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1995 SUMMARY REPORT

SECTION 319 NATIONAL MONITORING PROGRAM PROJECTS

Nonpoint Source Watershed Project Studies

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Disclaimer

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Chapter 1

Introduction

Monitoring of both land treatment and water quality to document water quality improvement from nonpoint source (NPS) pollution controls is necessary, in at least a few projects, to provide information to decision makers regarding the effectiveness of NPS pollution control efforts. The United States Environmental Protection Agency (USEPA) Section 319 National Monitoring Program is designed to provide information on pollution control efforts by documenting water quality changes associated with land treatment.

The Section 319 National Monitoring Program projects comprise a small subset of NPS pollution control projects funded under Section 319 of the Clean Water Act as amended in 1987. Currently, projects are focused on stream systems, but USEPA intends to expand into ground water, lakes, and estuaries as suitable project criteria are developed. The goal of the program is to support 20 to 30 watershed projects nationwide that meet a minimum set of project planning, implementation, monitoring, and evaluation requirements designed to lead to successful documentation of project effectiveness with respect to water quality protection or improvement. The projects are nominated by their respective USEPA Regional Offices, in cooperation with state lead agencies for Section 319 funds. USEPA Headquarters reviews all proposals, negotiates with the regions and states regarding project detail, and recommends that regions fund acceptable projects using a regional 5% set-aside of Section 319 funds.

The selection criteria used by USEPA Headquarters for Section 319 National Monitoring projects are primarily based on the components listed below. In addition to the specific criteria, emphasis is placed on projects that have a high probability of documenting water quality improvements from NPS controls over a 5- to 10-year period.

- Documentation of the water quality problem, which includes identification of the pollutant(s) of primary concern, the source(s) of those pollutants, and the impact on designated uses of the water resources.
- Comprehensive watershed description.
- Well-defined critical area that encompasses the major sources of pollution being delivered to the impaired water resource. Delineation of a critical area should be based on the primary pollutant(s) causing the impairment, the source(s) of the pollutant(s), and the delivery system of the pollutants to the impaired water resource.
- A watershed implementation plan that uses appropriate best management practice (BMP) systems. Systems of BMPs are a combination of individual BMPs designed to reduce a specific NPS problem in a given location. These BMP systems should address the primary pollutant(s) of concern and should be installed and utilized on the critical area.
- Quantitative and realistic water quality and land treatment objectives and goals.
- High level of expected implementation and landowner participation.
- Clearly defined NPS monitoring program objectives.
- Water quality and land treatment monitoring designs that have a high probability of documenting changes in water quality that are associated with the implementation of land treatment.
- Well-established institutional arrangements and multi-year, up-front funding for project planning and implementation.

- Effective and ongoing information and education programs.
- Effective technology transfer mechanisms.

Minimum tracking and reporting requirements for land treatment and surface water quality monitoring have been established by USEPA for the National Monitoring Program projects (USEPA, 1991). These requirements should be considered minimum guidelines for those projects whose objective is to evaluate water quality changes at a watershed or subwatershed level occurring as a result of land treatment implementation. These minimum reporting requirements for Section 319 National Monitoring Program projects are listed in Appendix I.

This publication is an annual report on the thirteen Section 319 National Monitoring Program projects and one ground water pilot project approved as of October 31, 1995 (Chapter 2). Project profiles were prepared by the North Carolina State University (NCSU) Water Quality Group under the USEPA grant entitled Nonpoint Source Watershed Project Studies, and by the Oregon State University Water Resource Research Institute. Profiles have been reviewed and edited by personnel associated with each project.

The thirteen surface water monitoring projects selected as Section 319 National Monitoring Program projects are Peacheater Creek (Oklahoma), Warner Creek Watershed (Maryland), Totten and Eld Inlet (Washington), Elm Creek (Nebraska), Lake Champlain (Vermont), Lake Pittsfield (Illinois), Long Creek (North Carolina), Morro Bay (California), Oak Creek Canyon (Arizona), Otter Creek (Wisconsin), Pequea and Mill Creek (Pennsylvania), Sny Magill (Iowa), and Sycamore Creek (Michigan). The fourteenth project, Snake River Plain, Idaho, is a pilot ground water project.

Each project profile includes a project overview, project description, and maps. In the project description section, water resources are identified, water quality and project area characteristics are described, and the water quality monitoring program is outlined. Project budgets and project contacts are also included in the description.

Proceedings of the Third Annual Section 319 National Monitoring Program conference, held in Seattle, Washington, from October 2-6, 1995, are contained in Chapter 3. Chapter 4 consists of ten fact sheets on agricultural nonpoint source pollution control concepts developed from the Rural Clean Water Program.

The Appendices include the minimum reporting requirements for Section 319 National Monitoring Program projects (Appendix I), a list of abbreviations (Appendix II), and a glossary of terms (Appendix III) used in the project profiles. A list of project documents and other relevant publications for each project is included in Appendix IV. Appendix V contains a matrix for the Section 319 National Monitoring Program Projects.

REFERENCES

USEPA. 1991. *Watershed Monitoring and Reporting for Section 319 National Monitoring Program Projects.* Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

Chapter 2

Section 319
National Monitoring Program
Project Profiles

This chapter contains a profile of each of the Section 319 National Monitoring Program projects approved as of October 31, 1995 arranged in alphabetical order by state. Each profile begins with a brief project overview, followed by detailed information about the project, including water resource description; project area characteristics; information, education, and publicity; nonpoint source control strategy; water quality monitoring; total project budget; impact of other federal and state programs; other pertinent information; and project contacts.

Sources used in preparation of the profiles include project documents and review comments made by project coordinators and staff.

Project budgets have been compiled from the best and most recent information available.

Abbreviations used in the budget tables are as follows:

Proj Mgt ..... Project Management
I&E ..... Information and Education
LT ..... Land Treatment
WQ Monit ..... Water Quality Monitoring
NA ..... Information Not Available

A list of project documents and other relevant publications for each project may be found in Appendix IV.

Arizona

Oak Creek Canyon
Section 319
National Monitoring Program Project

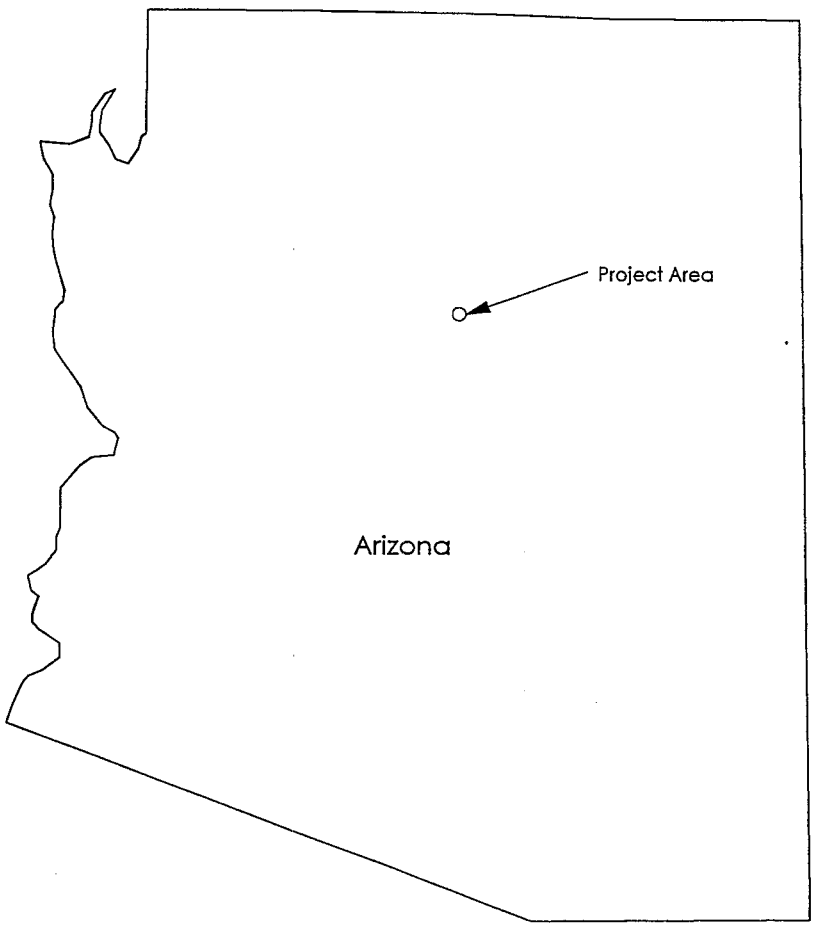

Figure 1: Oak Creek Canyon (Arizona) Project Location

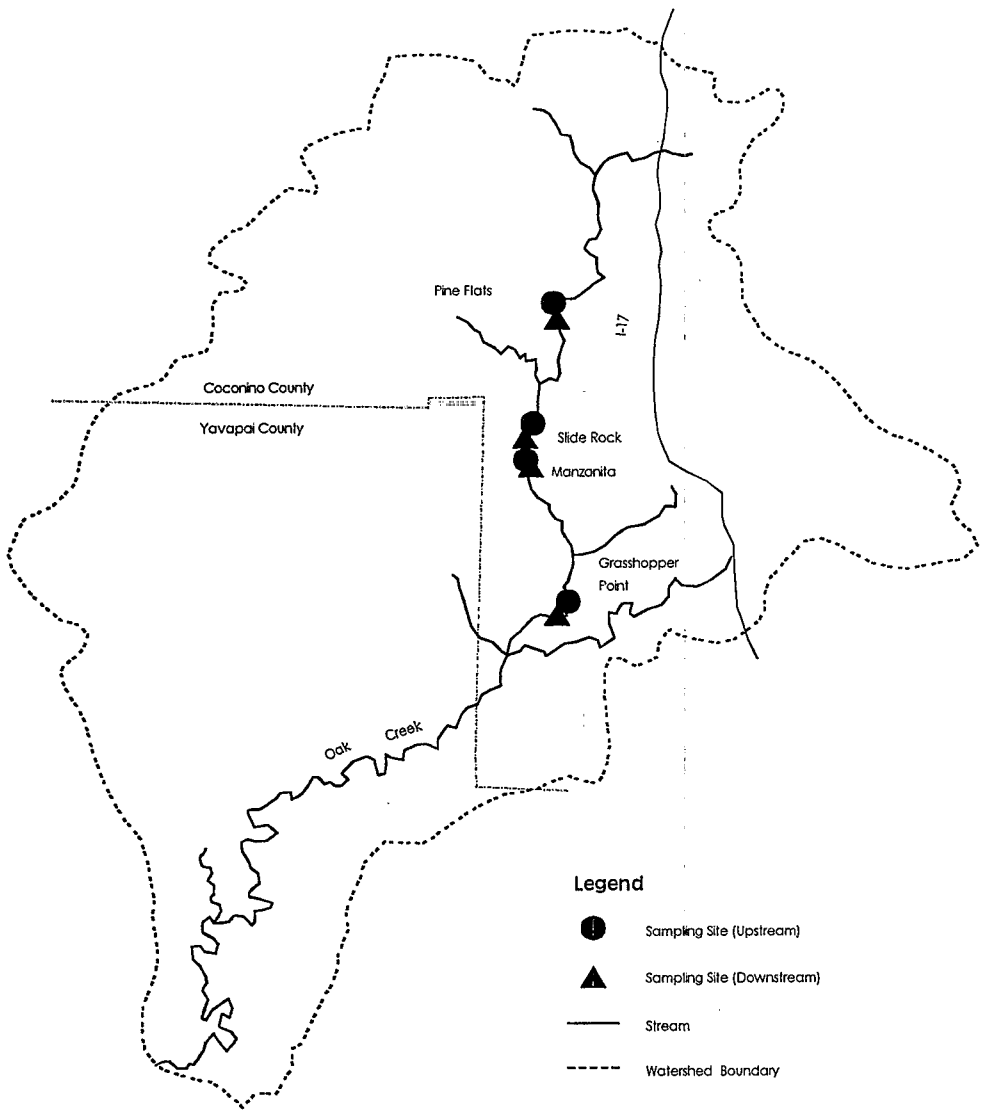

Figure 2: Water Quality Monitoring Stations for Oak Creek Canyon (Arizona)

PROJECT OVERVIEW

Oak Creek flows through the southern rim of the Colorado Plateau (Figure 1). The Oak Creek Canyon National Monitoring project focuses exclusively on that segment of water located in the canyon portion of Oak Creek, a 13-mile steep-walled area of the creek that extends from the city limits of Sedona to the Mogollon Rim, thirteen miles northward. Although Oak Creek Canyon watershed encompasses 5,833 acres, only 907 primarily recreational acres are considered critical for the Oak Creek Canyon water.

The Oak Creek National Monitoring Program project focuses on the implementation and documentation of integrated best management practice (BMP) systems for three locations: Slide Rock State Park, Pine Flats Campground, and Slide Rock Parking Lot. The eleven-acre Slide Rock State Park is used by more than 350,000 swimmers and sunbathers each season and Pine Flats Campground accommodates approximately 10,000 campers each season. Such use at both locations causes excess fecal coliform and nutrient levels in Oak Creek. Slide Rock State Park parking lot accommodates over 90,000 vehicles each season. Runoff of pollutants associated with automobiles drains into Oak Creek.

The BMPs implemented at Slide Rock State Park and Pine Flats Campground include enhanced restroom facilities, better litter control through more intense monitoring by State Park officials of park visitors, and the promotion of visitor compliance with park and campground regulations on facilities' use, littering, and waste disposal. The BMPs implemented at the Slide Rock Parking Lot include periodic cleaning of the detention basin, promotion of an aerobic environment in the basin, periodic sweeping of the parking lot, and, if necessary, retrofitting the detention basin itself.

A paired-site upstream/downstream water quality monitoring design is used to evaluate the effectiveness of BMPs for improving water quality at Slide Rock State Park. Grasshopper Point, a managed water recreation area similar to Slide Rock State Park, serves as the control. Water quality monitoring stations are located upstream and downstream of both the Slide Rock (treatment) and Grasshopper Point (control) swimming areas. A paired-site upstream/downstream water quality monitoring design is also used for Pine Flats Campground and Manzanita Campground. Pine Flats Campground is the treatment site, while Manzanita serves as the control site. As before, monitoring stations are upstream/downstream of campground sites. For these two studies, weekly grab samples are taken from May 15 through September 15 for seven years.

The Slide Rock Parking Lot study evaluates the effectiveness of a detention basin designed to limit pollutants from entering the Creek. An event-based BMP-effectiveness monitoring scheme is being used. Automatic samplers, triggered by rainfall, have been installed at inflow and outflow points of the detention basin. Each one collects samples of the first flush and composite periodic samples of the rainfall.

PROJECT DESCRIPTION

Water Resource Type and Size

Oak Creek cuts deep into the southern rim of the Colorado Plateau. It drops approximately 2,700 feet from its source along the Mogollon Rim to its convergence with the Verde River. The Creek averages about 13 cubic feet per second (cfs) at the study area, but increases to 60 cfs downstream at its confluence with the Verde.

The study sites for this project are located in Oak Creek Canyon (Figure 1). This portion of the watershed is characterized by steep canyons and rapid water flows with sharp drops forming waterfalls and deep, cold pools. Oak Creek Canyon is the primary recreational area in the watershed.

Water Uses and Impairments

Designated beneficial uses of Oak Creek include full body contact (primarily in Oak Creek Canyon), cold water fishery and wildlife habitat (primarily Oak Creek Canyon), drinking water (along the entire course), agriculture (the lower third), and livestock watering (lower third). Oak Creek is designated as a Unique Water, with very high water quality standards.

