Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Quality Monitoring Results for Northern Cassia County, Idaho

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ISDA Technical Results Summary #24 January 2005

Introduction

The Idaho State Department of Agriculture (ISDA) developed the Regional Agricultural Ground Water Quality Monitoring Program to characterize degradation of ground water quality by contaminants leaching from agricultural sources. The objectives of the program are to: (1) characterize ground water quality related primarily to nitrate and pesticides, (2) determine if legal pesticide use contributes to aquifer degradation, (3) relate data to agricultural land use practices, and (4) provide data to support Best Management Practices (BMP) and/or regulatory decision making and evaluation processes. ISDA currently is implementing 14 regional ground water quality monitoring projects in Idaho (Figure 1). Additional projects currently are being planned for other areas of the state.

The regional monitoring project in northern Cassia County (Figure 1) was initiated in 1998 as a result of previous monitoring by the Idaho Department of Water Resources (IDWR). A water well in the northern Cassia County area, tested during the first round of IDWR's Statewide Ambient Ground Water Quality Monitoring Program, exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) of 10 milligrams per liter (mg/L) for nitrate-nitrogen (NO_3-N) (Neely and Crockett, 1999). Numerous wells also tested in the 2 to 10 mg/L range for NO_3-N (Neely and Crockett, 1999). To establish this regional monitoring project, ISDA randomly selected domestic wells in the area and coordinated with homeowners to conduct ground water sampling.

Nutrients, common ions, stable isotopes, and pesticides have been and are being evaluated to determine impacts to ground water and locate potential sources. Laboratory results indicate that numerous domestic wells in the Cassia County have exceeded 10 mg/L for NO_3-N during the seven-year period (1998 to 2004) of ISDA testing. Evaluation of mean and median NO_3-N levels suggest no trend or a slight decreasing trend with concentrations ranging between 5.1 to 6.3 mg/L. Stable isotope testing of selected wells suggest fertilizers to be the dominant source of NO_3-N found in the ground water. Low level detections of various pesticides also have occurred between the 1998 and 2004 time period. However, no detections have exceeded any EPA health standards for pesticides in drinking water. ISDA currently is working to

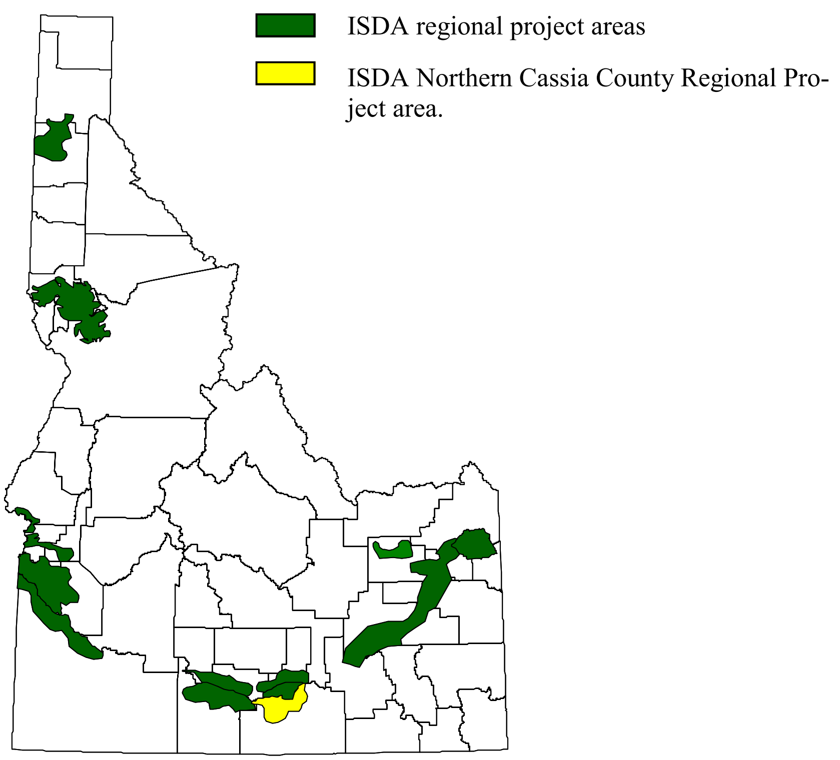

Figure 1. Locations of ISDA Regional Agricultural Ground Water Quality Monitoring Program projects including northern Cassia County project area.

advise residents and officials of the area to reduce further ground water contamination and possible health risks. ISDA will continue ground water monitoring to assist with these efforts.

