Idaho State Department of Agriculture
Division of Agricultural Resources

Assessment of Water Quality in the Sunnyside Area Washington County, Idaho

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ISDA Technical Results Summary #14

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Introduction

The Idaho State Department of Agriculture (ISDA) Sunnyside monitoring project began in November 2002 as a result of citizen concerns of possible ground water contamination in the area surrounding a confined animal feeding operation (CAFO) and onion disposal site (Figure 1). Previous monitoring by ISDA during the Southern Washington and Northern Payette Counties Alluvial Aquifer regional project indicated that ground water quality in the Weiser area is impacted by nitrates (Bahr, 2000). Twenty-two of fifty-two wells sampled during the spring of 2002 in the Weiser area (Figure 2, Fox, 2002) exceeded the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL)[1] of 10 milligrams per liter (mg/L) for nitrate-nitrogen (NO_3-N). The Idaho Department of Environmental Quality (IDEQ) has designated the Weiser area as the number one nitrate priority area in the state of Idaho.

Nutrients, common ions, dissolved metals, isotopes, and bacteria were evaluated during ISDA's testing in the Sunnyside area in November 2002. Laboratory results indicated a majority of domestic wells (73%) in the project area had NO_3-N concentrations that exceeded 10 mg/L. In addition, a majority of domestic wells (58%) had $\delta^{15}N$ isotope values that indicated an animal or human waste source of NO_3-N. IDEQ sampled ten wells for nitrate in 1989 in the area of the onion disposal site (Figure 3). A majority of wells (70%) had NO_3-N concentrations that exceeded 10 mg/L.

ISDA is currently working to advise regulatory agencies, residents, and officials of the area to minimize further ground water contamination and possible health risks. Ground water monitoring will continue at least through 2003 to assist with these efforts.

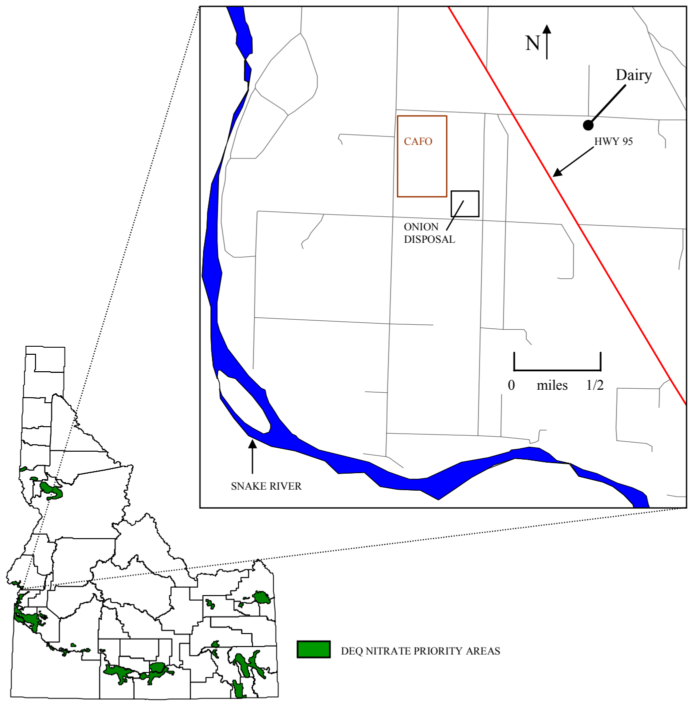

Figure 1. Sunnyside project area and location of DEQ nitrate priority areas.

Methods

To establish this local monitoring project, ISDA selected domestic wells up, down, and side gradient of the CAFO and onion disposal site and coordinated with homeowners to conduct ground water sampling. The CAFO freshwater outlet drain and Snake River slough were also sampled. All sampling was conducted after a quality assurance project plan (QAPP) was established. Permission was granted by the land owners prior to sampling.

