Idaho State Department of Agriculture
Division of Agricultural Resources

Ground Water Quality Monitoring Update for the Bliss Local Project Area
Gooding County, Idaho

Craig Tesch, P.G.
Kathryn Dallas

ISDA Technical Results Summary #36 December 2007

Introduction

Recent and historical ground water monitoring indicate that nitrate-nitrogen (NO_3-N) has contaminated a shallow aquifer and several springs northwest of Bliss, Idaho (Figure 1). Past monitoring of a spring (Butler Spring) fed by this shallow aquifer has shown that elevated nitrate levels have been present since at least 1994. The Twin Falls Office of the Department 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 currently. In addition to Butler Spring, ISDA samples approximately 15 domestic wells annually and a second spring (Walker Spring) monthly for nitrate. Nitrate and nitrogen isotope test results suggest fertilizer and animal waste as potential sources of contamination.

Land use in the area consists of irrigated agriculture, past and present confined animal operations, and rural housing. There are over 2000 acres of irrigated agricultural fields within 3.5 miles upgradient of Butler 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 had historically been in operation at the eastern boundary of the project area, but is no longer in business.

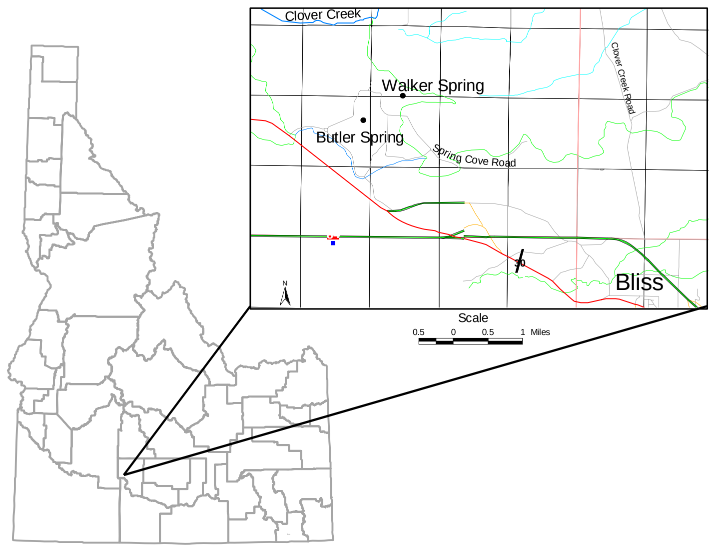


Figure 1. Northwest Gooding County project area.

Methods

Nitrate, 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 nitrate and bacteria by the EPA certified State of Idaho Health and Welfare Laboratory in Boise, Idaho. Field quality assurance/quality control protocols consisted of duplicate samples (at 10% of the sample load) along with blank samples (one set per sampling event). Isotope samples were collected, frozen, and shipped to the Stable Isotope Laboratory, University of Idaho, Forest Resources and 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, confined animal 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 nitrate 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.

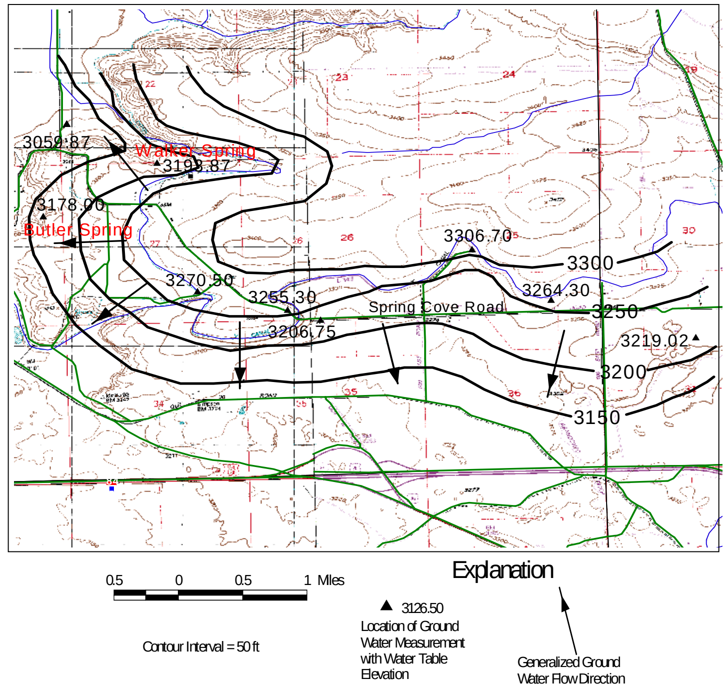


Figure 2. Water table contour map of shallow aquifer (Bahr, et. al., 2000).

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 and to the south in the central and eastern portions of the project area. 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 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

ISDA began monitoring in the Bliss project area in November 1999 with sampling continuing currently. Sampling results indicate nitrate impacts have occurred to the springs and shallow aquifer. Results are summarized and presented in the following sections.

Nitrate

Butler Spring

A total of 97 Butler Spring samples have been analyzed for nitrate over the last eight years (Figure 3). Results indicate a minimum of 5.21 mg/L in October 2005 and a maximum concentration of 14.4 mg/L in February 2006. The EPA MCL health standard of 10 mg/L was exceeded 12 times. The median nitrate value for all events was 8.2 mg/L (Table 1).

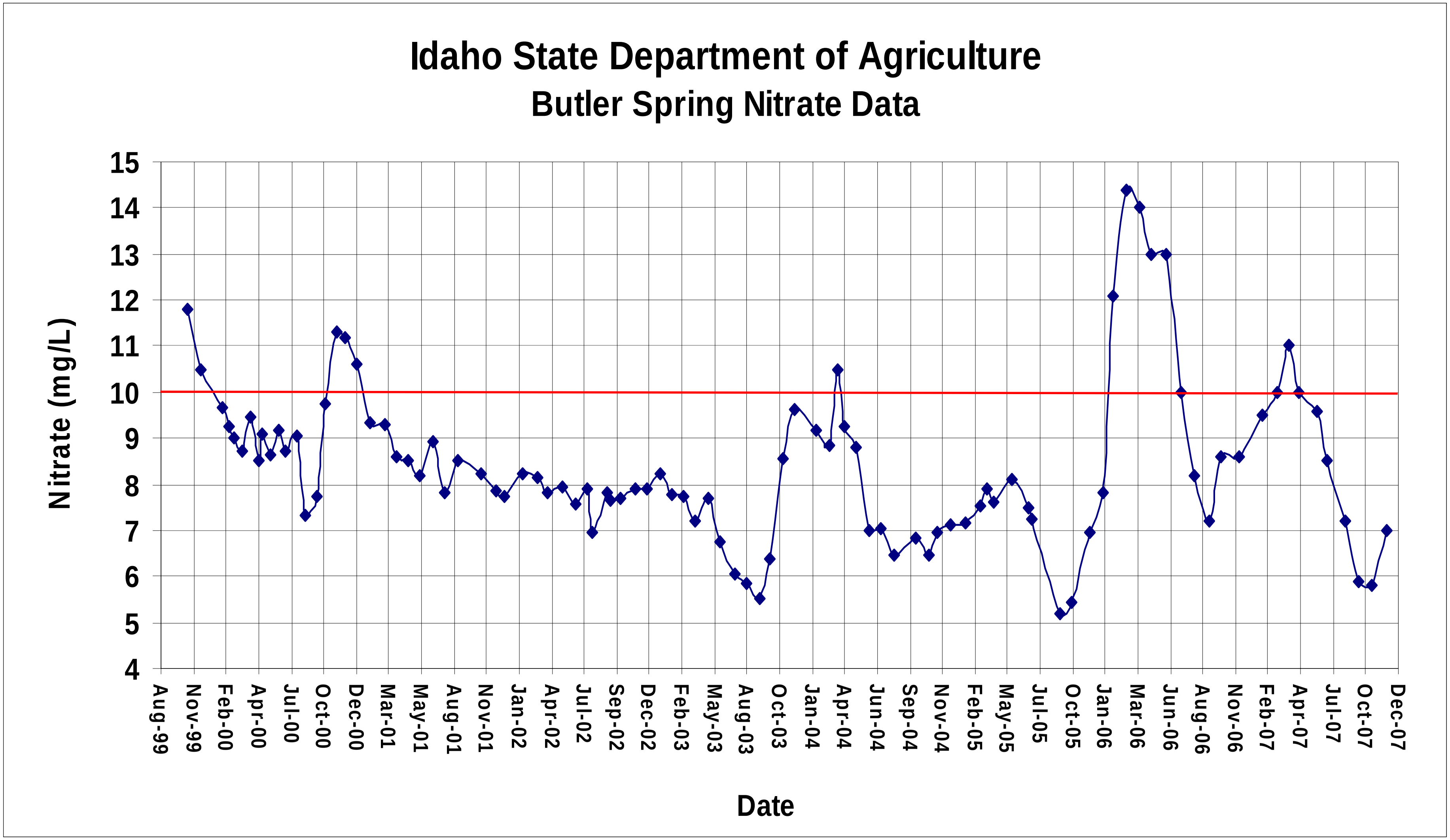


Figure 3. Nitrate concentrations in Butler Spring from November 1999 through November 2007.

