Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Nitrate Monitoring In Cassia County, Idaho

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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 ISDA currently is conducting follow-up monitoring at dairy wells with previous nitrate levels above 10 milligrams per liter (mg/L) in Idaho, including a project in Cassia County (Figure 1). The objectives of the monitoring are to: (1) characterize ground water quality, primarily related to nitrate-nitrogen (NO_3-N), (2) relate data to agricultural land use practices, and (3) provide data to support Best Management Practices (BMP) and/or regulatory decision making and evaluation processes.

The ISDA Cassia County dairy monitoring project began in 2000 as a result of previous monitoring by the ISDA Dairy Bureau. Nine of twelve and four of twelve dairy wells in the area exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) of 10 mg/L for nitrate in 2000 and 2002, respectively. To establish this project, ISDA selected adjacent domestic wells in the area for testing and re-tested the dairy wells.

Nutrients, common ions, and N-15 isotopes were evaluated during ISDA's testing. Laboratory results indicated that numerous wells located south of Burley have NO_3-N levels that suggest some type of land use influence on ground water quality. ISDA is currently working to advise residents and officials of the area on how to minimize further ground water contamination and possible health risks. Monitoring results and evaluations of nitrate sources will assist in recommendations for dairy and farm improvements for ground water protection.

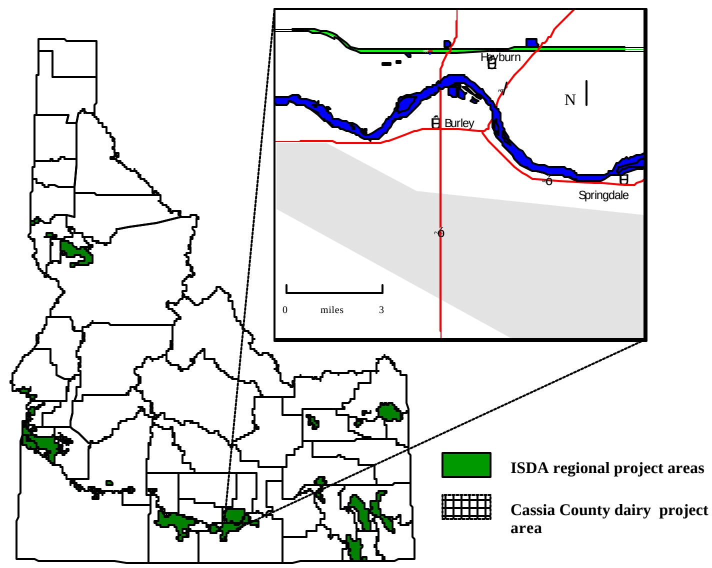

Figure 1. Location of Cassia County dairy monitoring project and other ISDA regional project areas.

Description of Project Area

The Cassia County dairy monitoring project encompasses an approximately 6 mile wide by 12 mile long area of livestock operations and irrigated agricultural land adjacent to the Snake River (Figure 1). The main sources of water for irrigation include diversions from the Snake River, local runoff, and deep wells (Maxwell, 1981). Sprinkler irrigation is the primary local irrigation method. Major crops in the area include alfalfa hay, sugar beets, potatoes, corn, wheat, barley, beans, and oats (Gerhardt, et. al., 2000). Eleven of the twelve dairies sampled in 2000 and 2002 reside in the sampling area of Figure 1. The eleven dairies within the sampling area hold less than 600 animal units each. The dairy not located in the sampling area is approximately twelve miles northeast of Springdale, across highway I-84.