Nutrients, common ions, dissolved metals, isotopes, and bacteria were evaluated during ISDA's testing. All sample collection followed the established ISDA QAPP

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

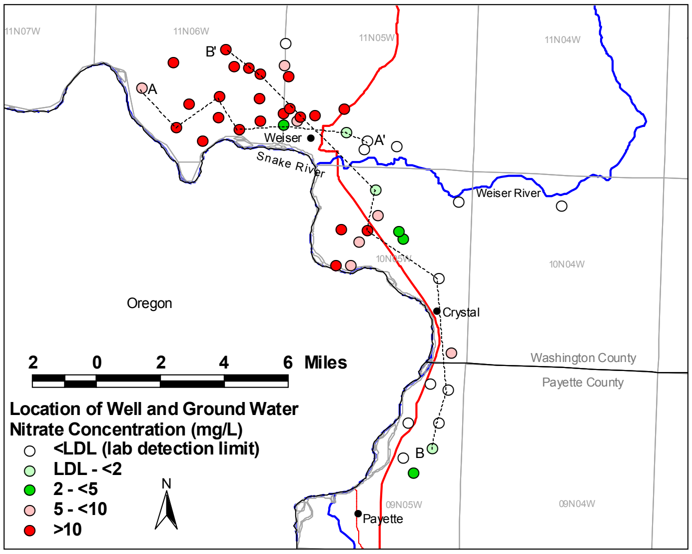

Figure 2. Location of wells sampled by ISDA in Washington and Payette Counties, Spring 2002. Colors represent nitrate-nitrogen concentrations (Fox, 2002).

for preservation, handling, storage, and shipping. 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). The field blanks consisted of laboratory grade deionized water. The blank samples were used to determine the integrity of the field team's sample handling, the cleanliness of the sample containers, and the accuracy of the laboratory methods.

Samples were sent to the University of Idaho Analytical Sciences Laboratory (UIASL) in Moscow, Idaho. The UIASL utilizes EPA approved and validated methods.

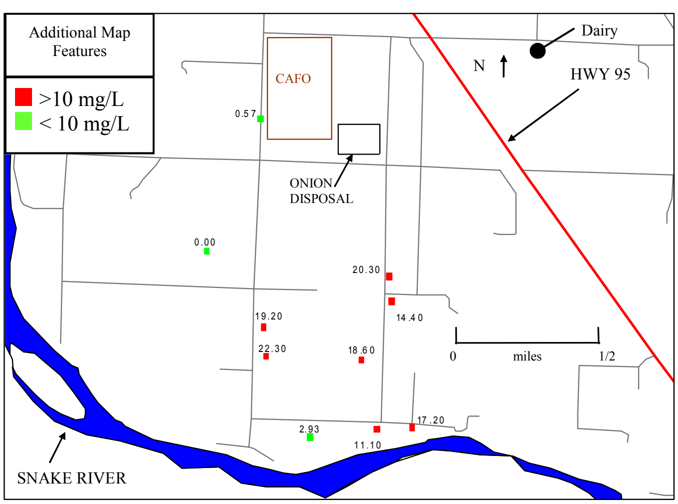

Figure 3. Nitrate concentrations at 10 wells in the Sunnyside monitoring area obtained by DEQ in 1989.

UIASL conducted tests for nitrate, nitrite, ammonia, orthophosphorus, chloride, sulfate, bromide, and fluoride using EPA Methods 300.0 and 350.1. UIASL also conducted tests for alkalinity and dissolved metals using EPA Methods 310.1 and 200.7. Internal laboratory spikes and duplicates were also completed as part of UIASL's quality assurance program.

Bacteria samples were analyzed by the State of Idaho Health and Welfare Laboratory in Boise, Idaho. Isotope samples were collected, frozen, and shipped to the North Carolina State University Stable Isotope Laboratory, in Raleigh, North Carolina for analysis.

Description of Project Area

The Sunnyside project encompasses an approximately one mile wide and three mile long area of agricultural, commercial, and residential land adjacent to the Snake River (Figure 1). Land use in the area consists of irrigated agricultural fields, a confined animal feeding operation, a dairy operation, an onion disposal site, commercial businesses, and rural housing. The major crop in the area is alfalfa. Additional crops include wheat, corn, and onions. Feedlot and dairy manure is applied to land within the project area.