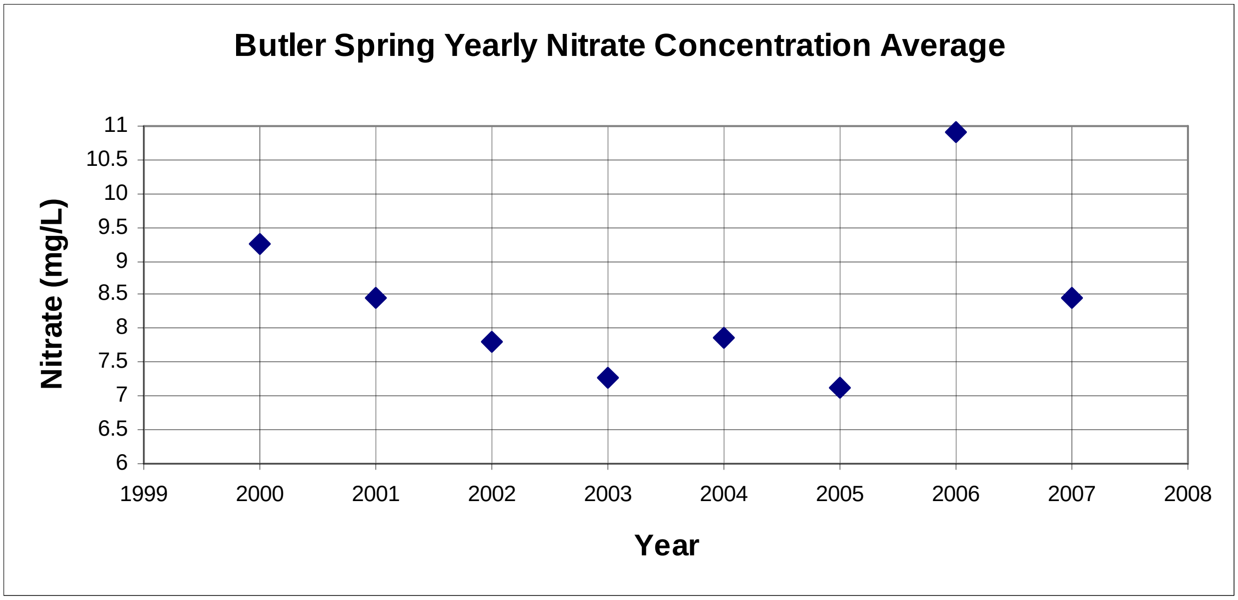


Figure 4. Mean nitrate concentrations by year in Butler Spring from November 1999 to December 2007.

Periods with significant nitrate concentration spikes that have occurred during the eight year study (Figure 3) include: Nov-99, Nov-00, Dec-03, Mar-04, Feb-06, and Mar-07. Comparing mean nitrate concentrations by year (Figure 4) suggests a downward trend in average nitrate concentrations from 2000 through 2005. In 2006, however, an approximate 4 mg/L increase resulted in an average nitrate concentration above the EPA MCL. This jump was followed by a decrease in average nitrate for 2007 back below the EPA MCL of 10 mg/L.

Table 1. Distribution of nitrate concentrations across all sampling events of Butler Spring from November 1999 to December 2007.

Concentration Range (mg/L)	Nov-99 through Nov-07
	# samples (% samples)
0.0 to 5.0	0 (0.0%)
5.0 to 10.0	85 (87.6%)
> 10.0	12 (12.4%)
Total	97 (100%)
Mean Value	8.45 mg/L
Median Value	8.2 mg/L
Maximum Value	14.4 mg/L

Walker Spring

A total of 45 Walker Spring samples have been analyzed for nitrate over the last eight years (Figure 5). Results indicate a minimum of 3.9 mg/L in September 2005 and a maximum concentration of 34.3 mg/L in February 2006. The EPA MCL health standard of 10 mg/L was exceeded 23 times. The median nitrate value for all events was 10.4 mg/L (Table 2).

Table 2. Distribution of nitrate concentrations across all sampling events of Walker Spring from November 1999 to December 2007.

Concentration Range (mg/L)	Nov-99 through Nov-07
	# samples (% samples)
0.0 to 5.0	2 (5%)
5.0 to 10.0	20 (45%)
> 10.0	23 (51%)
Total	45 (100%)
Mean Value	12.0 mg/L
Median Value	10.4 mg/L
Maximum Value	34.3 mg/L

Periods with significant nitrate concentration spikes that have occurred during the eight year study (Figure 5) include: Mar-00, Feb-06, and Feb-07. Nitrate patterns and spikes have followed those of Butler Spring since approximately July 2005 (Figure 5).

Domestic and Dairy Wells

Approximately 15 domestic and dairy wells have been analyzed yearly for nitrate over the last eight years (Figure 6). Nitrate trends for individual wells from 1999 through 2007 can be found in Appendix 1. Overall results from 2002 through 2007 (Table 3) indicate a maximum concentration of 12.5 mg/L in 2002 and a median concentration ranging from 3.1 mg/L in 2004 to

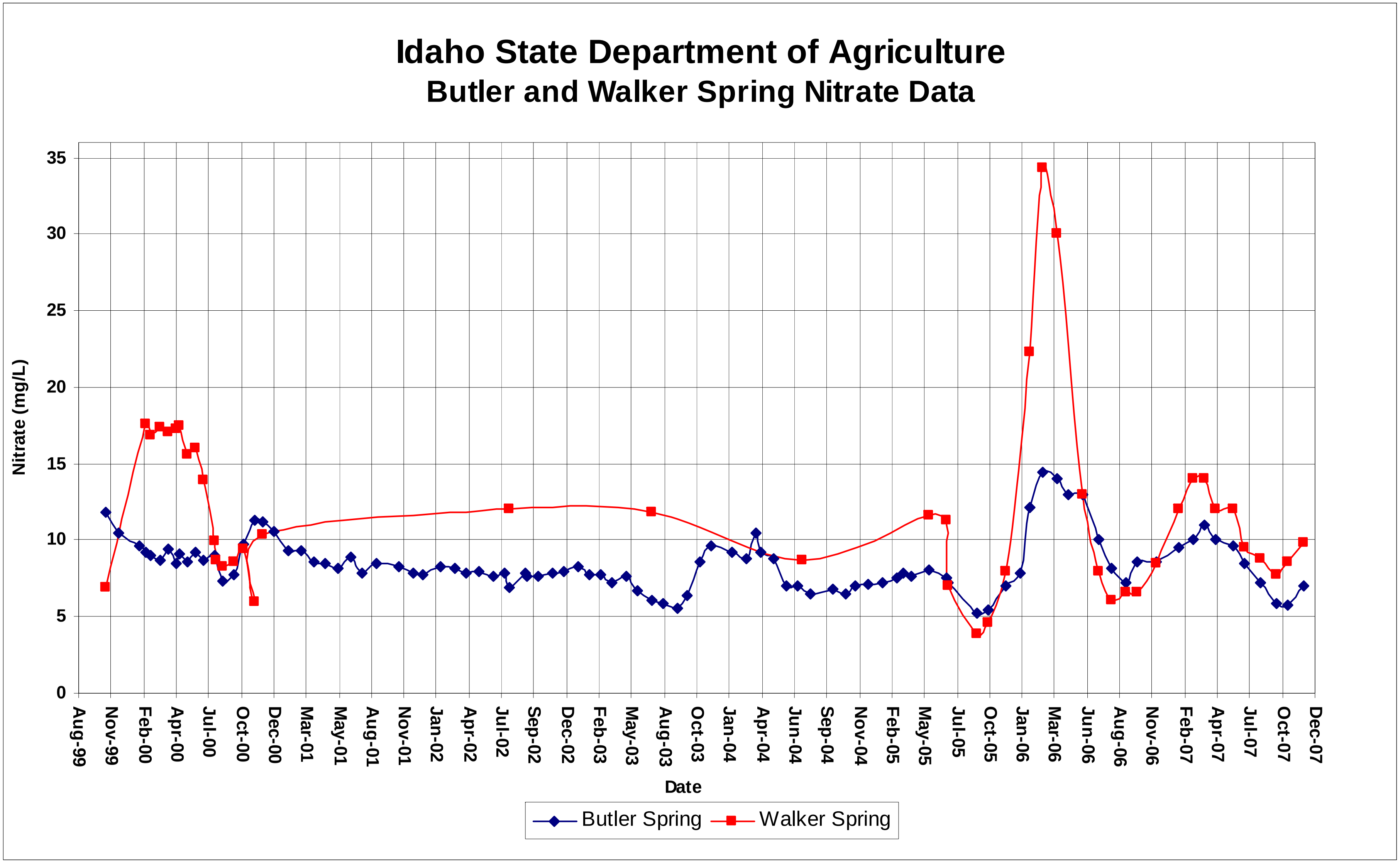


Figure 5. Nitrate concentrations in Walker and Butler Springs from November 1999 through November 2007.