Methods

To establish this project, ISDA statistically assessed IDWR Statewide Program nitrate, chloride, and atrazine monitoring data. ISDA statistically determined that sampling 46 randomly selected domestic wells would provide adequate data to evaluate overall ground water quality underlying the area. All sampling was conducted after a quality assurance project plan (QAPP) was established. Permission was gained from the land owners prior to sampling.

Water samples were collected annually in the summer from 1998 to 2004. All sample collections followed established ISDA protocols (on file at ISDA main office) for handling, storage, and shipping. Testing of common ions was completed at the Magic Valley Laboratory in Twin Falls, Idaho from 1998 to 2001. Beginning in 2002, common ion testing has been completed at the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, which included tests for nitrate, nitrite, ammonia, orthophosphorous, chloride, sulfate, bromide, and fluoride using EPA Methods 300.0 and 350.1. Duplicates and blank samples were collected and submitted as a part of the QAPP.

Since 2001, samples have been collected from selected wells following ISDA protocols for nitrogen isotope and oxygen isotope analysis. Samples were frozen and shipped via Federal Express one-day service to the North Carolina State University (NCSU) Stable Isotope Laboratory in Raleigh, North Carolina.

Due to budgetary constraints in 2004, the NSCU Stable Isotope Laboratory was unable to conduct isotope testing for ISDA. Isotope samples collected in 2004 were therefore sent to the Idaho Stable Isotopes Laboratory at the University of Idaho in Moscow, Idaho. Samples were collected and shipped following ISDA protocols. Results of 2004 isotope testing are still pending.

In 1998, 2000, and 2002, samples were sent to UIASL for pesticide analysis. UIASL used gas chromatography scans for pesticides utilizing EPA methods 507, 508, and 515.1. Duplicates, blanks, and matrix spikes/matrix spike duplicates were collected and submitted as a part of the QAPP.

Land Use

The Cassia County regional ground water project encompasses an approximately 16 by 30 mile expanse of agricultural land in northern Cassia County (Figure 1). Major crops in the area include alfalfa, sugar beets, potatoes, corn, wheat, barley, beans, and oats (Idaho Agricultural Statistics Service, 2004). Many small and large dairies and feedlots also are located in the area. Nitrogen from commercial fertilizers, residues from legume crops, septic system effluent, and animal waste provide the greatest potential source of nitrate contamination to ground water in the study area.

Hydrogeology/Geology

The hydrogeology of Cassia County consists of an upper aquifer within sedimentary alluvial deposits overlying a lower aquifer situated in fractured basalt. The majority of wells evaluated within the regional ground water study draw ground water from the upper sedimentary alluvial aquifer (Figure 2). Based on well drillers' reports from domestic wells in the project area, typical depth to ground water is less than 50 feet below ground level in the upper aquifer and over 150 feet below ground level in the lower aquifer.

The shallow aquifer medium is composed of alluvial deposits, mainly sand and gravel, with interbedded clay layers (Figure 2). Major sources of recharge to the underlying ground water system include, applied irrigation water, canal leakage, surface water leak-

