Ground Water Quality Technical Report No. 16

Ground Water Quality Investigation
and
Wellhead Protection Study
Grand View, Idaho

Idaho Department of Environmental Quality
Technical Services Division
October 2000

Ground Water Quality Investigation and Wellhead Protection Study Grand View, Idaho

By Edward Hagan

Idaho Department of Environmental Quality
Technical Services Division
Ground Water Quality Technical Report No. 16
October 2000

Idaho Department of Environmental Quality
1410 North Hilton
Boise, ID 83706

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACKNOWLEDGEMENTS

This report, evaluating potential sources of nitrate found in public and domestic wells in the Grand View, Idaho, area, was a cooperative effort of the Idaho Department of Environmental Quality (DEQ) and local residents. The support of the public water system operator, Mr. Leon Nielson, was essential in conducting this project. Additionally, without the cooperation and assistance of local well owners who allowed DEQ to sample their wells, this study would not have been possible.

Funding for the laboratory analyses was provided by a U.S. Environmental Protection Agency § 319 Nonpoint Source Management Program Grant. DEQ personnel collected the samples, analyzed the data, and prepared the report.

DEQ personnel – Linda Boyle, Scott Short, Rob Taylor, and Gerry Winter –participated in the review of this document and provided thoughtful editorial and technical comments to improve the report. Joe Baldwin assisted with sampling and with creating the water quality tables. Tonia Mitchell created the graphics in the report. Amy Luft contributed editorial comments and prepared the final report for publication.

DEQ also wishes to acknowledge the assistance received from Mr. John Bokor, Idaho Rural Water Association, in coordinating the project.

1.0 ABSTRACT

Ground water in the City of Grand View, Idaho, area was sampled in August and November 1998 to evaluate potential sources of nitrogen contributing to elevated nitrate levels in the ground water. Grand View was one of five communities in Idaho to receive technical assistance from the Idaho Department of Environmental Quality and financial assistance from a U.S. Environmental Protection Agency § 319 Grant to investigate causes of elevated nitrates in their drinking water systems. The communities can utilize the information from these studies to implement ground water protection programs.

Monitoring of the Grand View public water system has historically shown nitrate levels near the drinking water standard of 10 milligrams per liter. Potential sources of nitrate in the area include domestic septic systems, chemical fertilizer application on agricultural lands, and legume crops.

The ground water quality evaluation consisted of a review of previous water quality data and the collection and analysis of water samples from 12 wells near Grand View. Numerous laboratory analyses were performed to assess the potential sources of elevated nitrate. Water samples were analyzed for major ions, nitrate, ammonia, pesticides, and nitrogen isotope ratios. The nitrogen isotope analysis has been utilized only recently by the Idaho Department of Environmental Quality.

Nitrate was the only chemical analyzed that was detected in concentrations greater than the drinking water maximum contaminant level of 10 milligrams per liter (approximately 10 parts per million). Nitrate was detected in water samples collected from 11 of the 12 locations. The shallow alluvial aquifer underlying the area appears to contain the highest concentrations of nitrate. The nitrogen isotope results indicate the predominant source of nitrate is inorganic chemical fertilizer. No pesticides were detected in any water samples.

Based on the investigation results, regional ground water protection efforts should focus on managing inorganic commercial fertilizers. Other nitrogen sources may impact ground water quality on a localized scale and should be managed on a case-by-case basis.

2.0 INTRODUCTION: BACKGROUND AND PURPOSE OF PROJECT

In May 1998 the Idaho Department of Environmental Quality (DEQ) selected five communities within the state to be included in the Wellhead Protection Viability Demonstration Project. The project was designed to assist community water systems serving populations less than 10,000 impacted by nonpoint source contaminants such as nitrate. Water systems with detections of nitrate within 25 percent of the drinking water maximum contaminant level (MCL) were selected for the project. The City of Grand View, Idaho, was one of the communities selected because of elevated nitrate concentrations in its municipal well and its commitment to protecting and managing its ground water resource. This study focused on community water systems impacted by nitrate due to the widespread occurrence of nitrate in ground water.

Excessive levels of nitrate can cause serious illness and sometimes death in infants less than six months old. The primary hazard from consuming water high in nitrate is methemoglobinemia (sometimes referred to as "blue-baby syndrome"). The condition occurs because nitrite, which is transformed from nitrate in the digestive system, causes the iron in the hemoglobin to oxidize, creating methemoglobin. This methemoglobin lacks the oxygen-carrying capacity of hemoglobin. In most cases health deteriorates over a period of days, with symptoms including shortness of breath and blueness of skin.

Ground water quality data, including common ions, nutrients, bacteria, pesticides, and nitrogen isotopes, were collected and interpreted to determine the source of nitrate found in the ground water. All the analyses, except for the nitrogen isotope ratio analysis, are common tests that can be conducted by most analytical laboratories. The nitrogen isotope ratio analysis is an analytical procedure that is performed primarily at universities and research laboratories. The nitrogen isotope information is extremely valuable in the evaluation of sources contributing to elevated levels of nitrate in the ground water. Numerous scientific articles have documented the benefit of employing nitrogen isotopes in environmental studies (Gormly and Spalding, 1979; Aravena et al., 1993; Exner and Spalding, 1994; Gellenbeck, 1994; and Seiler, 1996). Recently, DEQ used nitrogen isotope analyses to identify sources of nitrate contamination in Ada County, Idaho (Howarth, 1999).

DEQ activities during this study included the following six items.

(1) DEQ representatives met with city officials from Grand View to explain the project and to enlist them as project participants.

(2) Wells were sampled and, where feasible, water levels were measured.

(3) An inventory of potential contaminant sources was conducted.

(4) The wellhead protection area for Grand View was delineated.

(5) All ground water quality results were received and sent to the respective well owners.

(6) This summary report was prepared.

2.1 Purpose and Objectives

The purposes of this project are to collect ground water quality and hydrogeologic information to evaluate elevated nitrate concentrations near Grand View and to assist the local residents in protecting their ground water resources. The project should help identify sources of nitrate impacting the drinking water supply of the city and surrounding domestic wells. The specific objectives of the project include:

- collecting and analyzing ground water quality data and locating potential sources of ground water contamination in the vicinity of Grand View;
- estimating the wellhead protection area for Grand View using two different methods;
- comparing the sizes of the areas and the number of potential contaminant sources within the different wellhead protection areas; and
- assessing potential sources of nitrate contamination in the vicinity of Grand View and utilizing nitrogen isotope and hydrochemical data to identify, where possible, the source or sources of nitrate contamination in the ground water.

2.2 Study Area

Grand View is located in Owyhee County on the south side of the Snake River, approximately 23 miles southwest of Mountain Home (Figure 1) at the intersection of State Routes 67 and 78. The land within the city limits is occupied by schools, homes, service businesses, and government offices. Grand View provides municipal drinking water and sewer service to approximately 500 residents. Homes outside the city limits maintain private domestic wells and individual septic systems. Sprinkler and gravity-irrigated farming are the predominant uses of the land surrounding Grand View. An infrared aerial photograph image of the area taken in July 1987 shows the intensity of the agricultural activities (Figure 2). Generally, red areas indicate dense, vigorously growing vegetation, while light areas are devoid of vegetation. An explanation of the colors shown on the image is provided in Appendix A. More recent aerial photographs indicate land use remains mostly unchanged since 1987. These photographs are black and white and do not illustrate land uses as clearly as the infrared image. Crops grown in the area include alfalfa, wheat, beans, sugar beets, potatoes, corn, and peppermint (AgriMet, 1999). A beef feed lot, containing approximately 150,000 cattle, is located north of the Snake River and is hydraulically down gradient from the city water supply. The Grand View wastewater treatment facility is also located north of the Snake River. Based on their down-gradient locations, the large confined animal feeding operation and the wastewater plant should not impact Grand View's drinking water supply.

2.3 Historic Water Quality Data

Available historic water quality data for nitrate, bacteria, and organic compounds including pesticides and herbicides were reviewed and summarized for any evidence of trends occurring within the last 10 years. The review included the public water system monitoring data for the Grand View public drinking water system contained in the DEQ Drinking Water Information Management System, and nitrate data from domestic wells collected by the public water system operator in 1995 and 1996.

Nitrate results from 1993 through 1999 were reviewed and are shown in Table 1. The results indicate that nitrate concentrations (measured as total nitrogen) have fluctuated between 3 milligrams per liter (mg/l) and 10.5 mg/l over this time period. The federal and state drinking water standard, or MCL, for nitrate is 10 mg/l. (The units of mg/l and parts per million (ppm) are roughly equivalent, so the MCL of 10 mg/l is approximately 10 ppm.) The nitrate concentrations versus time data shown in Figure 3 suggest there is a seasonal variation in nitrate levels. The highest levels tend to occur in the spring, while the lowest levels tend to occur in the fall. It is possible the nitrate levels may be influenced by water containing very low levels of nitrate leaking from canals in the area, including the Grand View Mutual Canal located 50 feet hydraulically upgradient of the wells. The water from the canals likely infiltrates during the spring and summer and mixes with and dilutes the higher nitrate ground water in the aquifer, thus reducing nitrate levels in the fall and summer. There is a lag between when the canals start flowing and when the nitrate levels begin to decrease because water leaking from the canals does not instantly infiltrate the aquifer. It takes approximately two months for canal water to move down to the ground water, assuming a steady infiltration rate of 1.5 feet/day (Hillel, 1980).

Laboratory tests conducted between 1990 and 1999 indicate water samples collected from the Grand View water system did not contain volatile organic compounds or synthetic organic compounds. No inorganic compounds other than nitrate were detected above MCLs. Bacteria results from samples collected in 1998 and 1999 indicate that total coliform bacteria are rarely detected in the Grand View water system.

FIGURE 2
Grand View, Idaho
1987 Aerial Photo Showing Land Use, Wellhead Protection Area and Sampling Locations

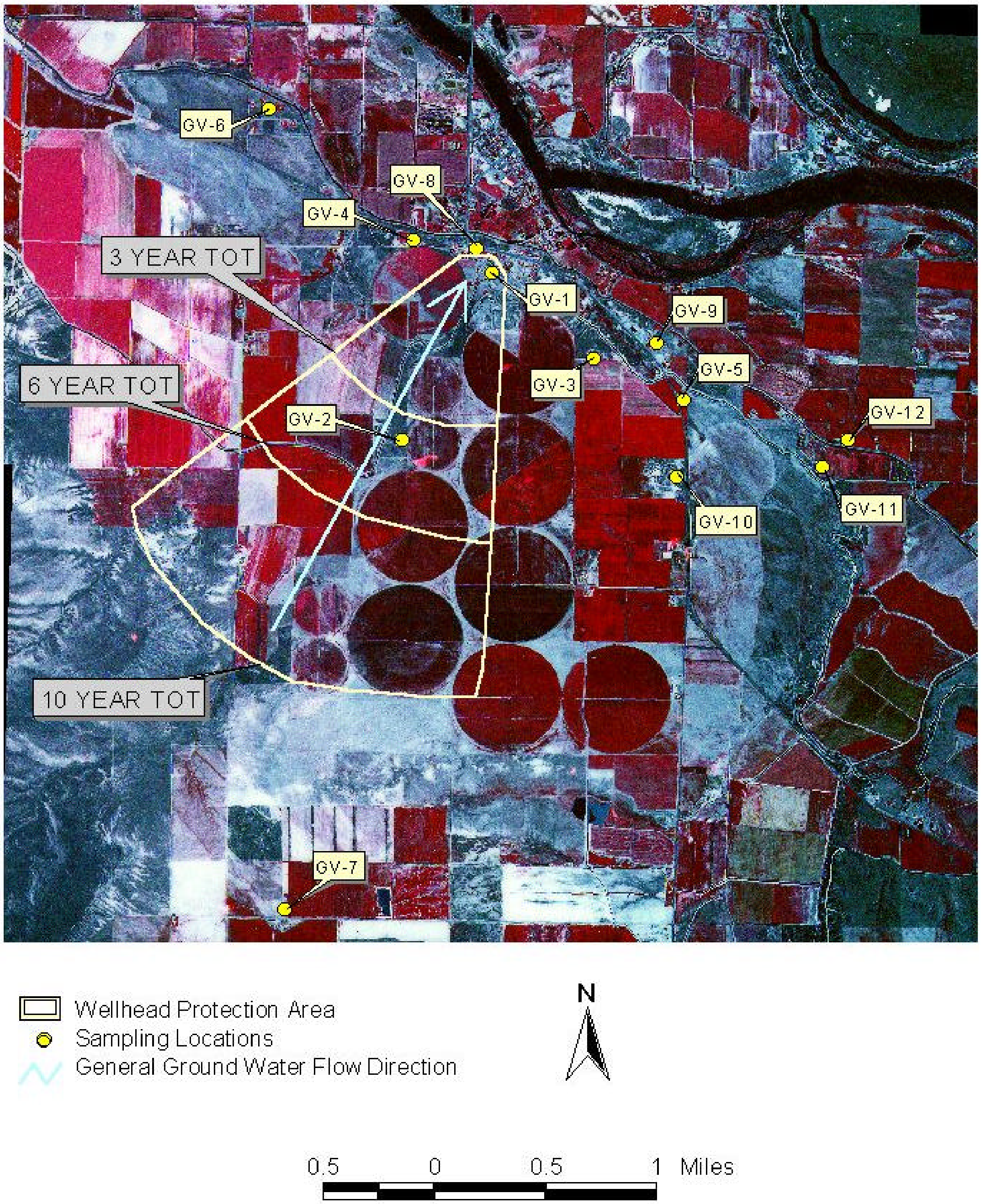
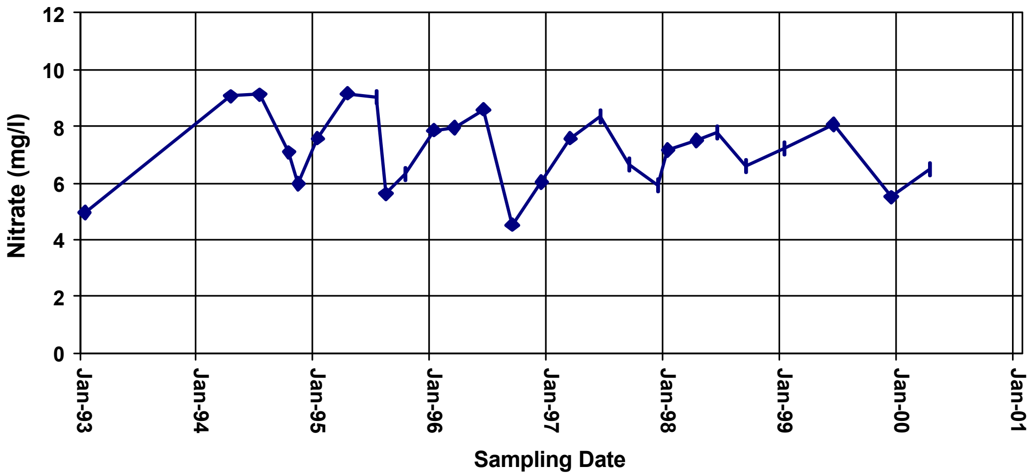


