Idaho State Department of Agriculture
Division of Agricultural Resources

Five-Year Water Quality Monitoring Results of Butler Spring, Gooding County, Idaho

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Introduction

Recent and historical ground water monitoring indicate that nitrate-nitrogen (NO_3-N) has contaminated the source water to a spring (Butler Spring) northwest of Bliss, Idaho (Figure 1). Past monitoring of the spring has shown that elevated nitrate levels have been present since at least 1994. The Twin Falls Office of the Division of Environmental Quality (DEQ) sampled and detected nitrate in the Butler Spring at 11.1 milligrams per liter (mg/L) in October 1994 and 8.0 mg/L in August 1995. In July 1999, the Butler Spring again was sampled by DEQ and found to have a nitrate concentration of 18.5 mg/L. The Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL)[1] for NO_3-N is 10 mg/L.

The Idaho State Department of Agriculture (ISDA) began monitoring the Butler Spring on a monthly basis in November 1999 with sampling continuing today. A five year analysis of nitrate, bacteria, and nitrogen isotope test results suggest a fertilizer source of contamination.

Land use in the area consists of irrigated agriculture, two dairy operations, and rural housing. There are over 2000 acres of irrigated agricultural fields within 3.5 miles upgradient of the spring. Crops include alfalfa, wheat, corn, beets, beans, and potatoes. Immediately east of the Butler spring is a dairy operation, which began operation in April 1995. Prior to this period, a cattle feeding operation was located at this dairy site for numerous years. Another dairy operation is at the eastern boundary of the project area.

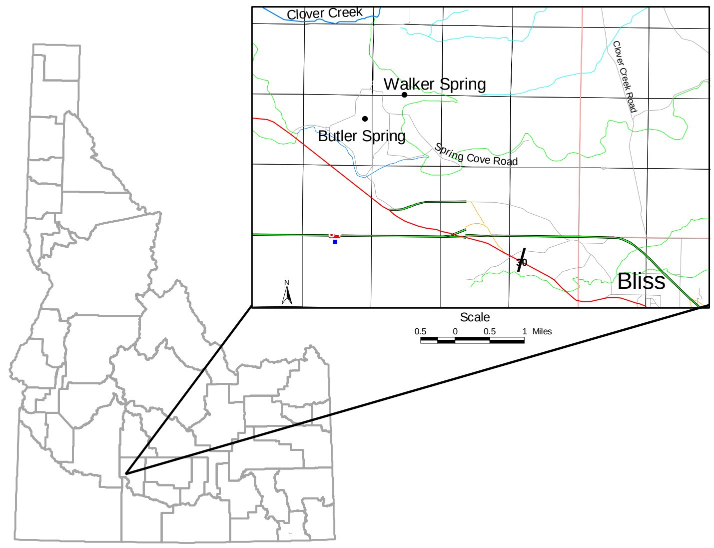

Figure 1. Northwest Gooding County project area.

Methods

Nitrate-nitrogen, bacteria, and nitrogen isotopes were evaluated during ISDA's testing. All sample collection followed the established ISDA quality assurance project plan for preservation, handling, storage, and shipping. Samples were analyzed for NO_3-N and bacteria by the State of Idaho Health and Welfare Laboratory in Boise, Idaho. Isotope samples were collected, frozen, and shipped to the University of Nebraska-Lincoln Water Sciences Laboratory, in Lincoln, Nebraska for analysis.

[1]MCLs represent the EPA health standard for drinking water.

Description of Project Area

The Bliss project area encompasses an approximately two mile wide and four mile long area of agricultural and residential land adjacent to the Snake River (Figure 1). Land use in the area consists of irrigated agriculture, two dairy operations, and rural housing. There are over 2000 acres of irrigated agricultural fields within 3.5 miles upgradient of the spring. Crops include alfalfa, wheat, corn, beets, beans, and potatoes. Dairy manure is applied to some agricultural fields within the project area.