Shallow ground water conditions exist across this area. Typically, depths to ground water are less than 20 feet. A potential source of recharge to this shallow system comes from applied irrigation waters. Shallow subsurface alluvial deposits (primarily sands and gravels) conducive to leaching underlie the Sunnyside area. Potential sources for NO_3-N leaching to ground water in the area include cattle manure, land applications of manure, wastewater lagoons, applied nitrogen-based fertilizers, rotations of legume crops, and septic systems.

Hydrogeology

The project area lies within the western Snake River Plain, which is a basin filled with sedimentary deposits and volcanic rocks. The sedimentary deposits make up the major portion of the shallow aquifer in the project area (Figure 4). Using data from well logs, the shallow aquifer is composed of clays, silts, sands, and gravels. The majority of these sediments accumulated during prehistoric and historic Snake River deposition (Newton, 1991). Coarse-grained channel-type deposits may exist across the project area constituting preferential pathways for ground water flow and contaminant migration.

A geologic cross-section has been constructed using well logs from the project area (Figure 4). A layer of clay,

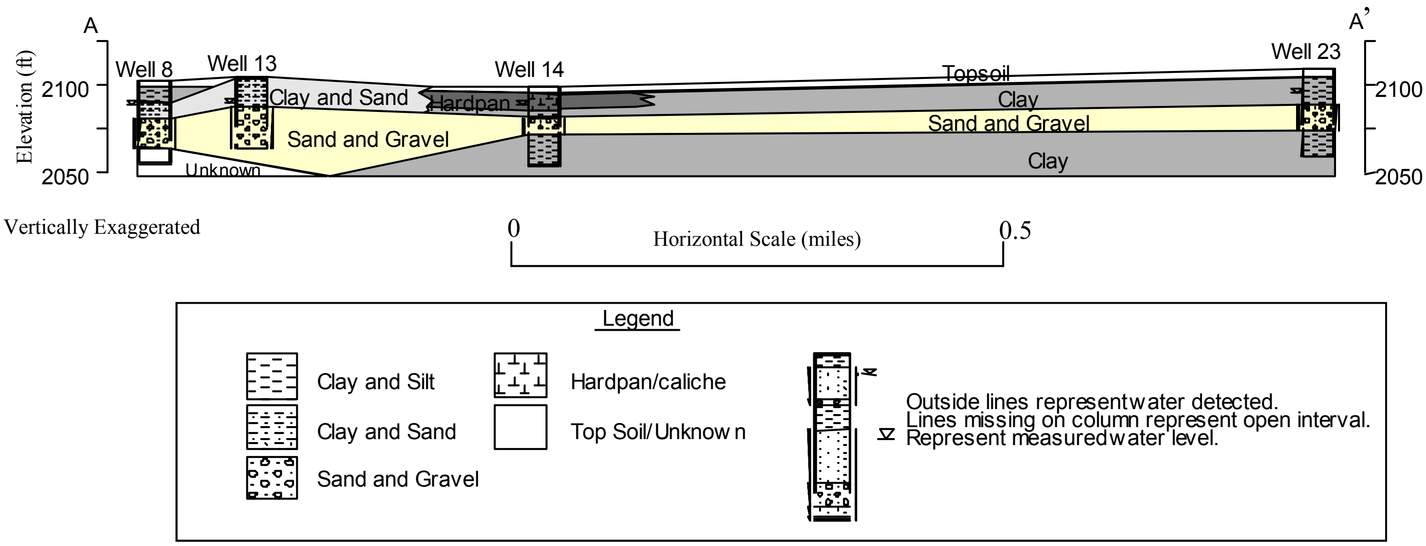

Figure 4. Geologic cross-section of Sunnyside area. See Figure 5(b) for cross-section location.

approximately fifteen feet in thickness, overlies a sand and gravel aquifer that varies from a minimum nine feet in thickness to an unknown maximum. A majority of wells are screened in this sand and gravel zone. A thick layer of blue clay underlies the shallow sand and gravel aquifer. The blue clay separates the shallow alluvial aquifer from the deeper sedimentary aquifer (Newton, 1991).

