SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM ASSESSMENT PROJECT FINAL REPORT

AN INTEGRATED WATERSHED APPROACH TO PROTECT GROUNDWATER QUALITY IN GOSHEN COUNTY, WYOMING PROJECT NO.

by

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This project was conducted in cooperation with the State of Wyoming and the United States Environmental Protection Agency, Region 8.

Grant No.

EXECUTIVE SUMMARY

PROJECT TITLE: AN INTEGRATED WATERSHED APPROACH TO PROTECT GROUNDWATER QUALITY IN GOSHEN COUNTY, WYOMING

PROJECT START DATE: September 1, 2003   PROJECT COMPLETION DATE: June 30, 2006

FUNDING:	TOTAL BUDGET:	$250,000.00

TOTAL EPA GRANT:	$150,000.00
TOTAL BUDGETED MATCH:	$100,000.00
TOTAL EXPENDITURES OF EPA FUNDS:	$150,000.00
TOTAL SECTION 319 MATCH ACCRUED:	$100,000.00
BUDGET REVISIONS:	$ 0.00
TOTAL EXPENDITURES:	$250,000.00

SUMMARY OF ACCOMPLISHMENTS:

The Goshen County Nitrate Project began on September 1, 2003. The major targets of this project were to establish a steering committee and network participants to share and update information as it became available, establish and implement an effective monitoring program including lysimeter and groundwater analysis for nitrate, analyze samples for nitrate, and conduct educational meetings with network participants. The project implementation plan was completed in October, 2003. A steering committee was organized to oversee the sampling design and analysis and help serve as a liaison for the network of working partners. Meetings were held in December 2003, March, 2004, and March 2005. A network of stakeholder was organized allowing for the establishment of 22 sampling sites. A total of 375 groundwater samples were collected and analyzed for nitrate, nitrite, and ammonia between August 2003 and May 2006. A total of 16 lysimeters were installed at four different farm sites north of Torrington. During the summers of 2003, 2004, and 2005 a total of 242 lysimeter samples were collected and analyzed. Soil sampling was conducted on four occasions between 2003 and 2006. A total of 152 soils samples have been collected and analyzed. Results indicate a significant trend (alpha = 0.05) in 9 of the 16 sites for which data was sufficient for statistical analysis. Five sites had nitrate trends which were increasing while four had nitrate trends that were decreasing. Additionally, water samples in 11 of the 22 wells exceeded the primary drinking water standard of 10 mg/L as established by the U.S. Environmental Protection Agency. A meeting of network landowners and other stake holders was held at Eastern Wyoming College in Torrington in February, 2005. Information was shared with attendees and a discussion was held. Project progress and available data and analysis were presented at professional symposia and meetings in 2004 and 2005.

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INTRODUCTION

Wyoming is headwaters to many states. In many parts of Wyoming groundwater is the only source of drinking water, because surface water is either absent or already appropriated. Thus, protection of quality of groundwater is important. This watershed is one of four major irrigated agricultural areas in Wyoming. The North Platte River Valley watershed area ranks number one in amount of farmlands and value of cash crops. The annual value of the agriculture industry for this area is approximately $150 million.

The North Platte River Valley watershed area encompasses about 20,700 acres and lies on the north side of the Platte River Watershed, near the eastern border of Wyoming . Elevation in the watershed range from 4,060 to 4,310 feet mean sea level (MSL). The surficial geology of the area is primarily unconsolidated deposits of Quaternary age composed of sand and gravel. These deposits are underlain by the Brule Formation of Tertiary age and are hydraulically connected to the North Platte River. The groundwater in the study area resides within an alluvial aquifer and varies in depth from 10-100 ft. Primary crops grown are alfalfa, corn, sugar beets, dry beans, hay, and small grains. The land use in the watershed is dominated by the irrigated agriculture, followed by rangelands and others. Irrigation methods include both surface and sprinkler systems. Groundwater is the source for culinary water use by all residents in the watershed area.

Previous groundwater monitoring studies in this area indicate that some Public Water Supply (PWS) and private domestic wells exceeded the drinking water limit for nitrate (10 mg/L as N), consequently, the U.S. Environmental Protection Agency required treatment on the PWS wells that exceeded the limit. Prior groundwater monitoring studies for nitrate were conducted by the Town of Torrington, U.S. Geological Survey, and University of Wyoming. The Town of Torrington and U.S. Geological Survey conducted nitrate monitoring studies from 1994-1998 (Parks, 1991; Goertler et al., 1997; Miller and Gerhard, 1999). Results from these monitoring studies suggested a significant trend at 34 of the 72 sites. Twenty-six sites had nitrate concentrations that were increasing, and eight sites had nitrate concentrations that were decreasing. These monitoring studies also identified that the potential source of nitrate in groundwater in and around Torrington is from organic nitrogen, or ammonium or nitrate fertilizer.

The University of Wyoming conducted a pilot citizens monitoring network study in Torrington to assess quality of groundwater with respect to nitrate and pesticides in 1993. Thirteen landowner's wells were selected with the assistance of local cooperative extension service along the North Platte River Valley upstream and downstream of the town of Torrington. Samples were collected before, during, and after the growing season and monitored for pH, nitrate, atrazine, and aldicarb. Results of these studies suggested that wells located outside the North Platte River floodplain had nitrate concentrations above the EPA drinking water limit and wells located within the North Platte River floodplain had the nitrate concentrations below the EPA drinking water limit. However, nitrate concentrations declined in ten wells and increased in three wells after the growing season (Goertler et al., 1997). Recently, USDA-NRCS proposed a watershed plan for North Platte River Valley to protect the quality of groundwater (NRCS, 1995). However, there is a need to develop a more comprehensive and integrated watershed approach though the local groups including citizens, producers of livestock and farmers, Town of

Torrington, and NRCS to assess the quality of groundwater and implement BMPs to help sustain the agriculture industry in this area.