Well logs show that depth to ground water in the shallow aquifer ranges from approximately 15 to 85 feet below ground level. Potential sources of recharge to this shallow system include applied irrigation waters, precipitation, and canal leakage. Potential sources for NO_3-N leaching to ground water in the area include applied nitrogen-based fertilizers, cattle manure, land applications of manure, wastewater lagoons, septic systems, and crop residues.

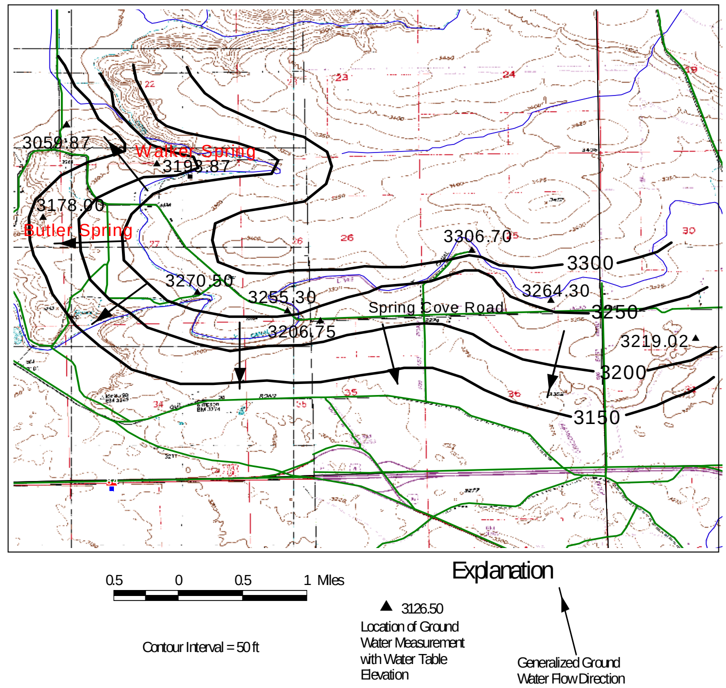

Figure 2. Water table contour map of shallow aquifer.

Hydrogeology

The Bliss study area lies within the eastern Snake River Plain and is mainly Quaternary basalts and sediments of the Idaho Group geologic formation. Quaternary basalts appear to be exposed around Butler Spring. Underlying the Quaternary basalt are Tertiary sedimentary rocks of the Glenns Ferry Formation and Tertiary Banbury Basalt, both of which are part of the Idaho Group (Garabedian, 1992). Well logs show that shallow wells in the project area are generally completed in the upper Quaternary basalts while deep wells are completed in the lower Banbury Basalt.

Horizontal ground water flow directions in the project area were determined for the shallow aquifer by measuring static water levels in shallow wells of the project in late November 1999. Static water level measurements were used to determine ground water elevations that were subsequently contoured to develop a shallow aquifer ground water flow map (Figure 2). Results of this analysis indicate that general ground water flow is to the west in the vicinity of the Butler Spring. Results also indicate ground water flow directions tend to mimic the grade of local topography.

Hydraulic characteristics of basalt may vary widely within a short distance. Homogeneous conditions must be assumed to minimize and approximate hydrologic conditions of the basalt aquifer on a larger scale. One modeled hydraulic conductivity (K) of basalt in the area of Butler Spring is 0.9×10^{-4} ft/s (Garabedian, 1992). This K value falls in the middle of a published K range for basalt of $0.07 - 5 \times 10^{-7}$ ft/s (Freeze and Cherry, 1979). Ground water flow velocity is calculated to be 7.8 ft/day (approximately 0.5 miles/year) using the modeled K value. Ground water flow velocity varies from 0.04 ft/day to 6048 ft/day using the published basalt K range (Freeze and Cherry, 1979).