Table 1. Nitrate Results for Grand View Wells (1993-1999)

Sample Date	Nitrate Concentration (mg/l)[1]		
	Well #1	**Well #2**	**Average**
01/25/93	6.78	3.08	4.93
04/14/94	9.05	Not sampled	9.05
07/19/94	9.12	Not sampled	9.12
10/03/94	7.09	Not sampled	7.09
11/01/94	6.81	5.13	5.97
01/03/95	7.66	7.52	7.59
04/05/95	9.75	8.57	9.16
07/05/95	10.50[2]	7.58	9.04
08/28/95	Not sampled	5.60	5.60
10/02/95	7.66	4.96	6.31
01/02/96	7.86	Not sampled	7.86
03/04/96	7.59	8.30	7.95
06/04/96	9.28	7.94	8.61
09/10/96	4.46	4.58	4.52
12/03/96	6.59	5.47	6.03
03/03/97	7.01	8.14	7.58
06/04/97	8.55	8.17	8.36
09/02/97	7.80	5.51	6.66
12/01/97	6.04	5.81	5.93
01/05/98	6.81	7.55	7.18
04/01/98	Samples not uniquely identified		7.52
06/01/98	Samples not uniquely identified		7.78
09/01/98	Samples not uniquely identified		6.60
01/04/99	Samples not uniquely identified		7.24
06/01/99	Samples not uniquely identified		8.09
12/01/99	Samples not uniquely identified		5.50
04/04/00	Samples not uniquely identified		7.20

[1]mg/l is approximately equivalent to parts per million
[2]Above MCL

FIGURE 3.
Grand View, Idaho
Average Nitrate Levels



2.4 Previous Investigations

Grand View water system personnel collected ground water samples in 1995 and 1996 for nitrate analysis from nine domestic wells and from the Grand View Mutual Irrigation Canal located immediately south of the city wells. Eight of the nine wells were sampled both years; nitrate levels increased in six of the eight wells. Nitrate levels above 10 mg/l (roughly equivalent to 10 ppm) were measured in four wells in 1995 and five wells in 1996. The nitrate levels ranged from a low of 0.644 mg/l in the canal water to a high of 23.7 mg/l in well GV-3. Seven of the wells sampled during these years (GV-1, GV-2, GV-3, GV-4, GV-5, GV-8, and GV-9) were sampled during this investigation.

3.0 CHARACTERIZATION OF THE WELLHEAD PROTECTION AREA

3.1 Climate

Based on precipitation records for 1961 through 1990, the mean annual precipitation in Grand View is approximately seven inches (Idaho State Climate Services, 1999). The monthly precipitation varies from an average low of 0.21 inches in July to an average high of 0.86 inches in November. The mean annual temperature is approximately 52 ^{o} F (Idaho State Climate Services, 1999). July is the warmest month with a mean temperature of 74.7^{o} F. January is the coldest month with a mean temperature of 29.9^{o} F. The U.S. Bureau of Reclamation Hydromet/Agrimet station in Grand View measured 8.26 inches of precipitation during the October 1, 1997, through September 30, 1998, water year. The growing season in the Grand View area is approximately 150 days per year (USDA, 1991).

3.2 Soils

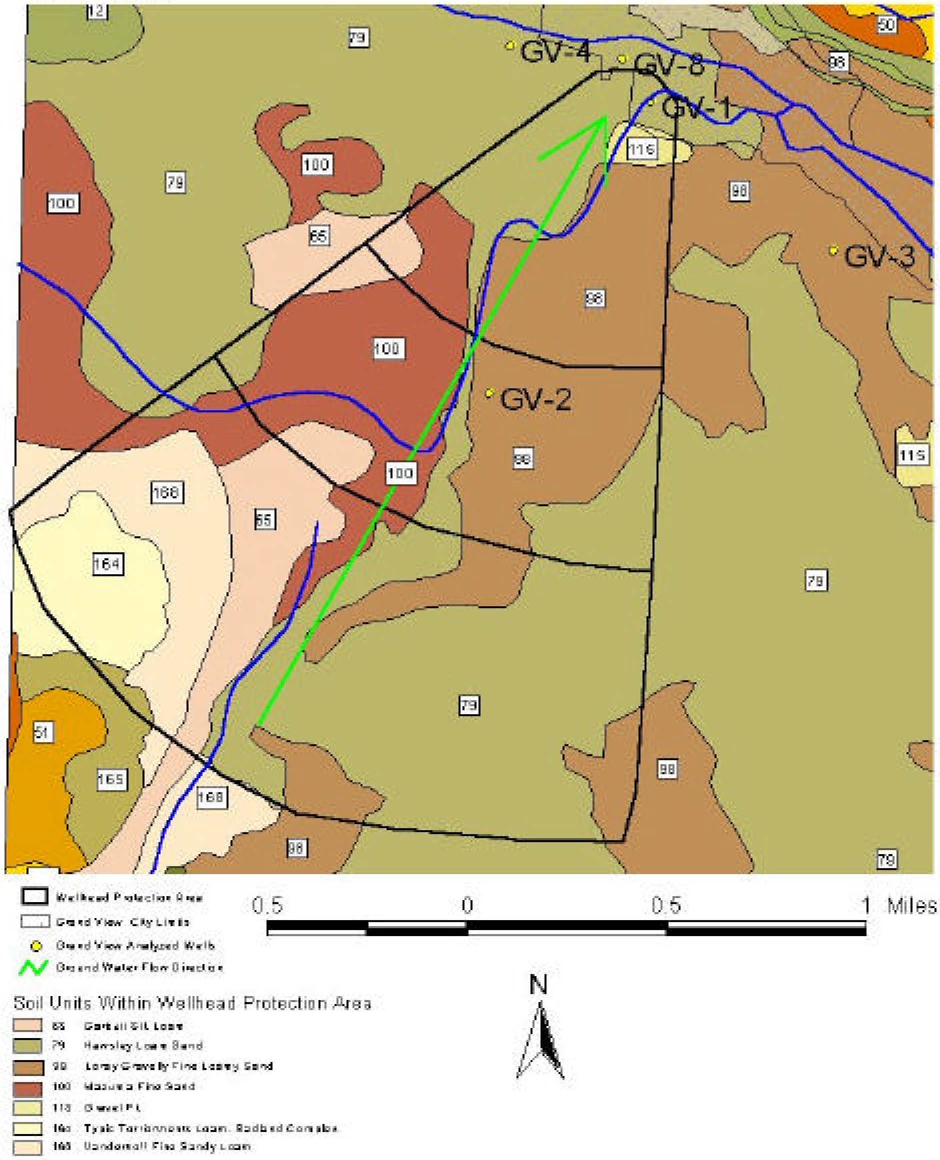
Numerous soil types are located in the study area (Figure 4). In general, the surface is covered with sandy soils that allow rapid infiltration of precipitation. The predominant soil types in the wellhead protection area are Hawsley loamy sand and Loray gravelly fine sandy loam. A gravel deposit is located immediately upgradient of the city wells.

Hawsley loamy sand and the Loray gravelly fine sand cover approximately two-thirds of the wellhead protection area (Figure 4). These soils have a low available water capacity and a rapid permeability, meaning water moves quickly through them (2 to 20 inches per hour). The other soils within the wellhead protection area are well-drained sandy or silty loams with moderate permeability (0.6 to 2 inches per hour) and moderate to high available water holding capacity.

3.3 Hydrogeology

Grand View's public water supply wells are located within a hydrogeologic environment predominated by Quaternary alluvium (Figure 5). The alluvium is present at the surface to a depth of approximately 130 feet near the city wells. Grand View wells draw water from sand and gravel zones within the unconfined alluvial aquifer. A thick sequence of blue clay and shale of the Idaho Formation underlies the alluvium and acts as a base for the alluvial aquifer. The Idaho Formation consists of poorly- to well-stratified terrestrial and lake deposits and lenticular beds of sand, sandstone, silt, and clay. Water in the alluvium is unconfined, while water under artesian pressure is found within permeable beds within the Idaho Formation. The well driller's logs were reviewed and used to create a geologic cross-section illustrating subsurface conditions in the area (Figure 6). Well driller's logs are included in Appendix B.

FIGURE 4
Grand View, Idaho
Soil Unit Map



Water level data from the Idaho Department of Water Resources indicate the regional ground water flow direction in the area is to the north-northwest under a hydraulic gradient of approximately 0.01 feet/foot (Bendickson, 1998). Water level measurements were collected from ten wells in August 1998 to determine the direction of ground water flow in the study area. The water level elevations represented on Figure 7 indicate that the ground water in the alluvial aquifer is moving to the north under a gradient of approximately 50 feet per mile (0.01 feet/foot).

