Idaho State Department of Agriculture
Division of Agricultural Resources

Regional Ground Water Quality Monitoring Results for Idaho, Lewis, and Nez Perce Counties, Idaho 2001-2007

Rick Carlson
Jessica Atlakson

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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 13 regional ground water quality monitoring projects in Idaho. Additional projects currently are being planned for other areas of the state.

This ISDA Regional Ground Water Monitoring Project in Idaho, Lewis and Nez Perce Counties (Figure 1) was initiated in 2001 as a result of completion of the Idaho Ground Water Quality Plan and Agricultural Ground Water Quality Protection Program for Idaho. In part, these documents mandate regional-scale monitoring of aquifers in the state that may be vulnerable to agricultural activities. Additionally, prior testing by the Idaho Department of Environmental Quality found 20 percent of 55 wells tested across the Camas Prairie exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) for nitrate of 10 milligrams per liter (mg/L) (Bentz, 1998). Also, previous ground water monitoring by the Idaho Department of Water Resources found a well in Nez Perce County that exceeded the EPA MCL for nitrate (Neely and Crockett, 1999).

Nutrients, common ions, stable isotopes, field parameters, and pesticides have been and are currently being evaluated to determine impacts to ground water and locate potential sources. Laboratory results from testing in 2001 through 2007 indicate areas showing water quality degradation from nitrate and to a lesser extent pesticides. Multiple wells in an area between the towns of Cottonwood and Nez Perce and south of Lewiston have

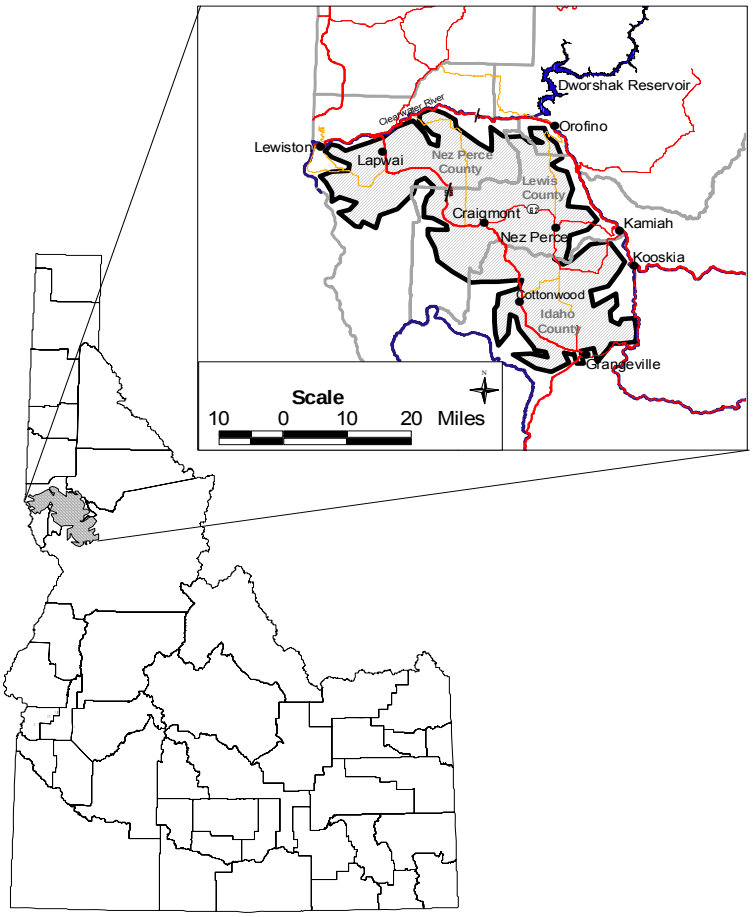

Figure 1. Location of ISDA Regional Ground Water Monitoring Project in Idaho, Lewis, and Nez Perce Counties.

had detections above the EPA MCL for nitrate at sometime during the 2001 to 2007 testing. Also, several wells within the project area have tested positive for pesticides. Of the wells testing positive for pesticides, two well sites have had concentration levels that warrant continued evaluation. One site is located approximately six miles southeast of Lewiston and has had detections of atrazine and atrazine breakdown products with concentrations above half the EPA MCL of 3 parts per billion. The other location, which is approximately six miles east of Ferdinand, has had detections of the pesticide compound triallate that exceed drinking water levels established by the U. S. Food Quality Protection Act.