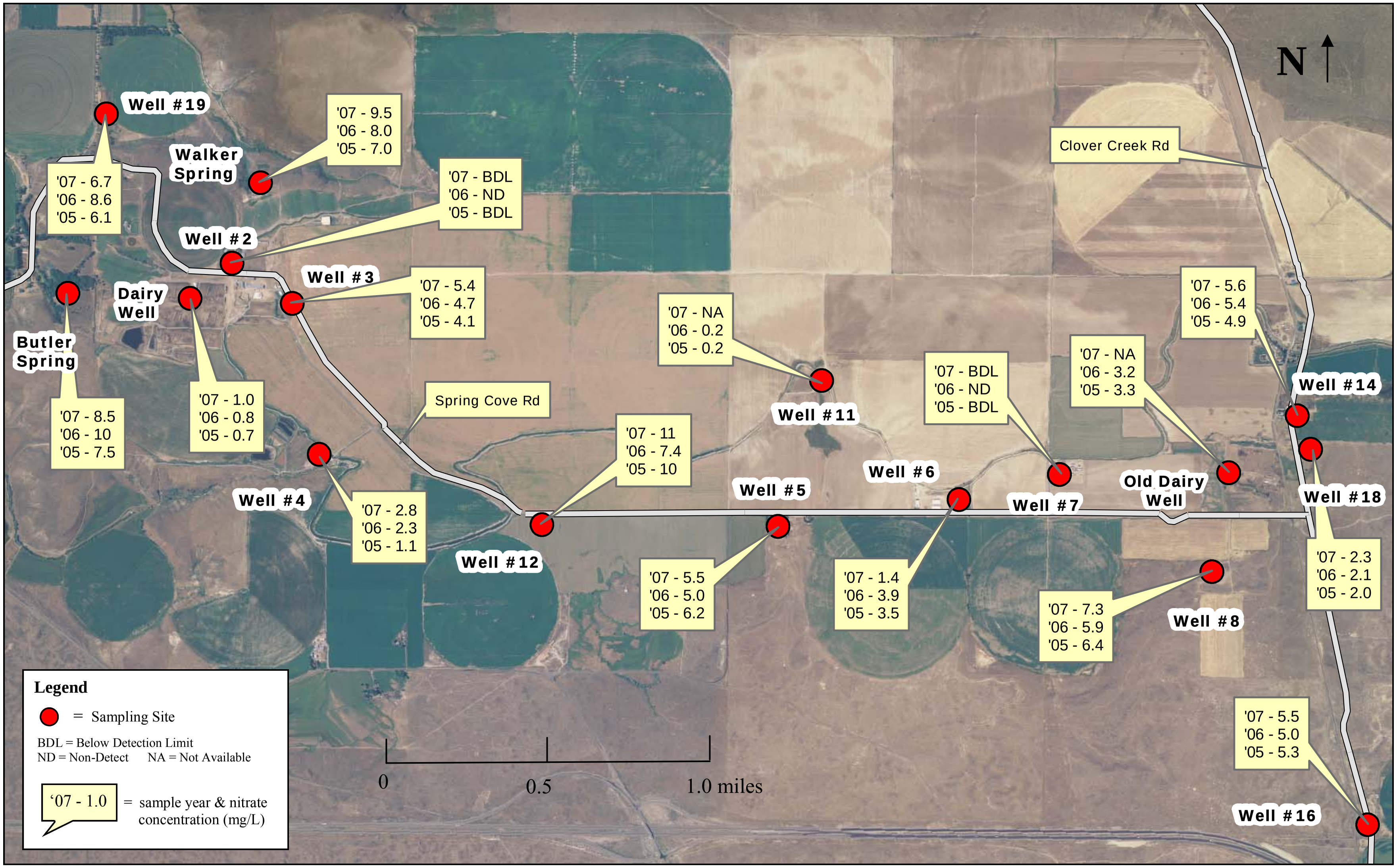


Figure 6. Bliss project site map with Butler Spring, Walker Spring, and well sampling locations and IDs. Nitrate concentrations (mg/L) closest to July in each of the last three years are noted at each site.

Table 3. Distribution of nitrate concentrations and statistics across sampling events in domestic and dairy wells from 2002 through 2007.

Concentration Range (mg/L)	2002	2003	2004	2005	2006	2007
	# samples (% samples)	# samples (% samples)	# samples (% samples)	# samples (% samples)	# samples (% samples)	# samples (% samples)
0.0 to 5.0	8 (57%)	9 (64%)	9 (69 %)	10 (67%)	9 (64%)	6 (46%)
5.0 to 10.0	4 (29%)	3 (22%)	4 (31%)	4 (27%)	5 (36%)	6 (46%)
> 10.0	2 (14%)	2 (14%)	0 (0.0%)	1 (6%)	0 (0.0%)	1 (8%)
Total	14 (100%)	14 (100%)	13 (100%)	15 (100%)	14 (100%)	13 (100%)
Mean Value	5.0 mg/L	4.2 mg/L	3.3 mg/L	3.6 mg/L	3.5 mg/L	4.2 mg/L
Median Value	4.7 mg/L	4.4 mg/L	3.1 mg/L	3.5 mg/L	3.6 mg/L	5.4 mg/L
Maximum Value	12.5 mg/L	10.7 mg/L	7.8 mg/L	10.1 mg/L	8.6 mg/L	11 mg/L

5.4 mg/L in 2007. Mean nitrate ranged from 3.3 mg/L in 2004 to 5.0 mg/L back in 2002. Median and mean nitrate values indicate a slight decreasing trend in nitrate concentrations from 2002 through 2004 but a slight increasing trend from 2004 through 2007. The EPA MCL health standard of 10 mg/L was exceeded six times over the past six years in domestic wells tested. Of the six occurrences, well #12 exceeded the nitrate MCL three times, well #6 two times, and well #5 one time (See Appendix 1).

Domestic Wells - Quarterly Sampling Event

Ten domestic wells were sampled quarterly from 2006 to 2007 (Figure 7 and Table 4). Nitrate statistics indicate mean, median, and maximum nitrate concentrations of wells with depth to water less than 100 feet in the project area are higher than those with depth to water greater than 100 feet (Table 5). For example, the most recent event, January 2007, indicates a median nitrate value of 7.0 mg/L and a maximum value of 9.2 mg/L in wells with depth to water less than 100 feet while wells with

