Ground Water Quality Technical Report No. 7

An Evaluation of Bacteria in Ground Water Near Mountain Home, Elmore County, Idaho

Idaho Division of Environmental Quality
Southwest Idaho Regional Office
March 1996

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Prepared by:

Rob Howarth

Idaho Division of Environmental Quality
Southwest Idaho Regional Office
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Abstract

A reconnaissance ground water study has been conducted in the Mountain Home vicinity in response to complaints about bacteria contamination in wells. The Central District Health Department began reporting bacterial contamination incidents to the Idaho Division of Environmental Quality, Southwest Idaho Regional Office in January, 1993.

Potential sources of bacteria contamination include:

! subsurface sewage disposal systems (septic tanks and drain fields).

! leaking municipal sewer lines.

! contaminated surface water (e.g., natural streams, irrigation water, storm water runoff).

! confined animal rearing areas.

This investigation encompassed and area of approximately 36 square miles with downtown Mountain Home located in the south central part of the area. Six ground water samples and four surface water samples were collected and analyzed for bacteria and other chemical parameters in an attempt to evaluate the relationship between surface water and persistent bacteria contamination in ground water. Ground water samples were obtained from domestic drinking water wells and from monitoring wells near the abandoned Mountain Home landfill. Results indicate that surface water is not directly hydraulically connected to the domestic wells sampled.

Existing literature and well drillers' reports highlight the vulnerability of Mountain Home's aquifer system to contamination. Some general areas of concern include:

! disposal of storm water in abandoned gravel quarries or other subsurface disposal without treatment.

! dense residential development reliant on individual subsurface sewage disposal systems.

! leaking municipal sewer lines.

! solid waste disposal in abandoned gravel quarries.

! improperly constructed or abandoned wells.

Introduction

A reconnaissance ground water quality study was conducted in the Mountain Home vicinity in response to complaints about bacteria contamination in wells. The Central District Health Department (CDHD) began reporting bacterial contamination incidents to the Idaho Division of Environmental Quality, Southwest Idaho Regional Office (DEQ) in January, 1993. Well water samples are routinely collected by CDHD as part of a mortgage survey requested by lending institutions when certain homes are sold. Mortgage survey water samples are typically analyzed for total coliform (TC) and fecal coliform (FC) bacteria. A seasonal discoloration of shallow ground water supplies in a localized area of Mountain Home was also reported to DEQ. This problem was reported during a period of intense snow melt during late January, 1993 and may be related to TC and FC contamination in some wells.

In 1992, CDHD began tracking the number of wells showing the presence of either TC or FC bacteria. Throughout 1992 and 1993, approximately 40 wells near Mountain Home failed the bacterial tests by exhibiting the presence of either TC or FC bacteria. Bacterial contamination occurred in both shallow (e.g., 42 feet total depth) and deep (e.g., 550 total depth) domestic wells. Some wells continue to produce positive bacteria results even after chlorine disinfection procedures are followed (Bob Fox, personal communication, 1993).

TC bacteria is generally considered an indicator of pathonogenic ground water contamination. While TC bacteria themselves may not represent a public health concern, other bacteria and viruses associated with TC bacteria represent serious health concerns. The potential correlation between illnesses and water-borne pathogens in the study area is beyond the scope of this study and has not been investigated.

Potential sources of bacteria contamination include:

- subsurface sewage disposal systems (septic tanks and drain fields).
- leaking municipal sewer lines.
- contaminated surface water (e.g., natural streams, irrigation water, storm water runoff).
- confined animal rearing areas.

The impact from each of these sources can be worsened by poor well construction practices. Wells with poor seals allow easily-contaminated, near-surface water to percolate to deeper aquifers.

Purpose and Objectives

The purpose of this report is to present the results of limited ground water and surface water sampling conducted near Mountain Home in the summer of 1993 by DEQ. General hydrogeological characteristics of the study area were determined through a review of existing literature.

The main objective of this investigation is to provide information to the general public and to planning agencies regarding the most likely source(s) of bacterial contamination in the area's ground water. A secondary objective is to provide comments and recommendations as a means of promoting prevention of further ground water degradation from any anthropogenic contaminant.

Literature Review

A significant amount of published information related to ground water in Elmore County and Mountain Home exists. Previous studies describe the area's geology, hydrogeology, ground water and surface water chemistry, and water supply potential. Many of these investigations resulted from concern over increasing development of ground water for agricultural irrigation.

Ralston and Chapman (1968) described the geology and ground water occurrence in the Mountain Home area with emphasis on the effects of increasing ground water development on the hydrologic system. Later, Ralston and Chapman (1970) presented the findings of an investigation of the geology, ground water occurrence, and ground water chemistry and temperature in a 940 square mile area of southern Ada and western Elmore Counties.

Investigations of ground water level declines due to intense development were reported by Young (1977), Norton et al., (1982), and Young and Norvitch (1984). Young's report also included an evaluation of ground water chemistry and isotopic analyses as a means of predicting recharge areas.

Detailed information on ground water quality was reported by Parliman and Young (1990) and by Parliman (1982). Young et al. (1992) provided information on seasonal changes in ground water quality and on ground water levels and flow direction.

A vast set of literature describing the physical/chemical characteristics, persistence, fate, and transport of microbial contaminants also exists. A quarterly report published by the National

Governors' Association (1995) summarized a survey of wells performed in nine midwestern states. The survey included an evaluation of bacteria, nitrate, and the pesticide, atrazine.

Samples were collected from 6,500 wells in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. Approximately 41% of the samples were found to be contaminated with TC bacteria. In addition 14% of the samples contained nitrate above the Safe Drinking Water Act maximum contaminant level (MCL) of 10 milligrams per liter (mg/l). A much smaller percentage of samples, 0.25%, contained atrazine at concentrations greater than the Safe Drinking Water Act MCL of 0.003 mg/l. The report concluded that the cause of the TC bacteria contamination and a means of preventing it will be difficult to discern, even with the large data set. The investigators did find that older wells are more likely to be contaminated than newer wells. The average age of the wells in the midwestern survey was 30 to 35 years. It is surmised that older well construction standards may not be as adequate as newer standards in preventing ground water contamination.

Mink et al. (1975) provided a summary of an early literature review and a study of the impacts of subsurface sewage disposal systems in Ada and Canyon Counties. Their study was based on water samples collected from 16 piezometers in five developed areas (subdivisions) in the Boise Basin. The investigation found that "…widespread ground water contamination is probably occurring in those areas where water tables penetrate the areas of influence of septic tank drain fields."

Key investigation results or characteristics of microbial contamination reported in the literature are summarized as follows:

- The average volume of liquid-transported wastes received by a typical subsurface sewage disposal system is approximately 42 gallons per person per day (Wilhelm et al., 1994).

- Under conditions of inadequate design, construction, siting, operation, and maintenance, subsurface sewage disposal systems are the most frequently reported source of ground water contamination (Bicki et al., 1984).

- From 1946 to 1977, there were 264 disease outbreaks and 62,273 cases of illness related to contaminated ground water in the United States. Subsurface sewage disposal systems were implicated in 42% of the outbreaks and 71% of the illnesses (Bicki et al., 1984).

! Bacteria range in size from 0.2 to five microns and viruses from 0.005 to 0.1 microns; the pore entrance size of aquifer materials is 0.7 to seven microns for fine- to coarse-grained silts, 24 to 240 microns for fine- to coarse-grained sands, and 720 to 7,200 microns for fine- to coarse-grained gravels (Vance, 1995).

! Bacteria removal from wastewater percolating through soil is inversely proportional to the particle size of the soil (Bicki et al., 1984).

! The use of indicator organisms such as TC or FC bacteria may be inaccurate in some cases because pathogens are not always present in feces. Therefore, the presence of fecal organisms (like FC and TC bacteria) in water does not necessarily indicate the presence of pathogens (Bicki et al., 1984).

! Bacteria migration is impeded by unsaturated soil conditions and enhanced by saturated conditions (Bicki et al., 1984).

! Factors affecting bacteria survival include soil moisture content, temperature, pH, and organic matter content. Conditions favorable to survival are high moisture content, low temperature, alkaline pH, and high organic matter content.

! Bacteria seldom survive longer than 10 days under adverse conditions. Survival may extend beyond 100 days under favorable conditions.

! Factors affecting bacteria transport include (Vance, 1995):

(1) **mechanical processes** such as filtration in the aquifer matrix.

(2) **adsorption processes**; bacteria have an overall negative charge on the surface of their cell wall; increasing the ionic strength of ground water increases bacterial capability to adhere to soil surfaces.

(3) **biological processes**; adhesion to an attachment surface is initially reversible given adequate shearing from ground water flow; irreversible binding takes place through the cellular production of exopolymers that anchor the cell to a binding surface.