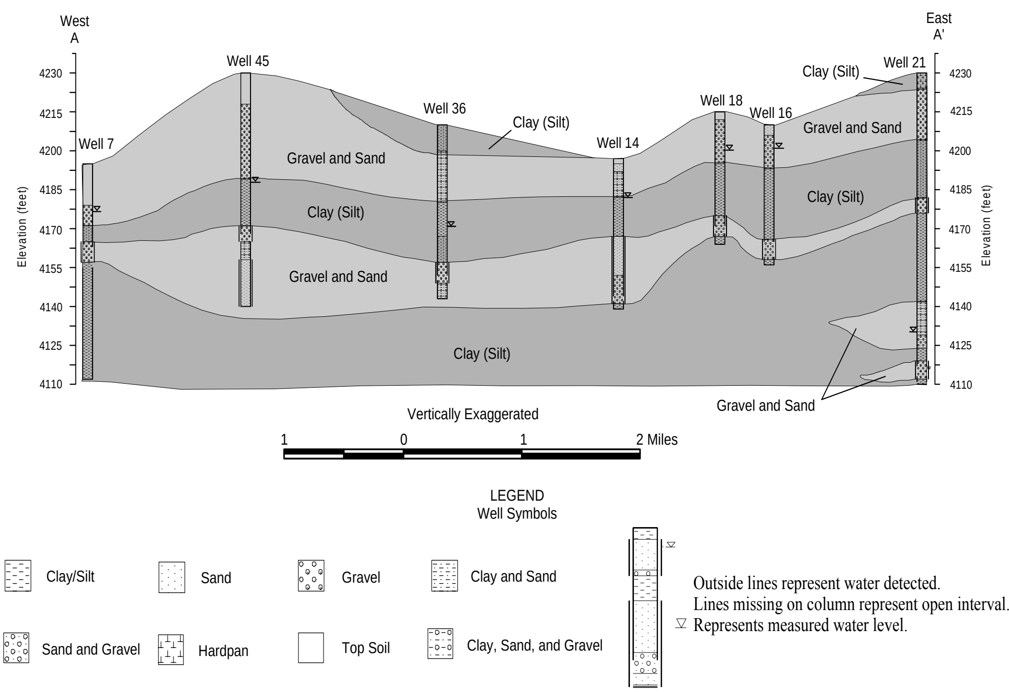

Figure 2. West to east geologic cross section of upper alluvial deposits based on well drillers' reports within study area. Refer to Figure 3 for geologic cross section line. (after Tesch, et. al., 2002).

age, and precipitation. Ground water flow direction in the study area is variable (Tesch, et. al., 2002).

Results

Beginning in the summer of 1998 and continuing through the present, ISDA Water Program staff have been conducting annual ground water sampling in the northern Cassia county area. The following section provides a summary of nitrate, pesticide, and stable isotope testing from 1998 through 2004. Other water quality data (e.g., sulfate, ammonia, chloride) not presented in this report is available on the ISDA website at http://www.agri.idaho.gov/gw/gwdatasummary.htm.

Nitrate

Of the constituents being sampled, nitrate presents a concern because of potential adverse health effects. Although chronic, long term health risks of nitrate consumption are not fully understood; short term effects are well documented. Methemoglobinemia (blue baby syndrome), which is characterized by the reduced ability of the blood to carry oxygen in infants, can afflict infants consuming water with high levels of nitrate (Parliman, 2000). Consumption of large concentrations of nitrate also may be associated with non-Hodgkins lymphoma (Parliman, 2000).

Results of ground water sampling in the northern Cassia County area from 1998 to 2004 indicate ground water from a number of wells exceed the EPA MCL. Figure 3 illustrates the range of nitrate concentrations found in local ground water in 2004 with red sites indicating those currently exceeding the EPA MCL for nitrate. Based on a statistical evaluation of 42 wells that have consistently been sampled over the seven-year period of ISDA testing, 9% to 19% of wells exceed the EPA MCL (Table 1). Maximum concentrations are typically between 12 mg/L to 16 mg/L. Most exceedances appear to occur in an area east of State Highway 27. An anomalously high value of 68 mg/L was recorded at one site in 1998.

For all years tested, there were numerous detections of nitrate between 5.0 and 10 mg/L (Table1). Statistical findings indicate anywhere from 33% to 45% of wells fall within this cate-