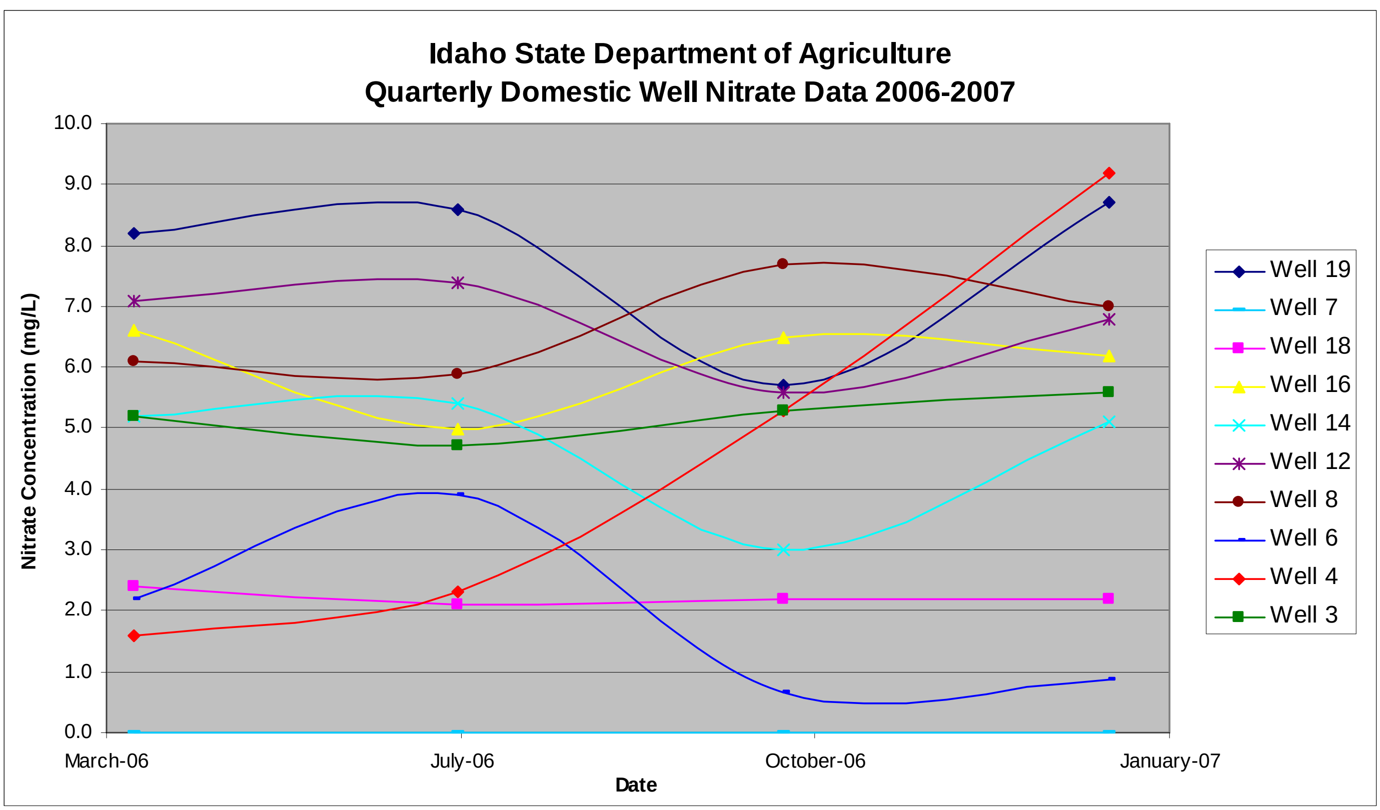


Figure 7. Quarterly nitrate concentrations in ten domestic wells in the Bliss project area from 2006 to 2007.

depth to water greater than 100 feet have a median value of 5.1 mg/L and a maximum concentration of 6.2 mg/L.

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 & McDonnell, 1998).

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

Table 4. Nitrate concentrations across quarterly sampling events in ten domestic wells from 2006 to 2007 (See Figure 6 for well locations).

Well #	Well Depth (feet)	Depth to Water (ft) Fall 1999	Nitrate (mg/L) April-06	Nitrate (mg/L) July-06	Nitrate (mg/L) October-06	Nitrate (mg/L) January-07
4	106	50	1.6	2.3	5.3	9.2
19	NA	62	8.2	8.6	5.7	8.7
6	NA	65	2.2	3.9	0.7	0.9
12	NA	85	7.1	7.4	5.6	6.8
8	145	87	6.1	5.9	7.7	7.0
14	345	158	5.2	5.4	3.0	5.1
18	250	160	2.4	2.1	2.2	2.2
16	450	231	6.6	5.0	6.5	6.2
3	385	320	5.2	4.7	5.3	5.6
7	432	NA	0.0	0.0	0.0	0.0

*NA = Not available

Table 5. Nitrate statistics for quarterly sampling events in ten domestic wells from 2006 to 2007.

Quarterly Statistics	Nitrate (mg/L) April-06	Nitrate (mg/L) July-06	Nitrate (mg/L) October-06	Nitrate (mg/L) January-07
All 10 wells				
Mean Value	4.5	4.5	4.2	5.2
Median Value	5.2	4.9	5.3	5.9
Maximum Value	8.2	8.6	7.7	9.2
5 wells - Depth to Water less than 100 ft				
Mean Value	5.0	5.6	5.0	6.5
Median Value	6.1	5.9	5.6	7.0
Maximum Value	8.2	8.6	7.7	9.2
5 Wells - Depth to Water greater than 100 ft				
Mean Value	3.9	3.4	3.4	3.8
Median Value	5.2	4.7	3.0	5.1
Maximum Value	6.6	5.4	6.5	6.2

makes determination of sources and extent of denitrification very difficult (Kendall & McDonnell, 1998).

Butler Spring

ISDA conducted $\delta^{15}N$ testing to use it as a possible indicator of NO_3-N source(s) in the ground water. Isotope values for 56 samples were available at the time of this report; results for most of 2006 and 2007 are pending at the laboratory. All samples were sent to the University of Nebraska-Lincoln Water Sciences Laboratory and the University of Idaho for $\delta^{15}N$ analysis.

Twenty-nine samples had values that suggested a fertilizer source and 26 had $\delta^{15}N$ values that indicated an organic or mixed source of nitrates (Table 6). One sample in January 2006 suggested an animal or human waste source.

Table 6. $\delta^{15}N$ results across all sampling events of Butler Spring from November 1999 through March 2006.

$\delta^{15}N$ Values ($^0/_{00}$)	Potential NO_3-N Source	Nov-99 through Mar-06
		# samples (% samples)
-5 to +5	Commercial Fertilizer	29 (51.8%)
+5 to +10	Organic Nitrogen in Soil or Mixed Source	26 (46.4%)
>10	Animal or Human Waste	1 (1.8%)
Total		56 (100%)

Walker Spring

Isotope values for the nine samples available from May 2005 through March 2006 indicated an organic or mixed source of nitrates (Table 7). $\delta^{15}N$ values of the samples ranged from 5.53 $^0/_{00}$ to 8.17 $^0/_{00}$. All samples were sent to the University of Nebraska-Lincoln Water Sciences Laboratory or the University of Idaho for $\delta^{15}N$ analysis. Isotope results from most of 2006 and 2007 are pending at the laboratory.

Table 7. $\delta^{15}N$ results from nine sampling events in 2005-2006 for Walker Spring.

$\delta^{15}N$ Values ($^0/_{00}$)	Potential NO_3-N Source	Nov-99 through Mar-06
		# samples (% samples)
-5 to +5	Commercial Fertilizer	0 (0%)
+5 to +10	Organic Nitrogen in Soil or Mixed Source	9 (100%)
>10	Animal or Human Waste	0 (0%)
Total		9 (100%)

Domestic Wells

Limited $\delta^{15}N$ data is available for domestic wells over the past three years. A majority of isotope samples await $\delta^{15}N$ analysis at the University of Idaho Forestry Lab and the University of Nebraska-Lincoln Water Sciences Laboratory. Isotope values for 10 samples available from July 2005 and July 2006 (Table 8) suggested a commercial fertilizer, organic, or mixed source of nitrates. $\delta^{15}N$ values of the samples ranged from 2.86 $^0/_{00}$ to 6.93 $^0/_{00}$.

Table 8. $\delta^{15}N$ results from July 2005 and July 2006 for domestic wells in the Bliss project area.

Well # (Figure 5)	$\delta^{15}N$ Values ($^0/_{00}$) July 2005	$\delta^{15}N$ Values ($^0/_{00}$) July 2006	Potential NO_3-N Source
5	2.86	NA	Commercial Fertilizer
8	3.88	4.93	Commercial Fertilizer
12	2.91	3.60	Commercial Fertilizer
14	NA	5.99	Organic Nitrogen in Soil or Mixed Source
16	5.92	6.93	Organic Nitrogen in Soil or Mixed Source
19	4.24	5.47	Commercial Fertilizer or Organic Nitrogen in Soil or Mixed Source

*NA = Not available

Conclusions

Ground water monitoring over an 8-year period indicates that nitrate has contaminated a shallow aquifer and several springs northwest of Bliss, Idaho. The EPA MCL health standard of 10 mg/L for nitrate was exceeded six times in six years in domestic wells, 12 times in eight years at Butler Spring, and 23 times in eight years at Walker Spring. The median nitrate values for Butler Spring and Walker Spring over 8 years were 8.2 mg/L and 10.4 mg/L, respectively, while the 2007 median nitrate value for domestic wells was 5.4 mg/L.

Nitrogen isotope test results in Butler Spring suggest a fertilizer or mixed source of contamination. One sample in January 2006 suggested an animal or human waste source. $\delta^{15}N$ values at Walker Spring suggest an organic or mixed source of nitrates. Nitrogen isotope values in domestic wells from July 2005 and July 2006 suggest a commercial fertilizer or mixed source of nitrate contamination.

Quarterly sampling of domestic wells indicated that wells with depth to water less than 100 feet had mean, median, and maximum nitrate concentrations that were higher during each sampling event than wells with depth to water greater than 100 feet. Nitrate concentrations were elevated above 5 mg/L, however, in several wells with depth to water greater than 100 feet.

ISDA began monitoring Butler Spring, Walker Spring, domestic wells, and dairy wells on a regular basis in November 1999. Monthly sampling at the springs and yearly sampling at the domestic wells will continue indefinitely. ISDA will continue monitoring to evaluate potential (current and historical) sources of contamination including commercial fertilization, dairy operations, and well construction.