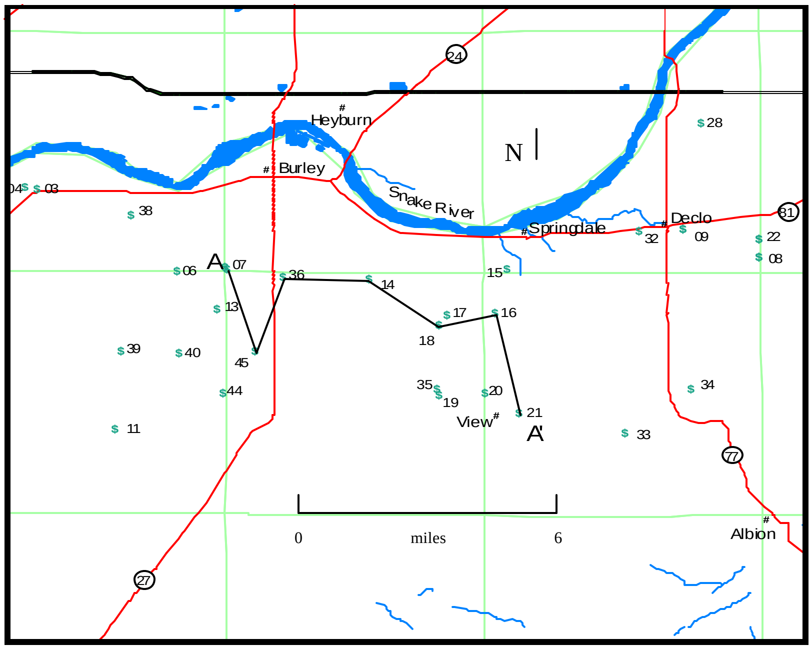

Figure 2. Location of wells sampled by ISDA and cross-section line from previous Cassia County regional study.