! In fractured bedrock environments, the following conclusions are supported (Allen and Morrison, 1973):

(1) Percolating sewage effluent was observed to traverse a horizontal distance exceeding 100 feet; it is suspected that distances may exceed several hundred feet, and

(2) Microbial filtration in or along fractures and joints is insufficient to prevent ground water contamination.

Study Area

Mountain Home lies on a broad, flat plateau which slopes gently to the southwest. The plateau, much of which is mantled by windblown sediments, is interrupted by volcanic features such as cinder cones, crater rings, and shield volcanos (Norton et al., 1982). The Mountain Home Plateau occupies approximately 1,220 square miles of the western Snake River Plain (Young, 1977). Mountain Home, with a population of about 9,000, has an elevation of around 3,140 feet above mean sea level. Surface water features in the area include Canyon Creek, Rattlesnake Creek, Mountain Home Reservoir, and numerous irrigation canals and laterals. All streams in the area are ephemeral and flow southward towards the Snake River.

This investigation encompassed an area of approximately 36 square miles (Figure 1) with downtown Mountain Home located in the south central part of the area. State Highway 67 represents the southern boundary and the summit of Lockman Butte represents the approximate northern boundary. The numbering system for identifying locations of wells and surface water sampling sites in this report is based on the common subdivision of land into townships, ranges, and sections (Figure 2). This subdivision of lands is called the public land survey system (PLSS). The location based on the PLSS is referenced to the Boise baseline and meridian. The first segment represents the township south of the Boise baseline, the second segment represents the range east of the Boise meridian, and the third is the section number. The three letters following the section number indicate the quarter-quarter-quarter section (10-acre tract) within the section. Quarter sections are labeled A, B, C, and D in counterclockwise order starting with the northeast quarter of the section. A numeral following the letters indicates the order in which wells within the 10-acre tract were sampled. An “S” following the numeral indicates that the sampling location is a surface water body rather than a well.

Climate

The area's climate is characterized by hot, dry summers and cold winters. Average winter and summer temperatures are 32° F and 71° F, respectively. Average annual precipitation is approximately 10 inches. About 40 percent of this precipitation occurs from April through September. Average snowfall is 13.8 inches (USDA Soil Conservation Service, 1991).

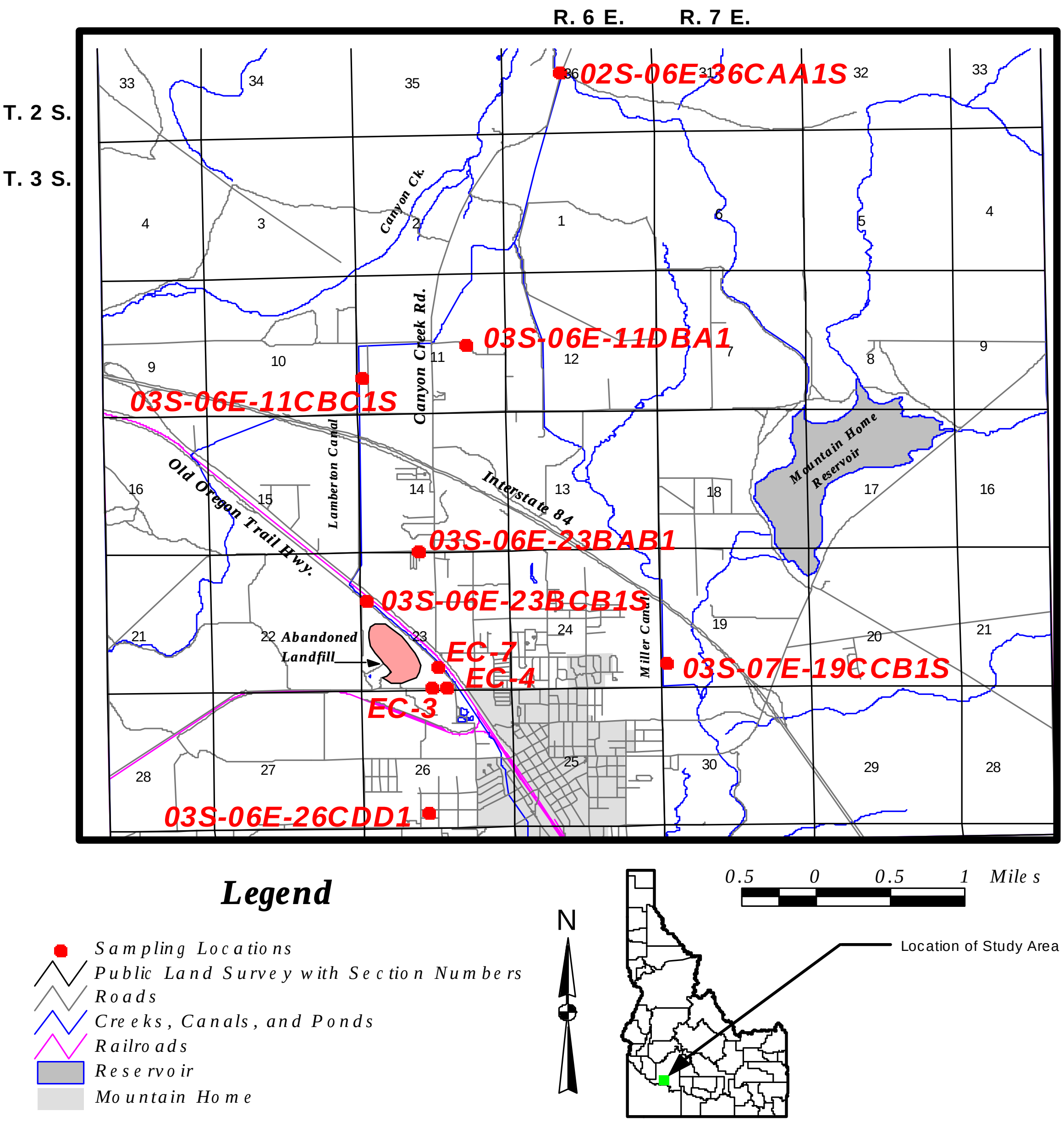


Figure 1. Study Area.

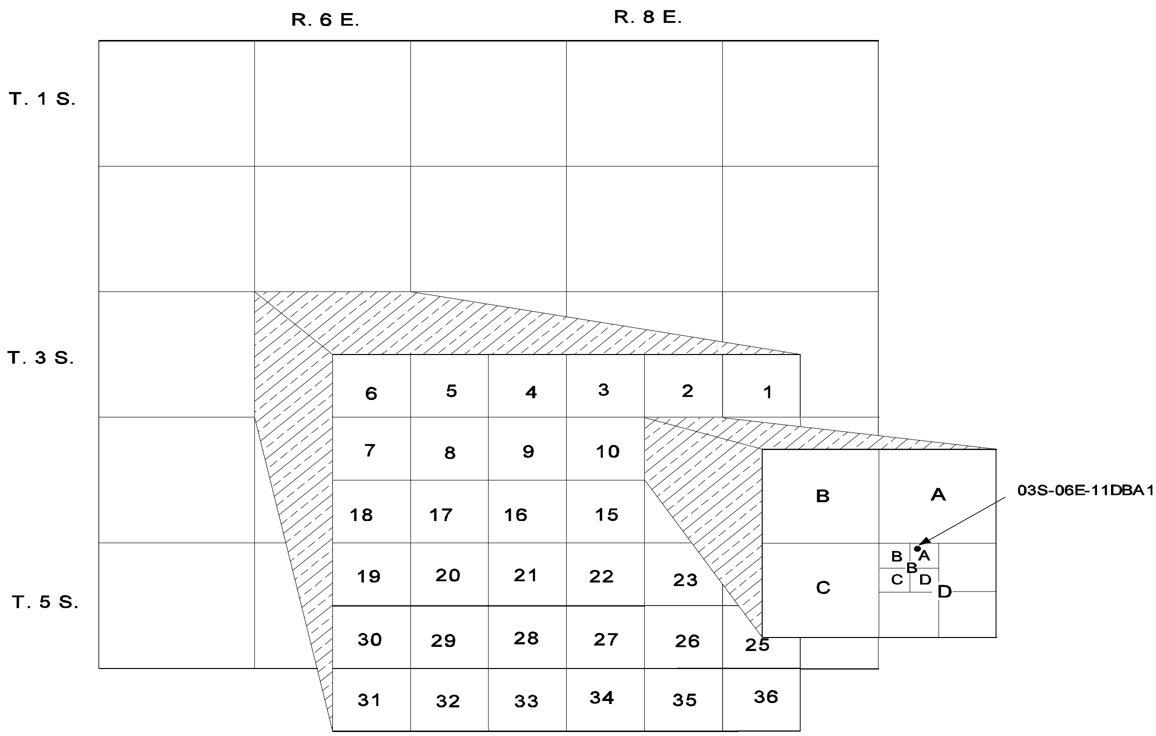


Figure 2. Sample Station Numbering System (modified from the USGS).