Oak Creek was designated as a Unique Water by the Arizona State Legislature in 1991 on the basis of (1) its popularity and accessibility as a water recreation resource; (2) its aesthetic, cultural, educational, and scientific importance; and (3) its importance as an agricultural and domestic drinking water resource in the Verde Valley. Two other criteria contributed to the designation of uniqueness: (1) Oak Creek Canyon is susceptible to irreparable or irretrievable loss due to the ecological fragility of its location, and (2) a surface water segment shall not be classified as unique water unless such segment is capable of being managed as a unique water. Management considerations shall include technical feasibility and the availability of management resources.

Biological, nutrient, and vehicular pollutants pose the most serious and pressing current threat to Oak Creek water quality. Oak Creek water quality is impaired by high fecal coliform levels, probably resulting from residential septic systems and the high usage of the campgrounds and day-use swimming areas by over 350,000 people during a concentrated period of time extending from May through September. Excessive nutrients, particularly phosphorus, which exceeds the 0.10 standard, threaten the water integrity of two impoundments located well below Oak Creek that provide a major source of drinking water for the City of Phoenix. The third type of pollution impairing Oak Creek is associated with motor vehicles and consists of heavy metals (such as lead and zinc), petroleum hydrocarbons, and total organic carbons. The pollution originates from the estimated four million vehicles traveling along State Highway 89A each year, as well as from drainage of numerous parking lots in the Oak Creek Canyon area during rainstorms and snow melts. This threatens all designated uses.

Pre-Project Water Quality

Water Recreation and Camping Areas

Human pathogens (bacteria and viruses) contaminate the Canyon segment of Oak Creek. Most of the attention has focused upon Slide Rock State Park and Grasshopper Point, the two managed "swimming holes" in the area. Fecal coliform counts peak in the summer during the height of the tourist season.

Fecal Coliform Levels by Season

Date	Fecal Coliform Count (#/100 ml)
July 15	463.7
August 15	392.5
June	61.2
September	54.3

Nutrient levels, especially phosphorus, are also of concern, as shown below:

Pine Flats Campground phosphorus (P) concentrations (the annual average standard is 0.10 mg/l)

Date	P (mg/l)
June, 1993	0.14
July, 1993	0.28
August, 1993	0.41
February, 1993	0.12
March, 1993	0.20
April, 1993	0.12

Slide Rock Parking Lot

Preliminary data suggest that the Slide Rock Parking Lot detention basin (a large, baffled concrete vault) is contributing to environmental damage rather than reducing it. Approximately four feet of stagnant water remains in the vault at all times. The data collected (see table below) indicate that the heavy rainfall cleanses the parking lot of pollutants and also flushes out significant amounts of pollutants contained in the detention basin.

Water Quality of the Detention Basin

Time	DO(mg/l)	pH	Zn(ug/l)
Before Rain July, 1993	0.0	4.79	222
After Rain October, 1993	4.5	6.6	38

Current Water Quality Objectives

Water Recreation Project Objectives:

- A 50% reduction in fecal coliform
- A 20% reduction in nutrients, particularly ammonia
- A 20% reduction in total organic carbons corresponding with a reduction in biological oxygen demand

Camping Project Objectives:

- A 50% reduction in fecal coliforms
- A 20% reduction in nutrients

Slide Rock Parking Lot Objectives:

- A 25% reduction of automobile-related pollutants that enter Oak Creek

Modifications Since Project Initiation

None.

Project Time Frame

1994 to 2001

Project Approval

1994

PROJECT AREA CHARACTERISTICS

Project Area

The entire Oak Creek watershed contains 300,000 acres. The project area, Oak Creek Canyon, encompasses 5,833 acres. However, the critical area comprises only 907 acres.

Relevant Hydrologic, Geologic, and Meteorologic Factors

Flow in Oak Creek ranges from an average 13 cfs, in the higher Oak Creek Canyon area, to 60 cfs at its confluence with the Verde River.

Annual precipitation in the Oak Creek watershed varies from a six-inch average in the Verde Valley to 20 inches per year on the higher elevations of the Mogollon rim. The majority of rainfall occurs during July and August of the rainy season (July 4 to September 15). Summer rainfall storm events are short and intense in nature (rarely lasting for more than a half-hour) and are separated by long dry periods. In a normal summer season, over twenty rainfall events occur.

Perennial flow in Oak Creek is sustained by ground water flow. The main source of ground water is the regional Coconino Aquifer. The majority of aquifers in the Oak Creek watershed are confined or artesian. Within the Oak Creek watershed, ground water flow is generally to the south, paralleling topography toward the low-lying valley floor.

Land Use

Land Use	Acres	%
Road	55	6
Campground and Parking Lots	123	14
Business and Residential	245	27
Floodplain	290	32
Undeveloped	194	21
TOTAL	907	100

Source: The Oak Creek 319(h) Demonstration Project National Monitoring Program Work Plan, 1994

Pollutant Source(s)

Pollutants in Oak Creek addressed in this study originate mainly from swimmers, campers, and motor vehicles.

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

Numerous organizations and individuals perceive themselves as "owners" of Oak Creek Canyon. It is in the best interest of the Oak Creek National Monitoring Program project to fully involve these groups and individuals in informational and educational activities.

The Oak Creek Advisory Committee, which was formed in 1992, involves federal, state, and local government agencies and private organizations such as Keep Sedona Beautiful and the Arizona River Coalition. The committee meets monthly to: keep participants informed of current project activities and results; gain insights into areas of concern; and learn about the suggested BMPs that are being implemented as part of the 319 National Monitoring Program.

Progress Towards Meeting Goals

With respect to the proposed Public Education Campaign for the Oak Creek Canyon Section 319 National Monitoring Program project, the following events have transpired:

- The U.S. Forest Service prepared a Public Education Plan for Slide Rock State Park and hired a Public Education Specialist to continue and expand the public education effort.
- The Arizona State Parks continue to develop a signage system and a brochure aimed at educating Slide Rock visitors.

NONPOINT SOURCE CONTROL STRATEGY

Slide Rock and Grasshopper Point (Water Recreation Project)

The access and ambience of restroom facilities located at the Slide Rock swimming area are being enhanced. Park officials are attempting to reduce the amount of trash disposal in unauthorized areas. Finally, social strategies have been implemented to promote compliance with park regulations.

Pine Flats and Manzanita (Campgrounds Project)

The nonpoint source control strategy for the campground project targets the upstream site of Pine Flats. Best management practices implemented at Pine Flats are designed to reduce pollutants associated with human use of campground facilities. The BMPs implemented include the installation of an enclosed shower for campers, enforcement of a clean zone between the creek and the campground, and the promotion of the use of existing restroom facilities. Direct contact by park personnel with visitors and the addition of more visible signs help accomplish these goals.

Slide Rock (Parking Lot Project)

The BMP strategy focuses on reducing runoff from the parking lot and parking lot detention basin. The existing detention basin is cleaned out before and after the rainy season. An aerobic environment within the basin has been promoted and street sweeping of the parking lot is also occurring.

Modifications Since Project Started

Subsequent to plan approval, and on the basis of data obtained during the first-year monitoring season, the Coconino County Health Department, in conjunction with the Arizona Department of Environmental Quality, U.S. Forest Service, Arizona Department of Transportation, Arizona Park Service and others, confirmed that fecal coliform levels were alarmingly high at Slide Rock State Park. The health department ordered closure of the facility until such time as (1) fecal levels decrease significantly and (2) a plan is presented to reduce future fecal levels.

Progress Towards Meeting Goals

An instrument for sampling visitors was prepared for the 1994 tourist season. However, Slide Rock State Park swimming area was closed for three weeks, beginning August 26, 1994, when fecal coliform levels became sufficiently high to pose a threat to public health (i.e. 3400 cfu/100ml). The closing of Slide Rock brought about a number of changes in the project. The Oak Creek Task Force was immediately formed and a number of BMPs were rapidly implemented, including:

- Complete closure of Slide Rock State Park recreational water area for three weeks.
- Erecting nearly one mile of permanent barricades on State Highway 89A, reducing the number of visitors having access by approximately one-half.
- Modernizing the single restroom located at the swimming area and constructing a more convenient path to the facility.
- Restricting the number of swimmers in the water at one time to 100 from September, 1994 through May, 1995. This BMP was based upon data provided by Northern Arizona University, which showed a high correlation between fecal coliform levels and number of swimmers in the water.

Perhaps most significantly, the Oak Creek Task Force formed two subgroups. The Management Team has assumed responsibility for planning and implementing the BMPs. The Sampling Team has responsibility for identifying pollutant sources, measuring the effectiveness of BMPs, and extending the water quality monitoring to other areas of Oak Creek Canyon. The unanticipated series of events have crystallized the original National Monitoring Plan (NMP) plan with respect to BMP planning and implementation.

WATER QUALITY MONITORING

Design

The water recreation project, which is a paired-site upstream/downstream monitoring design, is used to document the change in water quality as a result of the application of BMPs (Figure 2). The swimming sites at Slide Rock State Park (treatment site) and Grasshopper Point (the control site) are the paired comparison. Water quality monitoring stations are located above and below each swimming area.

The camping area project also uses a paired-site upstream/downstream monitoring design. The camping area at Pine Flats (treatment site) and the site at Manzanita (control site) have been selected for project monitoring. Upstream/downstream water quality monitoring stations have been installed at both sites.

A BMP effectiveness water quality monitoring design is being used for the Slide Rock Parking Lot study. Sampling will take place at the inflow point and the outflow point of the detention basin.

The three-year post-BMP implementation phase entails sampling protocols identical to those instituted in the calibration and project sampling phase. The object of this monitoring phase is to demonstrate the extent to which land treatment has reduced nonpoint source pollution.

Modifications Since Project Started

None.

Variables Measured

Slide Rock and Grasshopper Point (Water Recreation Project)

Biological

Fecal coliform

Chemical and Others

Nitrate (NO_3-N)
Total phosphorus (TP)
Total organic carbon (TOC)
Biological oxygen demand (BOD)

Explanatory Variables

Water temperature
Stream velocity and level
Number of users of the sites
Weekly precipitation

Pine Flats and Manzanita (Campgrounds Project)

Biological

Fecal coliform

Chemical and Other

Total nitrogen (TN)
Total phosphorus (TP)
Ammonia (NH_3-N)
Nitrate (NO_3-N)
Orthophosphate

Explanatory Variables

pH
Water temperature
Conductivity
Water flow rate
Dissolved oxygen (DO)
Total dissolved solids
Precipitation

Slide Rock Parking Lot Project

Chemical and Other

Total suspended solids (TSS)
Biological oxygen demand (BOD)
Total phosphorus (TP)
Soluble phosphorus
Total Kjeldahl nitrogen (TKN)
Nitrite ($N0_2$-N)
Nitrate ($N0_3$-N)
Lead (Pb)
Copper (Cu)
Zinc (Zn)

Explanatory Variables

Precipitation (Amount and Duration)
Runoff velocity
pH
Park attendance

Sampling Scheme

Slide Rock/Grasshopper Point (Water Recreation Project) and Pine Flats/Manzanita (Campgrounds Project)

Grab samples are collected weekly from May 15 through September 15. Samples are taken in the deepest part of the stream at each sampling site the first Saturday of every month from November through April.

Slide Rock Parking Lot Project

An event-based scheme is used to monitor runoff from the parking lot. An automatic sampler has been placed at the inflow point of the detention basin and at the outflow point of the basin. The samplers are triggered by rainfall events. A sample of the "first flush" is deposited in the first bottle. Thereafter, a sample will be taken every twenty minutes and composited in the second bottle, "post flush." Sample bottles are collected within five hours of each rain event.

The monitoring scheme for all three sites is presented below.

Monitoring Scheme for the Oak Creek Canyon 319 National Monitoring Program

Design	Activity/ Sites*	Variables Sampled**	Covariates***	Frequency	Time	Duration
	Water Recreation					
Paired-site upstream/ downstream	Slide Rock (T) Grasshopper Point (C)	Fecal coliform NO_3- N TP Organic Carbons	Water temp. pH Level & flow Rainfall Visitor count	9/15-5/15 monthly 5/15-9/15 weekly	12 pm - 5 pm Saturdays	1-2 years pre-BMP 1-2 years BMP 3 years post-BMP
	Camping					
Paired-site upstream/ downstream	Pine Flats (T) Manzanita (C)	Fecal coliforms NO_3- N TP	pH Water temp. Conductivity Water flow rate Dissolved oxygen Total dissolved solids Weekly rainfall	9/15-5/15 monthly; 5/15-9/15 weekly	12 pm - 5 pm Saturdays	1-2 years pre-BMP 1-2 years BMP 3 years post-BMP
	Parking Runoff					
BMP effectiveness	Slide Rock Parking Lot	TSS, BOD, COD, TP, SP, TKN, NO_2- N, NO_3- N, Cu, Pb, and Zn	pH Rainfall amt. Rainfall dur. Runoff velocity	Minimum of 20 event driven samples with priority to: 1. 7/4 to 9/15	Event driven; usually in the afternoon or early evening 2. 9/15 to 7/4	2 years pre-BMP 1-2 years BMP 3 years post-BMP

* T = the treatment site; C = the control site
** Basic pollution parameters will remain constant throughout the 6-7 years of the project with the exception of the parking lot project. The number of basic parameters will be reduced through Years I and II; those which are not detected in six sampling events will be discarded.
***All covariate parameters will be sampled throughout the 6-7 years of the project in order to assure project credibility. However, those which do not significantly vary with basic parameters will be dropped from statistical analysis after Year I of the project.

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

The project team stores all raw data in STORET and reports the project results in USEPA's Nonpoint Source Management System (NPSMS) software. Additionally, data is entered in a Geographical Information System (GIS).

NPSMS Data Summary

Currently unavailable.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

The DOS SYSTAT for Windows program (Wilkinson, Leland. *SYSTAT: The System for Statistics,* Evanston, IL: SYSTAT, Inc., 1990) was used for statistical analysis. Multiple correlations for each factor were obtained. Sufficient data points (at least twenty for each factor) were available to provide valid and reliable data. Generally, analysis revealed extremely high correlations for most water quality parameters at all locations.

Project personnel have concluded that a significant amount (30.79%) of the ammonia recorded at the Slide Rock downstream is deposited in the water column between the upstream and downstream location. The ammonia source is unconfirmed. The most probable source is visitors urinating in the water or on the terrain nearby; however, other possibilities have not been eliminated. Perhaps the "black water" vault at the restroom is leaking. Ammonia may be released into the water column from roiled sediments; however, the probability is slight since (1) ammonia is highly soluble and retention in sediments is slight and (2) ammonia is assimilated into the environment quite rapidly. Therefore, ammonia may be produced from some other source. Ammonia source determination will continue.

Approximately 98% of the time, fecal coliform is deposited in significant amounts (88.2%) into the water column between upstream and downstream sites at Slide Rock.

Identifying fecal coliform sources is difficult. Slide Rock visitors are, undoubtedly, a source of pollution (i.e., discarding dirty diapers in the water and defecating in the water or on land nearby). However, visitor behavior cannot account for the cyclical nature of elevated fecals in this area. High levels of fecals (i.e., levels approaching the current water quality standard of 800 cfu/100 ml for a single measure) historically and in Year 1 of this project were only detected during the "monsoon season" — roughly between July 15 and September 15 of each year. There are no exceptions. If visitors were the sole source of elevated fecals, then high levels should have occurred between Memorial Day and July 4, when visitor counts are as high as during the monsoon season. This has not occurred; therefore, there must be one or more other sources of fecal coliform. Northern Arizona University is currently exploring the monsoon season source of fecal coliform in a project separate from the Oak Creek National Monitoring Program project.