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 has started and included the installation of dedicated monitoring wells to further evaluate the ground water.

Recommendations

ISDA recommends continued monitoring in the project area.

Testing should include, but not be limited to:

- Continued ground water monitoring for nutrients and common ions.
- 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.

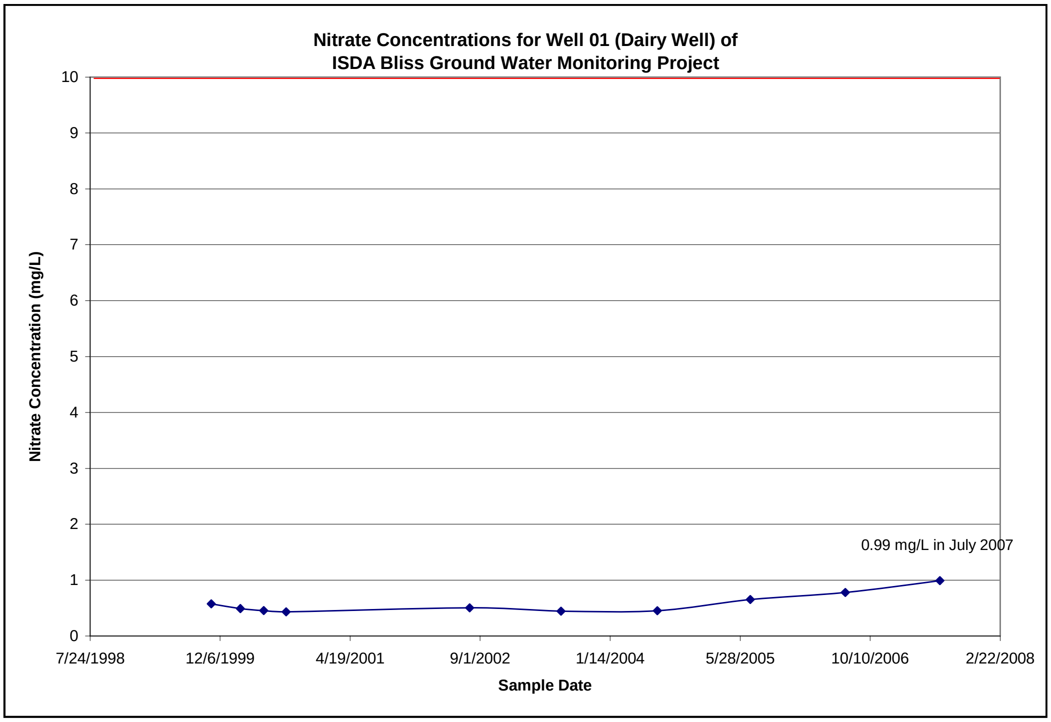
Freeze, R. A., and Cherry, J.A., 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, pp. 29.

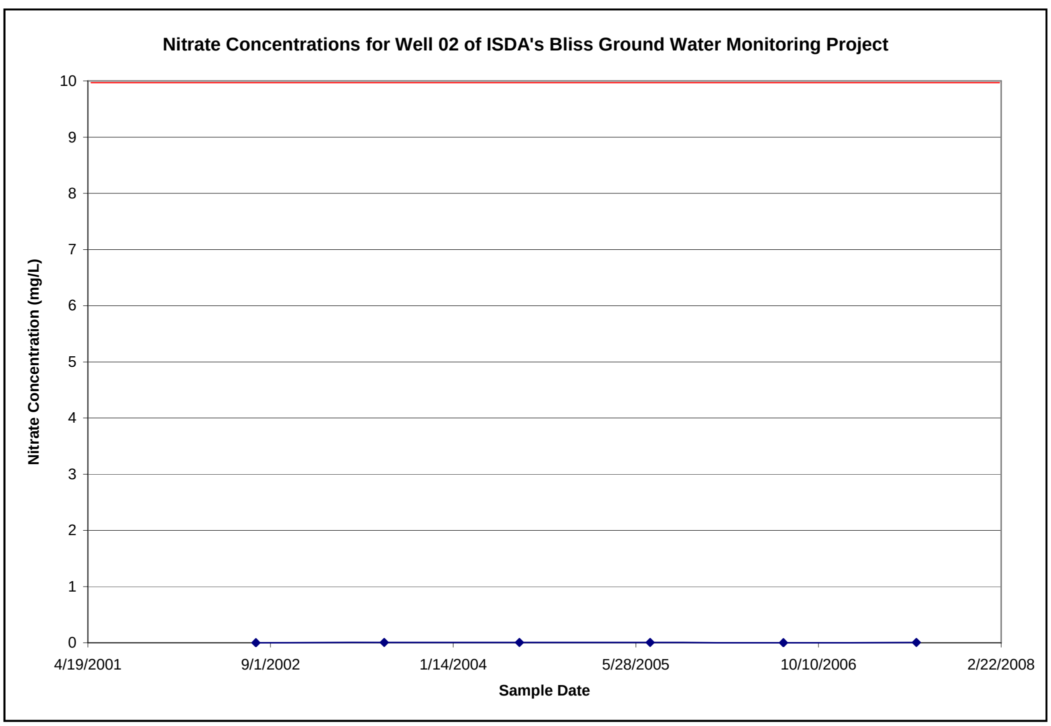
Garabedian, S. P., 1992. Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 1408-F, 65 p.

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

Appendix 1

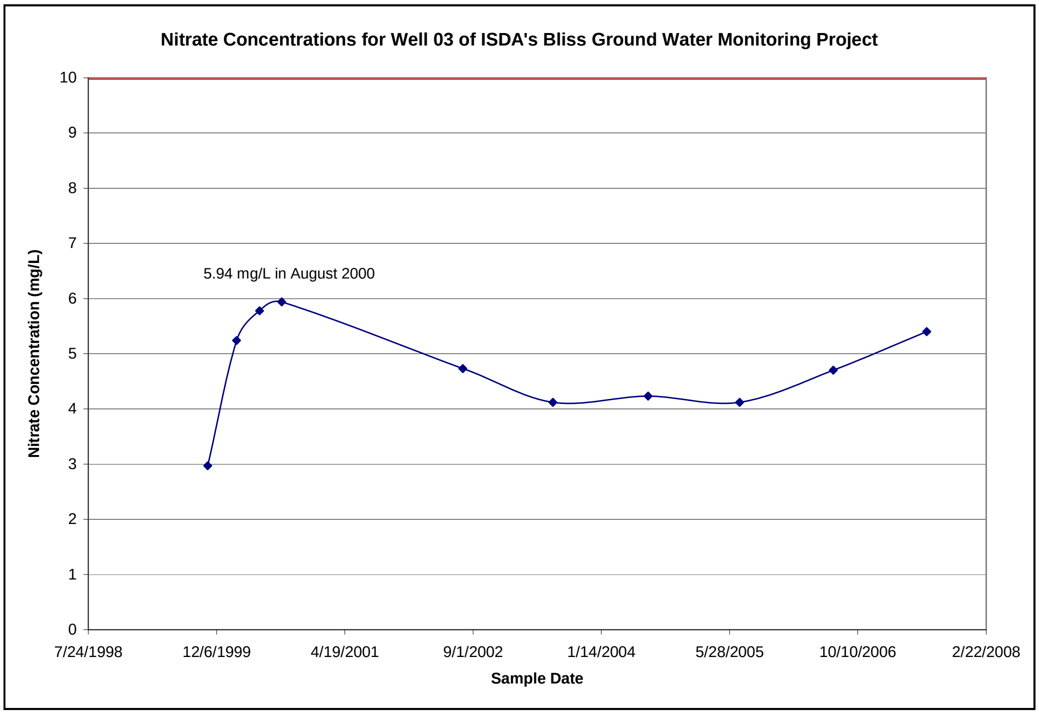
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