PROJECT PRODUCT OUTCOMES, TARGETS, AND TASK ACTIVITY

PROJECT PRODUCT SUMMARY

Product outcome: The desired final product for this project is to develop an integrated watershed approaches to implement effectiveness of BMPs in protecting groundwater quality in Goshen County. This goal includes monitoring the quality of groundwater for nitrate, develop methods to evaluation of effectiveness of Best Management Practices (BMPs) and education and training of local community through the network of working partners.

Target 1: Complete grant administration requirements as per the project implementation plan (PIP) and grant contract. Also conduct a literature review and collect available nitrate data in the study area.

Task 1: Complete required grant reports and other administration reports and collect available nitrate data for the project area.

Products: Quarterly reports, progress reports, annual reports, and final reports. Collection of available nitrate data for groundwater in North Platte River Valley watershed.

Target 2: Conduct annual meetings with the established steering committee and network participants to share and update information.

Task 2: Hold meetings on an annual basis with the established steering committee which includes representatives from the City of Torrington, USGS, NRCS, DEQ, State Engineer's Office, Wyoming Water Development Commission, and University of Wyoming. Also, hold meetings with network participants currently consisting of 15 local farmers and citizens. Provide information on current project progress and discuss results to date.

Products: Use of GIS watershed maps for sampling sites, including groundwater vulnerability ratings, depth to groundwater, soil types, and fertilizer and cropping systems. Input from working partners on project implementation, and development of methods to evaluate of the effectiveness of BMPs.

Target 3: Establishment and Implementation of an Effective Monitoring Program.

Task3: Establish a Lysimeter Study. These studies include the establishment of field lysimeters on sites which are implementing BMPs (flood irrigation systems versus sprinkler irrigation and split fertilizer application versus one-time application) at two depths (0-40 cm and 40-80 cm) to collect irrigation water moving through the soil system. Water moving through the soil subsurface system will be sampled and analyzed for nitrate. In addition, soil samples by depth will be collected at several depths (A, B, and C Horizons) and analyzed for residual nitrate. Collection and analysis of soil and pore water samples will follow the methods and procedures of ASTM D4700-91 and D4696-92. Total number of lysimeter water samples include approximately 420 (140 per year) and total number of soil samples include 54 (18 per year).

Products: Changes in concentration of nitrate with respect to time and BMPs. Movement of nitrate under different management practices. Determine the time and frequency for groundwater monitoring for nitrate to evaluate the effectiveness of BMPs.

Task 4: Establish a Groundwater Monitoring Study: We propose to monitor existing groundwater wells within the network of working partners for nitrate for three years in the North Platte Valley watershed. This three year monitoring program is necessary to observe possible trends in nitrate concentrations and evaluate positive management practices. Each year, groundwater samples will be collected quarterly (before seeding, middle of the crop growth, and after the harvest). However, the time and frequency of water sampling will be determined based on the trend analysis from the lysimeter studies. From each site, duplicate samples will be collected and preserved according to the procedures of SAP (Sampling and Analysis Plan). These procedures include purging well for a few minutes until the pH reading of water becomes stable, measuring the field temperature and EC (Electrical Conductivity) of the sample. Samples will be analyzed for nitrate using an EPA approved method. We will employ local Eastern Wyoming College students on a part-time basis to collect samples. Students will be given training, at the Eastern Wyoming College (under the guidance of Chris Wenzel), on how to collect and preserve groundwater samples for nitrate analysis.

Products: Collection and preservation of samples. Collection of field analytical data for samples including pH, temperature, dissolved oxygen, Eh, turbidity, and EC. Completion of QA/QC (Quality Assurance and Quality Control) procedures including chain of custody, statistical analysis (means and standard deviation), identification of laboratory for analysis, and transport of samples to the analytical lab.

Target 4: Collection and Analysis of Samples for nitrate.

Task 5: Samples will be analyzed for nitrate using ion chromatography (IC). Number of groundwater samples per year = 100. Number groundwater samples for three years = 300. Number of quality control samples (10% of 360) = 36. Approximate total number of samples for nitrate analysis for three years = 336. Number of lysimeter samples per year = 140 with the number of lysimeter samples for 3 years being 420. Number of soil samples per year = 18 with the number of soil samples for 3 years being 54. Collection and analysis of samples will be conducted by a student as a part of his/her thesis project through the Department of Renewable Resources, College of Agriculture, University of Wyoming. As water quality data becomes available, data will be transferred as a Excel spreadsheet to Chris Wenzel, Biology Department, Eastern Wyoming through e-mail as attachment. From there data will be managed and transferred to the working partners before organizing local meetings and workshops.

Products: Credible water quality data for groundwater samples with respect to nitrate. Organization of project data. Generation of Excel data spreadsheet for nitrate. Development of interpretations for the project data. Presentation of data to the network of working partners (local citizens, livestock producers and farmers, Town of Torrington personnel, and NRCS personnel) as data becomes available and gathering input from working partners on the project progress and implementation.

Target 5: Evaluation of BMPs.