Personnel from the Oak Creek National Monitoring Program project continue to explore two possible sources of fecal pollution occurring at downstream Slide Rock: 1) visitors pollute the water directly by depositing excrement into the water or on the land nearby (which is washed into the water) and 2) visitors pollute the water indirectly by roiling fecal-laden sediments washed downstream to the Slide Rock area.

TOTAL PROJECT BUDGET

The estimated budget for the Oak Creek Canyon Nonpoint Source Pollution Monitoring Program project for the life of the project is:

Project Element	Funding Source ($)			
	Federal	State	Local	Total
Proj Mgt	70,000	70,000	70,000	210,000
LT	30,200	65,000	35,500	130,700
WQ Monit	424,800	NA	608,140	1,032,940
TOTALS	525,000	135,000	713,640	1,373,640

Source: Tom Harrison (Personal Communication), 1994

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The Oak Creek National Monitoring Project complements several other programs (federal, state, and local) located in the Verde Valley:

- The U.S. Geological Survey has initiated a comprehensive water use/water quality study focusing on the northcentral Arizona region extending from the City of Phoenix to the Verde Valley.
- The Verde Watershed Watch Program, a 319(h) funded program run by Northern Arizona University. The program is designed to train students and teachers from seven high schools (located within the river basin) in macroinvertebrate and water chemistry sampling to evaluate the effects of BMP implementation.
- The Arizona Department of Environmental Quality has established the Verde Nonpoint Source Management Zone in the state.
- The Colorado Plateau Biological Survey has established a major riparian study project focusing on the Beaver Creek/Montezuma Wells area of the Verde Valley.

Members of the Oak Creek Canyon National Project are active participants in all of these groups. Activities are under way to consolidate and coordinate these efforts.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

None.

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California

Morro Bay Watershed
Section 319
National Monitoring Program Project

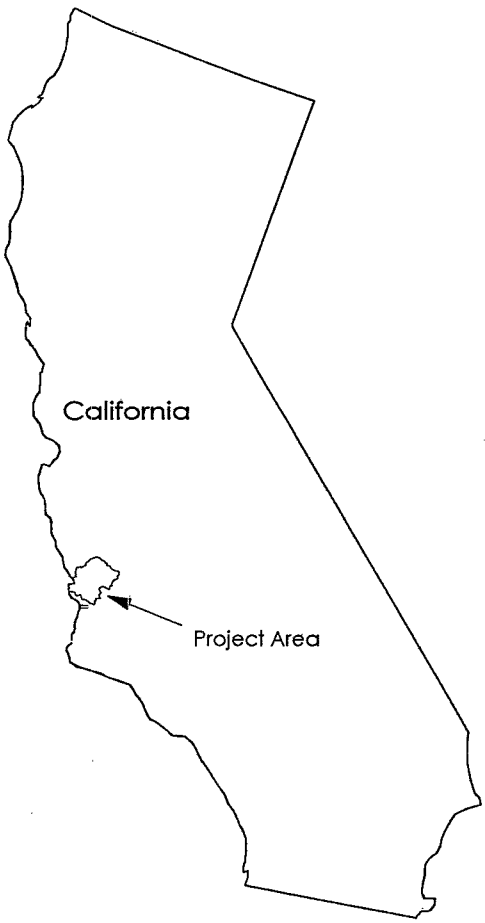

Figure 3: Morro Bay (California) Watershed Project Location

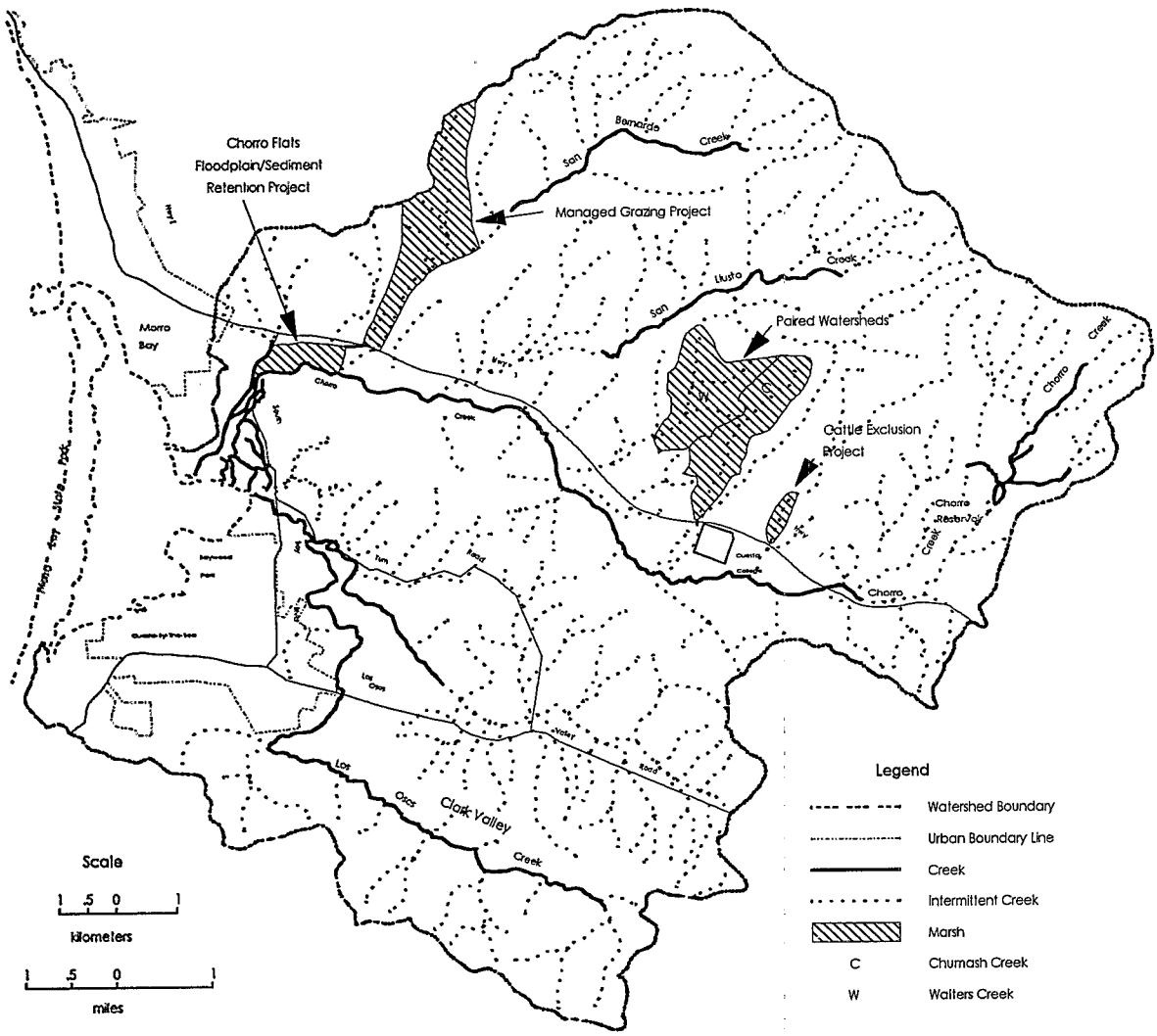

Figure 4: Paired Watersheds (Chorro Creek and Los Osos Creek) in Morro Bay (California)

PROJECT OVERVIEW

The Morro Bay watershed is located on the central coast of California, 237 miles south of San Francisco in San Luis Obispo County (Figure 3). This 76-square mile watershed is an important biological and economic resource. Two creeks, Los Osos and Chorro, drain the watershed into the Bay. Included within the watershed boundaries are two urban areas, prime agricultural and grazing lands, and a wide variety of natural habitats that support a diversity of animal and plant species. Morro Bay estuary is considered to be one of the least altered estuaries on the California coast. Heavy development activities, caused by an expanding population in San Luis Obispo County, have placed increased pressures on water resources in the watershed.

Various nonpoint source pollutants, including sediment, bacteria, metals, nutrients, and organic chemicals, are entering streams in the area and threatening beneficial uses of the streams and estuary. The primary pollutant of concern is sediment. Brushland and rangeland contribute the largest portion of this sediment, and Chorro Creek contributes twice as much sediment to the Bay as does Los Osos Creek. At present rates of sedimentation, Morro Bay could be lost as an open water estuary within 300 years unless remedial action is undertaken. The objective of the Morro Bay Watershed Nonpoint Source Pollution and Treatment Measure Evaluation Program is to reduce the quantity of sediment entering Morro Bay.

The U.S. Environmental Protection Agency (USEPA) Section 319 National Monitoring Program project for the Morro Bay watershed was developed to characterize the sedimentation rate and other water quality conditions in a portion of Chorro Creek, to evaluate the effectiveness of several best management practice (BMP) systems in improving water quality and habitat quality, and to evaluate the overall water quality at select sites in the Morro Bay watershed.

A paired watershed study on tributaries of Chorro Creek (Chumash and Walters Creeks) evaluates the effectiveness of a BMP system in improving water quality (Figure 4). BMP system effectiveness is being evaluated for sites outside the paired watershed. In addition, water quality samples taken throughout the watershed will document the changes in water quality during the life of the project.

PROJECT DESCRIPTION

Water Resource Type and Size

The total drainage basin of the Morro Bay watershed is approximately 48,450 acres. The monitoring effort is focused on the Chorro Creek watershed. Chorro Creek and its tributaries originate along the southern flank of Cuesta Ridge, at elevations of approximately 2,700 feet. Currently three stream gauges are operational in the Chorro Creek watershed: one each on the San Luisito, San Bernardo, and Chorro creeks. Annual discharge is highly variable, ranging from approximately 2,000 to over 20,000 acre-feet, and averaging about 5,600 acre-feet. Flow is intermittent in dry years and may disappear in all but the uppermost areas of the watershed. In spite of the intermittent nature of these creeks, both Chorro and Los Osos creeks are considered cold-water resources, supporting anadromous fisheries (steelhead trout).

Morro Bay is one of the few relatively intact natural estuaries on the Pacific Coast of North America. The beneficial uses of Morro Bay include recreation, industry, navigation, marine life habitat, shellfish harvesting, commercial and sport fishing, wildlife habitat, and rare and endangered species habitat.

A number of fish species (including anadromous fish, which use the Bay during a part of their life cycle) have been negatively impacted by the increased amount of sediment in the streams and the Bay. Sedimentation in anadromous fish streams reduces the carrying capacity of the stream for steelhead and other fish species by reducing macroinvertebrate productivity, spawning habitat, egg and larval survival rates, and increasing gill abrasion and stress on adult fish. Although trout are still found in both streams, ocean-run fish have not been observed in a number of years.

Accelerated sedimentation has also resulted in significant economic losses to the oyster industry in the Bay. Approximately 100 acres of oyster beds have been lost due to excessive sedimentation. Additionally, fecal coliform bacteria carried by streams to the Bay have had a negative impact on the shellfish industry, resulting in periodic closures of the area to shellfish harvesting (NRCS, 1992). Elevated fecal coliform counts have been detected in water quality samples taken from several locations in the watershed. Elevated fecal coliform detections, exceeding 1600 Most Probable Number/100 ml, have generally been found in areas where cattle impact on streams is heavy.

The Tidewater Goby, a federally endangered brackish-water fish, has been eliminated from the mouths of both Chorro and Los Osos creeks, most likely as a result of sedimentation of pool habitat in combination with excessive water diversion.

Pre-Project Water Quality

The two creeks that flow into the estuary (Chorro Creek and Los Osos Creek) are listed as impaired by sedimentation, temperature, and agricultural nonpoint source pollution by the State of California (Central Coast Regional Water Quality Control Board, 1993).

Studies conducted within the watershed have identified sedimentation as a serious threat in the watershed and estuary. Results of a Natural Resources Conservation Service (NRCS) Hydrologic Unit Areas (HUA) study show that the rate of sedimentation has increased tenfold during the last 100 years (NRCS, 1989b). Recent studies indicate that the estuary has lost 25% of its tidal volume in the last century as a result of accelerated sedimentation, and has filled in with an average of two feet of sediment since 1935 (Haltiner, 1988). NRCS estimated the current quantity of sediment delivered to Morro Bay to be 45,500 tons per year (NRCS, 1989b).

Current Water Quality Objectives

The overall goal of the USEPA Section 319 National Monitoring Program project is to evaluate improvements in water quality resulting from implementation of BMPs. The following objectives have been identified for this project:

- Identify sources, types, and amounts of nonpoint source pollutants (see the list of variables that will be monitored under Water Quality Monitoring), originating in paired watersheds in the Chorro Creek watershed (Chumash and Walters Creeks).
- Determine stream flow/sediment load relationships in the paired watersheds.
- Evaluate the effectiveness of BMPs implemented as a BMP system in improving water quality in one of the paired sub-watersheds (Chumash Creek).

- Evaluate the effectiveness of three implemented BMP systems in improving water or habitat quality at selected Morro Bay watershed locations.
- Monitor overall water quality in the Morro Bay watershed to identify problem areas for future work, detect improvements or changes, and contribute to the database for watershed locations.
- Develop a Geographical Information System (GIS) database to be used for this project and in future water quality monitoring efforts.

Modifications Since Project Initiation

None.

Project Time Frame

August 1, 1993 - June 30, 2003

Project Approval

1993

PROJECT AREA CHARACTERISTICS

Project Area

The Morro Bay watershed drains an area of 48,450 acres into the Morro Bay estuary on the central coast of California. The Bay is approximately 4 miles long and 1 3/4 miles wide at its maximum width. The project area is primarily located in the northeast portion of the Morro Bay watershed.

Relevant Hydrologic, Geologic, and Meteorologic Factors

Morro Bay was formed during the last 10,000 to 15,000 years (NRCS, 1989a). A postglacial rise in sea level of several hundred feet resulted in a submergence of the confluence of Chorro and Los Osos creeks (Haltiner, 1988). A series of creeks that originate in the steeper hillslopes to the east of the Bay drain westward into two creeks, Chorro and Los Osos, which drain into the Bay. The 400-acre salt marsh has developed in the central portion of the Bay in the delta of the two creeks. A shallow ground water system is also present underneath the project area.

The geology of the watershed is highly varied, consisting of complex igneous, sedimentary, and metamorphic rock. Over fifty diverse soils, ranging from fine sands to heavy clays, have been mapped in the area. Soils in the upper watershed are predominantly coarse-textured, shallow, and weakly developed. Deeper medium- or fine-textured soils are typically found in valley bottoms or on gently rolling hills. Earthquake activity and intense rain events increase landslide potential and severity in sensitive areas.

The climate of the watershed is Mediterranean: cool, wet winters and warm, dry summers. The area receives about 95% of its 18-inch average annual precipitation between the months of November and April. The mean air temperatures range from lows around 45 degrees in January to highs of 75 degrees in October, with prevailing winds from the northwest averaging about 15 to 20 miles per hour.

Land Use

Approximately 60% of the land in the watershed is classified as rangeland. Typical rangeland operations consist of approximately 1,000 acres of highly productive grasslands supporting cow-calf enterprises. Brushlands make up another 19% of the watershed area. Agricultural crops (truck, field, and grain crops), woodlands, and urban areas encompass approximately equal amounts of the landscape in the watershed.