FIGURE 5
Grand View, Idaho
Generalized Geologic Map Units With Cross Section Location

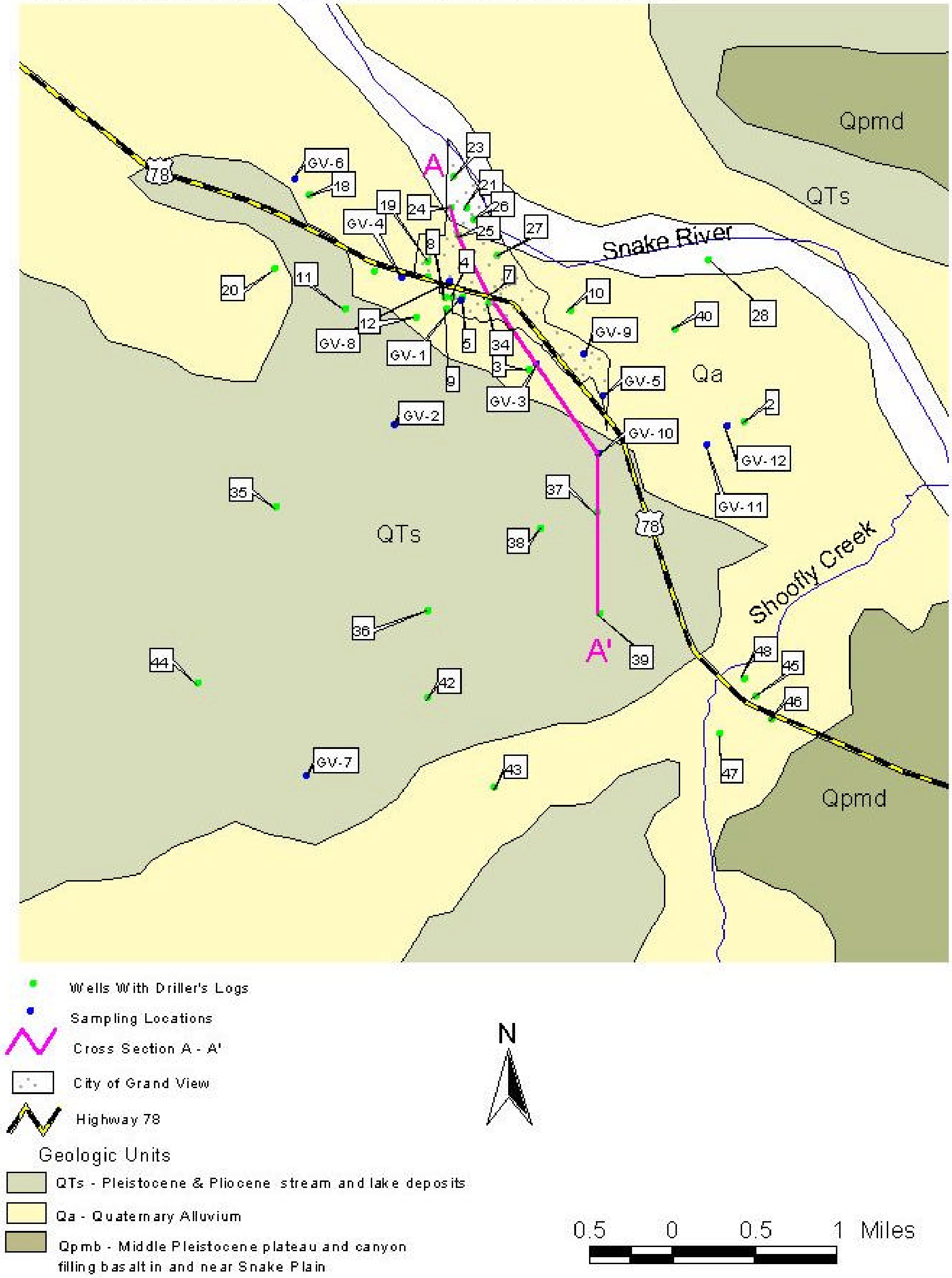
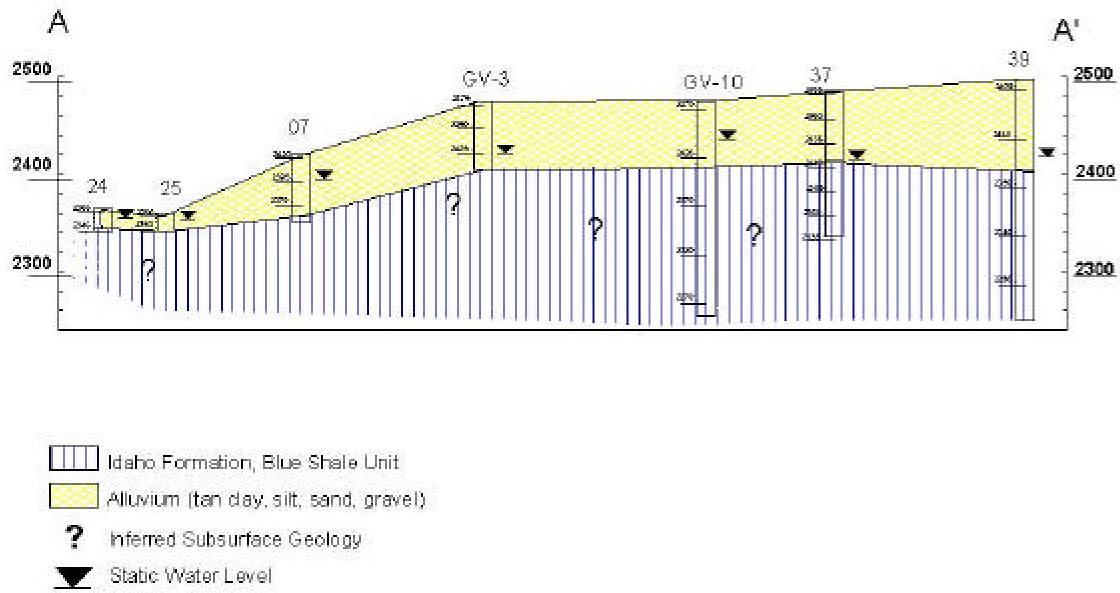


FIGURE 6
Grand View, Idaho
Generalized Geologic Cross Section A - A'

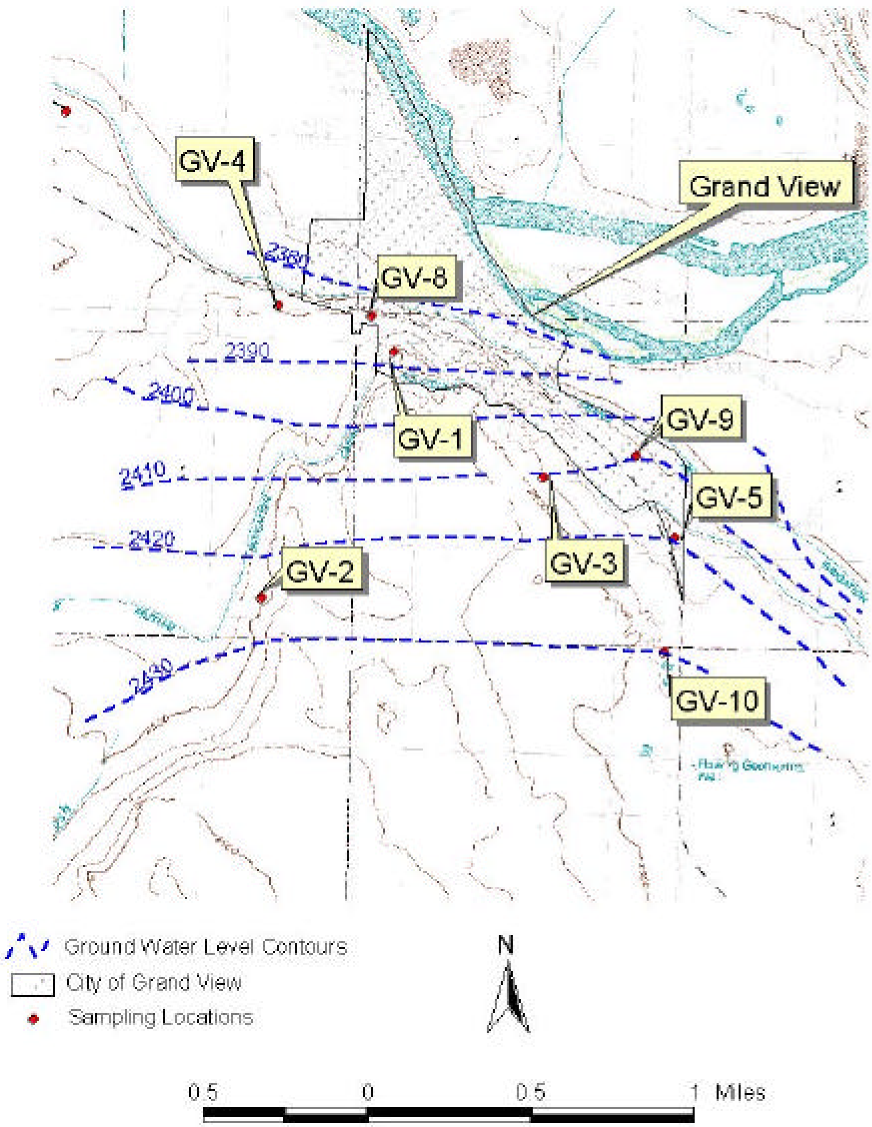


3.4 Wellhead Protection Area Delineation

The wellhead protection area for Grand View was developed using two different methods: the Basic Method and the Refined Analytical Method. Comparison of the wellhead protection delineation methods was done to evaluate if collection of site-specific hydrogeologic information is scientifically or economically justified. A single wellhead protection area was developed for Grand View because its two wells are located only about 300 feet apart. The two methods are described in Chapter 4 of *the Idaho Wellhead Protection Plan* (DEQ, 1997).

In accordance with the *Idaho Wellhead Protection Plan* (DEQ, 1997), the wellhead protection area for Grand View is composed of four zones (IA, IB, II, and III). Zone IA, the sanitary setback zone, extends at least 50 feet from the well. The outer boundaries of the remaining zones represent the distance it takes water to travel to a specific well within a specific time period. For example, water at the outer three-year time of travel boundary would take three years to travel to the well. The three-year time-of-travel corresponds to Zone IB; the six-year time-of-travel corresponds to Zone II; and the ten-year time-of- travel corresponds to Zone III.

FIGURE 7
Grand View, Idaho
Ground Water Level Contour Map



The wellhead protection area zones are designed so that appropriate levels of management can be applied to contaminant sources within those zones. Typically, more stringent management practices are applied to contaminant sources closer to a well and less stringent management practices are applied to contaminant sources further from a well. Ideally, all contaminant sources within a wellhead protection area should be managed in a manner to prevent contamination from reaching a water supply well.

3.4.1 Basic Method

The Basic Method uses generalized hydrogeologic information for the major aquifer types in Idaho and the well pumping rate to create wellhead protection areas. The delineation of a wellhead protection area involves drawing circles around the well for the three-, six-, and ten-year time-of-travel boundaries. The radius for each time-of-travel boundary is determined from pumping rate tables contained in the *Idaho Wellhead Protection Plan* (DEQ, 1997) that are specific for each generalized Idaho aquifer type. This method is used when site-specific data are not available. An advantage of this method is the low cost and ease with which a delineation can be performed. A disadvantage is the delineation does not use site-specific data; and therefore may not accurately represent the source area of the drinking water.

The Basic Method wellhead protection area was calculated using an unconsolidated alluvium aquifer type and a pumping rate of 100 gallons per minute. Table 4.8c in the *Idaho Wellhead Protection Plan* (DEQ, 1997) was used to determine the radii of the wellhead protection area zones. The wellhead protection area estimated using the Basic Method encompasses over 77,000 acres (120 square miles).

3.4.2 Refined Analytical Method

The Refined Analytical Method utilizes site-specific hydrogeologic information and a ground water flow computer model to delineate wellhead protection areas. The refined wellhead protection area was delineated by DEQ using the Wellhead Analytic Element Model (WhAEM 2000) ground water flow computer model distributed by the U.S. Environmental Protection Agency (EPA) (Kraemer, 2000). The wellhead protection area for Grand View should be considered to be only an approximation because seasonal variations in ground water flow conditions have not been determined. The WhAEM 2000 model assumes the aquifer is uniform within the entire wellhead protection area and pumping rates do not change. In reality, the aquifer thickness, the ground water flow direction, the hydraulic conductivity, and the effective porosity all vary within the wellhead protection area. To account for this variability, average values are used in the computer model to estimate the wellhead protection areas.

