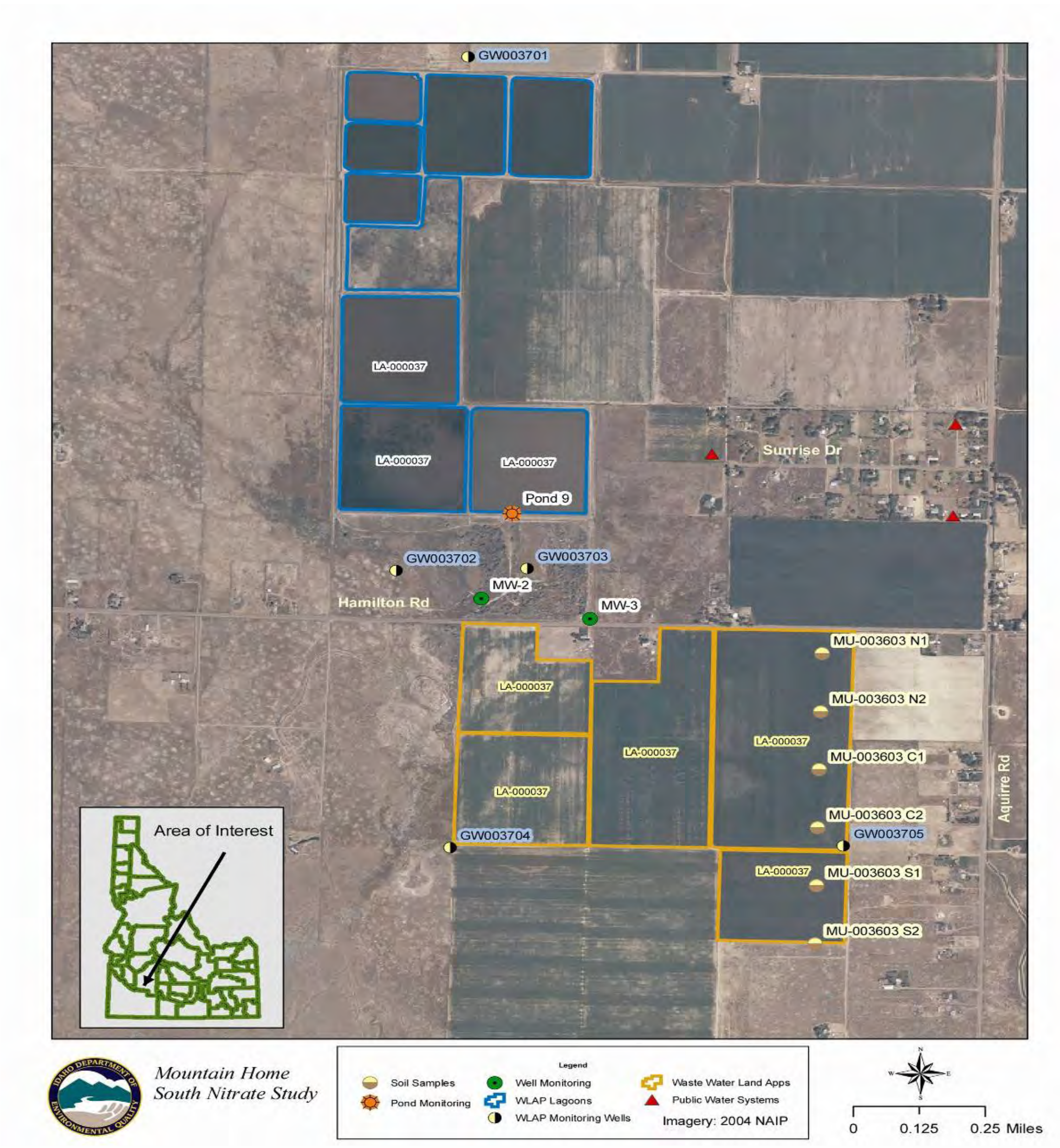
Ground Water Quality Technical Report No. 36

Mountain Home South Ground Water Nitrate Study



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List of Acronyms, Abbreviations, and Symbols

^{18}O	one of the isotopes of oxygen
^{2}H	deuterium, an isotope of hydrogen
$\delta^{15}N$	the ratio of the two stable isotopes of nitrogen (^{15}N and ^{14}N)
CGWA	critical ground water area
Cl	chloride
DEQ	Idaho Department of Environmental Quality
GMWL	global meteoric water line
IDWR	Idaho Department of Water Resources
ISDA	Idaho Department of Agriculture
Ma	megaannum (million years ago)
mg/L	milligrams per liter
mL	milliliter
µM	millimole
NO_3-N	nitrogen as nitrate
NRCS	Natural Resources Conservation Service
‰	parts per thousand (permil)
SMOW	Standard Mean Ocean Water
SO_4	sulfate
TKN	Total Kjeldahl nitrogen
USGS	U.S. Geological Survey
VSMOW	Vienna Standard Mean Ocean Water

Summary

This report presents the results of a ground water study to evaluate high levels of nitrate in water south of Mountain Home, Idaho. In 1998, the project began after elevated pesticide detections were found by the Idaho Department of Water Resources' statewide program, which also found rising nitrate concentrations. Then due to concern over elevated nitrate in domestic wells, the Idaho Department of Agriculture (ISDA) began collecting water samples in the area. The Idaho Department of Environmental Quality (DEQ) joined ISDA in collecting samples from 1998 to September 2008. In all, ISDA and DEQ sampled 73 wells and surface water sites. Several ground water sites were sampled up to13 times. Surface water sites that were sampled included wastewater treatment lagoons, an agricultural irrigation pond, an irrigation canal, and two drainage water retention ponds.

Domestic wells near the Mountain Home wastewater lagoons and just east of the city's wastewater reuse land application fields showed a dramatic increase in concentrations of the contaminants nitrate, chloride, and sulfate. Because of this, DEQ carried out a study to determine whether the lagoons, the agricultural fields where wastewater is applied, or both, were responsible for the increase in concentrations of contaminants.

The study area lies over a shallow perched aquifer and a deep regional aquifer underneath. The perched aquifer occurs in layers of sediments and is sustained by water seepage from a reservoir and canals, deep percolation from irrigation water, and seepage from the wastewater treatment lagoons. The deep regional aquifer occurs in fractured basalt and is recharged by leakage from the perched aquifer and by runoff from the hills north of the city.

DEQ and ISDA collected ground water samples from private domestic wells and had them analyzed for major ions (calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, and sulfate); nitrogen (nitrate-N, nitrite-N, and ammonia); field parameters (pH, specific conductance, temperature, and dissolved oxygen); total dissolved solids; and the environmental isotopes of oxygen (^{18}O), hydrogen (^{2}H, known as deuterium), and nitrogen (^{15}N). Analysis of isotope results indicated that oxygen and deuterium can serve as useful tracers of wastewater impacts to ground water. By testing water from various locations for oxygen and hydrogen isotopes, researchers can determine the path water takes. This is because the isotopes show up in most samples and indicate the path the water has followed.

Analysis of major ion results indicates that ground water at most sampling locations is a calcium-magnesium bicarbonate type water. Analysis of water quality data indicates a human-caused source of contamination from elevated levels of chloride, nitrate, sulfate, and total dissolved solids. However, this study was not able to identify the precise source of the contamination. Elevated levels of contaminants at many domestic wells in the study area cannot be explained by seepage from the lagoon system or from the wastewater reuse area or from area septic systems. To further complicate the picture, contaminant increases did not occur at all the wells that are located within the contaminated zone in the perched aquifer but are drilled further into the deep regional aquifer. In fact, for these types of wells, uncontaminated and contaminated wells are sometimes found next to each other.

Nitrate concentrations at sample sites ranged from below the laboratory detection limit up to 37 milligram per liter. Sulfate concentrations also vary widely; however, they were used to outline the extent of contamination in the perched aquifer.

The soil and ground water samples from the vicinity of the Mountain Home wastewater treatment lagoons and land application fields did not identify the source of the dramatically increasing concentrations of nitrate, chloride, and sulfate. However, the study did indicate that leakage from the lagoons recharges the perched aquifer. Wastewater that is land applied to agricultural fields during the summer months may also recharge the perched aquifer, but it cannot be the source of the elevated concentrations. A different source of contamination is likely because the concentrations of nitrate, chloride, and sulfate in the wastewater are lower than concentrations found in the perched aquifer underneath.

This study concludes that elevated concentrations of contaminants in wells completed in the deep regional aquifer can best be explained by a combination of two factors: 1) a contaminated zone in the overlying perched aquifer, and 2) leaky well casing seals at the area where basalt and alluvium (sediment) come into contact.

Introduction

The purpose of this study is to evaluate elevated nitrate in ground water in an area south of Mountain Home, Idaho. This report presents water chemistry data collected by the Idaho Department of Agriculture (ISDA) and the Idaho Department of Environmental Quality (DEQ).

Monitoring in the area began with a regional nitrate ground water sampling event initiated by ISDA in 1998 to respond to resident concerns that nitrate concentrations were increasing in domestic wells. The elevated nitrate concentrations were found as a result of a statewide ISDA pesticide sampling program. Annual sample collection began in 2000 from 28 wells, and additional wells were added as the project progressed through 2008. Analysis of results from the ISDA sampling program indicated that nitrate concentrations were greater than the Idaho Ground Water Quality standard of 10 milligrams per liter (mg/L) for nitrate as nitrogen. In addition, repeat sample collection indicated that nitrate, chloride, and sulfate concentrations were increasing in some wells. Between 2004 and 2006, a dramatic and sharp increase in these constituent concentrations was observed in a few of the wells.

This report also presents the results of the site-specific work conducted by DEQ near the Mountain Home wastewater lagoons and just east of the land application fields. To help understand the fate and transport of nitrate and the potential cause of nitrate increases in certain wells, the geological and hydrogeologic framework of the area will be reviewed to help evaluate the water quality issues that have been occurring in the last eleven years.

Study Area

Figure 1 below shows the area south of Mountain Home where the investigation was conducted. The study area is approximately one mile south of town, where the land use consists of a mixture of agricultural fields, rural residential, open range, and the city's wastewater treatment system. Irrigation canals transmit water to farmland in the study area between the months of April and October. So that wells mentioned in this report can be located, a township, range and section overlay is also shown below on Figure 2. (Appendix A describes the well numbering system used in this report.) Hamilton Road crosses the study area from east to west, and South 18th Street crosses the study area from north to south.

The City of Mountain Home's wastewater treatment facility is located in the study area. The facility has been in operation for more than 30 years and currently consists of wastewater treatment and storage lagoons that cover about 205 acres and when full, can hold a total volume of 406 million gallons of water. During the growing season (April 1 through October 31), disinfected wastewater is land applied in accordance with a DEQ reuse permit to 258 acres of agricultural fields located south and southeast of the lagoons. (See Figure 2.) During the non-growing season, wastewater is stored in the lagoons.

Climate and Precipitation

The Mountain Home area is characterized by hot dry summers and mild winters. Climate data is is available from August 1, 1948 to December 31, 2005 from the Western Regional Climate Center (2008). Precipitation records show that the average annual precipitation for this period was 9.98 inches; most precipitation falls in the winter and spring months, with the mean annual snowfall about 10.7 inches. In general, all precipitation that falls on the mountain plain is transpired by native vegetation and is not available for deep percolation (Newton, 1991). Average annual temperatures range from 65 °F to 37 °F. Wind speeds average about 7 miles per hour and range from 7 to 16 miles per hour 41% of the time according to the Mountain Home Wastewater Operations Plan (City of Mountain Home, 1988).

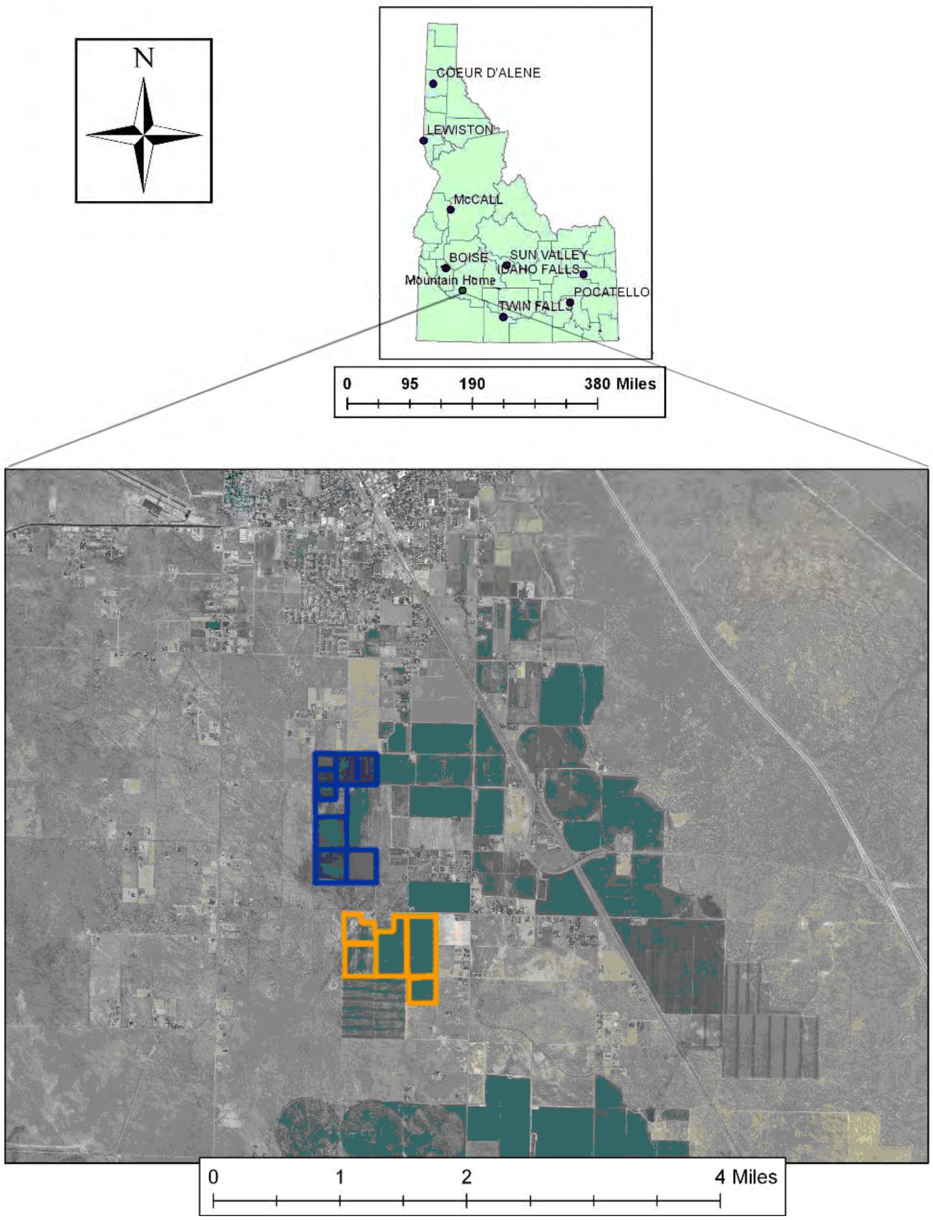

Figure 1. Mountain Home south study area. Blue lines represent the wastewater treatment lagoons, and yellow lines represent the wastewater land application site.

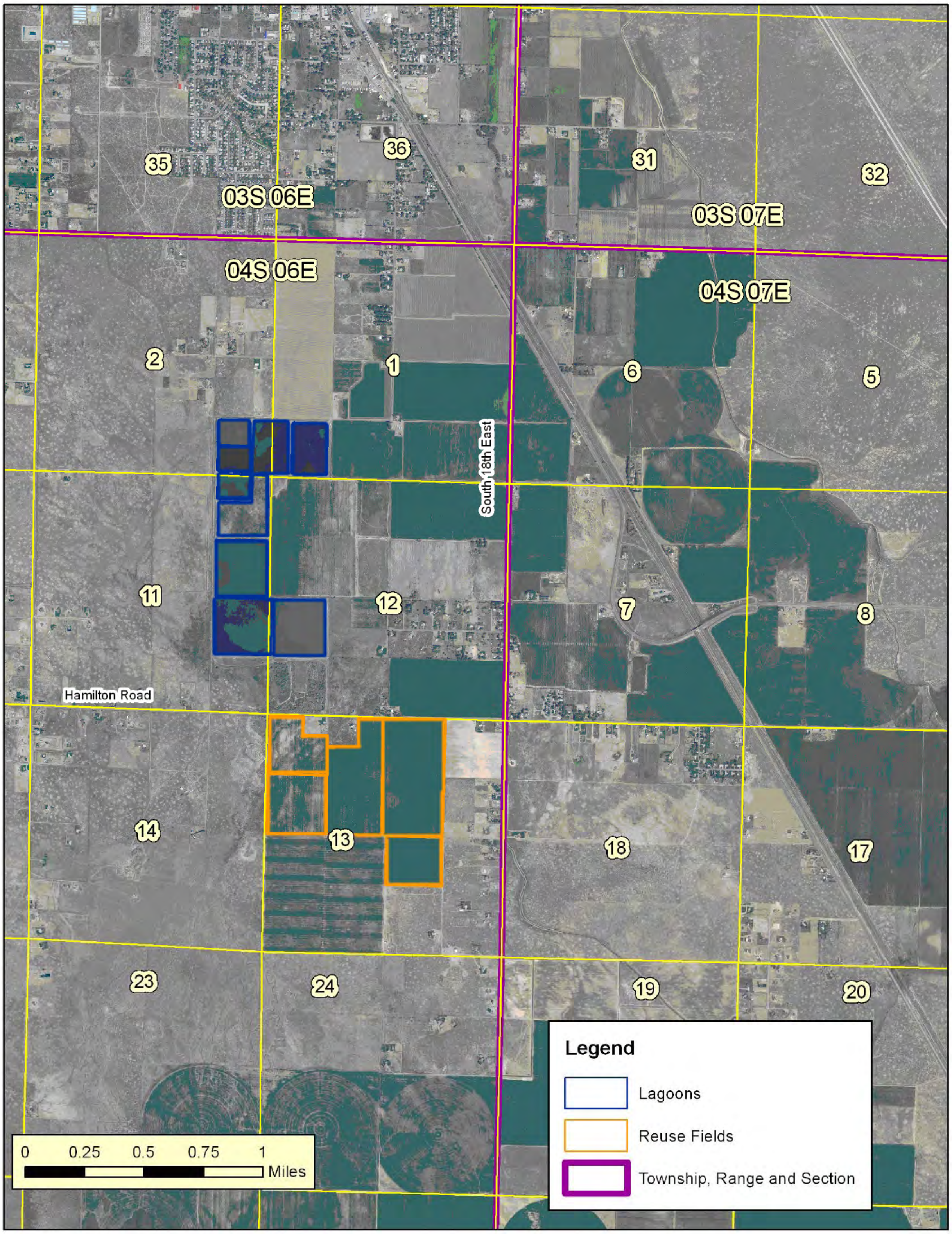

Figure 2. Mountain Home south study area with township, range, and section overlay showing City of Mountain Home wastewater treatment lagoons and reuse fields.

Geologic Framework

The geology of the Mountain Home area provides a context for understanding the local hydrogeology and explains the recharge to the regional aquifer system. The area described by Shervais, et al. (2002) and Wood and Clemens (2002) provides this information and is summarized as follows. Mountain Home lies on the northeastern margin of the western Snake River Plain, as shown in Figure 3. The western Snake River Plain is a northwest-trending graben that extends northwest-southeast from the Idaho-Oregon border nearly to Twin Falls, a distance of about 170 miles; the plain is about 40 miles wide in the Mountain Home area.

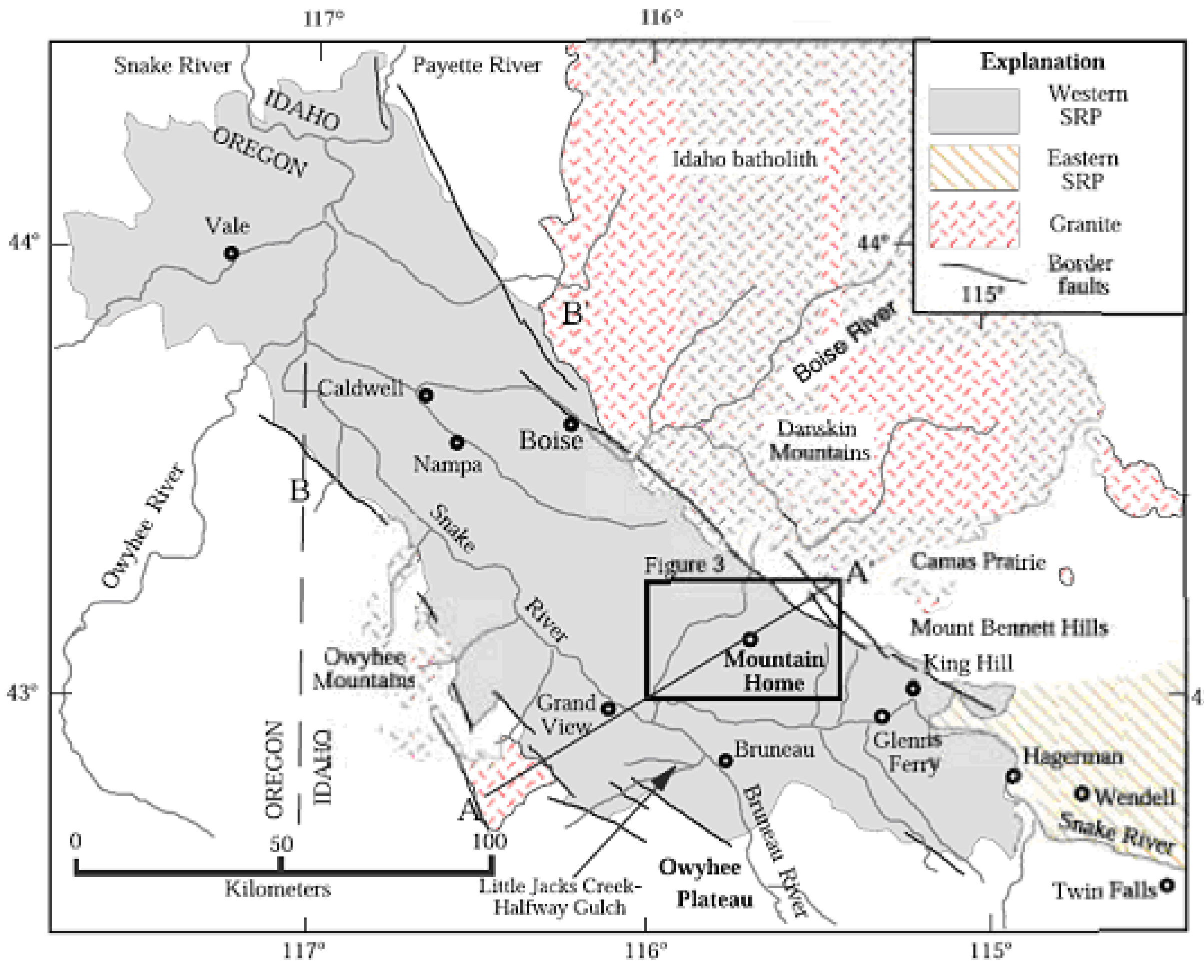

Figure 3. Regional map of the western Snake River Plain showing Mountain Home, the Danskin Mountains to the north, and the Mount Bennett Hills to the northeast (adapted from Shervais et al., 2002).

The graben, which is described as an intracontinental rift basin associated with the Yellowstone Hotspot, is bounded on the northeast and southwest by normal faults. Displacement on range front faults along the Danskin Mountains and Mount Bennett Hills northeast of Mountain Home is as much as 9,000 feet, based on results from the Bostic 1-A well. This well, located at 04S 08E 25CCC, was drilled during 1973 as an oil and gas exploration well to a total depth of 9,676 feet (Arney et al., 1984).

Formation of the basin appears to have coincided with the position of the Yellowstone Hotspot at the Bruneau-Jarbidge eruptive center, located in the area of the current Owyhee Plateau (Figure

3). Heating related to the hotspot is believed to have resulted in lithospheric expansion that produced a northwest trending zone of weakness. Normal faulting along the margins of this zone from about 11 to about 9 million years ago (Ma) was accompanied first by eruption of rhyolite lavas, and as the basin subsided, by placement of basalt and deposition of Chalk Hills Formation sediments in ancient Lake Idaho. This phase of Lake Idaho occupied the basin during the period from about 10 to about 6 Ma. The lake elevation began to decline about 6 Ma, the lake retreated to deeper parts of the basin, and Chalk Hills sediments were eroded from the lake margins. In the Mountain Home area, a thick basalt sequence was deposited over the eroded Chalk Hills Formation.

Between 6 and 4 Ma, lake levels began to rise again, in part due to increased stream flow from a larger drainage area created by the eastward shift in the location of the Continental Divide. The eastern shift is believed to have been caused by uplift associated with eastward migration of the Yellowstone Hotspot location. Sediments deposited in this phase of Lake Idaho are included in the Glenns Ferry Formation. These sediments become finer towards the central part of the basin and consist of clay, silt, and sand-sized material. Rivers around the lake margin deposited coarse grained sand and gravel in deltaic and shoreline deposits. Depending on the lake elevation, these deltaic deposits were confined to areas adjacent to the mountain fronts (high lake elevations) or were deposited further out into the basin (low-lake elevations). Water levels in Lake Idaho rose to a maximum elevation of about 3,600 feet, when a spillway located north of Weiser was overtopped, establishing a connection to the Columbia River that exists today. Prior to this event, Lake Idaho was believed to have been a closed drainage basin, although there is some evidence for a southwest drainage out of the basin through eastern Oregon and northern California. Geochronological and paleontological evidence indicates that lake drainage to the Columbia River began sometime between 3.8 and 2 Ma (Van Tassel et al., 2001; Smith et al., 2000). The stratigraphic relationships just described are illustrated in the cross-section shown in Figure 4.

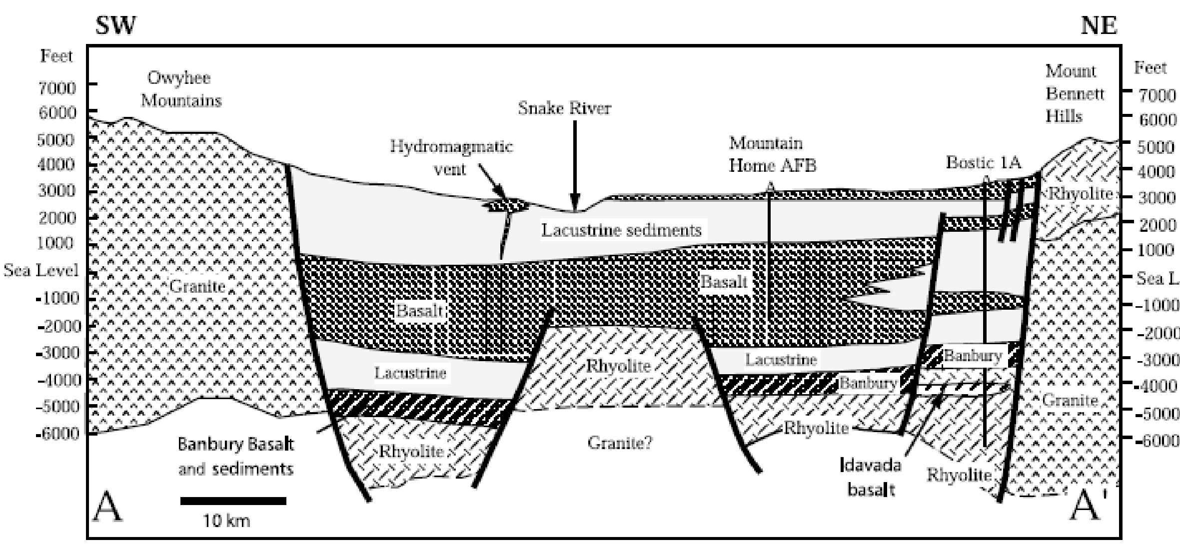

Figure 4. Interpretative cross-section across the western Snake River Plain in the vicinity of Mountain Home. Line of section A-A' is shown on Figure 3. (Adapted from Shervais, et al., 2002).

Rhyolite encountered in the lower part of the Bostic 1A well provides the information to determine offset on the range front faults associated with the early basin development. Lacustrine sediments of the Glenns Ferry Formation lie beneath a basalt cap that spreads outward from the

Mount Bennett Hills and the Danskin Mountains. Granite has not been encountered in any deep wells drilled on the plain.

The uppermost basalt units are post-Lake Idaho in age and have been dated at less than 2 Ma in age. Faulting related to Basin and Range extension that occurred after passage of the Yellowstone Hot Spot provided an avenue for these extrusive basalt flows. Drillers' logs for wells located south of Mountain Home show that the uppermost basalt is from about 460 to about 540 feet thick and is underlain by deposits of clay, sand, and gravel that most likely represent the Glens Ferry Formation. Lost circulation is common for many wells drilled in basalt in this area, so lithologic information is available from only a few wells, and thus detailed lithologic knowledge is often incomplete.

South of Hamilton Road (Figure 2), wells drilled deeper than about 500 feet encountered clay, sand, and gravel deposits. These sedimentary units probably belong to the Glenns Ferry Formation. This material grades north into basalts that were extruded from the range front faults to the north of Mountain Home. Deposition of both units probably occurred at the same time, so the units probably are interfingered.

A geologic map adapted from Shervais et. al. (2002), presented below as Figure 5, shows the surficial geology in the area. Surficial basalt flows cover a wide area surrounding Mountain Home. Shervais et. al. (2002) describe five flows as "plateau forming basalts," because they cap the underlying Glenns Ferry sediments and preserve them from erosion. Of interest to this investigation is the Basalt of Rattlesnake Springs, shown by the symbol QTrs on Figure 5, which is the youngest and largest of the five plateau-forming basalts. This unit originated from a shield volcano located about 9 miles southwest of Mountain Home, and the flow covers a large area surrounding the vent. Basalt flows from other volcanic vents located north, east, and west of this flow formed what is described as a moat or a topographic low where plateau basalts are absent. This area includes the city of Mountain Home and lies at the downstream end of the Rattlesnake drainage.

Alluvial sediments, labeled Qal on the geologic map, were transported by Rattlesnake Creek and deposited in the topographic low. Concurrent alluvial deposition and basalt placement may have occurred, and basalt flows were not able to encroach into the moat area. The thickness of the alluvium, presented in Figure 6, was determined from drillers' logs for wells located within the outline of the alluvial deposits. The alluvium consists of clay silt, sand, and gravel in thickness ranging up to about 80 feet. The variable alluvial thickness shows the relief on the underlying basalt surface.