Land Use	Acres	%
Agricultural Crops	3,149	7
Woodland	3,093	7
Urban	3,389	8
Brushland	8,319	19
Rangeland	26,162	59
Total	44,112	100

Source: NRCS, 1989a

Pollutant Source(s)

It has been estimated that 50% or more of the sediment entering the Bay results from human activities. Sheet and rill erosion account for over 63% of the sediment reaching Morro Bay (NRCS, 1989b). An NRCS *Erosion and Sediment Study* identified sources of sediment to the Bay, which include activities on rangeland, cropland, and urban lands (NRCS, 1989b). The greatest contribution of sediment to the Bay originates from upland brushlands (37%) because of the land's steepness, parent material, and lack of undercover, as well as from rainfall. Rangelands are the second-largest source of sediment entering into streams (12%). Cattle grazing has damaged riparian areas by stripping the land of vegetation and breaking down bank stability. The unvegetated streambanks, as well as overgrazed uplands, have resulted in accelerated erosion. Other watershed sources that contribute to sediment transport into Morro Bay include abandoned mines, poorly maintained roads, agricultural croplands, and urban activities.

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

At least one informal educational program on the 319 National Monitoring Program project and the watershed will be conducted each year. Information and education (I&E) programs, thus far, have been workshops about the water quality problems within the watershed (for landowners and local agency personnel), and a presentation before the Central Coast Regional Water Board. Future public presentations about the Morro Bay 319 National Monitoring Program project will be made to groups such as Friends of the Estuary, the Morro Bay Natural History Association, and the Morro Bay Task Force, as well as Cal Poly State University (Cal Poly) and Cuesta Community College.

Progress Towards Meeting Goals

Presentations on the monitoring program were made at a Regional Water Quality Control Board public hearing and at the annual Soil and Water Conservation Society Conference (California Chapter). In addition, educational outreach efforts were made at a Cooperative Extension erosion control workshop, the Morro Bay Museum of Natural History, a 4-H watershed education day, the California Biodiversity Council, a Morro Bay Task Force meeting, and Cal Poly Coastal Resources and Marine Biology classes. Publicity generated includes an excellent article in the local newspaper and a featured spot on the local evening news.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Paired Watershed

In the paired watershed, a BMP system is being used to control nonpoint source pollutants. Cal Poly is responsible for implementing the BMP system on Chumash Creek, which is one of the streams in the paired watershed. The implemented

BMPs include: 1) fencing the riparian corridor; 2) creating smaller pastures for better management of cattle-grazing activities; 3) providing appropriate water distribution to each of these smaller pastures; 4) stabilizing and revegetating portions of the streambank; and 5) installing water bars and culverts on farm roads where needed. During the project, riparian vegetation is expected to increase from essentially zero coverage to at least 50% coverage. The project team has established a goal of a 50% reduction in sediment following BMP implementation.

BMP Systems at Sites within the Morro Bay Watershed

The NRCS has designed three different BMP systems throughout the watershed. These three systems are being evaluated for their effect on water and habitat quality. A floodplain sediment retention project will be established at Chorro Flats to retain sediment (sediment retention project). A riparian area along Dairy Creek, a tributary of Chorro Creek, has been fenced and revegetated (cattle exclusion project). Fences have been installed to allow rotational grazing of pastures on the 1,400-acre Maino ranch (managed grazing project). The goals for these projects during the next 10 years are to achieve a 33.8% decrease in sediment yield from the sediment retention project, a 66% reduction in sediment yield from the cattle exclusion project, and a 30% reduction in sediment as a result of the managed grazing project.

Modifications Since Project Started

Modifications occurred at Chorro Flats due to emergency post-fire concerns. An existing level breech was widened so that the flood plain could serve as a sediment deposition area.

Progress Towards Meeting Goals

Paired Watershed Study: Funding has been acquired through CWA 319(h) for implementation of improvements on the paired watershed. A Technical Advisory Committee has been formed, and implementation for land improvements on the Chumash Creek watershed is underway.

Sediment Retention Project: The Chorro Flats project has obtained funding ($90,000) for the engineering design of the flood plain restoration project. All environmental documents have been completed and engineering design is underway, but installation is still a few years away. Engineering design is underway. $300,000 has been acquired through 319(h) funds towards project implementation.

Cattle Exclusion Project: Dairy Creek fencing for riparian exclusion was completed in the summer of 1995.

Managed Grazing Project: In 1994, the Maino Ranch completed installation of watering devices and fencing and is being managed as planned in a timed grazing project.

WATER QUALITY MONITORING

Design

Two watersheds have been selected for a paired watershed study. Chumash Creek (400 acres) and Walters Creek (480 acres) both drain into Chorro Creek. These creeks have similar soils, vegetative cover, elevation, slope, and land use activities. The property surrounding these two creeks is under the management of Cal Poly. Because the rangeland being treated is owned by Cal Poly, project personnel will be able to ensure continuity and control of land management practices.

The paired watershed monitoring plan entails three specific monitoring techniques: stream flow/climatic monitoring, water quality monitoring, and biologi-

cal/habitat monitoring. The duration of the calibration period (the period during which the two watersheds are monitored to establish statistical relationships between them), has been completed within the past two years. After the calibration period was completed, a BMP system was installed in one of the watersheds (Chumash Creek). The other watershed, Walters Creek, will serve as the control.

Other systems of BMPs will be or have been established at different locations in the Morro Bay watershed. Water quality will be monitored using upstream/downstream and single station designs to evaluate these systems. An upstream/downstream design has been adopted to monitor the water quality effect of a floodplain/sediment retention project and a cattle exclusion project. A single station design on a subdrainage is being used to evaluate changes in water quality from implementation of a managed grazing program.

In addition to BMP effectiveness monitoring, ongoing water quality sampling is taking place at selected sites throughout the Morro Bay watershed to document long-term changes in overall water quality and to discern problem areas in need of further restoration efforts.

Modifications Since Project Started

Because of very limited runoff during the 1993-1994 sampling year, only one sampling event occurred. However, because of extreme wetness during the 1994-1995 rainy season, sufficient data for baseline information was collected.

Variables Measured

Biological

Fecal coliform
Riparian vegetation

Chemical and Other

Suspended sediment (total filterable solids)
Turbidity
Nitrate (NO_3-N)
Phosphate (P)
Conductivity
pH
Dissolved oxygen (DO)
Temperature

Explanatory Variables

Precipitation
Stream flow
Evaporation
Animal units

Sampling Scheme

Weekly grab samples are taken for at least 20 weeks during the rainy season, starting on November 15 of each year or after the first runoff event. The samples from the paired watershed are analyzed for suspended sediment, turbidity, nitrate, phosphate, fecal coliform, and other physical parameters. The Dairy Creek cattle exclusion is being analyzed for suspended sediment, turbidity, nutrients, fecal coliform, and other physical parameters. Suspended sediment and turbidity is being monitored at the Chorro Flats sediment retention area. In addition, year-round samples for pH, dissolved oxygen, turbidity, temperature, and fecal coliform are conducted every two weeks at several additional sampling sites throughout the Morro Bay Watershed.

In the paired watershed, suspended sediment samples are collected during storm events using automated sampling equipment set at even intervals (30-minute). The water collected from each individual sample are analyzed for suspended sediment, turbidity, and conductivity.

Bedload sediment is sampled after each flow event (4 to 10 events per rainy season) for total mass. Physical (particle size) analysis is performed on composite bedload samples.

Vegetation is assessed via aerial photography conducted biannually in March and September during the first, fifth, and tenth years of the project. On both the paired watershed and the Maino property, four permanent vegetation transects are conducted two times each year to sample vegetation and document changes during the life of the project.

Monitoring Scheme for the Morro Bay Watershed 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency for WQ Sampling	Frequency for Vegetation Sampling	Duration
Paired	Chumash Creek[T] and Walters Creek [C]	Fecal coliform Riparian vegetation Suspended sediment & bedload sediment Turbidity Nitrate Phosphate Conductivity pH Dissolved oxygen	Precipitation Stream flow Evaporation Animal units	Start after first run-off and weekly grab samples thereafter for 20 weeks. Storm event based monitoring (every 30 minutes).	March & Sept. aerial photography in 1st, 5th, & 10th year. Vegetation transects twice per year.	2 yrs pre-BMP 1 yr BMP 6 yrs post-BMP
Upstream/ downstream	Chorro Flats: Sediment Retention Project	Suspended sediment Turbidity Sediment deposition	Precipitation Stream flow Evaporation Animal units	Storm event monitoring (hourly)	March & Sept. aerial photography in 1st, 5th, & 10th year.	4 yrs pre-BMP 1 yr BMP 4 yrs post-BMP
Upstream/ downstream	Dairy Creeks Cattle Exclusion Project	Suspended sediment Turbidity Fecal coliform Nitrate Phosphate Physical parameters	Precipitation Stream flow Evaporation Animal units	Weekly during rainy season starting around Nov. 15.	March & Sept. aerial photography in 1st, 5th, & 10th year.	1 yr pre-BMP 1/2 yr BMP 7 yrs post-BMP
Single downstream	Maino Ranch: Managed Grazing Project	Suspended sediment Turbidity Fecal coliform Riparian vegetation	Precipitation Stream flow Evaporation Animal units	Weekly during the rainy season.	March & Sept. aerial photography in 1st, 5th, & 10th year. Vegetation transects twice per year.	0-1 yr pre-BMP 8 yrs post-BMP

[T]Treatment watershed
[C]Control watershed

Modifications Since Project Started

Modifications will be made to sediment analysis techniques in upcoming years. This year, evaporation was used to process suspended sediment samples; however, dissolved solids are high in this watershed and contribute significantly to the total weight of the samples. In the future, analysis will be for total filterable solids. A relationship between conductivity and dissolved solids is being developed to convert this year's data to filterable solids. In addition to suspended solids and turbidity, conductivity is being measured for each suspended sediment sample during event monitoring. However, composite samples from event monitoring will no longer be analyzed for total N, total P, or pH. Grab sampling continues unchanged for nitrate, total P, pH, conductivity, and turbidity.

The winter of 1993-1994 was atypical; only one rainfall event produced significant runoff. Sediment, turbidity, and flow data from this event were collected. A year of even interval grab sampling (winter 1994-1995) was obtained, with sampling conducted once every two weeks. During the rainy season (20 weeks beginning December 15), grab samples were collected once per week. A coshocton sampler was installed to collect flow from a small drainage on the Maino property, but flows were insufficient to start sample collection. Though the study design requires even-interval sampling year round, this is not feasible in several locations (including the paired watersheds) because the flow becomes intermittent or ceases entirely during summer months.

Water Quality Data Management and Analysis

Data Management

Data and BMP implementation information is handled by the project team. As required by the USEPA Section 319 National Monitoring Program Guidance, data is entered into STORET and reported using the Nonpoint Source Management System Software (NPSMS). A Geographical Information System (GIS), ARC/INFO, is used to map nonpoint pollution sources, BMPs, and land uses, and to determine resulting water quality problem areas.

A Quality Assurance Project Plan, for project water quality sampling and analysis, has been developed by the Central Coast Regional Water Quality Control Board. The plan is used to assure the reliability and accuracy of sampling, data recording, and analytical measurements.

Data Analysis

Parametric and nonparametric statistical tests are being adopted to analyze the data. Possible tests include simple regression, analysis of variance, paired T-tests between turbidity, suspended sediment, flow, and other variables. A two-way contingency table for comparison of the levels of pollutant concentrations and levels of explanatory variables will be used in the future as trends appear. Three variable contingency tables were prepared; these include time (season or year), pollutant concentration, and an explanatory variable (such as flow or land treatment).

NPSMS Data Summary

NPSMS quartile data has not yet been developed due to the lack of adequate trend data. Data will be entered into STORET using NPSMS software as trends appear.

Modifications Since Project Started

None.

Progress Toward Meeting Goals

A revised Quality Assurance Plan has been developed, implemented, and submitted to USEPA for review. It is available at the Regional Water Quality Control Board office. GIS data layers entered this past year (using ARC/INFO) include sample site locations, streams, flood zones, ground water basins, geology, soils, vegetation, land use, and topography. Initial analysis of the data is relatively simple, including basic statistics and graphical representation of water quality parameters versus flow and precipitation.

TOTAL PROJECT BUDGET

The estimated budget for the Morro Bay watershed National Monitoring Program project for the period of FY95 is:

Project Element	Funding Source ($)		
	Federal	State	Sum
Proj Mgt	20,000	N/A	20,000
I&E	25,000	N/A	25,000
* LT	130,000	1,593,500	1,723,500
WQ Monit	55,000	20,000	75,000
TOTALS	230,000	1,613,500	1,843,500

* Land Treatment dollars are largely to be used for permanent structures. These funds will be used for matching funds throughout the duration of the project, not just for the fiscal year. The amounts shown will be utilized over the entire project period.

Source: Karen Worcester (Personal Communication), 1995

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The Central Coast Regional Water Quality Board is conducting a study of the abandoned mines in the watershed with USEPA 205(j) funds. The Board has also obtained a USEPA Near Coastal Waters grant to develop a watershed work plan, incorporate new USEPA nonpoint source management measures into the Basin Plan, and develop guidance packages for the various agencies charged with the responsibility for water quality in the watershed.

The Department of Fish and Game Wildlife Conservation Board provided funding ($48,000) for steelhead habitat enhancement on portions of Chorro Creek. The State Department of Parks and Recreation funded studies on exotic plant invasions in the delta as a result of sedimentation. The California Coastal Commission used Morro Bay as a model watershed in development of a pilot study for a nonpoint source management plan pursuant to Section 6217 of the Federal Coastal Zone Management Act Reauthorization Amendments of 1990.

The California Assembly Bill 640 became law in January, 1995. This bill was written by the Friends of the Estuary and carried by Assemblywoman, now Congresswoman, Andrea Seastrand. It establishes Morro Bay as the first "State Estuary," and mandates that a comprehensive management plan be developed for

the bay and its watershed by locally involved agencies, organizations, and the general public. On July 6, 1995, Morro Bay was accepted into the National Estuary Program. This "National Estuary" designation provides 1.3 million dollars for planning over a three year period. Current effort is under way by the Morro Bay State Estuary Watershed Council to create the foundation for this planning process.

In addition to the USEPA 319 National Monitoring Program project being led by the California Central Coast Regional Water Quality Control Board, several other agencies are involved in various water quality activities in the watershed. The California Coastal Conservancy contracted with the Coastal San Luis Resource Conservation District in 1987 to inventory the sediment sources to the estuary, to quantify the rates of sedimentation, and to develop a watershed enhancement plan to address these problems. The Coastal Conservancy then provided $400,000 for cost share for BMP implementation by landowners. HUA grant funding has been obtained for technical assistance in the watershed ($140,000/year), Cooperative Extension adult and youth watershed education programs ($100,000/year), and cost share for farmers and ranchers ($100,000/year) for five years. An NRCS Range Conservationist was hired through 319(h) funds ($163,000) to manage the range and farm land improvement program. Cooperative Extension has also received a grant to conduct detailed monitoring on a rangeland management project in the watershed. The California National Guard, a major landowner in the watershed, has contracted with the NRCS ($40,000) to develop a management plan for grazing and road management on the base. State funding from the Coastal Conservancy and the Department of Transportation has been used to purchase a $1.45 million parcel of agricultural land on Chorro Creek just upstream of the Morro Bay delta, which is being restored as a functioning flood plain. Without the cooperation of these agencies and without their funding, this project would be unable to implement BMPs or educate landowners about nonpoint source pollution.

Modifications Since Project Started

Twin Bridges, a major passage to Morro Bay which has undergone heavy sediment deposition and flooding, will be modified as design plans to reroute South Bay Boulevard over Chorro Creek are currently being developed.