Soils

The soils found in the area of investigation are described in the *Soil Survey of Elmore County Area, Idaho, Parts of Elmore, Owyhee, and Ada Counties* (USDA Soil Conservation Service, 1991). Two general soils units were mapped in the Mountain Home area. The first unit is the Timmerman-Royal-Buko. The unit is formed in mixed alluvium and is found on stream terraces. It is nearly level to strongly sloping, very deep, well drained and somewhat excessively drained. The second unit is the Colthorp-Chilcott-Kunaton. The parent material for this unit is loess and alluvium derived from various rock types. It is positioned on basalt plains, is nearly level to strongly sloping, shallow to moderately deep, and well drained.

Typical soils found in the area include:

- Buko fine sandy loam, 1-4% slopes.
- Chilcott silt loam, 0-4% slopes.
- Colthorp-Kunaton complex, 0-8% slopes.
- Colthorp-Rock outcrop complex, 4-20% slopes.

All of these soils are described as severely limiting the effectiveness of septic tank absorption (drain) fields. The limiting factors include poor filtering capability, the occurrence of a cemented pan, shallow depth to bedrock, or excessively slow percolation. These factors can lead to sewage emerging at the land surface or rapid percolation of poorly-treated sewage effluent to the ground water.

Geology and Hydrogeology

The geologic units in the study area consist of volcanic and fluvial and lacustrine sedimentary deposits ranging from Cretaceous to Holocene in age. A description of the major geologic units found near Mountain Home and their water-bearing characteristics (modified from Young, 1977) is found in Table 1.

Table 1. Geologic Units and Their Water-bearing Characteristics

Period	Epoch	Geologic Unit	Description	Water-bearing Characteristics
Quaternary	Holocene	Alluvium	Unconsolidated clay, silt, sand, and gravel occurring beneath flood plains of Boise and Snake Rivers. Crops out in narrow belts along major tributaries and in a broad belt near Mountain Home. Thickness probably does not exceed 70 feet.	Hydraulic conductivity generally high; however, because of thinness and irregularity of beds, yields to wells are generally small to moderate. Most important along Boise River flood plain where well yields of 2,500 gal/min are reported.
	Holocene and Pleistocene	Basalt of Snake River Group	Vesicular olivine basalt, light to dark gray, irregular to columnar jointing. Crops out on much of Mountain Home Plateau and in Boise Valley. Intercalated in places with older terrace gravels. Thickness of flows probably does not exceed 550 feet.	Hydraulic conductivity variable. Where saturated, reported well yields range from 20 to 3,100 gal/min; however, the basalt is above water table in most of the study area.
	Pleistocene	Bruneau Formation of Idaho Group	Includes fan deposits consisting largely of coarse sand derived from decayed granitic rocks. Thickness of fan deposits does not exceed 300 feet. Also includes vesicular olivine basalt, dark gray to black, weathers to reddish-gray-brown. Thickness of basaltic flows is about 800 feet in study area. Unit also includes detrital material, dominated by massive lake beds of white-weathering fine silt, clay, diatomite, and minor amounts of sand.	Fan deposits are generally above water table. Basalt composes principal aquifer in Mountain Home area. Reported well yields from basalt range from 10 to 3,500 gal/min. Detrital material generally has low hydraulic conductivity.
Quaternary and Tertiary	Pleistocene and Pliocene	Glenns Ferry Formation of Idaho Group	Poorly consolidated detrital material and minor flows of olivine basalt. Includes lake and stream deposits consisting of massive silt layers, cemented sand beds, thin beds of dark clay, olive silt, and granitic sand and fine pebble gravel. Maximum thickness is about 2,000 feet.	Hydraulic conductivity generally low. Reported well yields range from 3 to 350 gal/min.

Ground water occurs primarily in two aquifers near Mountain Home. The first aquifer is a shallow, perched system occupying about 38,000 acres (Young, 1977; Figure 3). Ground water in the perched aquifer is found mainly in the clay, silt, sand, and gravel of the Quaternary Alluvium. Snake River Group basalts and fan deposits and basalts of the Bruneau Formation beneath the alluvium also contain water from the perched system. Depth to water in this system varies considerably but is found as shallow as 10 feet below land surface.

The second aquifer is a deeper regional system. The deeper, regional system provides water for municipal and irrigation wells near Mountain Home. The most productive zones are found in the basalt flows of the Bruneau Formation of the Idaho Group (Norton et al., 1982). Depth to water in the regional system varies from 200 to 400 feet below land surface. Recharge to the regional aquifer system occurs through precipitation on exposed silicic volcanic mountains north of Mountain Home (Idavada Volcanics), through percolation from ephemeral streams on the plateau, and through percolation from the perched aquifer. The perched aquifer is recharged through leakage from Mountain Home Reservoir, Rattlesnake Creek, Canyon Creek, and various canals and laterals used to convey irrigation water. Water imported to Mountain Home Reservoir from Little Camas Reservoir (20 miles east of Mountain Home) increases the amount of water available for recharge (Norton et al., 1982).

Ground water flow direction in both the perched and regional aquifer system is generally to the south or southwest. Norton et al. (1982) reported a significant variation in ground water flow direction and depth in the perched system immediately north of Mountain Home for the period 1976 to 1981. They attributed this change to development of the perched system as a domestic water supply. Young et al. (1992) indicated that ground water levels near Mountain Home fluctuate up to about 10 feet seasonally due to ground water withdrawals for irrigation. Young and Norvitch (1984) reported downward water level trends of more than two feet per year in at least two observation wells near Mountain Home.

A local drilling contractor, Ron Hiddleston (personal communication, 1993), has described the regional basalt aquifer as highly fractured with occasional large, cavernous openings. A video log taken in the newest Mountain Home municipal well confirmed the occurrence of cavernous openings of sufficient size to prevent reflection of the light associated with the down-hole video camera. In addition, Hiddleston described the rapid transport of drilling foam used in the construction of the municipal well to an existing residential well approximately one mile away in the time span of less than two days.