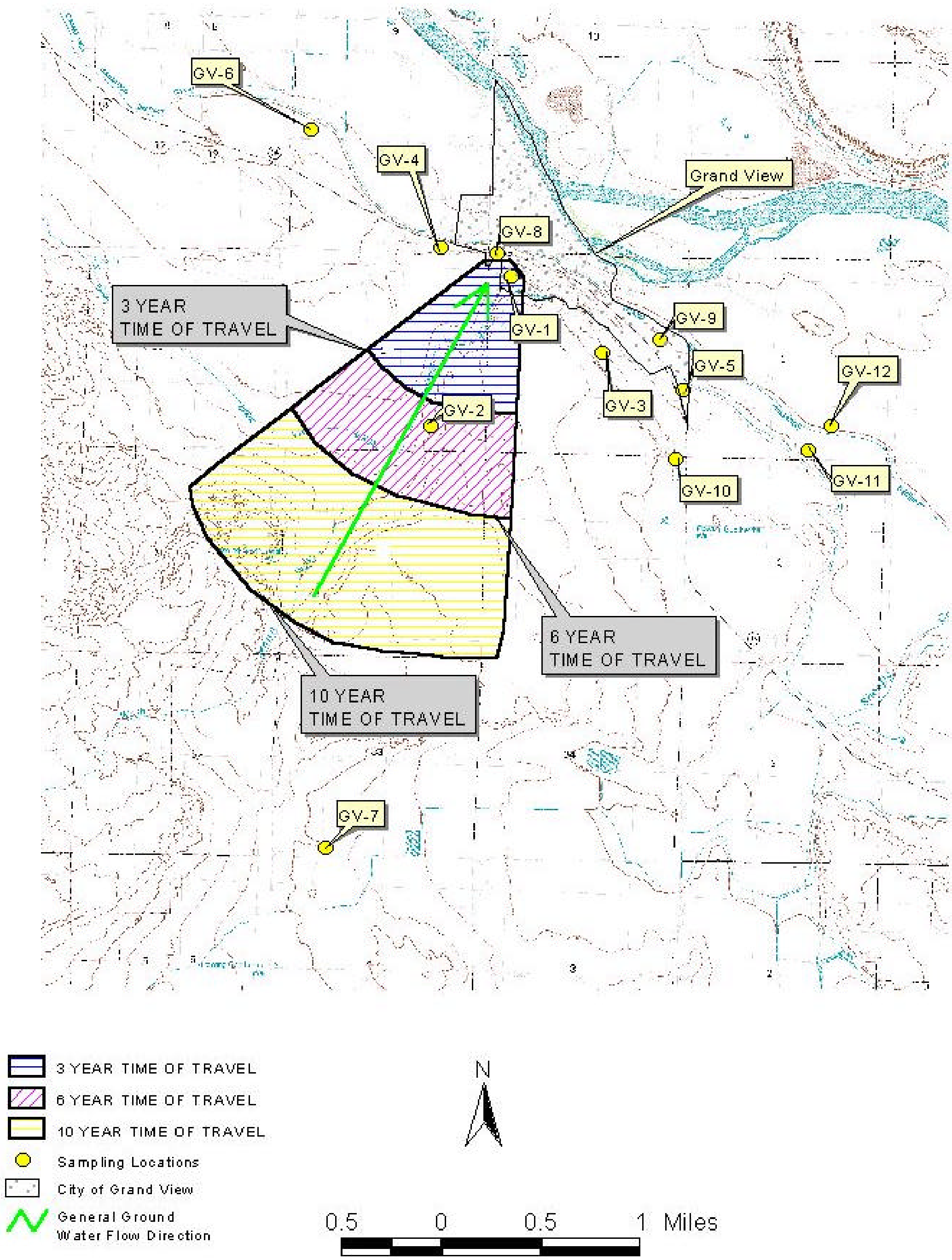
The geologic map and ground water flow data indicate the source of the drinking water supply for Grand View moves through a coarse sand and gravel aquifer. The aquifer hydraulic properties used in the computer model are representative of unconsolidated alluvium. The aquifer parameters shown in Table 2 were used to delineate the wellhead protection area for Grand View. The wellhead protection area estimated using the Refined Analytical Method encompasses 1,341 acres (2 square miles) and is shown in Figure 8.

Table 2. Aquifer Parameters Used in Refined Wellhead Protection Area Delineation

Aquifer Parameter	Value	Comments
Hydraulic Conductivity (feet/day)	150	Within range for sand and gravel, K[1] value from wellhead plan = 250 feet/day
Aquifer Thickness (feet)	100	Approximate thickness of water producing zones, based on driller's logs
Ground Water Flow Direction	S to N	Based on water levels - August 1998
Ground Water Gradient (feet/foot)	0.01	Calculated by WhAEM 2000 computer model. Similar to gradient based on water levels – August 1998
Well Pumping Rate (gallons/day)	144,000 (100 gpm)	450 users @ consumption rate = 320 gallons per user
Recharge Rate (inches/year)	24	Based on irrigation, canal losses, and precipitation
Effective Porosity (%)	0.30	Coarse sand and gravel with few fines
Ground Water Velocity (feet/day)	3	Calculated by computer model. 10-year time-of-travel distance/3650 days

[1]K = Hydraulic Conductivity

FIGURE 8
Grand View, Idaho
Wellhead Protection Area, Refined Analytical Delineation Method



4.0 POTENTIAL CONTAMINANT SOURCES

A potential contaminant source is simply a location where there is or was an activity having the potential to release contaminants into the ground water at a level of concern. The activity may be associated with a business, industry, or operation involving the use, transport, storage, or manufacture of the potential contaminants. Identification of a business, industry, or operation as a potential contaminant source does not mean that the business, industry, or operation is out of compliance with any local, state, or federal regulation, and it does not necessarily mean that the business, industry, or operation has or will cause contamination. What it does mean is that the potential for contamination (or pollution as it is sometimes called) exists due to the nature of the business, industry, or operation.

Potential sources of contamination are often separated into two categories: point sources and nonpoint sources. Point sources of contamination occur at discrete locations and are associated with facilities that handle large quantities of a contaminant. For example, ground water can be contaminated by a single point source at a specific location, such as a leaking storage tank. Point sources of contamination include industrial facilities, animal feeding operations, waste disposal sites, and large accidental spills. Additionally, point sources can be associated with small businesses, abandoned wells, and other activities located in every community.

Nonpoint sources of contamination are more difficult to distinguish because they are associated with everyday activities and occur on an area-wide basis. Typically, contamination results when a large mass of contaminant is dispersed over a large area. No single release may be enough to affect ground water quality, but the cumulative effects of widespread releases may adversely impact ground water quality. Nonpoint sources of contamination include subdivisions with a high septic system density, fertilizer and manure applications on agricultural land, and legume crops.

In November 1998 a contaminant inventory of the study area was conducted by DEQ State Office staff. The potential contaminant inventory involved identifying and documenting potential contaminant sources within the Grand View refined wellhead protection area. The potential contaminant inventory provides: 1) information on the locations of potential contaminant sources, especially those that present the greatest risks to the water supply, and 2) a reliable basis for developing a wellhead protection plan to reduce the risks to the water supply.

4.1 Potential Contaminant Sources – Point

A computerized review of databases containing businesses that could be potential sources of contamination identified only two potential sources in the wellhead protection area: a gravel pit located just south of the wells and a geothermal well site located within the wellhead protection area near the six-year time-of-travel boundary (Table 3). The gravel pit contains equipment storage and maintenance buildings and fuel pumps. Activities associated with the gravel pit, such as equipment maintenance and fuel storage, are potential sources of contamination. The geothermal well is considered a potential source of fluoride contamination because it may act as

Table 3. Grand View Wellhead Protection Area Potential Point Source Contaminant Inventory

Site #	Type of Facility	Potential Contaminants	Wellhead Protection Zone
P1	Gravel pit operation with equipment storage and potential fuel storage	Fuel, oils, solvents	0-3 year time of travel
P2	Geothermal well	Fluoride – IOCs[1]	3-6 year time of travel

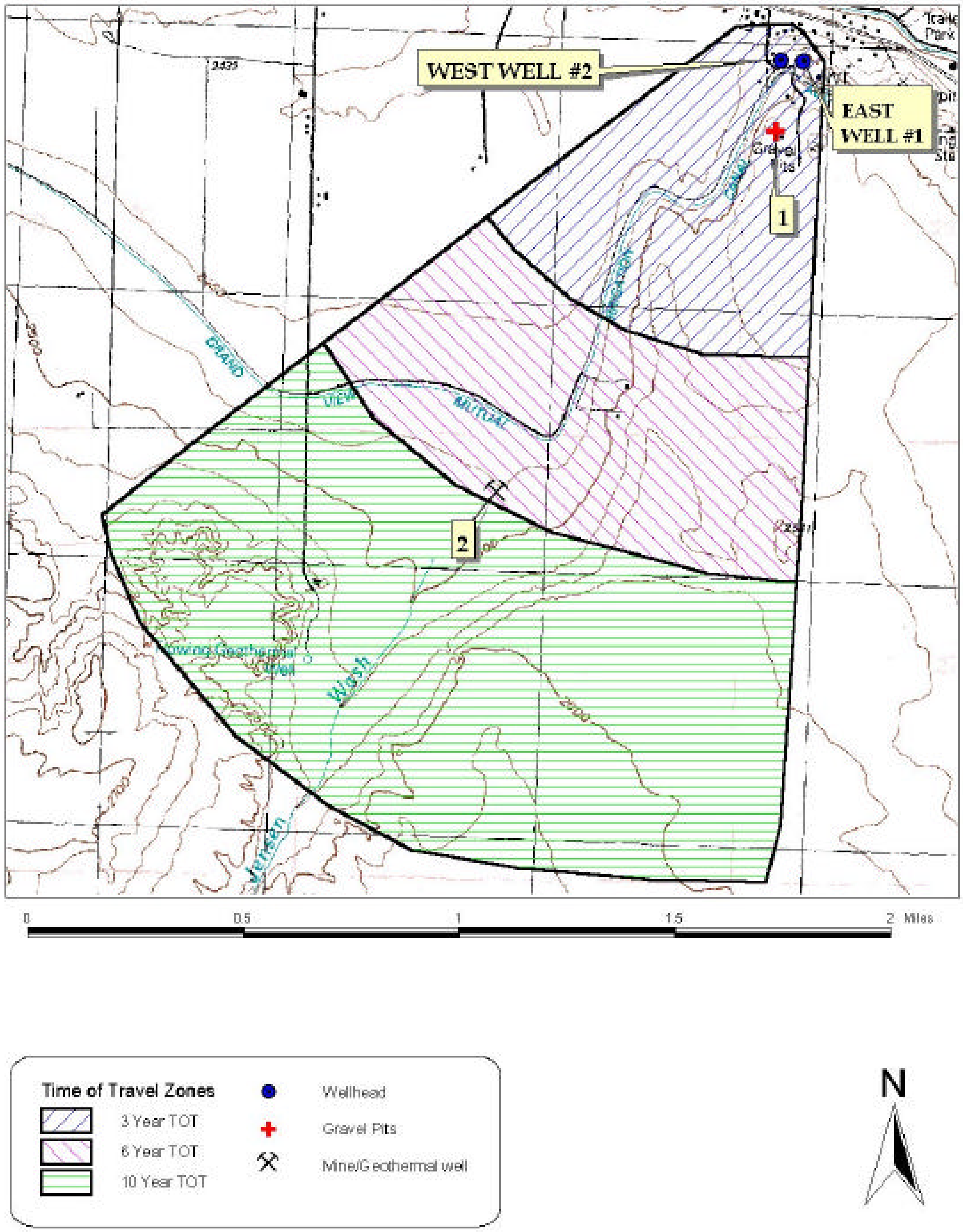
[1]Inorganic Chemicals

a conduit for water from the deeper aquifer (which contains elevated fluoride levels) to mix with the drinking water aquifer. The potential contaminant sources are located on Figure 9.

4.2 Potential Contaminant Sources – Nonpoint

Irrigated agricultural operations that use fertilizers, herbicides, and insecticides appear to be the primary potential nonpoint sources of contamination surrounding Grand View. The primary crop within the wellhead protection area is alfalfa; secondary crops include beans, corn, sugar beets, potatoes, and peppermint.

FIGURE 9.
Grand View, Idaho
Potential Contaminant Inventory



5.0 GROUND WATER SAMPLING

Ground water sampling was conducted in August and November 1998. The August sampling included 12 wells (see Figure 8) that were sampled for major ions (bicarbonate alkalinity, calcium, chloride, fluoride, magnesium, potassium, sodium, and sulfate), nitrate (NO_3 as nitrogen), total ammonia (as nitrogen), and total dissolved solids. The purpose of the August sampling was to identify wells containing high levels of nitrate. In November, samples were collected from the seven wells containing the highest nitrate or ammonia levels (GV-1 through GV-7). A stable nitrogen isotope ratio analysis was conducted on the samples. In addition, they were analyzed for total coliform bacteria and *E-coli* bacteria. A scan for organochlorine/ organophosporous herbicides/insecticides was conducted using EPA Method 525.2. The water samples from City Well #1 also were analyzed for chlorinated herbicides using EPA Method 515.1. The water sample from Well GV-7 was analyzed for ammonia in addition to the other analytes because it previously contained elevated ammonia levels.

Duplicate samples were collected at City Well #1 in August for quality control purposes. All samples were collected in containers provided by the state of Idaho Bureau of Laboratories (Idaho State Lab). The Idaho State Lab in Boise completed all analyses except for the stable nitrogen isotope ratios. Coastal Science Laboratories, Inc. in Austin, Texas, performed the nitrogen stable isotope ratio analyses.

Ground water samples were collected from outside faucets or taps as close as possible to the wellhead to reduce the potential for contamination from plumbing and hoses. All wells were pumped prior to sample collection to remove water from the wells and ensure that the water samples were representative of aquifer conditions. The specific conductance, temperature, pH, and dissolved oxygen of the purged water were measured with a Horiba U-10 Water Quality meter to monitor water chemistry. Field measurements were continued until water quality parameters stabilized, indicating water from the aquifer, not stagnant water from the well casing, was being discharged. Samples were not field filtered, but were acidified and chilled as needed for preservation.