Task 6: Organize nitrate data and develop interpretations to evaluate the effectiveness of BMPs such as irrigation system, cropping system, and fertilizer application system as related to the quality of groundwater with respect to nitrate. Data obtained from the lysimeter study and groundwater monitoring study will help determine the effectiveness of BMPs. Present the information on BMPs to the steering committee and network participants. Steering Committee members suggested that data obtained from this 3 year study is not sufficient to evaluate the effectiveness of BMPs such as irrigation system, cropping system, and fertilizer application system as related to the quality of groundwater with respect to nitrate. The committee further suggested that current project will help establish methods (e.g., landowner's net work, irrigation system, and fertilizer application) for monitoring data to evaluate the effectiveness of BMPs. A section 319 Project Implementation Plan was submitted and approved in February, 2006 to focus on the evaluation of BMP's for the next three years. The additional information gathered will enable us to determine whether the implementation of BMP's such as center-pivot irrigation have been successful in reducing nitrates in Goshen County groundwater.

Products: Establishment of methods to determine effectiveness of different BMPs in minimizing the downward movement of nitrate in soils. Timely presentation of information on the BMPs to the working partners. Manuals and/or workshop reports on BMPs.

Target 6: Technology and information transfer through educational meetings and workshops.

Task 7: Promptly organize local meetings and workshops to the working partners. Present water quality data to working partners and discuss potential trends in nitrate concentrations in the study area. Identify management practices such as fertilizer application methods (e.g., split vs one time, liquid vs granules) and irrigation systems (sprinkler vs surface) which have positive impact on the quality of groundwater and discuss advantages and disadvantages of these methods with the working partners (local citizens, livestock producers and farmers, Town of Torrington personnel, and NRCS personnel).

Products: Transfer of monitoring results to user groups. Technology transfer to working partners. Development of extension bulletins and reports. Identification and implementation of best management practices. Development of video tapes and programs on success stories.

PLANNED AND ACTUAL MILESTONES AND COMPLETION DATES.

Planned and actual milestones and completion dates for the seven tasks are presented in Table 1.

Table 1. Planned and Actual Milestones and Completion Dates.

Task	**Planned Products**	**Actual Products**	**Planned Completion Data**	**Actual Completion Date**
Task 1. Complete required reports and search literature for nitrate data..	1 Final Report 3 Annual Reports 2 Semi-Annual Reports	1 Final Report 3 Annual Reports 2 Semi-Annual Reports	September 2006 October 2005 April 2006	September 2006 October 2005 April 2006
Task 2. Establish a working partners network and share information..	3 Steering Committee Meetings 1 meeting with farmers	3 Steering Committee Meetings 1 meeting with farmers	March 2005 February 2005	March 2005 February 2005
Task 3. Establish a Lysimeter/Soils Study.	50-100 Lysimeter samples during the growing season 9 soil samples twice a year.	65-140 Lysimeter samples during the growing season 9 soil samples twice a year.	August 2006 July 2006	August 2006 July 2006
Task 4. Establish a groundwater monitoring study.	25 samples quarterly each year	25 samples quarterly each year	August 2006	August 2006
Task 5. Analyze samples for nitrate.	Excel spreadsheets Data interpretation	Excel spreadsheets Data interpretation	August 2006	August 2006
Task 6. Organize data to evaluate BMP's.	Trend graphs for lysimeter/soils data	Trend graphs for lysimeter/soils data (BMP's not evaluated due to small data set).	August 2006	Task not yet complete, (to be completed by August 2009).
Task 7. Technology transfer and educational meetings.	12 letters to landowners (quarterly for 3 years) providing data.	12 letters to landowners (quarterly for 3 years) providing data.	August 2006	August 2006

EVALUATION OF PRODUCT OUTCOME ACHIEVEMENT AND RELATIONSHIP TO THE STATE NPS MANAGEMENT PLAN

MONITORING RESULTS

Groundwater Monitoring Wells

Table 2 presents summary statistics for all NPRV watershed wells sampled within the study area. Samples collected from the 22 alluvial well stations used in the monitoring program had a wide range of NO_3^- concentrations. The lowest concentration of NO_3^- was a sample from RR69, a domestic well completed in third terrace deposits, with a concentration of 0.49 mg/L as N. The highest concentration of NO_3^- (135 mg/L as N) was a sample collected at NR49. Preliminary analysis by water quality professionals in the Steering Committee suggest that NO_3^- concentrations in well NR49 are influenced by a point source of contamination. Eleven of 22 wells exceeded the MCL at least once during the 2003 through 2005 study. The number of wells exceeding the MCL at least once increases to 14 of 22, however, when the entire 1994 through 2005 dataset is evaluated. Exceedences were seen in all wells completed in NPRV floodplain deposits. Eight of 22 sites had mean NO_3^- concentrations greater than the MCL for NO_3^-; however, after adjustment for normality (Thode, 2002), a tolerance interval test showed that as many as 12 of the 16 wells analyzed for groundwater NO_3^- trends produced water that consistently exceeded (alpha = 0.05) the MCL throughout the eleven-year time period for which data was available. Three of the four wells meeting the compliance limit, DV20a, TM1 and WSH20, were completed in the third terrace. GCE62 was the only well completed in floodplain deposits consistently producing water with NO_3^- concentrations below 10 mg/L as N. Individual results of tolerance interval testing are presented in the addenda.

Soil Study

Table 3 presents results of initial soil sampling of the NPRV watershed conducted in September 19, 2003. Results of soils testing at four sampling locations within the study area indicated that the primary source of extractable N found in shallow loamy fine sands sampled was available as NO_3^- and NO_2^-. Organic matter concentration typically did not exceed two percent. Additionally, data indicated that a greater concentration of extractable N remained in the upper 12" of the soil profile at sprinkler irrigated sites when compared to flood irrigated sites following primary growth and irrigation periods. In three of four sampling locations, total extractable N decreased with sample depth. Results of the 2003 soils study indicated the leaching of N into deeper portions of the soil profile was more prevalent at flood irrigated sites and prompted project investigators to conduct a more comprehensive study of NPRV watershed soils the following year.