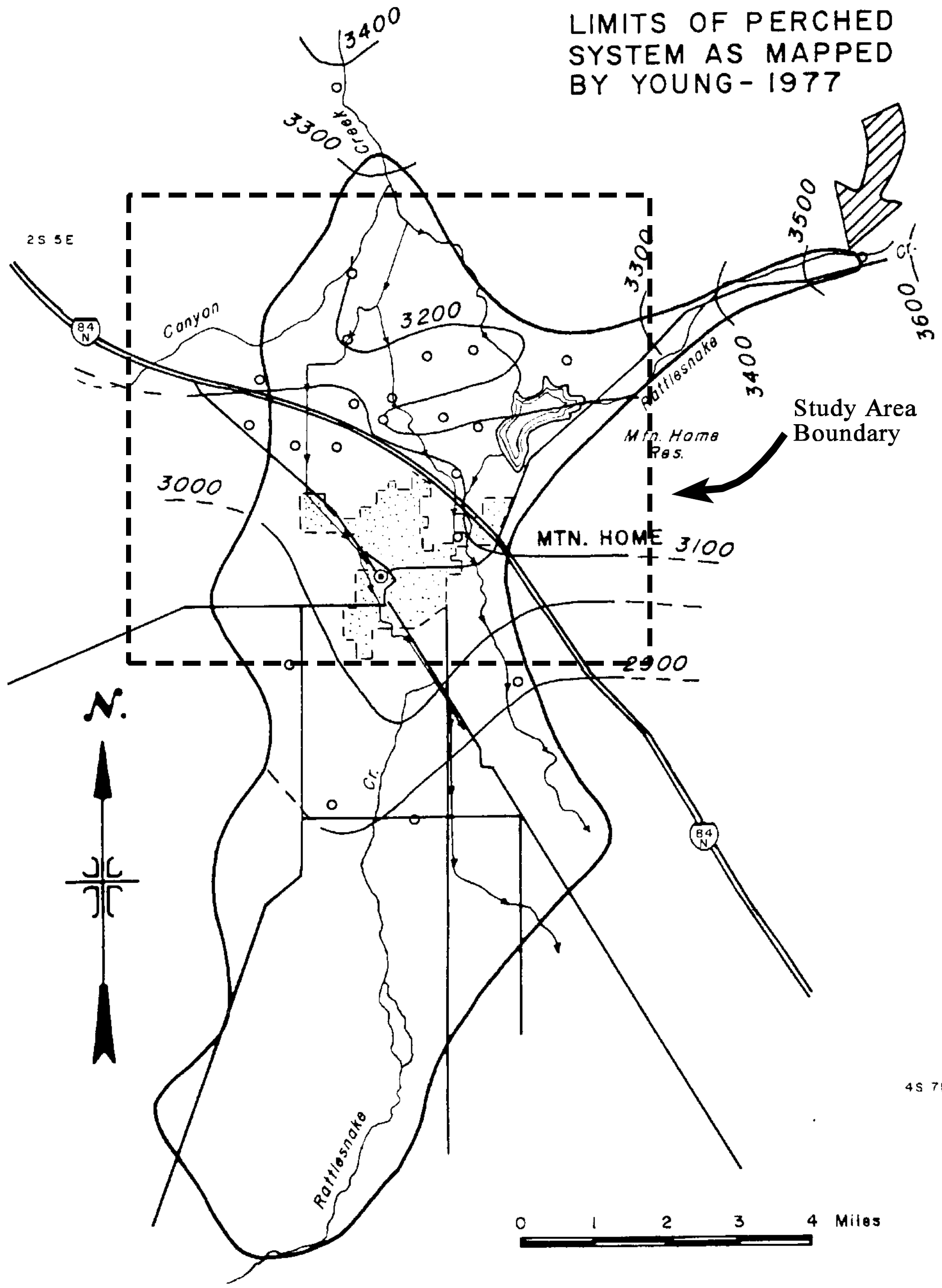


Figure 3. Water Levels and Extent of the Perched Aquifer, 1981 (from Norton, et al., 1982).

Land Use

The area of this investigation is confined to urbanized land in the vicinity of Mountain Home. The primary structures and activities are related to residential life, commercial businesses, and some industries. The northern part of the study area contains some range and pasture land used for livestock grazing. Potential contributions to ground water contamination come from septic tank effluent, leaking municipal sewage lines, landfills, urban storm water disposal, and household chemical use and disposal.

Water Use

The municipal water supply for the town of Mountain Home is provided by six wells each producing from 600 to 2,100 gallons per minute. Most of the wells produce water from 800 to 1000 feet below ground surface. Total monthly production ranges from 90 million to 243 million gallons (Bill Lego, personal communication, 1994).

Homes not served by the municipal water supply use individual domestic or community wells. A random selection of approximately 40 well drillers' reports filed at the Idaho Department of Water Resources indicates that the depths of these wells range from 150 to 550 feet. The majority are drilled to depths of 200 to 300 feet. At least one home in the study area uses the shallow perched aquifer as a domestic water supply through a 42-foot deep well.

Minimal agricultural irrigation takes place within the boundaries of this limited study area. Some pasture land does exist north of Mountain Home. Both diversions from Canyon Creek and ground water supplies are used to irrigate these rural parcels (Norton et al., 1982).

Materials and Methods

This reconnaissance study included the collection and analysis of ground water and surface water samples. The analytical results of these samples (Appendix A) allow some simple hydrochemical evaluations to be made and provide a foundation from which to base more detailed studies. Even though this investigation focused on bacterial contamination, the majority of the samples were also analyzed for common inorganic constituents in an attempt to characterize water from different sampling sites and determine potential sources of the bacterial contamination.

The recently-abandoned Mountain Home landfill was identified as a potential contaminant source in the southern part of the study area. The landfill operated from 1964 to 1986 in an abandoned 55-acre gravel quarry. The original gravel pit was excavated into the shallow perched ground water system at a depth of 25 to 30 feet below ground surface. Seasonal fluctuations of the shallow ground water system bring ground water into contact with buried waste (Feast, 1990). Samples were collected from existing monitoring wells at the facility and analyzed for TC and FC bacteria and fecal streptococci (FS).

Ground Water and Surface Water Sampling

Three ground water samples and three surface water samples were collected on July 21, 1993. The ground water samples were collected from domestic wells with existing operable pumps. The wells selected for sampling each have a history of bacterial contamination and each was thought to have a well driller's report available for a review of construction and lithologic details. However, a well driller’s report for well 03S-06E-23BAB1 could not be located despite a thorough search. Information on the depth of the well was obtained through public water supply records on-file at DEQ but has not been verified.

Each well was purged a minimum of 15 minutes before the samples were collected. Surface water samples (grab samples) were collected from flowing stretches of Canyon Creek, the Miller Canal, and the Lamberton Canal at locations that were free of visible debris. Field measurements of temperature, pH, specific conductance, and dissolved oxygen were recorded at each sampling location. Due to the reconnaissance nature of this project, field quality control samples were not collected. All sample analyses were performed by the State of Idaho, Bureau of Laboratories (State Lab). Internal laboratory quality control checks were performed by the State Lab in accordance with their standard operating protocols. The State Lab has verified that the accuracy goals prescribed by the analytical methods have been achieved. The analytes, corresponding laboratory analytical methods, and sample preservation methods are listed in Table 2.

Table 2. Chemical Constituents Evaluated in Water Samples

Parameter	Method	Container	Preservation	Holding Time
Calcium	EPA 215.1	P	Cool, 4E C	60 days
Magnesium	EPA 242.2	P	Cool, 4E C	60 days
Sodium	EPA 273.1	P	Cool, 4E C	60 days
Potassium	EPA 258.1	P	Cool, 4E C	60 days
Chloride	EPA 325.3	P	Cool, 4E C	28 days
Alkalinity	EPA 310.1	P	Cool, 4E C	14 days
Sulfate	EPA 375.4	P	Cool, 4E C	28 days
Fluoride	EPA 340.3	P	Cool, 4E C	28 days
Ammonia	EPA 350.1	P	2 ml/l conc. H_2SO_4	28 days
Nitrate	EPA 353.2	P	2 ml/l conc. H_2SO_4	28 days
Nitrite	EPA 353.2	P	2 ml/l conc. H_2SO_4	28 days
Total Dissolved Solids	EPA 160.1	P	Cool, 4E C	28 days
Hardness	EPA 130.2	P	Cool, 4E C	28 days
Manganese	EPA 243.1	P	3 ml/l 1:1 dil. HNO_3	60 days
Iron	EPA 236.1	P	3 ml/l 1:1 dil. HNO_3	60 days
Total Coliform	Membrane Filter	P	Cool, 4E C	24 hours
Fecal Coliform	Membrane Filter	P	Cool, 4E C	24 hours
Fecal Streptococci	Membrane Filter	P	Cool, 4E C	24 hours

P = Plastic (polyethylene)

A cursory evaluation of analytical accuracy is accomplished by calculating cation-anion balances for each sample (Table 3). The balance errors ranged from 1.4 to 8.1 percent. The average balance error for the six water analyses is 4.9 percent. The suggested allowable balance error is generally considered variable depending on the ionic concentration of the samples. Total dissolved solids (TDS) concentration is considered a measure of the ionic concentration of a sample. As the ionic concentration increases, the allowable balance error decreases. Acceptable balance errors, given the range of TDS concentrations, for this set of data is four to seven percent. Therefore, on average, the acceptance criteria are met. However, certain individual sample analyses do exceed the acceptance criteria given their TDS concentrations.

Ground water samples were collected on September 22, 1993 from three monitoring wells located at the Mountain Home landfill (monitoring wells designated EC-3, EC-4, and EC-7). An additional surface water sample (grab sample) was collected from the Lamberton Canal near the landfill. The monitoring well samples were collected using a Grundfos submersible sampling pump following purging of a minimum of three casing volumes of water. The pump and hoses were decontaminated between sampling points by flushing the system with a dilute chlorine bleach solution followed by a distilled water rinse.

The three monitoring well samples and the surface water sample collected on September 22, 1993 were analyzed by the State Lab for TC, FC, and FS. Field measurements of temperature, pH, specific conductance, and dissolved oxygen were also made at each of the sampling locations. Analytical results and field measurements for all water samples are found in Appendix A.

Table 3. Cation-Anion Balance Errors

Sample Location	Total Cations (meq/l)	Total Anions (meq/l)	Cation-Anion Balance Error (%)
02S-06E-3CAA1S	0.72	0.70	1.4
03S-06E-11CBC1S	0.79	0.70	6.0
03S-06E-11DBA1	6.10	5.19	8.1
03S-06E-23BAB1	2.57	2.29	5.8
03S-06E-26CDD1	3.17	3.42	3.8
03S-07E-19CCB1S	0.72	0.66	4.4

Results and Discussion

Bacteria and streptococci (microorganism) results alone provide little information regarding the source of TC contamination. Table 4 summarizes the microorganism analytical results.

