EVALUATION OF IRRIGATION APPLICATION MANAGEMENT PRACTICES TO PROTECT GROUNDWATER QUALITY

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ABSTRACT

Agricultural management practices relative to irrigation application and type and frequency of nitrogen fertilizer application can impact levels of nitrates in groundwater. In recent history, high levels of nitrates were reported in public water supply wells in Goshen County, WY. Subsequent research efforts concluded that likely sources of nitrate were organic soil nitrogen and ammonium or nitrate fertilizer. Some focus was then turned to agricultural production higher up in the watershed. Best Management Practices relative to irrigation and nitrogen application were identified and implemented and water quality monitoring began. This study established long term water quality analysis to determine if significant changes are occurring in nitrate levels relative to implementation of BMPs. A network of landowners was created and lysimeter studies, soil surveys and groundwater well locations, were established to sample and analyze for nitrate. Lysimeter data was highly variable and showed no consistent trend in leaching of NO_3^- - N into lower depths when compared with flood irrigated sites. Soil NO_3^- - N suggested that sprinkler irrigated sites decreased nitrate leaching from upper soil profile into lower depths when compared with flood irrigated sites. In the monitoring wells, long term mean nitrate concentrations from 1994-2009 show that 7 of 22 wells exceeded the U.S. Environmental Protection Agency (U.S. EPA) Primary Drinking Water Standard of 10 ppm NO_3^- - N. Overall project findings suggest that problems with regard to high groundwater NO_3^- - N concentrations still persist in some of the monitoring wells of the study area and highlight the need for continued water quality monitoring and implementation of agricultural BMPs.

INTRODUCTION

In many parts of Wyoming, groundwater is the only source of drinking water as surface water is either absent or already appropriated. Protecting the quality of this groundwater is crucial. In the study area of the North Platte River Valley Watershed (NPRVW), agricultural production is significant, ranking first in the state for amount of farmland and value of cash crops (NRCS, 1995; Goerter et. al, 1997; Reddy and Lin, 2000). Consequently, land use in the watershed is dominated by irrigated agriculture. Previous groundwater monitoring studies in the area indicated some Public Water Supply and private domestic wells exceeded the U.S. EPA Primary Drinking Water Standard for nitrate of 10 ppm. The Town of Torrington and the U.S. Geological Survey conducted nitrate monitoring studies from 1995-1998. Results suggested a significant trend in 34 of 72 sites. Twenty-six had increasing nitrate concentrations and eight

had decreasing concentrations. The study also identified potential sources of nitrate in groundwater to be from organic nitrogen, ammonium, or nitrate fertilizer (Miller and Gerhard, 1999).

In 1993, the University of Wyoming launched its involvement to contribute research to this area to protect groundwater quality. The most recent project began in March of 2007 with the purpose of evaluating current Best Management Agricultural Practices, continuing effective monitoring programs utilizing lysimeters, continuing soil and groundwater sampling and analyzing for nitrate, and conducting educational workshops with network participants to disseminate current findings.

OBJECTIVES

- Monitor groundwater wells within the Torrington wellhead protection area for nitrates on a seasonal (quarterly) basis.
- Determine the rate of nitrate movement through the upper-most soil layers.
- Determine soil properties and nitrate leaching through the A, B, and C horizons.
- Evaluate the effectiveness of BMPs on their ability to reduce nitrate levels in groundwater.
- Provide information and education to scientific, agricultural, and municipal stakeholders with the hope that this information will translate to consistent use of BMPs and thus a significant reduction in agriculture-sourced nitrates in groundwater.

METHODS

A network of working partners consisting of citizens, livestock producers, farmers, Town of Torrington and NRCS personnel all within the North Platte River Valley has been established. These partners were identified based on their land use activity and irrigation system (flood or sprinkler). Lysimeter studies were conducted to determine the movement of nitrate in soils. A total of 16 lysimeters were established at four different farm sites north of Torrington. During the summers of 2007, 2008 and 2009 a total of 172 lysimeter soil pore water samples were collected and analyzed. Water samples from the lysimeter study were analyzed for nitrate to determine the downward movement of nitrate in soils. Soil samples from the lysimeter study were also collected and analyzed for residual nitrate. Soil sampling was conducted on two occasions between 2007 and 2009. A total of 184 soil samples have been collected and analyzed. A total of 22 groundwater sampling sites were established to monitor for nitrate and to evaluate the effectiveness of the BMPs. To date, a total of 200 groundwater samples have been collected and analyzed for nitrate (May 2007 - August 2009).

RESULTS AND DISCUSSION

Lysimeter data for NO_3^- - N was highly variable and showed no consistent trend in leaching of NO_3^- - N between sprinkler irrigated versus flood irrigated sites. Soil NO_3^- - N suggested that sprinkler irrigated sites decreased nitrate leaching from upper soil profile into lower depths when compared with flood irrigated sites (see Table 1).

Table 1. NO_3^- - N concentrations in soils.

2004 - 2008 Deep Soils Testing				
Soil depth (in.)	Irrigation Method	Soil Horizon	Mean NO_3^- - N (Mg/Kg)	
			Summer	Winter
0	Sprinkler	A1	55.67	14.33
4	"	A1-2/AC	15.00	13.33
22	"	C	14.67	7.67
60	"	C+	11.67	11.00
0	Flood	A1	11.33	4.67
7	"	A1-1/B2/C1	21.00	4.00
23	"	C/B3	9.00	1.00
64	"	C+	16.00	1.00
0	Control	A1	5.00	9.33
4	"	AC/B	1.00	1.33
23	"	C	1.00	1.00
60	"	C+	1.00	0.00

Results of groundwater monitoring data indicated a significant trend (alpha = 0.05) in 9 of the 16 sites for which data was sufficient for statistical analysis. Four sites had nitrate trends which were increasing while three sites had nitrate trends that were decreasing. Concentration of NO_3^- - N in water samples from 11 of the 22 wells exceeded the primary drinking water standard of 10 ppm as nitrogen at least once during the study's sampling period (2003 – 2009; see Table 2 for 2003 – 2004 information).

Table 2. Mean NO_3^- - N concentrations in groundwater wells, 2003-2004.

Groundwater Sampling for NO_3^- - N ppm August 2003 - August 2004	
Mean value	Percent of Wells
<5	32%
5<10	47%
>10	21%

Additionally, at least one groundwater site was apparently influenced by a discrete source of NO_3^- - N contamination (i.e. a point source of pollution). Groundwater monitoring data based on mean NO_3^- - N concentrations from 1994-2009 suggest that 7 of 22 monitoring wells exceeded the Primary Drinking Water Standard.

SUMMARY

Overall project findings suggest that problems with regard to high groundwater NO_3^- - N concentrations still persist in some of the monitoring wells of the study area and highlight the need for continued water quality monitoring. Thus, groundwater samples will continue to be collected and analyzed for nitrate quarterly. Updated research results are being shared promptly with working partners. Furthermore, educational and technical assistance meetings will be conducted to further evaluate BMPs and their effectiveness in protecting groundwater quality from agriculture production based sources of nitrate.

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