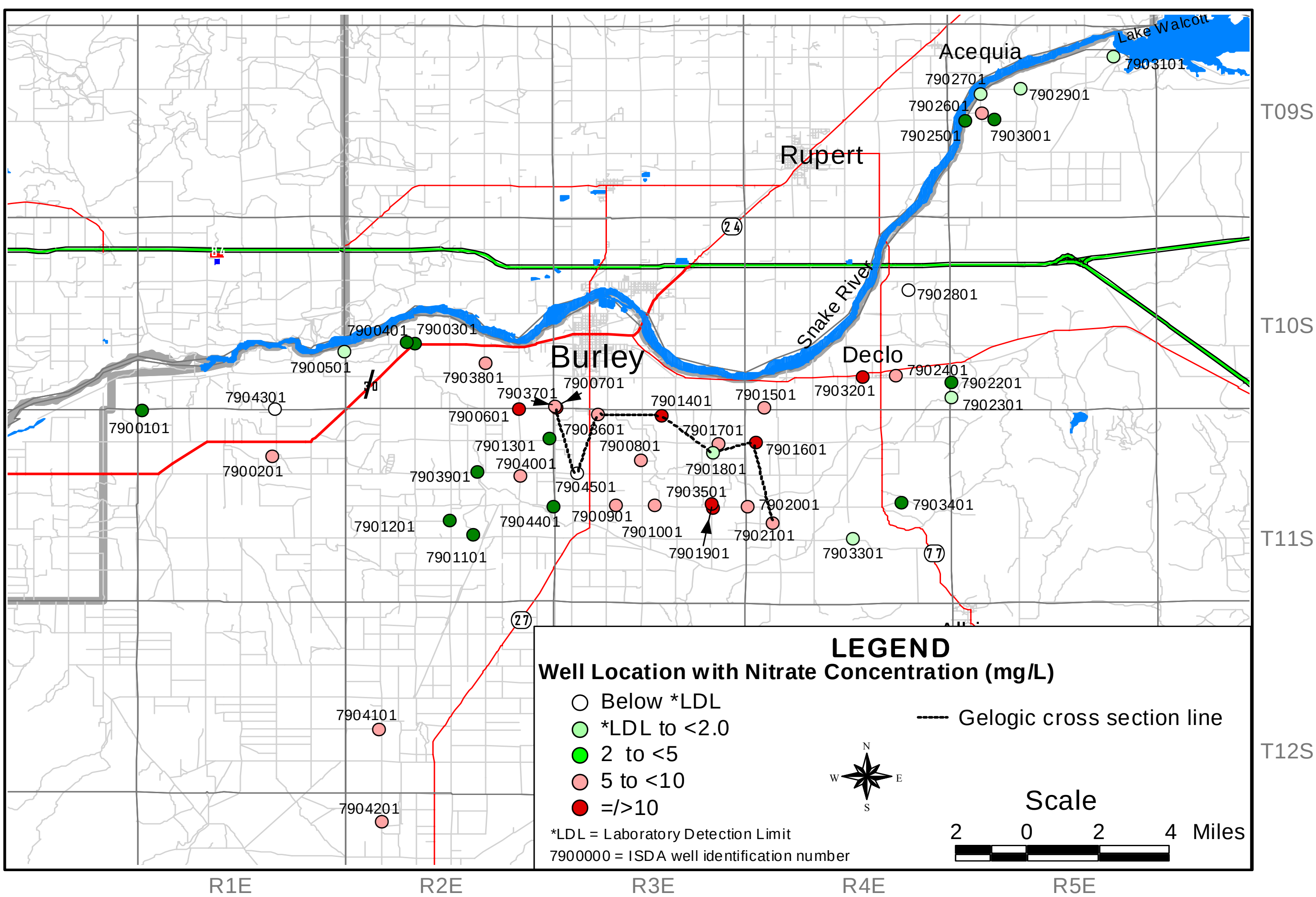

Figure 3. Map of wells with geologic cross section line, ISDA identification numbers, and groundwater nitrate concentration ranges from sampling in 2004.

Table 1. Statistical summary of nitrate detections in ground water from domestic wells during 1998 to 2004.

Statistical category	1998	1999	2000	2001	2002	2003	2004
Number of Wells	42	42	42	42	42	42	42
<LDL* (0.033)	0%	0%	0%	0%	0%	0%	0%
LDL to <2.0	12%	12%	14%	14.3%	17%	17%	16.7%
2.0 to <5.0	38%	33%	24%	33.3%	31%	31%	28.6%
5.0 to <10	33%	38%	45%	33.3%	42.5%	42.5%	38%
>/=10	17%	17%	17%	19.1%	9.5%	9.5%	16.7%
Mean Nitrate (mg/L)	7.3	6.3	6.3	6.0	6	5.3	5.8
Median Nitrate (mg/L)	5.4	6.1	6.3	5.4	5.3	5.1	5.6
High Nitrate (mg/L)	68	16	12	13	12	15	16

*LDL - Laboratory Detection Limit

gory of nitrate concentrations. Similar percentages can be found for the 2 mg/L to 5 mg/L nitrate concentration range. Many ground water scientists in Idaho believe that nitrate levels exceeding 2 mg/L are above any naturally occurring levels and indicate human impacts.

Median and mean concentration can be a useful tool to evaluate any potential trends either increasing, decreasing, or neither. Evaluation of mean and median values from the 42 wells shown in Table 1 suggest that levels appear to be somewhat constant or decreasing. Mean concentrations have ranges from 7.3 mg/L (1998) to 5.3 mg/L (2003). Median concentrations have ranges from 5.1 mg/L (2003) to 6.3 mg/L (2000).

Pesticides

ISDA has conducted three pesticide sampling events, testing all wells that are or were part of the project during that year. The years of sampling included 1998, 2000, and 2002. ISDA did not test pesticides every year due to the expense of the testing. Although there have been a number of detections during each year of testing, the detections have been low in concentration and results suggest declining trends in both overall average concentrations and maximum detection values (Table 2). ISDA plans to do another round of pesticide testing in 2005.