OTHER PERTINENT INFORMATION

In addition to state and federal support, the Morro Bay watershed receives tremendous support from local citizen groups. The Friends of the Estuary, a citizen advocacy group, is invaluable in its political support of Morro Bay, including an effort to nominate the Bay for the National Estuary Program. The Bay Foundation, a nonprofit group dedicated to Bay research, funded a $45,000 study on the freshwater influences on Morro Bay, developed a library collection on the bay and watershed at the local community college, and is actively cooperating with the Morro Bay National Monitoring Program project in development of a watershed GIS database. The Bay Foundation also recently purchased satellite photographs of the watershed, which will prove useful for the monitoring program effort. The Friends of the Estuary and the Bay Foundation of Morro Bay are cooperating to develop a volunteer monitoring program for the Bay itself, which includes water quality monitoring.

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Idaho

Eastern Snake River Plain
Section 319
National Monitoring Program Project

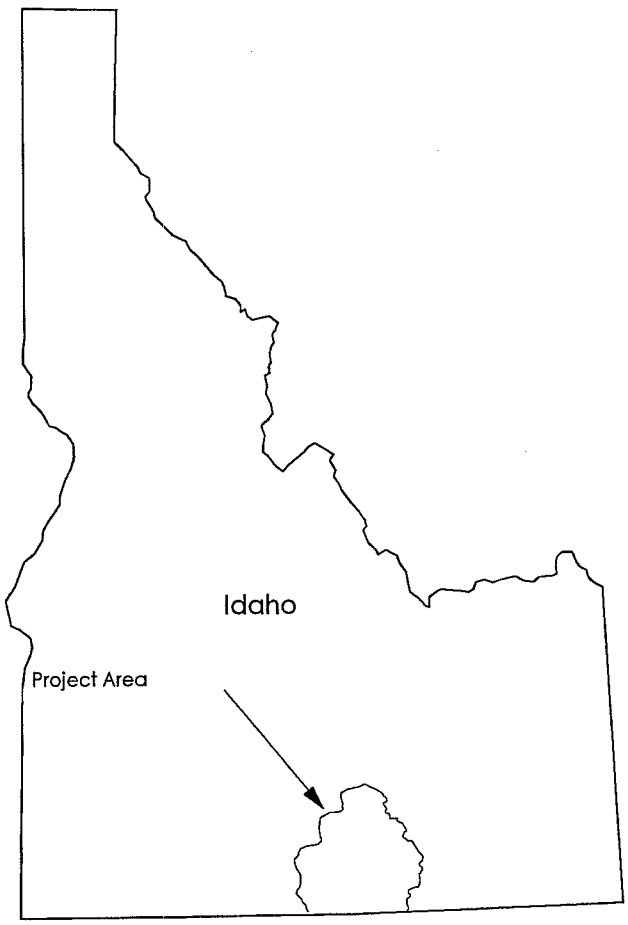

Figure 5: Eastern Snake River Plain (Idaho) Demonstration Project Area Location

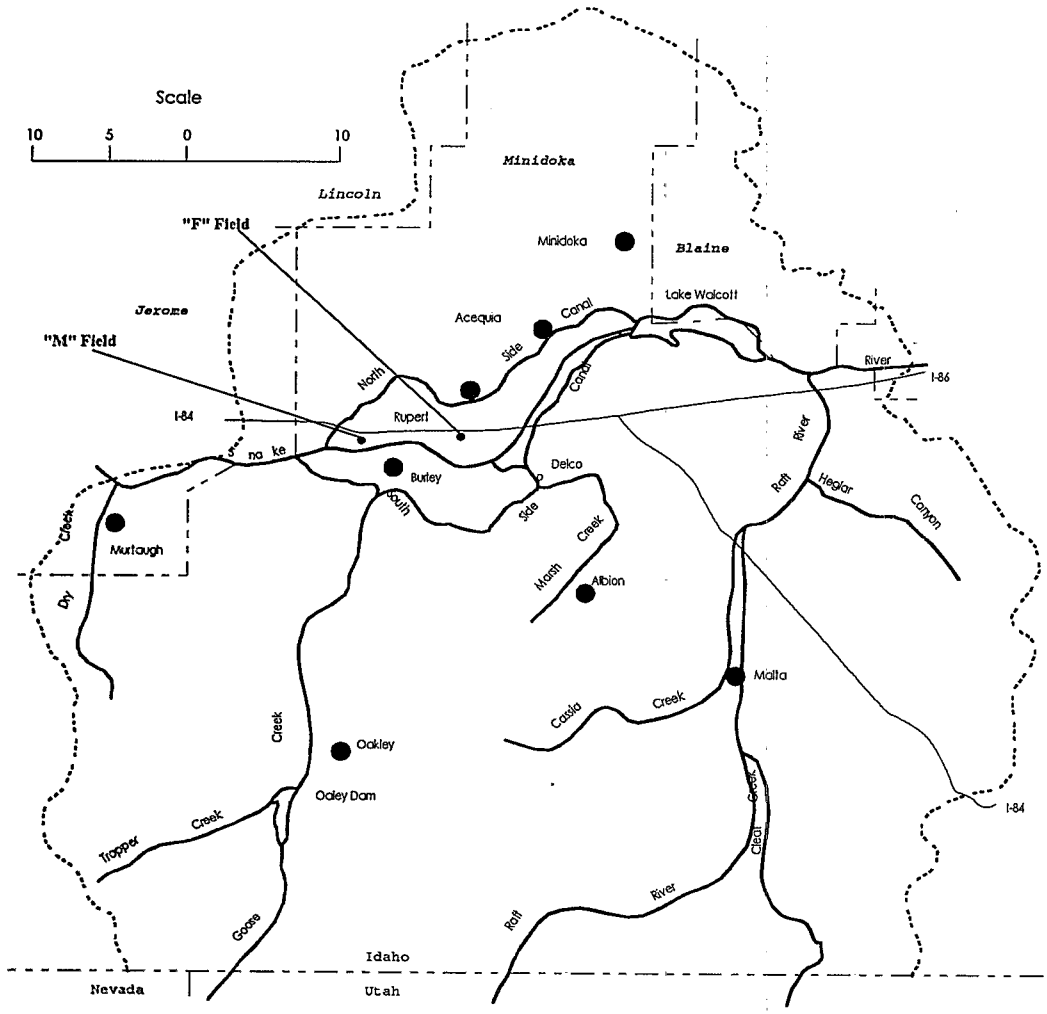

Figure 6: Eastern Snake River Plain (Idaho) Demonstration Project Area

PROJECT OVERVIEW

The Idaho Eastern Snake River Plain is located in southcentral Idaho in an area dominated by irrigated agricultural land (Figure 5). The Eastern Snake River Plain aquifer system, which provides much of the drinking water for approximately 40,000 people living in the project area, underlies about 9,600 square miles of basaltic desert terrain. The aquifer also serves as an important source of water for irrigation. In 1990, this aquifer was designated by the U.S. Environmental Protection Agency (USEPA) as a sole source aquifer.

Many diverse crops are produced throughout the Eastern Snake River Plain region. Excessive irrigation, a common practice in the area, creates the potential for nitrate and pesticide leaching and/or runoff. Ground water monitoring indicates the presence of elevated nitrate levels in the shallow aquifer underlying the project area.

The objective of a seven-year United States Department of Agriculture (USDA) Demonstration Project within the Eastern Snake River Plain (1,946,700 acres) is to reduce adverse agricultural impacts on ground water quality through coordinated implementation of nutrient and irrigation water management (Figure 6). As part of this project, two paired-field monitoring networks (constructed to evaluate best management practices (BMPs) for nutrient and irrigation water management effects) are funded under Section 319 of the Clean Water Act.

PROJECT DESCRIPTION

Water Resource Type and Size

In the intensely irrigated areas overlying the Eastern Snake River Plain aquifer, shallow, unconfined ground water systems have developed primarily from irrigation water recharge. Domestic water is often supplied by these shallow systems. Within the project area, the general flow direction of the shallow ground water system is toward the north from the river; however, localized flow patterns due to irrigation practices and pumping effects are very common. This ground water system is very vulnerable to contamination because of the 1) proximity of the shallow system to ground surface, 2) the intensive land use overlying the system, and 3) the dominant recharge source (irrigation water) of the ground water.

Water Uses and Impairments

Some wells sampled for nitrate concentrations have exceeded state and federal standards for allowable levels. This occurrence of elevated nitrate concentrations in the ground water impairs the use of the shallow aquifer as a source of drinking water. Low-level pesticide concentrations in the ground water have been detected in domestic wells and are of concern in the project area. Both nitrate and potential pesticide concentrations threaten the present and future use of the aquifer system for domestic water use.

Pre-Project Water Quality

Ground water data collected and analyzed within the project area indicate the widespread occurrence of nitrate concentrations that exceed state and federal drinking water standards. In a study conducted from May 1991 through October 1991, 195 samples were taken from 54 area wells and analyzed for nitrate. Average nitrate concentrations were around 6.5 milligrams per liter (mg/l), with a maximum of 28 mg/l. The federal Maximum Contaminant Level (MCL) for nitrate concentrations of 10 mg/l was exceeded in 16 % of the wells at least once during the sampling period. Five percent of the wells yielded samples that continuously exceeded the MCL during the sampling period.

Ninety-eight samples were collected from the same 54 wells and analyzed for the presence of 107 pesticide compounds. Fourteen of the 54 wells yielded samples with at least one detectable pesticide present, but all concentrations measured were below the federal Safe Drinking Water MCL or Health Advisory for that compound. Even though the wells now meet MCL standards, pesticide concentrations are still believed to be a future concern for the Eastern Snake River Plain Aquifer.

Current Water Quality Objectives

The overall Demonstration Project objective is to decrease nitrate and pesticide concentrations through the adoption of BMPs on agricultural lands. Specific project objectives for the USEPA 319 National Monitoring Program project are:

- Evaluate the effects of irrigation water management on nitrate-nitrogen leaching to the ground water. A paired-field study, referred to as "M," will allow a comparison of ground water quality conditions between regular irrigation scheduling and the use of a 12-hour sprinkler duration.
- Evaluate the effects of crop rotation on nitrate-nitrogen leaching to the ground water. A paired-field study, referred to as "F," will allow a comparison of water quality conditions between the amount of nitrogen leached to ground water as a result of growing beans after alfalfa, which generate nitrogen, and the growing of grain after alfalfa, which utilizes excess nitrogen in the soil.

Source: James Osiensky (Personal communication), 1993.

Modifications Since Project Initiation

An original objective was to compare the effects of sprinkler versus gravity applied irrigation water on ground water nitrate-nitrogen concentrations, but was deleted because project personnel felt that this information was apparent and available.

Project Time Frame

October 1991 - October 1997

Project Approval

1992

PROJECT AREA CHARACTERISTICS

Project Area

The USDA Demonstration Project comprises over 1,946,000 acres. The ground water quality monitoring activities are limited to a 30,000-acre area of south Minidoka County. The 319 National Monitoring Program project consists of two sets of paired five-acre plots (a total of four five-acre plots) located in this 30,000-acre area (Figure 6). The paired-fields are located in the eastern and western portions of the area to illustrate BMP effects in differing soil textures. The "M" field soils are silty loams. The "F" field soils are fairly clean, fine to medium sands. Due to the differences in soils and the traditional irrigation methods employed on these fields (flood and furrow respectively), the "M" field has relatively lower spatial variability of existing water quality than the "F" field. The "F" field also shows greater influences from adjacent fields.

Relevant Hydrologic, Geologic, and Meteorologic Factors

The average annual rainfall is between 8 and 12 inches. Shallow and deep water aquifers are found within the project area. Because of the hydrogeologic regime of the project area, there is a wide range of depths to ground water. Soils in the demonstration area have been formed as a result of wind and water deposition. Stratified loamy alluvial deposits and sandy wind deposits cover a permeable layer of basalt. Soil textures vary from silty clay loams to fine sandy loams. These soils are predominantly level, moderately deep, and well drained.

Land Use

In the project area, over 99% of the land is irrigated. Of the irrigated cropland, at least 85% of the land is in sprinkler irrigation and the other 15% is in furrow. A diversity of crops are grown in the area: beans, wheat, barley, potatoes, sugar beets, alfalfa, and commercial seed.

Pollutant Source(s)

Within the project area, there are over 1,500 farms with an average size of 520 acres. Nutrient management on irrigated crops is intensive. Heavy nitrogen application and excessive irrigation are the primary causes of water quality problems in the shallow aquifer system. In addition, over 80 different agrochemicals have been used within the project area. Excessive irrigation may cause some leaching of these pesticides into ground water (Idaho Eastern Snake River Plain Water Quality Demonstration Project, 1991).

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

Presently, there is no plan to implement a separate information and education (I & E) campaign for the 319 National Monitoring Program project. I & E for the Snake River 319 National Monitoring Program project is included in the Demonstration Project I & E program.

Two Eastern Snake River Plain Demonstration Project brochures have been published. One brochure, targeting the local public, was designed to provide a general explanation of the project. The second explains results from the nitrate sampling of the project area. A survey was conducted to gain insight into the attitudes of both the general public and farmers. The results of these surveys have been published. In addition, presentations have been conducted and Demonstration Project displays have been exhibited in the area.

Progress Toward Meeting Goals

The USDA demonstration project continues to provide the I&E component for this project. Weekly university articles are produced on the demonstration project. Project information is disseminated through university and producer conferences. Presentations on the project are made to the public through local and regional outlets, such as the American Association of Retired Persons, Future Farmers of America, and primary and secondary education institutions. In addition, a public information workshop is held annually within the project area for project participants, cooperators, and interested individuals. Information has been disseminated through local and regional television and radio programs and newspaper articles. Presentations have also been made to local and regional agricultural producers, local irrigation districts and canal companies, industry representatives, and industry supply vendors. Cooperating farm operations performing improved management practices for water quality are marked by project display boards to maximize exposure to the local population. These operations are also visited and displayed during the numerous project organized field trips for targeted audiences.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

The NPS control strategy for the demonstration project focuses on nitrogen, pesticide, and irrigation water management practices that will reduce the amount of nutrients and pesticides in surface water and the amount leached into the ground water.

- Fertilizer evaluations and recommendations based on soil tests, petiole analysis, crop growth stage, crop type, rotation, and water sampling are being adopted.
- Farmers have been asked to incorporate pesticide management strategies into their farming practices.
- An irrigation management program has been implemented for each participating farm in the Demonstration Project.

The NPS control strategy for the 319 National Monitoring Program project is to reduce applied water in the "F" field and to plant grain in the "M" field. Sugar beets, potatoes, and grains are grown in the "M" field. Alfalfa, dry beans, and grains are grown in the "F" field.

The "M" paired field is used to establish existing baseline conditions which exist using a "wheel line" sprinkler system. After baseline conditions have been established, the water application rate to the "BMP" side of the paired field will be approximately half that of the control side.

Baseline conditions, which exist under sprinkler-irrigated alfalfa production, are being established on the "F" paired field. After baseline conditions have been established, the "BMP" side of the paired field will be planted in grain, while the "control" side of the field will be planted in beans.

Modifications Since Project Started

Farmstead Assessment System and Homestead Assessment System (Farm*A*Syst/ Home*A*Syst), a wellhead protection program, have been added to the demonstration project. These programs will aid in ground water risk assessment for the rural homeowner.

Progress Toward Meeting Goals

Thirty farms within the Eastern Snake River Plain demonstration area were targeted to receive BMPs. Seventy-five farms currently have received direct technical and financial assistance for BMP installation on their farm.

Both fields, which are part of the Eastern Snake River Plain National Monitoring Program project, were converted to sprinkler from furrow and flood irrigation in 1993. Comparison demonstrations between sprinkler and gravity irrigation systems are not occurring because project personnel feel that this information is apparent and available.

Nonpoint source control strategy and design problems in the paired-field water quality monitoring design are associated with coordination between project personnel and producers. This occurs because landowners lack long term commitments to production activity scheduling and, during the producers growing season, heavy daily schedules lead to a lack of accessibility to producers.