Methods

To establish this project, ISDA staff developed a project boundary based on known aquifer characteristics and agricultural landuse mapping obtained from the University of Idaho INSIDE Idaho website (University of Idaho, 1997). ISDA staff then statistically assessed Idaho Department of Water Resources Statewide Program nitrate, chloride, and atrazine monitoring data. ISDA statistically determined that sampling 71 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 developed and approved. Permission was gained from the home owners prior to sampling.

Water samples have been collected annually in the summer from 2001 to 2007. 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 University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow. Tests included 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.

In 2001, 2004, and 2007 samples were sent to UIASL for pesticide analysis. Duplicates, blanks, and matrix spikes/ matrix spike duplicates were collected and submitted as a part of the QAPP. Due to a relatively high concentrations of atrazine and desethyl atrazine found at one well south of Lewiston, a localized project was initiated and monitoring of wells in the area is ongoing. More information on detections from this monitoring study can be found on the ISDA website at http://www.agri.idaho.gov/Categories/Environment/water/gwpesticides.php.

From 2002 through 2005, samples were collected from selected wells for nitrogen isotope analysis following ISDA protocols. Samples were frozen and shipped via Federal Express one-day service to North Carolina State University (NCSU) Stable Isotopes Laboratory in Raleigh, North Carolina and the University of Idaho Stable Isotopes Laboratory in Moscow, Idaho.

Description of Project Area

The regional monitoring project area includes portions of Idaho, Lewis, and Nez Perce County (Figure 1). The project covers approximately 950 square miles of agricultural lands that are bounded to the north and east by the Clearwater River and to the west and south by forested non-agricultural lands. Also included within the boundary of the study area is a large portion of the Nez Perce Indian Reservation. The reservation boundary encompasses the central and northern portions of the regional project boundary.

The dominant agricultural practice within the area is dry land farming. Major crops in the area include wheat, barley, beans, oats, peas, and alfalfa (Idaho Agricultural Statistics Service, 2006). Additionally, turfgrasses are grown for seed. Some small dairies and livestock operations also are located in the area. Nitrogen from commercial fertilizers, residue from legume crops, septic system effluent, and animal waste provide the greatest potential source of nitrate contamination to ground water in the study area.

Ground water underlying the area is primarily used for human consumption by municipalities and private farmsteads. The majority of wells evaluated within the regional ground water study draw ground water from interbeds of Columbia River basalts that underlie the area (Bentz, 1998). A few wells are located in localized alluvial aquifers, shallow springs, and granitic medium sources. Based on well drillers' reports from domestic wells in the project area, average static water levels range from 20 to 403 feet below land surface (Table 1).

Table 1. Well information.

Well Depth (feet)	Wells	Average Static Water Level (Feet)	Ranges of Static Water Levels (Feet)
< 100	8	20	+0 to 44
100 to < 200	14	45	+0 to 95
200 to < 300	13	131	51 to 196
300 to < 400	19	169	+0 to 300
400 to < 500	8	245	25 to 370
500 and above	9	403	12 to 580

Major sources of recharge to the underlying ground water system are precipitation and surface water leakage (Bentz, 1998). Ground water flow directions in the study area appear to be

variable and in general towards the larger streams and rivers in the region.

Results

The following section provides a summary of nitrate, pesticide, and stable isotope testing from 2001 through 2007. 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/Categories/Environment/water/gwinorganics.php.

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 have been 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 project area from 2001 to 2007 indicate nitrate problems in an area between the towns of Cottonwood and Nez Perce and to a lesser extent from Lewiston to east of Lapwai. Figure 2 illustrates nitrate concentrations found in ground water underlying the area in 2007. Based on evaluation of 67 wells consistently sampled over the seven-year period of ISDA testing, six to 10 percent of wells exceeded the EPA MCL of 10 mg/L for any given year (Table 2). Maximum concentrations per year ranged from 29 mg/L to 47 mg/L. These maximum concentrations occured consistently at a well approximately seven miles northeast of Cottonwood.