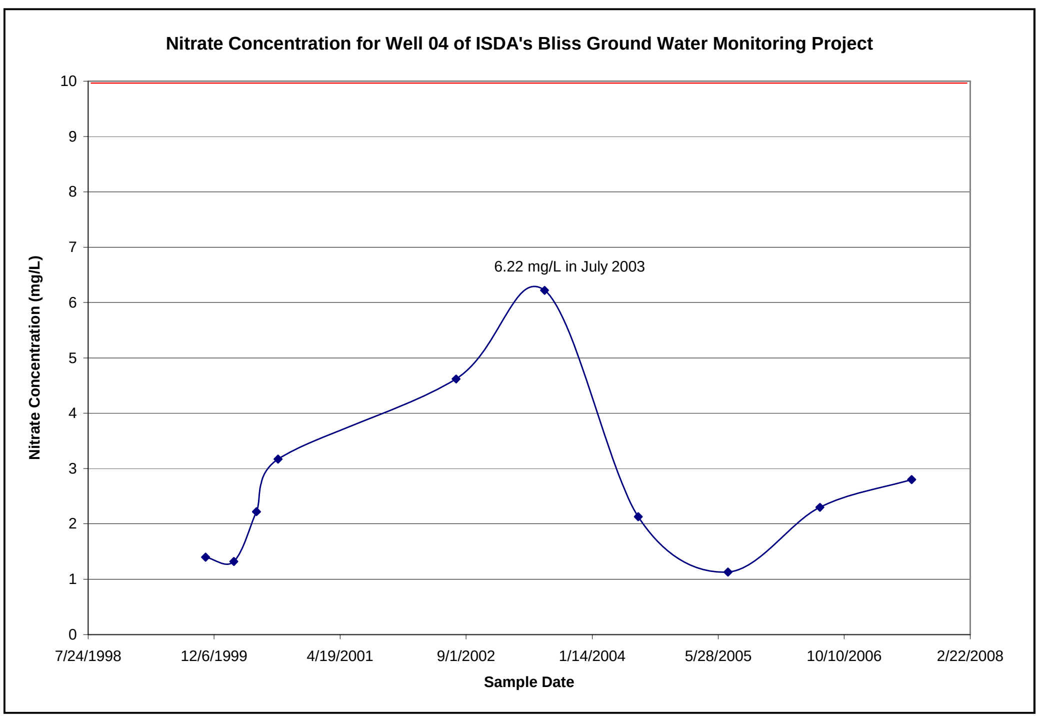




Appendix 1

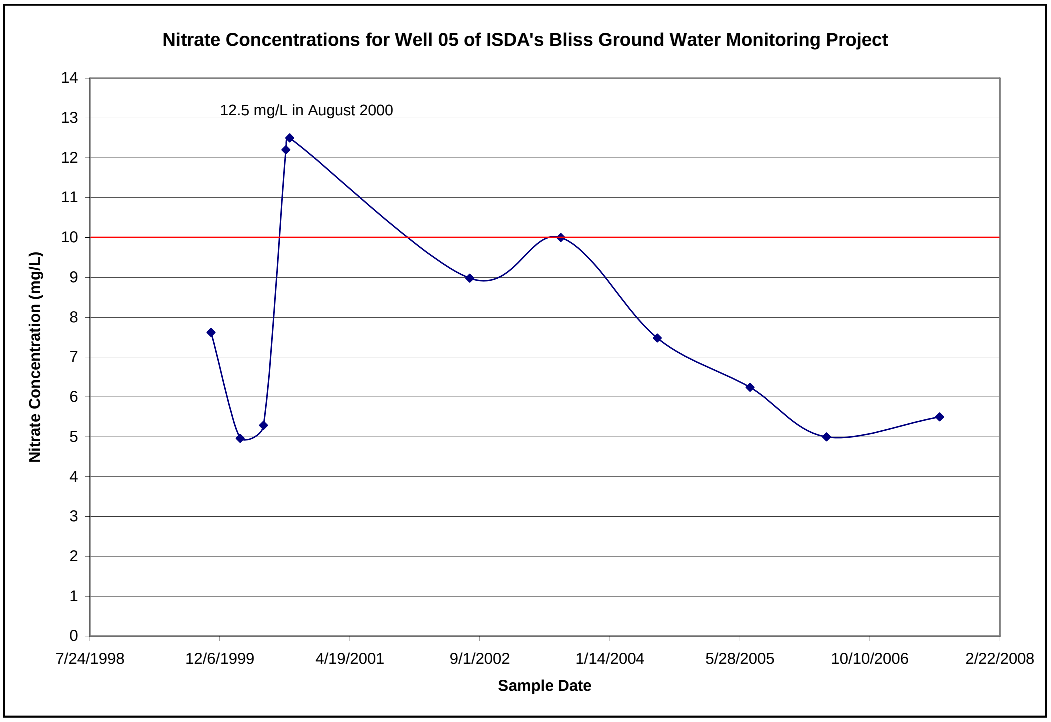
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

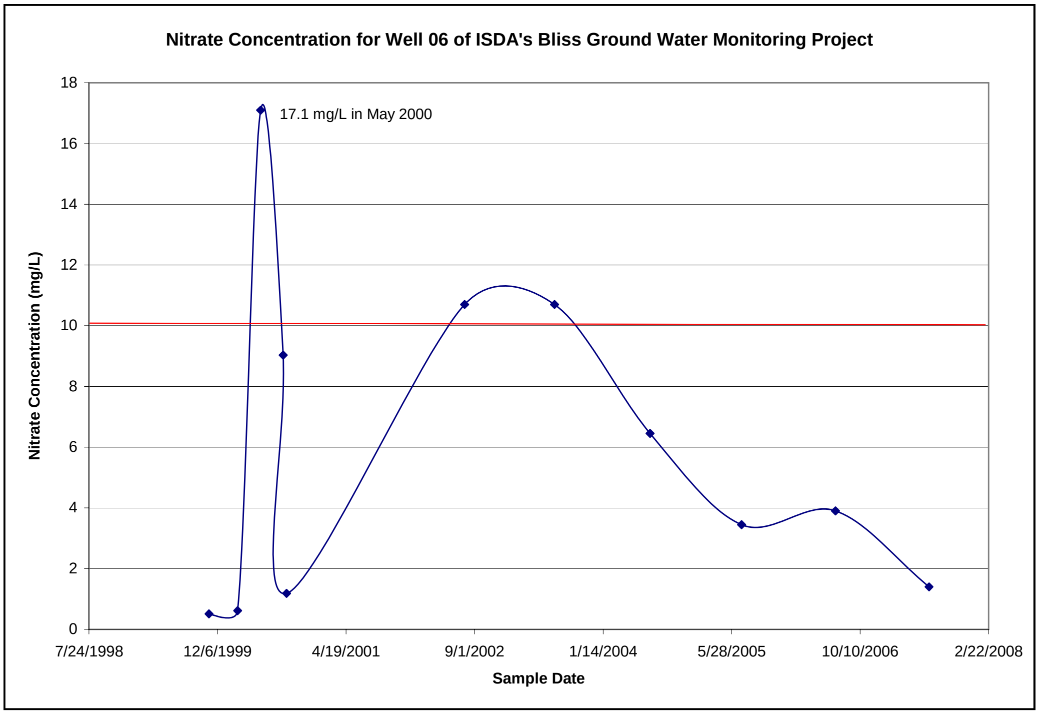




Appendix 1

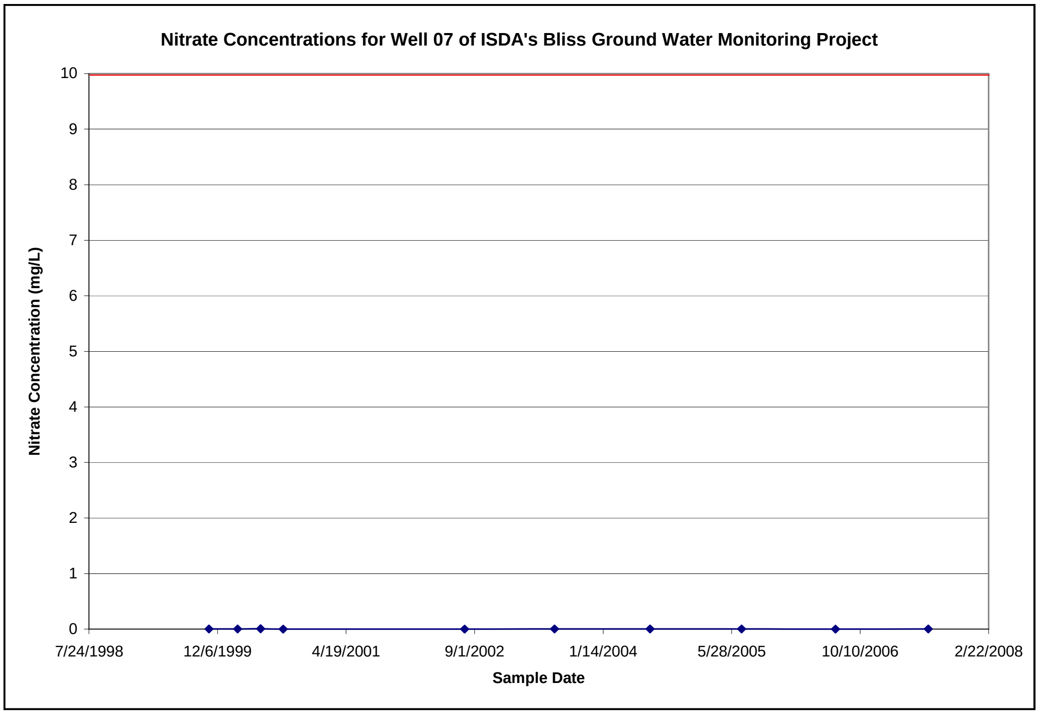
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