Horizontal ground water flow directions in the project area were determined by contouring static water level measurements using Surfer™ computer software (Figure 5). Surveying of well head elevations, along with static water level measurement, was conducted by ISDA at a majority of the wells in the project area. Figure 5(a) illustrates the effects of CAFO pumping on ground water levels. Removing the pumping influence of the CAFO wells (Figure 5b) demonstrates that general ground water

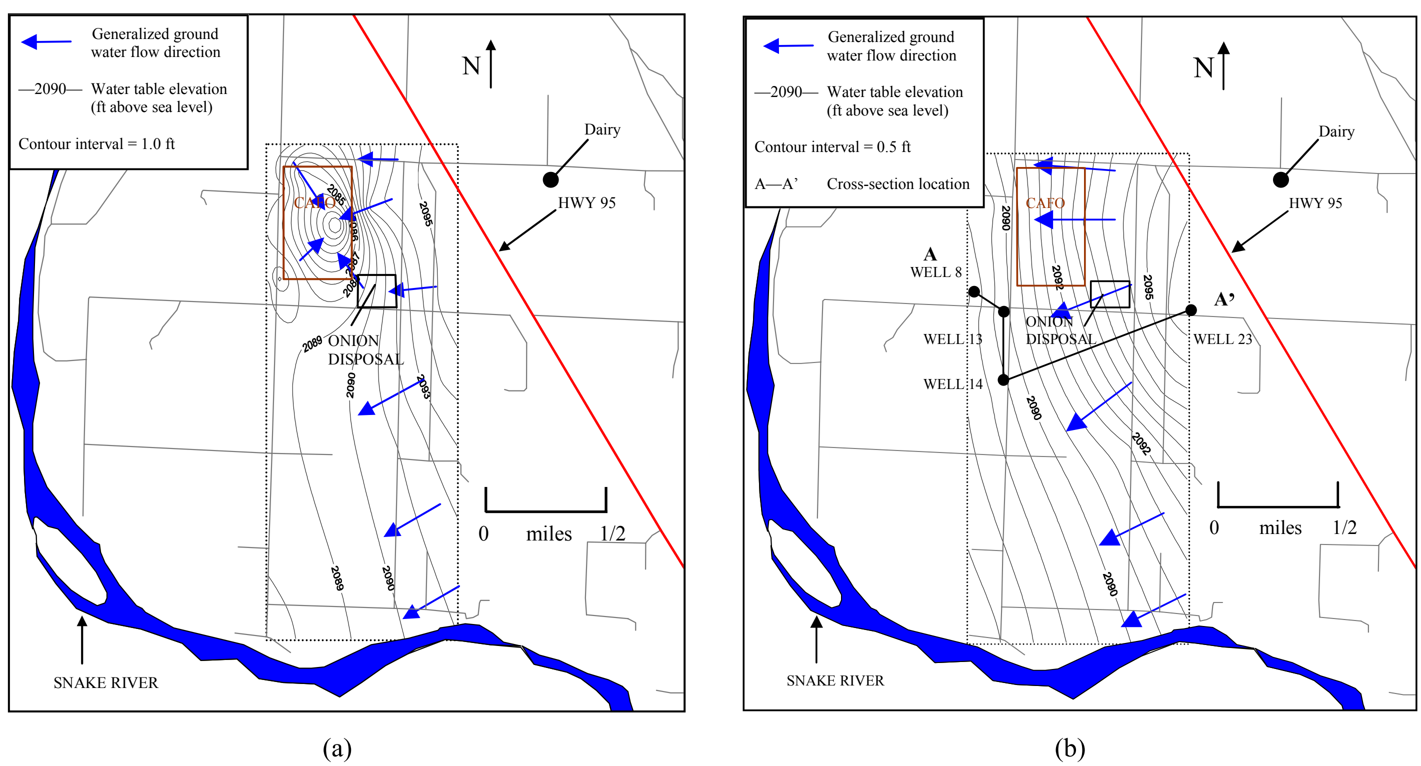

Figure 5. Ground water flow maps showing (a) pumping-induced ground water gradients and (b) the potentiometric surface after removing the pumping influence of CAFO wells. Cross-section location for Figure 4 is indicated on Figure 5(b).

movement is toward the Snake River, an area of probable ground water discharge. The potentiometric surface does correspond with known ground water movement characteristics and theory.