Overlying the alluvium are soils of variable thickness. Soils in the Mountain Home area have been mapped by the Natural Resources Conservation Service Elmore County soil survey (NRCS, 1991), and consist of loams, clay loams, and silt loams. Soil depths in 4S 6E sections 1, 11, and 12 are about 60 inches, while soils are only about 23 inches deep in 4S 6E sections 13 and 14. The available water capacity (amount of water the soil will hold after free drainage) ranges from 0.12 to 0.21 inches per inch for soils in the area.

These soils and alluvium sit in an area surrounded by basalt, and this area is where the extent of the perched aquifer exists.

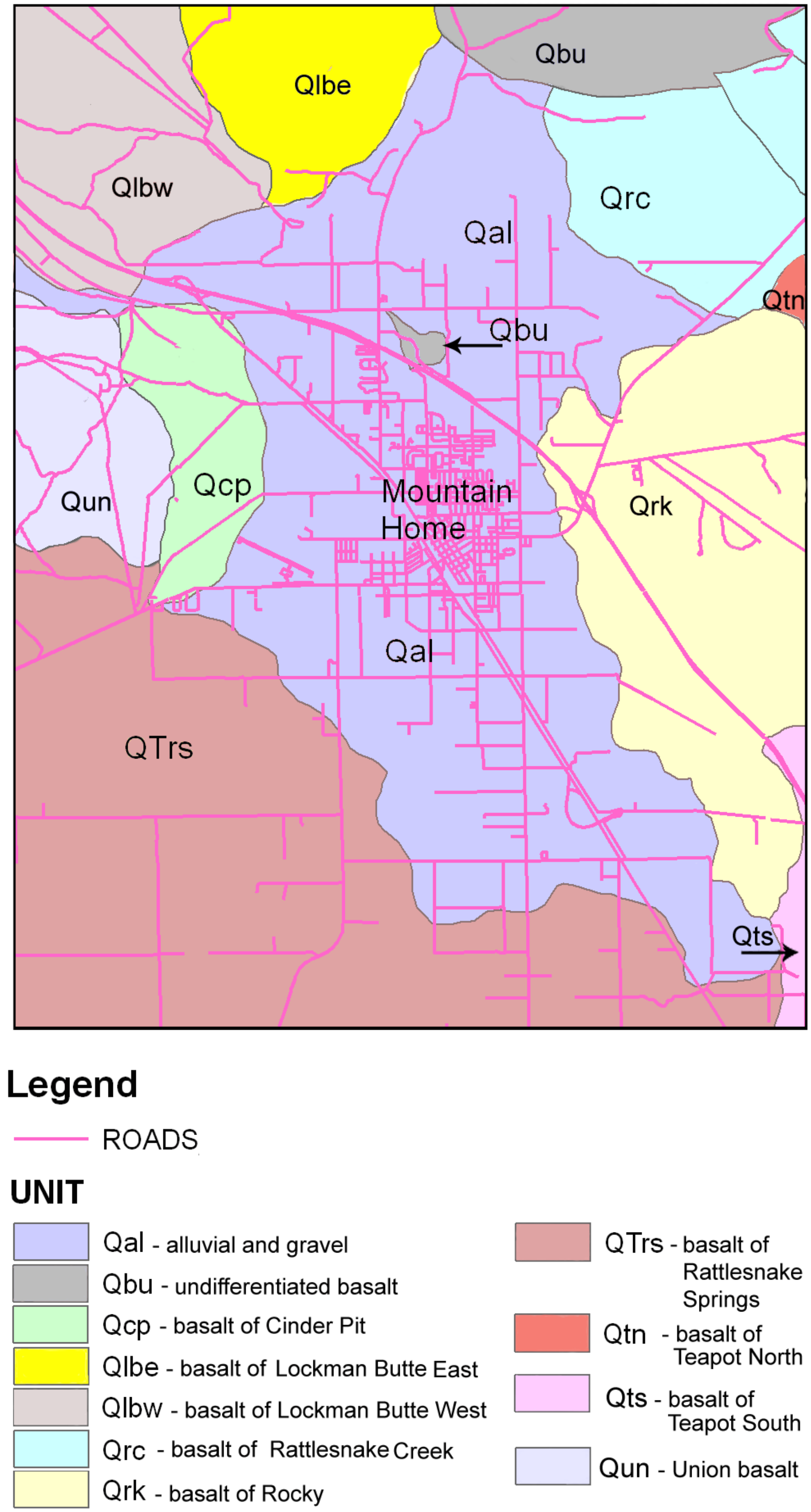

Figure 5. Geologic map and explanation of units for the Mountain Home area. (Figure adapted from Shervais et al., 2002)

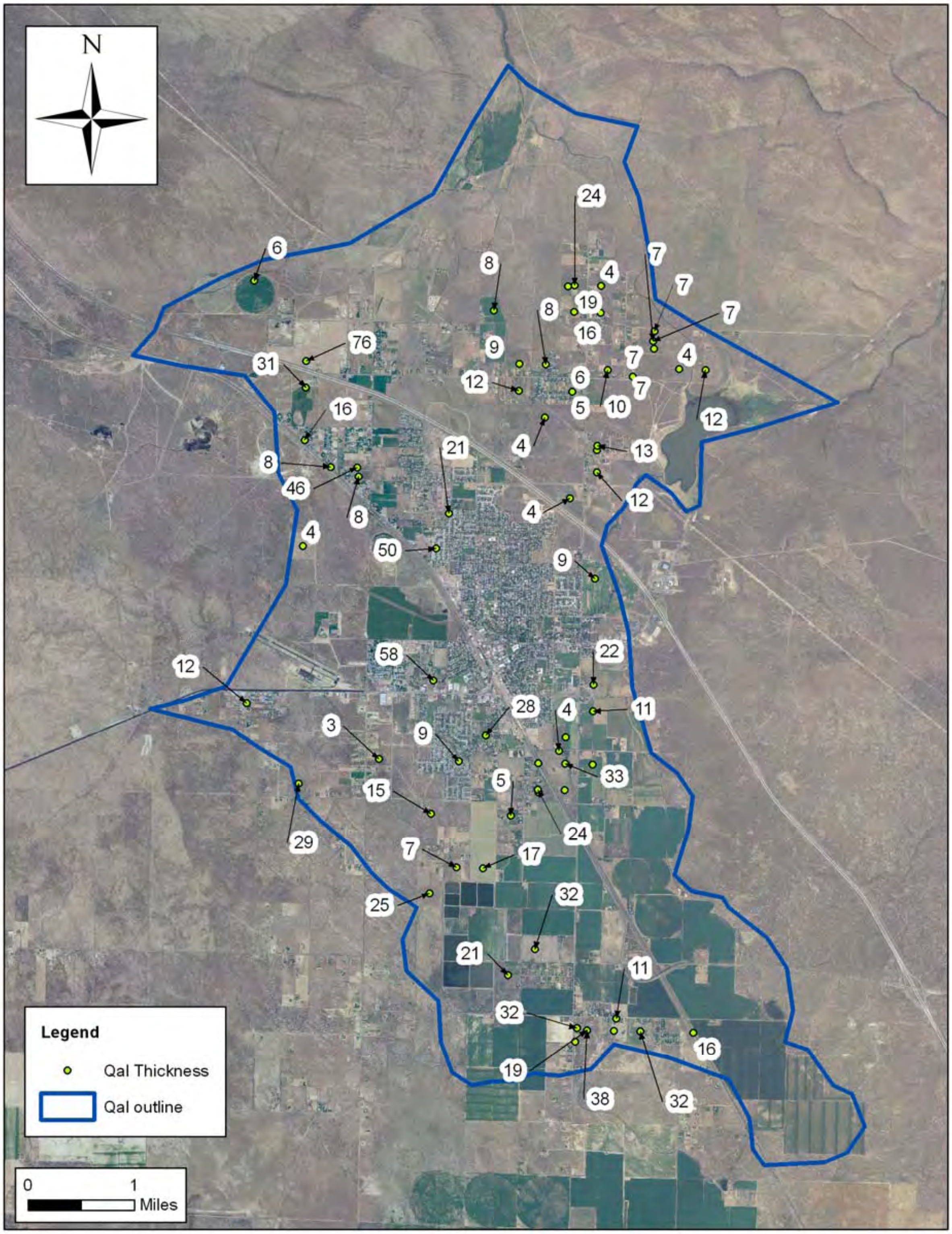

Figure 6. Map showing outline of Qal in the Mountain Home area and alluvium thickness, in feet, from selected wells. Qal outline adapted from Shervais, et al, 2002.

Hydrogeology

There are two distinct aquifers within the study area—a shallow perched aquifer and a deep regional aquifer. Additional perched zones occur between the shallow and regional aquifer in localized areas. The characteristics of each aquifer are discussed below.

Perched Aquifer

Saturated sediments in the shallow alluvial material north and south of Mountain Home occupy about 38,000 acres (Young, 1977). The extent of the alluvial material is labeled Qal on Figure 5. The alluvium thickness can be determined from drillers' logs that show the contact with the underlying basalt. Figure 6 shows a map of the alluvial deposit thickness as determined from drillers' logs. Within the Mountain Home City limits, the alluvium is as much as 80 feet thick. This thickness decreases to 20 to 30 feet south of town, in the vicinity of the wastewater treatment lagoons.

Canal leakage, leakage from Mountain Home Reservoir, recharge from Rattlesnake Creek, leakage from the Mountain Home wastewater treatment lagoons, and deep percolation from irrigation provide recharge water to the perched aquifer. The main canals that deliver irrigation water to irrigated land within the study area are shown in Figure 8.

Ground water in the perched aquifer moves from east to west as shown in Figure 7 below, which outlines potentiometric contours on the water table of the perched aquifer. Along the western edge of the perched aquifer, ground water percolates downward into the underlying basalt units. The perched aquifer exists because leakage into the underlying basalt is less than the rate of recharge to the alluvium. Leakage is controlled by the nature of the sediments that were deposited on the exposed basalt surface by streams flowing out of the mountains to the north. Coarse-grained material was deposited in and north of Mountain Home, nearer to the mountain front; gravel pits in Mountain Home are evidence of the coarse-grained nature of the alluvium in this area. Fine-grained material was carried further to the south, providing a more effective seal at the sediment-basalt interface in the study area. Fractures, joints and rubble zones in the basalt flow top were filled in with these fine-grained sediments, resulting in a low-permeability horizon that extends down into the flow top. Some water leaks through this zone, but recharge is sufficient to maintain saturation throughout most of the alluvial material.

The lagoons were designed for seepage to occur, and, given the large surface area, there is the potential for significant seepage. The lagoons cover an area of about 205 acres. Annual lagoon seepage based upon 2002-2003 testing is an estimated 780 acre-feet/year contributing to the aquifer. The water surface in the lagoons is several feet above the surrounding land surface. A ground water mound likely exists around the lagoons so that ground water moves radially outward from the lagoons. The northern five lagoons serve as facultative treatment lagoons, and the two southernmost lagoons are storage lagoons. The storage lagoons are filled during the fall, winter, and early spring months of the following year and then drawn down as the water is used for crop irrigation during the summer. It is believed that recharge from the lagoon system as a whole is relatively constant throughout the year so that water levels in the perched aquifer, at least around the lagoons, are stable. Information is not available to determine canal leakage, leakage from Mountain Home Reservoir, or losses from Rattlesnake Creek. Recharge to ground water from canals and laterals is limited to the irrigation season.

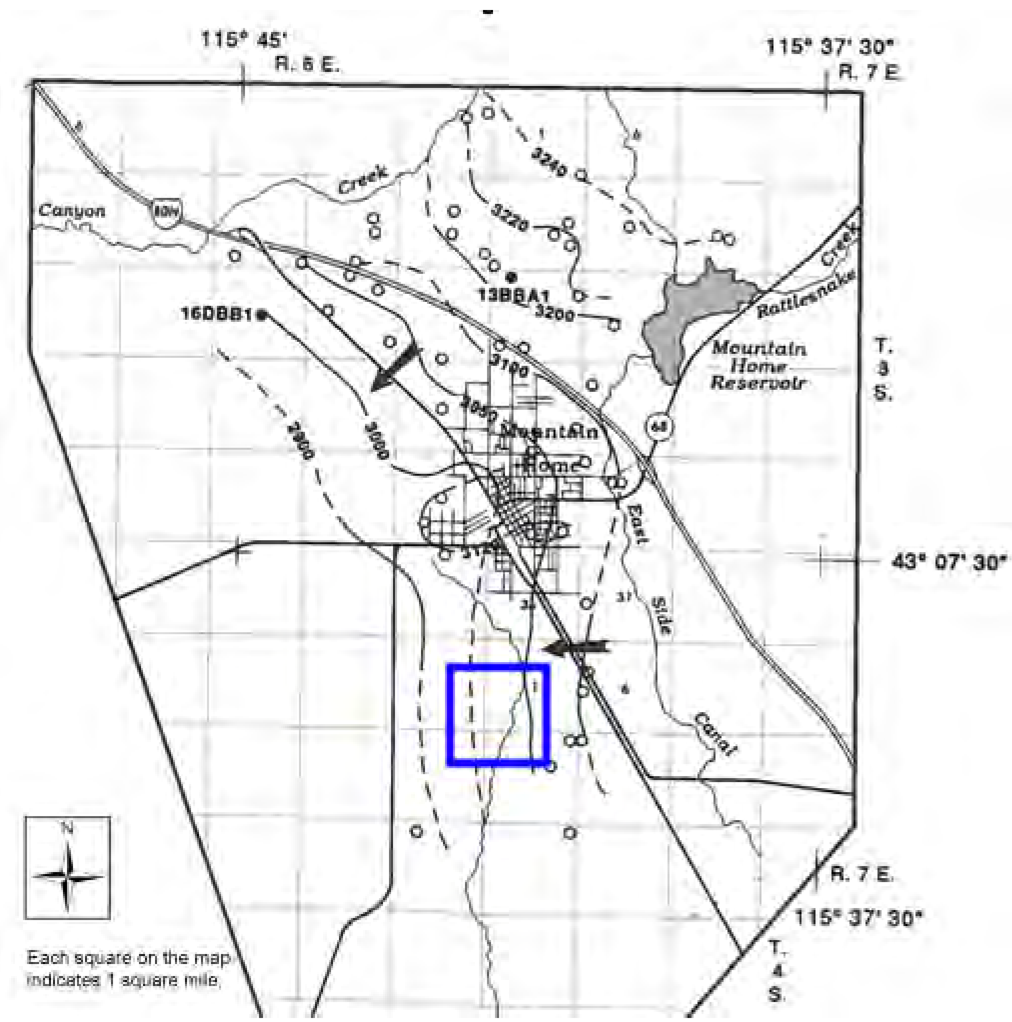

Figure 7. Potentiometric contours on the perched water table, Mountain Home area (adapted from Young et. al., 1992). Blue outline shows general location of Mountain Home wastewater treatment facility.

Regional Aquifer

The regional aquifer occurs at depths of about 500 feet below land surface. North of Hamilton Road the aquifer occurs in permeable zones of highly fractured basalt or cinder layers that occur within dense, relatively unfractured flow units. The elevation on the regional water table ranges from 2,900 to 2,700 feet above sea level in the study area. The ground water flow direction is generally to the southwest as shown in Figure 8 below. The potentiometric information for was developed by the Idaho Department of Water Resources (IDWR) in 1982 and updated in 2007; these contours represent the most recent ground water flow information for the area. The regional aquifer in the Mountain Home area was declared a critical ground water area (CGWA) by IDWR in 1982. A CGWA is all or part of a ground water basin that does not have sufficient ground water to provide a reasonably safe supply for irrigation or other uses at the current or projected rates of withdrawal.

The range front faults which parallel the northeast side of the Mountain Home region have placed low permeability rhyolite in the foothills adjacent to the more permeable basalt and Glenns Ferry sediments on the plains. This faulting has created a hydrologic boundary condition that magnifies the effect of ground water withdrawals in the Mountain Home area and, coupled with limited recharge, has resulted in continued ground water level declines in the regional aquifer. Figure 9 shows hydrographs from wells located at 04S 06E 14ACA1 and 03S 06E 35BCC1, in the Mountain Home CGWA. Water levels at these wells have declined 26.8 and 51.2 feet, respectively, since water level measurements began. Data analysis indicates that water level declines are not uniform across the area. The potentiometric contours shown in Figure 8 were developed in 1982, and while water level declines have occurred in the Mountain Home area, the general ground water flow direction is still probably to the west-southwest. It was beyond the scope of this project to determine site-specific ground water flow conditions in the regional aquifer.

Intermediate Perched Aquifer

In this study area, intermediate perched aquifers supplied by leakage from the shallow perched aquifer are evidenced by wells that have water levels deeper than the perched aquifer but higher than the regional aquifer. Wells completed in intermediate perched aquifers are found south of the wastewater treatment lagoons, along Hamilton Road. It is important to note that because of the head difference between the perched and regional aquifers, some downward leakage is occurring through the low permeability sediments between the shallow sands and gravels and the deeper underlying basalt flows.

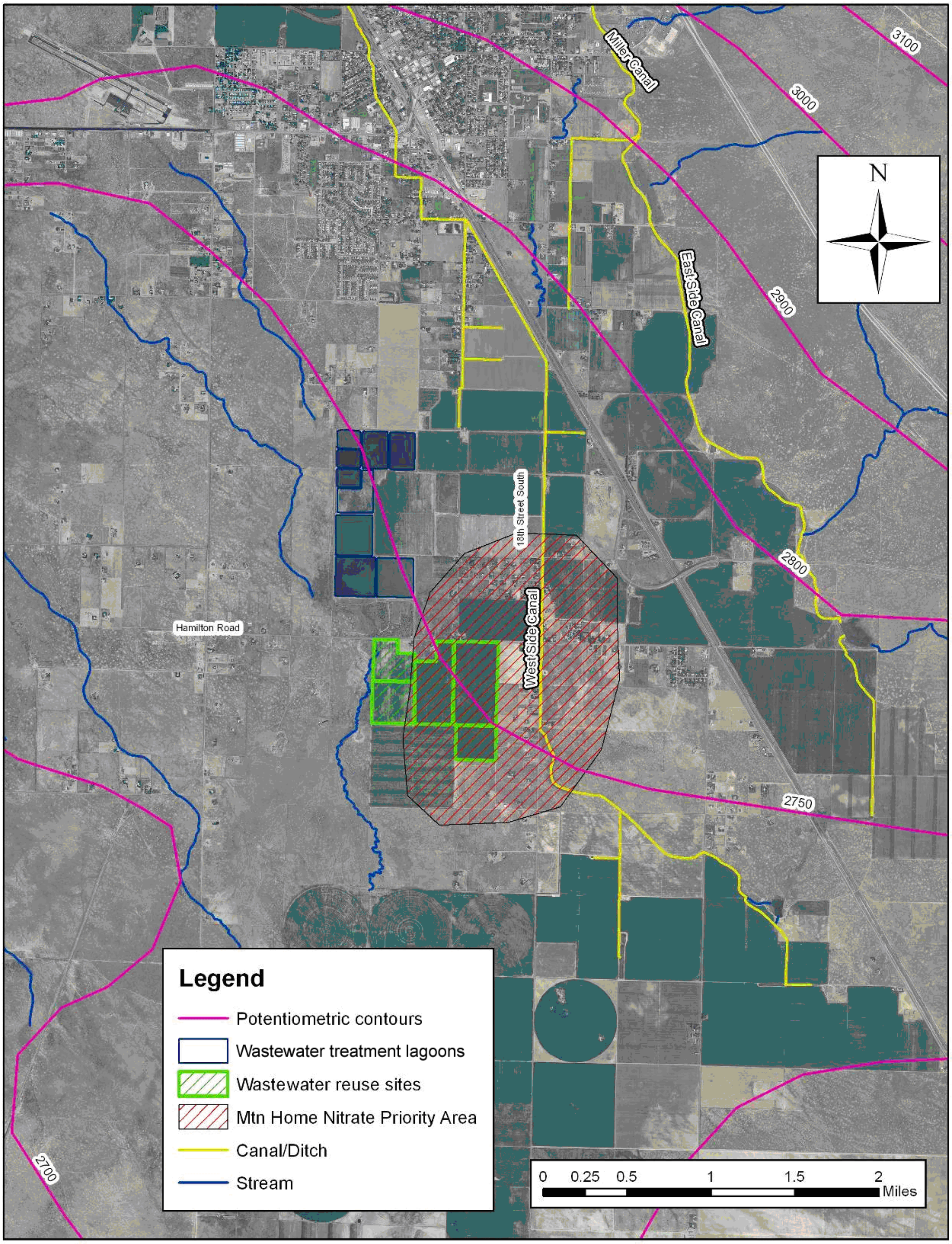

Figure 8. Potentiometric contours on the regional water table and location of irrigation canals, wastewater treatment lagoons, and wastewater reuse sites in the area south of Mountain Home. Also shown is the Mountain Home nitrate priority area. Potentiometric contours from IDWR GIS coverage, updated with July 2007 water level measurements. Note inclusion of 2,750 foot contour.

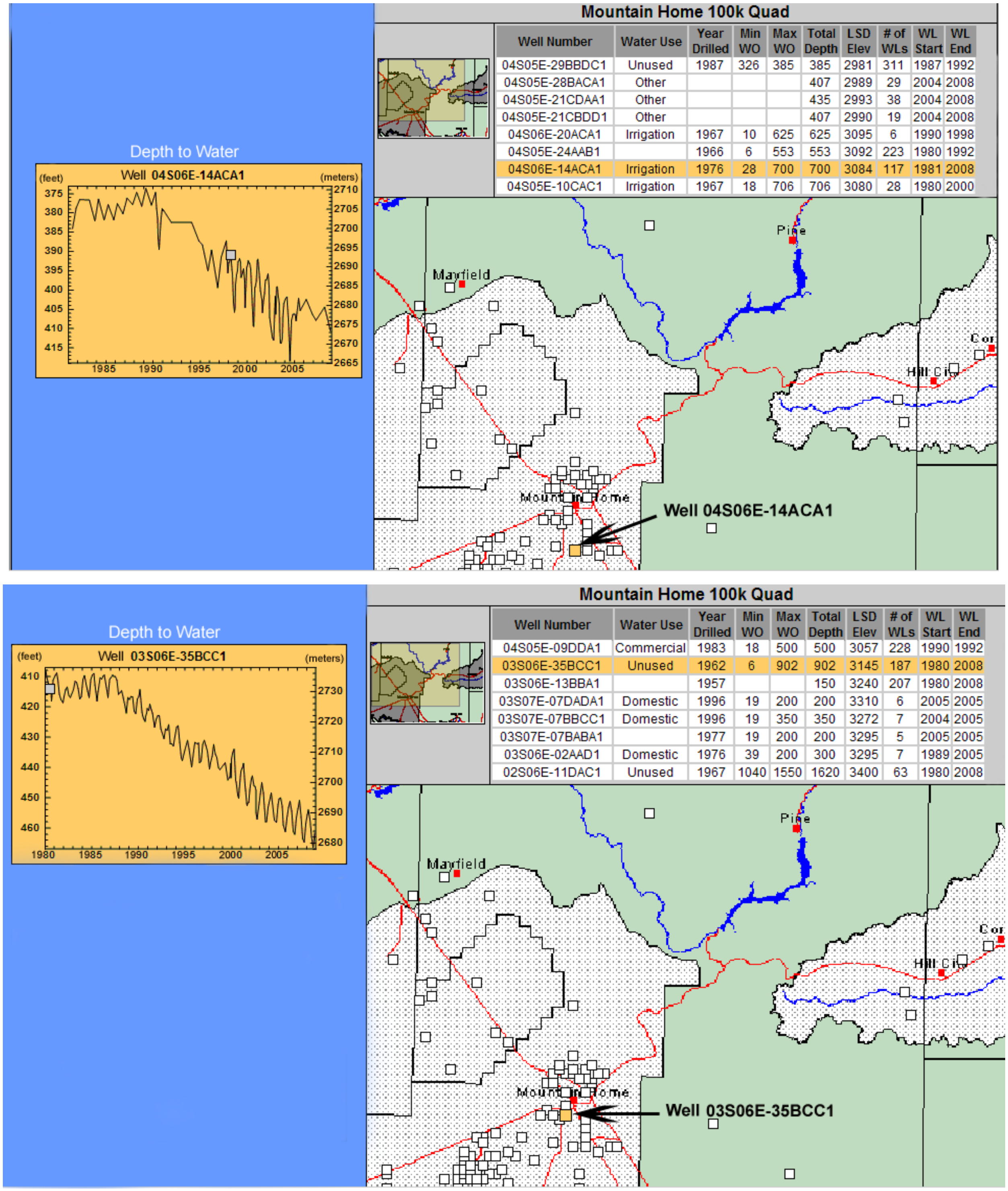

Figure 9. Depth to water for an irrigation well located at 04S 06E 14ACA1 and an unused well located at 03S 06E 35BCC1 showing water level declines from 1981 to 2008 and 1980 to 2008, respectively (IDWR data).

Sampling Program

Both ISDA and DEQ conducted ground water investigations in the study area. The following discussion gives a brief history, then describes these sampling programs and the rationale for the work.

The history of the data in this study begins in 1989 when elevated ground water nitrate was first noted in the study area in well 6 at a concentration of 9.4 mg/L (Table 6 in Appendix B). This well was subsequently included in the IDWR statewide monitoring network, one of about 1,600 ground water monitoring sites designed to monitor water quality in major aquifers throughout the state. In 1991, nitrate concentrations in well 6 exceeded the Idaho Ground Water Quality Standard of 10 mg/L and have remained above this MCL for subsequent samples. Based on a review of the statewide monitoring results, ISDA began a regional sampling program in the Mountain Home area in 1998. This investigation, identified as ISDA Project 810, began with a sampling program for wells 1 through 7. As the project proceeded, additional sample locations were added to the network to assess the extent of elevated nitrate.

ISDA Sampling Program

ISDA began a sampling program to evaluate the occurrence of elevated nitrate in domestic wells in the vicinity of 18th Street and Hamilton Road. Figure 10 below shows the location of the ISDA wells that have been sampled, along with identification numbers referring to wells, sampling locations, or both. Table 6 in Appendix B lists sample locations, analytes, and laboratory results and also includes sampling data collected by IDWR and U.S. Geological Survey. Samples were analyzed for nitrate as N (nitrate), nitrite as N (nitrite), orthophosphorus (OrthoP), chloride, sulfate, ammonia, bromide, and fluoride. Table 7 lists the results for the field parameters of temperature, pH, and specific conductance for ISDA sample locations. Samples also were collected for analysis of the stable isotopes of oxygen and deuterium. These results are provided in Table 11 in Appendix B.

Results are available for well 6 since 1989; sampling on a large scale began in 2001 with 31 wells in the sampling network (Table 6). Wells 1, 2, 3, 4, and 5 were added to the sampling network in 1998, and additional wells were included to evaluate the scope of nitrate impacts as the project proceeded. Surface water samples were collected in 2001, and the results are listed in Table 7.

DEQ Sampling Program

The work performed by DEQ in 2006 and 2007 to evaluate the source of the increase in nitrate concentrations at a few of the wells included the following:

- Samples from all wells were analyzed for nitrate-N, chloride, and sulfate (Table 8 in Appendix B). Some samples were analyzed for the common ions calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulfate (Table 10 in Appendix B). Samples from selected locations also were analyzed for the stable isotopes of oxygen, deuterium, and nitrogen. Oxygen and deuterium results are shown in Table 11 in Appendix B.

- Collection of water samples from the wastewater lagoons and irrigation ditches to compare the water quality of the surface water with the ground water.

- Collection of ground water samples from the two shallow monitoring wells (MW-2 and MW-3) installed south of the wastewater lagoons and ground water samples from domestic supply wells in the area to compare the water quality between shallow and deep wells and to compare the ground water quality with the surface water quality. Nitrate, chloride, and sulfate data were collected for wells MW-2 and MW-3 from 1990 through 2005 as required by a DEQ wastewater reuse permit issued to the city of Mountain Home for the wastewater treatment facility. These data were supplemented with data collected by DEQ during the 2006 and 2007 field seasons (wells S15, S30, and S40; see Table 8). Lagoon samples were collected from the wastewater treatment system, and laboratory and field results are presented in Table 8 and Table 9 in Appendix B. Isotope results from ground water, surface water, and lagoon samples are included in Table 11.

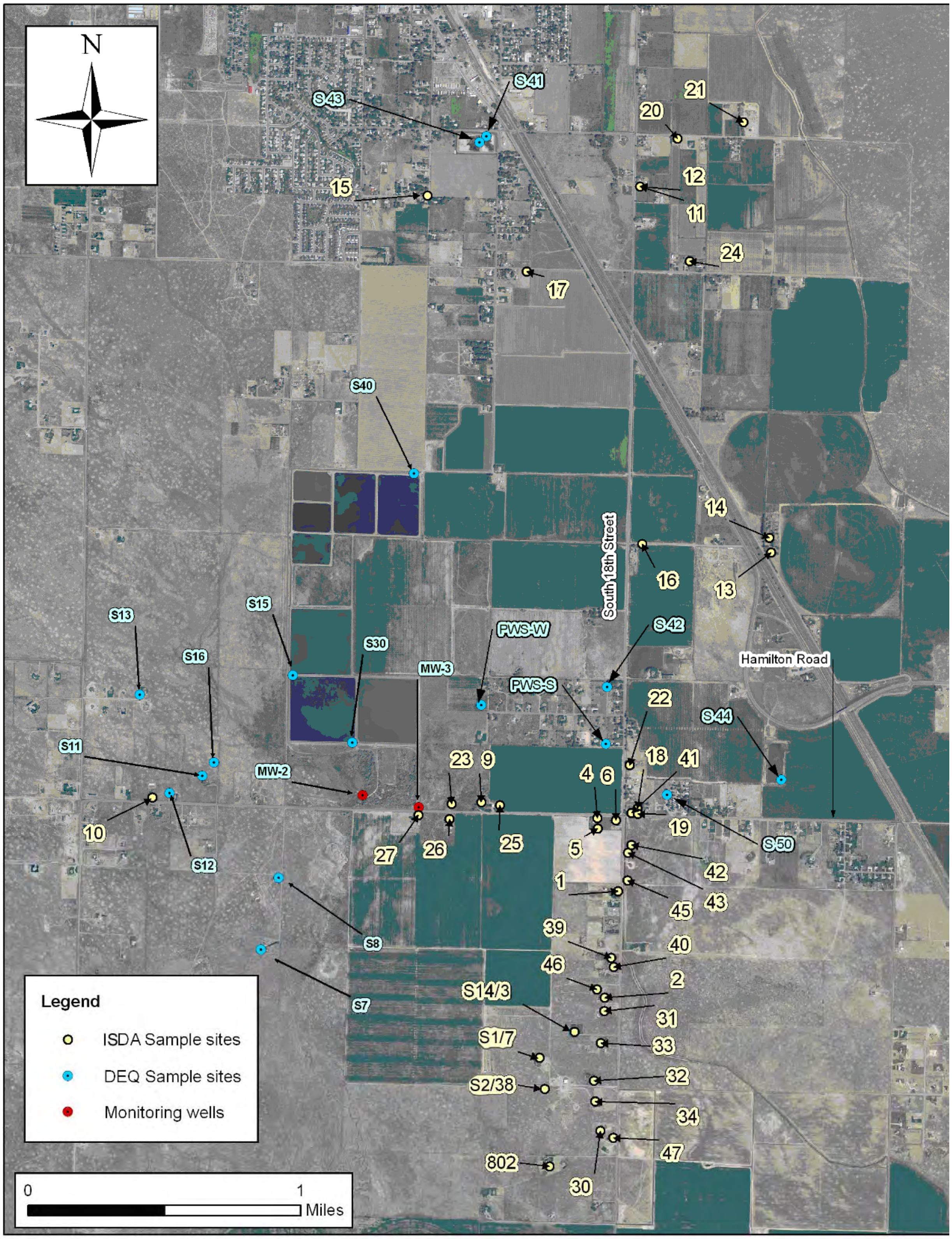

Figure 10. Sample locations and identification numbers for sites sampled by ISDA and DEQ in the Mountain Home south study area. (Well S14/3 was sampled by both DEQ and ISDA; in ISDA data, S14/3 is referred to as well 3.)