5.1 General Ground Water Quality

The major ion chemistry was evaluated because the chemical composition of ground water is a function of the mineral composition of the aquifer material as well as the residence time of the aquifer. Therefore, the major ion chemistry sometimes can be used as an indicator of the rock type of the aquifer. The other analyses (nitrate, nitrogen isotope, ammonia, pesticides, herbicides, and bacteria) were used as indicators of different types of contamination from a variety of anthropogenic activities. The specific organic compounds contained in herbicides and insecticides that were analyzed for are contained in Appendix C.

5.2 Nitrogen Isotopes

Isotopes of an element have the same number of protons but a different numbers of neutrons. Elements have a predominant isotope and less abundant isotopes. The standard notation for identifying different isotopes is to write the sum of the number of protons and neutrons in the upper left corner of the symbol of the element (e.g., ^{1}H=common hydrogen with one proton and zero neutrons; ^{3}H=[tritium] hydrogen with one proton and two neutrons).

The stable nitrogen isotope ratio analysis was conducted on the samples to identify the source of nitrate in the ground water. This test provides a measurement of the ratio of the two most abundant isotopes of nitrogen, ^{14}N and ^{15}N. The ratio of these two isotopes is a useful indicator of sources of nitrogen contamination because unique $^{15}N/^{14}N$ ratios are associated with each of the predominant sources of nitrogen contamination.

The nitrogen isotopes ^{15}N and ^{14}N constitute an isotope pair. The lighter isotope ^{14}N is significantly more abundant in the environment than ^{15}N. In the atmosphere there is one atom of ^{15}N per 273 atoms of ^{14}N (Drever, 1988). The ratio of the heavier isotope to that of the lighter isotope in a substance can provide useful information because the slight differences in the mass of the isotopes cause slight differences in their behavior. Stable isotopes are measured as the ratio of the two most abundant isotopes of a given element. Isotope values for nitrogen and other elements are presented in the delta notation:

$$\delta^{15}N = \{[(^{15}N/^{14}N)_{sample}\ )\ (^{15}N/^{14}N)_{air}\ ] - 1\} \text{ x } 1000.$$

The δ-value is expressed as parts per thousand or per mil ($^{0}/_{00}$) difference from the reference. For example, a $\delta^{15}N$ value of +10 per mil has 10 parts per thousand (one percent) more ^{15}N than the reference. A positive δ-value is said to be “enriched” or “heavy,” while a negative δ-value is said to be “depleted” or “light.” The reference standard for the stable isotopes of nitrogen ($^{15}N/^{14}N$) is atmospheric nitrogen (Clark and Fritz, 1997).

Several steps in the nitrogen cycle can modify the stable-isotope composition of a nitrogen-containing chemical. These changes, called fractionation, occur as a result of physical and chemical reactions. Isotopic effects, caused by slight differences in the mass of two isotopes, tend to cause the heavier isotope to remain in the starting material of a chemical reaction. Denitrification, for example, causes the nitrate of the starting material to become isotopically heavier. Volatilization of ammonia results in the lighter isotope preferentially being lost to the atmosphere, and the ammonia that remains behind becomes isotopically heavier.

These isotopic effects mean that, depending on its origin, the same compound may have different isotopic compositions. For stable isotopes to provide a useful tool in identifying sources of nitrogen contamination, the isotopic composition of the potential source materials must be distinguishable. Major potential sources of nitrogen contamination in the environment commonly have characteristic $^{15}N/^{14}N$ ratios. Typical $\delta^{15}N$ values for important sources of nitrogen contamination are presented in Table 4. For example, if a ground water sample contained a nitrogen isotope δ^{15}N value of -1 $^{0}/_{00,}$ it would indicate commercial fertilizer is the source of the nitrogen. These sources can also be present in different combinations. For instance, while a nitrogen isotope δ^{15}N value of +4 to +9 $^{0}/_{00}$ generally indicates organic nitrogen in the soil, a value in this range could also be the result of a mixture of commercial fertilizer and animal waste.

Table 4. Nitrogen Sources Associated with d^{15}N Values (Seiler, 1996)

Nitrogen Source	ä ^{15}N ($^{0}/_{00}$)
Precipitation	-3
Commercial Fertilizer	-4 to +4
Organic Nitrogen in Soil	+4 to +9
Animal or Human Waste	> +10

6.0 RESULTS AND DISCUSSION

Multiple analytical tests were performed on the ground water samples collected during this investigation to develop multiple lines of evidence to distinguish if specific sources are responsible for the elevated nitrate levels in Grand View drinking water. Well information, field parameter measurements, and analytical results for Grand View are summarized in Tables 5 and 6 and discussed in later sections. The general chemistry of the ground water is presented first, followed by a discussion of nitrate and nitrogen isotope results. The bacteria and pesticides data are then summarized and finally, the quality assurance results are reviewed.

Table 5. Well Information and Field Parameter Measurements

Well	Sample Date	Depth to water (ft)	Well Depth[1] (ft)	Water Temp (°F)	Specific conductance (µmhos/cm)	pH	Dissolved Oxygen (mg/l)[2]
GV-1	08/27/98	85.35	131 - L	63	910	7.4	7.0
GV-2	08/27/98	65.40	172 - R	61	910	7.5	4.6
GV-3	08/27/98	53.49	70 - L	61	1,400	7.6	9.9
GV-4	08/27/98	35.52	63 - R	63	940	7.7	4.5
GV-5	08/27/98	31.50	80 - R	61	1,400	6.8	8.8
GV-6	08/27/98	46.82	68 - R	61	1,200	7.7	1.0
GV-7	08/27/98	62.39	725 - R	70	750	7.5	0.1
GV-8	08/27/98	39.48	65 - M	63	770	7.5	7.2
GV-9	08/27/98	19.17	45 - R	63	740	7.4	4.7
GV-10	08/27/98	39.25	220 - R	66	1,000	7.3	0.1
GV-11	08/27/98	18.94	100 - L	64	620	7.1	7.6
GV-12	08/27/98	3.84	UNK	59	580	7.8	8.1

[1]R = depth reported by well owner, M = measured depth, L = depth from driller's log, UNK = unknown
[2]mg/l is roughly equivalent to parts per million, so 7.0 mg/l = 7.0 parts per million

6.1 Field Measurements

Water quality parameters (temperature, specific conductance [a measure of salinity, reported in units called mhos or in millionths of mhos, called micro {µ} mhos], pH, and dissolved oxygen) were monitored in the field on August 27, 1998, using a Horiba U-10 water quality meter to allow an initial evaluation of aquifer conditions. No field measurements were performed during the sampling event in November 1998. Water temperatures were 61° F or 63° F for 8 of the 12 samples. The warmest temperature ground water was extracted from the wells drawing water from the Idaho Formation (GV-7 and GV-10). Ground water samples from these wells also had the lowest dissolved oxygen and contained significant levels of ammonia.

The specific conductance ranged from 580 to 1400 µmhos/cm and was generally highest in water samples from wells with high nitrate. The pH readings ranged from 6.8 to 7.8 standard units. The lowest pH was measured in the water sample from the well with the most anomalous water chemistry (GV-5). The other water samples had pH values between 7.1 and 7.8 standard units.

Table 6. Grand View Vicinity Wells' Inorganic Analytical Results

	Sample	Nitrate	Nitrogen Isotope (per mil)	Ammonia	HCO3	SO4	Ca	CL	Mg	Na	K	F	TDS	Ion Balance (%)
GV-1	08/27/98	9.050	--[2]	<0.005	272	123.0	48.0	52.6	26.70	93	11.4	0.70	576	2.44
GV-1b[3]	08/27/98	9.000	--	<0.005	--	--	47.8	--	26.80	92	11.4	--	581	--
GV-1	11/12/98	7.040	2.3	--	--	--	--	--	--	--	--	--	--	--
GV-2	08/27/98	8.390	--	<0.005	363	91.5	50.0	36.8	26.80	100	106.0	2.59	585	2.35
GV-2	11/12/98	8.130	2.7	--	--	--	--	--	--	--	--	--	--	--
GV-3	08/27/98	23.600	--	<0.005	521	159.0	48.2	63.6	23.60	250	7.5	0.75	955	6.09
GV-3	11/12/98	14.100	2.4	--	--	--	--	--	--	--	--	--	--	--
GV-4	08/27/98	9.320	--	<0.005	365	89.1	44.7	37.8	38.10	87	15.2	0.47	578	3.44
GV-4	11/12/98	9.030	1.9	--	--	--	--	--	--	--	--	--	--	--
GV-5	08/27/98	7.920	--	<0.005	271	296.0	101.4	129.0	49.00	110	19.8	0.34	1018	0.51
GV-5	11/12/98	7.780	3.6	--	--	--	--	--	--	--	--	--	--	--
GV-6	08/27/98	14.600	--	<0.005	416	160.0	61.6	63.8	39.30	132	16.0	0.25	793	1.08
GV-6	11/12/98	17.100	3.9	--	--	--	--	--	--	--	--	--	--	--
GV-7	08/27/98	0.809	--	9.140	366	47.8	22.4	16.6	6.69	110	12.8	0.49	459	(-4.79)
GV-7	11/12/98	1.660	5.3[4]	8.560	--	--	--	--	--	--	--	--	--	--
GV-8	08/27/98	6.650	--	<0.005	261	92.2	43.4	39.3	27.30	64	12.8	0.64	600	1.46
GV-9	08/27/98	2.120	--	0.005	279	95.2	52.2	30.4	24.00	60	5.4	1.12	454	(-0.58)
GV-10	08/27/98	<0.005	--	4.040	699	111.0	89.4	74.1	40.20	150	19.5	<0.10	875	(-3.48)
GV-11	08/27/98	0.722	--	<0.005	238	74.9	39.3	20.8	17.10	58	5.6	0.93	349	(-0.11)
GV-12	08/27/98	0.824	--	<0.005	249	56.2	45.7	21.5	18.30	43	7.5	0.87	363	(-0.08)

[1]mg/l is approximately equivalent to parts per million, so 9.14 mg/l equals 9.4 parts per million

[2]Not Analyzed

[3]Duplicate of GV-1

[4]Nitrogen isotope ratio analysis performed on ammonia

Dissolved oxygen ranged from a low of 0.1 mg/l to a high of 9.9 mg/l. The lowest values were measured in wells completed in the Idaho Formation. The highest dissolved oxygen values were observed in wells completed in the alluvium.

6.2 General Ground Water Chemistry

The major ion chemistry data were evaluated using the Piper Diagram graphical technique. This graphical method is useful for illustrating variations in major ions between different aquifers. The Piper Diagram is a convenient method for comparing a large number of chemical analyses because numerous water samples can be plotted on a single diagram. Water samples with different major ion chemistries will plot on different portions of the Piper Diagram.

The Piper Diagram (Figure 10) depicts the major ion composition of each water sample on a single plot. Water samples with similar chemistry plot in the same area on the diagram. The major cations (calcium [Ca], magnesium [Mg], sodium [Na], and potassium [K)]) are plotted on the left triangle. The major anions (chloride [C], bicarbonate [HCO_3], and sulfate [SO_4]) are plotted on the right triangle. The plotted points for each water sample are then projected to the upper diamond-shaped area that shows cation and anion groups as a percentage of total milliequivalents per liter of sample. All but three of the water samples plot in the same area of the diagram. The Piper Diagram indicates that the chemistry of water samples GV-3, GV-5, and GV-7 deviate considerably from the other samples due to differences in cation and anion chemistry.