In addition, ground water flow direction appears to correspond to topographic slope, another characteristic common to shallow ground water. In general, the map indicates the general direction of ground water movement is west to southwest (Figure 5b).

Results

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

Nitrate

ISDA conducted NO_3-N testing of twenty-two wells during November 2002 in the Sunnyside area (Table 1). The CAFO freshwater outlet drain and the Snake River slough were also tested for nitrates (Figure 6). Results of ground water sampling indicate a maximum concentration of 37 mg/L (Table 1). The MCL health standard of 10 mg/L was exceeded in 73% of the wells. The median nitrate value for all wells was 14 mg/L.

Nitrate-nitrogen concentrations are most elevated in the areas west, or downgradient, of the CAFO and east, or upgradient, of the onion disposal site (Figures 6 and 7). The number of detections over 10 mg/L are of concern because of potential health risks. The detection over 10 mg/L in the slough is a concern because of potential nitrate loading into the Snake River.

Table 1. Distribution of nitrate concentrations in 22 wells sampled in November 2002.

Concentration Range (mg/L)	Number of Wells	% of Total
0.0 to 10.0	6	27.3
10.0 to 20.0	8	36.3
20.0 to 30.0	6	27.3
> 30.0	2	9.1
Total	22	100.0
Mean Value	15.9 mg/L	
Median Value	14 mg/L	
Maximum Value	37.0 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 and 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 makes determination of sources and extent of denitrification very difficult (Kendall and McDonnell, 1998).

In November 2002, ISDA chose to conduct $\delta^{15}N$ testing to use it as a possible indicator of NO_3-N source(s) in the ground water. Because of the cost of testing and limited resources, nineteen wells, the Snake River slough, and the CAFO lagoon were selected for testing. Wells chosen for nitrogen isotope testing had NO_3-N concentrations above 10 mg/L. The samples were sent to the North Carolina State University Stable Isotope Lab for $\delta^{15}N$ analysis.

Results of $\delta^{15}N$ testing returned values that ranged from +2.34 $^0/_{00}$ to +18.09 $^0/_{00}$. Eleven wells had values that suggested an animal or human waste source (Table 2), one suggested a fertilizer source, and seven had $\delta^{15}N$ values that indicated an organic or mixed source of

Table 2. $\delta^{15}N$ results for Sunnyside monitoring project, November 2002.

$\delta^{15}N$ Values ($^0/_{00}$)	Potential NO_3-N Source	2002 19 wells total	% of Total Wells
-5 to +5	Commercial Fertilizer	1	5.3
+5 to +10	Organic Nitrogen in Soil or Mixed Source	7	36.8
>10	Animal or Human Waste	11	57.9