Table 4 presents results of NPRV watershed soil sampling conducted at six irrigated cornfields and three control sites in July 2004 and February 2005. Results are presented for extractable NO_3^- in milligrams per kilogram (mg/kg) by soil horizon. As expected, extractable NO_3^- concentrations were greater in July 2004 samples from most irrigated sites when compared to February 2005 samples taken from the same locations. Planting had taken place and starter fertilizer had been applied to each irrigated site approximately two months prior to the July sampling; however, irrigation had typically been underway at sprinkler irrigated sites for over a month whereas flood irrigated sites were not able to apply irrigation water until just over a week prior to sampling. NO_3^- concentrations remained fairly static at control sites during both sampling events with the highest NO_3^- concentrations existing in the A horizon (USDA, 1981). The soil solum in heavily cultivated areas of the NPRV, including those soils sampled by this study, typically averages 20” (USDA, 1981). Soils sampled in the NPRV study area typically lacked a developed B horizon (USDA, 1981). C horizons in soils sampled typically ranged from 20” to 60” (USDA, 1981).

Table 5 presents summary statistics for the July 2004 and February 2005 soil sampling events. NO_3^- concentrations are presented for comparison of soils sampled at sprinkler irrigated, flood irrigated, and control sites within the study area. Samples from “AC” soil horizons falling within the first 20” of soil depth were evaluated with other samples as part of the soil solum or A/B horizons. Results of this study were variable. Additionally, the small sample size presents difficulties in making a determination as to the overall impact of different irrigation methods on available NO_3^- found in NPRV watershed soils. Analysis of extractable NO_3^- concentration in samples collected for this study does, however, indicate that extractable NO_3^- concentrations remained higher throughout the soil profile in samples collected at sprinkler irrigated sites during the dormancy period in February 2005. Extractable NO_3^- in February 2005 samples from flood irrigated sites was comparable to those collected at control sites, indicating that a significant quantity of extractable NO_3^- found in July soil samples may have been leached through the soil profile during the irrigation period. Fertilization rates and crop yield were similar for both flood irrigated and sprinkler irrigated sites; therefore, it could be determined that a greater level of N use efficiency was achieved at sprinkler irrigated sites included in this study. N use efficiency is important both economically (less need for annual fertilizer supplementation) and to the prevention of N leaching into the shallow alluvial aquifer system found in the NPRV watershed.

Soil Pore Water Study

Figure 1-4 present results of NPRV watershed soil pore water sampling conducted at four irrigated cornfields during the 2004 irrigation season. Results are presented for NO_3^- (as N) by depth and sample date. Results of the soil pore water study were highly variable among individual sampling locations and among individual lysimeters. Additionally, lysimeter functionality and variable moisture conditions made sample collection inconsistent. The most complete dataset was collected at soil pore water monitoring site, L2. The data shows large variation in measured NO_3^- concentrations among the two lysimeters installed at the 40-80 cm depth. While both showed a downward trend from the beginning to the end of the irrigation season, the close proximity of the lysimeters coupled with the large variation in recordable NO_3^- concentration would suggest that data recovered from the L2 monitoring site was more reflective of soil pore water NO_3^- levels within the small sampling location rather than the field as a whole. NO_3^- levels recorded at soil pore water sampling locations were indicative of those recorded during the July 2004 and February 2005 soil sampling events in that the lowest concentrations of NO_3^- were recorded at the end of the irrigation season as available NO_3^- was either utilized by planted crops or leached below the soil solum. Results of soil pore water sampling suggest that further monitoring will be necessary to quantify the rate of movement and concentration of NO_3^- in soil pore water at the 0-40 cm and 40-80 cm depth.

PUBLIC INVOLVEMENT AND COORDINATION

Goshen County Groundwater Nitrate Citizen's Network

The foundation of the Citizen's Network developed for this study consisted of municipalities, businesses, and individuals identified in the early stages of project development as those willing to participate in a study of this nature either by their involvement in previous research conducted in the watershed or by their relationship with previous and/or current investigators. With its involvement in the Citizen's Network and representation on the Steering Committee, the City of Torrington has served as an essential partner to project investigators throughout the design and implementation processes of Integrated Watershed Approach to Protect Groundwater Quality in Goshen County, Wyoming. The city's support and cooperation has presented investigators with a unique opportunity to build relationships with key individuals involved with this study and, furthermore, to eliminate a number of variables with the potential to have had an enormous influence on the quality of the study's overall technical findings. An agreement with the City of Torrington and some private landowners presented project investigators with the opportunity to sample much of the same well system monitored extensively by the City and the USGS during their 1994 through 1998 studies of groundwater NO_3^- in the NPRV watershed. Access to these monitoring sites has provided an excellent point of comparison for determining, with far greater accuracy, trends in the study area's overall groundwater NO_3^- concentrations.

Public Participation

Private cooperation was required for gaining access to monitoring wells used in the City of Torrington and USGS studies (1994 through 1998), as well as for the development of a baseline monitoring system for groundwater, soils, and soil pore water, and to better isolate areas of specific land-use for pinpointing the effects of revised BMPs on down-gradient groundwater quality within the study area. Key sampling areas for this study were determined based on aquifer sensitivity ratings, land-use activity, cropping and fertilizer system, irrigation type, soil type, and BMPs already implemented. The result of this preliminary research was a list of potential individuals to be included in the Citizen's Network.