Evaluation of mean values from the 67 wells consecutively sampled from 2001 to 2007 and shown in Table 2 suggest that levels appear to be somewhat constant or slightly increasing (Figure 3). Mean concentrations ranged from a low of 3.1 mg/L in 2001 to 3.7 mg/L in both 2003 and 2006.

Median concentrations suggest no trend with a median of 1.3 mg/L calculated for five of the seven years of testing (Table 2). The highest median (1.9 mg/L) was calculated from monitoring data collected from the 2003 sampling event (Table 2).

In general, ground water quality with respect to nitrate appears to be degraded in two loosely defined areas. The first and apparently most degraded area occurs between the towns of Nez Perce and Cottonwood. Three detec-

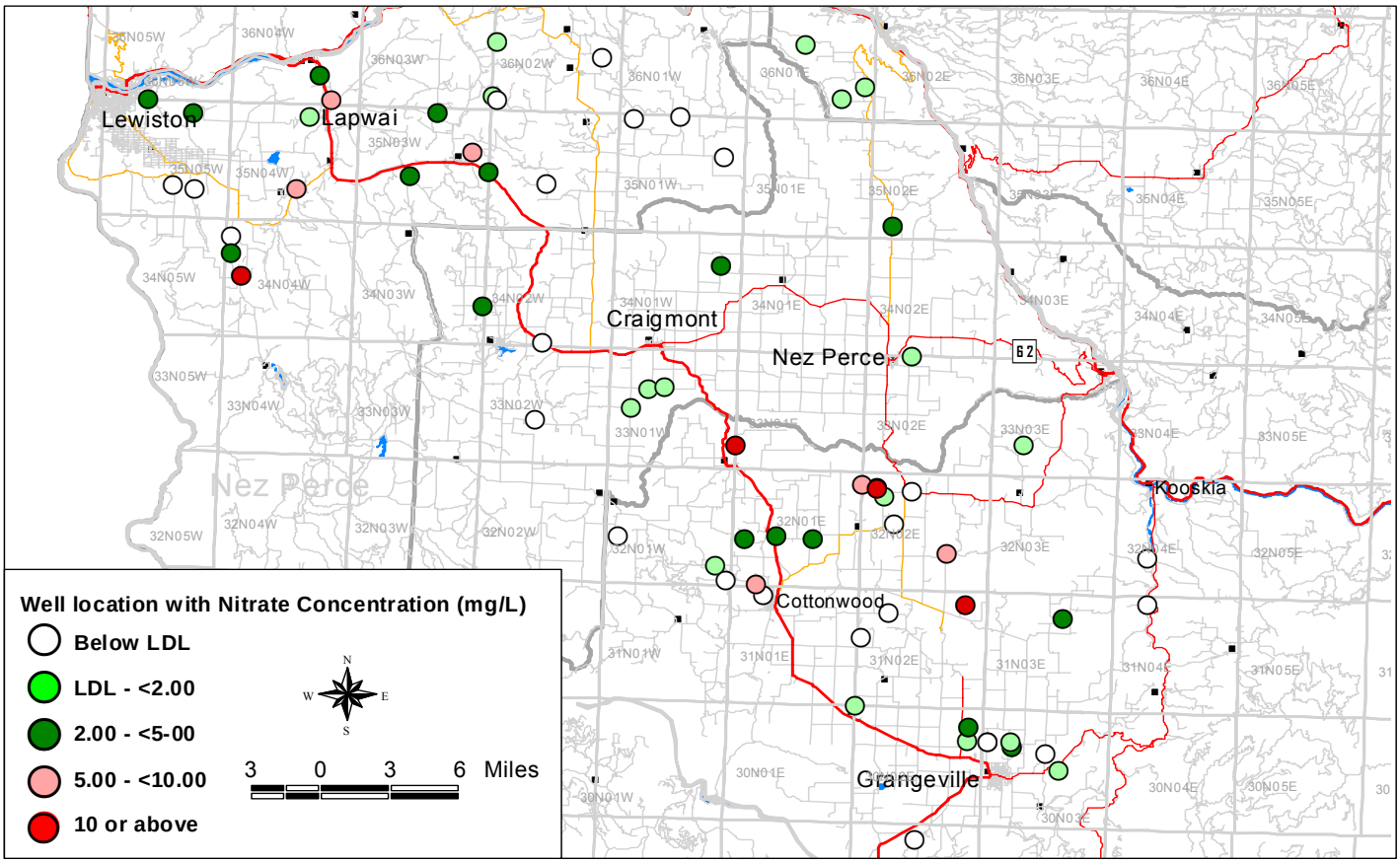