Testing of ground water samples collected during 1998 detected the presence of atrazine, dacthal, diuron, hexazinone, metolachlor, and simazine (Table 2). There were a total of 33 positive pesticide detections with atrazine and simazine being the most commonly detected pesticides. Detections of atrazine and simazine combined represented 73% (24 detections) of the 33 positive detections in 1998. All pesticide detections were below any health standard as set by the EPA or the state of Idaho.

Testing of ground water samples collected during the summer of 2000 detected the presence of atrazine, bromacil, dacthal, diuron, prometon, and simazine (Table 2). There were a total of 30 positive pesticide detections with

Table 2. Pesticide testing results for detections in ground water from domestic for 1998, 2000, and 2002.

Pesticide		Year 1998			Year 2000			Year 2002			
Chemical Name	Trade Names	Detects1998	Avg. Detect Conc. (µg/l)	Max. Conc. (µg/L)	Detects 2000	Avg. Detect Conc. (µg/l)	Max. Conc. (µg/L)	Detects 2002	Avg. Detect Conc. (µg/l)	Max. Conc. (µg/L)	Health Standard (µg/L)
Atrazine	Atrazine	17	0.22	0.33	17	0.11	0.30	13	0.07	0.15	3 (MCL)*
Bromacil	Hyvar, Krovar	0	--	--	1	1.7	1.7	0	--	--	70 (HAL)**
Dacthal	Dacthal	4	2.10	4.4	1	8.7	8.7	0	--	--	70 (HAL)**
Desthyl Atrazine[1]	-----	--[2]	--	--	--[2]	--	--	18	0.05	0.14	3 ***
Diuron	Karmex, Krovar	2	0.41	0.48	2	0.23	0.33	0	--	--	10 (HAL)**
Hexazinone	Velpar	2	0.09	0.09	0	--	--	0	--	--	400 (HAL)**
Metolachlor	Dual Magnum, Pennant, Magnum	1	0.10	0.10	0	--	--	0	--	--	100 (HAL)**
Prometon	Pramitol, Gesafram, Caliber	0	--	--	1	0.08	0.08	0	--	--	100 (HAL)**
Simazine	Princep	7	0.19	0.64	8	0.05	0.19	2	0.08	0.13	4 (MCL)*

*MCL - EPA Maximum Contaminant Level
**HAL - EPA Lifetime Health Advisory Level
*** EPA health standard not available. Standard listed is used by ISDA based on toxicological similarities to atrazine parent product.
[1]Breakdown product of atrazine.
[2]Compound not tested for during this sampling event.