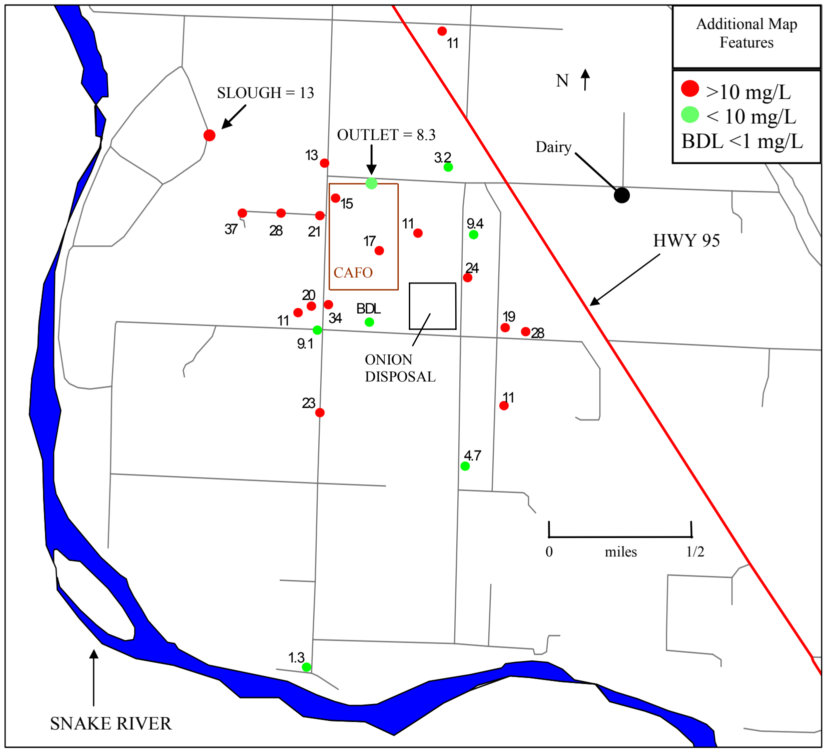

Figure 6. Nitrate concentrations at 22 wells, CAFO freshwater outlet drain, and Snake River slough in the Sunnyside monitoring area.

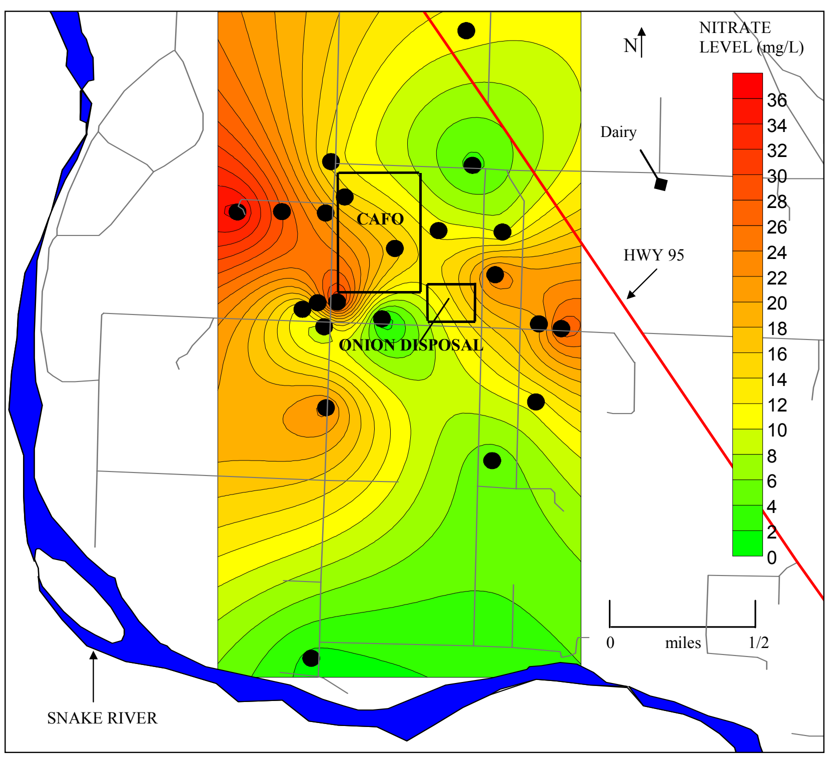

Figure 7. Kriged contour map of ground water nitrate concentration from sampled wells (black dots) in the Sunnyside area.

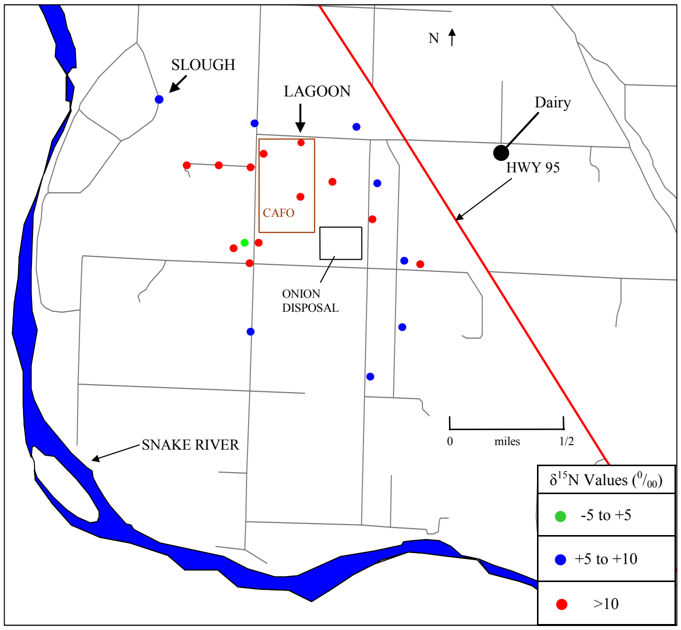

Figure 8. $\delta^{15}N$ values at 19 wells, CAFO lagoon, and Snake River slough in the Sunnyside area.