Background on Water Chemistry and Isotopes

There are a variety of ways to evaluate the geochemistry of water and compare different water chemistries from one place to another. Comparison of constituent concentrations is the simplest approach, as it is difficult for waters to contain concentrations of constituents at higher concentrations than are present at a suspected source. The anions nitrate, chloride, and sulfate were analyzed to compare constituent concentrations from one sample/location to the next. The major ions (calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulfate) were available for samples collected at four sites by DEQ; historical major ion data were retrieved for 15 sites from the USGS (U.S. Geological Survey) National Water Information System database (Table 10). Nitrate, sulfate, and chloride were analyzed for all sites sampled by DEQ and ISDA.

Isotopes of oxygen and hydrogen were also analyzed from selected sample locations by DEQ and ISDA to compare the regional source(s) of ground waters.

The field parameters of temperature, dissolved oxygen, and specific conductance were recorded at the time of sample collection for all sampling locations. All these analytes were used to evaluate impacts to ground water. In particular, nitrate, sulfate, and chloride concentrations were evaluated. Background information for these parameters is presented in the following sections.

Nitrate

The Idaho Ground Water Quality Rule has established the ground water quality standard for nitrate as 10 mg/L. Sensitive populations (infants, people in poor health, and the elderly) can be susceptible to problems from short-term nitrate exposure. Infants younger than six months of age are especially sensitive to nitrate poisoning, which may result in serious illness or death. The illness occurs when nitrate is converted to nitrite in the baby's body. Nitrite reduces the amount of oxygen in the baby's blood, causing shortness of breath and blueness of the skin (the illness is often called “blue baby syndrome”). The technical term for this condition is “methemoglobinemia.” This illness can cause the baby's health to deteriorate rapidly over a period of days.

Sources of nitrate in ground water include commercial fertilizer, human or animal waste, nitrogen from soil organic matter, and nitrogen in precipitation. The movement of nitrate in ground water is conservative, meaning that nitrate ions do not sorb or degrade as water passes through soil or rocks, but instead move readily with the flow of water. The presence of elevated nitrate in a water supply indicates an anthropogenic source and the possibility for other contaminants to migrate to ground water.

Nitrogen in ground water also can occur in the ammonia (NH_4) and total Kjeldahl nitrogen (TKN) forms. Nitrogen in both the ammonia and TKN forms are not plant available, but must first be oxidized to the nitrate form. Oxidization happens under aerobic ground water conditions, where oxygen dissolved in ground water is utilized by bacteria in the conversion of ammonia and organic nitrogen to nitrate nitrogen. The ammonia and TKN forms constitute most of the nitrogen in the wastewater treatment lagoons and also in domestic wastewater. Ground water in the Mountain Home area contains sufficient dissolved oxygen to complete the nitrification process, with the result that nitrate is the dominant nitrogen form found in ground water.

Sulfate

The major sources of sulfate in ground water are precipitation, domestic and municipal wastewater, certain fertilizer formulations, and dissolution of gypsum from geologic materials. Gypsum (calcium sulfate, written as $CaSO_4$) deposits are formed in evaporative conditions in sedimentary rocks. This process usually requires desert conditions in shallow marine basins, or along coastal tidal flats, and commonly occurs in association with halite and dolomite in evaporite basins. Although Lake Idaho sediments contain gypsum deposits, gypsum is not found in the basalt alluvial material in the study area.

Sulfate also could come from ammonium sulfate fertilizer, written as $(NH_4)_2SO_4$, which is a common source of nitrogen for crops. This formulation contains 21% nitrogen as ammonium ions and 24% sulfur as sulfate ions. Elemental sulfur may be applied in agricultural situations to counteract certain soil conditions.

Ambient sulfate conditions in the Mountain Home area can be evaluated by reviewing sulfate over a regional area. Ambient sulfate concentrations in areas not affected by contaminant sources reflect all the naturally occurring processes that have occurred as ground water moves through soil and rocks, so that elevated concentrations reflect sulfate contribution from anthropogenic sources.

Chloride

Chloride in ground water can originate from road salting for deicing, domestic and municipal wastewater, and deep percolation of irrigation water. The U.S. Environmental Protection Agency conducted sampling on septic tank effluent to document water quality impacts from chloride. For eleven samples, the mean chloride concentration was 70 mg/L, and chloride concentrations ranged from 37 to 110 mg/L (US EPA, 2002). Ambient chloride concentrations also reflect all the naturally occurring geochemical processes, so that elevated concentrations reflect chloride contribution from anthropogenic sources.

Background Ground Water Conditions

Ambient (or “background”) ground water concentrations for a particular analyte or chemical can be defined as the lowest concentration of that analyte naturally occurring in a particular area. Multiple samples from a well that show stable concentrations—i.e., little or no increasing or decreasing concentration trends—are the best indicator of background conditions. Table 1 shown below shows nitrate, chloride, and sulfate data that were evaluated to determine background conditions in the study area. Wells l2, 802, and 11 are completed in the regional aquifer; well 30 is believed to be completed in the regional aquifer because no alluvial sediments are present in the shallow subsurface at this well location. Well 15, at a depth of 140 feet, is completed in an intermediate perched aquifer; water chemistry at this well is representative of conditions in the shallow perched aquifer.

Table 1. Average nitrate (NO_3-N), chloride (Cl), and sulfate (SO_4) concentrations that represent background water conditions for ISDA wells.

IDA Well #	Well total depth (feet)	Average concentration NO$_3$-N mg/L	Cl mg/L	SO$_4$ mg/L	Number of observations (n)
2	530	1.6	13.6*	32.7	11
802	586	1.1	9.3	19.3	7
10	Unk	1.1		35.2	7
11	557	2.2	5	11.9	9
15	140	1.8	6.9	12.9	9
23	Unk	1.6	13.6	34.3	9
25	Unk	0.7	8	17.5	10
27	Unk	1.4	12.2	29.5	9
30	Unk**	1	8.7	18.1	3

*Ten chloride sample results are available for well 2. ** Well 30 is believed to be completed in the regional aquifer.

Background nitrate concentrations in the study area range from about 1 to about 2 mg/L, background chloride concentrations range from 5 to about 14 mg/L, and background sulfate concentrations range from about 12 to about 34 mg/L. Chloride results for well 10 were not considered because concentrations were elevated and trending down compared to other wells. (See Figure 11 below.) For the purposes of this report, elevated nitrate means any nitrate concentration greater than 2 mg/L, elevated chloride means any chloride concentration greater than 14 mg/L, and elevated sulfate means any sulfate concentration greater than 35 mg/L.

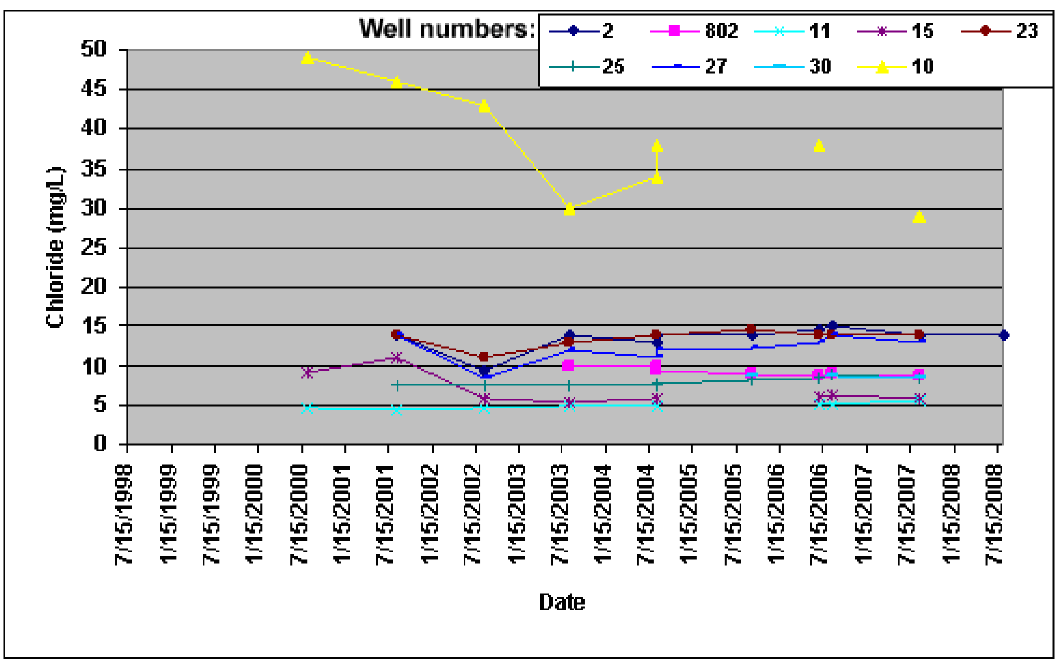

Figure 11. Plot of chloride concentrations for wells used to determine background ground water conditions in the Mountain Home study area.

Field Parameters

The field parameters of temperature, pH, specific conductance, and dissolved oxygen were measured while a well was purged. Samples were collected when values for the parameters were within 10% of the previous reading. At this point, the well was considered to have been adequately purged, and fresh water was produced from the aquifer and a representative water sample collected from the aquifer. Field parameters, especially dissolved oxygen and specific conductance, can be used as a diagnostic tool to evaluate water chemistry results. The dissolved oxygen concentration in ground water is a measure of the oxygen available for chemical reactions. Dissolved oxygen concentrations indicate whether certain ions are mobile and what chemical reactions might be occurring. Specific conductance is a measure of the ease with which water will conduct an electrical current, and it is a direct measure of the dissolved constituents in ground water. Parameters such as nitrate, total dissolved solids, and the major ions (calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulfate) are positively correlated with specific conductance. Plots of specific conductance versus other parameters can provide lines of evidence for contaminant sources.

Stable Isotopes

The stable isotopes of oxygen (^{18}O), hydrogen (^{2}H, commonly referred to as deuterium), and nitrogen (^{15}N) were analyzed to evaluate the impact of surface water sources on ground water in the perched and regional aquifers. For oxygen and deuterium, the same or similar isotope signature found in a surface water source and in ground water would suggest a connection between the two. The following discussion is summarized from Clark and Fritz (1997).

Oxygen and Deuterium Isotopes

The stable isotope ratios of oxygen and deuterium in atmospheric water vapor are subject to changes that begin when water evaporates from the ocean. Oxygen and deuterium isotope ratios continue to evolve as an air mass moves inland and the water vapor condenses to form precipitation. Oxygen and deuterium isotope ratios in precipitation can vary for different storm events in a particular area and for summer versus winter storm events for the same area. Isotope ratios can also vary for storm events that occur at different latitudes and at differing altitude and/or temperature conditions. Once precipitation infiltrates and enters an aquifer, further changes in oxygen and deuterium ratios are limited because evaporative processes are no longer active. Seasonal isotopic variations in the recharged water become damped out once the water enters an aquifer. Oxygen and deuterium results are often compared to the Global Meteoric Water Line (GMWL), which describes the relationship between oxygen and deuterium in fresh surface water samples on a worldwide basis. The equation describing a best fit line for these data is:

$\delta^{2}H = 8\ \delta^{18}O + 10$ ‰ SMOW (Craig, 1961b, as cited in Clark and Fritz, 1997),

where SMOW is Standard Mean Ocean Water, used as a reference. VSMOW (Vienna Standard Mean Ocean Water) has since replaced SMOW as the accepted reference for the GMWL. Samples from the Mountain Home south study were submitted to the University of Arizona Laboratory for Isotope Geochemistry for oxygen and deuterium isotope analysis. The analysis of oxygen and deuterium isotopes is typically conducted on sample sizes of a few milliliters (ml) since oxygen and hydrogen atoms comprise most of the sample. The stated analytical precision at this lab is 0.9 ‰ (parts per thousand, or permil)for oxygen isotopes and 0.08 ‰ for deuterium isotopes.

Nitrogen Isotopes

Selected samples were analyzed for the stable isotopes of nitrogen ($^{15}N/^{14}N$). The following discussion of nitrogen isotopes (^{15}N) is taken from Clark and Fritz, 1997. Fractionation of nitrogen isotopes occurs during the nitrogen cycle, with the result that certain potential sources of nitrogen contamination have distinguishable isotopic signatures. The ratio of ^{15}N to ^{14}N, written as $\delta^{15}N$ and expressed as parts per thousand (or permil, ‰) commonly ranges from -5 permil to +20 permil in ground water (Kendall and McDonnell, 1998). Table 2 below lists $\delta^{15}N$ values for common nitrogen sources. Samples from the Mountain Home south study were submitted to the University of Arizona Laboratory for Isotope Geochemistry for nitrogen isotope analysis. The stated analytical precision at this lab is 0.15 ‰ for nitrogen isotopes. The University of Arizona recommends a nitrogen sample size of 10-100 millimoles (µM) for nitrogen isotope analysis, or 0.14 to 1.4 milligrams of N, so the sample volume submitted should be large enough to obtain the required sample mass.

Table 2. Typical $\delta^{15}N$ values from various nitrogen sources (from Seiler, 1996).

Potential Nitrate Source	**$\delta^{15}N$ (‰)**
Precipitation	-3
Commercial fertilizer	-4 to +4
Organic nitrogen in soil or mixed nitrogen source	+4 to +9
Animal or human waste	Greater than +9

Results and Discussion

ISDA and DEQ sampled 73 wells and surface water features over a period of ten years in an area south of Mountain Home. Overall the results establish that there is a contaminated zone of elevated nitrate, chloride, and sulfate in the perched aquifer. In addition, water chemistry in the regional aquifer shows elevated nitrate, chloride, and sulfate concentrations. Contamination in regional aquifer wells is quite variable for both location and time. This section presents sampling results for the perched aquifer and regional aquifer and a discussion.

Perched Aquifer

Water chemistry in the perched aquifer has two distinct chemical signatures and trends, based on nitrate, chloride, and sulfate concentrations:

The first distinct chemical signature occurs north of Hamilton Road, where water in the perched aquifer has low nitrate, chloride, and sulfate concentrations and time series plots show that concentrations are relatively stable (wells 12, 15, 17 and 24; see Figure 12). Analysis of the available data indicates that the perched aquifer exists at background water chemistry conditions in this portion of the regional aquifer.

The second distinct chemical signature is in the vicinity of Hamilton Road and South 18th Street, where water in the perched aquifer has elevated nitrate, chloride, and sulfate concentrations and time series plots show that concentrations are highly variable. In fact, dramatic concentration increases of doubling or tripling of constituents have occurred over time (wells 4, 6, 9, and 19; see Figure 13 below).

In this area with the second distinct chemical signature, the perched aquifer appears to be impacted by anthropogenic sources. In order to establish the extent of the contamination zone, DEQ evaluated water chemistry in wells 4, 6, 9, 19, 46, MW-3 and MW-2. Water chemistry from the upgradient wells S50 and 6, east of Hamilton Road and South 18th Street, was reviewed. Water chemistry from downgradient wells 9, MW-3, and MW-2, west of Hamilton Road and South 18th Street, was also reviewed. From the discussion above, the extent of the perched aquifer may extend as far south as well 46.

In the eastern, upgradient area of the contaminated zone, limited information is available to define the extent of the zone and origin of the contamination. There are no water chemistry data from the perched aquifer east of the intersection of Hamilton Road and South 18th Street, but nitrate concentrations from well S50 (to be presented below) may provide information about the extent of impacts in the overlying perched aquifer. Well S50 is a 457-foot deep public water supply well completed in the regional aquifer and is located east of the intersection of Hamilton Road and 18th Street (see Figure 10). Nitrate concentrations at this well ranged from 8.3 to 11.6 mg/L during the period December 1993 through January 1996. (See Figure 15.) Well S50 is completed in the regional aquifer, but for reasons listed below, water chemistry at the well is believed to reflect water chemistry conditions in the perched aquifer. This is the easternmost well where water chemistry data are available; the data may indicate that an anthropogenic nitrogen source lies upgradient of this well.

For the downgradient extent of the contaminated zone, analysis of water chemistry data indicates that the impacted zone extends to the west at least as far as well 9, which appears to be consistent with the east-west flow direction for the perched aquifer shown in Figure 7. In the evaluation of this western extent, the wastewater treatment site and its contribution to the perched aquifer were considered. The nitrate concentration at MW-3, which was completed in the perched aquifer west of the intersection of Hamilton Road and South 18th Street and southeast of the Mountain Home wastewater treatment lagoons, increased to about 7 mg/L during the 1998 through 2000 period and then declined to about 3 mg/L by September 2005 (Figure 14). The nitrate concentration at MW-2 has consistently remained nearly equal to or less than the laboratory detection limit of 0.1 mg/L; therefore, MW-2 reflects water leaking from the treatment lagoons. MW-3, which is located farther south of the lagoons, may have been on the northern edge of the contaminant plume described above.

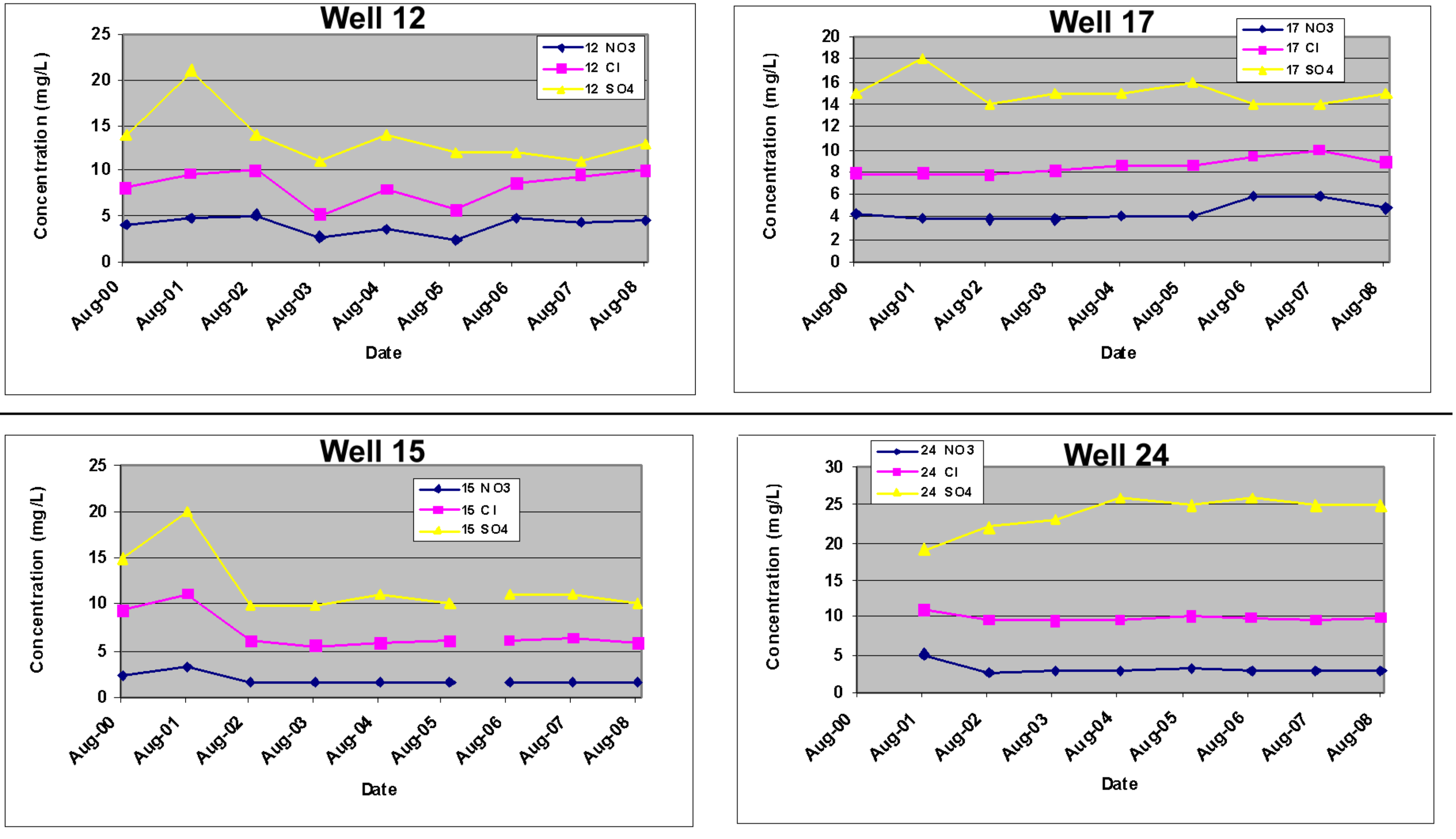

Figure 12. Plots of nitrate (NO_3-N), chloride (Cl), and sulfate (SO_4) results for wells 12, 15, 17, and 24, completed in the perched aquifer, northern part of study area.

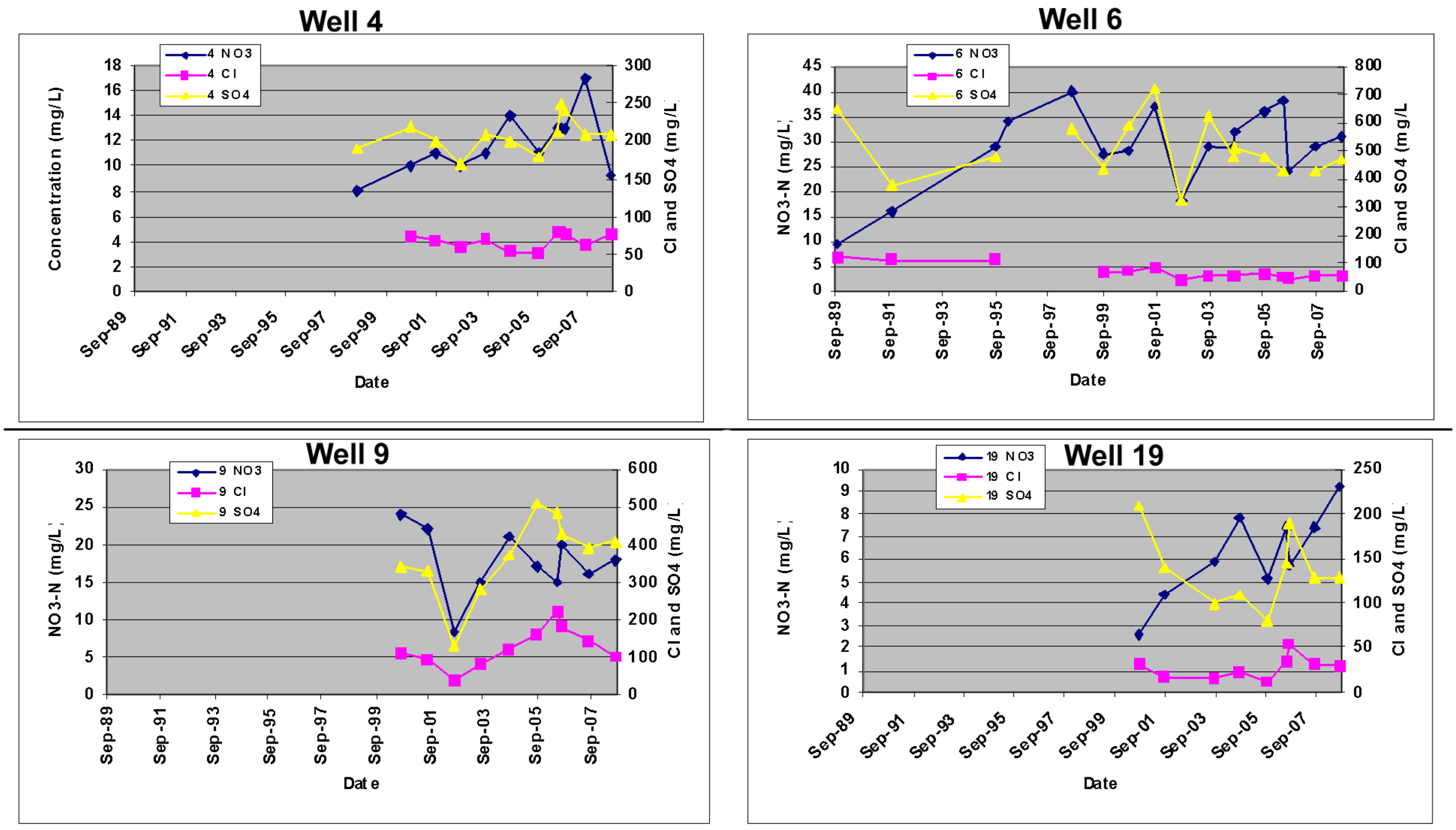

Figure 13. Nitrate, chloride, and sulfate concentration for wells 4, 6, 9, and 19, completed in the perched aquifer, near the intersection of Hamilton Road and South 18th Street.

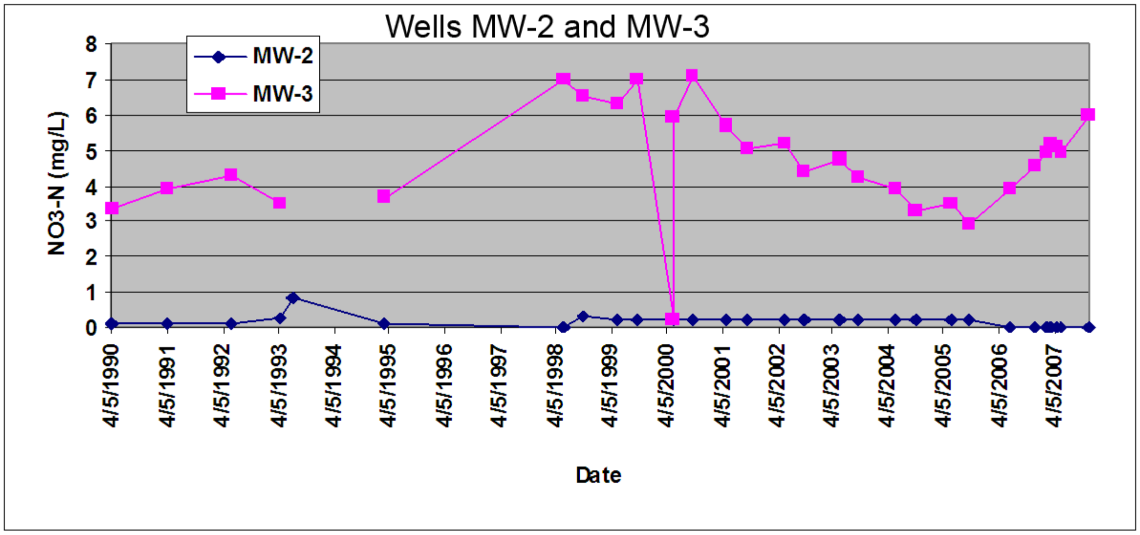

Figure 14. Nitrate concentrations at MW-2 and MW-3 for the period May 1990 through November 2007.

The nitrate concentrations at MW-2 have consistently been at or near the laboratory detection level. One explanation for the absence of any nitrogen at this well may be the large grove of Russian olive trees (Elaeagnus angustifolia (L.)) that is growing adjacent to the southern end of the wastewater treatment lagoons. Russian olives have been categorized as a noxious weed in New Mexico and Utah and as an invasive weed in California, Nebraska, Wisconsin, and Wyoming. The trees put down a large taproot and extract water and nutrients from the soil and ground water. They are drought tolerant and can grow in alkaline soils. Dense stands form a monoculture that excludes native plant species. The absence of nitrate in the perched aquifer south of the lagoons may be due to plant uptake by the Russian olives. Russian olives also consume large quantities of water, similar to salt cedar, another invasive species. The source of elevated chloride found in the shallow ground water south of the lagoons is unknown but may be related to exclusion of salts as water is taken up by the trees.

There are no Russian olives on the west side of the lagoons, so ground water that moves to the west in the perched aquifer does not undergo phytoremediation, which is the removal of contaminants from the soil by plants. Therefore, nitrate concentrations in the perched aquifer along the west side of the lagoons may be higher than for the area south of the lagoons. Currently there are no monitoring wells in the perched aquifer along the west side of the lagoon system to evaluate this possibility.

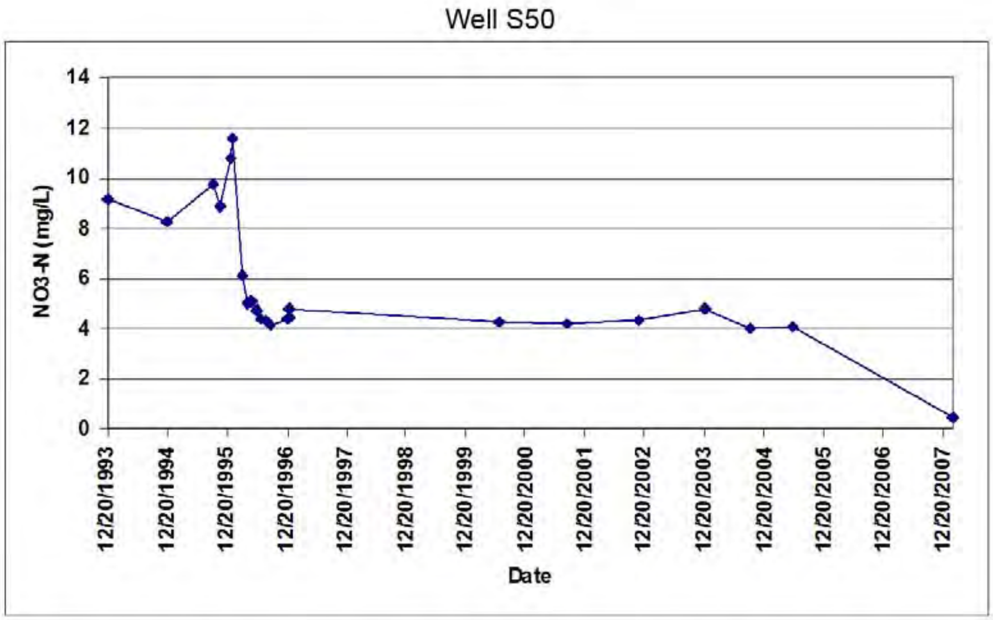

Figure 15. Nitrate concentrations at well S50, located east of the intersection of Hamilton Road and South 18th Street.