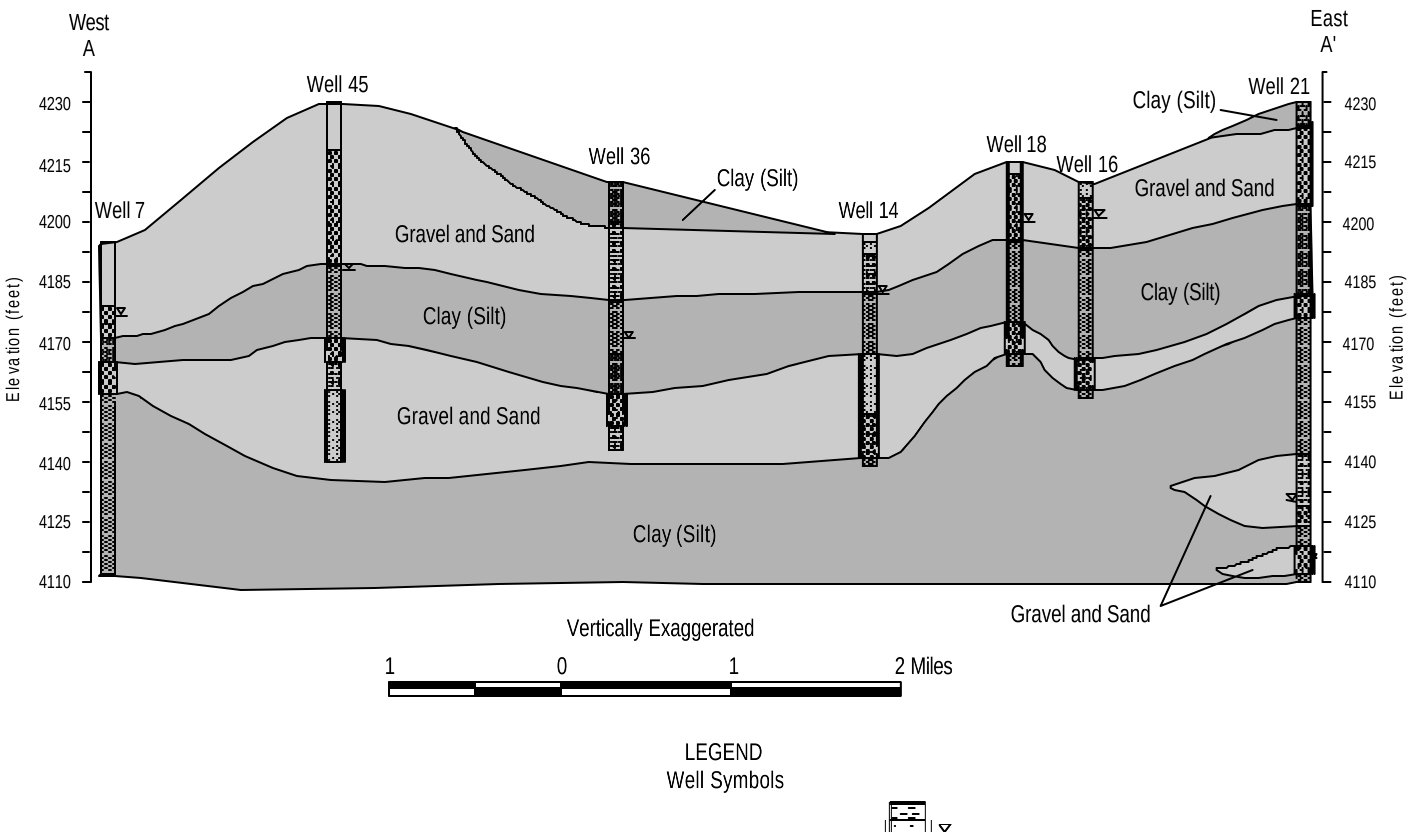

Figure 3. Cross section of shallow aquifer in Cassia County monitoring area. See Figure 2 for cross section location.

The hydrogeology of Cassia County consists of an upper aquifer composed of alluvial deposits (Figures 2 and 3) overlying a lower aquifer composed of fractured basalt. 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 is composed of alluvial deposits, mainly sand and gravel, with a few thin interbedded clay layers.

The shallow subsurface alluvial deposits are conducive to leaching of contaminants. Potential sources for nitrate leaching to the ground water in the area include applied nitrogen-based fertilizers, septic systems, cattle manure, legume crops, and wastewater lagoons. A potential source of recharge to this shallow system is applied irrigation waters. Ground water flow direction in the sampling area varies (Figure 4). The extent of interaction of the Goose Creek-Golden Valley and Marsh Valley aquifers with the Snake River is unreported. Ground water flow in the southern part of Minidoka County, near the Snake River, displays a "… complex pattern … because of recharge from the shallow, perched irrigation-induced alluvial aquifer in the Minidoka Irrigation District" (Minidoka Soil and Water Conservation District, 1996).

Results

Sampling results indicate NO_3-N impacts have occurred to the aquifer. Results are summarized and presented in the following sections.

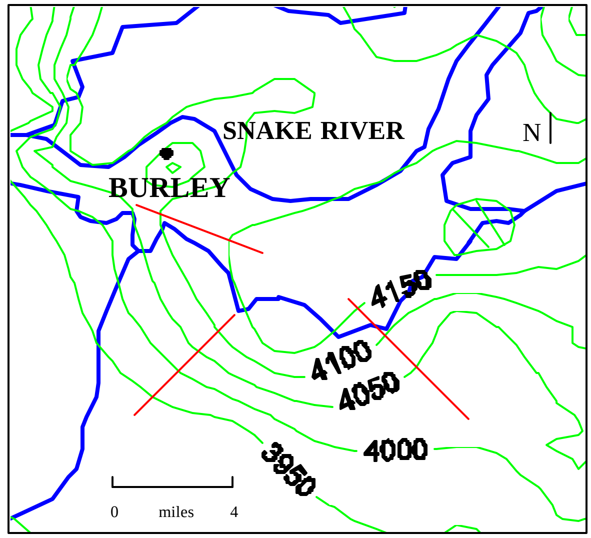

Figure 4. Ground water flow map of Cassia County showing direction of ground water flow (arrows) and equipotential lines (feet above sea level).

Nitrate

The ISDA conducted NO_3-N testing of 56 wells during 2000 and 2002 in Cassia County (Tables 1-3). Results of ground water sampling indicate a maximum concentration of 23.7 mg/L (Table 1). The number of wells over the MCL health standard of 10 mg/L was 26 in 2000 and 13 in 2002 (Table 1). The median nitrate value for all wells dropped from 9.5 mg/L in 2000 to 7.8 mg/L in 2002 (Table 1).

Table 1. Statistical comparison of nitrate concentrations in 56 wells sampled in October 2000 and August 2002.