nitrates. The eleven wells that suggested an animal or human waste source are in areas downgradient and upgradient from the CAFO (Figure 8).

Oxygen Isotopes

Denitrification is the removal of nitrogen from compounds, by bacteria in the soil, which results in the escape of nitrogen into the air. Analysis of both $\delta^{18}O$ and $\delta^{15}N$ of nitrate allows denitrification effects to be distinguished from mixing of sources. Amberger and Schmidt (1987) reported that denitrification results in enrichment in both ^{18}O and ^{15}N of the residual nitrate. This dual isotope approach takes advantage of the observation that the ratio of the enrichment in ^{15}N to the enrichment in ^{18}O in residual nitrate during denitrification appears to be about 2:1 (Amberger and Schmidt, 1987).

Wells in the project area that were tested for $\delta^{15}N$ were also tested for $\delta^{18}O$. A linear trendline matched to data from a plot of $\delta^{15}N$ versus $\delta^{18}O$ (Figure 9) shows a ratio much less than 2:1. This indicates that $\delta^{15}N$ values over +10 $^{0}/_{00}$ are due to animal or human waste sources and not denitrification processes.

Bacteria

Each well was tested for total coliform bacteria and Escherichia coli (E. coli) bacteria. Positive total

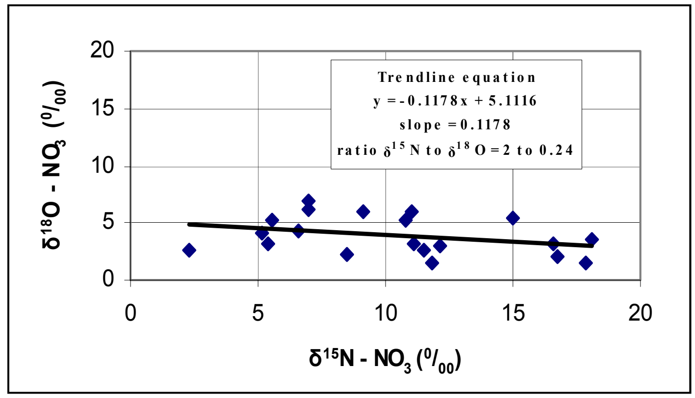

Figure 9. Plot of $\delta^{18}O$ versus $\delta^{15}N$ for 19 wells in the Sunnyside area.

coliform results may indicate the possibility of mammalian intestinal bacteria being present. Three wells and the CAFO freshwater outlet tested positive for total coliform (Table 3 and Figure 10). The only positive E. coli detection was found in the CAFO freshwater drainage outlet (Table 3).

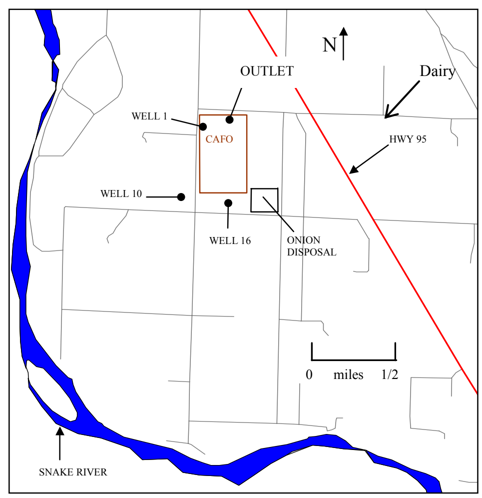

Figure 10. CAFO freshwater drain outlet and other bacteria hit locations from Table 3.