Figure 2. Map of wells locations and ground water nitrate concentration ranges from sampling in 2007.

Table 2. Statistical summary of nitrate detections in ground water from 67 domestic wells tested from 2001 through 2007.

Statistical category	2001	2002	2003	2004	2005	2006	2007
Number of Wells	67	67	67	67	67	67	67
<LDL* (0.05)	13 (19%)	18 (27%)	18 (27%)	15 (22%)	17 (25%)	14 (21%)	13 (19%)
LDL to <2.0	25 (37%)	19 (28%)	16 (24%)	22 (33%)	22 (33%)	22 (33%)	26 (39%)
2.0 to <5.0	19 (28%)	18 (27%)	17 (25%)	16 (24%)	17 (25%)	14 (21%)	12 (18%)
5.0 to <10	5 (7%)	7 (10%)	11 (16%)	8 (12%)	6 (9%)	10 (15%)	12 (18%)
>/=10	5 (7%)	5 (7%)	5 (7%)	6 (9%)	5 (7%)	7 (10%)	4 (6 %)
Mean Nitrate (mg/L)	3.1	3.2	3.7	3.3	3.4	3.7	3.3
Median Nitrate (mg/L)	1.3	1.5	1.9	1.3	1.3	1.3	1.3
High Nitrate (mg/L)	29	38	47	41	39	39	39

LDL - Laboratory detection limit.