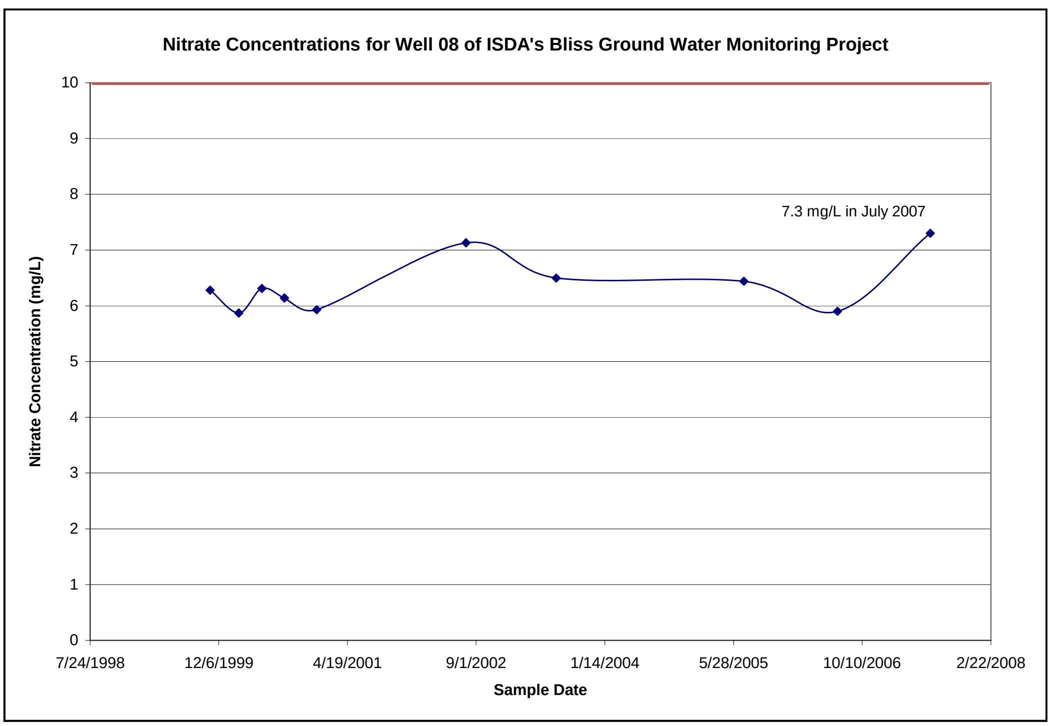




Appendix 1

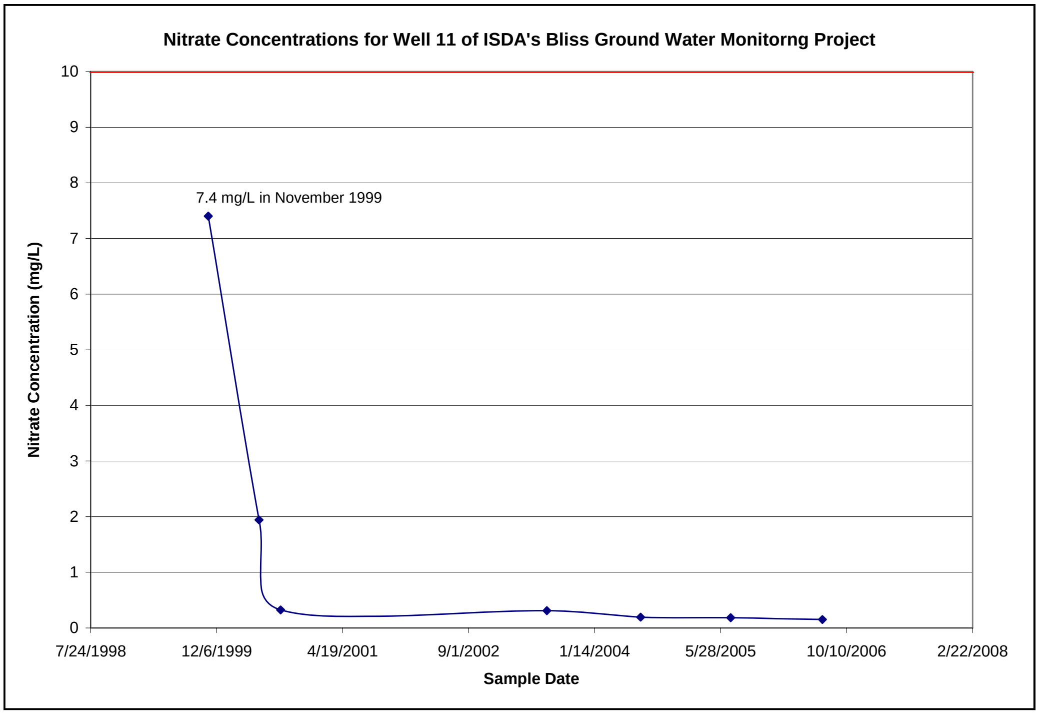
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

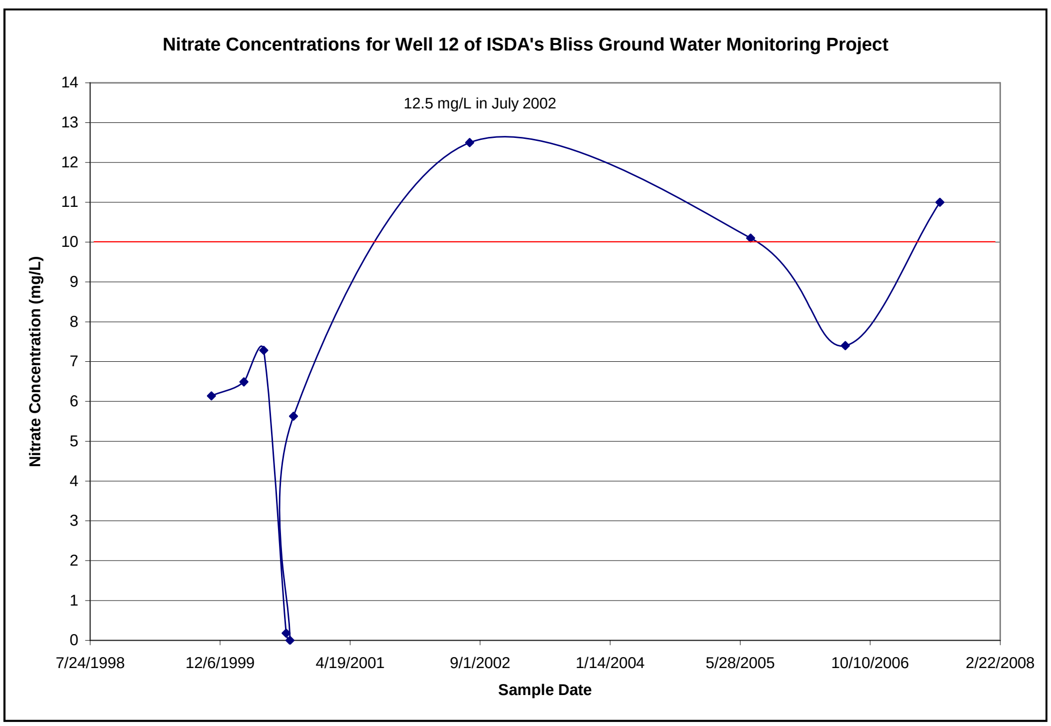




Appendix 1

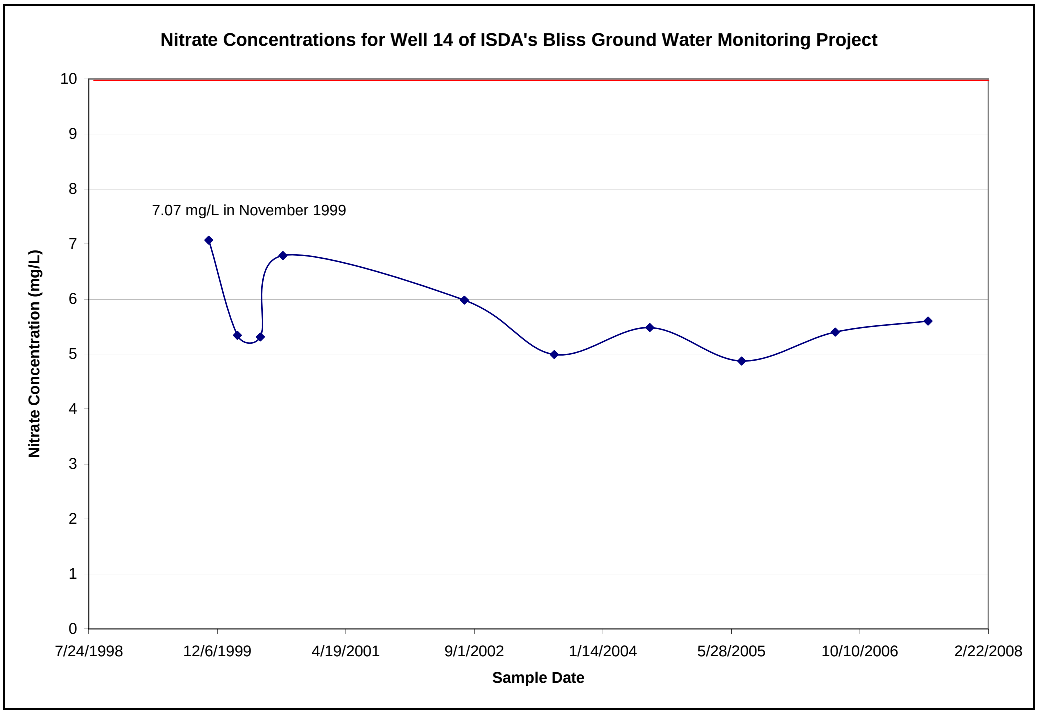
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