In evaluating the contamination plume, the timing of impacts to the perched aquifer can be inferred from nitrate concentration trends at wells 6 and S50. The nitrate concentration at well 6 was 9.4 mg/L in September 1989 and increased to 16 mg/L by October 1991, indicating that the onset of contamination in the perched aquifer occurred prior to 1989. As discussed above in looking at the eastern extent, nitrate concentrations at well S50 were elevated during the 1993 to 1995 time period and then decreased to 4-5 mg/L. This may indicate that a nitrate source in the perched aquifer was present east of S50 and then diminished after 1996. However, nitrate concentrations at well 6, completed in the perched aquifer, remain elevated as of 2008, indicating that the nitrate source still exists.

Oxygen and deuterium isotopes were used to evaluate the source of water in various wells in the study area. Figure 16, a plot of ^{18}O versus ^{2}H, shows that wastewater that has been in storage for the longest period (lagoon 9, sample location S30) and therefore has undergone the most evaporation, plots in the upper right part of the diagram. The variation in ^{18}O and ^{2}H for this sample location reflects the variation in evaporative conditions between summer and winter periods. Isotopic evidence shows that the water in the perched aquifer at MW-2 is primarily derived from lagoon leakage and represents an average of the isotope values from the lagoon source. Water at MW-3 and wells 4, 6, and 9 in the perched aquifer had a similar isotope signature as the regional aquifer, and thus had no signature indicative of lagoon leakage. These isotopic data indicate that the lagoon is affecting wells west of MW2 and confirm that the ground water flow direction in the perched aquifer is northeast to southwest.

The above discussion established that water chemistry in portions of the perched aquifer are at background concentrations and that within the vicinity of Hamilton Road and South 18th Street, a zone of contamination exists. This contaminated perched zone provides evidence for contaminant occurrence in the regional aquifer.

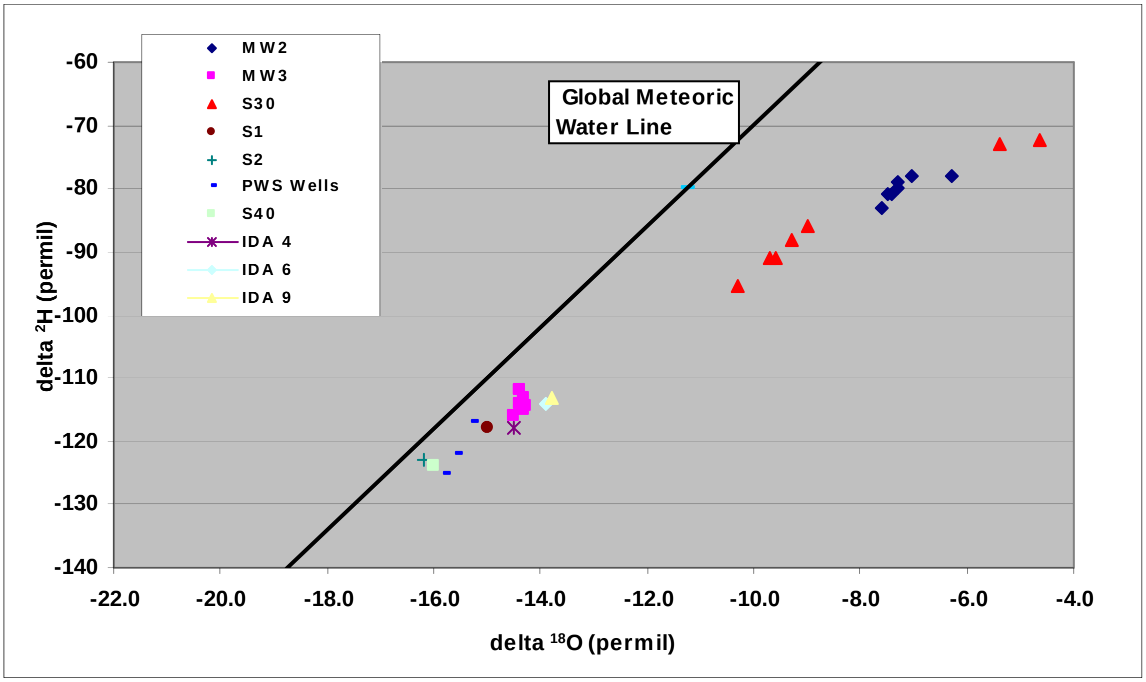

Figure 16. Plot of oxygen versus deuterium values for perched aquifer wells MW-2, MW-3, 4, 6, 9, water from the regional aquifer (S40, wells S1, S2 and PWS wells), and water from the wastewater treatment lagoon (S30).

Regional Aquifer

Nitrate, chloride, and sulfate concentrations are quite variable for wells completed in the regional aquifer, both with geographic location and with time. In the vicinity of Hamilton Road and South 18th Street, some regional wells have consistently had low nitrate, chloride, and sulfate concentrations; some wells initially had low nitrate, chloride, and sulfate concentrations and then underwent rapid concentration increases; and some wells have undergone steady concentration increases in the three constituents over time. Data from wells 1, 2, S14/3, 7, and 45 indicates that within a small area there are large water chemistry variations. Figure 17 shows nitrate, chloride, and sulfate concentrations at wells 1, 2, S14/3, and 7. A plot of nitrate, chloride, and sulfate concentrations for well 45, located adjacent to well 1, is shown in Figure 18. Locations for all wells are shown in Figure 10.

Nitrate, chloride, and sulfate concentrations at well 2 have been stable from 1998 through 2007 and are within the background concentration ranges described above. The perched aquifer probably overlies the regional aquifer at this location. It is reported that the perched aquifer exists at well 1 and may extend south, but the exact boundary is unknown. Nitrate concentrations at well 1 were 7.6 and 8 mg/L for the 1998 and 2002 sample events. Since then, nitrate, chloride and sulfate concentrations have undergone a steady increase; the well owners indicate that the perched aquifer is present at well 1. Well 1 is overlain by the perched aquifer and wells S14/3 and 7 are not. Nitrate, chloride, and sulfate concentrations at wells 3 and 7 were more or less within background ranges from 1998 through 2004 and then underwent rapid increases in all three constituents. The perched aquifer is believed to be absent at these two wells. The southern extent of the alluvial sediments is believed to occur at well S14/3. Nitrate, chloride, and sulfate concentrations at well 45 are significantly different from those at well 1, which is located about 270 feet to the southwest.

Nitrate, chloride, and sulfate concentrations at wells 39, 40, 46, 38, 33, 32, 47, 30, and 802 are at or near background concentrations. Well 31 is bounded on the north and south by these wells. Well 31 is located about 700 feet northeast of well S14/3 as discussed above, and data are available for three sample events from this well. The mean nitrate, chloride, and sulfate concentrations at well 31 are 11, 133, and 255 mg/L, respectively, which are all greater than background concentrations. There appears to be no consistent pattern to the contamination.

Wells 3, 7, and 31 lie on a northeast-southwest line, and all three wells have similar nitrate concentration histories – initial low concentrations followed by rapid concentration increases that stabilize at elevated values. Though wells 3 and 7 are believed to lie south of the perched aquifer, contaminants may be transported to these wells from the perched aquifer via a geological structure such as a fracture, collapse feature, or other structure commonly found in basalts.

There are three wells (wells 42, 43, and 45) north of well 31 that have sample results available from June 2006 through August 2008. A plot of nitrate, chloride, and sulfate concentrations at these wells (Figure 18) and mean concentrations (Table 3) show that all parameters were greater than ambient concentrations. These wells are located in the northwest quarter of T04S R07E S18. IDWR drillers logs show that all domestic wells in this quarter were drilled between July 2004 and May 2006, with the exception of one well drilled in March 1998. All domestic wells in this quarter were completed in the regional aquifer, and the perched aquifer is believed to overlie the regional aquifer at these three wells. Based on the IDWR data, wells 42, 43, and 45 are completed in the regional aquifer.

Table 3. Mean nitrate, chloride, and sulfate concentrations for wells 42, 43, and 45. (Number of samples = 3 except for well 42, where number of samples = 2). All three wells are completed in the regional aquifer.

Well #	Nitrate mg/L	Chloride mg/L	Sulfate mg/L
42	14	47.9	164
43	8.9	34.5	110
45	4.4	23.5	62.9

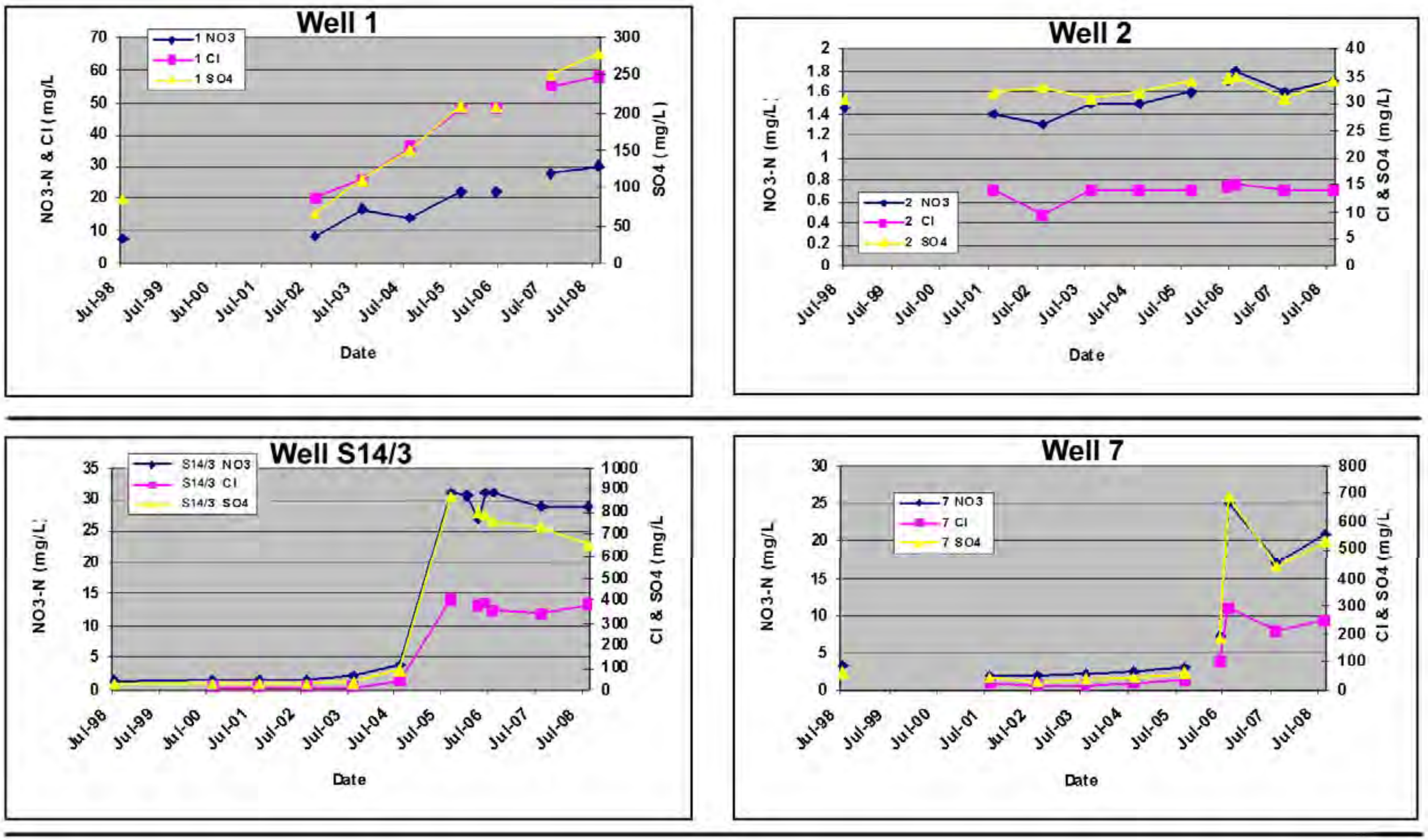

Figure 17. Nitrate, chloride, and sulfate concentration for wells 1, 2, S14/3, and 7 completed in the regional aquifer, near the intersection of Hamilton Road and South 18th Street.

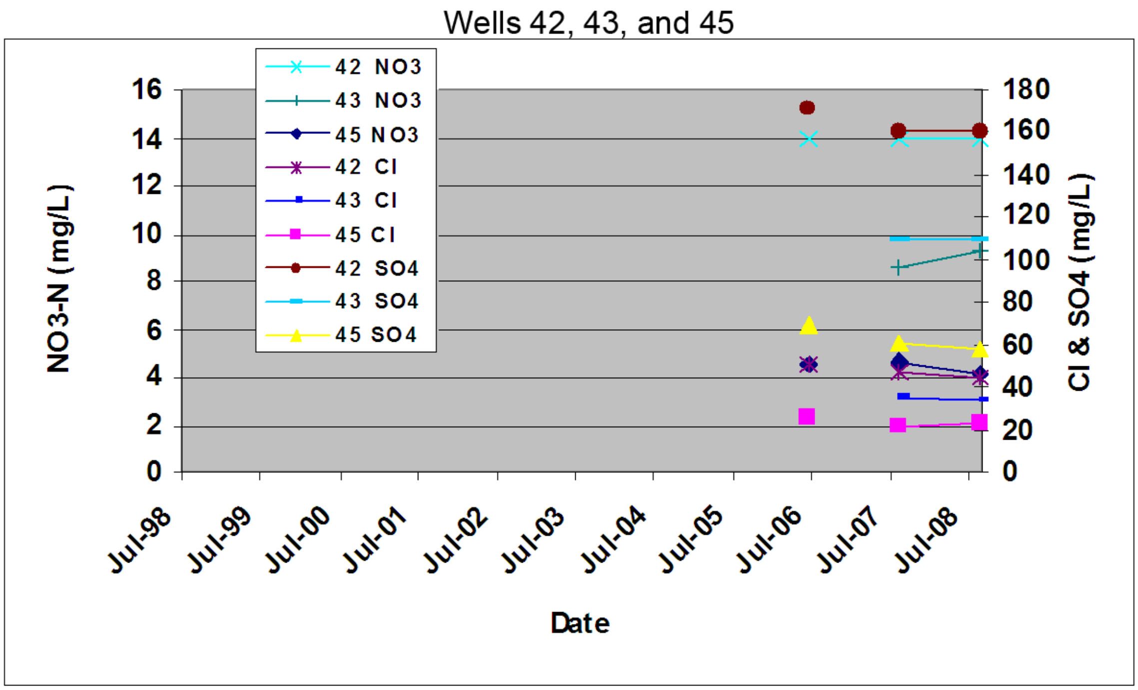

Figure 18. Nitrate, chloride, and sulfate concentrations for wells 42, 43, and 45, completed in the regional aquifer.

Farther to the west, DEQ collected samples from wells S7, S8, S11, S12, S13, and S16. This is the area where DEQ initiated a site-specific study to investigate impacts to ground water around the Mountain Home wastewater treatment facility. Results, listed in Table 8 in Appendix B, show that water chemistry at all these wells was near or at background concentrations for nitrate, chloride, and sulfate.

Overall, there is no consistent pattern to contaminant occurrence in wells completed in the regional aquifer. Some wells initially had background water chemistry concentrations and then underwent rapid changes, other wells have been at background concentrations for all monitoring events, some wells have undergone steadily increasing concentrations, and yet other wells have consistently had mid-range concentrations. Such a wide range in water chemistry at adjacent wells indicates that an area-wide contaminant plume in the regional aquifer does not exist.

Another method to evaluate water chemistry was also considered. A Piper trilinear plot for wells completed in the perched and regional aquifers illustrates the variations in water chemistry that were observed in the study area (Figure 19). Data for this plot, available from IDWR and USGS sources, are listed in Table 10 in Appendix B. Well identification numbers along with sulfate concentrations are shown in Figure 20. Two general water chemistry types were identified based on cation percentages (calcium, magnesium, sodium, and potassium). The wells shown in Figure 20 were completed in both perched and regional aquifers and are included in both Group I and Group II areas, as shown in Figure 20. There is no uniform water chemistry. Group II wells have sulfate concentrations less than and greater than 100 mg/L, and occur along a wide east-west zone. There was no region-wide sulfate occurrence found. The outlying areas have low sulfate concentrations, while the wells in both aquifers in the vicinity of Hamilton Road have high concentrations of sulfate and indicate an anthropogenic source of contamination. These sulfate concentrations can be used to delineate the extent of contamination in the perched aquifer. The plume of contaminated water in the perched aquifer appears to be about ¼ mile wide and runs along Hamilton Road. This inferred contamination zone is outlined in Figure 20.

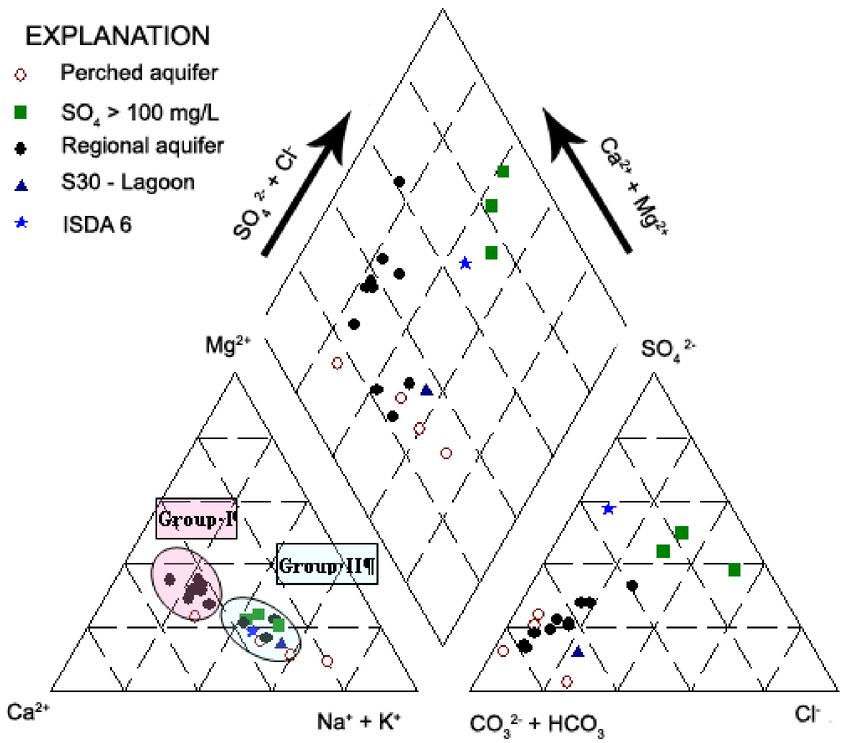

Figure 19. Piper trilinear diagram for wells completed in the perched and regional aquifers, Mountain Home South study area.

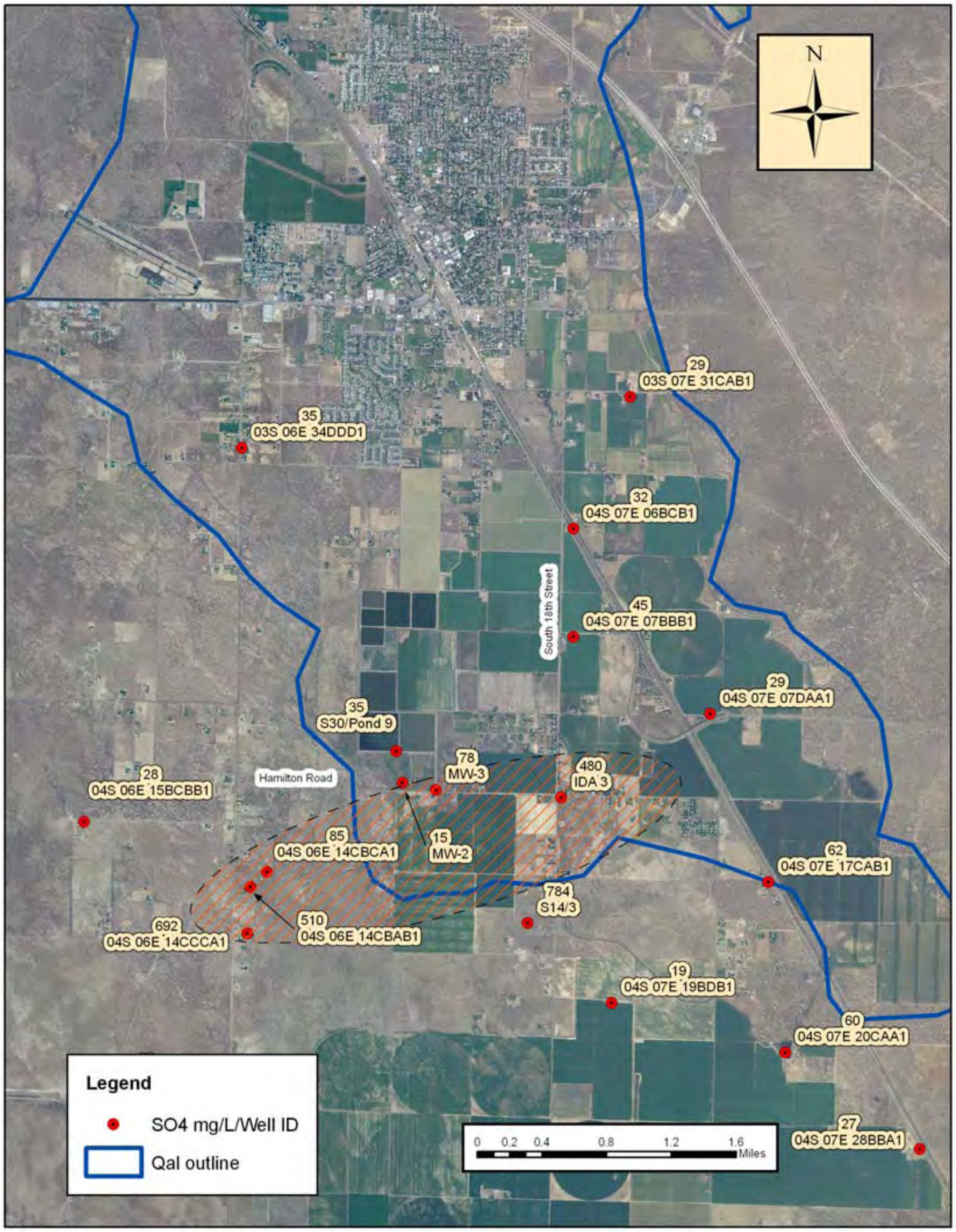

Figure 20. Sulfate concentrations and identification numbers for wells plotted in Piper diagram, Figure 19. Red cross-hatched area outlines inferred contaminated zone in perched aquifer. Blue outline indicates area of Quaternary alluvium (Qal) sediments in study area.

Elevated nitrate, chloride, and sulfate concentrations in regional aquifer wells can be explained by a combination of a contaminated zone in the overlying perched aquifer and leaky casing seals at the alluvium/basalt contact. Regional aquifer wells drilled through the contamination zone are at risk if the surface casing seal is not adequately seated or sealed into the basalt.

To evaluate casing seals and the depth to basalt, drillers' logs for 04S 06E Sections 12 and 13, and 04S 07E Sections 7 and 18 were reviewed for construction details. The alluvium/basalt contact was identified from the drillers' logs, and the length of casing into the basalt was calculated. Histograms showing this information are presented in Figure 21. Twelve wells in 04S 06E Section 13 were completed with the casing seated at the alluvial/basalt contact, as were five wells in 04S 07E Section 7 and six wells in 04S 07E Section 18. In 04S 06E Section 12, all six wells were completed with at least 2 feet of casing into the basalt; the greatest casing length into the basalt was 12 feet. The highest occurrence of contaminated wells occurs in 04S 06E, Section 13, which also had the corresponding highest number of wells with casing terminated at the alluvium/basalt interface. The inferred contaminated zone in the perched aquifer, shown in Figure 20, occurs in the area where contamination also has occurred in regional wells. No wells, perched or regional, located north or south of the perched aquifer contaminated zone are impacted. The casing seals in regional wells outside of this area may or may not be compromised, but if nitrate, chloride, or sulfate concentrations in the overlying perched aquifer are not greater than background concentrations, leakage to the regional aquifer would not be detectable.

A common well construction method in the Mountain Home area is to drill either an 8-inch or 10-inch pilot hole, set a 6-⅝ inch casing, and fill the annular space with bentonite. The well is then completed by drilling though the 6-5/8 inch casing to total depth with an open-hole completion in the basalt. For regional wells where the pilot hole and casing extend a few feet into the basalt, this completion may offer a better casing seal. Wells in which contaminant concentrations are gradually increasing are interpreted to represent a situation where a partial failure has occurred in the casing seal, and thus a small volume of water is leaking into the uncased part of the well. Contaminant increases have not occurred at some regional wells located within the perched aquifer zone of contamination; in some cases, these wells are adjacent to regional wells with elevated contaminant concentrations. This situation is believed to represent the difference between a well with an adequate casing seal and one with a failed casing seal. There appears to be a lag time between well construction and the onset of contamination in some regional wells, so there is no guarantee that the casing seal will remain intact in regional wells drilled through the contaminated zone in the perched aquifer.

Wells drilled along South 18th Street south of Hamilton Road, 04S 06E Section 13, seem to be especially vulnerable to contamination. Regional aquifer wells with effective surface seals (such as wells 2, 802, 10, 39, 45, and 46) are not impacted by contaminated water in the perched aquifer. Some wells have always had concentrations less than 5 mg/L (wells 2, 23, 32, 33, 38, 45, 47), some wells have had gradually increasing nitrate concentrations (wells 18, 19, and 41), and some wells have had low initial concentrations followed by rapid nitrate increases. These trends can all be explained by a casing failure over a contaminated plume in the perched aquifer.

It should be noted that samples were not analyzed for bacteria (*E. coli,* total coliform, fecal coliform) as part of this study. These contaminants could exist in any area of the perched aquifer, given the shallow depth to water and permeable nature of the alluvial sediments. Howarth (1996) documented an area in the northern part of Mountain Home where bacteria were detected in wells completed in both the perched and regional aquifer. One contaminant pathway identified by Howarth was leakage of contaminated water from the perched to the regional aquifer via inadequate well casing completions. The occurrence of elevated nitrate and other constituents in perched and regional aquifer wells indicates that pathogens and other contaminants could be present.

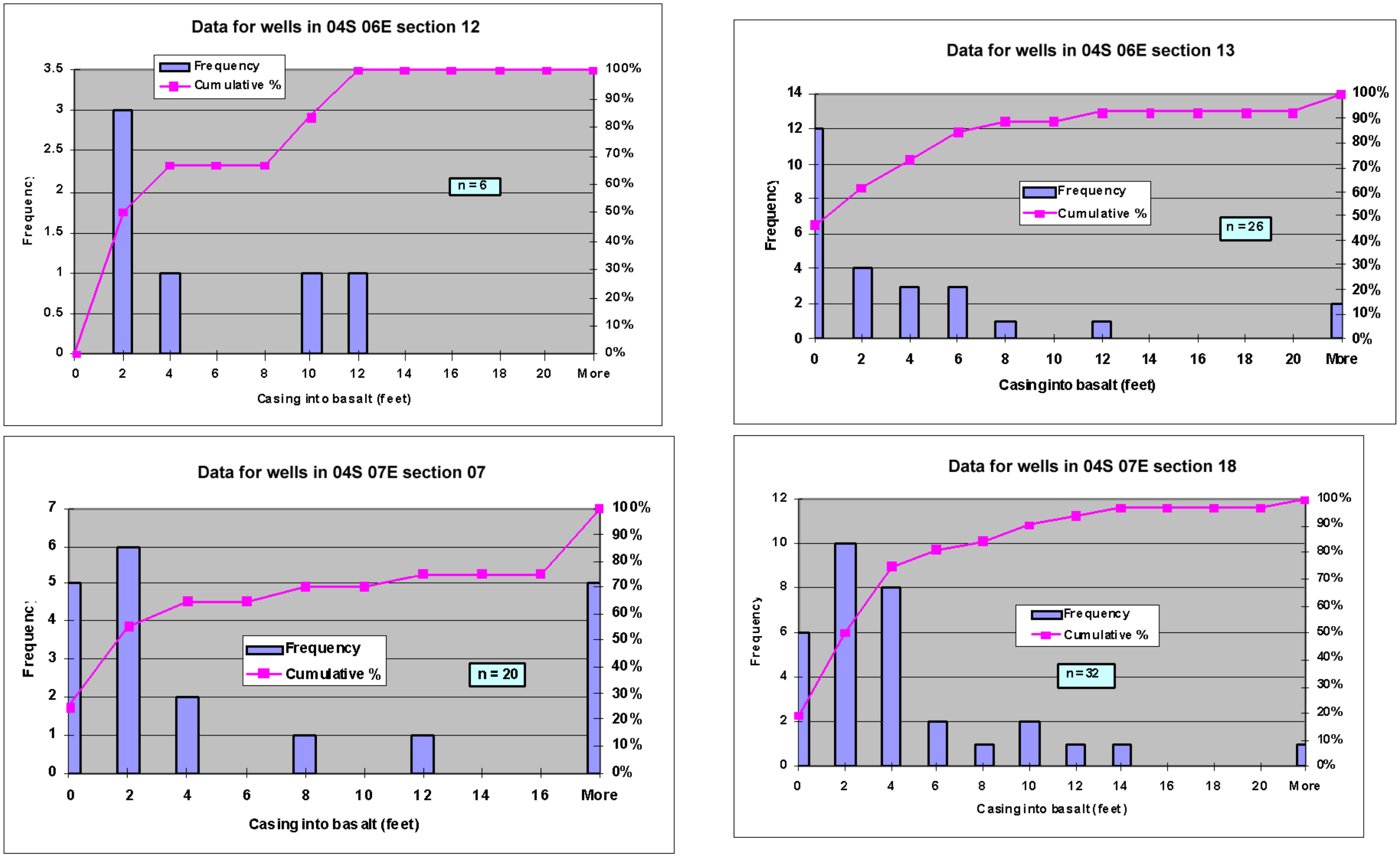

Figure 21. Histogram of depth of casing into basalt for wells in 04S 06E sections 12 and 13, and 04S 07E, sections 7 and 18.

Ground Water Impacts from Wastewater

One purpose of this study was to evaluate ground water impacts from the Mountain Home wastewater treatment system, which includes lagoons and fields where wastewater is applied. Impacts could occur either through lagoon leakage or from deep percolation from treated wastewater applied to fields as irrigation. Treated wastewater is the sole source of irrigation water used for crop production in the reuse fields, and if water is supplied in excess of crop needs, deep percolation below the crop root zone could result. Nitrate and other constituents could be transported with this downward moving water.