Results

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

Nitrate

ISDA began monitoring the Butler Spring on a monthly basis in November 1999 with sampling continuing today. Sampling frequency deviated slightly in the past with occasional increases and two missed events. A total of 64 Butler Spring samples have been analyzed for nitrate over the last five years (Figure 3). Results indicate a minimum of 5.53 mg/L in September 2003 and a maximum concentration of 11.8 mg/L in November 1999. The EPA MCL health standard of 10 mg/L was exceeded six times. The median nitrate value for all events was 8.23 mg/L (Table 1).

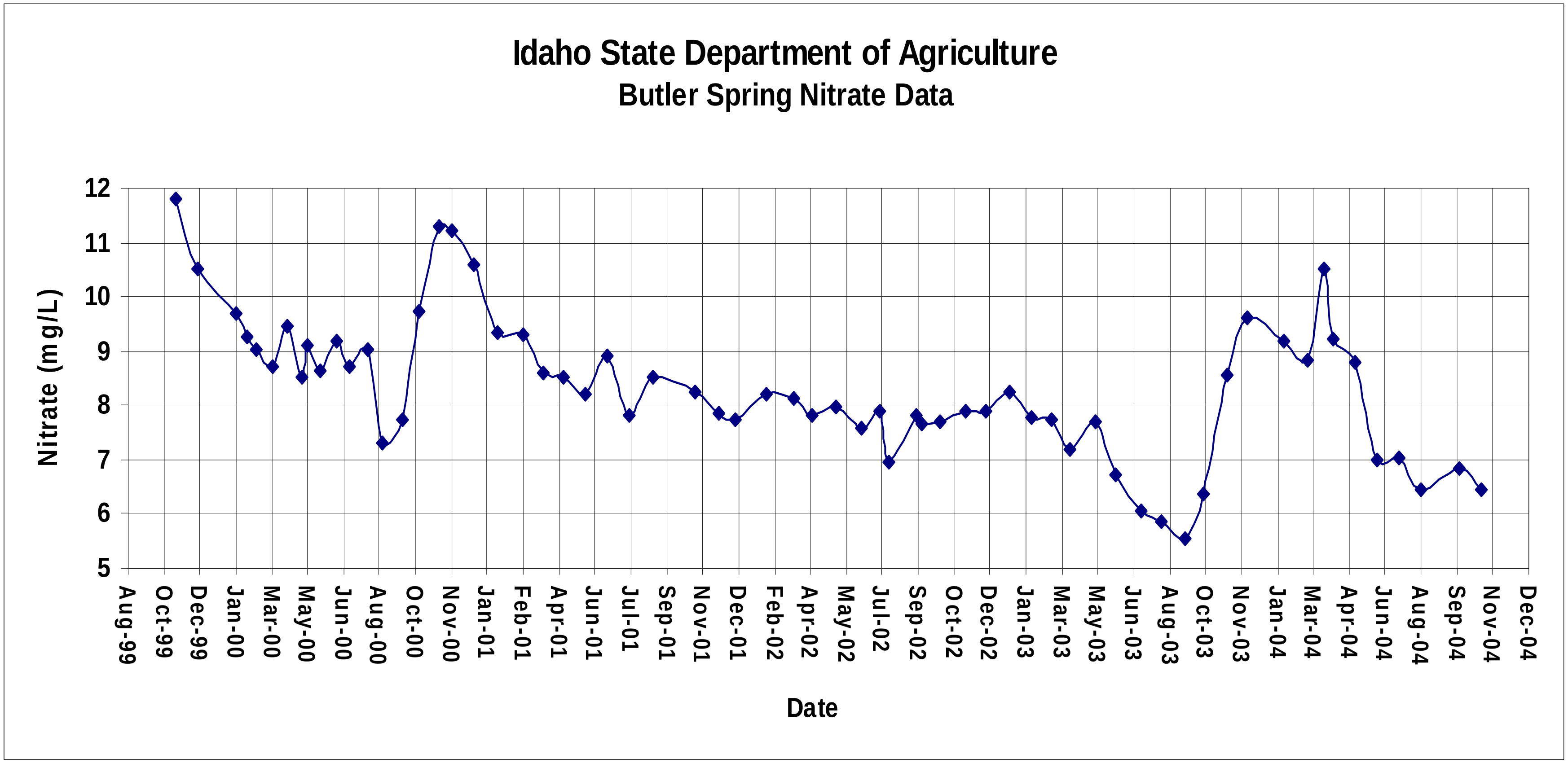

Figure 3. Change in nitrate concentration in Butler Spring from November 1999 through October 2004.