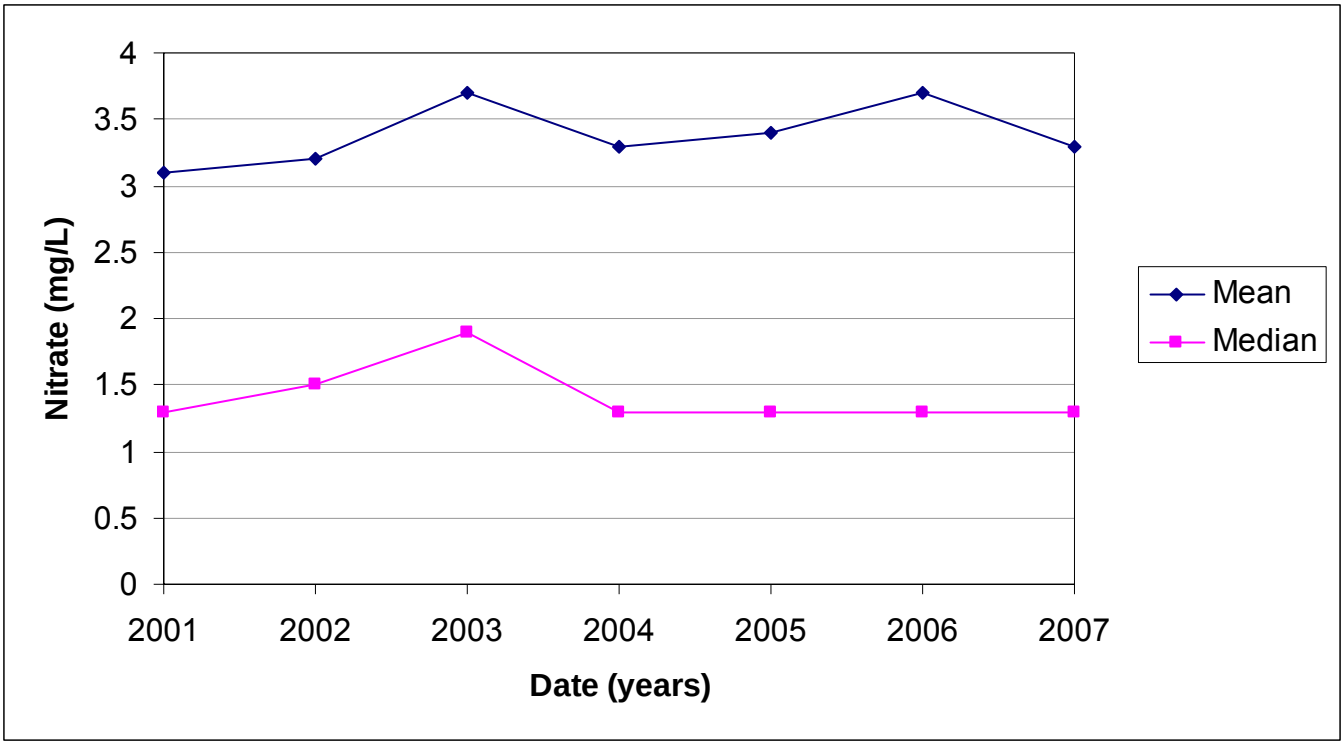

Figure 3. Plot of mean and median nitrate concentrations found in regional ground water based on 67 randomly selected wells tested consecutively from 2001 to 2007.

tions in 2007 exceeded the EPA MCL within this area (Figure 2). Elevated detections also occur within an area beginning approximately six miles south of Lewiston and extending northeast towards Lapwai. One detection exceeding the MCL south of Lewiston was detected in 2007 (Figure 2).

Pesticides

During 2001, 2004, and 2007, ISDA conducted pesticide sampling in all wells that were part of the project during that year. Additionally, ISDA has conducted one or more follow-up testing events at wells having a positive pesticide detection. Pesticide compounds detected include: atrazine, desthyl atrazine (DEA), deisopropyl atrazine (DIA), bromacil, dacthal, diuron, metribuzin, picloram, and triallate. ISDA plans to do another full round of pesticide testing in 2010 for all wells in the project.

Although there have been a number of locations with positive detections, only two sites have had detections with concentration levels that warrant concern (Figure 4). One well located approximately six miles south of Lewiston had detections of atrazine at 1.5 micrograms per liter (µg/L) and desethyl atrazine at 1.8 µg/L in 2001 (Figure 4a). These concentration levels are at 50 percent and 60 percent of the health standard of 3 µg/L used by