Analytical data from lagoon influent, represented by sample S40 (Figure 10 and Table 8 in Appendix B), show that nitrate, chloride, and sulfate concentrations are similar to ambient concentrations for water in both the perched and regional aquifers. The wastewater influent represents a mixture of storm runoff and municipal wastewater that is combined with ground water pumped from the regional aquifer. The regional aquifer is the source of all municipal water for the city. The chemical input from the various waste sources does not result in significant water chemistry changes in the wastewater. The low nitrate, chloride, and sulfate concentrations in the lagoons eliminate the lagoons as the source of elevated nitrate, chloride, and sulfate in the perched aquifer.

The fate of lagoon seepage as it moves through the perched aquifer and subsequently downward to the regional aquifer can be evaluated through the use of ^{18}O and ^{2}H isotope data. DEQ and ISDA collected samples from domestic wells at various dates, and the results are listed in Table 11 in Appendix B and shown graphically in Figure 22. Evaporative processes affect both isotopes in the same manner, so only deuterium values were plotted on Figure 22. A plot of ^{18}O versus ^{2}H for selected wells near the Mountain Home wastewater treatment facility is shown in Figure 23.

Figure 22 shows that deuterium values for most perched and regional aquifer wells fall within the range of -115 to -130 permil, which establishes this water as a ground water end member. Deuterium results for S30, the most downstream and highly evaporated lagoon, are shown in Figure 23. The lagoon isotopic variations reflect summer and winter evaporative conditions; isotope results at MW-2 represent an average of all lagoon isotopic values. The wastewater isotope values can be used as a second end member for the study area.

Isotopic results show that well S14/3 and three wells sampled by DEQ on May 14, 2008 (wells S11, S12, and S16) are impacted by lagoon seepage, because they plot as a mixed water between the two end members (Figure 23). Wells S7, S8, and S13 do not have a lagoon isotopic signature. Seepage data indicate that the lagoons are leaking; however, there are insufficient data to determine the specific ground water flow in this small area and why these wells are not impacted by lagoon seepage.

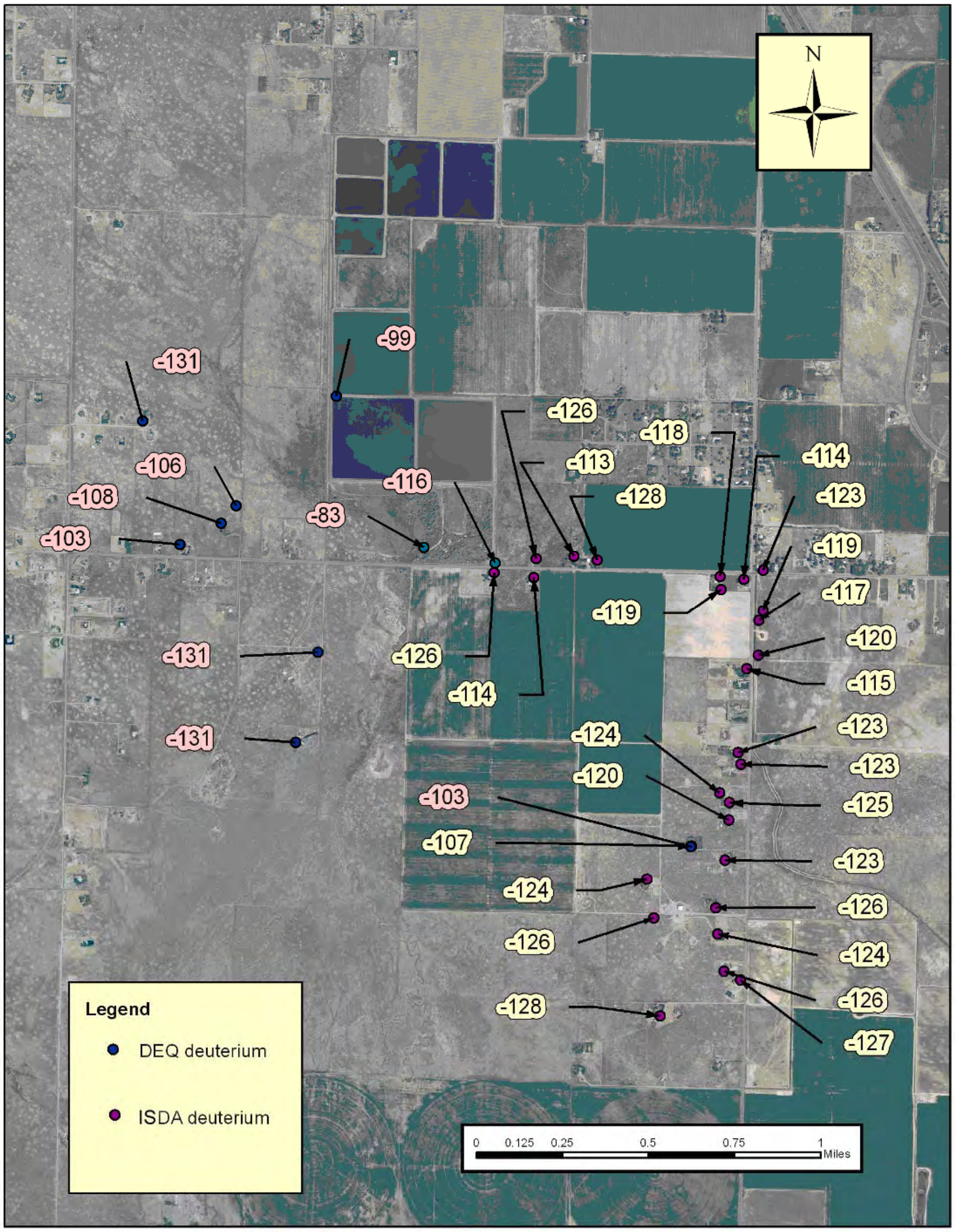

Figure 22. Deuterium results from ISDA and DEQ samples for wells completed in the perched and regional aquifers. Results shown in yellow are from ISDA, and results in pink are from DEQ.

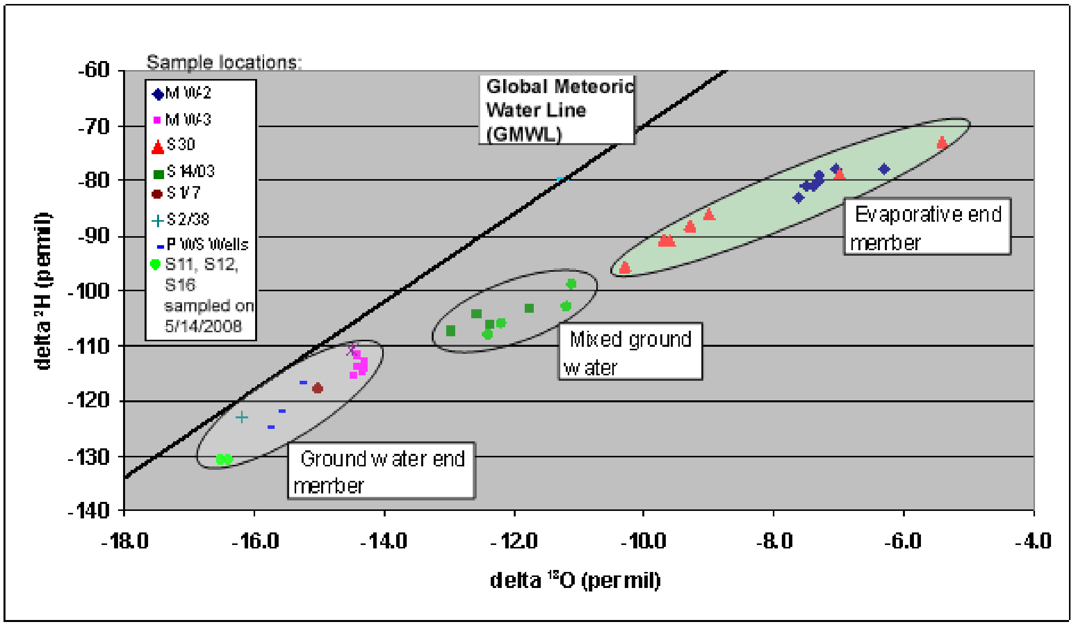

Figure 23. Plot of ^{18}O versus ^{2}H for wells in the Mountain Home South study area.

Well S14/3 is located about one mile southeast and cross-gradient of the lagoon system, yet it produces water that is a mixture of regional ground water and lagoon seepage. One explanation for the impact is as follows: wastewater is applied to fields shown in Figure 10. The field located in the southeastern part of the land application area has shallow soils, ranging from 6 to 18 inches deep. The available water capacity of these thin soils is substantially less than for the fields to the north, where soil depths range from 24 to 60 inches.

An appropriate irrigation application on the northern fields would be too high for the southeastern field. Deep percolation of wastewater applied to the southeastern field may have occurred, and this water could migrate through the fractured basalt to the regional aquifer and to well S14/3.

Soil tests conducted at the end of the 2006 growing season on fields used for wastewater application showed elevated soil nitrate levels. It is believed that the farmer applied supplemental nitrogen in excess of crop requirements and that this nitrogen remained in the soil at the end of the growing season. Residual nitrogen can be transported to the water table by winter precipitation events or by over-irrigation during the following season, resulting in elevated ground water nitrate levels. This could explain elevated nitrate concentrations at well S14/3, although elevated chloride, and sulfate concentrations at this well cannot be explained by deep percolation of wastewater. With this possible exception, lagoon seepage is not the source of elevated nitrate, chloride, and sulfate concentrations in water in either the perched or regional aquifers.

Another graphical evaluation method utilizing oxygen isotope data in combination with chloride and sulfate concentrations is shown in Figure 24.

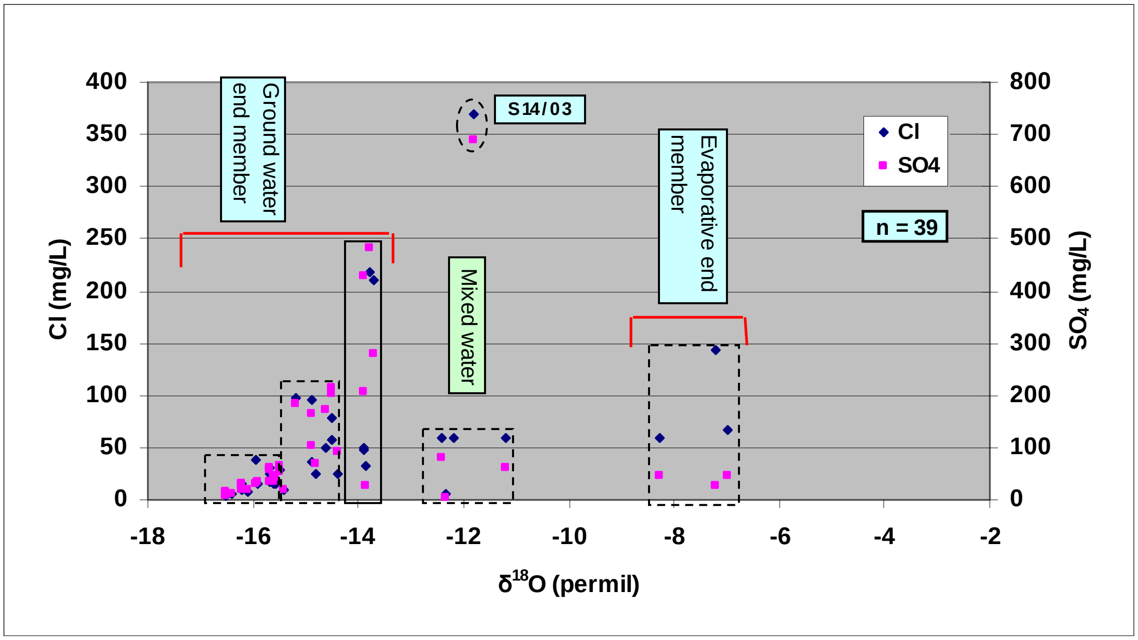

Figure 24. Plot of oxygen isotopes versus chloride and sulfate concentrations, for all ISDA and DEQ sample locations.

As the water becomes more evaporated, the oxygen isotopic values become less negative. In the plot in Figure 24, evaporated water plots to the right, indicating that the water is from a more highly evaporated source. Oxygen isotope values in Figure 24 reflect the two end members and the mixed ground water identified in Figure 23. The addition of chloride and sulfate concentrations to the plot of 18O values (Figure 24) illustrates the relationship between major ions and isotopes. Wells in the ground water end member group with the most negative isotope values also have the lowest chloride and sulfate concentrations, an indication of ambient water quality and no contaminant impacts. Two additional groups of wells in the ground water end member group can be delineated where less negative isotope values correspond to increasing contaminant concentrations. These latter two groups represent wells with varying degrees of leakage from the contaminated zone in the perched aquifer, which is impacting the regional ground water aquifer.

Wells S11 and S16 in the mixed water group are regional aquifer wells located southwest and downgradient of the wastewater treatment lagoons. These wells are impacted by lagoon seepage as indicated by the oxygen isotope but not impacted by perched water contamination, because nitrate and chloride are at background concentrations. Well S12 in the mixed water group appears to be in the intermediate zone between the perched and regional aquifer and is also impacted by lagoon seepage, as indicated by isotope results.

Wells in the evaporated end member group (MW2, S30, and S15) represent sample locations that are wells and lagoons.

Well S14/3 does not fit into any of the three major isotope/major ion groups. The reason for this difference is unknown.

Nitrogen Isotopes

ISDA and DEQ analyzed ground water and lagoon samples for nitrogen isotopes, and the results are shown in Table 4.

Table 4. Nitrogen isotope results from DEQ and ISDA sample locations in the Mountain Home south area.

Site ID	Sample Date	NO_3-N (mg/L)	^{15}N (permil)
MW-2	05/14/2007	0.67	7.7
MW-2	11/14/2007	0.66	7.8
MW-3	11/21/2006	5.09	13.5
MW-3	04/16/2007	5.65	14.2
MW-3	05/14/2007	5.01	14.4
MW-3	11/14/2007	6.31	14.6
S30 (Pond 9)	11/20/2006	10.6	14.6
S30 (Pond 9)	04/16/2007	19.4	10.3
S30 (Pond 9)	05/14/2007	21.9	11.3
S15 (Pond 8)	11/14/2007	22.68	10.6
S40 (Pond 1)	11/14/2007	46.27*	0.9
S14/3	04/16/2007	35.41	4.5
S1	05/14/2007	12.42	4.6
S2	05/14/2007	2.71	7.1
PWS-W	11/20/2006	1.9	8.0
S42 (PWS-N)	11/20/2006	2.4	9.3
PWS-S	11/20/2006	3.3	7.6
1	9/19/2005	22	3.6
2	9/19/2005	1.6	6.17
S14/3	9/14/2005	31	1.26
4	9/19/2005	11	4.25
6	9/14/2005	36	3.41
9	9/19/2005	17	15.94
10	9/14/2005	1.4	9.11
16	9/19/2005	2.7	12.24
18	9/19/2005	6.9	8.85
19	9/19/2005	5.1	4.76

Site ID	Sample Date	NO_3-N (mg/L)	^{15}N (permil)
26	9/19/2005	12	14.1

***** Most nitrogen in S40 was in either the NH_4 or TKN form, which may not have been recovered for nitrogen isotope analysis.

Figure 25 is a histogram showing the distribution of nitrogen isotopes based on the isotopic ranges listed in Table 4. Values were averaged for sites with more than one isotope result, such as MW-2, MW-3, and the wastewater lagoon system.

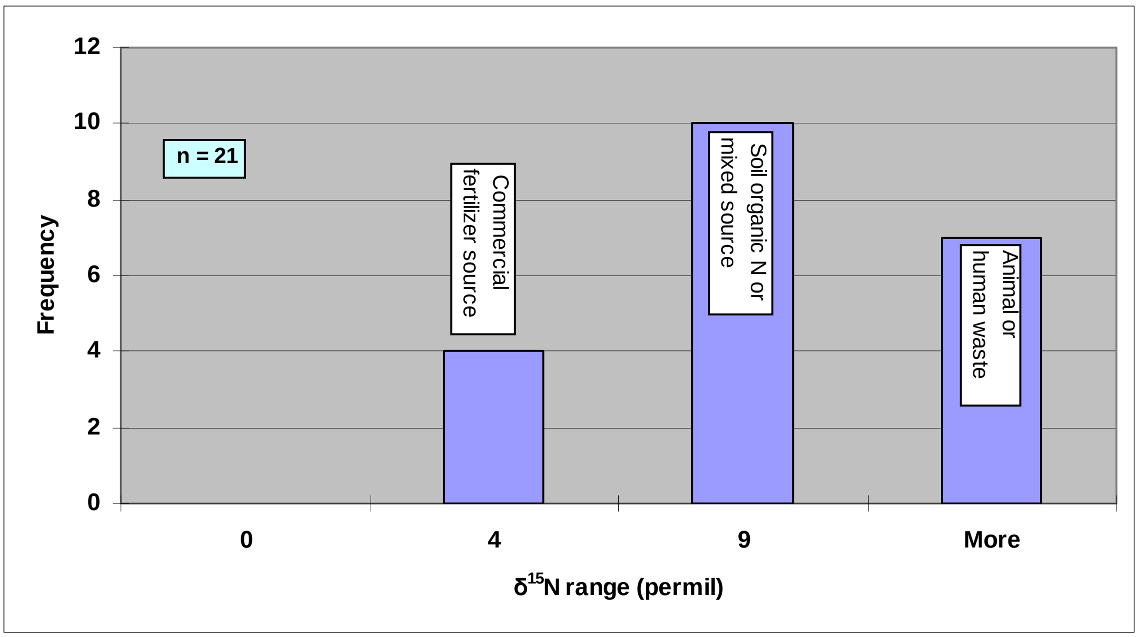

Figure 25. Histogram of $\delta^{15}N$ values for ISDA and DEQ samples.

Four wells fall in the commercial fertilizer source range. The nitrogen isotope signature for wells S14/3, 1, and 6 is within the range of a commercial fertilizer. (Sample S40 also falls in this range, but there may have been problems with nitrogen recovery in this sample because the nitrogen was in either the ammonia or TKN form.) The nitrogen isotope value for municipal wastewater, which contains human waste, should be 9 permil or greater. Well 1, which has a $\delta^{15}N$ value of 3.6 permil, is upgradient of agricultural fields, so it seems unlikely that an agricultural commercial fertilizer source could impact this well. A possible mechanism for nitrogen transport to well S14/3 was described previously.

Seven wells (see Table 4) had nitrogen isotope values greater than 9 permil, and these values are typical of human or animal sources. All homes in the study area are served by individual septic tanks and drain fields, and these treatment systems could be a possible nitrogen source to the perched aquifer. There are insufficient data to determine if drain fields are contributing nitrogen at the concentrations seen in these seven wells.

Ten wells fall in the soil organic nitrogen or mixed source range. Since the nitrogen isotope results for these ten wells show a mixed source, no conclusion can be made regarding the source of nitrogen.

Nitrogen Source Evaluation

Another method to evaluate sources of nitrogen is to prepare scatter plots of nitrate versus chloride concentration for wells sampled. Numerous investigators have documented a positive correlation between nitrate and chloride concentrations in domestic wastewater. A different nitrogen source such as commercial fertilizer could be present if nitrate increases occur without similar chloride increases. Figure 26 presents scatter plots for all ISDA wells where nitrate and chloride data are available. The plots show a positive increase for both nitrate and chloride in wells S14/3, 7, 9, 26, 31, and 39, an indication that these wells are impacted by on-site wastewater treatment systems. Nitrate and chloride concentrations at the remaining wells show a nitrate increase without a corresponding chloride increase, a possible indication of a commercial fertilizer source.

No apparent source could be identified that would account for the elevated nitrate, chloride, and sulfate concentrations in the perched aquifer. There is an irrigation pond located in T04S R07E southeast quarter of section 7. As mentioned previously, gravel pits are commonly found in the alluvial sediments in this area. This pond is believed to have been a former gravel pit that was excavated to the water table and now is used for irrigation supply. Ponds have the potential to be a source of ground water contamination. An evaluation of the land use history of this pond would be useful.

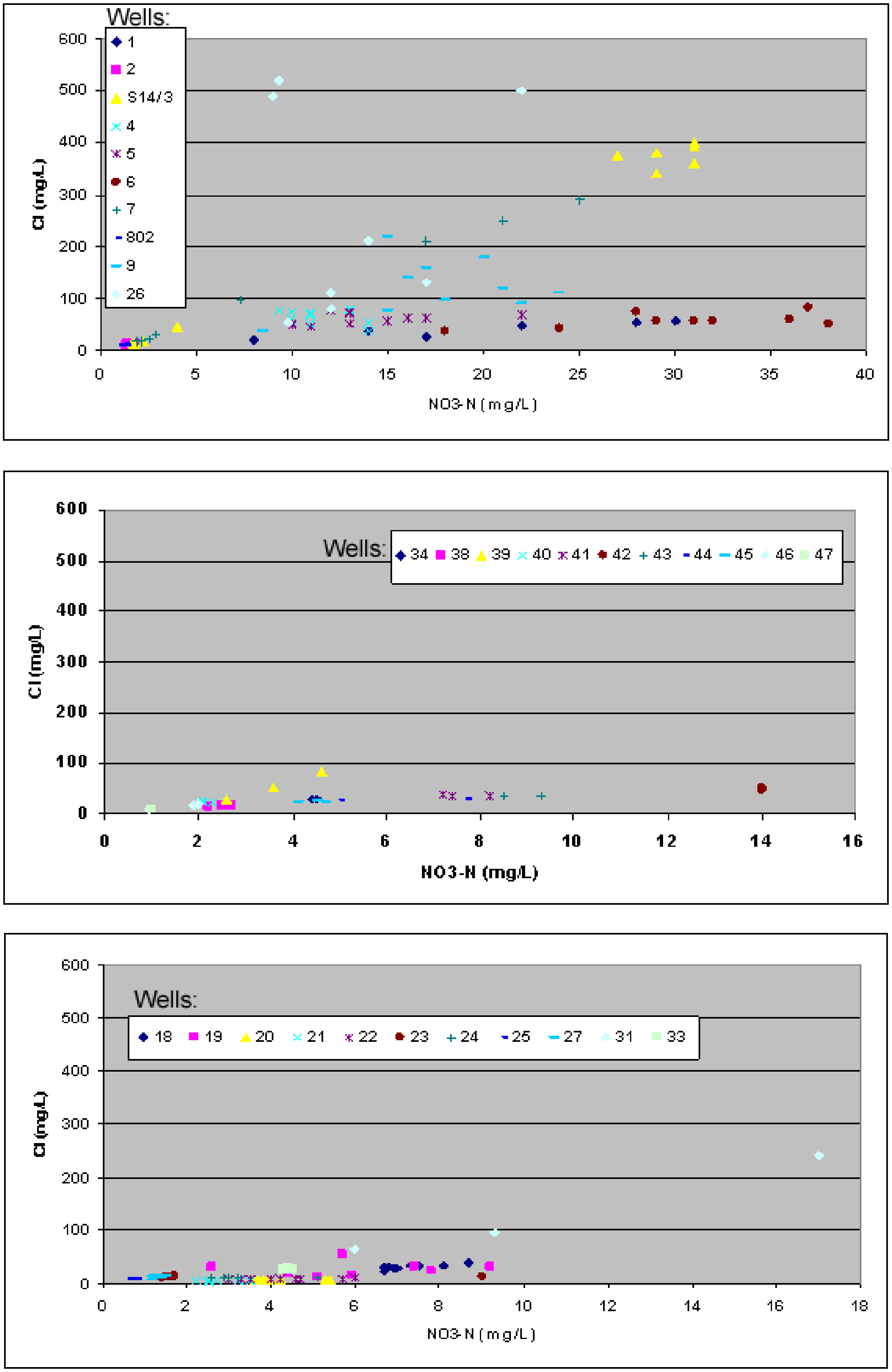

Figure 26. Scatter plots of nitrate versus chloride concentration for wells sampled by ISDA.

Trend Evaluation

Trends are good indicators of water quality changes in the perched and regional aquifers. A table showing constituent concentrations by well is provided in Appendix B. Source identification and evaluation of plume extent are important, but it is also important to determine if contaminant contribution to the shallow perched aquifer is continuing. If a contaminant source has been removed, then contaminant concentrations would be expected to decline as advective transport moves the plume mass beyond monitoring wells. A stable trend at a contaminated well, i.e., no increase or decrease in concentrations, implies that a source or sources is still contributing contaminants to ground water. The trend analysis and concentration ranges indicate that in 20 wells, concentrations of nitrate, sulfate, and chloride have decreased, only slightly increased, or remained relatively constant over time. In six wells, however, nitrate, sulfate, and chloride increased dramatically between 2005 and 2006 to levels greater than federal primary or secondary maximum contaminant levels and have remained elevated.

The Mann-Kendall nonparametric statistical test can be used to evaluate water quality trends over time. This statistical method requires at least four data points for evaluation of trends. The 90% confidence level was selected, and this test was used to assess nitrate trends for wells where at least four samples were collected. (The number of samples collected determines the version of the Mann-Kendall test used for this evaluation.) A spreadsheet adapted from the State of Wisconsin's Department of Natural Resources Remediation and Development Program Form 4400-215 was used for wells that had from four to ten sample results. A version of the Mann-Kendall test offered by the US Geological Survey was used for wells with more than 10 data points. Nitrate concentrations at wells 1, S14/3, and 6 initially were low and then underwent dramatic increases. At these wells, it was obvious that an upward concentration trend existed for the entire data set, so it wasn't necessary to apply statistical methods to the entire data set. The point of interest for this statistical test was to assess the trend of that portion of the data set with elevated concentrations.

Table 5 lists the statistical results for 27 wells, grouped by well location with respect to the impacted area of the perched aquifer. The results show that there is either a stable or increasing trend for all wells within the impacted area outlined in Figure 20. The one exception is well 9, a well in the perched aquifer. The overall trend indicates that there has been no decrease in contaminant concentrations in the impacted area. The Mann-Kendall analysis shows increasing, decreasing, and stable nitrate concentrations for wells located north and south of the impacted area. Wells north and south of the impact area generally have nitrate concentrations in the 1.0 to 6.0 mg/L range, and small changes in concentration could account for the trends identified in Table 5.

Table 5. Mann-Kendall statistical evaluation of nitrate data from ISDA monitoring wells in Mountain Home South study area.

Well ID	Analysis Method	Well Total Depth (ft)	No. of observations (n)	MK statistic (S)	Trend Description	Notes
1	MK short	530	6	12	Increasing	Impact area
2	USGS MK	475	11	16	Increasing	Impact area
3	MK short	463	7	-5	Stable/No trend	Impact area
4	USGS MK	140	13	29	Stable/No trend	Impact area
5	USGS MK	190	12	44	Increasing	Impact area
6	MK short	79	15	2	Stable/No trend	Impact area
9	MK	30	10	-8	Decreasing	Impact area
10	MK		9	21	Increasing	Impact area
18	MK	300	10	34	Increasing	Impact area
19	MK	18	9	21	Increasing	Impact area
23	MK		9	21	Increasing	Impact area
25	MK		10	35	Increasing	Impact area
26	MK		8	-3	Stable/No trend	Impact area
27	MK		9	28	Increasing	Impact area
7	MK	460	10	30	Increasing	S of impact area
802	MK	586	7	-18	Decreasing	S of impact area
11	MK	557	9	25	Increasing	N of impact area
12	MK	89	9	-2	Stable/No trend	N of impact area
13	MK	340	8	14	Increasing	N of impact area
14	MK		9	-10	Decreasing trend at the 80% C.L.; no trend at the 90% C.L.	N of impact area
15	MK	140	9	-19	Decreasing	N of impact area
16	MK		8	-8	Decreasing trend at the 80% C.L.; no trend at the 90% C.L.	N of impact area
17	MK	140	9	15	Increasing	N of impact area
20	MK	500	8	-19	Decreasing	N of impact area
21	MK	85	7	8	Increasing trend at the 80% C.L.; no trend at the 90% C.L.	N of impact area
22	MK	20	9	6	Stable/No trend	N of impact area

MK short = indicates that the beginning low nitrate concentration values were dropped from the data set
USGS MK = US Geological Survey version of Mann-Kendall test.
MK = Mann-Kendall statistical evaluation
C.L. = confidence level

Conclusions

Analysis of data from wells and surface water from 1996 through 2008 indicates an unidentified anthropogenic source of contamination in the perched aquifer in the study area south of Mountain Home. This data supports that inadequate casing seals are the most likely transport mechanism from the perched aquifer to the regional aquifer.

Water chemistry data were evaluated to define a zone or plume of contamination in the perched aquifer that extends east and west of South 18th Street, along Hamilton Road. Impacted conditions in regional aquifer wells can be explained by leaky casing seals at the alluvium/basalt interface, for wells that are drilled through the zone of contamination in the perched aquifer and extend into the regional aquifer. Nitrate, chloride, and sulfate concentrations in several wells in the vicinity of Hamilton Road and South 18th Street have increased dramatically since the mid-1990s and have remained at elevated levels, while concentrations at adjacent wells are at or close to background. Nitrate, chloride, and sulfate concentrations at some wells have undergone slow, steady increases.

The source of the elevated nitrate, chloride, and sulfate was investigated using water chemistry and isotope tools. Historical water chemistry data from wells in the study area were evaluated to determine if elevated sulfate (greater than 100 mg/L) is common in the area. Background nitrate, chloride, and sulfate concentrations were established using water chemistry data from wells north of Hamilton Road. Background nitrate concentrations range from 0.7 to 2.2 mg/L, background chloride concentrations range from 5 to 13.6 mg/L, and background sulfate concentrations range from 11.9 to 35.2 mg/L, based on average concentrations from nine wells. A point source large enough to result in the elevated nitrate, chloride and sulfate concentrations at several wells has not been identified.

Stable isotope results indicate that lagoon seepage is recharging the perched aquifer south and west of the wastewater treatment facility, and that this lagoon seepage has migrated to the intermediate and regional aquifer at some wells. At other regional aquifer wells downgradient of the lagoons, there is no isotopic evidence of perched aquifer leakage.

Oxygen, deuterium, and nitrogen isotope results suggest that deep percolation of treated wastewater effluent applied to fields permitted for wastewater application may be migrating to domestic well S14/3, which is completed in the regional aquifer. This well is located approximately one mile southeast and cross-gradient of the lagoon system, so the direct percolation route of wastewater to the well is not plausible. However, deep percolation from wastewater applied to an adjacent reuse field may have migrated through the vadose zone to the well. This is a possible explanation for the source of oxygen isotope values. If commercial fertilizer applied to this field was carried through fractured zones in the basalt to well S14/3, this would be a possible source of nitrogen to this well. Sulfate and chloride concentrations in the treated wastewater effluent are much lower than concentrations observed in well S14/3, so an unidentified source of chloride and sulfate exists, if this explanation is valid.