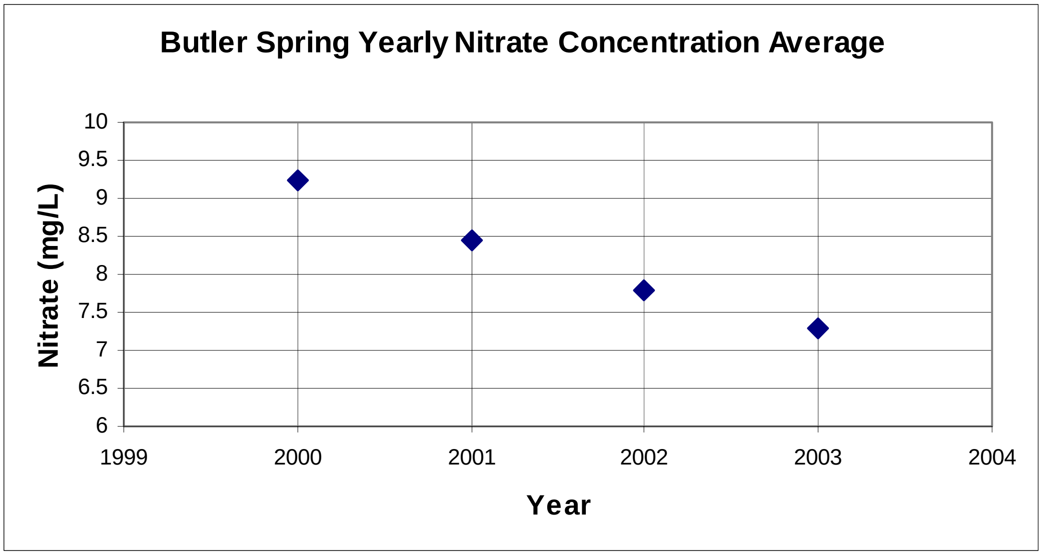

Figure 4. Change in complete yearly nitrate averages in Butler Spring from November 1999 through October 2004.

Four significant nitrate concentration spikes occurred during the five year study (Figure 3): Nov-99, Nov-00, Dec-03, and Mar-04. Comparing complete yearly nitrate averages (Figure 4), however, reveals a downward trend in average concentration from 2000 through 2003.

Nitrogen Isotopes

The ratio of the common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N relative to a known standard (denoted $\delta^{15}N$) 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, and organic nitrogen within the soil. Each of these NO_3-N source categories has a potentially distinguishable nitrogen isotopic signature. The typical $\delta^{15}N$ range for fertilizer is –5 per mil ($^0/_{00}$) to +5 $^0/_{00}$, while typical values for waste sources are greater than +10 $^0/_{00}$. $\delta^{15}N$ values between +5 $^0/_{00}$ and +10 $^0/_{00}$ can indicate an organic or mixed source (Kendall and McDonnell, 1998).

Table 1. Distribution of nitrate concentrations across all sampling events of Butler Spring from November 1999 through October 2004.

Concentration Range (mg/L)	Nov-99 through Oct-04
	# samples (% samples)
0.0 to 5.0	0 (0.0%)
5.0 to 10.0	58 (90.6%)
> 10.0	6 (9.4%)
Total	64 (100%)
Mean Value	8.34 mg/L
Median Value	8.23 mg/L
Maximum Value	11.8 mg/L

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

ISDA conducted $\delta^{15}N$ testing to use it as a possible indicator of NO_3-N source(s) in the ground water. Isotope samples were not collected during every sampling event. Isotope values for 45 samples were available at the time of this report; results for the summer of 2004 are pending. All samples were sent to the University of Nebraska-Lincoln Water Sciences Laboratory for $\delta^{15}N$ analysis.