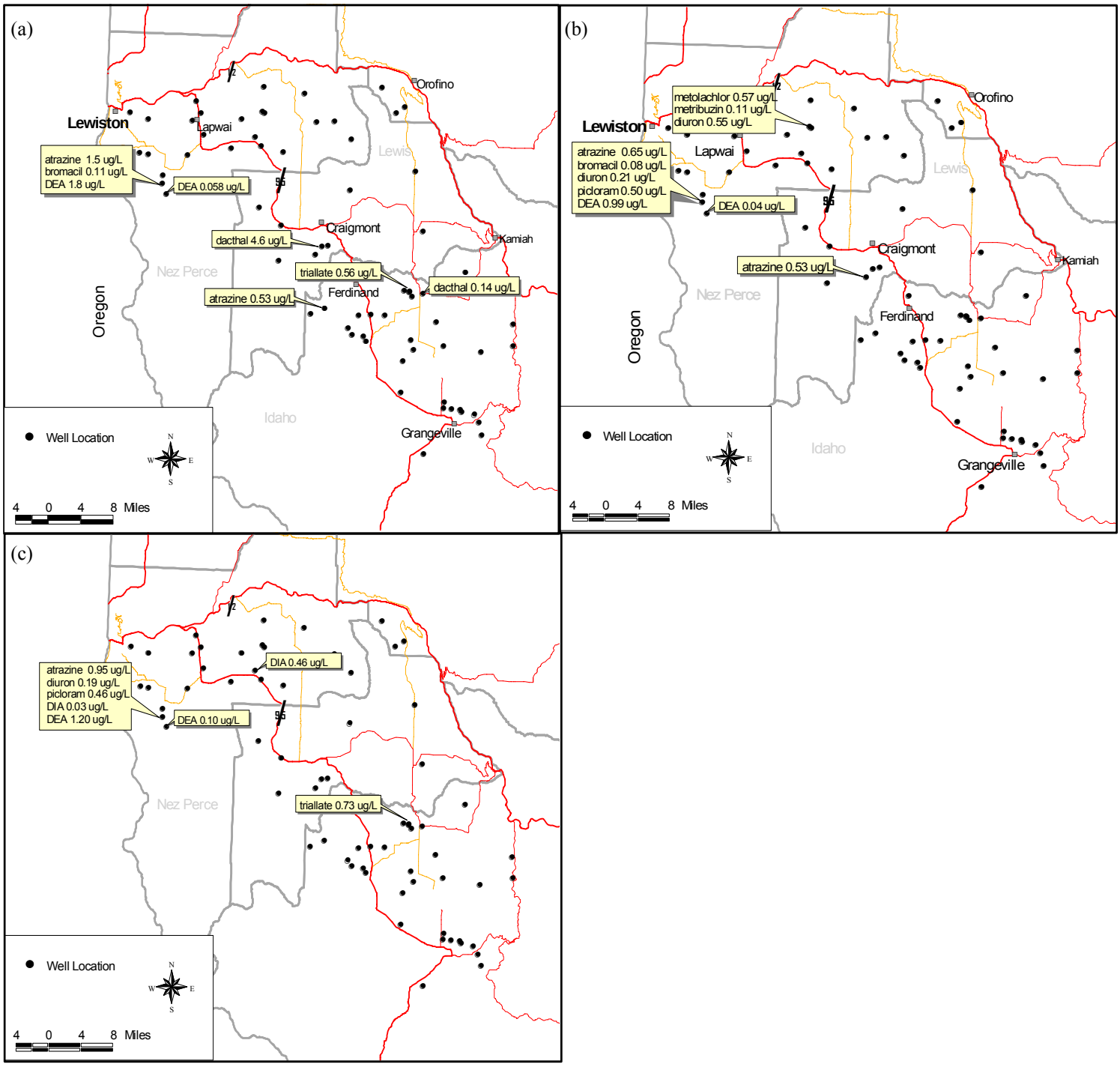

Figure 4. Maps showing well locations and pesticide detections from ISDA testing in (a) 2001, (b) 2004, and (c) 2007.

ISDA, respectively. The atrazine and DEA detections at this well also were elevated during the 2004 and 2007 sampling events. The other site is approximately six miles east of the town of Ferdinand. The well water at this site tested at 0.56 µg/L in 2001 and 0.73 µg/L for triallate in 2007 (Figures 4a and 4c). These concentration levels exceed the 0.45 µg/L health standard used by ISDA for this compound as well as the Federal Food Quality Protection Act. ISDA has increased monitoring and protection activities associated with these detections as prescribed by the Rules Governing Pesticide Management Plans for Ground Water Protection (IDAPA 02.03.01).

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 include applied commercial fertilizers, animal or human waste, pre-