The original goal for the Citizen's Network was to provide project investigators, via public participation, with access to: (1) two sprinkler-irrigated sites; (2) two flood-irrigated sites; and (3) at least 20 additional sites for groundwater sampling identified as unique or critical with regard to land-use and/or location. The four irrigation sites were to be used for soil and soil pore water studies.

The first individuals selected from the pool of potential candidates to take part in the Citizen's Network were those identified as willing to participate in a study of this nature either by their involvement in previous research conducted in the area or by their relationship with previous and/or current investigators. To fulfill all sampling requirements, it was also necessary to build new relationships with individuals. Potential candidates were contacted by project investigators and informed of the goals and objectives for the study. Most candidates expressing interest were also met with in person. The development of a functioning Citizen's Network that would provide project investigators with sufficient access to sampling sites for the August 2003 sampling event was completed during the early summer months of 2003. As the project progressed, it was determined that one additional sprinkler-irrigated site, one additional flood irrigated site, and several additional native range sites would be beneficial for a more comprehensive study of NPRV watershed soils and soil pore water. It was also determined that the number of groundwater sampling locations should be increased to compensate for the potential loss of wells from the monitoring network. These revisions required additional members to be added to the Citizen's Network. Project investigators identified new members following the same protocol used in the original development of the Citizen's Network.

EDUCATION AND INFORMATION

Upon agreement to participate in the Citizen's Network, each new member was provided with updated contact information for project investigators. Members were encouraged to inquire about testing results, project progress, and to share any knowledge which they felt could be useful to project investigators. Information provided by members of the Citizen's Network ranged from land history and land-use practices to clarification of NPRV hydrogeologic structure.

Data collected from the sampling of wells, soil pore water, and/or soils was transferred in writing to any member of the Citizen's Network requesting such information. For confidentiality purposes, only data collected from lands associated with the member were made available in the report. Letters containing the data and an information sheet explaining to the member how to interpret the data were either mailed or hand-delivered by project investigators. Each member was also provided with a copy of *Consumer Fact Sheet on: Nitrates/Nitrites* (EPA 811-F-95-002-C) outlining the environmental regulation of NO_3^- and NO_2^- and detailing human health issues associated with consuming waters contaminated by N compounds (EPA, 1995).

To encourage the continued involvement of the Citizen's Network with the project and to thank members for their support, a meeting of the Citizen's Network was held February 16, 2005, at Eastern Wyoming College in Torrington. Both Steering Committee and Citizen's Network members were invited to bring any friends or neighbors who might be interested in learning more about the NPRV watershed. Participating members of the Citizen's Network and Steering Committee were introduced to begin the meeting. A presentation by project investigators covering the general progress of the project to date was then followed by a question and answer period. Steering Committee members in attendance were also given the opportunity to speak regarding their role in the project.

CONCLUSIONS AND RECOMMENDATIONS

The desired final product for this project is to develop an integrated watershed approaches to implement effectiveness of BMPs in protecting groundwater quality in Goshen County. This goal includes monitoring the quality of groundwater for nitrate, develop methods to evaluation of effectiveness of Best Management Practices (BMPs) and education and training of local community through the network of working partners. A total of 375 groundwater samples were collected and analyzed for nitrate and nitrite between August 2003 and May 2006. A total of 16 lysimeters were installed at four different farm sites north of Torrington. During the summers of 2003, 2004, and 2005 a total of 242 lysimeter samples were collected and analyzed. Soil sampling was conducted on four occasions between 2003 and 2006. A total of 152 soils samples have been collected and analyzed.

Results indicate a significant trend (alpha = 0.05) in 9 of the 16 sites for which data was sufficient for statistical analysis. Five sites had nitrate trends which were increasing while four had nitrate trends that were decreasing. Additionally, water samples in 11 of the 22 wells exceeded the primary drinking water standard of 10 milligrams per liter (mg/L) as nitrogen (N) set by the United States Environmental Protection Agency (EPA) at least once during the study's 2003 through 2005 sampling period. Additionally, at least one groundwater site was apparently influenced by a discrete source of NO_3^- contamination, i.e. a "point" source. A meeting of network landowners and other stake holders was held at Eastern Wyoming College in Torrington in February, 2005. Information was shared with attendees and a discussion was held. Project progress and available data and analysis were presented at professional symposia and meetings in 2004 and 2005.

Data collected from the sampling of wells, soil pore water, and/or soils was transferred in writing to any member of the Citizen's Network requesting such information. For confidentiality purposes, only data collected from lands associated with the member were made available in the report. Letters containing the data and an information sheet explaining to the member how to interpret the data were either mailed or hand-delivered by project investigators. Each member was also provided with a copy of *Consumer Factsheet on: Nitrates/Nitrites* (EPA 811-F-95-002-C) outlining the environmental regulation of NO_3^- and NO_2^- and detailing human health issues associated with consuming waters contaminated by N compounds. Overall project findings suggest that problems with regard to high groundwater NO_3^- concentrations persist throughout much of the study area and highlight the need for continued water quality monitoring to evaluate effectiveness of BMPs in minimizing the movement of NO_3^- into the groundwater. A section 319 Project Implementation Plan was submitted and approved in February, 2006 to focus on the evaluation of BMP's for the next three years. The additional information gathered will enable us to determine whether the implementation of BMP's such as center-pivot irrigation have been successful in reducing nitrates in Goshen County groundwater.

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LIST OF APPENDICES

Table 2: Summary statistics for groundwater monitoring wells.