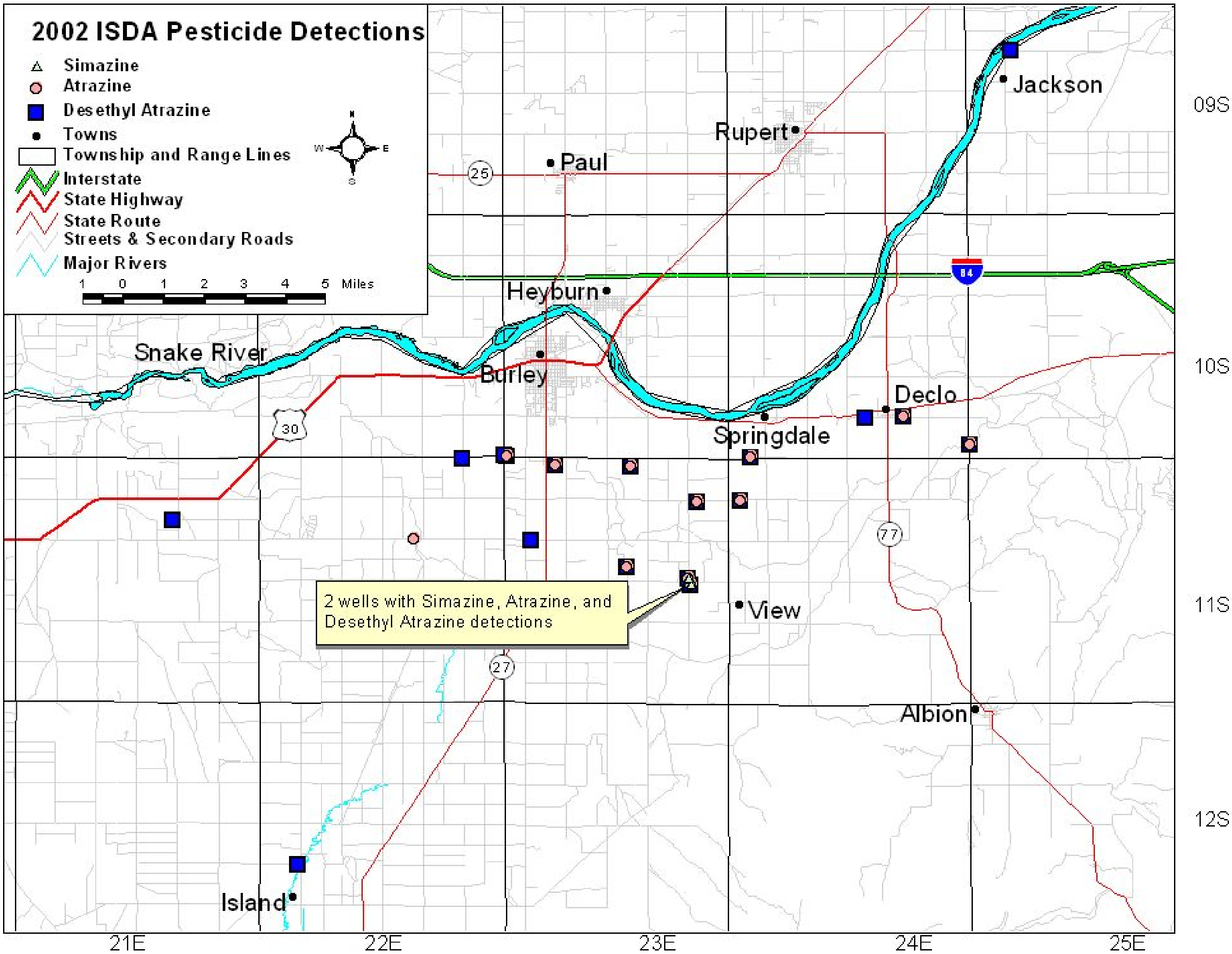

Figure 4. Map showing location and pesticide detection from ISDA testing in 2002.

atrazine and simazine being the most commonly detected pesticides. Again, all pesticide detections were below any health standard as set by the EPA or the state of Idaho.

Testing of ground water samples collected during the summer of 2002 detected the presence of atrazine, atrazine desthyl, and simazine (Table 2 and Figure 4). In 2002, atrazine desthyl (a breakdown product of atrazine) was added to the testing regiment and was the most commonly detected compound. The other compounds previously detected in 1998 and 2000 were not detected in 2002 (i.e., bromacil, dacthal, metolachlor, diuron, and prometon. Again, all pesticide detections were below any health standard as set by the EPA or the state of Idaho.

Nitrogen and Oxygen Isotopes

Overview

The ratio (denoted $\delta^{15}N$) of the common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N can be useful in determining sources of nitrate. Common sources of nitrate in ground water are from applied commercial fertilizers, animal or human waste, precipitation, residues from legume crops, and other organic nitrogen sources within the soil. Each of these nitrate source categories has a distinguishable nitrogen isotopic signature. Figure 5 illustrates ranges of $\delta^{15}N$ determined through numerous research studies. Typical $\delta^{15}N$ ranges for fertilizer and waste are –5 $^0/_{00}$ to +5 $^0/_{00}$ and greater than 10, respectively. Numbers between 5 $^0/_{00}$ and 10 $^0/_{00}$ generally are believed to indicate an organic or mixed source.

Use of nitrogen isotopes as the sole means to determine nitrate source should be done with great care. $\delta^{15}N$ values of fertilizer and animal waste in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, ion exchange, and plant uptake) that can significantly modify the $\delta^{15}N$ values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrifi-