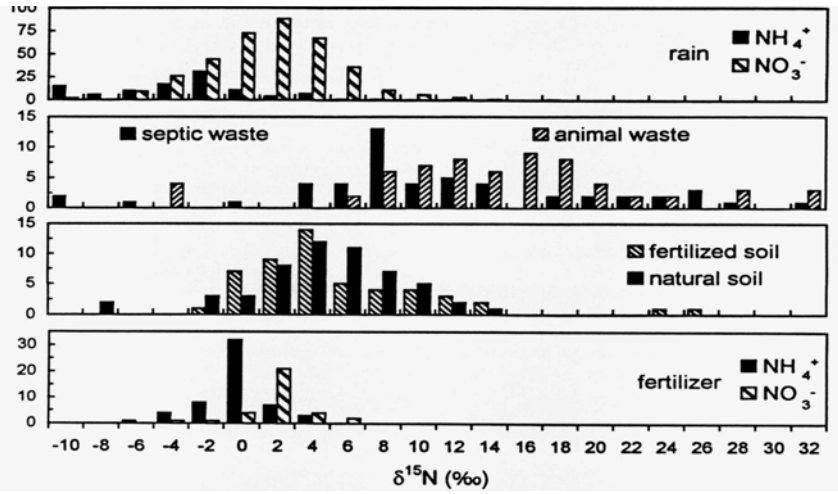

Figure 5. Ranges of δ ^{15}N found in the hydrosphere based on a number of nitrogen isotope studies (after Kendall and McDonnell, 1998).

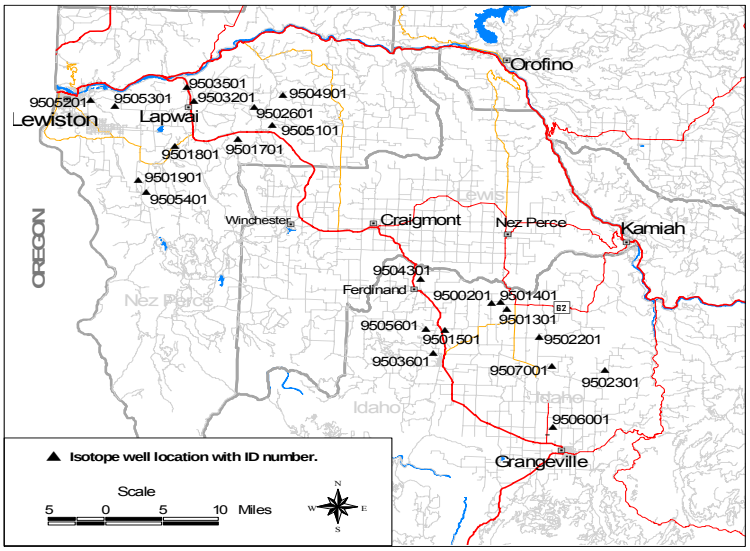

Figure 6. Location of wells tested for $^{\delta 15}$N.

Table 3. Nitrogen isotope findings. Numbers expressed in per mil.

	2002	2003	2004	2005
9500201	7.020	5.31	nt	nt
9501301	nt	6.26	nt	4.45
9501401	7.923	13.91	nt	9.90
9501501	7.299	6.18	5.51	nt
9501701	6.821	nt	nt	nt
9501801	nt	9.21	5.18	nt
9501901	3.103	nt	nt	nt
9502201	nt	5.06	nt	4.87
9502301	12.209	9.25	nt	5.34
9502601	2.310	nt	nt	nt
9503201	2.263	4.80	3.75	4.05
9503501	nt	8.03	nt	6.17
9503601	18.318	16.22	13.95	10.67
9504301	2.386	5.67	4.66	5.48
9504901	nt	nt	6.64	3.66
9505101	10.660	9.22	7.02	6.86
9505201	7.813	10.29	6.95	9.55
9505301	3.444	nt	nt	6.19
9505401	5.024	2.72	-0.42	1.58
9505601	nt	nt	nt	4.74
9506001	2.975	nt	nt	nt
9507001	4.556	6.84	nt	5.12
nt = not tested				

cipitation, residues from legume crops, and other organic nitrogen sources within the soil. Each of these nitrate source categories has a nitrogen isotopic signature. Figure 5 illustrates ranges of δ^{15}N determined through numerous research studies. Typical δ^{15}N ranges for fertilizer and waste are -5 to +5 per mil ($^{0}/_{00}$) and greater than $10^{0}/_{00}$, 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. δ^{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 δ^{15}N values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnell, 1998).

Findings

ISDA Water Program staff implemented δ^{15}N 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, only limited isotope testing was undertaken. Only select sites testing above 5 mg/L nitrate the previous year had samples collected the following year for stable isotope testing.