Summary Statistics for Groundwater Monitoring of 22 Alluvial Wells in the North Platte River Valley Watershed										
Geologic Unit/ Location	Well ID	2003 through 2005 Depth (ft)			1994 through 2005 Water Quality Sampling (mg/L as N)					
		Well Depth	Mean Depth to Water	Std. Deviation	Number of Observations	Minimum NO_3^- Conc.	Maximum NO_3^- Conc.	Mean NO_3^- Conc.	Std. Deviation	NO_3^- levels complied with primary drinking water standards[1]
Third terrace north of Interstate Canal	DBD3	86.4	73.3	n/a	43	0.82	15.20	12.56	2.68	NO
	CJ66*	180.3	142.6	0.92	6	3.00	5.17	4.28	0.88	n/a
	BM1*	100.2	90.7	0.32	3	0.53	9.46	4.61	4.52	n/a
Third terrace south of Interstate Canal	DBW19	24.9	8.8	0.68	51	0.75	42.10	8.56	7.91	NO
	DV20a	73.1	64.6	2.87	46	0.85	6.08	3.68	0.82	YES
	TM1	132.1	112.9	0.25	54	2.92	9.14	6.28	1.30	YES
	WSH20	164.9	82.3	1.57	50	1.76	4.83	2.53	0.68	YES
	RR69*	97.5	31.8	4.04	6	0.49	1.62	1.21	0.40	n/a
	DVWR1 *	126.0	51.5	0.47	6	4.22	9.55	6.96	1.71	n/a
Ridge between terrace and floodplain	SP39	46.5	36.0	0.66	50	7.47	15.10	10.60	1.31	NO
	DBH1*	80.0	35.9	0.64	6	10.54	20.59	14.54	3.60	n/a
	TSF27*	133.8	94.9	1.02	6	5.09	9.61	7.18	1.68	n/a
North Platte River Valley floodplain	FG71	33.0	n/a	n/a	46	4.34	21.00	14.56	4.02	NO
	FG72	35.6	27.2	1.09	42	2.14	13.88	6.94	2.98	NO
	GC64	24.3	12.3	0.40	49	5.26	14.90	8.40	2.45	NO
	GCE62	25.8	9.3	1.12	50	2.54	13.50	5.10	1.74	YES
	HAR27	36.9	25.4	1.98	52	5.07	17.10	11.60	2.90	NO
	LE43	34.4	24.1	0.42	50	7.48	16.00	12.32	1.60	NO
	LM42	34.3	23.0	0.36	50	8.45	16.10	11.46	1.57	NO
	NR49**	36.9	25.5	1.08	50	3.91	135.00	26.06	26.84	NO
	PP61	32.5	21.8	0.24	50	4.40	19.20	9.82	3.29	NO
	UW70	28.2	23.8	0.55	43	5.39	14.60	9.31	2.97	NO

[1]10 mg/L as N

n/a - not available

seasonality determined

FG72- increasing trend

DBD3 - decreasing trend

LM42 - no trend

Table 3: Results of Soil Testing.

Results of Soils Testing at Four Sites in the NPRV Watershed, September 19, 2003								
Site ID	**Location (Decimal Degrees)**	**Sample Date**	**Irrigation Method**	**depth (inches)**	**Organic Matter (%)**	**NO_3^- $+NO_2^-$ as N (mg/kg)**	**NH_4 as N (mg/kg)**	**Total Extractable N (mg/kg)**
1	N 42⁰05.499' W 104⁰10.070'	9/19/2003	Flood	0 to 6	1	4	0.7	**4.7**
				6 to 12	1.1	3	1.0	**4**
2	N 42⁰06.050' W 104⁰12.245'	9/19/2003	Flood	0 to 6	1.2	4	0.5	**4.5**
				6 to 12	1.1	4	0.5	**4.5**
3	N 42⁰60.289' W 104⁰12.403'	9/19/2003	Sprinkler	0 to 6	2.1	59	0.6	**59.6**
				6 to 12	1.4	36	0.7	**36.7**
4	N 42⁰08.354' W 104⁰17.306'	9/19/2003	Sprinkler	0 to 6	1.6	13	0.9	**13.9**
				6 to 12	1.4	12	0.8	**12.8**

Table 4: Comparison of Control Soil NO_3^- and Irrigation Method.

Results of Soils Testing at Nine Sites in the NPRV Watershed, July 2004 and February 2005				
Site ID	Depth (inches)	Soil Horizon	July 2004 NO_3^- as N (mg/kg)	February 2005 NO_3^- as N (mg/kg)
Sprinkler Irrigated Sites				
S1	0 to 4	A1	105	8
	4 to 22	AC	38	23
	22 to 60	C	33	18
	60 to 72	C+	22	15
S2	0 to 2	A1	57	20
	2 to 17	AC	5	7
	17 to 60	C1&2	10	3
	60 to 72	C+	12	7
S3	0 to 3	A1-1	5	15
	3 to 16	A1-2	2	10
	16 to 60	C	1	2
	60 to 72	C+	1	n/s
Flood Irrigated Sites				
F1	0 to 3	A1-1	5	5
	3 to 16	A1-2	7	5
	16 to 30	C	1	1
	30 to 72	C+	1	1
F2	0 to 5	A1	10	5
	5 to 23	B2&3	1	6
	23 to 64	C1&2&3	4	1
	64 to 72	C+	1	2
F3	0 to 7	A1	19	4
	7 to 15	C1	55	1
	15 to 54	C2	22	1
	54 to 72	C3+	46	0
Control Sites				
C1	0 to 2	A1	10	18
	2 to 17	AC	1	1
	17 to 60	C1&2	1	1
	60 to 72	C+	1	0
C2	0 to 3	A1	3	8
	3 to 23	C1	1	1
	23 to 60	C2	1	1
	60 to 72	C+	n/s	0
C3	0 to 4	A1	2	2
	4 to 22	AC	1	2
	22 to 60	C	1	1
	60 to 72	C+	2	0

n/s - no sample

Table 5: Summary Statistics for Comparison.