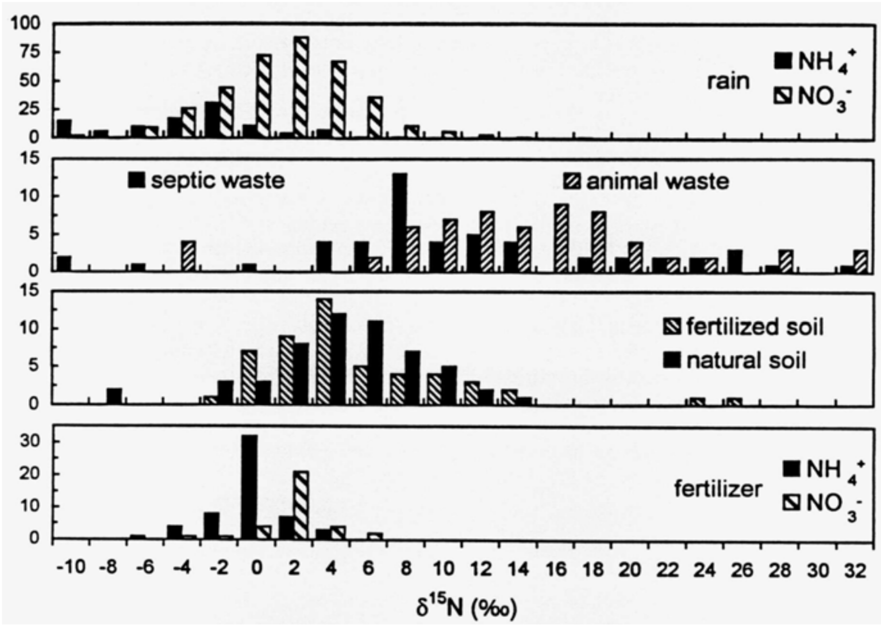

Figure 5. Ranges of $\delta^{15}N$ found in the hydrosphere based on a number of nitrogen isotope studies (after Kendall and McDonnell, 1998).

cation very difficult (Kendall and McDonnell, 1998).

^{18}Oxygen (^{18}O) fractionization of the nitrate molecule together with $\delta^{15}N$ can be used to trace the effects of denitrification (Clark and Fritz, 1997). Denitrification results in enrichment of both $\delta^{15}N$ and $\delta^{18}O_{NO_3}$. By analyzing both $\delta^{15}N$ and $\delta^{18}O_{NO_3}$, denitrification effects can be distinguished from mixing sources since the ratio of enrichment in $\delta^{15}N$ to $\delta^{18}O_{NO_3}$ is about 2:1 (Kendall et. al, 1995).

Findings

ISDA Water Program staff opted to implement $\delta^{15}N$ and $\delta^{18}O_{NO_3}$ testing in order to use it as a possible indicator of source(s) of nitrate in the ground water. Because of the cost of testing and limited resources, only a portion of the wells in the area were selected for testing. This included all wells exceeding 10 mg/L for nitrate and a number of spatially distributed wells with nitrate detections above 5 mg/L. To date, samples have been collected for testing during three separate sample events.

Nine sites were initially selected in the study area to conduct isotope testing. The number of sites was expanded in 2002, and 2003 to learn more about possible sources. Results of $\delta^{15}N$ testing in 2001 returned values that ranged from 3.06 to 10.28 $^{0}/_{00}$ (Table 3). Fifty-six percent of these wells suggested a potential fertilizer souce. One well (well 7900138) tested above 10 for $\delta^{15}N$. The rest of the $\delta^{15}N$ results (33%) tested between 5 $^{0}/_{00}$ and 10 $^{0}/_{00}$, which suggests an organic or mixed source.

Twenty sites were selected in 2002 to conduct isotope testing. Results of $\delta^{15}N$ testing in 2002 returned values that ranged from 0.59 $^{0}/_{00}$ to 7.75 $^{0}/_{00}$ (Table 3). Sixty-five percent of these wells suggested a potential fertilizer source. No wells returned $\delta^{15}N$ isotope numbers above 10 $^{0}/_{00}$ that might suggest a solely animal or human waste source. Well 7900138 was not tested in 2002 or 2003 because of lower nitrate concentrations. The rest of the $\delta^{15}N$ (35%) tested between 5 $^{0}/_{00}$ and 10 $^{0}/_{00}$, which suggests an organic or mixed source.

Sixteen sites were sampled in 2003 for $\delta^{15}N$ isotopes. Results of $\delta^{15}N$ testing in 2003 returned values that ranged from 4.12 to 9.47 $^{0}/_{00}$ (Table 3). Thirty one percent of these wells suggested a potential fertilizer source. No wells returned $\delta^{15}N$ isotope numbers above 10 $^{0}/_{00}$ that might suggest a solely animal or human waste source. The majority of the $\delta^{15}N$ results for selected wells (69%) tested between 5 $^{0}/_{00}$ and 10 $^{0}/_{00}$, which suggests an organic or mixed source. This may suggest a shift in contaminant sources possibly related to some land use changes.