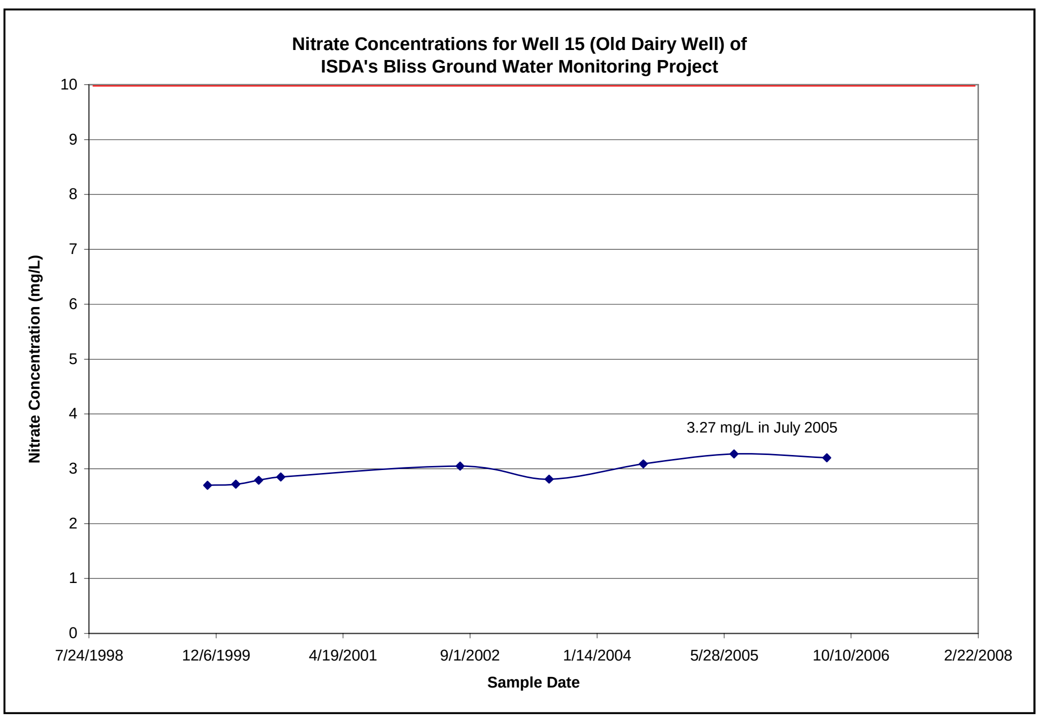




Appendix 1

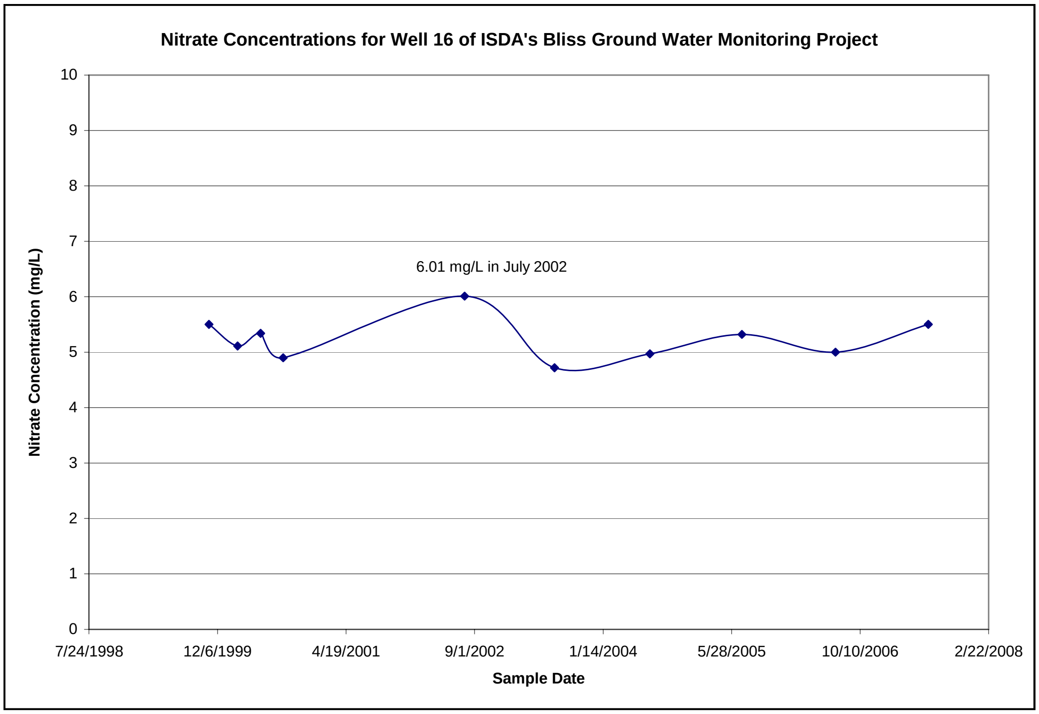
Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.

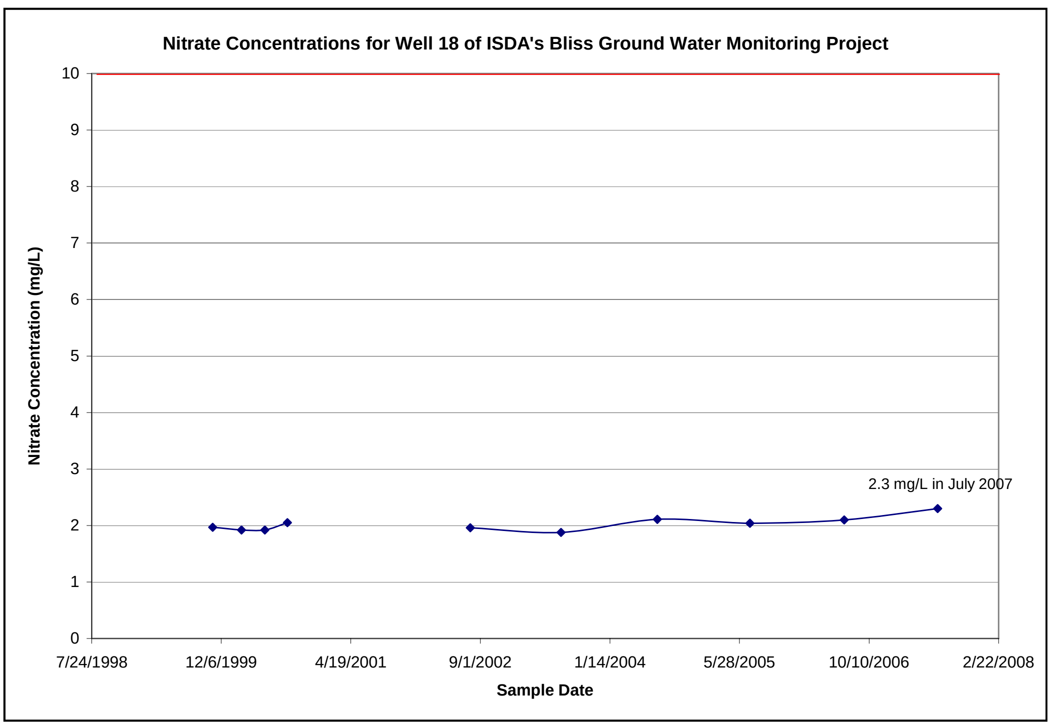




Appendix 1

Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.





Appendix 1

Nitrate Concentrations from 1999-2007 for individual wells in the Bliss Project Area with peak nitrate noted.