Changes in the type of crops produced and the production methods employed during baseline monitoring have been detrimental to the experimental design. Scheduled crop rotations have been changed to meet commodity market demands on the "F" field, and cost share negotiations with the "M" field land owner for project participation lead to implementation of the same irrigation water supply system in both the BMP test field and the control field. These events have lead to extension of the monitoring project in order to reestablish baseline water quality data.

Additionally, full monitoring has been problematic. Producers are required to act on uncontrollable events which hamper the logistics of rigidly scheduled sampling

activities. For example, weather or available labor or equipment may cause a producer to perform unscheduled field activities during a scheduled ground water sampling event. Monitoring information obtained on spatial soil variability has lead to installation of additional infield instrumentation. The number and arrangement of the field instrumentation has complicated production field work as producers are forced to manipulate production equipment around monitoring instrumentation.

The dynamics of NPS ground water quality monitoring of land use changes has complicated project progress. As the monitoring project proceeds, new information is obtained, analyzed, and applied. The original monitoring design was based on the best available understanding of the local ground water system. Ground water quality information gained during baseline monitoring demonstrated a high degree of spatial variability in the paired fields. In order to address the spatial variability of the system and document ground water quality changes resulting from land use, the monitoring system has been expanded to provide a more intensive monitoring system based on a geostatistical evaluation of data obtained. Sampling and maintenance of this more intensive system has required more time and resources than originally planned.

WATER QUALITY MONITORING

Design

The 319 National Monitoring Program portion of the Demonstration Project incorporates two field networks consisting of 24 constructed wells, 8 of which are centrally located "permanent" wells, and 4 of which are peripheral "temporary" wells, installed on both fields.

Modifications Since Project Started

The scope of work has been increased to evaluate spatial variability within the two paired fields. In addition to monthly ground water sample collection, a statistically designed soil water sampling program has been initiated. Soil water samples, using a suction lysimeter (soil water samplers), are collected during the growing season at both the "F" and "M" paired fields. The soil water sampling program is important in the interpretation of the ground water samples collected from in-field monitoring wells.

Twenty three lysimeters were installed at the "F" field during June, 1994. Each lysimeter is 12 inches in length and is installed at a 60 degree angle with the horizontal. This method of installation places the ceramic cup approximately one meter below land surface, which is within one meter of the water table. The lysimeters are the pressure vacuum type. The areal distribution of lysimeters installed in June, 1994, is based upon grain size analyses of soil samples collected at the "F" field.

Nitrate samples were collected from the lysimeters for the months of July, August, September, and October, 1994. Basic univariate statistics were computed and a preliminary geostatistical analysis was conducted. Based on these results, the following modifications of the sampling plan were necessary:

- Reduce the length of the shortest lags.
- Increase the overall number of short lags produced by the sampling configuration.
- Include a greater number of the original soil sample locations as lysimeter installation locations.

To accomplish these goals, 22 additional lysimeters were installed at the "F" field in May, 1995 (Field Map 1). The lysimeters are 12 inches in length and are the pressure vacuum type. The lysimeters are installed vertically with the ceramic cups positioned at one meter below land surface. Installation of the additional lysimeters will help to more adequately define spatial dependence at short distances.

Six lysimeters were installed at the "M" field in July, 1994. The lysimeters were installed vertically to a depth of one half meter below ground surface. Placement of the lysimeters was based upon particle size analyses of soil samples collected from the "M" field.

Samples were collected from the lysimeters in August, September, and October, 1994. Analysis of the data showed the following modifications of the sampling plan were necessary:

- Installation of additional lysimeters in a more dispersed distribution across the test field.
- Incorporation of the original soil sample locations in the lysimeter distribution.

To accomplish these goals, the original 6 lysimeters were removed and reinstalled as part of the 25 placed at the "M" field in May, 1995 (Field Map 2). The lysimeters are the pressure vacuum type and are installed to a total depth of one half meter below land surface. Installation of the new sampling network will assist in the characterization of the spatial dependence of nitrate at the "M" field.

Progress Toward Meeting Goals

Baseline data is still being collected.

Variables Measured

Chemical and Other

Nitrate (NO_3-N)
pH
Temperature
Conductivity
Dissolved oxygen (DO)
Total dissolved solids (TDS) on a monthly basis
Total Kjeldahl nitrogen (TKN) and Ammonium (NH_4-N) on a quarterly basis
Organic scans for pesticide on a semiannual basis

Explanatory Variables

Precipitation
Crop
Soil texture
Nutrient content of the irrigation water

Sampling Scheme

Paired Field Networks
Type: Grab
Frequency and season: Monthly, third week of each month starting April, 1992

A number of explanatory variable monitoring activities have been undertaken by some of the other agencies participating in the project. Variables to be considered in this project include precipitation, crop, soil texture, and nutrient content of the irrigation water. In addition, vadose zone suction lysimeters are being used to monitor nitrate transport.

Monitoring Scheme for the Eastern Snake River Plain 319 National Monitoring Program Project

Design	Site	Primary Variables	Covariates	Frequency of WQ Sampling	Duration
Paired field	"M" field	Nitrate pH Temperature Conductivity Dissolved oxygen Total dissolved solids Total Kjeldahl nitrogen Ammonium Pesticides	Precipitation Crop Soil texture Nutrient content of the irrigation water	Monthly for primary pollutants except Pesticides (sampled) semiannually) and Nitrogen (quarterly)	4 yrs pre-BMP 1 yr BMP 2 yrs post-BMP
Paired field	"F" field	Nitrate pH Temperature Conductivity Dissolved oxygen Total dissolved solids Total Kjeldahl nitrogen Ammonium Pesticides	Precipitation Crop Soil texture Nutrient content of the irrigation water		4 yrs pre-BMP 1 yr BMP 2 yrs post-BMP

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

The Idaho Division of Environmental Quality is entering raw water quality data in the USEPA STORET system. Data is also entered into the USDA Water Quality Project's Central Data Base, and the Idaho Environmental Data Management System. Because this is a ground water project, the NonPoint Source Management System (NPSMS) software has limited utility.

This project is using geostatistical analysis to evaluate ground water quality influences from land use activities. Geostatistics is the branch of applied statistics that focuses on the characterization of spatial dependence of attributes that vary in value over space (or time) and the use of that dependence to predict values at unsampled locations. The usefulness of a geostatistical analysis is dependent upon the adequate characterization of the spatial dependence and of the parameter of interest in the given environment. The degree to which spatial dependence is characterized is a function of the configuration of the sampling locations. Thus, the bulk of the effort of a geostatistic investigation centers around designing an areal distribution of sampling locations which ensures that spatial dependence of the parameter of interest can be recognized if it exists. Geostatistical factors, which must be considered in the design of a sampling plan, include the number of samples and the magnitude and density of separation distances provided by a given configuration.

NPSMS Data Summary

None.

Modifications Since Project Started

None.

Progress Toward Meeting Goals

Baseline data are still being collected.

TOTAL PROJECT BUDGET

The estimated budget for the Eastern Snake River Plain National Monitoring Program project for the period of FY 92 - 95:

Project Element	Funding Source ($)			
	Federal	State	Local	Sum
Proj Mgt	NA	NA	NA	NA
I&E	NA	NA	NA	NA
LT	NA	NA	NA	NA
WQ Monit	278,291	NA	NA	278,291
TOTALS	278,291	NA	NA	278,291

Source: Osiensky and Long, 1992; John Cardwell (Personal Communication, 1995)

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

None.

OTHER PERTINENT INFORMATION

The Eastern Snake River Plain Demonstration Project is led by the USDA Natural Resources Conservation Service (NRCS), the University of Idaho Cooperative Extension Service (CES), and the Consolidated Farm Service Agency (CFSA). In addition to the three lead agencies, this project involves an extensive state and federal interagency cooperative effort. Numerous agencies, including the Idaho Division of Environmental Quality, the University of Idaho Water Resource Research Institute, the USDA Agricultural Research Service, the Idaho Department of Water Resources, U.S. Geological Survey, and Idaho Department of Agriculture, have taken on various project tasks.

The Idaho Department of Environmental Quality and the Idaho Water Resource Research Institute will be responsible for the 319 National Monitoring Program portion of the project.

An institutional advantage of this project is that the NRCS and the CES are both located in the same office. Also, three local Soil and Water Conservation Districts, East Cassia, West Cassia and Minidoka, as well as the Minidoka and Cassia County Consolidated Farm Service Agency (CFSA), county committees and the Cassia County Farm Bureau make up the Project State Committee.

A regional well monitoring network consisting of existing domestic sandpoint (driven) wells has also been established within the Demonstration Project Area. The regional network is intended to augment the paired-field data and provide a means to document the influence of the Demonstration Project on the quality of the area's shallow ground water system. This network consists of 25 wells which

have been monitored for nitrogen-nitrate concentrations on a quarterly basis for an average of 12 sampling events.

During implementation of the regional domestic well water quality monitoring portion of the USDA project, agricultural chemicals and nitrate-nitrogen have been detected at levels of concern and measured in samples collected from domestic wells. The herbicide *Dacthal* has been detected at low levels in samples collected from one well during each sampling event. The same well yielded a single sample with 2,4-D measured at 195 ppb. Other wells have yielded samples containing nitrate-nitrogen as high as 30 mg/l. Concern generated by this data has led to site-specific ground water investigations by the Idaho Division of Environmental Quality and Idaho Department of Agriculture. This investigation demonstrated that the Dacthal contamination in the ground water originated on-site. The elevated nitrate-nitrogen levels measured in samples obtained from the site's monitoring network indicate that the nitrate-nitrogen concentration measured in the ground water decreases as ground water moves from the adjacent agricultural production fields toward the homestead.

The Mann-Kendall nonparametric statistical trend test was used to determine if a significant trend exists in the concentration of nitrate-nitrogen measured in the samples collected from these wells. Each data set was evaluated for the existence of outliers using a standard T-test. Data outliers were removed from data sets prior to subjecting the data to trend analysis. At the 90% confidence level, 9 (36%) of the wells show a statistically significant decreasing trend and 6 (24%) show a decreasing trend at the 95% confidence level. One well (4%) shows an increasing trend in nitrate-nitrogen concentrations measured in collected samples from the well at both the 90 and 95% confidence levels. The remaining wells do not show a statistically significant trend at the 90 or 95% confidence levels. In the future, when adequate data points are available, the Mann-Kendall statistical trend analysis will be used to analyze these data.

In addition, limited sampling and analyses of ground water drainage systems, irrigation return flows, and injection wells have identified nutrients and pesticides in certain surface water bodies within the project area. Nitrate-nitrogen concentrations in subsurface tile drain effluent as high as 8 mg/l have been measured. The herbicides MCPA and 2,4-D were detected in return flow irrigation water entering into an injection well. The 2,4-D was measured at levels greater than the allowable Safe Drinking Water MCL of 70 ppb. Concern generated from evaluation of this data has prompted Department of Environmental Quality (DEQ) to request an expansion of the existing surface water quality monitoring efforts.

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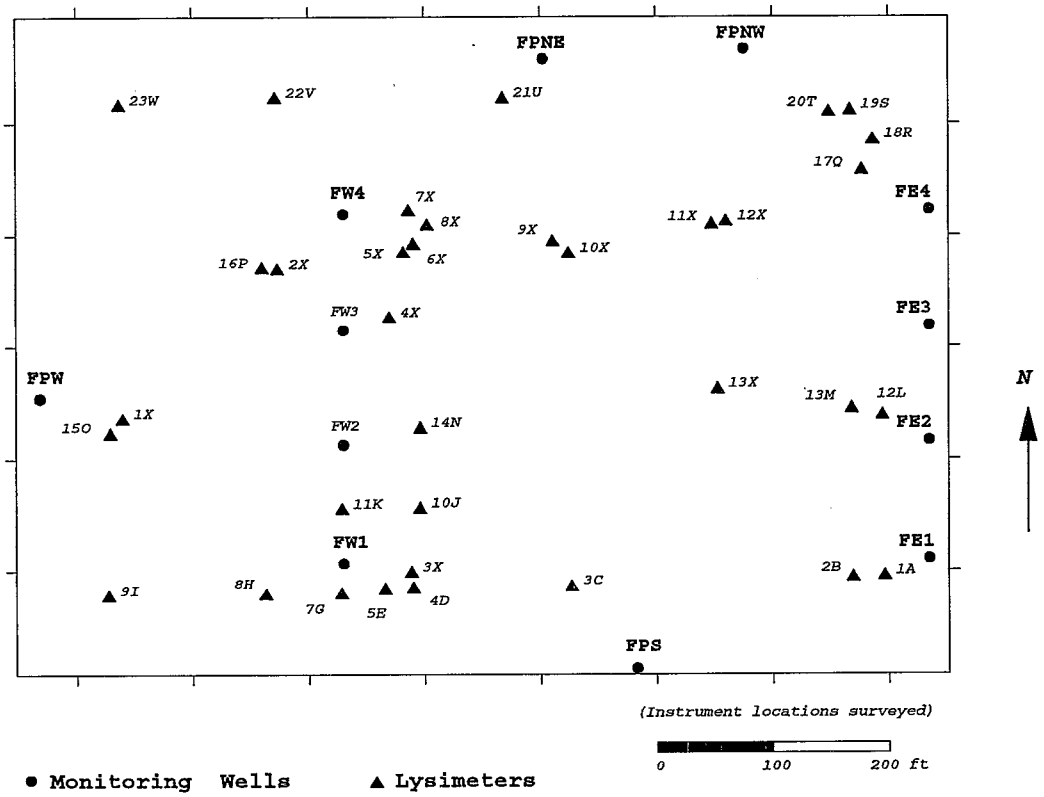
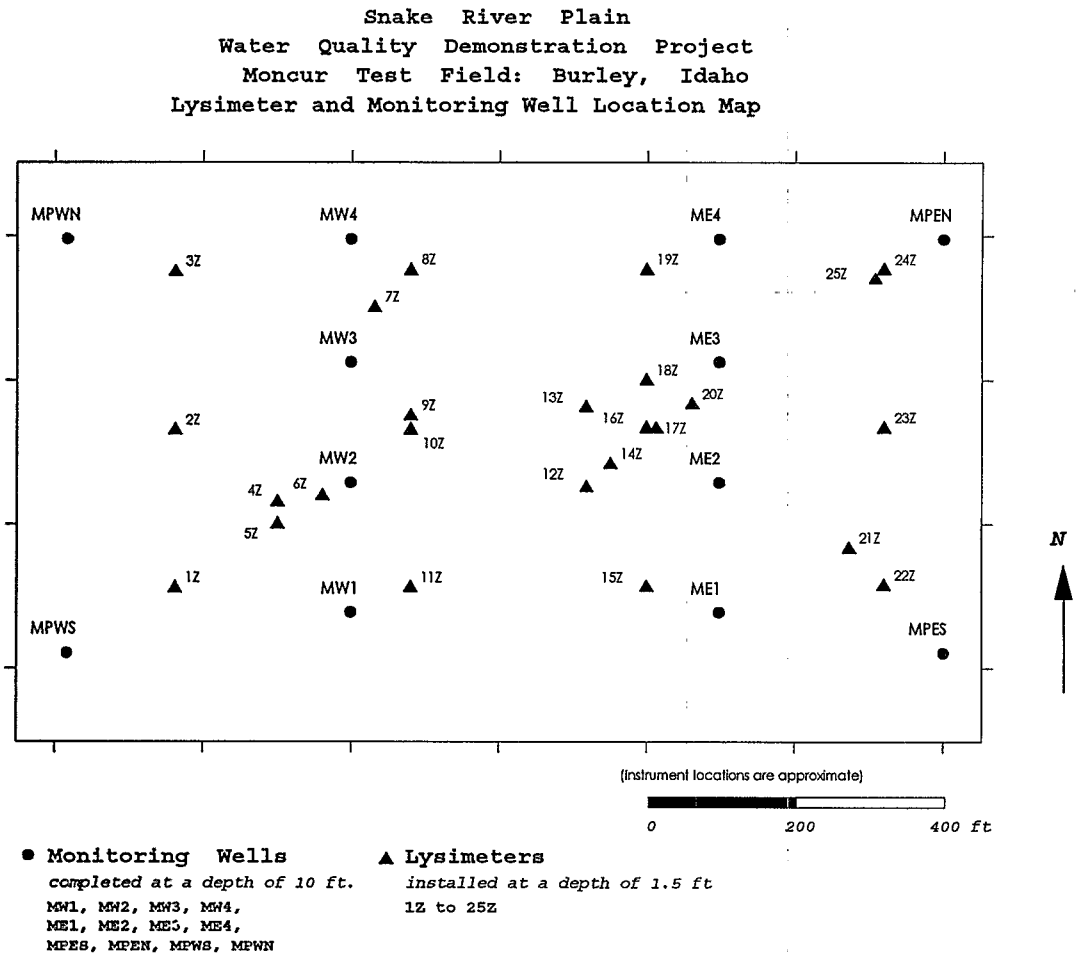
Snake River Plain
Water Quality Demonstration Project
Forgeon Test Field: Burley Idaho
Lysimeter and Monitoring Well Location Map



● Monitoring Wells
completed at a depth of 10 ft.
FE1, FE2, FE3, FE4,
FW1, FW2, FW3, FW4,
FPS, FPW, FPNE, FPNW

▲ Lysimeters
installed at a depth of 3 ft
1A to 23W
1X to 13X

Field Map 1.