Table 3. Positive bacteria detects for Sunnyside monitoring project, November 2002.

Location	Nitrate (mg/L)	Total Coliform (colonies per 100 ml)	Ecoli (colonies per 100 ml)
Outlet sample	8.3	7700	1100
Well 1	15	1	<1
Well 10	20	3	<1
Well 16	<1	12	<1

Sources of bacteria in the ground water could be contaminated piping systems, septic tanks, domestic animal waste sources, and contaminated surface waters located near the wells sampled. Bacteria in the ground water could also be associated with nearby CAFO waste, waste handling systems, or lagoons.

Conclusions

Ground water within the shallow alluvial aquifer of the project area is significantly impacted from NO_3-N. The high NO_3-N concentrations and the large number of NO_3-N detections within the project area are of concern. The Sunnyside area is highly vulnerable to ground water and surface water contamination due to (1) shallow ground water conditions, (2) shallow subsurface alluvial deposits, primarily sands and gravels, and (3) proximity to the Snake River.

In November 2002, 16 or 73% of the wells sampled exceeded the EPA MCL of 10 mg/L for NO_3-N; 8 or 36.4% of all wells exceeded 20 mg/L for NO_3-N. Areas having the highest NO_3-N concentrations are downgradient of the CAFO.

The large number of $\delta^{15}N$ values exceeding +10 $^0/_{00}$ suggest that animal or human waste sources are contributing to high NO_3-N concentrations. Oxygen isotope analysis indicates that $\delta^{15}N$ values over +10 $^0/_{00}$ are due to animal or human waste sources and not denitrification processes. High NO_3-N and $\delta^{15}N$ values downgradient of the CAFO suggest that the CAFO is contributing to ground water contamination. High NO_3-N and $\delta^{15}N$ values upgradient of the onion disposal site suggest other potential sources of NO_3-N including land application of manure, septic systems, and a dairy east of Highway 95.

Bacteria contamination is a concern at the freshwater outlet of the CAFO. High concentrations of total coliform and E. coli may be discharging into the Snake River via the outlet through an underground pipe system. In addition, the NO_3-N detection over 10 mg/L at the slough indicates potential nitrate loading into the Snake River. The $\delta^{15}N$ value at the slough (+9.75 $^0/_{00}$) is in the high end of the organic nitrogen/mixed source range and suggests potential NO_3-N inputs from organic nitrogen, animal waste, and/or human waste.

Recommendations

ISDA recommends the following improvements, for water quality, be made to the existing CAFO facility:

- Prevention of surface water runoff.
- Facility lagoon(s) to meet state requirements.
- Drainage of lagoon, evaluation of lagoon liner, and installation of approved liner if needed.
- Investigation of ground water table interaction with lagoons after irrigation season begins.
- Elimination of overflow at freshwater cattle troughs.
- Overall improvements in manure management.
- Establishment and implementation of a nutrient management plan.
- Clarification of the EPA NPDES permit.

ISDA recommends continued and more intensive monitoring in the project area.

Testing should include, but not be limited to:

- Additional testing for pharmaceuticals and DNA.
- Continued ground water monitoring for nutrients, common ions, and bacteria.
- Continued isotope testing to determine possible NO_3-N sources.
- Additional static water level measurement.
- Soil sampling and soil pore water sampling.
- ISDA effectiveness monitoring as BMP programs or regulatory changes are implemented.
- Installation of monitoring wells. Locations should include, but not be limited to, areas up and downgradient of the CAFO and onion disposal site.
- Additional monitoring east of the CAFO to determine high NO_3-N sources.
- Assessment of the pipe system under the CAFO and the piping leading north from the CAFO freshwater outlet.
- Identification of land application areas.

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, pesticide, 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.
- Additional assessment of water quality data to better evaluate water chemistry.

ISDA will continue to work with the regulated facilities to protect ground water. ISDA recommends that the Weiser River Soil Conservation District (SCD) lead an agricultural response related to unregulated nonpoint sources of pollutants. The Weiser River SCD should work with local agrichemical professionals, landowners, agencies, and the IDEQ Weiser Nitrate Ground Water Protection Committee 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.

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