Surface water samples collected in the northern part of the study area contain relatively low concentrations of TC, FC and FS and are comparable with most of the domestic well analytical results. The highest concentration of TC occurs in the Lamberton Canal near the northern boundary of the Mountain Home landfill. The highest quantifiable FC concentration measured came from domestic well 03S-06E-26CDD1. This is a 550-foot deep well drilled in 1992 with casing extending through 60 feet of sediment (reported as sand and gravel on the well driller's report; see Appendix B) and into basalt. The borehole is uncased through "lava" and "cinders." This well has experienced a continued occurrence of positive TC and FC tests. The driller reported that repeated attempts have been made to assess the integrity of the well casing including a video logging evaluation (Ron Hiddleston, personal communication, 1993). The intrusion of shallow ground water into the well would logically be the suspected source of the persistent bacteria contamination.

Table 4. Microorganism Analytical Results

Sample Location	Total Coliform (CFU/100 ml)	Fecal Coliform (CFU/100 ml)	Fecal Streptococci (CFU/100 ml)	Nitrate (mg/l)	Well Depth (feet)
0 2S-06E-36CAA1S	12	12	< 2	0.114	Surface Water
03S-06E-11DBA1	8	< 2	< 2	9.450	42
03S-06E-11CBC1S	8	10	14	0.099	Surface Water
03S-06E-23BAB1	< 2	< 2	< 2	1.820	300 (unconfirmed)
03S-07E-19CCB1S	14	8	68	< 0.005	Surface Water
03S-06E-26CDD1	88	26	2	4.120	550
03S-06E-23BCB1S	9,400	10	64	Not Analyzed	Surface Water
EC-3	< 2	< 2	< 2	Not Analyzed	28.5
EC-4	< 2	< 2	< 2	Not Analyzed	29.5
EC-7	Confluent Growth	Confluent Growth	< 2	Not Analyzed	33.2

The ground water sample from monitoring well EC-7 located near the Mountain Home landfill contained numerous bacterial colonies that resulted in a confluent growth on the membrane filters used for analysis. The confluent growth prevented positive identification and counting of the individual colonies. It does indicate that significant bacterial contamination exists in the water sample.

Nitrate is often used as an indicator of contamination from human or animal wastes. The surface water samples analyzed contained low nitrate concentrations or concentrations below the level of detection. The shallowest well sampled during this study contained an elevated nitrate concentration of 9.45 mg/l, slightly below the MCL of 10 mg/l. Well sample 03S-06E-26CDD1 contained the highest TC count but a lower nitrate concentration of 4.12 mg/l. Therefore, in this case, a direct correlation between TC and nitrate concentrations does not appear to exist.

Other data evaluation techniques were applied to the six analytical results that included general chemical parameters (i.e., cations, anions, and nutrients). These techniques were used in an attempt to characterize the interaction of surface water and ground water in the study area and to determine whether direct surface water infiltration into individual wells could account for the persistent bacterial contamination. The following evaluation tools were employed:

- Trilinear plot.
- Composition plots (x-y scatter plots).
- Fingerprint (Schoeller) diagram.

Each of these methods was used to help identify trends or compositional variations in the water quality data. The small sample population resulted in inherent uncertainty when attempting to evaluate the analyses by graphical means. However, these tools still provide useful insights into the hydrogeochemistry of the ground water system as long as the limitations associated with the small data set are recognized.

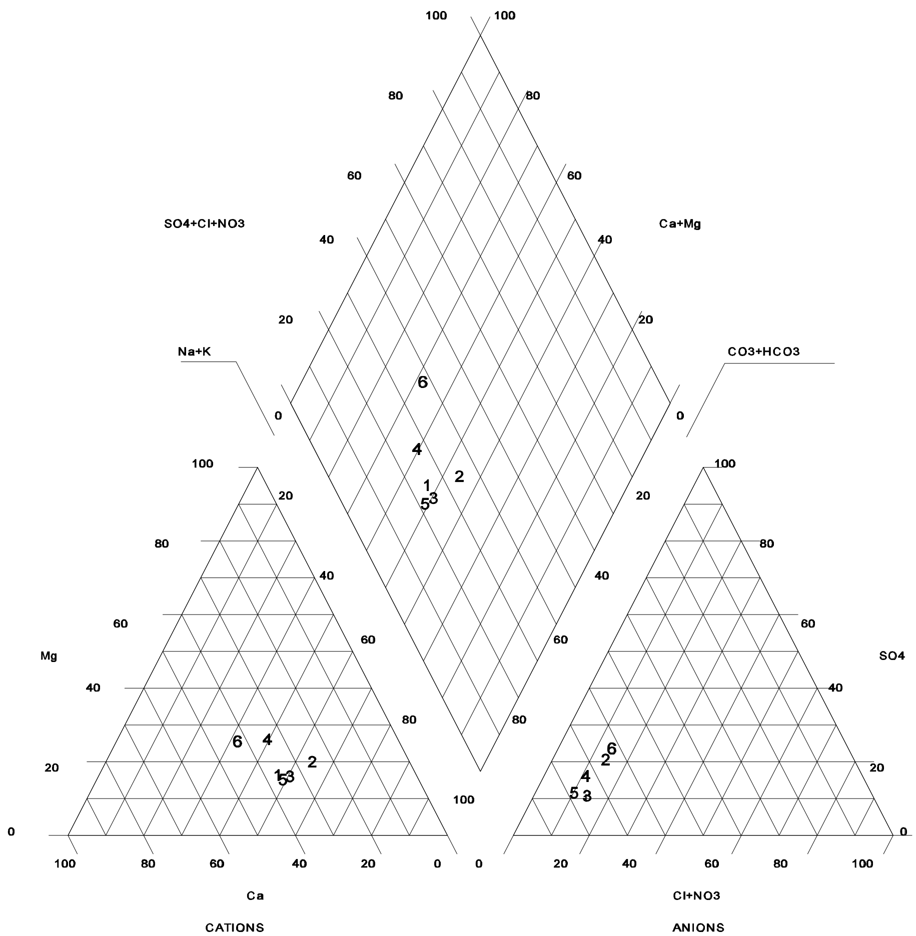
Under natural conditions, the major ion composition of ground water is controlled by soluble minerals in the aquifer and the residence time of water in the aquifer. A general relationship between the mineral composition of the natural water and the solid minerals with which the water has been in contact is expected. This simple relationship can be complicated by the mixing of water from interconnected aquifers with different compositions. The system may also be affected by chemical reactions such as cation exchange, adsorption of dissolved ions, and biological influences (Hem, 1985).

Figure 4 is a trilinear plot used to display major ion water chemistry (Piper, 1944). The diagram shows concentrations in percent milliequivalents per liter (meq/l) of the major cations and anions for each water sample. The major cations of each water sample (calcium, magnesium, sodium, and potassium) are plotted on the left triangle. The major anions of each water sample (carbonate, bicarbonate, chloride, sulfate, and nitrate) are plotted on the right triangle. The plotted points for each water sample are then projected to the upper diamond-shaped area to show cation and anion groups as a percentage of the sample. Water samples with similar chemistry plot in the same area on the diagram. The trilinear diagram indicates some variability in the compositions of the well water samples. The three surface water samples plot nearly at the same point indicating the same ionic composition. In all cases, sodium and calcium are the dominant cations and bicarbonate is the dominant anion.

Figures 5 and 6 present compositional diagrams of the major ions plotted against the total dissolved ions (TDI; the sum of major cations and anions). Figure 5 displays graphs of common cations versus TDI. Figure 6 displays graphs of common anions versus TDI. Both axes represent concentrations in meq/l. This type of diagram is used to determine whether there are compositional differences (water types) in the sample set. Data that plot in linear trends represent mixing of water with low dissolved ion concentrations and water with higher dissolved ion concentrations. Data that plot as more than one cluster indicate separate types of water that are not mixed. A random distribution of data indicates that many individual, unrelated water types exist or that the analytical quality of the data is poor (Mazor, 1991).

Both weak linear trends and sample clusters are apparent on Figures 5 and 6. These trends indicate that the well water samples vary in their solute concentrations. The surface water samples (low ionic concentrations) are all very similar to each other. The linear trends may indicate that water with low solute concentrations is mixing in varying percentages with water of higher solute concentrations. The dominant water type in the overall system is calcium/sodium-bicarbonate.

Figure 7 is a fingerprint diagram of six ground water and surface water samples. The numbers labeling the lines correspond to the reference number for each sample found in Appendix A. Each line on the diagram is a graphical representation of the concentration of the major ionic species of each sample. Water samples containing higher concentrations of ions plot higher on the diagram than those containing lower concentrations. Parallel lines indicate various dilutions of a similar water type. Lines with a fan shape indicate mixing of two distinct water types (Mazor, 1991). Figure 7 shows that sample locations 1, 3, and 5 (the three surface water samples) exhibit similar ionic compositions. Well water samples 4 and 6 also resemble each other in ionic composition. However, all three well samples (sample locations 2, 4, and 6) exhibit different ionic compositions than the three surface water samples.