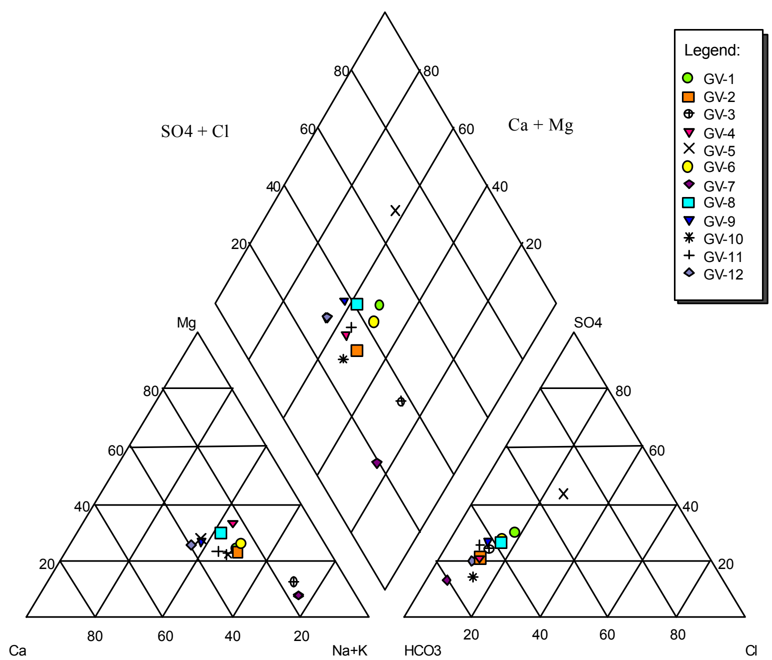
The water samples are separated into five different water types (Waterloo Hydrogeologic, 1998-1999). Seven of the water samples have basically the same water chemistry and are classified as a Na-Ca-Mg (Mg-Ca)-HCO_3-SO_4 water type. Two samples, classified as Na-Ca-Mg (Mg-Ca)-HCO_3, are chemically very similar to the first water type but contain less sulfate. The water samples that have the most anomalous chemistry again appear to be from wells GV-3, GV-5, and GV-7. The water types of are summarized in Table 7.

Table 7. Types of Water Sampled in Grand View City Wells

Water Type	Water Sample Location
Na-Ca-Mg-HCO_3-SO_4 or Na-Mg-Ca-HCO_3-SO_4	GV-1, GV-2, GV-9, GV-11 GV-4, GV-6, and GV-8
Na-Ca-Mg-HCO_3 or Ca-Na-Mg-HCO_3	GV-10 and GV-12
Na-HCO_3-SO_4	GV-3
Ca-Na-Mg-SO_4-HCO_3 -Cl	GV-5
Na-HCO_3	GV-7

The water sample from GV-3 contained the highest concentration of sodium and high bicarbonate and sulfate levels. This well also yielded water samples with nitrate concentrations of 23.6 mg/l and 14.1 mg/l. The well is constructed to a depth of approximately 70 feet and is completed within the alluvium. The elevated levels of sulfate and sodium suggest the well, at the

FIGURE 10
Grand View, Idaho
Piper Diagram



time it was sampled in August, had been impacted by animal or human wastes. However, the nitrogen isotope results indicate the nitrate levels in November are due to commercial fertilizer, rather than from animals or wastes. It is possible ground water chemistry varies seasonally in response to changes in land use and water use associated with the growing season.

The water sample from GV-5 contained the highest levels of sulfate, chloride, calcium, magnesium, and total dissolved solids measured in any of the samples. The depth of the well is reported to be 80 feet and therefore should draw from the alluvium. Elevated levels of chloride, sulfate, and sodium suggest the ground water is impacted by animal waste or human waste. However, the nitrogen isotope results indicate the nitrate impacts are due to commercial fertilizer. Once again, ground water chemistry may be influenced by seasonal variations in land use and water use.

The variations in water quality in the water sample from GV-7 are attributable to the well being completed in a deeper confined aquifer within the Idaho Formation. Water samples from this well contained the highest ammonia concentration, the highest temperature, and basically no dissolved oxygen. The water chemistry in this well should not be affected by seasonal variations in land use.

6.3 Nitrate and Ammonia Results

Nitrate was detected in 11 of the 12 water samples collected in August 1998 and in all seven follow-up samples collected in November 1998. Ammonia was detected in three of the 12 water samples collected in August 1998. In November, ammonia analysis was conducted only on the water sample from GV-7, the well with the highest ammonia concentration. The nitrate and ammonia results are contained in Table 6. Five of the seven samples collected in November 1998 contained lower nitrate concentrations than samples collected from the same wells in August 1998. This trend is consistent with the seasonal variation exhibited by samples collected from Grand View public water supply wells. The nitrate results from the August sampling event are summarized in Figure 11. The November results are shown in Figure 12.

Water samples from GV-3 and GV-6 contained nitrate levels above the drinking water standard for nitrate of 10 mg/l in both August 1998 and November 1998. The water samples collected from GV-3 contained a nitrate concentration of 23.6 mg/l in August 1998, and 14.1 mg/l in November 1998. The water samples collected from GV-6 contained nitrate concentrations of 14.6 mg/l and 17.1 mg/l in August and November, respectively. No other water samples contained nitrate above 10 mg/l.

Water samples collected in August 1998 from wells believed to be completed in the Idaho Formation, GV-7 and GV-10, had nitrate levels of 0.809 mg/l and <0.005 mg/l, respectively. Water samples from wells with ground water depths of less than 20 feet below land surface, GV-9, GV-11, and GV-12, had nitrate levels of approximately 2 mg/l and lower. These wells appear to be influenced by surface water containing low concentrations of nitrates. The water samples from the other five wells sampled in August 1998, including Grand View Well #1, contained nitrate levels ranging from 6.65 mg/l to 9.32 mg/l. These wells are completed in the alluvial aquifer with depths to water ranging from 39 to 85 feet below land surface.

These nitrate results indicate higher nitrate concentrations (above 6 mg/l) are present in the alluvial aquifer supplying the city wells. Low nitrate concentrations (below 2 mg/l) were measured in water samples collected from wells screened in the Idaho Formation and from wells influenced by surface water with very shallow depths to ground water. The variation in nitrate levels appears to be primarily the result of hydrogeologic conditions under which ground water occurs because the land use is consistent throughout the study area.

FIGURE 11
Grand View, Idaho
Nitrate and Ammonia Concentrations, August, 1998

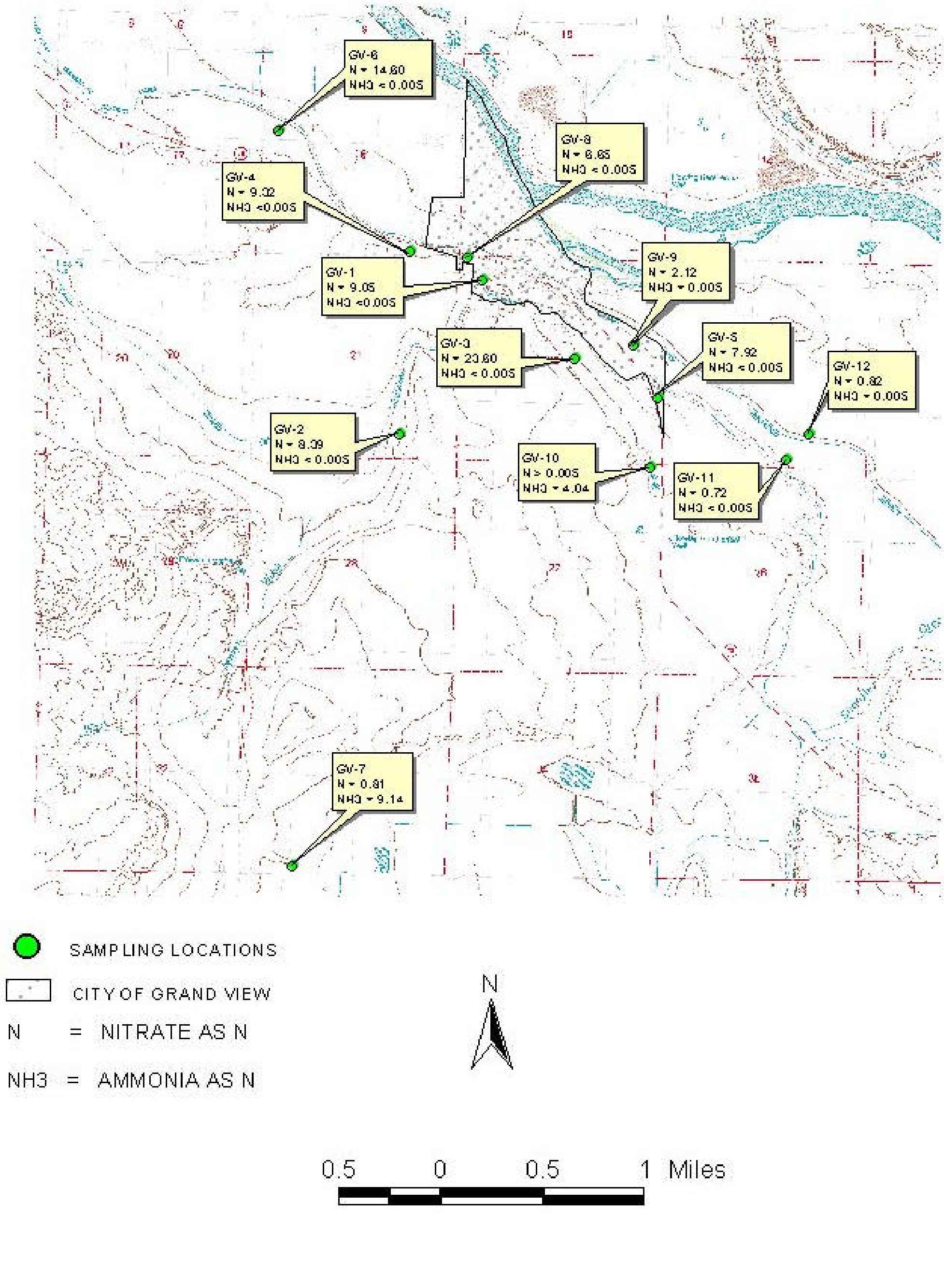
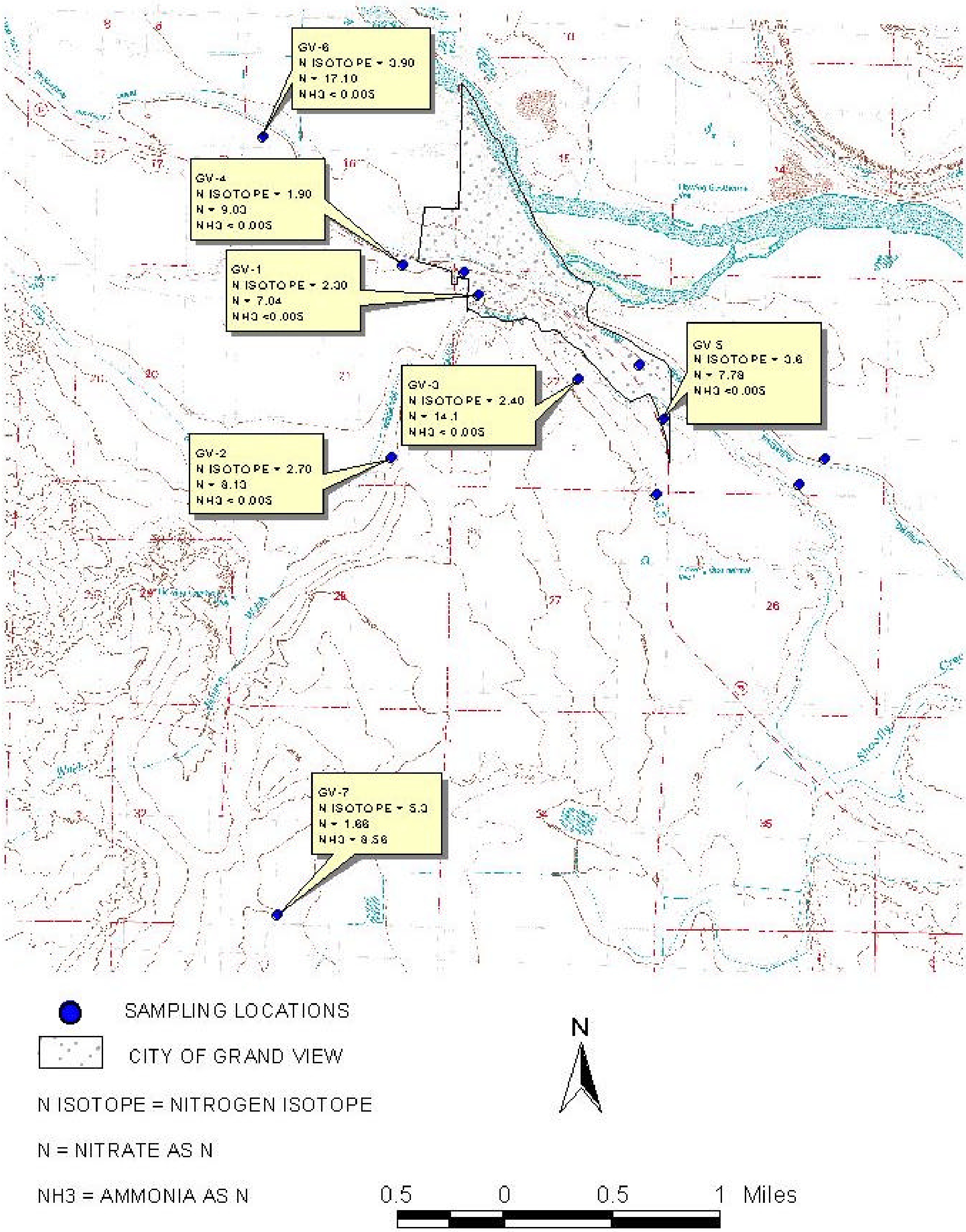


FIGURE 12
Grand View, Idaho
Nitrate and Ammonia Concentrations With Nitrogen Isotopes, November 1998



6.4 Nitrogen Isotope Results

The nitrogen isotope analyses were conducted to evaluate the causes of the elevated nitrate levels in the ground water. The nitrate nitrogen isotope $\delta^{15}N$ values varied from +1.9 $^{0}/_{00}$ to +3.9 $^{0}/_{00}$. The $\delta^{15}N$ results, coupled with the agricultural land use, strongly suggest the elevated nitrate levels in these wells are likely a result of inorganic commercial nitrogen fertilizer leaching to ground water (see Table 4). According to Seiler (1996), these $\delta^{15}N$ values fall within the range indicative of commercial fertilizer sources (-4 $^{0}/_{00}$ to +4 $^{0}/_{00}$). One sample, GV-7, did not contain sufficient nitrate for the laboratory to conduct the nitrogen isotope analysis. However, the ammonia concentration yielded a $\delta^{15}N$ value of +5.3 $^{0}/_{00.}$ This value is representative of nitrogen naturally occurring in the geologic formation. The nitrogen isotope results are summarized in Table 6 and shown on Figure 12.