Nitrate concentrations in MW-2, located adjacent to the wastewater treatment lagoons, have always been near or at laboratory detection levels. Nitrogen in the wastewater is in the organic form, but it would be expected to oxidize to the inorganic or nitrate form once it enters ground water. Phytoremediation by a grove of Russian olive trees around the monitoring well is the best explanation for the near total removal of nitrogen in this part of the perched aquifer south of the lagoon system. Water in the perched aquifer west of the lagoon system may contain measurable nitrate since there are no trees in this area for phytoremediation.

Overall, the investigation did not identify the source of the dramatically increasing nitrate, chloride, and sulfate concentrations observed at wells S14/3, 7, 9, 26, 31, and 39. The study showed that lagoon seepage water or effluent that is land applied to agricultural fields during the summer months was not the source of the elevated concentrations. A different, unknown contaminant source is indicated.

It is concluded that contamination in the deep regional aquifer is believed to be related to well construction practices. Well construction for most wells in the study area includes a pilot hole drilled to basalt and installation of a surface casing. The annular space is filled with bentonite, and the remainder of the well is completed as an open hole into the basalt. Wells drilled through the perched aquifer into the regional aquifer are at risk of a casing seal failure or leakage due to the head difference between the perched and regional aquifers and the limited casing depth in the basalt. This can create a preferential flow conduit for ground water movement to the regional aquifer. Examination of drillers' logs show that for some wells the casing was terminated at the alluvial/basalt contact, and for many wells, the casing extended only a few feet into the basalt. This investigation supports that inadequate casing seals are the most likely transport mechanism of contaminants from the perched aquifer to the regional aquifer. Even if wells are constructed to the updated IDWR construction standards, there is the potential for contamination to migrate to the regional aquifer through the fractures and joints in the basalt. In this area of fractured basalt, the best protection would be a casing extended to the water table.

It is recommended that an inventory be conducted of potential contaminant sources in the area, including surface water bodies (irrigation canals and holding ponds) in the region. In addition wells with elevated nitrate, chloride, and sulfate concentrations should be resampled to evaluate trends. Bacteria analysis was not conducted as part of this study. If contaminants are migrating from the perched to the regional aquifer via leaky casing seals, pathogens also could be impacting regional aquifer wells. Bacteria sampling should be carried out for candidate wells. Also, a bacteria sampling program should be carried out for all contaminated wells in the study area. The water chemistry data indicate that there is a lag time between when wells were drilled and the onset of contamination, indicating that casing seal failure can occur at some time in the future. Regional aquifer wells that are not currently impacted may become impacted some time in the future. Wells in this area should be completed in accordance with the updated IDWR construction standards. If the saturated alluvium extends beyond 38 feet, then well casings should extend into the basalt.

Recommendation for future work for this area also includes a camera survey for contaminated wells completed in the regional aquifer to check for leakage from the perched to the regional aquifer. A camera survey should reveal if leakage is occurring and is moving down the open-hole portion of a well.

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Appendix A. Well Numbering System

WELL- AND SPRING-NUMBERING SYSTEM

The well- and spring-numbering system (diagram below) used by the U.S. Geological Survey in Idaho indicates the location of wells and springs within the official rectangular subdivision of public lands, with reference to the Boise base line and Meridian. The first two segments of the number designate the township (north or south) and range (east or west). The third segment gives the section number; four letters, which indicate the 1/4 section (160-acre tract), 1/4-1/4 section (40-acre tract), 1/4-1/4-1/4 section (10-acre tract), and 1/4-1/4-1/4-1/4 section (2 1/2-acre tract); and serial number of the well within the tract.

Quarter sections are designated by the letters A, B, C, and D in counterclockwise order from the northeast quarter of each section. Forty-acre, 10-acre, and 2 1/2-acre tracts within each quarter section are lettered in the same manner. Well 4S-3E-23CDD1, for example, is in the SE1/4SE1/4SW1/4 sec. 23, T. 4 S., R. 3 E., and is the first well inventoried in that tract. Springs are designated by the letter "S" following the last numeral; for example, 4S-3E-35DCA1S.

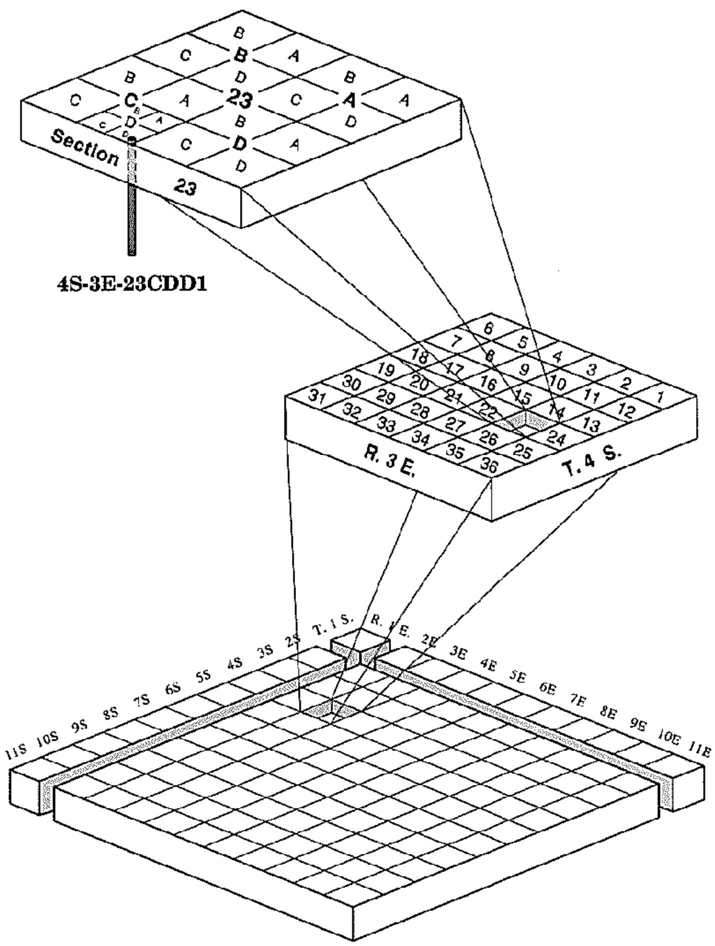

Figure 27. Well- and Spring-Numbering System (Young et al., 1992)

Appendix B. Analytical Results

Table 6. Laboratory data for ISDA Project 810. (NA = not analyzed; ND = non detect; BDL = positive detection but below the quantitation limit; SW = surface water sample. Note that ISDA wells 3, 7, and 38 were also sampled by DEQ and are referred to as wells S14/3, S1/7, and S2/38, respectively, in DEQ results).

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
8100101	1	04S 06E 13ADA	530	7/15/98	7.64	NA	NA	NA	85	NA	ND	NA
8100101	1	04S 06E 13ADA	530	8/21/02	8	ND	BDL	20	66	BDL	0.17	0.27
8100101	1	04S 06E 13ADA	530	8/12/03	17	ND	0.15	26	110	BDL	0.15	0.38
8100101	1	04S 06E 13ADA	530	8/17/04	14	ND	0.14	36	150	BDL	0.48	0.35
8100101	1	04S 06E 13ADA	530	9/19/05	22	ND	0.11	48	210	BDL	0.26	0.39
8100101	1	04S 06E 13ADA	530	6/27/06	22	<0.01	NA	48.3	207	0.038	NA	NA
8100101	1	04S 06E 13ADA	530	8/13/07	28	ND	0.15	55	250	BDL	0.31	0.32
8100101	1	04S 06E 13ADA	530	8/6/08	30	ND	BDL	58	280	BDL	0.37	0.38
8100201	2	04S 06E 13DAD1	475	7/15/98	1.46	NA	NA	NA	30.7	NA	ND	NA
8100201	2	04S 06E 13DAD1	475	8/20/01	1.4	ND	ND	14	32	BDL	BDL	0.18
8100201	2	04S 06E 13DAD1	475	8/19/02	1.3	ND	BDL	9.4	33	BDL	BDL	0.13
8100201	2	04S 06E 13DAD1	475	8/12/03	1.5	ND	ND	14	31	BDL	BDL	0.16
8100201	2	04S 06E 13DAD1	475	8/17/04	1.5	ND	0.11	13	34	BDL	0.13	0.19
8100201	2	04S 06E 13DAD1	475	8/17/04	1.5	ND	ND	14	32	BDL	0.13	0.19
8100201	2	04S 06E 13DAD1	475	9/19/05	1.6	ND	ND	14	34	BDL	0.12	0.2
8100201	2	04S 06E 13DAD1	475	6/27/06	1.7	<0.01	NA	14.7	34.6	<0.005	NA	NA
8100201	2	04S 06E 13DAD1	475	8/23/06	1.8	ND	ND	15	35	BDL	0.12	0.2
8100201	2	04S 06E 13DAD1	475	8/23/07	1.6	ND	BDL	14	31	BDL	BDL	0.19
8100201	2	04S 06E 13DAD1	475	8/6/08	1.7	ND	ND	14	34	BDL	0.12	0.21
8100301	3	04S 06E 13DDB	463	7/15/98	1.51	NA	NA	NA	31	NA	ND	NA
8100301	3	04S 06E 13DDB	463	8/10/00	1.7	ND	ND	13	31	ND	0.16	0.17
8100301	3	04S 06E 13DDB	463	8/16/01	1.6	ND	BDL	13	28	BDL	BDL	0.17
8100301	3	04S 06E 13DDB	463	8/19/02	1.7	ND	BDL	11	31	BDL	BDL	0.13
8100301	3	04S 06E 13DDB	463	8/12/03	2.2	ND	ND	16	34	BDL	0.12	0.15
8100301	3	04S 06E 13DDB	463	8/17/04	4	ND	ND	45	89	BDL	0.41	0.16
8100301	3	04S 06E 13DDB	463	9/14/05	31	ND	BDL	400	870	BDL	2.2	1.2
8100301	3	04S 06E 13DDB	463	1/13/06	30.7	NA	NA	NA	NA	BDL	NA	NA
8100301	3	04S 06E 13DDB	463	4/5/06	27	<0.005	0.105	374	799	0.022	NA	NA
8100301	3	04S 06E 13DDB	463	6/27/06	31	<0.01	NA	391	784	0.007	NA	NA
8100301	3	04S 06E 13DDB	463	8/23/06	31	ND	0.11	360	760	BDL	1.7	0.27
8100301	3	04S 06E 13DDB	463	8/13/07	29	ND	BDL	340	730	BDL	1.5	0.31
8100301	3	04S 06E 13DDB	463	8/6/08	29	ND	ND	380	650	BDL	1.4	0.41
8100401	4	04S 06E 13AAA1	140	7/15/98	8.07	NA	NA	NA	191	NA	ND	NA
8100401	4	04S 06E 13AAA1	140	8/9/00	10	ND	ND	75	220	ND	0.51	0.33
8100401	4	04S 06E 13AAA1	140	8/15/01	11	ND	BDL	69	200	BDL	0.47	0.24
8100401	4	04S 06E 13AAA1	140	8/20/02	10	ND	BDL	59	170	BDL	0.48	0.14
8100401	4	04S 06E 13AAA1	140	8/11/03	11	ND	ND	71	210	BDL	0.47	0.23
8100401	4	04S 06E 13AAA1	140	8/19/04	14	ND	ND	53	200	BDL	0.38	0.29
8100401	4	04S 06E 13AAA1	140	8/19/04	14	ND	0.14	36	150	BDL	0.48	0.35
8100401	4	04S 06E 13AAA1	140	9/19/05	11	ND	ND	52	180	BDL	0.31	0.22
8100401	4	04S 06E 13AAA1	140	6/27/06	13	BDL	NA	78.2	214	<0.005	NA	NA
8100401	4	04S 06E 13AAA1	140	8/24/06	13	ND	ND	81	250	BDL	0.48	BDL
8100401	4	04S 06E 13AAA1	140	10/26/06	13	NA	NA	77.2	241	BDL	NA	NA
8100401	4	04S 06E 13AAA1	140	8/16/07	17	ND	BDL	62	210	BDL	0.41	BDL
8100401	4	04S 06E 13AAA1	140	8/4/08	9.3	ND	BDL	76	210	BDL	0.52	0.2
8100501	5	04S 06E 13AAA2	190	7/15/98	9.2	NA	NA	NA	170	NA	ND	NA
8100501	5	04S 06E 13AAA2	190	8/9/00	10	ND	ND	51	180	ND	0.36	0.24
8100501	5	04S 06E 13AAA2	190	8/15/01	11	ND	BDL	46	170	BDL	0.34	0.24
8100501	5	04S 06E 13AAA2	190	8/20/02	10	ND	ND	49	170	BDL	0.36	0.15
8100501	5	04S 06E 13AAA2	190	8/11/03	13	ND	ND	52	180	BDL	0.33	0.23
8100501	5	04S 06E 13AAA2	190	8/17/04	13	ND	ND	72	230	BDL	0.53	0.25
8100501	5	04S 06E 13AAA2	190	9/19/05	13	ND	ND	74	230	BDL	0.44	0.26
8100501	5	04S 06E 13AAA2	190	6/27/06	15	<0.01	NA	58	202	0.011	NA	NA
8100501	5	04S 06E 13AAA2	190	8/24/06	22	ND	ND	67	270	BDL	0.35	0.23
8100501	5	04S 06E 13AAA2	190	10/26/06	16	NA	NA	61.5	218	BDL	NA	NA
8100501	5	04S 06E 13AAA2	190	8/16/07	12	ND	BDL	76	220	BDL	0.52	BDL
8100501	5	04S 06E 13AAA2	190	8/4/08	17	ND	BDL	63	220	BDL	0.41	0.25

Table 6. Continued

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
OF 90-112	6	04S 06E 13AAA3	79	9/26/89	9.4	NA	NA	120	650	NA	NA	NA
Statewide	6	04S 06E 13AAA3	79	10/7/91	16	NA	NA	109	380	NA	NA	NA
Statewide	6	04S 06E 13AAA3	79	8/8/95	29	NA	NA	110	480	NA	NA	NA
8100601	6	04S 06E 13AAA3	79	2/26/96	34	NA	NA	NA	NA	NA	NA	NA
8100601	6	04S 06E 13AAA3	79	7/15/98	40	NA	NA	NA	577	NA	ND	NA
Statewide	6	04S 06E 13AAA3	79	9/8/99	27.4	NA	NA	66	440	NA	NA	NA
8100601	6	04S 06E 13AAA3	79	8/10/00	28	ND	0.13	74	590	ND	0.54	0.79
8100601	6	04S 06E 13AAA3	79	8/16/01	37	ND	ND	82	720	BDL	0.58	0.87
8100601	6	04S 06E 13AAA3	79	8/20/02	18	ND	0.13	37	320	BDL	0.38	0.46
8100601	6	04S 06E 13AAA3	79	8/11/03	29	ND	0.12	57	620	0.18	0.45	0.51
Statewide	6	04S 06E 13AAA3	79	7/14/04	28.8	NA	NA	55.4	480	NA	NA	NA
8100601	6	04S 06E 13AAA3	79	8/19/04	32	ND	0.15	58	510	BDL	0.41	0.52
8100601	6	04S 06E 13AAA3	79	9/14/05	36	ND	0.12	61	480	BDL	0.34	0.69
8100601	6	04S 06E 13AAA3	79	6/27/06	38	<0.01	NA	50.5	429	<0.005	NA	NA
8100601	6	04S 06E 13AAA3	79	8/24/06	24	ND	NA	44	NA	BDL	0.25	0.4
8100601	6	04S 06E 13AAA3	79	8/16/07	29	ND	0.1	57	430	BDL	0.46	0.22
8100601	6	04S 06E 13AAA3	79	8/6/08	31	ND	0.11	56	470	BDL	0.34	0.56
8100701	7	04S 06E 13DCD	460	7/15/98	3.33	NA	NA	NA	58.7	NA	ND	NA
8100701	7	04S 06E 13DCD	460	8/16/01	1.9	ND	ND	21	43	BDL	0.16	0.15
8100701	7	04S 06E 13DCD	460	8/20/02	1.9	ND	BDL	16	29	BDL	0.16	0.11
8100701	7	04S 06E 13DCD	460	8/11/03	2.1	ND	ND	18	36	BDL	0.14	0.16
8100701	7	04S 06E 13DCD	460	8/17/04	2.5	ND	ND	24	44	BDL	0.19	0.17
8100701	7	04S 06E 13DCD	460	9/19/05	2.9	ND	ND	31	58	BDL	0.2	BDL
8100701	7	04S 06E 13DCD	460	6/27/06	7.3	<0.01	NA	97	184	<0.005	NA	NA
8100701	7	04S 06E 13DCD	460	8/23/06	25	ND	ND	290	690	BDL	1.2	0.3
8100701	7	04S 06E 13DCD	460	8/13/07	17	ND	BDL	210	440	NA	1.1	0.27
8100701	7	04S 06E 13DCD	460	8/6/08	21	ND	ND	250	530	BDL	1	0.25
8100801	8		480	8/8/00	4.1	ND	0.33	25	52	ND	0.25	ND
8100801	8		480	8/16/01	4.1	ND	BDL	23	46	BDL	0.21	0.12
8100801	8		480	8/20/02	4	ND	ND	17	33	BDL	0.18	BDL
8100802	802	04S 06E 24ADB	586	9/16/03	1.3	ND	ND	10	21	BDL	BDL	0.6
8100802	802	04S 06E 24ADB	586	8/17/04	1.3	ND	ND	9.8	21	BDL	0.1	0.53
8100802	802	04S 06E 24ADB	586	9/14/05	1.2	ND	ND	9.4	21	BDL	BDL	0.56
8100802	802	04S 06E 24ADB	586	6/27/06	1.1	<0.01	NA	9.08	19.4	0.005	NA	NA
8100802	802	04S 06E 24ADB	586	8/23/06	1.1	ND	ND	8.8	18	BDL	BDL	0.49
8100802	802	04S 06E 24ADB	586	8/13/07	1	ND	BDL	9	18	BDL	BDL	0.54
8100802	802	04S 06E 24ADB	586	8/7/08	1	ND	ND	8.7	18	BDL	BDL	0.53
8100901	9	04S 06E 12CDD	30	8/8/00	24	ND	0.15	110	340	ND	0.61	0.83
8100901	9	04S 06E 12CDD	30	8/20/01	22	ND	0.18	92	330	BDL	0.5	0.57
8100901	9	04S 06E 12CDD	30	8/20/02	8.4	ND	BDL	38	130	BDL	0.49	0.5
8100901	9	04S 06E 12CDD	30	8/11/03	15	ND	0.14	78	280	BDL	0.4	0.63
8100901	9	04S 06E 12CDD	30	8/18/04	21	ND	0.17	120	370	BDL	0.61	0.54
8100901	9	04S 06E 12CDD	30	9/19/05	17	ND	0.18	160	510	BDL	0.82	0.89
8100901	9	04S 06E 12CDD	30	6/27/06	15	0.11	NA	219	484	0.019	NA	NA
8100901	9	04S 06E 12CDD	30	8/24/06	20	ND	0.18	180	430	BDL	0.73	0.73
8100901	9	04S 06E 12CDD	30	8/16/07	16	ND	0.2	140	390	BDL	0.67	0.55
8100901	9	04S 06E 12CDD	30	8/5/08	18	ND	0.21	98	410	BDL	0.46	0.7
8101001	10	04S 06E 11CDC	Unk	8/8/00	1	ND	0.3	49	46	ND	0.26	0.35
8101001	10	04S 06E 11CDC	Unk	8/16/01	0.65	ND	0.23	46	39	BDL	0.2	0.31
8101001	10	04S 06E 11CDC	Unk	8/21/02	0.98	ND	0.18	43	34	BDL	0.2	0.25
8101001	10	04S 06E 11CDC	Unk	8/11/03	0.96	ND	BDL	30	27	BDL	0.12	0.17
8101001	10	04S 06E 11CDC	Unk	8/18/04	1.1	ND	0.12	34	30	BDL	0.2	0.2
8101001	10	04S 06E 11CDC	Unk	9/14/05	1.4	ND	0.12	38	33	BDL	0.14	0.23
8101001	10	04S 06E 11CDC	Unk	8/23/06	1.7	ND	0.15	38	39	BDL	0.17	0.18
8101001	10	04S 06E 11CDC	Unk	8/7/08	1.2	ND	ND	29	34	BDL	0.16	0.17

Table 6. Continued.

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
8101101	11	03S 07E 3131CBC1	557	8/9/00	1.9	ND	ND	4.7	11	ND	ND	ND
8101101	11	03S 07E 3131CBC1	557	8/20/01	1.9	ND	ND	4.5	11	BDL	ND	0.1
8101101	11	03S 07E 3131CBC1	557	8/19/02	2	ND	ND	4.7	11	BDL	BDL	BDL
8101101	11	03S 07E 3131CBC1	557	8/12/03	2.3	ND	ND	4.9	12	BDL	ND	BDL
8101101	11	03S 07E 3131CBC1	557	8/18/04	2.5	ND	ND	4.9	13	BDL	ND	BDL
8101101	11	03S 07E 3131CBC1	557	9/19/05	2.3	ND	ND	5	12	BDL	ND	BDL
8101101	11	03S 07E 3131CBC1	557	8/18/06	2.1	ND	ND	5.1	11	BDL	ND	BDL
8101101	11	03S 07E 3131CBC1	557	8/30/07	2.5	ND	BDL	5.2	13	BDL	ND	BDL
8101101	11	03S 07E 3131CBC1	557	8/4/08	2.6	ND	BDL	5.6	13	BDL	ND	BDL
8101201	12	03S 07E 31CBC2	89	8/9/00	4.1	ND	0.25	8.1	14	ND	ND	0.18
8101201	12	03S 07E 31CBC2	89	8/20/01	4.9	ND	0.24	9.7	21	BDL	ND	0.2
8101201	12	03S 07E 31CBC2	89	8/19/02	5.2	ND	0.22	10	14	BDL	BDL	0.16
8101201	12	03S 07E 31CBC2	89	8/12/03	2.8	ND	0.21	5.2	11	BDL	ND	0.2
8101201	12	03S 07E 31CBC2	89	8/18/04	3.7	ND	0.3	8	14	BDL	ND	0.21
8101201	12	03S 07E 31CBC2	89	9/20/05	2.5	ND	0.27	5.7	12	BDL	ND	0.2
8101201	12	03S 07E 31CBC2	89	8/28/06	4.8	ND	0.27	8.7	12	BDL	ND	0.17
8101201	12	03S 07E 31CBC2	89	8/30/07	4.3	ND	0.3	9.4	11	BDL	ND	0.18
8101201	12	03S 07E 31CBC2	89	8/4/08	4.7	ND	0.28	10	13	BDL	ND	0.2
8101301	13	04S 07E 27ABB	340	8/9/00	0.93	ND	0.18	17	100	ND	0.16	0.46
8101301	13	04S 07E 27ABB	340	8/16/01	2.7	ND	0.19	12	67	BDL	BDL	0.46
8101301	13	04S 07E 27ABB	340	8/19/02	1.8	ND	0.16	10	47	BDL	BDL	0.4
8101301	13	04S 07E 27ABB	340	8/12/03	1.8	ND	0.14	8.7	56	BDL	BDL	0.41
8101301	13	04S 07E 27ABB	340	8/18/04	3.7	ND	ND	32	130	NA	0.21	0.17
8101301	13	04S 07E 27ABB	340	9/14/05	2.4	ND	0.15	9.8	60	BDL	BDL	0.39
8101301	13	04S 07E 27ABB	340	8/28/06	4.1	ND	0.13	19	79	BDL	0.15	0.4
8101301	13	04S 07E 27ABB	340	8/23/07	2.7	ND	0.16	11	60	BDL	BDL	0.33
8101401	14	04S 07E 06DCC	Unk	8/9/00	3.9	ND	ND	38	150	ND	0.3	0.26
8101401	14	04S 07E 06DCC	Unk	8/16/01	3.7	ND	ND	35	140	BDL	0.22	0.23
8101401	14	04S 07E 06DCC	Unk	8/19/02	3.5	ND	BDL	27	100	BDL	0.22	0.11
8101401	14	04S 07E 06DCC	Unk	8/12/03	3.7	ND	ND	32	130	BDL	0.21	0.16
8101401	14	04S 07E 06DCC	Unk	8/18/04	1.3	ND	0.2	8	59	BDL	BDL	0.39
8101401	14	04S 07E 06DCC	Unk	9/14/05	4.4	ND	ND	36	130	BDL	0.21	0.19
8101401	14	04S 07E 06DCC	Unk	8/28/06	3.2	ND	ND	25	100	BDL	0.16	0.2
8101401	14	04S 07E 06DCC	Unk	8/23/07	3.5	ND	BDL	25	110	BDL	0.15	0.21
8101401	14	04S 07E 06DCC	Unk	8/5/08	3.5	ND	ND	24	110	BDL	0.15	0.18
8101501	15	03S 06E 36CBD	140	8/9/00	2.2	ND	0.14	9.3	15	ND	ND	0.3
8101501	15	03S 06E 36CBD	140	8/16/01	3.2	ND	BDL	11	20	0.11	ND	0.32
8101501	15	03S 06E 36CBD	140	8/2/02	1.6	ND	ND	6	9.9	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	8/13/03	1.5	ND	ND	5.5	9.8	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	8/19/04	1.6	ND	ND	5.8	11	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	9/19/05	1.5	ND	ND	5.9	10	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	8/28/06	1.6	ND	ND	6.1	11	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	8/23/07	1.5	ND	ND	6.3	11	BDL	ND	BDL
8101501	15	03S 06E 36CBD	140	8/5/08	1.5	ND	ND	5.8	10	BDL	ND	BDL
8101601	16	04S 07E 06CCC	Unk	8/10/00	2.3	ND	0.24	14	44	ND	ND	0.43
8101601	16	04S 07E 06CCC	Unk	8/21/02	3.1	ND	0.16	8.9	31	BDL	BDL	0.28
8101601	16	04S 07E 06CCC	Unk	8/13/03	1.8	ND	0.22	9.5	38	BDL	BDL	0.37
8101601	16	04S 07E 06CCC	Unk	8/18/04	5.8	ND	0.36	22	89	NA	BDL	0.27
8101601	16	04S 07E 06CCC	Unk	9/19/05	2.7	ND	0.27	6.1	18	0.13	ND	0.43
8101601	16	04S 07E 06CCC	Unk	8/24/06	3.7	ND	0.24	9.3	46	BDL	BDL	0.25
8101601	16	04S 07E 06CCC	Unk	8/30/07	1.2	ND	0.24	6.7	27	BDL	ND	0.39
8101601	16	04S 07E 06CCC	Unk	8/5/08	1.1	ND	0.26	5.6	23	BDL	ND	0.35
8101701	17	04S 06E 01ABA	140	8/10/00	4.2	ND	0.11	&.90	15	BDL	ND	0.16
8101701	17	04S 06E 01ABA	140	8/20/01	3.9	ND	0.24	7.9	18	BDL	ND	0.19

Table 6. Continued.

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
8101701	17	04S 06E 01ABA	140	8/21/02	3.8	ND	0.14	7.7	14	BDL	ND	0.13
8101701	17	04S 06E 01ABA	140	8/12/03	3.8	ND	0.2	8.1	15	BDL	ND	0.18
8101701	17	04S 06E 01ABA	140	8/19/04	4	ND	0.24	8.6	15	BDL	ND	0.2
8101701	17	04S 06E 01ABA	140	9/14/05	4	ND	0.21	8.6	16	BDL	ND	0.22
8101701	17	04S 06E 01ABA	140	8/28/06	5.9	ND	0.23	9.4	14	BDL	ND	0.16
8101701	17	04S 06E 01ABA	140	8/23/07	5.9	ND	0.24	9.9	14	BDL	ND	0.19
8101701	17	04S 06E 01ABA	140	8/4/08	4.7	ND	0.25	8.8	15	BDL	ND	0.2
8101801	18	04S 07E 07CCC1	300	8/7/00	6.8	ND	ND	30	83	ND	0.23	ND
8101801	18	04S 07E 07CCC1	300	8/15/01	6.7	ND	BDL	31	86	BDL	0.22	0.14
8101801	18	04S 07E 07CCC1	300	8/20/02	6.7	ND	BDL	24	68	BDL	0.2	0.1
8101801	18	04S 07E 07CCC1	300	8/11/03	6.7	ND	ND	29	86	BDL	0.19	BDL
8101801	18	04S 07E 07CCC1	300	8/17/04	7	ND	ND	28	85	BDL	0.23	0.16
8101801	18	04S 07E 07CCC1	300	9/19/05	6.9	ND	ND	29	79	BDL	0.19	BDL
8101801	18	04S 07E 07CCC1	300	6/27/06	7.3	<0.01	NA	33.6	89.8	<0.005	NA	NA
8101801	18	04S 07E 07CCC1	300	8/24/06	7.5	ND	ND	34	91	BDL	0.2	BDL
8101801	18	04S 07E 07CCC1	300	8/16/07	8.1	ND	BDL	34	100	BDL	0.21	BDL
8101801	18	04S 07E 07CCC1	300	8/4/08	8.7	ND	BDL	38	110	BDL	0.25	BDL
8101901	19	04S 07E 07CCC2	18	8/7/00	2.6	ND	0.33	32	210	ND	0.18	0.56
8101901	19	04S 07E 07CCC2	18	8/15/01	4.4	ND	0.22	17	140	BDL	BDL	0.48
8101901	19	04S 07E 07CCC2	18	8/11/03	5.9	ND	0.3	16	100	BDL	BDL	0.47
8101901	19	04S 07E 07CCC2	18	8/17/04	7.8	ND	0.34	22	110	BDL	0.12	0.45
8101901	19	04S 07E 07CCC2	18	9/19/05	5.1	ND	0.34	12	80	BDL	BDL	0.48
8101901	19	04S 07E 07CCC2	18	6/27/06	7.4	0.01	NA	34.4	145	0.012	NA	NA
8101901	19	04S 07E 07CCC2	18	8/24/06	5.7	ND	0.28	55	190	BDL	0.16	0.34
8101901	19	04S 07E 07CCC2	18	8/16/07	7.4	ND	0.3	31	130	BDL	0.17	0.38
8101901	19	04S 07E 07CCC2	18	8/4/08	9.2	ND	0.27	30	130	BDL	0.16	0.38
8102001	20	03S 07E 31CBA	500	8/16/01	5.3	ND	ND	8.4	36	BDL	BDL	BDL
8102001	20	03S 07E 31CBA	500	8/21/02	5.4	ND	BDL	7.9	34	BDL	BDL	BDL
8102001	20	03S 07E 31CBA	500	9/16/03	3.9	ND	0.13	7.7	26	BDL	BDL	BDL
8102001	20	03S 07E 31CBA	500	8/17/04	3.8	ND	ND	8.1	27	BDL	BDL	BDL
8102001	20	03S 07E 31CBA	500	9/14/05	4.2	ND	ND	8.2	25	BDL	BDL	BDL
8102001	20	03S 07E 31CBA	500	8/28/06	3.7	ND	ND	7.9	24	BDL	0.1	BDL
8102001	20	03S 07E 31CBA	500	8/23/07	3.8	ND	BDL	7.8	25	BDL	ND	BDL
8102001	20	03S 07E 31CBA	500	8/4/08	3.6	ND	BDL	8	24	BDL	BDL	BDL
8102101	21	03S 07E 31BDD	85	8/16/01	2.7	ND	0.14	4.2	20	BDL	ND	0.18
8102101	21	03S 07E 31BDD	85	8/13/03	2.2	ND	0.21	5.5	15	BDL	ND	0.23
8102101	21	03S 07E 31BDD	85	8/19/04	2.5	ND	0.25	5	14	BDL	ND	0.2
8102101	21	03S 07E 31BDD	85	9/14/05	4.2	ND	ND	8.2	25	BDL	BDL	BDL
8102101	21	03S 07E 31BDD	85	8/28/06	2.5	ND	0.24	2.9	14	BDL	ND	0.15
8102101	21	03S 07E 31BDD	85	8/23/07	3.2	ND	0.23	4.4	12	BDL	ND	0.18
8102101	21	03S 07E 31BDD	85	8/4/08	3.5	ND	0.24	5.4	14	BDL	ND	0.18
8102201	22	04S 06E 07CCB	20	8/16/01	4.2	ND	0.15	7.8	40	BDL	ND	0.27
8102201	22	04S 06E 07CCB	20	8/20/02	3.3	ND	0.23	6.7	33	BDL	ND	0.26
8102201	22	04S 06E 07CCB	20	8/12/03	4.6	ND	0.28	8.4	33	BDL	ND	0.25
8102201	22	04S 06E 07CCB	20	8/18/04	3	ND	0.37	8.8	38	BDL	ND	0.29
8102201	22	04S 06E 07CCB	20	9/19/05	4	ND	0.32	7.3	32	BDL	ND	0.27
8102201	22	04S 06E 07CCB	20	6/27/06	6	<0.01	NA	9.45	45.2	0.011	NA	NA
8102201	22	04S 06E 07CCB	20	8/24/06	5.7	ND	0.27	8.8	43	BDL	BDL	0.2
8102201	22	04S 06E 07CCB	20	8/30/07	4.7	ND	0.27	7.8	44	BDL	ND	0.28
8102201	22	04S 06E 07CCB	20	8/4/08	3.5	ND	0.29	6.7	39	BDL	ND	0.32
8102301	23	04S 06E 12CDC	Unk	8/16/01	1.5	ND	BDL	14	33	BDL	BDL	0.11
8102301	23	04S 06E 12CDC	Unk	8/20/02	1.4	ND	ND	11	32	BDL	BDL	BDL
8102301	23	04S 06E 12CDC	Unk	8/11/03	1.6	ND	ND	13	33	BDL	0.11	BDL
8102301	23	04S 06E 12CDC	Unk	8/18/04	1.7	ND	ND	14	36	NA	0.11	BDL

Table 6. Continued.