Comparison of Extractable Soil NO_3^- and Irrigation Methods for the NPRV Watershed, July 2004 and February 2005			
Irrigation Method	**Soil Horizon**	**July 2004 Mean NO_3^- as N (mg/kg)**	**February 2005 Mean NO_3^- as N (mg/kg)**
Sprinkler	A/B	35.33	13.83
	C	14.67	7.67
	C+	11.67	11.00
Flood	A/B	8.40	5.00
	C	20.50	1.00
	C+	16.00	1.00
Control (none)	A/B	3.40	6.20
	C	1.00	1.00
	C+	1.50	0.00

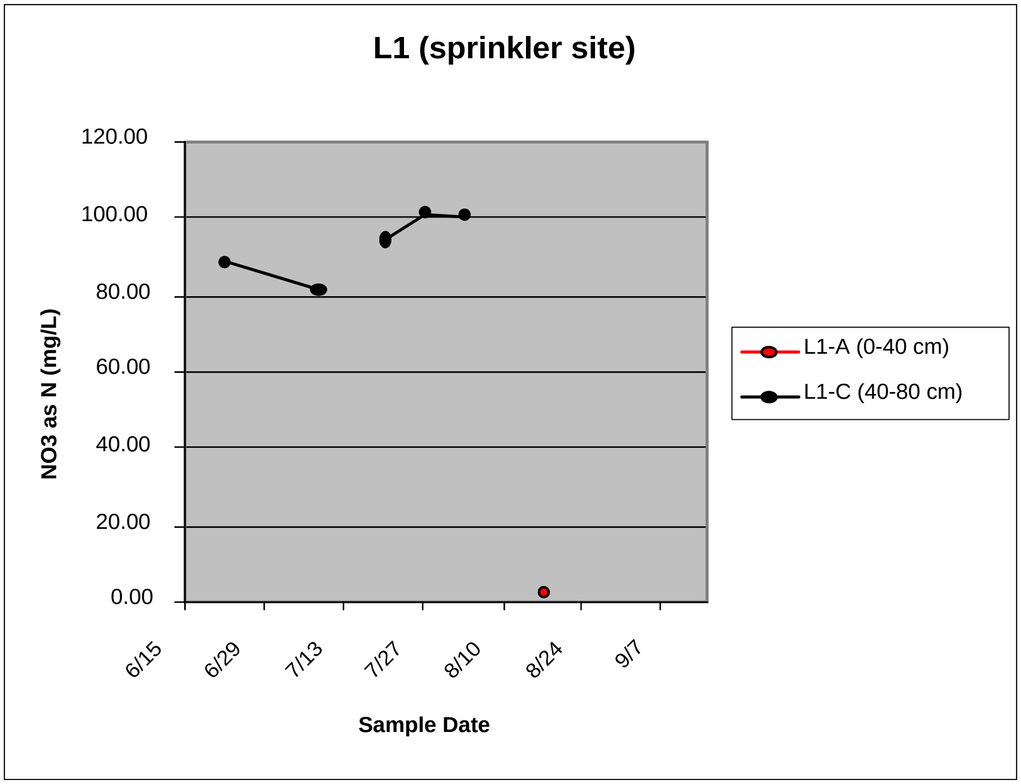

Figure 1. Nitrate Concentration in Soil Pore Water at Monitoring Site L 1.

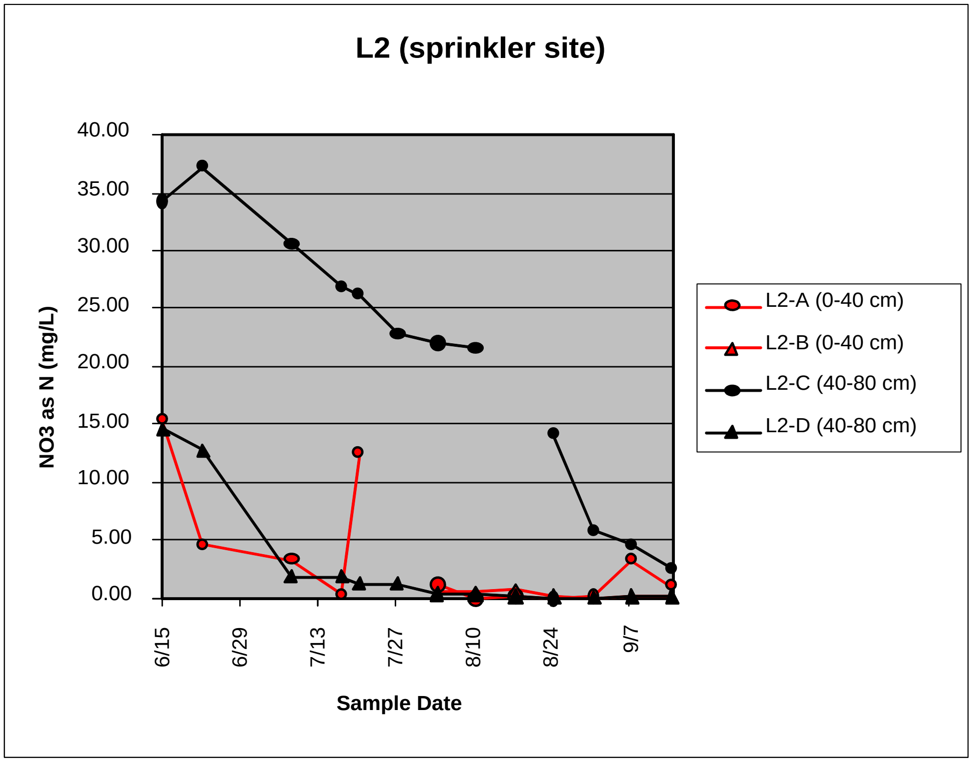

Figure 2. Nitrate Concentration in Soil Pore Water at Monitoring Site L 2.

