OWNER
Name: Mr. & Mrs. Donald Kane

2. CURRENT MAILING ADDRESS [illegible] Road House Road
Fairfield, Connecticut 06430

3. WELL LOCATION
County: Granite
Township ______ N/S Range ______ E/W
______ ¼ ______ ¼ Section [illegible]
Lot: 1 Block ______
Subdivision: Rock Creek Acres
Tract Number ______

4. PROPOSED USE Domestic: X Stock ☐ Irrigation ☐
Other ☐ specify ______

5. DRILLING METHOD ______ cable, ______ air rotary, X forward rotary, ______ reverse rotary, ______ jetted, ______ other (specify) Driven

6. WELL LOG

Depth (ft.) From	To	Formation
0	27	Clay, Gravel & Cobblestones
27	[illegible]	Clay, Gravel, Cobblestones
		Sand & Water

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)	Perforations and/or Screen: Slot Size	From (feet)	To (feet)
6"	6" ID 1530 PSI	+1½	60'			

Was casing left open end? X Yes ______ No
Was a packer or seal used? ______ Yes XXX No
If so, what material ______
Was the well gravel packed? ______ Yes X No
To what depth was the well grouted? 20 ft.
Material used in grouting: bentonite surface seal
Well head completion: Pitless adapter ______ Yes ______ No
Top casing 18 in. or greater above grade X Yes ______ No

8. WELL TEST DATA

The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.

All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:

a) Air X Pump ______ Bailer ______
b) Static water level immediately before testing [illegible] ft. If flowing; closed-in pressure ______ psi ______ gpm
Controlled by: ______ valve, ______ reducers, ______ other (specify) ______
c) Depth at which pump is set for test [illegible]
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping) 100+ gpm
e) Maximum drawdown during the test [illegible] ft
f) Duration of test: Pumping time 1 hrs
Recovery time [illegible] hrs
g) Recovery water level [illegible] ft
Amount of time after pumping recovery level water data was taken ______ hrs

Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.

NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

9. WAS WELL PLUGGED OR ABANDONED? ______ Yes X No
If yes, how? ______

10. DATE COMPLETED October 22, 1987

11. DRILLER/CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

November 4, 1987
Date

CAMP WELL DRILLING & PUMP SUPPLY
Firm Name

1522 S. 14th W., Missoula, MT 59801
Address

Phil Bolke 7
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

Well D20