All of the $\delta^{15}N$ values below 3 $^{0}/_{00}$ were detected in the ground water samples collected from wells located hydraulically downgradient of irrigated cropland on topographically higher areas south/southwest of State Route 78 (GV-1, GV-2, GV-3, and GV-4). These low $\delta^{15}N$ values suggest the nitrate levels are strongly influenced by commercial fertilizer. Water samples from these wells contained nitrate ranging from 7 mg/l to 14.1 mg/l.

The two water samples containing $\delta^{15}N$ values between 3 $^{0}/_{00}$ and 4 $^{0}/_{00}$ are located at slightly lower elevations east (GV-5) and north (GV-6) of State Route 78. The higher nitrogen isotope ratios suggest water in these wells is influenced by both chemical fertilizer and organic nitrogen sources from the decomposition of legume crops such alfalfa and beans. GV-5 had a nitrate level of 7.78 mg/l while GV-6 had a nitrate level of 17.1 mg/l.

6.5 Bacteria Results

The water samples were analyzed for total coliform bacteria as an indicator of potential bacterial contamination. Coliform bacteria are common in the environment and are not generally harmful. However, the presence of coliform may indicate the water is contaminated with organisms that cause diarrhea, cramps, nausea, headaches, and fatigue. Samples for total coliform bacteria were collected from six of the seven sampling sites – the sample from GV-7 was not analyzed for bacteria. Three of the six samples (GV-2, GV-3, and GV-4) contained total coliform bacteria. The highest total coliform level detected was 57 colony-forming units per 100 ml (CFU/100 ml) detected in the water sample from GV-4. Water samples GV-2 and GV-3 had total coliform levels of 3 CFU/100 ml.

E-Coli bacteria were analyzed to evaluate if the bacterial contamination was associated with animal or human wastes. *E-Coli* is also a useful indicator that pathogens are present in the ground water. *E-Coli* bacteria were not present in any of the samples.

6.6 Pesticide Results

Water samples from six of the seven wells sampled in November 1998 (GV-7 was excluded) were analyzed for the presence of organic compounds contained in herbicides and insecticides commonly applied in the area. Over 120 compounds were included in the EPA Method 525.2 analysis that was performed on the samples (Appendix C). An additional 17 herbicide compounds were analyzed in the water sample collected from Grand View City Well #1 (Appendix C). There were no organic compounds detected in any of the samples. It should be noted that the laboratory tests used in this study do not encompass the entire suite of compounds present in herbicides and insecticides. Rather, the tests are used as indicators of potential for ground water contamination caused by herbicide and insecticide use.

6.7 Quality Assurance Results

To evaluate the reproducibility of the analytical results, a duplicate sample was collected from GV-1 and analyzed for nitrate, ammonia, calcium, magnesium, sodium, potassium; and total dissolved solids. All the analyses differed by 0.6% or less. The samples were submitted to two different laboratories for nitrogen isotope ratio analysis. Unfortunately, only one laboratory was able to complete the analysis.

To evaluate the accuracy of the major ion analyses, a cation-anion balance was conducted. Cations are positively charged ions, such as calcium, sodium, and potassium: anions are negatively charged ions such as chloride, sulfate, and bicarbonate. The cation-anion balance is calculated by subtracting anions from cations and dividing by total ions. A cation-anion balance error indicates either a lack of accuracy or that ions are present in the water that were not analyzed. The balance errors ranged from -4.79 percent to 6.09 percent. These errors are relatively low, indicating the analyses were accurate and no significant ions were missed. The ion balance results are included in Table 6.

7.0 CONCLUSIONS

- The ground water in the Grand View area contains elevated levels of nitrate. Nitrate levels in Grand View wells are highest in the spring and lowest in the fall. The nitrate levels in the city wells may be influenced by infiltration from nearby irrigation canals. Leakage of water from the canals appears to dilute the nitrate concentrations in the ground water supplying the city wells.
- Ground water chemistry in the alluvial aquifer may be influenced by seasonal changes in land and water use. Seepage from canals and cropland may alter the ground water chemistry during part of the year.
- The shallow alluvial aquifer contains the highest concentrations of nitrate. Ground water from wells that draw from the blue clay/shale in the Idaho Formation below the alluvial aquifer typically contains much lower nitrate levels.
- The nitrogen isotope analyses indicate that, at the time of sampling in November 1998, commercial fertilizer was the predominant source of the nitrate contained in the ground water.
- The widespread occurrence of elevated nitrate levels suggests nonpoint sources of nitrate, such as application of commercial fertilizer on cropland, are impacting ground water quality.
- The wellhead protection area created using the Refined Analytical Method was significantly different in shape and size than the wellhead protection method created with the Basic Method. The refined delineation decreased the size of the wellhead protection area from 77,000 acres to 1,360 acres. Potential contaminant sources may decrease from 113 sources to two sources (assuming the source per acre ratio is the same).

8.0 RECOMMENDATIONS

- Ground water protection efforts should focus on managing the use of commercial fertilizer. Best management practices should be implemented to reduce nitrate leaching from the soil into the ground water.

- Ground water quality monitoring should be conducted concurrent with best management practice implementation to evaluate the effectiveness of these practices.

- Quarterly monitoring of major ions and nitrogen isotopes may be useful to evaluate seasonal changes in ground water chemistry and to test the hypothesis that canal leakage has a significant impact on the city wells' water quality.

- Future land uses within the Grand View wellhead protection area should be protective of ground water quality. A wellhead protection plan should be developed by Grand View to provide written documentation to guide future protection efforts.

9.0 REFERENCES

Aravena, R., M.I. Evans, and J.A. Cherry, 1993, *Stable Isotopes of Oxygen and Nitrogen in Source Identification of Nitrate from Septic Systems:* Ground Water, Vol. 31. No. 2.

Bendickson, S., 1998, Idaho Department of Water Resources, Personnel Communication.

Clark, I.D. and P. Fritz, 1997, *Environmental Isotopes in Hydrogeology*: Lewis Publishers.

Drever, J.I., 1988, *The Geochemistry of Natural Waters*: Prentice-Hall.

Exner, M.E. and R.F. Spalding, 1994, *N-15 Identification of Nonpoint Sources of Nitrate Contamination Beneath Cropland in the Nebraska Panhandle: Two Case Studies*: Applied Geochemistry, Vol. 9, 73-81.

Gellenbeck, D.J., 1994, *Isotopic Compositions and Sources of Nitrate in Ground Water From Western Salt River Valley, Arizona*: U.S. Geological Survey Water-Resources Investigations Report 94-4063.

Gormly, J.R. and R.F. Spalding, 1979, *Sources and Concentrations of Nitrate-Nitrogen in Ground Water of the Central Platte Region, Nebraska*: Ground Water: Vol. 17, No. 3, 291-301.

Hillel, D., 1980, *Applications of Soil Physics*: Academic Press.

Howarth, R.B., 1999, *Assessment of Sources of Elevated Nitrate in Ground Water in Northwest Ada County, Idaho, Using Environmental Isotopes*, Idaho Division of Environmental Quality, Ground Water Quality Technical Report No. 11.

Idaho Division of Environmental Quality, 1997, *Idaho Wellhead Protection Plan*.

Idaho State Climate Services, 1999, http://www.uidaho.edu/~climate.

Johnson, B.R. and G.L. Raines, 1996, *Digital Representation of the Idaho State Geologic Map: a Contribution to the Interior Columbia River Basin Ecosystem Management Project*: U.S. Geological Survey Open-File Report 95-960.

Kraemer, S.R., H.M. Haitjema, and V.A. Kelson, 2000, *Working with WhAEM2000 Source Water Assessment for a Glacial Outwash Well field, Vincennes, Indiana*: U.S. Environmental Protection Agency, Office of Research, EPA/600/R-00/022.

Seiler, R.L., 1996, *Methods for Identifying Sources of Nitrogen Contamination of Ground Water in Valleys in Washoe County, Nevada*: U.S. Geological Survey Open-File Report 96-461.

U.S. Department of Agriculture (USDA) Soil Conservation Service, 1991, *Soil Survey of Elmore County Area, Parts of Elmore, Owyhee, and Ada Counties*.

Waterloo Hydrogeologic Inc., 1998-1999, *AquaChem V.3.7 for Windows 95/98/NT, Aqueous Geochemical Analysis, Plotting and Modeling Software*.

APPENDICES

APPENDIX A

INTERPRETATION OF COLOR INFRARED AERIAL PHOTOGRAPHY

USGS
science for a changing world

The Interpretation of Color Infrared Aerial Photography

Color infrared photography, often called 'false color photography', is widely used for the interpretation of natural resources. Due to the subjected degrees of degradation in handling before exposure and the use of high speed film in color infrared photography, aerial photographs can and do vary in overall color tone. This variability may cause complications within the interpretation of colors between each unique photograph. The following guidelines are provided for our customers to aid them in their interpretations of this particular type of photography.

Knowledge of vegetation vigor and density is important in the interpretation of the various red shades within aerial photography. The color red is frequently associated with live vegetation. Very intense shades of red indicate dense vegetation that is growing quite vigorously. An irrigated alfalfa field would be an example of such vegetation. An evergreen forest, which also may be quite vegetatively dense, would not appear in a similar red tone since its level of growth activity is less compared to the irrigated alfalfa field.

As the amount of vegetation density and vigor decreases, the different red tones may change to more lighter red and pink colors. When the plant density activity becomes too low, the faint red coloring is overcome by the stronger colors representing the soil on which the plants have been growing. For instances such as these, the ground area would appear in shades of white, blue, or green, depending on the soil type and moisture content. When the plant vigor decreases, the vegetation would show as paler shades of red and pink, various shades of green, and possibly even tan in color. Dead vegetation, wheat stubble for example, would often be portrayed in tints of green or tan.

Bare soils appear as patches of white, blue, or green in most agricultural regions. Generally speaking, the moister the soil, the darker the soil color. Soil composition affects all color ranges shown on aerial photographs. Dry, sandy land will appear white in color. With the addition of moisture to this land, the white coloring turns into light gray or light tan. Soils composed of clay are darker in color than the sandy areas as well as tending toward more blue-green tones. Clay soils holding extreme moisture would resemble darker shades of the same colors. These identical soils, when high in organic matter, such as silt or loam, would be viewed darkest in the same corresponding color scheme.

In aerial photography, man-made features correlate their colors to the materials with which they were constructed . For example, asphalt (whose coloring ranges from dark to light) and concrete roads (whose coloring ranges from light to dark) vary in intensity on opposite ends of the color spectrum depending on their age. Gravel or dirt roads are shown as less intense colors due to their variations in soil make-up and composition. A town's streets and buildings could be considered similar to the above examples with their color also relying on their material textures .

Water, as expected, appears through various shades of blue ranging from nearly black to very pale. Pristine water has a black appearance. With the increase of sediment deposits in beds of water, the aerial photography colors turn slowly to lighter blue tones. Shallow water would reflect the material present in its stream bottom. For example, a shallow creek, bottom included, would be viewed as a white color in order to mirror the high levels of built-up sand.