Results from testing from 2002 through 2005 showed that the majority of sites returned δ^{15}N consistent with fertilizer, organic, or mixed sources (Table 3 and Figure 6). Four sites that returned δ^{15}N greater than $10^{0}/_{00}$ one or more times through 2002 to 2005 may represent locations having potential animal or human waste impacts; sites 9501401, 9502301, 9503601, and 9505101 (Table 3 and Figure 6).

Conclusions

Results of ground water sampling in the Idaho, Lewis, and Nez Perce Counties area from 2001 to 2007 indicate nitrate problems in two distinct areas within the project boundary; a pronounced area between the towns of Cottonwood and Nez Perce and to a lesser extent from Lewiston to east of Lapwai. Over the entire study area, six to 11 percent of wells exceeded the EPA MCL of 10 mg/L for any given year (Table 2). Maximum concentrations per year ranged from 29 mg/L to 47 mg/L. Highest nitrate levels appear to occur consistently in an area between the towns of Cottonwood and Nez Perce

Evaluation of mean values from the 67 wells consecutively sampled from 2001 to 2007 suggest that levels appear to be somewhat constant. In general, ground water quality with respect to nitrate appears to be good in the northeastern portion and most southern regions of the study area.

Nitrogen isotope testing suggests that higher nitrate levels found at testing sites most commonly come from fertilizer, organic, or mixed sources. Results of nitrogen isotope testing suggest that four sites tested may specifically be impacted from a waste source, either animal or human.

Ground water samples returned positive pesticide detections from numerous sites during testing in 2001, 2004, and 2007. Of these detections, concentration levels found at two sites have warranted increased monitoring and protection activities. One well located approximately six miles south of Lewiston consistently returned atrazine and desthyl atrazine levels near or above 50 percent of the MCL of 3.0 µg/L. Another well location located approximately seven miles northeast of Cottonwood had a detection of 0.73 µg/L in 2007 for the pesticide compound triallate that exceeded the health standard used by ISDA as well as the U. S. Food Quality Protection Act. ISDA has increased monitoring and protection related activities in relationship to both of these sites.

Recommendations

ISDA recommends continued monitoring in the project area. ISDA further recommends that measures to reduce localized nitrate impacts and potential future pesticide impacts on ground water be addressed and implemented. ISDA recommends that:

- Pesticide applicators use the core Best Management Practices recommended by the ISDA Water Program, especially in the area near the elevated atrazine and desethyl atrazine and triallate detections.
- Growers and agrichemical professionals conduct nutrient and pesticide management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service (NRCS) Nutrient Management Standard.
- Pesticide applicators follow the NRCS Pesticide Management Standard.
- Producers and agrichemical dealers evaluate their storage, mixing, loading, rinsing, containment, and disposal practices.
- Homeowners assess lawn and garden practices, especially near wellheads with elevated nitrate or pesticide detections.
- Local residents assess animal waste management practices.
- State and local agencies assess impacts from private septic systems near impaired areas.
- Home and garden retail stores establish outreach programs to illustrate proper application and management of nutrients and pesticides.
- Responsible parties assess pesticide application practices to protect ground water.

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References

Bentz, B. 1998. A Reconnaissance of Nitrite/Nitrate in Camas Prairie Ground Water Volume I, Lewis and Idaho County, Idaho. Idaho Department of Environmental Quality. Lewiston Regional Office. 42 pp.

Idaho Agricultural Statistics Service, 2006. 2006 Idaho agricultural statistics. Idaho Department of Agriculture, 65 p.

Kendall, C., and McDonnell J. J., 1998. Isotope tracers in catchment hydrology, Elsevier Science B.V., Amsterdam. pp. 519-576.

Neely, K. W., and Crockett, J. K., 1999. Nitrate in Idaho's ground water: Idaho Department of Water Resources Technical Results Summary No. 1, 12 p.

Parliman, D.J., 2000. Nitrate concentrations in ground water in the Henry's Fork Basin, Eastern Idaho. USGS Fact Sheet FS-029-00, February 2000, 6 p.

University of Idaho. INSIDE Idaho Interactive Numeric and Spatial Information Data Engine. http:// inside.uidaho.edu/asp/theme.asp, 1997.