Nitrate Concentrations (mg/L) and Statistics	2000	2002	2000	2002
	Number of Wells	Number of wells	% of Total	% of Total
0.0 to 2.0	5	4	8.9	7.1
2.0 to 5.0	6	11	10.7	19.6
5.0 to 10.0	19	28	33.9	50.0
> 10.0	26	13	46.4	23.2
Total	56	56	100.0	100.0
Mean Value (mg/L)	9.7	8.1		
Median Value (mg/L)	9.5	7.8		
Maximum Value (mg/L)	23.7	23.0		

Table 2. Statistical comparison of nitrate concentrations at 12 dairies sampled in October 2000 and August 2002.

Nitrate Concentrations (mg/L) and Statistics	2000 Number of Dairy Wells	2002 Number of Dairy Wells	2000 % of Total	2002 % of Total
0.0 to 2.0	0	0	0	0
2.0 to 5.0	0	1	0	8.3
5.0 to 10.0	3	7	25.0	58.3
> 10.0	9	4	75.0	33.3
Total	12	12	100.0	100.0
Mean Value (mg/L)	12.4	10.2		
Median Value (mg/L)	12.5	9.7		
Maximum Value (mg/L)	17.4	16.0		

Table 3. Statistical comparison of nitrate concentrations at 44 domestic wells sampled in October 2000 and August 2002.

Nitrate Concentrations (mg/L) and Statistics	2000 Number of Wells	2002 Number of Wells	2000 % of Total	2002 % of Total
0.0 to 2.0	5	4	11.4	9.1
2.0 to 5.0	6	10	13.6	22.7
5.0 to 10.0	16	21	36.4	47.7
> 10.0	17	9	38.6	20.5
Total	44	44	100.0	100.0
Mean Value (mg/L)	8.9	7.6		
Median Value (mg/L)	8.5	7.5		
Maximum Value (mg/L)	23.7	23		

Samples obtained only from dairy wells (Table 2) show a drop in median nitrate value from 12.5 mg/L in 2000 to 9.7 mg/L in 2002. Samples obtained only from domestic wells show a drop in median nitrate value from 8.5 mg/L in 2000 to 7.5 mg/L in 2002 (Table 3).

Nitrate concentrations show a general decrease from 2000 to 2002 and are most elevated in the area southeast of Burley (Figure 5). High NO_3-N concentrations and the number of detections over 10 mg/L near populated areas is of concern because of potential health risks.

Nitrogen Isotopes

The ratio of the common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N relative to a known standard (denoted $d^{15}N$) can be useful in determining sources of NO_3-N. Common sources of NO_3-N in ground water are applied commercial fertilizers, animal or human waste, precipitation, and organic nitrogen within the soil. Each of these NO_3-N source categories has a potentially distinguishable nitrogen isotopic signature (Table 4). The typical $d^{15}N$ range for fertilizer is –5 $^0/_{00}$ to +5 $^0/_{00}$, while typical values for waste sources are greater than 10 $^0/_{00}$. $d^{15}N$ values between 5 $^0/_{00}$ and 10 $^0/_{00}$ can indicate an organic or mixed source (Kendall and McDonnel, 1998).

Use of nitrogen isotopes as the sole means to determine NO_3-N sources should be done with great care. $d^{15}N$ values in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, plant uptake, etc.) that can modify the $d^{15}N$ values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrification very difficult (Kendall and McDonnel, 1998).

Table 4. $d^{15}N$ results for Cassia County dairy nitrate monitoring project, 2000.

$d^{15}N$ Values ($^0/_{00}$)	Potential Contaminant Source	2000 49 wells total	% of Total Wells
-5 to +5	Commercial Fertilizer	12	24.5
+5 to +10	Organic Nitrogen in Soil	17	34.7
>10	Animal or Human Waste	20	40.8

(a)

(b)