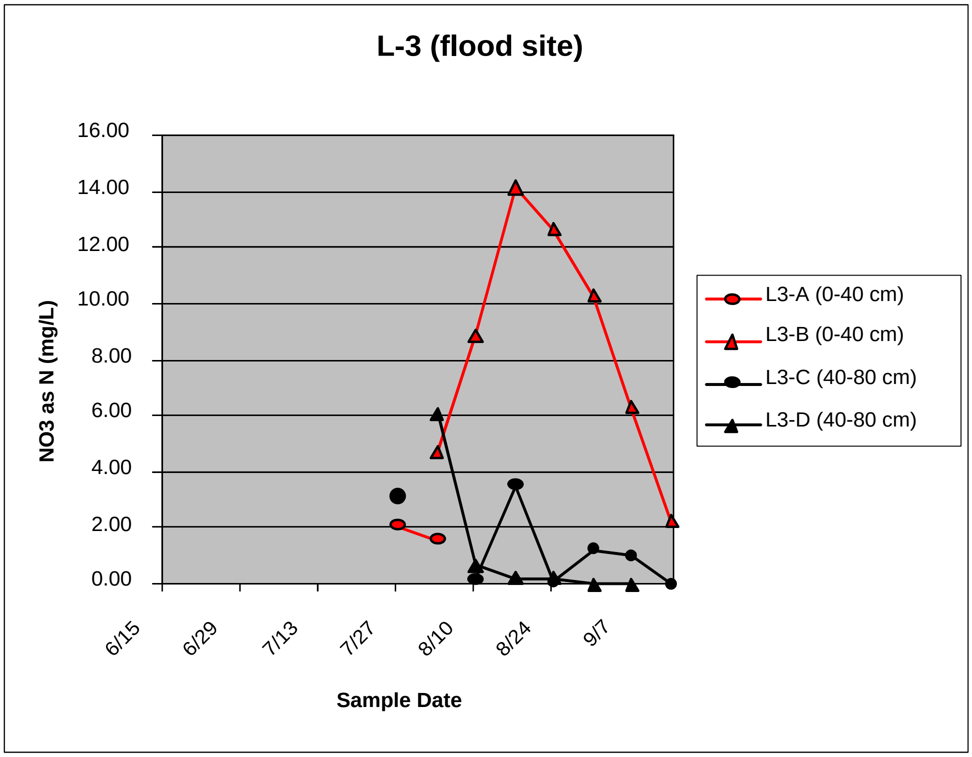

Figure 3. Nitrate Concentration in Soil Pore Water at Monitoring Site L 3.

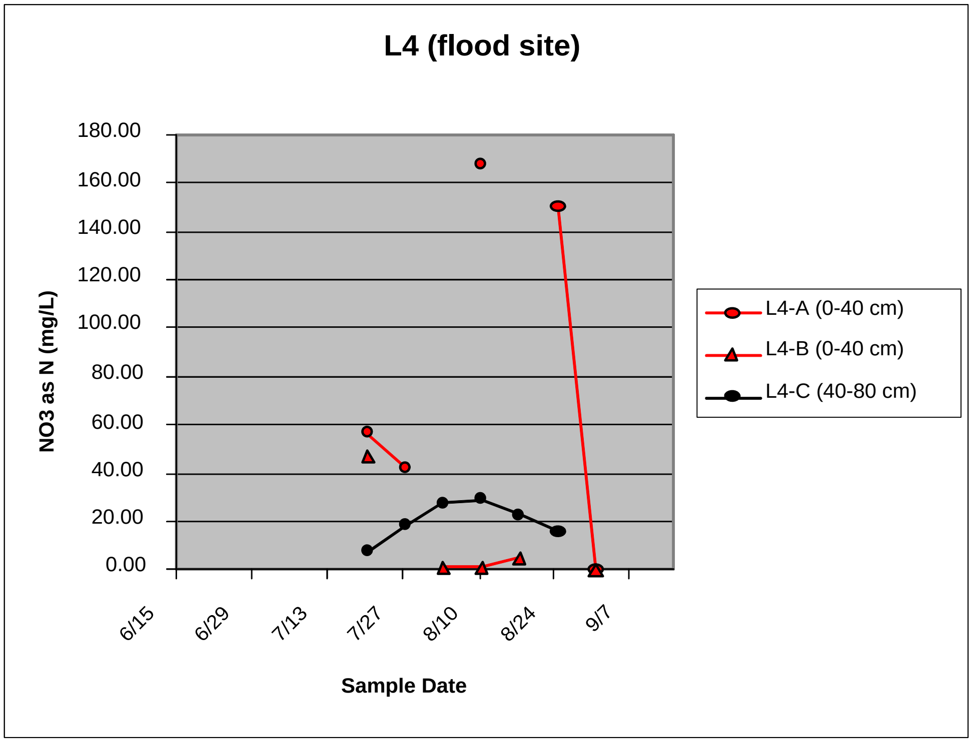

Figure 4. Nitrate Concentration in Soil Pore Water at Monitoring Site L 4.