Symbol	Sample Location	TDS (ppm)
1	02S-06E-36CAA1S	53
2	03S-06E-11DBA1	360
3	03S-06E-11CBC1S	54
4	03S-06E-23BAB1	164
5	03S-07E-19CCB1S	72
6	03S-06E-26CDD1	248

Figure 4. Trilinear Diagram.

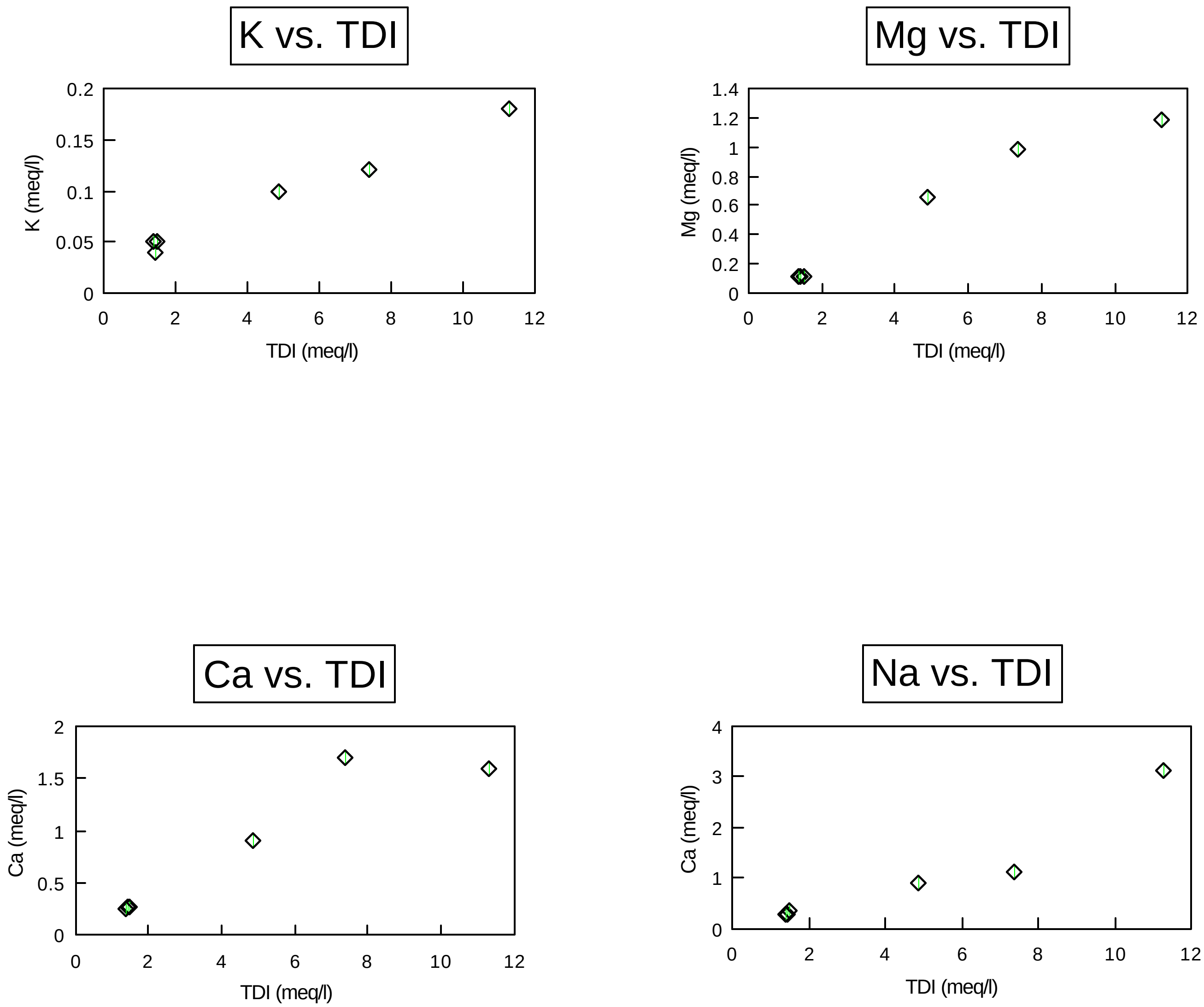


Figure 5. X-Y Plots of Major Cations Versus Total Dissolved Ions.

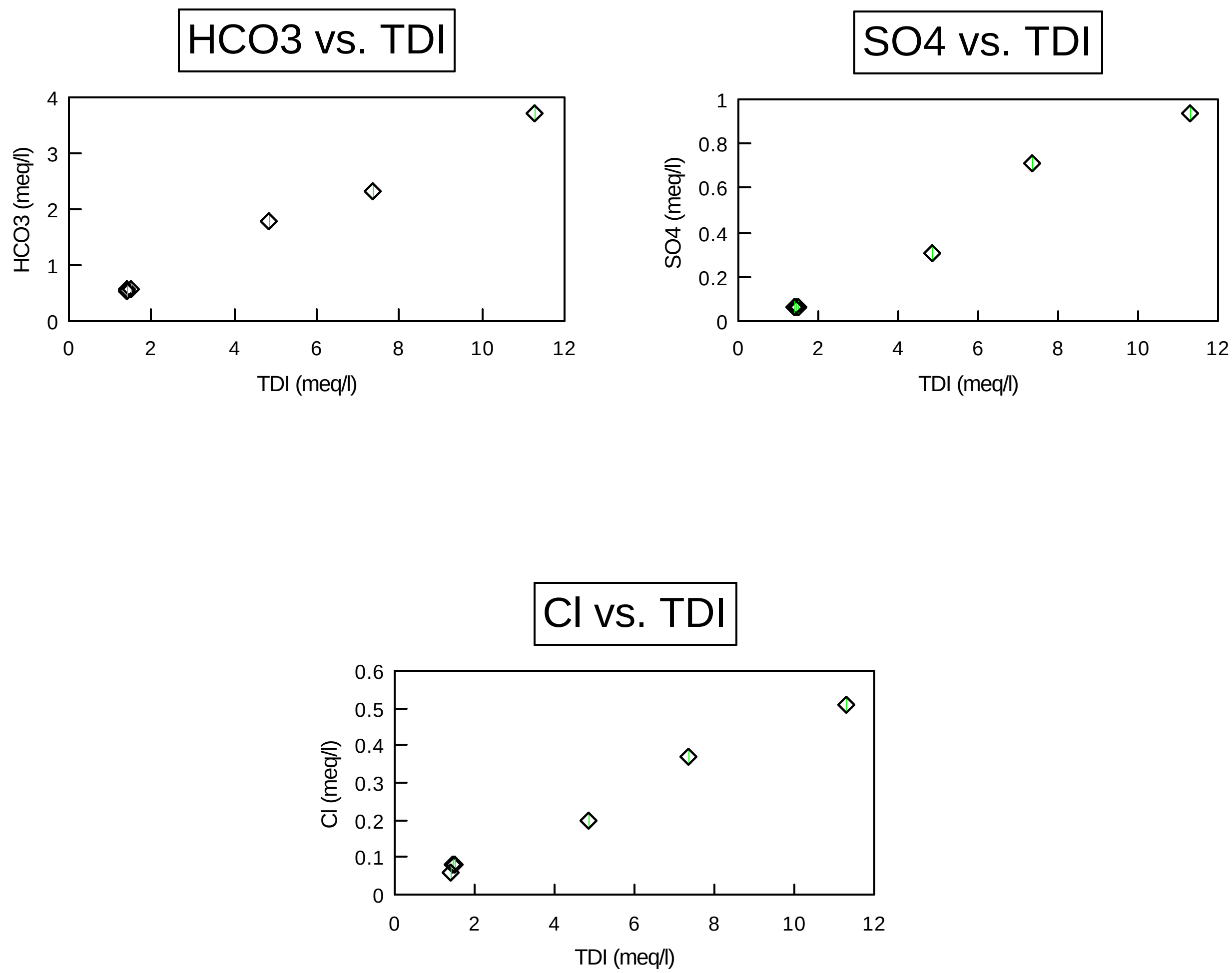


Figure 6 X-Y Plots of Major Anions Versus Total Dissolved Ions.