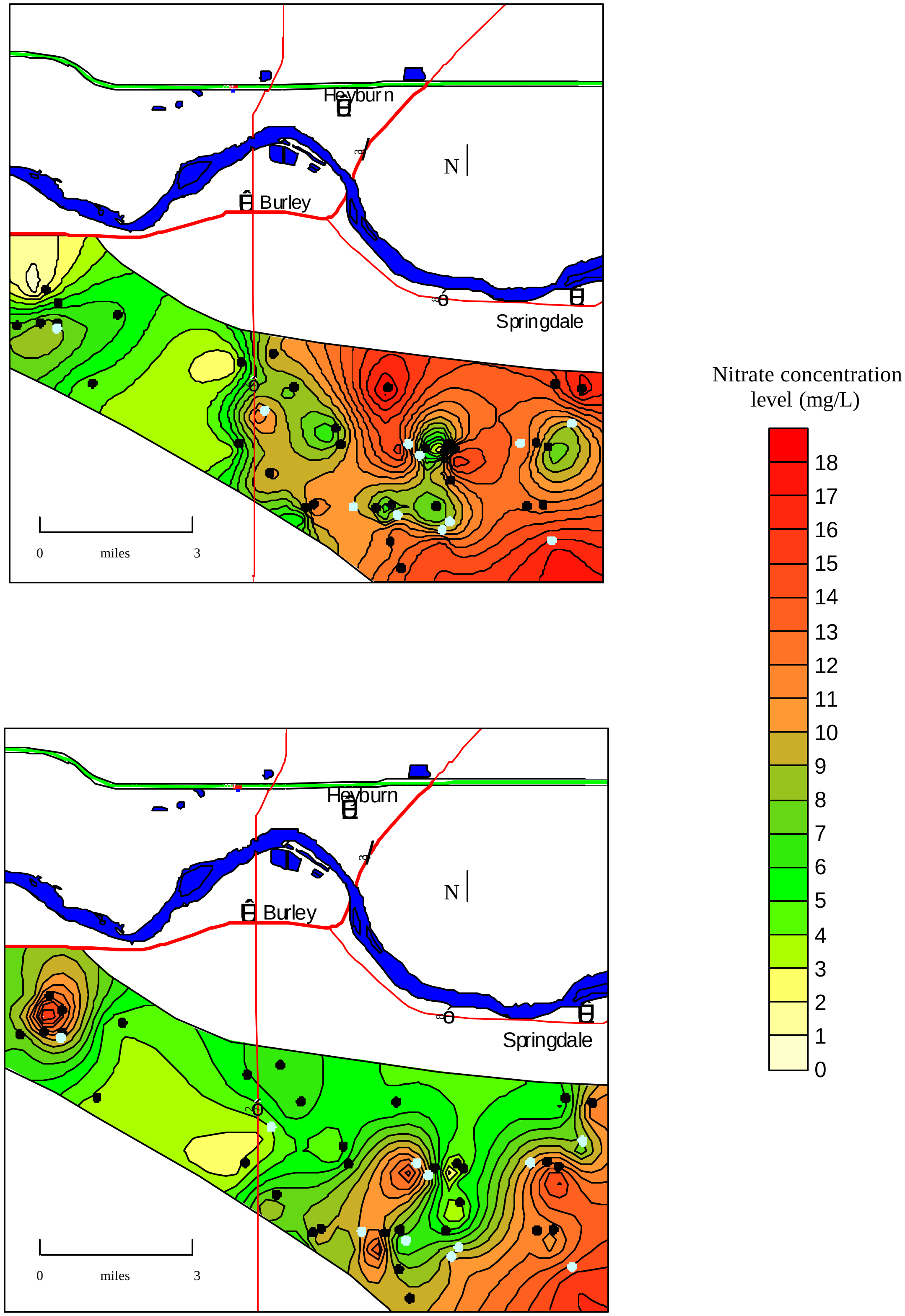

Figure 5. Kriged contour map of ground water nitrate concentration south of Burley for (a) 2000 and (b) 2002. Black dots indicate domestic wells and blue dots indicate dairy wells.