Snake River Plain
Water Quality Demonstration Project
Moncur Test Field: Burley, Idaho
Lysimeter and Monitoring Well Location Map
MPWN
MW4
ME4
MPEN
3Z
8Z
19Z
25Z
24Z
7Z
MW3
ME3
18Z
13Z
20Z
9Z
2Z
16Z
17Z
23Z
10Z
MW2
14Z
ME2
4Z
6Z
12Z
5Z
21Z
N
1Z
11Z
15Z
22Z
MW1
ME1
MPWS
MPES
(instrument locations are approximate)
0
200
400 ft
● Monitoring Wells
completed at a depth of 10 ft.
MW1, MW2, MW3, MW4,
ME1, ME2, ME3, ME4,
MPES, MPEN, MPWS, MPWN
▲ Lysimeters
installed at a depth of 1.5 ft
1Z to 25Z

Field Map 2.

Illinois

Lake Pittsfield
Section 319
National Monitoring Program Project

Figure 7: Lake Pittsfield (Illinois) Location

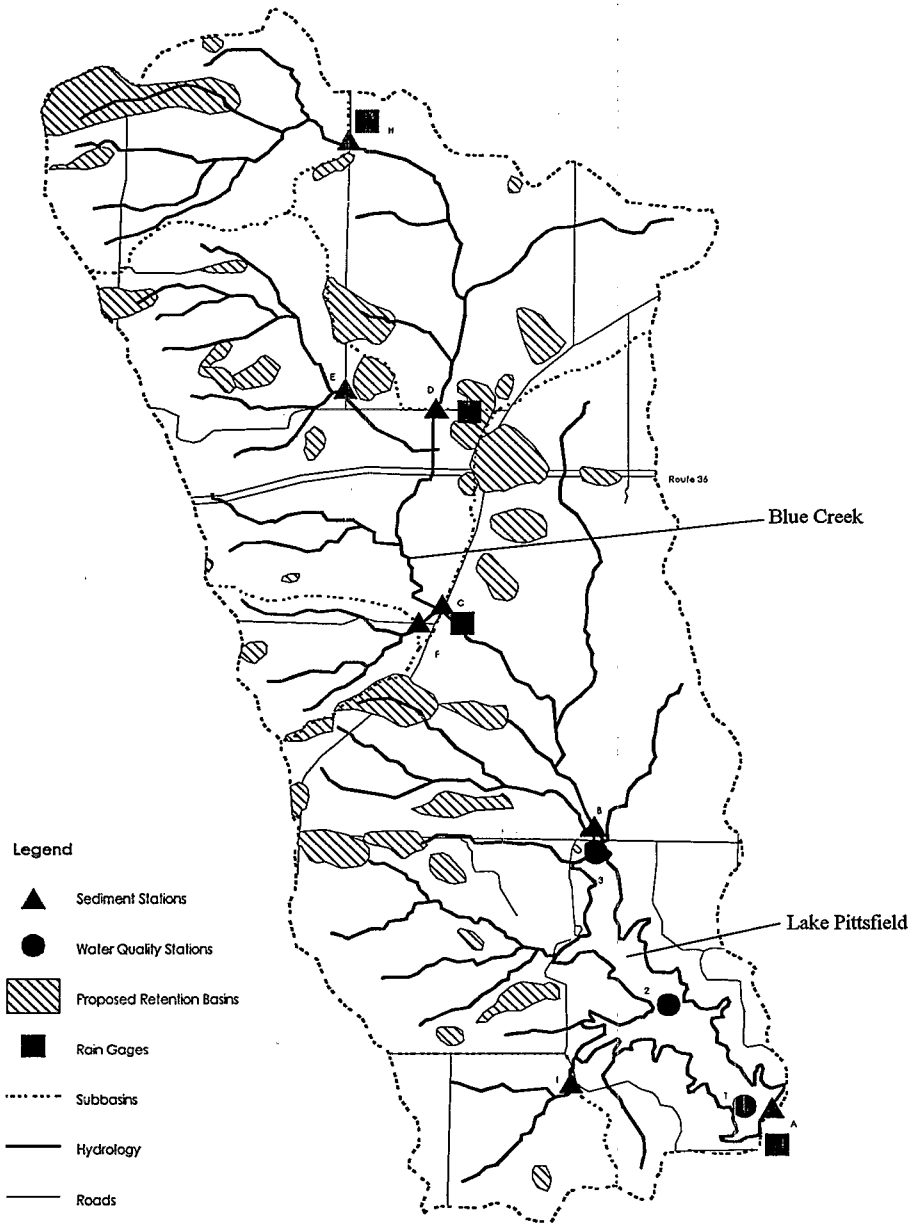


Figure 8: Water Quality Monitoring Stations for Blue Creek Watershed and Lake Pittsfield (Illinois)

PROJECT OVERVIEW

Lake Pittsfield was constructed in 1961 to serve both as a flood control structure and a public water supply for the city of Pittsfield, a western Illinois community of approximately 4,000 people. The 6,956.2-acre watershed (Blue Creek Watershed) that drains into Lake Pittsfield is agricultural. Agricultural production consists primarily of row crops (corn and soybeans). Small livestock operations consist of hog production, generally on open lots, and some cattle on pasture.

Sedimentation is the major water quality problem in Lake Pittsfield. Sediment from farming operations, gullies, and shoreline erosion has decreased the surface area of Lake Pittsfield from 262 acres to 219.6 acres in the last 33 years. Other water quality problems are excessive nutrients and atrazine contamination. The lake is classified as hypereutrophic, a condition caused by excess nutrients.

The major land treatment strategy is to reduce sediment transport into Lake Pittsfield by constructing settling basins throughout the watershed, including a large basin at the upper end of Lake Pittsfield. Water Quality Incentive Project (WQIP) money, provided through the Consolidated Farm Service Agency, is being used to fund conservation tillage, integrated crop management, livestock exclusion, filter strips, and wildlife habitat management. An information and education program on the implementation of all of the best management practices (BMPs) used to control sediment, fertilizer, and pesticides is being conducted by the Pike County Soil and Water Conservation District (SWCD).

The Illinois State Water Survey (ISWS) is conducting the Blue Creek Watershed water quality monitoring program in order to evaluate the effectiveness of the settling basins. Water quality monitoring consists of storm event tributary sampling, lake water quality monitoring, and lake sedimentation rate monitoring.

Land-based data are being used by the ISWS to develop watershed maps of sediment sources and sediment yields using a geographical information system (GIS). The data for the different GIS layers consist of streams, land uses, soils, lake boundary, sub-watersheds, topography, and roads.

PROJECT DESCRIPTION

Water Resource Type and Size

Lake Pittsfield is a 219.6-acre lake located near the city of Pittsfield in Pike County (western Illinois) (Figure 7).

Water Uses and Impairments

Lake Pittsfield serves as the primary drinking water source for the city of Pittsfield. Secondarily, the lake is used for recreational purposes (fishing and swimming). Decreased storage capacity in Lake Pittsfield, caused by excessive sedimentation, is the primary water quality impairment. Lake eutrophication and occasional concentrations of atrazine above the 3 ppb Maximum Contaminant Level (MCL) also impair lake uses.

Pre-Project Water Quality

Lake sedimentation studies have been conducted four times: in 1974, 1979, 1985, and 1992. Almost 15% of Lake Pittsfield's volume was lost in its first 13 years (see table below). An additional 10% of the lake's volume was lost in the next 18 years (1974 to 1992), suggesting that the rate of sedimentation has slowed. The majority of the lake volume that has been lost is at the Blue Creek inlet into the lake, which is in the upper north portion of the lake.

Lake Pittsfield Sedimentation Studies.

Year of Survey	Lake Age (Years)	Lake Volume		Sediment Volume		Original Volume Loss (%)
		ac-ft	MG	ac-ft	MG	
1961		3563	1161			
1974	13.5	3069	1000	494	161	13.9
1979	18.3	2865	933	697	227	19.6
1985	24.3	2760	899	803	262	22.5
1992	31.5	2679	873	884	288	24.8

Source: Illinois Environmental Protection Agency, 1993

Long-term water quality monitoring data demonstrate that the lake has been, and continues to be, hypereutrophic. In 1993, Lake Pittsfield's water quality was found to exceed the Illinois Pollution Control Board's general use water quality standards for total phosphorus (0.05 mg/l). Total phosphorus standards of 0.05 mg/l were exceeded in 70% of the samples. The 0.3 mg/l standard for inorganic nitrogen was exceeded in 60% of the water samples. Water quality samples collected in 1979 had similar concentrations in terms of phosphorus and nitrogen.

Current Water Quality Objectives

The objectives of the project are to:

- reduce sediment loads into Lake Pittsfield and
- evaluate the effectiveness of sediment retention basins.

Modifications Since Project Initiated

None.

Project Time Frame

March 1, 1993 - September 30, 1995 (Watershed)
September 1, 1992 - 1994 (Monitoring Strategy)
Note: Money for monitoring is approved yearly. Contingent upon funding, monitoring is expected to be continued through 1999. This will allow monitoring for a period of four years past installation of sediment retention basins.

Project Approval

Initially funded in 1992 as a 319 Watershed Project. Monitoring began in 1992 and was officially approved in 1994.

PROJECT AREA CHARACTERISTICS

Project Area

The 7,000-acre Blue Creek watershed that drains into Lake Pittsfield is located in western Illinois (Figure 7). The terrain is rolling with many narrow forested draws in the lower portion of the watershed. The topography of the watershed's upper portion is more gentle and the draws are generally grassed.

Relevant Hydrologic, Geologic, and Meteorologic Factors

The area surrounding Lake Pittsfield receives approximately 39.5 inches of rainfall per year, most of which falls in the spring, summer, and early fall. Soils are primarily loess derived. Soils in the upper portion of the watershed developed under prairie vegetation, while those in the middle and lower portions of the watershed were developed under forest vegetation.

Land Use

Some sediment-reducing BMPs are currently being used by area farmers as a result of a program (Special Water Quality Project) that was started in 1979. Pike County SWCD personnel encouraged the use of terraces, no-till cultivation,

contour plowing, and water control structures. Many terraces were constructed and most farmers adopted contour plowing. However, greater adoption of no-till and other soil conserving BMPs is still needed.

Land Use	Acres	%
Agricultural	3350.5	48
Forest/Shrub	1505.1	21
Pasture/Rangeland	1374.9	20
Residential	132.4	2
Reservoir/Farm Ponds	258.7	4
Roads/Construction	137.1	2
Park	197.5	3
TOTAL	6956.2	100

Source: Illinois Environmental Protection Agency. 1993. Springfield, IL.

Pollutant Source(s)

Cropland, pasture, shoreline, and streambanks

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

Information and education is being conducted by a private organization (Farm Bureau) and the Pike County SWCD. Two public meetings have been held to inform producers about the project. Articles about the project have appeared in the local newspapers. Currently, farmers are being surveyed about their attitudes on water quality. This survey is being conducted by University of Illinois Extension personnel.

Progress Towards Meeting Goals

Information and education activities are ongoing.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

The nonpoint source control strategy is based on reducing sediment movement off-site and limiting the transport of sediment into the water resource, Lake Pittsfield.

Section 319 funds are being used to build between 25 and 35 small (approximately two acres each) sediment retention basins. These basins are used to limit the transport of sediment into Lake Pittsfield. In addition, a larger basin, capable of trapping 90% of the sediment entering Lake Pittsfield at the upper end, is being constructed with 319 funds.

Funds from the WQIP are used to encourage the adoption of BMPs that will reduce the movement off-site of sediment, fertilizer, and pesticides. These BMPs include conservation tillage, integrated crop management, livestock exclusion, filter strips, and wildlife habitat management.

In order to reduce shoreline erosion, shoreline stabilization BMPs will be implemented using Section 314 Clean Lakes Program funds. Old rip rap will be repaired, and new rip rap will be installed along the shoreline.

Modifications Since Project Started

Due to heavy rains and flooding in 1993, the section 319 fund ending date was extended from February 28, 1995 to September 30, 1995.

Progress Towards Meeting Goals

A total of 29 sediment basins and the large riprap basin will be completed by September 30, 1995.

WATER QUALITY MONITORING

Design

- Storm sampling at four stations on the main channel into Lake Pittsfield (Blue Creek) and three stations at major tributaries to Blue Creek (Figure 8).
- Trend monitoring during baseflow of Blue Creek at one station.
- Trend monitoring at the three stations located in Lake Pittsfield.
- Lake sedimentation studies were conducted before and after dredging and will be conducted again.
- A shoreline severity survey is being conducted. The results of this survey allow shoreline to be evaluated.

Modifications Since Project Started

Ravine erosion stabilization techniques are not being evaluated.

Variables Measured

Biological

None

Chemical and Other

Lake
Orthophosphorus (OP)
Total phosphorus (TP)
Dissolved phosphorus
Total Kjeldahl nitrogen (TKN)
Nitrite (NO_2-N) + nitrate (NO_3-N)
Total suspended solids (TSS)
Volatile suspended solids (VSS)
pH
Total alkalinity
Phenolphthalein alkalinity
Specific conductivity
Water temperature
Air temperature
Dissolved oxygen (DO)
Atrazine

Explanatory Variables

Rainfall

Sampling Scheme

Storm sampling is being conducted at four stations located on Blue Creek (stations B, C, D, and H — see Figure 8). These stations are equipped with ISCO automatic samplers and manual DH-59 depth-integrated samplers. A pressure transducer triggers sampling as the stream rises. The samplers measure stream height. In addition, the streams are checked manually with a gauge during flood events to determine the stage of the stream. During these flood events, the stream

is rated to determine flow in cubic feet per second. Stream stage is then correlated with flow in order to construct a stream discharge curve. Water samples are analyzed to determine sediment loads.

Three stations located on tributaries of either Blue Creek or Lake Pittsfield (stations E, F, and I - see Figure 8) are also being monitored during storm events. Station I is equipped with an ISCO automatic sampler, while stations E and F are sampled manually. Base stream flow is sampled monthly on Blue Creek at Site C (see Figure 8).