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
8102301	23	04S 06E 12CDC	Unk	9/19/2005	1.6	ND	ND	14	33	BDL	0.12	BDL
8102301	23	04S 06E 12CDC	Unk	6/27/2006	1.7	<0.01	NA	14.6	36.1	0.019	NA	NA
8102301	23	04S 06E 12CDC	Unk	8/23/2006	1.7	ND	ND	14	36	BDL	0.14	BDL
8102301	23	04S 06E 12CDC	Unk	8/16/2007	1.7	ND	BDL	14	34	BDL	0.11	BDL
8102301	23	04S 06E 12CDC	Unk	8/7/2008	1.7	ND	ND	14	36	BDL	0.13	BDL
8102401	24	03S 07E 31CCD	25	8/16/2001	5.1	ND	0.18	11	19	BDL	ND	0.34
8102401	24	03S 07E 31CCD	25	8/19/2002	2.6	ND	ND	9.6	22	BDL	BDL	BDL
8102401	24	03S 07E 31CCD	25	8/12/2003	2.9	ND	ND	9.4	23	BDL	BDL	BDL
8102401	24	03S 07E 31CCD	25	8/18/2004	3	ND	ND	9.7	26	BDL	BDL	BDL
8102401	24	03S 07E 31CCD	25	9/14/2005	3.2	ND	ND	10	25	BDL	BDL	BDL
8102401	24	03S 07E 31CCD	25	8/28/2006	2.9	ND	ND	9.9	26	BDL	0.1	BDL
8102401	24	03S 07E 31CCD	25	8/30/2007	2.9	ND	ND	9.7	25	BDL	BDL	BDL
8102401	24	03S 07E 31CCD	25	8/4/2008	3	ND	ND	9.8	25	BDL	BDL	BDL
8102501	25	04S 06E 12DCC	Unk	8/20/2001	0.66	ND	ND	7.5	16	BDL	ND	0.14
8102501	25	04S 06E 12DCC	Unk	8/20/2002	0.6	ND	ND	7.5	16	BDL	BDL	0.11
8102501	25	04S 06E 12DCC	Unk	8/11/2003	0.7	ND	ND	7.6	17	BDL	BDL	BDL
8102501	25	04S 06E 12DCC	Unk	8/19/2004	0.74	ND	ND	7.6	17	BDL	0.1	BDL
8102501	25	04S 06E 12DCC	Unk	8/19/2004	0.76	ND	ND	7.6	17	BDL	ND	BDL
8102501	25	04S 06E 12DCC	Unk	9/19/2005	0.7	ND	ND	7.7	17	BDL	ND	BDL
8102501	25	04S 06E 12DCC	Unk	6/27/2006	0.78	<0.01	NA	8.18	18.4	0.031	NA	NA
8102501	25	04S 06E 12DCC	Unk	8/24/2006	0.8	ND	ND	8.5	19	BDL	ND	BDL
8102501	25	04S 06E 12DCC	Unk	8/16/2007	0.83	ND	BDL	8.9	19	BDL	ND	BDL
8102501	25	04S 06E 12DCC	Unk	8/7/2008	0.83	ND	ND	8.6	19	BDL	BDL	BDL
8102601	26	04S 06E 13BAA	Unk	8/20/2001	12	ND	0.17	81	210	0.12	0.4	0.64
8102601	26	04S 06E 13BAA	Unk	8/13/2003	17	ND	0.11	130	260	BDL	0.48	0.6
8102601	26	04S 06E 13BAA	Unk	8/18/2004	9.8	ND	0.1	53	160	0.13	0.29	0.48
8102601	26	04S 06E 13BAA	Unk	9/19/2005	12	ND	0.14	110	230	BDL	0.44	BDL
8102601	26	04S 06E 13BAA	Unk	6/27/2006	14	0.14	NA	211	280	0.036	NA	NA
8102601	26	04S 06E 13BAA	Unk	8/23/2006	9.3	ND	0.12	520	530	BDL	1.1	0.56
8102601	26	04S 06E 13BAA	Unk	8/16/2007	9	ND	BDL	490	620	0.21	0.99	0.6
8102601	26	04S 06E 13BAA	Unk	8/5/2008	22	ND	ND	500	650	BDL	1.1	1.1
8102701	27	04S 06E 13BBA	Unk	8/20/2001	1.2	ND	ND	14	28	BDL	BDL	0.14
8102701	27	04S 06E 13BBA	Unk	8/21/2002	1.2	ND	BDL	8.4	27	BDL	BDL	0.1
8102701	27	04S 06E 13BBA	Unk	8/11/2003	1.3	ND	ND	12	28	BDL	BDL	BDL
8102701	27	04S 06E 13BBA	Unk	8/19/2004	1.4	ND	ND	11	29	BDL	0.12	BDL
8102701	27	04S 06E 13BBA	Unk	9/19/2005	1.4	ND	ND	12	32	BDL	0.12	BDL
8102701	27	04S 06E 13BBA	Unk	6/27/2006	1.4	<0.01	NA	12.3	30.5	NA	NA	NA
8102701	27	04S 06E 13BBA	Unk	8/23/2006	1.4	ND	ND	13	29	BDL	0.11	0.16
8102701	27	04S 06E 13BBA	Unk	8/16/2007	1.5	ND	BDL	14	31	BDL	0.1	BDL
8102701	27	04S 06E 13BBA	Unk	8/7/2008	1.5	ND	ND	13	31	BDL	0.12	BDL
8102801	28		Unk	8/22/2001	BDL	ND	0.1	50	110	BDL	0.24	0.43
8102901	29		Unk	8/22/2001	4.5	ND	0.22	33	120	0.11	0.22	0.54
8103001	30	04S 06E 24AAD1	Unk	6/26/2006	0.92	<0.01	NA	8.8	18.4	0.018	NA	NA
8103001	30	04S 06E 24AAD1	Unk	8/20/2007	0.99	ND	ND	8.8	18	BDL	BDL	0.59
8103001	30	04S 06E 24AAD1	Unk	8/6/2008	1	ND	ND	8.6	18	BDL	BDL	0.65
8103101	31	04S 06E 13DAD2	Unk	6/26/2006	9.3	<0.01	NA	94.8	164	<0.005	NA	NA
8103101	31	04S 06E 13DAD2	Unk	8/23/2007	17	ND	BDL	240	480	BDL	1.2	0.34
8103101	31	04S 06E 13DAD2	Unk	8/6/2008	6	ND	ND	64	120	BDL	0.34	0.16
8103201	32	04S 06E 13DDD	Unk	6/26/2006	2.8	<0.01	NA	17.6	35.4	<0.005	NA	NA
8103201	32	04S 06E 13DDD	Unk	8/13/2007	2.5	ND	ND	16	32	BDL	0.13	0.49

Table 6. Concluded.

IDA ID #	Plotting #	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Nitrite mg/L	OrthoP mg/L	Chloride mg/L	Sulfate mg/L	Ammonia mg/L	Bromide mg/L	Fluoride mg/L
8103301	33	04S 06E 13DDA	Unk	6/26/06	4.4	<0.01	NA	28	53.4	<0.005	NA	NA
8103301	33	04S 06E 13DDA	Unk	8/13/07	4.3	ND	ND	27	57	BDL	0.21	BDL
8103301	33	04S 06E 13DDA	Unk	8/6/08	4.5	ND	ND	26	53	BDL	0.22	0.15
8103401	34	04S 06E 24AAA	Unk	6/26/06	4.4	<0.01	NA	29.8	57	<0.005	NA	NA
8103401	34	04S 06E 24AAA	Unk	8/13/07	4.4	ND	BDL	29	58	BDL	0.23	BDL
8103401	34	04S 06E 24AAA	Unk	8/6/08	4.5	ND	ND	28	57	BDL	0.25	0.16
8103501	35		SW	8/15/01	BDL	ND	0.44	67	31	0.12	0.3	0.74
8103601	36		SW	8/15/01	ND	ND	0.25	69	13	0.15	0.22	0.33
8103701	37		SW	8/15/01	ND	ND	0.28	67	18	BDL	0.23	0.37
8103801	38	04S 06E 24ABA	Unk	6/26/06	2.2	NA	NA	15.5	31.7	<0.005	NA	NA
8103801	38	04S 06E 24ABA	Unk	8/13/07	2.5	ND	ND	16	30	NA	0.12	0.42
8103801	38	04S 06E 24ABA	Unk	8/6/08	2.7	ND	ND	17	35	BDL	0.14	0.45
8103901	39	04S 06E 13DAA1	Unk	6/26/06	2.6	<0.01	NA	29.4	64.3	0.008	NA	NA
8103901	39	04S 06E 13DAA1	Unk	8/13/07	4.6	ND	ND	84	150	BDL	0.61	0.23
8103901	39	04S 06E 13DAA1	Unk	8/7/08	3.6	ND	ND	51	110	BDL	0.4	0.17
8104001	40	04S 06E 13DAA2	Unk	6/26/06	2.1	<0.01	NA	25.7	62	<0.005	NA	NA
8104001	40	04S 06E 13DAA2	Unk	8/13/07	2.1	ND	ND	23	60	BDL	0.16	BDL
8104001	40	04S 06E 13DAA2	Unk	8/6/08	2.3	ND	ND	24	62	BDL	0.2	0.18
8104101	41	04S 07E 07CCC3	Unk	6/27/06	7.2	<0.01	NA	36.1	103	0.02	NA	NA
8104101	41	04S 07E 07CCC3	Unk	8/30/07	7.4	ND	BDL	36	110	BDL	0.24	BDL
8104101	41	04S 07E 07CCC3	Unk	8/4/08	8.2	ND	BDL	36	110	BDL	0.26	BDL
8104201	42	04S 07E 18BBB	Unk	6/27/06	14	<0.01	NA	50.7	171	0.006	NA	NA
8104201	42	04S 07E 18BBB	Unk	8/23/07	14	ND	0.12	48	160	BDL	0.29	0.17
8104201	42	04S 07E 18BBB	Unk	8/6/08	14	ND	ND	45	160	BDL	0.29	0.21
8104301	43	04S 07E 18BBC1	Unk	6/27/06	NA	NA	NA	NA	NA	<0.005	NA	NA
8104301	43	04S 07E 18BBC1	Unk	8/20/07	8.5	ND	ND	35	110	BDL	0.22	BDL
8104301	43	04S 07E 18BBC1	Unk	8/7/08	9.3	ND	ND	34	110	BDL	0.24	BDL
8104401	44		Unk	6/28/06	7.7	<0.01	NA	28.1	94.1	<0.005	NA	NA
8104401	44		Unk	8/20/07	5	ND	ND	25	76	BDL	0.16	BDL
8104501	45	04S 07E 18BBC2	Unk	6/28/06	4.5	<0.01	NA	25.4	69.6	<0.005	NA	NA
8104501	45	04S 07E 18BBC2	Unk	8/20/07	4.7	ND	BDL	22	61	BDL	0.17	BDL
8104501	45	04S 07E 18BBC2	Unk	8/7/08	4.1	ND	ND	23	58	BDL	0.2	BDL
8104601	46	04S 06E 13DAD3	Unk	6/28/06	2	<0.01	NA	19.7	44.7	<0.005	NA	NA
8104601	46	04S 06E 13DAD3	Unk	8/13/07	1.9	ND	ND	18	43	BDL	0.12	0.16
8104601	46	04S 06E 13DAD3	Unk	8/7/08	0.92	ND	ND	7.8	16	BDL	BDL	0.42
8104701	47		Unk	6/28/06	1	<0.01	NA	8.56	18.3	<0.005	NA	NA
8104701	47		Unk	8/20/07	1	ND	ND	8.8	18	BDL	BDL	0.45
8104701	47		Unk	8/7/08	1	ND	ND	8.7	18	BDL	BDL	0.46
8107101	71		SW	8/22/01	BDL	ND	0.5	93	49	0.37	BDL	0.34

NOTE: For ISDA ID# 8100601, some data are from Idaho Department of Water Resources Statewide database (Statewide) and U.S. Geological Survey Open-File Report 90-112 (OF 90-112).

Table 7. Field parameters for ISDA Project 810. (Temp = temperature, Spec Cond = specific conductance, µS/cm = microsiemens per centimeter, NA = not analyzed. SW in the well depth column indicates a surface water sampling site. Note that ISDA wells 3, 7, and 38 were also sampled by DEQ and are referred to as wells S14/3, S1/7, and S2/38, respectively, in DEQ results.)

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8100101	1	04S 06E 13ADA	360	7/15/1998	13.3	7.6	707
8100101	1	04S 06E 13ADA	360	8/21/2002	12.2	7.67	700
8100101	1	04S 06E 13ADA	360	8/12/2003	14.2	6.59	750
8100101	1	04S 06E 13ADA	360	8/17/2004	13.4	7.49	898
8100101	1	04S 06E 13ADA	360	9/19/2005	14.5	7.48	934
8100101	1	04S 06E 13ADA	360	6/27/2006	14	7.71	1180
8100101	1	04S 06E 13ADA	360	8/13/2007	14	7.79	1296
8100101	1	04S 06E 13ADA	360	8/6/2008	13.3	7.3	1262
8100201	2	04S 06E 13DAD1	475	7/15/1998	19.9	8.14	343
8100201	2	04S 06E 13DAD1	475	8/20/2001	20	7.61	312
8100201	2	04S 06E 13DAD1	475	8/19/2002	17.8	8.21	332
8100201	2	04S 06E 13DAD1	475	8/12/2003	19.8	7.14	256
8100201	2	04S 06E 13DAD1	475	8/17/2004	19.5	8.09	299
8100201	2	04S 06E 13DAD1	475	8/17/2004	19.5	8.09	299
8100201	2	04S 06E 13DAD1	475	9/19/2005	19.6	7.91	308
8100201	2	04S 06E 13DAD1	475	6/27/2006	19.6	8.3	361
8100201	2	04S 06E 13DAD1	475	8/23/2006	19.6	8.1	1581
8100201	2	04S 06E 13DAD1	475	8/23/2007	19.6	8.31	337
8100201	2	04S 06E 13DAD1	475	8/6/2008	19.6	7.75	313
8100301	3	04S 06E 13DDB	463	7/15/1998	20.3	8.29	343
8100301	3	04S 06E 13DDB	463	8/10/2000	20.1	8.05	354
8100301	3	04S 06E 13DDB	463	8/16/2001	20.8	7.92	296
8100301	3	04S 06E 13DDB	463	8/19/2002	19	8.2	214
8100301	3	04S 06E 13DDB	463	8/12/2003	20.1	7.16	296
8100301	3	04S 06E 13DDB	463	8/17/2004	19.8	8	713
8100301	3	04S 06E 13DDB	463	9/14/2005	17.4	7.84	2930
8100301	3	04S 06E 13DDB	463	1/13/2006	14.4	7.86	2980
8100301	3	04S 06E 13DDB	463	4/5/2006	15.1	7.97	2500
8100301	3	04S 06E 13DDB	463	6/27/2006	17.6	7.99	3220
8100301	3	04S 06E 13DDB	463	8/23/2006	16.6	7.71	1429
8100301	3	04S 06E 13DDB	463	8/13/2007	17.6	8.17	302
8100301	3	04S 06E 13DDB	463	8/6/2008	17.7	7.65	2699
8100401	4	04S 06E 13AAA1	140	7/15/1998	14	7.68	1065
8100401	4	04S 06E 13AAA1	140	8/9/2000	13.8	7.58	1205
8100401	4	04S 06E 13AAA1	140	8/15/2001	14	8.02	945
8100401	4	04S 06E 13AAA1	140	8/20/2002	12.4	7.67	1207
8100401	4	04S 06E 13AAA1	140	8/11/2003	14.3	6.81	1145
8100401	4	04S 06E 13AAA1	140	8/19/2004	14.2	7.5	1102
8100401	4	04S 06E 13AAA1	140	8/19/2004	14.2	7.5	1102
8100401	4	04S 06E 13AAA1	140	9/19/2005	14.2	7.48	878
8100401	4	04S 06E 13AAA1	140	6/27/2006	14.2	7.79	1229
8100401	4	04S 06E 13AAA1	140	8/24/2006	14.1	7.67	1189
8100401	4	04S 06E 13AAA1	140	10/26/2006	13.8	7.79	1250
8100401	4	04S 06E 13AAA1	140	8/16/2007	14.2	7.87	1231
8100401	4	04S 06E 13AAA1	140	8/4/2008	14.2	7.53	1112

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8100501	5	04S 06E 13AAA2	190	7/15/1998	14.4	7.73	1042
8100501	5	04S 06E 13AAA2	190	8/9/2000	14	7.58	1089
8100501	5	04S 06E 13AAA2	190	8/15/2001	14.1	7.27	1067
8100501	5	04S 06E 13AAA2	190	8/20/2002	12.6	7.59	1076
8100501	5	04S 06E 13AAA2	190	8/11/2003	14.4	6.76	1088
8100501	5	04S 06E 13AAA2	190	8/17/2004	14	7.59	1089
8100501	5	04S 06E 13AAA2	190	9/19/2005	13.9	7.59	990
8100501	5	04S 06E 13AAA2	190	6/27/2006	14.3	7.53	1169
8100501	5	04S 06E 13AAA2	190	8/24/2006	14	7.53	1350
8100501	5	04S 06E 13AAA2	190	10/26/2006	13.8	7.67	1289
8100501	5	04S 06E 13AAA2	190	8/16/2007	14.4	7.93	1140
8100501	5	04S 06E 13AAA2	190	8/4/2008	14.2	7.45	1216
8100601	6	04S 06E 13AAA3	79	7/15/1998	13.8	7.48	1996
8100601	6	04S 06E 13AAA3	79	8/10/2000	20.1	7.35	1646
8100601	6	04S 06E 13AAA3	79	8/16/2001	14.7	7.71	2340
8100601	6	04S 06E 13AAA3	79	8/20/2002	12.4	7.43	1552
8100601	6	04S 06E 13AAA3	79	8/11/2003	14	6.74	1805
8100601	6	04S 06E 13AAA3	79	8/19/2004	13.8	7.31	1967
8100601	6	04S 06E 13AAA3	79	9/14/2005	13.9	7.29	1629
8100601	6	04S 06E 13AAA3	79	6/27/2006	13.9	7.35	1799
8100601	6	04S 06E 13AAA3	79	8/24/2006	14.1	7.39	1417
8100601	6	04S 06E 13AAA3	79	8/16/2007	14.4	7.65	1606
8100601	6	04S 06E 13AAA3	79	8/6/2008	13.8	7.38	1742
8100701	7	04S 06E 13DCD	460	7/15/1998	20.3	8.18	617
8100701	7	04S 06E 13DCD	460	8/16/2001	20.3	7.88	362
8100701	7	04S 06E 13DCD	460	8/20/2002	18.4	8.06	345
8100701	7	04S 06E 13DCD	460	8/11/2003	20.2	7.05	309
8100701	7	04S 06E 13DCD	460	8/17/2004	19.7	8.04	355
8100701	7	04S 06E 13DCD	460	9/19/2005	19.7	7.92	416
8100701	7	04S 06E 13DCD	460	6/27/2006	19.5	8.07	944
8100701	7	04S 06E 13DCD	460	8/23/2006	19.5	7.68	1241
8100701	7	04S 06E 13DCD	460	8/13/2007	20.7	8.09	1649
8100701	7	04S 06E 13DCD	460	8/6/2008	20.3	7.54	2034
8100801	8		480	8/8/2000	21.8	8	455
8100801	8		480	8/16/2001	21	7.79	412
8100801	8		480	8/20/2002	19.7	7.98	439
8100802	802	04S 06E 24ADB	586	9/16/2003	24.6	7.22	242
8100802	802	04S 06E 24ADB	586	8/17/2004	23.6	8.07	264
8100802	802	04S 06E 24ADB	586	9/14/2005	25.2	7.83	252
8100802	802	04S 06E 24ADB	586	6/27/2006	24.3	8.29	321
8100802	802	04S 06E 24ADB	586	8/23/2006	25.3	8.05	277
8100802	802	04S 06E 24ADB	586	8/13/2007	24.2	8.57	263
8100802	802	04S 06E 24ADB	586	8/7/2008	25	7.98	254

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8100901	9	04S 06E 12CDD	30	8/8/2000	13.5	6.87	1682
8100901	9	04S 06E 12CDD	30	8/20/2001	14.2	6.68	1452
8100901	9	04S 06E 12CDD	30	8/20/2002	12.1	6.91	1367
8100901	9	04S 06E 12CDD	30	8/11/2003	14.2	6.12	1372
8100901	9	04S 06E 12CDD	30	8/18/2004	13.4	6.74	1793
8100901	9	04S 06E 12CDD	30	9/19/2005	13.7	6.76	2250
8100901	9	04S 06E 12CDD	30	6/27/2006	NA	6.82	NA
8100901	9	04S 06E 12CDD	30	8/24/2006	13.9	6.86	1998
8100901	9	04S 06E 12CDD	30	8/16/2007	14.3	7.24	1982
8100901	9	04S 06E 12CDD	30	8/5/2008	12.6	7.09	1782
8101001	10	04S 06E 11CDC		8/8/2000	14.7	7.34	777
8101001	10	04S 06E 11CDC		8/16/2001	15.2	6.81	689
8101001	10	04S 06E 11CDC		8/21/2002	13.2	7.38	831
8101001	10	04S 06E 11CDC		8/11/2003	16.4	6.57	496
8101001	10	04S 06E 11CDC		8/18/2004	16	7.45	594
8101001	10	04S 06E 11CDC		9/14/2005	15.9	7.3	539
8101001	10	04S 06E 11CDC		8/23/2006	16.1	7.45	276
8101001	10	04S 06E 11CDC		8/7/2008	16.3	7.58	446
8101101	11	03S 07E 3131CBC1	557	8/9/2000	18.1	8.26	262
8101101	11	03S 07E 3131CBC1	557	8/20/2001	18.2	7.99	259
8101101	11	03S 07E 3131CBC1	557	8/19/2002	16.4	8.22	223
8101101	11	03S 07E 3131CBC1	557	8/12/2003	17.8	7.27	
8101101	11	03S 07E 3131CBC1	557	8/18/2004	17.9	8.18	250
8101101	11	03S 07E 3131CBC1	557	9/19/2005	16.9	8.43	239
8101101	11	03S 07E 3131CBC1	557	8/18/2006	18.1	8.38	283
8101101	11	03S 07E 3131CBC1	557	8/30/2007	18.1	8.67	259
8101101	11	03S 07E 3131CBC1	557	8/4/2008	17.7	8.21	296
8101201	12	03S 07E 31CBC2	89	8/9/2000	13.4	6.8	
8101201	12	03S 07E 31CBC2	89	8/20/2001	14.2	7.06	512
8101201	12	03S 07E 31CBC2	89	8/19/2002	11.7	8.88	439
8101201	12	03S 07E 31CBC2	89	8/12/2003	13.8	6.21	364
8101201	12	03S 07E 31CBC2	89	8/18/2004		0	0
8101201	12	03S 07E 31CBC2	89	9/20/2005	13.7	6.62	396
8101201	12	03S 07E 31CBC2	89	8/28/2006	13.4	6.83	393
8101201	12	03S 07E 31CBC2	89	8/30/2007	14.7	7.89	440
8101201	12	03S 07E 31CBC2	89	8/4/2008	14.3	6.9	459
8101301	13	04S 07E 27ABB	340	8/9/2000	14.7	7.06	847
8101301	13	04S 07E 27ABB	340	8/16/2001	14.5	7.08	647
8101301	13	04S 07E 27ABB	340	8/19/2002	12	7.34	685
8101301	13	04S 07E 27ABB	340	8/12/2003	14.5	6.45	0.43
8101301	13	04S 07E 27ABB	340	8/18/2004	14.7	7.7	881
8101301	13	04S 07E 27ABB	340	9/14/2005	14.5	7.19	80.6
8101301	13	04S 07E 27ABB	340	8/28/2006	16.5	7.18	806

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8101301	13	04S 07E 27ABB	340	8/23/2007	15.2	7.23	750
8101401	14	04S 07E 06DCC		8/9/2000	14.5	7.69	973
8101401	14	04S 07E 06DCC		8/16/2001	14.2	7.55	884
8101401	14	04S 07E 06DCC		8/19/2002	13.3	7.83	886
8101401	14	04S 07E 06DCC		8/12/2003	14.7	7.04	882
8101401	14	04S 07E 06DCC		8/18/2004	15.3	7.09	668
8101401	14	04S 07E 06DCC		9/14/2005	14.2	7.77	816
8101401	14	04S 07E 06DCC		8/28/2006	14.6	7.78	842
8101401	14	04S 07E 06DCC		8/23/2007	14.3	7.91	839
8101401	14	04S 07E 06DCC		8/5/2008	14.6	7.68	791
8101501	15	03S 06E 36CBD	140	8/9/2000	14	6.82	384
8101501	15	03S 06E 36CBD	140	8/16/2001	13.6	6.68	370
8101501	15	03S 06E 36CBD	140	8/2/2002	19.5	8.23	250
8101501	15	03S 06E 36CBD	140	8/13/2003	19.6	7.35	255
8101501	15	03S 06E 36CBD	140	8/19/2004	18.3	8.28	251
8101501	15	03S 06E 36CBD	140	9/19/2005	18	8.13	231
8101501	15	03S 06E 36CBD	140	8/28/2006	20.6	8.38	287
8101501	15	03S 06E 36CBD	140	8/23/2007	18.5	8.52	254
8101501	15	03S 06E 36CBD	140	8/5/2008	19.1	8.39	249
8101601	16	04S 07E 06CCC		8/10/2000	14.1	6.84	435
8101601	16	04S 07E 06CCC		8/21/2002	12.8	6.83	388
8101601	16	04S 07E 06CCC		8/13/2003	14.3	6.14	379
8101601	16	04S 07E 06CCC		8/18/2004	15	6.63	617
8101601	16	04S 07E 06CCC		9/19/2005	13.7	6.87	293
8101601	16	04S 07E 06CCC		8/24/2006	14.9	6.67	413
8101601	16	04S 07E 06CCC		8/30/2007	15.4	7.07	335
8101601	16	04S 07E 06CCC		8/5/2008	14.1	6.94	313
8101701	17	04S 06E 01ABA	140	8/10/2000	13.9	6.9	526
8101701	17	04S 06E 01ABA	140	8/20/2001	13.7	6.72	476
8101701	17	04S 06E 01ABA	140	8/21/2002	13.8	7.6	449
8101701	17	04S 06E 01ABA	140	8/12/2003	14.5	6.02	461
8101701	17	04S 06E 01ABA	140	8/19/2004	14.1	6.91	423
8101701	17	04S 06E 01ABA	140	9/14/2005	14.5	7.04	428
8101701	17	04S 06E 01ABA	140	8/28/2006	14.4	6.97	520
8101701	17	04S 06E 01ABA	140	8/23/2007	15.1	7.02	485
8101701	17	04S 06E 01ABA	140	8/4/2008	14.5	7.02	467
8101801	18	04S 07E 07CCC1	300	8/7/2000	15.3	7.75	780
8101801	18	04S 07E 07CCC1	300	8/15/2001	14.7	7.28	813
8101801	18	04S 07E 07CCC1	300	8/20/2002	13.1	7.75	770
8101801	18	04S 07E 07CCC1	300	8/11/2003	14.6	6.96	778
8101801	18	04S 07E 07CCC1	300	8/17/2004	14.5	7.67	707
8101801	18	04S 07E 07CCC1	300	9/19/2005	14.2	7.73	831