Overall, $\delta^{15}N$ testing indicate that fertilizer may be the dominant source of nitrate found in the ground water of northern Cassia County. Evaluations for $\delta^{18}O_{NO3}$ testing results suggest no effects of denitrification, which corresponds overall to the low $\delta^{15}N$ values.

Table 3. Results of nitrogen isotope testing for selected wells.

	δ15N ($^{0}/_{00}$)		
Well ID	**2001**	**2002**	**2003**
7900601	9.45	3.47	5.92
7900801	NS	4.60	5.17
7900901	NS	3.65	5.67
7901001	NS	2.92	5.67
7901401	3.06	4.69	8.32
7901501	NS	5.25	4.12
7901601	NS	2.63	4.73
7901701	4.25	0.59	5.12
7901801	NS	5.05	NS
7901901	NS	5.11	8.94
7902001	3.31	3.30	NS
7902101	NS	2.27	4.83
7902401	NS	2.93	NS
7902601	5.76	7.10	9.47
7903201	7.59	4.55	7.20
7903401	NS	2.82	NS
7903501	NS	5.20	4.70
7903601	NS	7.75	4.78
7903701	NS	5.53	7.60
7903801	10.28	NS	NS
7904201	4.73	3.38	5.41
7904401	4.81	NS	NS
Potential Source	**Totals**	**Totals**	**Totals**
Fertilizer	5 (56%)	13 (65%)	5 (31%)
Mixed/Organic	3 (33%)	7 (35%)	11 (69%)
Animal/Human Waste	1 (11%)	0 (0%)	0 (0%)

NS = Not Sampled

Conclusions

Ground water underlying northern Cassia County is being impacted by nitrate and pesticides. Numerous nitrate detections have exceeded the EPA MCL for nitrate in drinking water over the seven-year period of ISDA monitoring. However, evaluation of yearly mean and median concentrations suggest nitrate levels to be constant or declining in concentrations. Pesticide detections were low in concentration; although, there is concern about multiple pesticide detections per sampling well. Little is understood about the health effects of consuming low quantities of multiple pesticides.

The number of wells exceeding 10 mg/L for nitrate is a potential health concern. For the seven-year period of this study, 9% to 19% of wells evaluated exceeded the EPA drinking water standard of 10 mg/L. Wells exceeding the health standard are situated to the east of State Highway 27 in northern Cassia County. The large number of wells between 5 to 10 mg/L also are of concern because of the potential to increase in concentration and exceed the health standard set by EPA.

Numerous pesticide detections also have been detected in ground water underlying northern Cassia County. By far the most numerous detections have been of the pesticides atrazine and simazine. Results of testing in 2002 suggest that concentrations of pesticides found in ground water are declining and the variety of pesticides detected is decreasing.

$\delta^{15}N$ testing results suggest overall that fertilizers may be having the largest impacts on ground water quality. Only one test over three years of ISDA testing has suggested a solely human or animal waste source of nitrate in ground water. However, 2003 testing indicates a shift. The majority of wells (69%) tested now show an organic or mixed source of nitrate. This suggests possible land use changes or potentially greater impacts from animal and/or human waste sources.

Recommendations

To evaluate water quality, determine water quality trends, and changing source contributions to aquifer degradation trends, ISDA recommends continued monitoring in the project area. ISDA further recommends that measures to reduce nitrate and pesticide impacts on the ground water be addressed and implemented. ISDA recommends that:

- Growers and agrichemical professionals conduct nutrient, pesticide, and irrigation water management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service Nutrient Management Standard (590).
- Producers and agrichemical dealers evaluate their storage, mixing, loading, rinsing, containment, and disposal practices.
- Homeowners assess lawn and garden practices, especially near wellheads.
- Local residents assess animal waste management practices.
- State and local agencies assess impacts from private septic systems.
- Home and garden retail stores establish outreach programs to illustrate proper application and management of nutrients and pesticides.
- Responsible parties assess current pesticide application practices to non-crop areas (examples: roadsides, railroads areas, etc).

ISDA recommends that the Cassia Soil and Water Conservation District lead a response process to create a plan of action to address these ground water contamination issues. The soil and water conservation districts should work with local agrichemical professionals, landowners, and agencies to implement this process and seek funding to support these efforts. ISDA will support these local partners in seeking funding and implementing a comprehensive program.

Acknowledgments

The authors would like to thank the well owners in the study area. Without their participation and cooperation, this study would not be possible.

Technical review of this document from the following individuals is greatly appreciated:

Gary Bahr, ISDA
Kirk Campbell, ISDA
Lance Holloway, ISDA

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