Twenty-nine samples had values that suggested a fertilizer source and 16 had $\delta^{15}N$ values that indicated an organic or mixed source of nitrates (Table 2). Zero samples suggested an animal or human waste source.

Table 2. $\delta^{15}N$ results across all sampling events of Butler Spring from November 1999 through October 2004.

$\delta^{15}N$ Values ($^{0}/_{00}$)	Potential NO_3-N Source	Nov-99 through Oct-04
		# samples (% samples)
-5 to +5	Commercial Fertilizer	29 (64.4%)
+5 to +10	Organic Nitrogen in Soil or Mixed Source	16 (35.6%)
>10	Animal or Human Waste	0 (0.0%)
Total		45 (100%)

Bacteria

Butler Spring was tested for total coliform bacteria and Escherichia coli (E. coli) bacteria during each sampling event. Positive total coliform results may indicate the possibility of mammalian intestinal bacteria being present. Eleven events tested positive for total coliform (Table 3). E. coli was not detected in any samples.

A contaminated piping system or surface waters located near the spring could be potential sources of bacteria in the ground water. Bacteria in the ground water could also be associated with nearby dairy waste, lagoons, or waste handling systems.

Table 3. Positive bacteria detects in Butler Spring.

Date	Nitrate (mg/L)	Total Coliform (colonies/100 ml)	Ecoli (colonies/100 ml)
Oct-04	No test	28	<1
Sep-04	6.82	1	<1
Aug-04	6.46	21	<1
Jul-04	7.04	3	<1
Dec-03	9.62	4	<1
Sep-03	5.53	6	<1
Aug-03	5.85	12	<1
Jul-03	6.05	7	<1
Sep-02	7.67	1	<1
Nov-01	7.84	4	<1
Sep-00	7.73	2	<1
Aug-00	7.32	4	<1

Conclusions

Monthly ground water monitoring over a five year period indicates that NO_3-N has contaminated the source water to Butler Spring northwest of Bliss, Idaho. The EPA MCL health standard of 10 mg/L for nitrate was exceeded six times in five years. The median nitrate value for all sampling events was 8.24 mg/L. A five year analysis of nitrate, bacteria, and nitrogen isotope test results suggest a fertilizer source of contamination.

ISDA began monitoring the Butler Spring on a monthly basis in November 1999 and sampling will continue on a monthly basis indefinitely. ISDA will continue yearly ground water monitoring of approximately 15 wells in the area of the spring to evaluate several other potential (current and historical) sources of contamination including two dairy operations (Bahr, et. al., 2000).

The Gooding Soil Conservation District, in cooperation with ISDA, secured an EPA Nonpoint Source Management §319 Grant through DEQ. This grant will allow improvement in nutrient and irrigation water management throughout the Bliss Nitrate Priority Area. Implementation of the grant is to begin in the winter of 2004-2005 and will continue through 2008.

Recommendations

ISDA recommends continued monitoring in the project area.

Testing should include, but not be limited to:

- Continued ground water monitoring for nutrients, common ions, and bacteria.
- Continued isotope testing.
- Additional static water level measurement.
- ISDA effectiveness monitoring as facility improvements, BMP programs, and/or regulatory changes are implemented.

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.

References

Bahr, G., Carlson, R., and Campbell, K., 2000. Ground and Surface Water Quality of Northwest Gooding County Water Quality Monitoring Results. ISDA Technical Results Summary #4, 3 p.

Freeze, R. A., and Cherry, J.A., 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, pp. 29.

Garabedian, S. P., 1992. Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 1408-F, 65 p.

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