Aerial photographs on degraded film cast an overall blue or green shadow on their images. When this occurs, the interpreter must consider how the overall cast has effected the original rendition of the photograph and therefore alter his or her scenic view.

Please refer any comments or questions to:

EROS Data Center
Customer Service
Mundt Federal Bldg.
Sioux Falls, SD 571980
1-800-252-GLIS
Ph. 605-594-6151
Fax. 605-594-6589
E-mail. custserv&edcmall. cr. usgs. gov

APPENDIX B

CITY OF GRAND VIEW
DRILLER'S LOGS

USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Water Administration

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Administration within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name: City of Grandview

Address: Grandview, Idaho

Owner's Permit No. ______

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Other (specify type)

☒ Municipal ☐ Industrial ☐ Stock ☐ Waste Disposal or Injection

4. METHOD DRILLED

☐ Cable ☒ Reverse Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 28 inches Total depth 130 feet

Casing schedule: ☒ Steel ☐ Concrete

Thickness	Diameter	From	To
.375 inches	12 inches	+2 feet	93 feet
.375 inches	12 inches	113 feet	120 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was a packer or seal used? ☒ Yes ☐ No

Perforated? ☐ Yes ☐ No

How perforated? ☐ Factory ☐ Knife ☐ Torch

Size of perforation ______ inches by ______ inches

Number		From	To
	perforations	feet	feet
	perforations	feet	feet
	perforations	feet	feet

Well screen installed? ☒ Yes ☐ No

Manufacturer's name Johnson

Type 304 Stainless Model No. ______

Diameter 12 Slot size 50 Set from 93 feet to 113 feet

Diameter ___ Slot size ___ Set from ______ feet to ______ feet

Gravel packed? ☒ Yes ☐ No Size of gravel 3/8-

Placed from 34 feet to 130 feet

from 24 to 34' - puddling clay

Surface seal depth 24 Material used in seal ☒ Cement grout ☐ Puddling clay ☐ Well cuttings

Sealing procedure used ☐ Slurry pit ☐ Temporary surface casing ☐ Overbore to seal depth

6. LOCATION OF WELL

Sketch map location must agree with written location.

N / W / E / S

Subdivision Name ______

Lot No. ______ Block No. ______

County Owyhee

NW ¼ NW ¼ Sec. 22, T. 5 N/S, R. 3 E/W

7. WATER LEVEL

Static water level 13 feet below land surface

Flowing? ☐ Yes ☐ No G.P.M. flow ______

Temperature ______ °F. Quality ______

Artesian closed in pressure ______ p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
265	13'	5

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
	0	80	brown sand/river rock/gravel		
	80	90	brown sand/gravel/clay		
	90	98	brown sand/gravel		
	98	103	cemented gravel		
	103	110	gravel with brown sand		
	110	120	gravel & river rock/sand		
	120	125	gravel/river rock/clay streaks		
	125	130	blue clay		

10. Work started 7/18/75 finished 7/25/75

11. DRILLERS CERTIFICATION

Firm Name Pete Cope Drilling Co., Inc. Firm No. 213

Address P.O. Box 561 - Meridian Date 7/26/75

Signed by (Firm Official) [signature] and (Operator) [signature]

USE ADDITIONAL SHEETS IF NECESSARY FORWARD THE WHITE COPY TO THE DEPARTMENT

1. WELL OWNER

Name City of Grandview

Address Grandview, Idaho

Owner's Permit No. ______

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test

☒ Municipal ☐ Industrial ☐ Stock

4. METHOD DRILLED

☐ Cable ☒ Reverse Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 24 inches Total depth 131 feet

Casing schedule: ☒ Steel ☐ Concrete

Thickness		Diameter		From		To	
.281	inches	26"	inches	+18"	feet	20	feet
.330	inches	12"	inches	0	feet	104	feet
.330	inches	12"	inches	124	feet	131	feet
	inches		inches		feet		feet
	inches		inches		feet		feet

Was a packer or seal used? ☐ Yes ☐ No

Perforated? ☐ Yes ☐ No

How perforated? ☐ Factory ☐ Knife ☐ Torch

Size of perforation ______ inches by ______ inches

Number		From		To	
	perforations		feet		feet
	perforations		feet		feet
	perforations		feet		feet

Well screen installed? ☒ Yes ☐ No

Manufacturer's name Johnson

Type Stainless Steel Model No. ______

Diameter 12 Slot size 50 Set from 104 feet to 124 feet

Diameter ___ Slot size ___ Set from ______ feet to ______ feet

Gravel packed? XX Yes ☐ No Size of gravel 3/8-

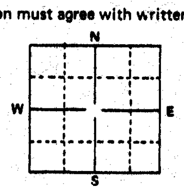
Placed from top feet to 131 feet

Surface seal? ☒ Yes ☐ No To what depth 20 feet

Material used in seal ☒ Cement grout ☐ Puddling clay

6. LOCATION OF WELL

Sketch map location must agree with written location.



57

County Owyhee

NW ¼ NW ¼ Sec. 22, T. 5 N/S, R. 3 E/W

7. WATER LEVEL

Static water level 96 feet below land surface

Flowing? ☐ Yes ☐ No G.P.M. flow ______

Temperature ______ °F. Quality ______

Artesian closed-in pressure ______ p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
	0	91	Sand		
	91	104	Coarse Sand	✓	
	104	105	Occasional small gravel & crs sand		
	105	111	larger gravel		
	111	115	gravel cemented		
	115	121	xxxxx sand & buckshot gravel		
	121	123	Gravel		
	123	124	tan clay		
	124	131	Blue clay		

10.

Work started 10/27/72 finished 11/1/72

11. DRILLER'S CERTIFICATION

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

Pete Cope Drilling Company 213

Driller's or Firm's Name Number

P.O. Box 561 Meridian, Idaho 83642

Address

Signed By [signature] 11/3/72 Date

USE ADDITIONAL SHEETS IF NECESSARY FORWARD THE WHITE, BLUE, AND PINK COPIES TO THE DEPARTMENT

APPENDIX C

HERBICIDE AND INSECTICIDE ANALYTES

State of Idaho
DEPARTMENT OF HEALTH AND WELFARE
Division of Health

Bureau of Laboratories

2220 Old Penitentiary Rd.
Boise, Idaho 83712
(208) 334-2235

DIRK KEMPTHORNE
Governor
DARRELL V MANNING
Acting Director
RICHARD H. SCHULTZ
Administrator

ORGANIC CHEMISTRY REPORT
CHLORINATED HERBICIDES - METHOD 515.1

Log No.: 98-1234 Sample: WATER Analyst: R. Donaly

Source: Grand View #1 Date Analyzed: 11/18/98 Reported: 1/12/99

ANALYTE	RESULTS (ug/L)
Acifluorfen	U
Bentazon	U
Chloramben	U
2,4-D	U
Dalapon	U
2,4-DB	U
DCPA (Dacthal)	U
Dicamba	U
3,5-Dichlorobenzoic acid	U
Dichloroprop	U
Dinoseb	U
5-hydroxydicamba	U
4-Nitrophenol	U
Pentachlorophenol	U
Picloram (Tordon)	U
2,4,5-T	U
2,4,5-TP (Silvex)	U

Surrogate recovery (2,4,6-TBP) - 116%

W Baker
Section Manager

1/12/99
Date

U - Undetected; Analytes are below minimum detection limits.

STATE OF IDAHO BUREAU OF LABS - ORGANIC CHEMISTRY SECTION

PAH'S, ORGANOCHLORINE/ORGANOPHOSPHOROUS PESTICIDES/HERBICIDES

Lab Number	98-1234
Date Analyzed	11/30/98
Instrument Used	GC/MS
Analyst	M. Sevier
Matrix	Water
Method	525.2
Sample Site Information	Grandview #1

COMPOUND	UG/L (circled) OR UG/KG	MDL IN WATER
Acenaphthene	U	0.11
Acenaphthylene	U	0.11
Alachlor	U	0.16
Aldrin	U	0.11
Ametryn	U	0.09
Anthracene	U	0.07
Atraton	U	0.16
Atrazine	U	0.08
Benz(a)anthracene	U	0.20
Benzo(b)fluoranthene	U	0.30
Benzo(k)fluoranthene	U	0.54
Benzo(g,h,i)perylene	U	0.05
Benzo(a)pyrene	U	0.03
Bromacil	U	0.10
Butachlor	U	0.08
Butylate	U	0.06
Butylbenzyl phthalate	U	0.25
Carboxin	U	1.40
a-Chlordane	U	0.12
g-Chlordane	U	0.11
t-Nonachlor	U	0.22
Chloroneb	U	0.09
Chlorobenzilate	U	1.30
2-Chlorobiphenyl	U	0.09
Chloropropham	U	0.11
Chlorpyrifos (Duraguard)	U	0.04
Chlorthalonil	U	0.12
Chrysene	U	0.08
Cyanazine	U	0.17
Cycloate	U	0.10
DCPA	U	0.09
4,4'-DDD	U	0.07
4,4'-DDE	U	0.08
4,4'-DDT	U	0.08
Diazinon	U	0.11
Dibenz(a,h)anthracene	U	0.01
di-n-Butyl phthalate	U	ND
2,3-Dichlorobiphenyl	U	0.14
Dichlorvos	U	0.15
Dieldrin	U	0.05
bis(2-ethylhexyl)adipate	U	0.09
bis(2-ethylhexyl)phthalate	U	ND
Diethyl phthalate	U	0.17
Dimethyl phthalate	U	0.06
2,4-Dinitrotoluene	U	0.10
2,6-Dinitrotoluene	U	0.16
Diphenamid	U	0.04
Disulfoton	U	0.62
Disulfoton sulfone	U	0.07
Disulfoton sulfoxide	U	0.20
Endosulfan I	U	0.30
Endosulfan II	U	0.44
Endosulfan sulfate	U	0.13
Endrin	U	0.29
Endrin aldehyde	U	0.19
EPTC	U	0.11
Piperalin (Pipron)	U	ND
Dienochlor (Pentac)	U	ND
Bromoxynil	U	ND
Dimethoate	U	ND
Acephate (Orthene)	U	ND

COMPOUND	UG/L (circled) OR UG/KG	MDL IN WATER
Ethoprop	U	0.11
Etridiazole	U	0.16
Fenamiphos	U	0.95
Fenarimol	U	1.20
Fluorene	U	0.06
Fluridone	U	0.55
a-BHC	U	0.20
b-BHC	U	0.31
d-BHC	U	0.21
g-BHC (Lindane)	U	0.15
Heptachlor	U	0.15
Heptachlor epoxide	U	0.06
2,2',3,3',4,4',6-Heptachlorobiphenyl	U	0.11
Hexachlorobenzene	U	0.13
2,2',4,4',5,6'-Hexachlorobiphenyl	U	0.11
Hexachlorocyclopentadiene	U	0.07
Hexazinone	U	0.11
Indeno(1,2,3-c,d)pyrene	U	0.06
Isophorone	U	0.04
Methoxychlor	U	0.08
Methyl paraoxon	U	0.17
Metolachlor	U	0.09
Metribuzin	U	0.16
Mevinphos	U	0.20
MGK 264 - isomer a	U	0.04
MGK 264 - isomer b	U	0.03
Molinate	U	0.09
Napropamide	U	0.06
Norflurazon	U	0.13
2,2',3,3',4,5',6,6'-Octachlorobiphenyl	U	0.13
Pebulate	U	0.08
2,2',3',4,6-Pentachlorobiphenyl	U	0.15
Pentachlorophenol	U	ND
cis-Permethrin	U	0.03
trans-Permethrin	U	0.07
Phenanthrene	U	0.06
Prometon	U	0.38
Prometryn	U	0.08
Pronamide	U	0.10
Propachlor	U	0.11
Propazine	U	0.12
Pyrene	U	0.07
Simazine	U	0.15
Simetryn	U	0.13
Stirofos	U	0.13
Tebuthiuron	U	2.80
Terbacil	U	2.10
Terbufos	U	0.10
Terbutryn	U	0.11
2,2',4,4'-Tetrachlorobiphenyl	U	0.04
Triademefon	U	0.33
2,4,5-Trichlorobiphenyl	U	0.08
Tricyclazole	U	2.60
Trifluralin	U	0.10
Vernolate	U	0.08
Pyrethrins (Pyrellin)	U	ND
Rotenone (Pyrellin)	U	ND
Metalaxyl (Subdue)	U	ND
Caffeine	U	ND
Fenarimol (Rubigan)	U	ND

SURROGATES

Percent Solids N/A

Acenaphthene-d10_59.5__Phenanthrene-d10_58.3__Chrysene-d10_61.9__Perylene-d10_45.1__

Supervisor________________ Date 12/28/98