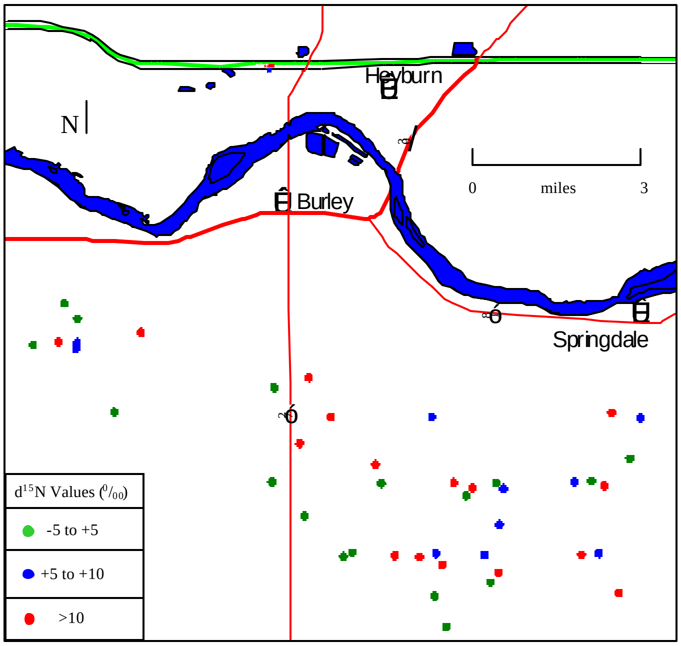

Figure 6. Ground water d15N map south of Burley.

ISDA conducted d15N testing of 49 of the 56 wells in 2000 to determine potential sources of NO_3-N in the ground water. Wells chosen for d15N testing had elevated NO_3-N concentrations. Water samples collected in 2000 were sent to the University of Illinois Laboratory, at Urbana-Champaign, for d15N analysis. Results of d15N testing returned values that ranged from -7.66 $^0/_{00}$ to 46.19 $^0/_{00}$. Twenty wells had values that suggested an animal or human waste source, 12 suggested a fertilizer source, and 17 had d15N values that indicated an organic or mixed source of nitrates (Table 4 and Figure 6). Six of the 20 wells that suggested an animal or human waste source are dairy wells. Results from 2002 d15N testing are pending.

Conclusions

Ground water within the shallow alluvial aquifer of the project area is being impacted from nitrates. Nitrate concentrations exceed the EPA MCL of 10 mg/L in 46% of the 56 wells sampled in 2000 and 23% in 2002. The areas that had the highest NO_3-N concentrations were southeast of Burley. The majority of wells sampled were less than 250 feet deep.

Agricultural practices likely contribute to the NO_3-N detections in the ground water of this project area. Testing results indicate NO_3-N impacts to the shallow ground water of the project area are widespread. Leaching of animal waste and fertilizers is a potential cause of NO_3-N entering the ground water. Leaching of nitrate from legume crops and septic systems are other potential sources. The number of wells over the MCL health standard of 10 mg/L was 26 in 2000 and 13 in 2002. Reduction in the number of wells that exceed the health standard for nitrate may be the result of better management practices or seasonal variation (sampling in August 2002 versus October 2000).

Recommendations

To determine if current farming practices are contributing to ground water degradation and to locate other potential contaminant sources, the ISDA recommends continued monitoring in the project area and evaluation of the dairies individually.

Testing may include, but not be limited to:

- Continued ground water monitoring for nutrients and common ions.
- Continued nitrogen isotope testing to determine possible nitrate sources and relative ages of ground water.
- Oxygen isotope testing to determine effects of nitrification and denitrification.
- Soil sampling and soil pore water sampling.
- Antibiotic and hormone testing of groundwater to determine potential human and animal waste sources.

ISDA further recommends that measures to reduce nitrate impacts on ground water be addressed and implemented. ISDA recommends that:

- Growers and agrichemical professionals conduct nutrient and irrigation water management evaluations.
- Producers follow the Idaho Agricultural Pollution Abatement Plan and Natural Resources Conservation Service Nutrient Management Standard.
- 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.
- Dairy facilities and records be further evaluated for pollution prevention.

ISDA recommends that the West Cassia Soil Conservation District lead a response process to create a plan of action to address these ground water contamination issues. The soil and water conservation district, SCC, and ISDA 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. ISDA will be working with the DEQ led Cassia Nitrate Committee in creating a plan for nitrate response.

References

Gerhardt, D.G., and Kurtz, T.E., 2000. Idaho Agricultural Statistics. Idaho Agricultural Statistics Service, p. 65.

Kendall, C., and McDonnell, J.J., 1998. Isotope Tracers in Catchment Hydrology. Elsevier Science B.V., Amsterdam, pp. 519-576.

Maxwell, H. B., 1981. Soil Survey of Cassia County, Idaho, Western Part. United States Department of Agriculture Soil Conservation Service, 150 p.

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