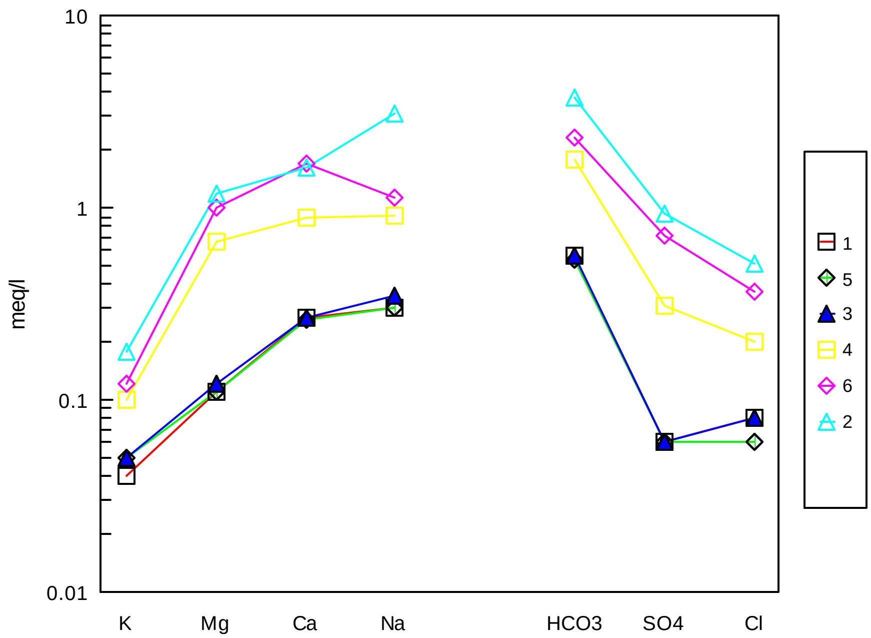


Figure 7. Fingerprint Diagram.

Approximately 40 well drillers' reports were reviewed to obtain an approximation of the depth to basalt in the study area. Figure 8 is a contour map depicting the depth to basalt. The map indicates the presence of a north-south trending "ridge" of shallow basalt. The depth to basalt appears to decrease to the east and north of Mountain Home. It follows that the ability of the subsurface to adequately filter wastewater would also diminish to the east and north as the probability of encountering shallow fractured basalt increases.

The ground water sample collected from domestic well 03S-06E-11DBA1 located north of Mountain Home near Canyon Creek Road had the highest nitrate concentration of 9.45 mg/l. This sample also had the highest specific conductance and TDS levels; 537 Fmhos/cm and 360 mg/l, respectively. The nitrate concentration is slightly less than the drinking water MCL of 10 mg/l and warrants continued monitoring of this well for nitrate because of potential health concerns. The well driller's report reflects poor well construction techniques with a shallow completion depth (42 feet), short length of casing (17 feet), and no well seal. This well is also located in an area with a shallow depth to basalt (Figure 8). The well construction information, the well site characteristics, and the water sample results indicate that this well is vulnerable to contamination. The sample results confirm that the water supply is contaminated with excessive concentrations of nitrate and TC bacteria.

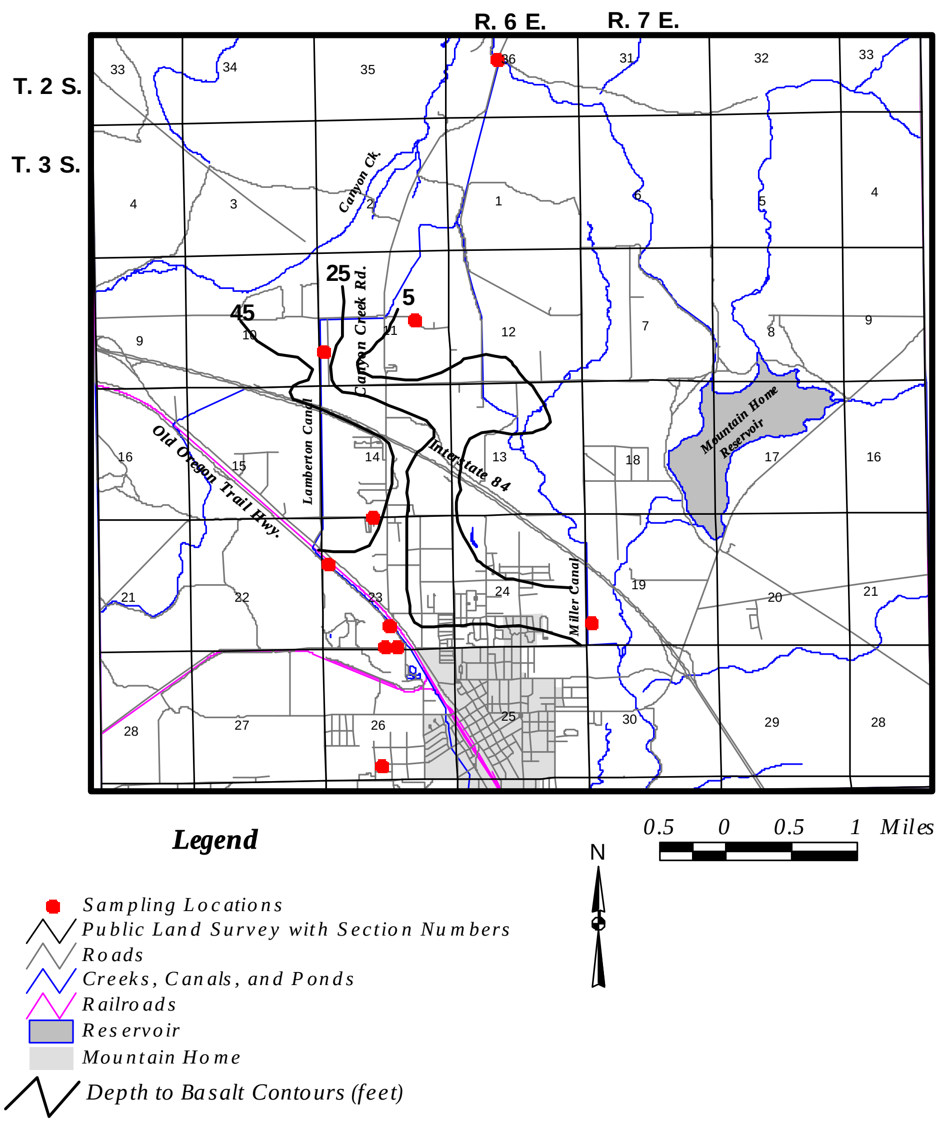


Figure 8. Depth to Basalt.

Conclusion and Recommendations

Infiltration of bacteria-contaminated surface water represents one of several potential sources of contamination to underground drinking water supplies. An evaluation of general water chemistry indicates differences between the surface water and ground water samples collected during this investigation. The variation in the concentrations of ions in the ground water samples may indicate that some degree of mixing with more ionically dilute water is taking place. Still, a distinction between the surface water and ground water ionic chemistry does exist. Based on information obtained during the literature review for this investigation, it can be concluded that the expected life-span of coliform bacteria is relatively short compared with the rate of geochemical processes. Therefore, it does not appear that bacteria-contaminated surface water is directly influencing the domestic wells that were sampled. However, reports of seasonal ground water discoloration indicate that locally intense snow melt or storm water runoff do impact certain wells on an intermittent basis.

Other potential sources of TC and FC contamination include subsurface sewage disposal systems (septic tanks and drain fields), leaking municipal sewer lines, and solid waste disposal areas (landfills). However, this study was not designed to investigate, in detail, any of these potential sources as the cause of widespread bacteria contamination in ground water in Mountain Home.

Geologic conditions make the aquifer system in the vicinity of Mountain Home vulnerable to contamination. Shallow perched ground water developed for domestic uses may lie in close proximity to subsurface sewage disposal drain fields and municipal sewer lines in some locations. The shallow aquifer system typically contains a high percentage of relatively coarse, permeable gravel. This material is limited in its ability to adequately filter bacteria-rich wastewater.

The regional aquifer system is composed of permeable zones such as the contacts between individual basalt flows or other fractures in basalt. Video logs of wells and the observation of the movement of drilling additives attest to the ability of this material to quickly transmit water. This geologic setting is conducive to the transport of bacteria contamination from source locations to ground water withdrawal points represented by wells.

Historic well construction practices are also likely inadequate to prevent shallow bacteria contamination from impacting drinking water supplies. The ability of basalt to maintain an open, uncased borehole has resulted in many private domestic wells being completed with minimal lengths of surface casing, often only the regulatory minimum of 18 feet of casing.

The results of this investigation do not allow identification of a specific source of bacteria contamination. The results do indicate that the sampled wells are not in direct hydraulic connection with nearby surface water bodies. Therefore, the variety of subsurface sources of bacteria contamination become suspect. A review of existing geologic and hydrogeologic literature and drillers' reports highlights the vulnerability of Mountain Home's aquifer system to contamination.

Based on this, it is recommended that the full array of land use practices that have the potential to affect ground water quality be reviewed by the local planning agencies. The potential impacts to ground water quality should become a consideration in all planning and development decisions.

Some general areas of concern include:

! disposal of storm water in abandoned gravel quarries or other subsurface disposal without treatment.

! dense residential development reliant on individual subsurface sewage disposal systems.

! leaking municipal sewer lines.

! solid waste disposal in abandoned gravel quarries.

! improperly constructed or abandoned wells.