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8101801	18	04S 07E 07CCC1	300	6/27/2006	15.1	7.88	813
8101801	18	04S 07E 07CCC1	300	8/24/2006	14.8	7.73	750
8101801	18	04S 07E 07CCC1	300	8/16/2007	15.3	7.98	807
8101801	18	04S 07E 07CCC1	300	8/4/2008	14.5	7.63	836
8101901	19	04S 07E 07CCC2	18	8/7/2000	13.1	7.36	801
8101901	19	04S 07E 07CCC2	18	8/15/2001	13	6.47	694
8101901	19	04S 07E 07CCC2	18	8/11/2003	13.2	6.6	97.4
8101901	19	04S 07E 07CCC2	18	8/17/2004	13.2	7.26	639
8101901	19	04S 07E 07CCC2	18	9/19/2005	13.4	7.33	587
8101901	19	04S 07E 07CCC2	18	6/27/2006	12.6	7.47	796
8101901	19	04S 07E 07CCC2	18	8/24/2006	13	7.21	937
8101901	19	04S 07E 07CCC2	18	8/16/2007	13.6	7.53	700
8101901	19	04S 07E 07CCC2	18	8/4/2008	12.6	7.1	706
8102001	20	03S 07E 31CBA	500	8/16/2001	14.2	5.25	595
8102001	20	03S 07E 31CBA	500	8/21/2002	14.5	7.87	617
8102001	20	03S 07E 31CBA	500	9/16/2003	15	6.96	451
8102001	20	03S 07E 31CBA	500	8/17/2004	14.5	7.67	707
8102001	20	03S 07E 31CBA	500	9/14/2005	15	7.69	361
8102001	20	03S 07E 31CBA	500	8/28/2006	15.8	7.69	386
8102001	20	03S 07E 31CBA	500	8/23/2007	15.1	7.85	433
8102001	20	03S 07E 31CBA	500	8/4/2008	15.5	7.62	411
8102101	21	03S 07E 31BDD	85	8/16/2001	14.5	5.79	459
8102101	21	03S 07E 31BDD	85	8/13/2003	16.1	6.12	407
8102101	21	03S 07E 31BDD	85	8/19/2004	18.1	6.95	360
8102101	21	03S 07E 31BDD	85	9/14/2005	16	7.01	414
8102101	21	03S 07E 31BDD	85	8/28/2006	16.4	6.92	497
8102101	21	03S 07E 31BDD	85	8/23/2007	17.9	7.01	441
8102101	21	03S 07E 31BDD	85	8/4/2008	14.6	7.2	455
8102201	22	04S 06E 07CCB	20	8/16/2001	14.5	7.53	510
8102201	22	04S 06E 07CCB	20	8/20/2002	12.4	7.2	419
8102201	22	04S 06E 07CCB	20	8/12/2003	14	6.37	0.44
8102201	22	04S 06E 07CCB	20	8/18/2004	15.2	7.16	461
8102201	22	04S 06E 07CCB	20	9/19/2005	14.5	6.98	380
8102201	22	04S 06E 07CCB	20	6/27/2006	14.9	7.13	541
8102201	22	04S 06E 07CCB	20	8/24/2006	14.1	7.23	509
8102201	22	04S 06E 07CCB	20	8/30/2007	14.9	7.52	451
8102201	22	04S 06E 07CCB	20	8/4/2008	13.9	7.49	403
8102301	23	04S 06E 12CDC		8/16/2001	16.8	7.9	298
8102301	23	04S 06E 12CDC		8/20/2002	16.7	8.28	314
8102301	23	04S 06E 12CDC		8/11/2003	18	7.12	287
8102301	23	04S 06E 12CDC		8/18/2004	19	8.06	303
8102301	23	04S 06E 12CDC		9/19/2005	17.7	8.3	328
8102301	23	04S 06E 12CDC		6/27/2006	18.1	8.28	320

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8102301	23	04S 06E 12CDC		8/23/2006	18.2	8.27	1436
8102301	23	04S 06E 12CDC		8/16/2007	19	8.7	307
8102301	23	04S 06E 12CDC		8/7/2008	18.4	8.34	311
8102401	24	03S 07E 31CCD	25	8/16/2001	12.7	6.44	652
8102401	24	03S 07E 31CCD	25	8/19/2002	15.3	8.23	359
8102401	24	03S 07E 31CCD	25	8/12/2003	16.6	7.14	290
8102401	24	03S 07E 31CCD	25	8/18/2004	16.5	8.04	366
8102401	24	03S 07E 31CCD	25	9/14/2005	16	8.13	350
8102401	24	03S 07E 31CCD	25	8/28/2006	16.7	8.04	408
8102401	24	03S 07E 31CCD	25	8/30/2007	16.9	8.36	341
8102401	24	03S 07E 31CCD	25	8/4/2008	16.5	7.99	368
8102501	25	04S 06E 12DCC		8/20/2001	15.9	7.82	195.5
8102501	25	04S 06E 12DCC		8/20/2002	17.6	8.28	227
8102501	25	04S 06E 12DCC		8/11/2003	18.3	7.25	219
8102501	25	04S 06E 12DCC		8/19/2004	18.3	8.26	226
8102501	25	04S 06E 12DCC		8/19/2004	18.3	8.26	226
8102501	25	04S 06E 12DCC		9/19/2005	17.5	7.99	211
8102501	25	04S 06E 12DCC		6/27/2006	18.1	8.29	NA
8102501	25	04S 06E 12DCC		8/24/2006	18.3	8.3	227
8102501	25	04S 06E 12DCC		8/16/2007	18.7	8.68	233
8102501	25	04S 06E 12DCC		8/7/2008	18.1	8.29	234.2
8102601	26			8/20/2001	14	6.59	1092
8102601	26			8/13/2003	13.8	6.15	1467
8102601	26			8/18/2004	14.2	6.83	952
8102601	26			9/19/2005	15.1	6.8	1397
8102601	26			6/27/2006	12.2	6.78	1735
8102601	26			8/23/2006	14.6	6.57	1443
8102601	26			8/16/2007	14.9	6.91	3140
8102601	26			8/5/2008	12.9	6.75	3120
8102701	27	04S 06E 13BBA		8/20/2001	17.8	7.79	244
8102701	27	04S 06E 13BBA		8/21/2002	16.8	8.32	277
8102701	27	04S 06E 13BBA		8/11/2003	17.8	7.26	274
8102701	27	04S 06E 13BBA		8/19/2004	18.6	8.26	261
8102701	27	04S 06E 13BBA		9/19/2005	17.7	8.51	301
8102701	27	04S 06E 13BBA		6/27/2006	18.7	8.27	294
8102701	27	04S 06E 13BBA		8/23/2006	17.4	8.28	1302
8102701	27	04S 06E 13BBA		8/16/2007	18.8	8.73	285
8102701	27	04S 06E 13BBA		8/7/2008	18.5	8.31	284.7
8102801	28			8/22/2001	15.2	6.81	718
8102901	29			8/22/2001	14	6.71	701
8103001	30	04S 06E 24AAD1		6/26/2006	24.8	8.26	353

Table 7. Continued.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8103001	30	04S 06E 24AAD1		8/20/2007	25.7	8.21	314
8103001	30	04S 06E 24AAD1		8/6/2008	26	7.95	288.2
8103101	31	04S 06E 13DAD2		6/26/2006	20	8.05	1259
8103101	31	04S 06E 13DAD2		8/23/2007	19.5	8.17	1990
8103101	31	04S 06E 13DAD2		8/6/2008	19.8	8	784
8103201	32	04S 06E 13DDD		6/26/2006	23	8.2	341
8103201	32	04S 06E 13DDD		8/13/2007	21.2	8.5	230
8103301	33	04S 06E 13DDA		6/26/2006	22.8	8.08	488
8103301	33	04S 06E 13DDA		8/13/2007	23.1	8.31	426
8103301	33	04S 06E 13DDA		8/6/2008	22.4	7.84	448
8103401	34	04S 06E 24AAA		6/26/2006	23.8	8.1	500
8103401	34	04S 06E 24AAA		8/13/2007	23.3	8.42	400
8103401	34	04S 06E 24AAA		8/6/2008	23	7.93	440
8103501	35		SW	8/15/2001	NA	NA	NA
8103601	36		SW	8/15/2001	NA	NA	NA
8103701	37		SW	8/15/2001	NA	NA	NA
8103801	38	04S 06E 24ABA		6/26/2006	23.4	8.25	317
8103801	38	04S 06E 24ABA		8/13/2007	24.9	8.47	272
8103801	38	04S 06E 24ABA		8/6/2008	23.8	7.95	313
8103901	39	04S 06E 13DAA1		6/26/2006	19.3	8.2	538
8103901	39	04S 06E 13DAA1		8/13/2007	19.8	8.37	384
8103901	39	04S 06E 13DAA1		8/7/2008	19.7	7.86	634
8104001	40	04S 06E 13DAA2		6/26/2006	19.8	8.19	499
8104001	40	04S 06E 13DAA2		8/13/2007	20.9	8.42	351
8104001	40	04S 06E 13DAA2		8/6/2008	21.1	7.74	410
8104101	41	04S 07E 07CCC3		6/27/2006	15.2	7.82	1030
8104101	41	04S 07E 07CCC3		8/30/2007	15.1	8.09	758
8104101	41	04S 07E 07CCC3		8/4/2008	14.9	7.56	836
8104201	42	04S 07E 18BBB		6/27/2006	14.8	7.71	1416
8104201	42	04S 07E 18BBB		8/23/2007	14.6	7.79	1150
8104201	42	04S 07E 18BBB		8/6/2008	14.5	7.86	987
8104301	43	04S 07E 18BBC1		6/27/2006	17.7	7.74	1234
8104301	43	04S 07E 18BBC1		8/20/2007	18	7.97	521
8104301	43	04S 07E 18BBC1		8/7/2008	17.5	7.43	765

Table 7. Concluded.

ISDA Well #	Well #	Township, Range, Section	Well Depth	Sample Date	Temp (deg C)	pH (units)	Spec Cond (µS/cm)
8104401	44			6/28/2006	16.8	8.11	512
8104401	44			8/20/2007	18.3	8.14	521
8104501	45	04S 07E 18BBC2		6/28/2006	19.6	8.11	526
8104501	45	04S 07E 18BBC2		8/20/2007	19.2	8.2	467
8104501	45	04S 07E 18BBC2		8/7/2008	19.1	7.81	483
8104601	46	04S 06E 13DAD3		6/28/2006	20.2	8.14	394
8104601	46	04S 06E 13DAD3		8/13/2007	20.1	8.45	346
8104601	46	04S 06E 13DAD3		8/7/2008	20	7.8	358
8104701	47			6/28/2006	24.2	8.09	298
8104701	47			8/20/2007	23.5	8.2	311
8104701	47			8/7/2008	25.1	7.76	272
8107101	71		SW	8/22/2001	NA	NA	NA

Table 8. Nitrate, chloride and sulfate data for DEQ samples. (NA = not analyzed. Number in bold indicates result was below the laboratory detection limit. SW in the well depth column indicates a surface water sampling site.)

Monitoring Well/Pond	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Chloride mg/L	Sulfate mg/L
MW-2	04S 06E 12CCC	14	4/5/1990	**0.1**	NA	NA
MW-2	04S 06E 12CCC	14	4/10/1991	**0.1**	NA	NA
MW-2	04S 06E 12CCC	14	6/3/1992	0.12	NA	NA
MW-2	04S 06E 12CCC	14	4/21/1993	0.26	NA	NA
MW-2	04S 06E 12CCC	14	7/7/1993	0.83	NA	NA
MW-2	04S 06E 12CCC	14	3/1/1995	**0.1**	NA	NA
MW-2	04S 06E 12CCC	14	5/28/1998	**0.02**	84	NA
MW-2	04S 06E 12CCC	14	10/7/1998	0.32	6	NA
MW-2	04S 06E 12CCC	14	5/19/1999	**0.2**	76	NA
MW-2	04S 06E 12CCC	14	9/22/1999	**0.2**	66	NA
MW-2	04S 06E 12CCC	14	5/10/2000	**0.2**	71	NA
MW-2	04S 06E 12CCC	14	5/16/2000	**0.2**	37	NA
MW-2	04S 06E 12CCC	14	9/26/2000	**0.2**	57	NA
MW-2	04S 06E 12CCC	14	5/8/2001	**0.2**	80	NA
MW-2	04S 06E 12CCC	14	9/19/2001	**0.2**	59	NA
MW-2	04S 06E 12CCC	14	5/14/2002	**0.2**	59	NA
MW-2	04S 06E 12CCC	14	9/25/2002	**0.2**	60	NA
MW-2	04S 06E 12CCC	14	5/20/2003	**0.2**	72	NA
MW-2	04S 06E 12CCC	14	9/23/2003	**0.2**	67	NA
MW-2	04S 06E 12CCC	14	5/27/2004	**0.2**	84	NA
MW-2	04S 06E 12CCC	14	9/28/2004	**0.2**	86	NA
MW-2	04S 06E 12CCC	14	5/24/2005	**0.2**	87	NA
MW-2	04S 06E 12CCC	14	9/21/2005	**0.2**	80	NA
MW-2	04S 06E 12CCC	14	06/27/06	0.01	104	15.2
MW-2	04S 06E 12CCC	14	11/21/06	0.01	120	20.6
MW-2	04S 06E 12CCC	14	02/12/07	0.01	174	35
MW-2	04S 06E 12CCC	14	03/12/07	0.01	174	33.4
MW-2	04S 06E 12CCC	14	04/16/07	0.01	170	29.9
MW-2	04S 06E 12CCC	14	05/14/07	0.01	167	28.8
MW-2	04S 06E 12CCC	14	11/14/07	**0.01**	101	19.7
MW-3	04S 06E 12CCD	13	4/5/1990	3.34	NA	NA
MW-3	04S 06E 12CCD	13	4/5/1991	3.93	NA	NA
MW-3	04S 06E 12CCD	13	3/31/1992	4.33	NA	NA
MW-3	04S 06E 12CCD	13	4/21/1993	3.53	NA	NA
MW-3	04S 06E 12CCD	13	7/7/1993	NA	NA	NA
MW-3	04S 06E 12CCD	13	3/1/1995	3.69	NA	NA
MW-3	04S 06E 12CCD	13	5/28/1998	7	32	NA
MW-3	04S 06E 12CCD	13	10/7/1998	6.55	22	NA
MW-3	04S 06E 12CCD	13	5/19/1999	6.3	32	NA
MW-3	04S 06E 12CCD	13	9/22/1999	7	38	NA
MW-3	04S 06E 12CCD	13	5/10/2000	**0.2**	57	NA
MW-3	04S 06E 12CCD	13	5/16/2000	5.92	37	NA
MW-3	04S 06E 12CCD	13	11/29/2000	7.08	148	NA
MW-3	04S 06E 12CCD	13	5/8/2001	5.72	33	NA
MW-3	04S 06E 12CCD	13	9/19/2001	5.04	39	NA
MW-3	04S 06E 12CCD	13	5/14/2002	5.19	34	NA
MW-3	04S 06E 12CCD	13	9/25/2002	4.43	33	NA

Table 8. Concluded.

Monitoring Location	Township, Range and Section	Well Depth	Sample Date	Nitrate mg/L	Chloride mg/L	Sulfate mg/L
MW-3	04S 06E 12CCD	13	5/20/2003	4.73	30	NA
MW-3	04S 06E 12CCD	13	9/23/2003	4.23	25	NA
MW-3	04S 06E 12CCD	13	5/27/2004	3.90	28	NA
MW-3	04S 06E 12CCD	13	9/28/2004	3.30	24	NA
MW-3	04S 06E 12CCD	13	5/24/2005	3.5	18	NA
MW-3	04S 06E 12CCD	13	9/21/2005	2.9	18	NA
MW 3	04S 06E 12CCD	13	6/27/2006	3.9	17.1	77.5
MW 3	04S 06E 12CCD	13	11/21/2006	4.6	24	93.4
MW 3	04S 06E 12CCD	13	2/12/2007	4.9	25.2	95.7
MW 3	04S 06E 12CCD	13	3/12/2007	5.2	24.3	94.5
MW 3	04S 06E 12CCD	13	4/16/2007	5.1	24.4	93.3
MW 3	04S 06E 12CCD	13	5/14/2007	4.9	23.2	90.6
MW 3	04S 06E 12CCD	13	11/14/2007	6.00	31.70	111.0
I-1	04S 07E 17BBB	SW	4/16/2007	1.9	32.5	23.6
I-1	04S 07E 17BBB	SW	5/14/2007	0.28	2.94	**2**
PWS-S	04S 06E 12DAA	Unknown	11/20/2006	3.3	20	56.7
PWS-W	04S 06E 12CAD	535	11/20/2006	1.9	10.2	24.1
S1	04S 06E 13DCD	460	5/14/2007	12	148	290
S11	04S 06E 11CDD	Unknown	5/14/2008	2.4	59	81
S12	04S 06E 11CDC	Unknown	5/14/2008	1.9	60	62
S13	04S 06E 11CBA	Unknown	5/14/2008	0.61	4.1	7
S14/3	04S 06E 13DDB	463	3/12/2007	34	340	810
S14/3	04S 06E 13DDB	463	4/16/2007	34	370	810
S14/3	04S 06E 13DDB	463	5/14/2007	30	337	750
S14/3	04S 06E 13DDB	463	5/14/2008	31	370	690
S14/3	04S 06E 13DDB	463	5/14/2008	31	370	690
S15	04S 06E 11DAB	Lagoon	11/14/2007	0.58	67.8	46.9
S15	04S 06E 11DAB	Lagoon	5/14/2008	4.4	50	35
S15	04S 06E 11DAB	Lagoon	9/8/2008	0.16	83	52
S16	04S 06E 11CDA	Unknown	5/14/2008	2.4	59	NA
S2	04S 06E 24ABA	590	5/14/2007	2.6	16.3	32.1
S30	04S 06E 12CBC	Lagoon	6/27/2006	3.1	48.6	35.2
S30	04S 06E 12CBC	Lagoon	11/20/2006	0.74	68	57.5
S30	04S 06E 12CBC	Lagoon	2/12/2007	0.25	55.3	44.6
S30	04S 06E 12CBC	Lagoon	3/12/2007	0.52	56.1	44.8
S30	04S 06E 12CBC	Lagoon	4/16/2007	1.1	57.4	45.9
S30	04S 06E 12CBC	Lagoon	5/14/2007	1.3	56.1	44.2
S30	04S 06E 12CBC	Lagoon	9/8/2008	0.99	73	49
S40	04S 06E 01CCA	Lagoon	11/14/2007	0.27	33.5	22.7
S40	04S 06E 01CCA	Lagoon	9/8/2008	0.018	42	36
S41	03S 06E 36CAA1	Pond	9/8/2008	2.3	33	25
S42	04S 06E 12DAD	Unknown	11/20/2006	2.4	17.3	43.6
S42	04S 06E 12DAD	Unknown	9/8/2008	2.5	16	42
S43	03S 06E 36CAA2	Pond	9/8/2008	0.11	44	44
S44	04S 07E 07DCB	Pond	9/8/2008	0.01	6.2	4.8
S7	04S 06E 14DBA	Unknown	5/14/2008	0.65	5.8	12
S8	04S 06E 14ACA	Unknown	5/14/2008	0.77	7.4	15

Table 9. Field parameters for samples collected by DEQ. (Temp = temperature, degrees Celsius, Sp Cond = specific conductance, μS/cm = microsiemens per centimeter, D.O. = dissolved oxygen, mg/L = milligrams per liter, NA = not analyzed.)

Monitoring Location	Sample Date	Sample Time	Temp (deg C)	pH (units)	Sp Cond (μS/cm)	D.O. (mg/L)
MW-2	06/27/06	1430	12.1	7.86	1170	4.77
MW-2	11/21/06	1425	12.9	6.97	1130	0.92
MW-2	02/12/07	1511	9.6	6.85	1340	0.4
MW-2	03/12/07	1545	10.8	7.13	1330	1.95
MW-2	04/16/07	1040	9.7	7.44	1410	0.7
MW-2	05/14/07	956	10.2	7.07	1380	1.85
MW-2	11/14/07	11:50	12.5	6.93	1100	0.07
MW 3	6/27/2006	1310	14	8.05	687	8.3
MW 3	11/21/2006	1455	14.6	7.37	735	2.91
MW 3	2/12/2007	1540	11	7.05	701	4.94
MW 3	3/12/2007	1610	11.4	7.86	630	5.7
MW 3	4/16/2007	1220	10.8	8.74	677	4.52
MW 3	5/14/2007	1058	12	7.45	618	3.27
MW 3	11/14/07	11:10	14.8	7.24	750	2.67
I-1	4/16/2007	1415	13.6	9.89	323	16.3
I-1	5/14/2007	1400	13.9	8.45	51	11.1
PWS-N	11/20/2006	1120	18	8.11	419	8.24
PWS-S	11/20/2006	1230	15.2	7.62	493	10.51
PWS-W	11/20/2006	1145	12.7	7.89	404	12.92
S1	5/14/2007	1333	16.8	8.01	1300	10.79
S14/3	3/12/2007	1630	16.5	8.41	2820	15.93
S14/3	4/16/2007	1355	17	9.42	3020	15.5
S14/3	5/14/2007	1200	17.1	7.99	2790	9.56
S2	5/14/2007	1305	24.6	8.25	262	9.39
S30	6/27/2006	1445	24.3	8.99	637	9.82
S30	11/20/2006	1325	6.1	7.95	773	10.15
S30	2/12/2007	1551	5	7.95	675	10.46
S30	3/12/2007	1515	10.1	9.53	579	19.99
S30	4/16/2007	1130	10.6	9.37	665	16.9
S30	5/14/2007	1040	15.3	8.35	601	8.64
S30	9/8/2008	10:15	NA	NA	NA	NA
S41	9/8/2008	2:45	NA	10.53	306	NA
S41	9/8/2008	2:10	18.6	8.6	401	NA
S43	9/8/2008	4:00	26	10.2	414	NA
S44	9/8/2008	3:00	19.3	10.2	114	NA

Table 10. Major ion data for wells and one wastewater treatment lagoon in the area south of Mountain Home.

Agency Code	Site ID	TRS	Sample Date	Well Depth (feet)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	CO3 (mg/L)	HCO3 (mg/L)	Cl (mg/L)	SO4 (mg/L)	TDS (mg/L)	NO2_NO3 (mg/L)
USGS	430649115430101	03S 06E 34DDD1	11/25/1980	550	33	10	55	6	0	240	15	35	315	4.1
USGS	430708115401001	03S 07E 31CAB1	11/20/1980	73	57	16	34	4.9	0	250	6.2	29	353	27
DEQ	S30	04S 06E 12CBC	6/27/2006	Lagoon	38	11	71	14	0	233	48.6	35.2	650	3.1
DEQ	MW-2	04S 06E 12CCC	6/27/2006	14	67	15	156	4.2	0	506	104	15.2	780	0.01
DEQ	MW-3	04S 06E 12CCD	6/27/2006	13	29	7.5	115	2	0	282	17.1	77.5	500	3.9
USGS	IDA 6	04S 06E 13AAA1	7/14/2004	79	140	44.9	206	5.23	0	359	55.4	480	1290	28.8
IDA	S14/IDA 3	04S 06E 13DDB	6/27/2006	463	214	100	350	6	0	351	391	784	1620	31
USGS	430432115424601	04S 06E 14CBAB1	11/28/2000	535	145	63.6	300	11.2	0	374	267	510	1590	14.2
USGS	430427115425301	04S 06E 14CBCA1	11/28/2000	530	58.9	24.5	17.7	4.23	0	129	53.1	84.5	363	2.57
USGS	430412115425401	04S 06E 14CCCA1	11/28/2000	520	271	106	368	6.86	0	205	730	692	2360	8.44
USGS	430447115440701	04S 06E 15BCBB1	8/13/2003	500	26.3	12.8	16	3.17	0	107	16.5	27.7	203	1.14
USGS	430319115440701	04S 06E 22CCC1	8/11/1976	500	30	11	15	3.4	0	110	17	29	202	1.7
USGS	430625115403401	04S 07E 06BCB1	7/13/2004	610	35.4	15.4	21.2	4.48	0	169	11.3	32	256	2.75
USGS	430550115403301	04S 07E 07BBB1	10/24/1989	22	34	8.9	51	6.9	0	204	12	45	316	2.4
USGS	430526115393201	04S 07E 07DAA1	7/10/2007	470	34	14.2	17.5	3.83	0	130	14.7	35.8	244	3.14
USGS	430432115390501	04S 07E 17CAB1	7/26/2005	500	43.2	21.7	24.8	4.41	0	157	26.7	61.7	326	4.08
USGS	430352115401301	04S 07E 19BDB1	8/10/1976	605	23	8.1	27	5.6	0	140	9.3	19	225	1.1
USGS	430337115385601	04S 07E 20CAA1	8/21/2002	625	43.3	16	30.7	5.04	0	148	29.9	60	331	3.99
USGS	430307115375601	04S 07E 28BBA1	9/12/1980	464	17	8.5	32	5.5	0	120	13	27	225	1.7

Table 11. Oxygen and deuterium isotope results for locations sampled by DEQ and ISDA. (SW in the well depth column indicates a surface water sampling site.)

Monitoring Location	Township, Range and Section	Well Depth (ft)	Sample Date	δ ^{18}O (permil)	δD (permil)
MW-2	04S 06E 12CCC	14	06/27/06	-6.3	-78
MW-2	04S 06E 12CCC	14	11/21/06	-7.0	-78
MW-2	04S 06E 12CCC	14	02/12/07	-7.3	-79
MW-2	04S 06E 12CCC	14	03/12/07	-7.4	-81
MW-2	04S 06E 12CCC	14	04/16/07	-7.5	-81
MW-2	04S 06E 12CCC	14	05/14/07	-7.3	-80
MW-2	04S 06E 12CCC	14	11/14/07	-7.6	-83
MW 3	04S 06E 12CCD	13	6/27/2006	-14.3	-114
MW 3	04S 06E 12CCD	13	11/21/2006	-14.3	-115
MW 3	04S 06E 12CCD	13	2/12/2007	-14.3	-113
MW 3	04S 06E 12CCD	13	3/12/2007	-14.4	-114
MW 3	04S 06E 12CCD	13	4/16/2007	-14.4	-112
MW 3	04S 06E 12CCD	13	5/14/2007	-14.4	-112
MW 3	04S 06E 12CCD	13	11/14/2007	-14.5	-116
I-1	04S 07E 17BBB	SW	4/16/2007	-13.1	-106
I-1	04S 07E 17BBB	SW	5/14/2007	-14.5	-111
PWS-S	04S 06E 12DAA	Unknown	11/20/2006	-15.3	-117
PWS-W	04S 06E 12CAD	535	11/20/2006	-15.8	-125
S1	04S 06E 13DCD	460	5/14/2007	-15.0	-118
S2	04S 06E 24ABA	590	5/14/2007	-16.2	-123
S7	04S 06E 14DBA	Unknown	5/14/2008	-16.4	-131
S8	04S 06E 14ACA	Unknown	5/14/2008	-16.5	-131
S11	04S 06E 11CDD	Unknown	5/14/2008	-12.4	-108
S12	04S 06E 11CDC	Unknown	5/14/2008	-11.2	-103
S13	04S 06E 11CBA	Unknown	5/14/2008	-16.5	-131
S14/3	04S 06E 13DDB	463	3/12/2007	-12.4	-106
S14/3	04S 06E 13DDB	463	4/16/2007	-12.6	-104
S14/3	04S 06E 13DDB	463	5/14/2007	-13.0	-107
S14/3	04S 06E 13DDB	463	5/14/2008	-11.8	-103
S14/3	04S 06E 13DDB	463	5/14/2008	-11.8	-103
S15	04S 06E 11DAB	Lagoon	11/14/2007	-7.0	-79
S15	04S 06E 11DAB	Lagoon	5/14/2008	-11.1	-99
S15	04S 06E 11DAB	Lagoon	9/8/2008	-2.8	-62
S16	04S 06E 11CDA	Unknown	5/14/2008	-12.2	-106
S30	04S 06E 12CBC	Lagoon	6/27/2006	-10.3	-95
S30	04S 06E 12CBC	Lagoon	11/20/2006	-5.4	-73
S30	04S 06E 12CBC	Lagoon	2/12/2007	-9.7	-91
S30	04S 06E 12CBC	Lagoon	3/12/2007	-9.6	-91
S30	04S 06E 12CBC	Lagoon	4/16/2007	-9.3	-88
S30	04S 06E 12CBC	Lagoon	5/14/2007	-9.0	-86
S30	04S 06E 12CBC	Lagoon	9/8/2008	-4.6	-72
S40	04S 06E 01CCA	Lagoon	11/14/2007	-16.0	-124
S40	04S 06E 01CCA	Lagoon	9/8/2008	-15.9	-125
S41	03S 06E 36CAA1	Pond	9/8/2008	-13.9	-116
S42	04S 06E 12DAD	Unknown	11/20/2006	-15.6	-122

Table 11. Concluded.

Monitoring Well/Pond	Township, Range and Section	Well Depth (ft)	Sample Date	δ ^{18}O (permil)	δD (permil)
S42	04S 06E 12DAD		9/8/2008	-15.5	-124
S43	03S 06E 36CAA2	Pond	9/8/2008	-6.7	-84
S44	04S 07E 07DCB	Pond	9/8/2008	-12.4	-109
1	04S 06E 13ADA	360	6/27/2006	-13.9	-115
2	04S 06E 13DAD1	475	6/27/2006	-15.6	-125
3	04S 06E 13DDB	463	9/14/2005	-12	-107
4	04S 06E 13AAA1	140	6/27/2006	-14.5	-118
5	04S 06E 13AAA2	190	6/27/2006	-14.5	-119
6	04S 06E 13AAA3	79	6/27/2006	-13.9	-114
7	04S 06E 13DCD	460	6/27/2006	-15.2	-124
0802	04S 06E 24ADB	586	8/23/2006	-15.4	-128
9	04S 06E 12CDD	30	6/27/2006	-13.8	-113
23	04S 06E 12CDC	Unknown	6/27/2006	-15.9	-126
25	04S 06E 12DCC	Unknown	6/27/2006	-16.1	-128
26	04S 06E 13BAB	Unknown	6/27/2006	-13.7	-114
27	04S 06E 13BBA	Unknown	6/27/2006	-16.2	-126
30	04S 06E 24AD1	Unknown	6/26/2006	-16.2	-126
31	04S 06E 13DAD2	Unknown	6/26/2006	-14.9	-120
32	04S 06E 13DDD	Unknown	6/26/2006	-15.7	-126
33	04S 06E 13DDA	Unknown	6/26/2006	-15.5	-123
34	04S 06E 24AAA	Unknown	6/26/2006	-15.7	-124
38	04S 06E 24ABA	Unknown	6/26/2006	-16.2	-126
39	04S 06E 13DAA1	Unknown	6/26/2006	-15.5	-123
40	04S 06E 13DAA2	Unknown	6/26/2006	-15.7	-123
41	04S 07E 07CCC3	Unknown	6/27/2006	-14.9	-123
42	04S 07E 18BBB	Unknown	6/27/2006	-14.6	-119
43	04S 07E 18BBC1	Unknown	6/27/2006	-14.8	-117
45	04S 07E 18BBC2	Unknown	6/28/2006	-14.8	-120
46	04S 06E 13DAD3	Unknown	6/28/2006	-15.6	-124
47	04S 06E 24AAD2	Unknown	6/28/2006	-16.2	-127