Specific recommendations for consideration by planning, resource, and health agencies include:

! Use best management practices (BMPs) with filter strips to treat storm water prior to disposal through permeable materials (a manual of storm water BMPs is available from the DEQ Southwest Idaho Regional Office).

! Use shallow drain fields or sand mounds in areas with a shallow depth to basalt (e.g., areas north and east of downtown Mountain Home).

! Replace old septic systems that do not have an effective soil depth to provide proper contaminant treatment (e.g., cesspools and seepage pits).

! Develop a wastewater infrastructure for areas with dense populations currently reliant on individual septic systems.

- Require new subdivisions within the city impact area to connect to the municipal wastewater collection system.

- Conduct an infiltration/exfiltration study of the municipal wastewater collection system.

- Request that IDWR thoroughly review well abandonment and construction practices in the vicinity of Mountain Home.

Depending upon the availability of personnel and financial resources, DEQ may continue monitoring actives and undertake special investigations such as virus studies, microscopic particulate analyses, and ground water tracer tests.

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Appendix A

Mountain Home Bacteria Investigation Results

Location ID	02S-06E-36CAA1S	03S-06E-11DBA1	03S-06E-11CBC1S	03S-06E-23BAB1	03S-07E-19CCB1S	03S-06E-26CDD1	03S-06E-23BCB1S	EC-3	EC-4	EC-7
Reference Number	1	2	3	4	5	6	7	8	9	10
Latitude (decimal degrees)	-115.6889	-115.7019	-115.6889	-115.7086	-115.6847	-115.7078	-115.7156	-115.7072	-115.71	-115.71
Longitude (decimal degrees)	43.2056	43.1772	43.1739	43.1556	43.1436	43.1283	43.1506	43.1414	43.1414	43.1436
Sample Date	07/21/93	07/21/93	07/21/93	07/21/93	07/21/93	07/21/93	09/22/93	09/22/93	09/22/93	09/22/93
FIELD MEASURMENTS										
Water Temp.(° C)	18	15	18	15	19	15	12	17	16	18
Specific Conductance (µmho/cm)	61	537	61	229	61	356	60	450	60	70
pH (standard units)	7.95	6.75	8.05	7.60	8.38	7.07	7.11	6.33	6.86	6.56
Dissolved Oxygen (mg/l)	9.5	6.2	9.4	7.4	8.7	7.9	7.6	1.2	6.1	4.5
LABORATORY MEASUREMENTS										
Alkalinity (total as CaCO3, mg/l)	28	187	28	89	27	117				
Ammonia (as N, mg/l)	0.036	<0.005	0.018	0.011	0.052	0.033				
Calcium (mg/l)	5.4	32.0	5.4	18.0	5.3	34.0				
Chloride (mg/l)	3	18	3	7	2	13				
Fluoride (mg/l)	0.16	0.40	0.18	0.41	0.17	0.26				
Hardness (as CaCO3, mg/l)	16	134	20	74	26	130				
Iron (mg/l)	1.07	0.25	1.18	0.02	1.19	0.03				
Magnesium (mg/l)	1.4	14.5	1.5	8.0	1.3	12.0				
Manganese (mg/l)	0.03	<0.01	0.05	<0.01	0.01	<0.01				
Nitrite Nitrogen (as N, mg/l)	0.008	<0.005	0.009	<0.005	0.008	<0.005				
Nitrate Nitrogen (as N, mg/l)	0.114	9.450	0.099	1.820	<0.005	4.120				
Potassium (mg/l)	1.4	7.0	2.0	3.8	2.0	4.6				
Sodium (mg/l)	7	72	8	21	7	26				
Sulfate (mg/l)	3	45	3	15	3	34				
Total Dissolved Solids (mg/l)	53	360	54	164	72	248				
Coliform, Total (CFU/100ml)	12	8	8	<2	14	88	9,400	<2	<2	CG*
Coliform, Fecal (CFU/100ml)	12	<2	10	<2	8	26	10	<2	<2	CG
Streptococci, Fecal (CFU/100ml)	<2	<2	14	<2	68	2	64	<2	<2	<2

*Note: CG = Confluent Growth

Appendix B

Summary driller's report for unsampled well near 03S-06E-23BAB1

NATURE OF WORK

Replacement

PROPOSED USE

Domestic

METHOD DRILLED

Air Rotary

WELL CONSTRUCTION

Thickness	Diameter	From	To
0.250	6	+2	89

Was casing drive shoe used? Yes

Was a packer or seal used? No

Perforated? No

Well screen installed? No

Gravel packed? No

Surface seal depth: 89

Material used in seal: bentonite

Sealing procedure used: Overbore to seal depth

Method of joining casing: Welded

LOCATION OF WELL

On McMurtrey Rd.

NE 1/4 NW 1/4 Sec. 23, T. 3 S. R. 6 E.

County: Elmore

WATER LEVEL

Static water level: 173

Flowing? No

WELL TEST DATA

Air

Discharge GPM: 35

Hours Pumped: 1

LITHOLOGIC LOG

Bore diam.	From	To	Material	Water Yes	Water No
8	0	86	Sand and gravel		
"	86	89	Gray lava		
6	89	111	Gray lava		
"	111	115	Brown cinders		
"	115	116	Brown lava		
"	116	126	Brown cinders		
"	126	135	Gray lava		
"	135	136	Brown cinders		
"	136	150	Gray lava		
"	150	156	Brown cinders		
"	156	183	Gray lava		
"	183	201	Brown lava & cinders		
"	201	225	Gray lava		
"	225	227	Brown cinders		
"	227	231	Gray lava		
6	231	303	Brown cinders 35 GPM	X	

Work started: 6-4-92 Finished: 6-5-92

Summary driller's report for 03S-06E-11DBA1

NATURE OF WORK

New well

PROPOSED USE

Domestic

METHOD DRILLED

Cable

WELL CONSTRUCTION

Thickness	Diameter	From	To
0.219	8		17

Was casing drive shoe used?

Was a packer or seal used?

Perforated? No

Well screen installed?

Gravel packed?

Surface seal depth:

Material used in seal:

Sealing procedure used:

Method of joining casing: Welded

LOCATION OF WELL

NE 1/4 NW 1/4 Sec. 11, T. 3 S. R. 6 E.

County: Elmore

WATER LEVEL

Static water level: 20

Flowing?

WELL TEST DATA

Bail

Discharge GPM:

Hours Pumped: 2

LITHOLOGIC LOG

Bore diam.	From	To	Material	Water Yes	Water No
8	0	2	Top soil		
"	2	10	Clay & gravel		
"	10	16	Gravel & clay		
"		16	Bed rock		
"	16	26	Blue lava		
"	26	36	"		
"	36	40	"		
"		42	Sand & gravel	yes	

Work started: 7-1-66 Finished: 7-10-66

Summary driller's report for 03S-06E-26CDD1

NATURE OF WORK

New well

PROPOSED USE

Domestic

METHOD DRILLED

Air Rotary

WELL CONSTRUCTION

Thickness	Diameter	From	To
0.250	6 5/8	+ 2	62

Was casing drive shoe used? No

Was a packer or seal used? No

Perforated? No

Well screen installed? No

Gravel packed? No

Surface seal depth: 62

Material used in seal: bentonite

Sealing procedure used: Overbore to seal depth

Method of joining casing: Welded

LOCATION OF WELL

Colthorp Ave.

SE 1/4 SW 1/4 Sec. 26, T. 3 S. R. 6 E.

County: Elmore

WATER LEVEL

Static water level: 400

Flowing? No

WELL TEST DATA

Air

Discharge GPM: 35

Hours Pumped: 1

LITHOLOGIC LOG

Bore diam.	From	To	Material	Water Yes	Water No
8	0	60	Sand and gravel	X	
"	60	62	Gray lava		
6	62	83	Gray lava		
"	83	110	Brown cinders		
"	110	220	Gray lava		
"	220	229	Brown cinders		
"	229	241	Gray lava		
"	241	247	Gray lava & red cinders		
"	247	256	Red & brown cinders		
"	256	265	Gray lava		
"	265	275	Red & brown cinders		
"	275	283	Gray lava		
"	283	285	Brown cinders		
"	285	335	Gray lava		
"	335	350	Brown lava		
"	350	363	Gray lava		
"	363	368	Brown lava		
"	368	443	Brown cinders		
"	446	453	Gray lava		
"	453	460	Brown lava		
"	460	478	Gray lava		
"	478	483	Red cinders		
"	483	491	Brown lava		
"	491	510	Brown cinders	X	
"	510	521	Gray lava		
"	521	523	Brown cinders	X	
"	523	536	Gray lava		
"	536	541	Brown cinders	X	
6	541	550	Gray lava		

Work started: 8-13-92 Finished: 8-15-92