Three lake sampling stations have been established to reflect the most shallow portion of the lake, a middle lake depth, and the deepest part of the lake. Water quality grab samples are taken monthly from April through October.

In Lake Pittsfield, in-situ observations are made for Secchi disk transparency and temperature and dissolved oxygen profiles at 2-foot intervals.

In addition, water chemistry samples are taken from the surface of all three lake stations, as well as the lowest depth at the deepest station, and analyzed for the chemical constituents listed above (see *Chemical and Other Variables Measured*).

Rain gauges have been placed near sampling sites C, D, and H (see Figure 8).

Monitoring Scheme for the Lake Pittsfield 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency	Duration
Storm sampling	Stations B, C, D, E, F, H, & I	Suspended sediments	Rainfall	During storms	2 yrs pre-BMP 1 yr BMP 3 yrs post-BMP
Single station	Station C	Total suspended solids	Rainfall	Monthly	2 yrs pre-BMP 1 yr BMP 3 yrs post-BMP
Single station	Lake stations 1, 2, & 3	Secchi disk transparency Dissolved oxygen Orthophosphorus Total phosphorus Ammonia + ammonium Ammonia nitrogen Total Kjeldahl nitrogen Nitrite + nitrate Total suspended solids Volatile suspended solids pH Total alkalinity Phenolphthalein alkalinity Specific conductivity Water temperature Air temperature Dissolved oxygen Atrazine	Rainfall	Monthly, April through October	2 yrs pre-BMP 1 yr BMP
Lake sedimentation study		Lake depth		Prior to dredging	
Shoreline erosion severity survey				Once	

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

The water quality monitoring data is entered into a database and then loaded into the USEPA (U.S. Environmental Protection Agency) water quality data base, STORET. Data is also stored and analyzed with the USEPA NonPoint Source Management System (NPSMS) software.

NPSMS Data Summary

Monitoring Station Parameters Report

PERIOD: Spring Season, 1994
STATION TYPE: Upstream Station — **PRIMARY CODE:** Station C

CHEMICAL PARAMETERS

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FLOW, STREAM, INSTANTANEOUS, CFS	S	cfs	13.3	12.0	10.7
INSTANTANEOUS YIELD	S	lbs/sec	.017	.004	.002
PRECIPITATION, TOTAL	S	in/day	.2	0	0
SEDIMENT, PARTICLE SIZE FRACT. < .0625 MM % dry wgt.	S	mg/L	49	24	10

STATION TYPE: Downstream Station — **PRIMARY CODE:** Station B

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FLOW, STREAM, INSTANTANEOUS, CFS	S	cfs	9.5	4.5	2.4
INSTANTANEOUS YIELD	S	lbs/sec	.042	.022	.007
PRECIPITATION, TOTAL	S	in/day	0	0	0
SEDIMENT, PARTICLE SIZE FRACT. < .0625 MM % dry wgt.	S	mg/L	133	69	40

Modifications Since Project Started

Included NPS national monitoring strategy for spring season at B and C sampling stations 2 years pre, 1 year during, and 3 years past.

Progress Towards Meeting Goals

TOTAL PROJECT BUDGET

The estimated budget for the Lake Pittsfield National Monitoring Program project for the period of FY 92-99 is:

Project Element	Funding Source ($) Federal	State	Local	Sum
Proj Mgt	NA	NA	NA	NA
I&E	NA	NA	NA	NA
LT (319)	620,100	NA	NA	620,100
WQ Monit	470,000	NA	NA	470,000
Cultural Practices (WQIP)	32,000	NA	NA	32,000
Dredge/Shoreline/ Aeration (314)	132,110	NA	904,000	1,036,110
TOTALS	1,254,210	NA	904,000	2,158,210

Source: State of Illinois, 1993; State of Illinois, 1992; Gary Eicken (Personal Communication), 1995

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

In 1979, the Pike County SWCD began a Special Water Quality Project that encouraged the implementation of terraces, no-till cultivation, contour plowing, and water control structures. This project was instrumental, along with drier weather conditions, in reducing soil erosion from an average of 5.8 tons per acre to 3.3 tons per acre (a 45% decrease).

In addition to the sediment-reducing shoreline BMPs, Section 314 funds are being used to install one destratifier (aerator) in Lake Pittsfield to increase oxygen concentrations throughout the lake, thereby increasing fish habitat. The lake will be dredged in 1996 to reclaim the original capacity of the lake.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

Many organizations have combined resources and personnel in order to protect Lake Pittsfield from agricultural nonpoint source pollution. These organizations are listed below:

- Consolidated Farm Service Agency (CFSA)
- City of Pittsfield
- Farm Bureau
- Illinois Environmental Protection Agency
- Illinois State Water Survey
- Landowners
- Pike County Soil and Water Conservation District

PROJECT CONTACTS

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Iowa

Sny Magill Watershed
Section 319
National Monitoring Program Project

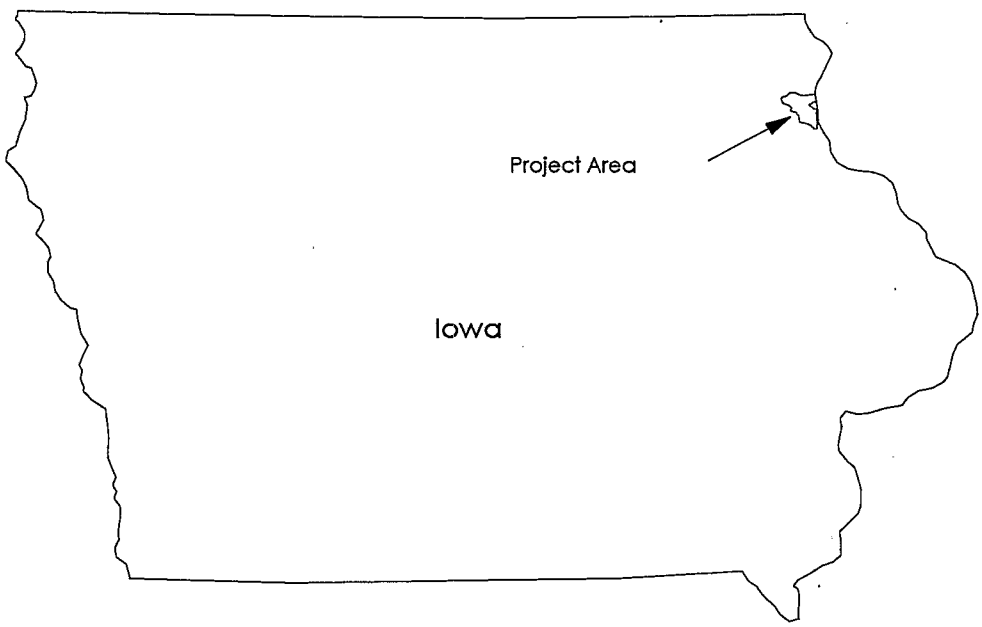

Figure 9: Sny Magill and Bloody Run (Iowa) Watershed Project Locations

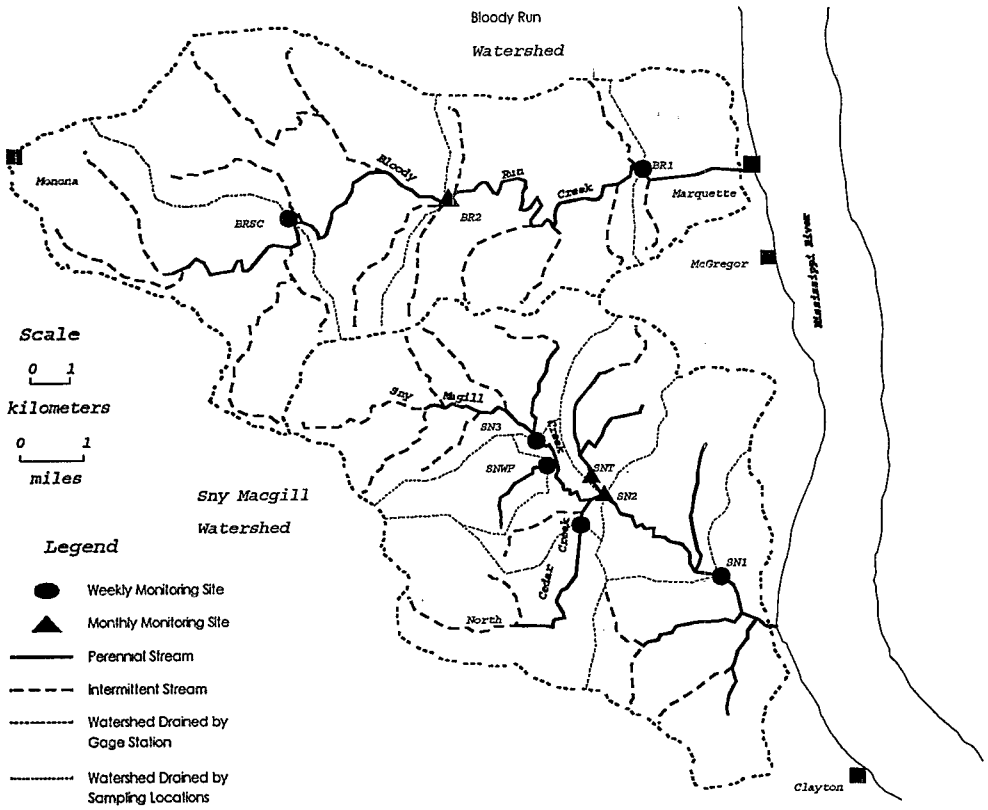

Figure 10: Water Quality Monitoring Stations for Sny Magill and Bloody Run (Iowa) Watersheds

PROJECT OVERVIEW

The Sny Magill watershed project is an interagency effort designed to monitor and assess improvements in water quality (reductions in sedimentation) resulting from the implementation of U.S. Department of Agriculture (USDA) land treatment projects in the watershed. The project areas include Sny Magill Creek and North Cedar Creek basins (henceforth referred to as the Sny Magill watershed) (Figure 9). Sny Magill and North Cedar creeks are Class "B" cold water streams located in northeastern Iowa. North Cedar Creek is a tributary of Sny Magill Creek. The creeks, managed for "put and take" trout fishing by the Iowa Department of Natural Resources (IDNR), are two of the more widely used recreational fishing streams in the state.

The entire Sny Magill watershed is agricultural, with no industry or urban areas. There are no significant point sources of pollution in the watershed. Land use consists primarily of row crop, cover crop, pasture, and forest. There are about 140 producers in the watershed, with farm sizes averaging 275 acres.

Water quality problems result primarily from agricultural nonpoint source (NPS) pollution; sediment is the primary pollutant. Nutrients, pesticides, and animal waste are also of concern.

Two USDA land treatment projects being implemented in the watershed allow producers to make voluntary changes in farm management practices that will result in improved water quality. Sediment control measures, water and sediment control basins, animal waste management systems, stream corridor management improvements, bank stabilization, and buffer strip demonstrations around sinkholes will be utilized to reduce agricultural NPS pollution. A long-term goal of a 50% reduction in sediment delivery to Sny Magill Creek has been established.

A paired watershed approach is being used with the Bloody Run Creek watershed serving as the comparison watershed (Figure 10). Subbasins within the Sny Magill watershed are being compared using upstream/downstream stations.

Primary monitoring sites, equipped with U.S. Geological Survey (USGS) stream gauges to measure discharge and suspended sediment, have been established on both Sny Magill and Bloody Run creeks. The primary sites and several other sites on both creeks are being sampled for chemical and physical water quality variables on a weekly to monthly basis. An annual habitat assessment is being conducted along stretches of both stream corridors. Biomonitoring of macroinvertebrates occurs on a bimonthly basis and an annual fisheries survey will be conducted.

PROJECT DESCRIPTION

Water Resource Type and Size

Sny Magill and North Cedar creeks are Class "B" cold water streams located in northeastern Iowa.

Water Uses and Impairments

Sny Magill and North Cedar creeks are managed for "put and take" trout fishing by the IDNR and are two of the more widely used streams for recreational fishing in Iowa. Sny Magill Creek ranks sixth in the state for angler usage.

The Sny Magill watershed drains an area of 35.6 square miles directly into the Upper Mississippi River Wildlife and Fish Refuge. The refuge consists of islands, backwaters, and wetlands of the Mississippi River. The creek also drains into part of Effigy Mounds National Monument. These backwaters are heavily used for fishing and also serve as an important nursery area for juvenile and young large-mouth bass.

The creeks are further designated as "high quality waters" to be protected against degradation of water quality. Only 17 streams in the state have received this special designation. The state's Nonpoint Source Assessment Report indicates that the present classifications of the creeks as protected for wildlife, fish, and semi-aquatic life and secondary aquatic usage are only partially supported. The report cites impairment of the creeks' water quality primarily by nonpoint agricultural pollutants, particularly sediment, animal wastes, nutrients, and pesticides. There are no significant point sources of pollution within the Sny Magill watershed.

Sediment delivered to Sny Magill creek includes contributions from excessive sheet and rill erosion on approximately 4,700 acres of cropland and 1,600 acres of pasture and forest land in the watershed. Gully erosion problems have been identified at nearly 50 locations.

There are more than 13 locations where livestock facilities need improved runoff control and manure management systems to control solid and liquid animal wastes. Grazing management is needed to control sediment and animal waste runoff from over 750 acres of pasture and an additional 880 acres of grazed woodland.

Streambank erosion has contributed to significant sedimentation in the creek(s). In order to mitigate animal waste and nutrient problems and improve bank stability in critical areas, improved stream corridor management designed to repair riparian vegetation and keep cattle out of the stream is necessary.

Pre-Project Water Quality

Water quality evaluations conducted by the University Hygienic Laboratory (UHL) in 1976 and 1978 during summer low-flow periods in Sny Magill and Bloody Run creeks showed elevated water temperatures and fecal coliform levels (from animal wastes) in Sny Magill Creek. Downstream declines in nutrients were related to algal growth and in-stream consumption. An inventory of macroinvertebrate communities was included from several reaches of the streams (Seigley et al., 1992).

Assessments in North Cedar Creek during the 1980s by IDNR and the USDA Natural Resources Conservation Service (NRCS) located areas where sediment is covering the gravel and bedrock substrata of the streams, lessening the depth of existing pools, increasing turbidity, and degrading aquatic habitat. Animal waste decomposition increases biochemical oxygen demand (BOD) in the streams to levels that are unsuitable for trout survival at times of high water temperature and low stream flows. The IDNR has identified these as the most limiting factors contributing to the failure of brook trout to establish a viable population (Seigley et al., 1992).

Several reports summarize pre-project water quality studies conducted in the two watersheds (i.e., water quality, including available data from STORET - Seigley and Hallberg, 1994; habitat assessment - Wilton, 1994; benthic biomonitoring - Schueller et al., 1994, and Birmingham and Kennedy, 1994; fish assessment - Wunder and Stahl, 1994) and Hallberg and others (1994) provide perspectives on water quality monitoring in northeast Iowa.

Current Water Quality Objectives

Project objectives include the following:

- To quantitatively document the significance of water quality improvements resulting from the implementation of the Sny Magill HUA Project and North Cedar Creek WQSP;
- To develop the protocols and procedures for a collaborative interagency program to fulfill the U.S. Environmental Protection Agency (USEPA) standards for Nonpoint Source Monitoring and Reporting Requirements for Watershed Implementation Projects;
- To refine monitoring protocols to define water quality impacts and the effectiveness of particular management practices;
- To develop Iowa's capacity for utilization of rapid habitat and biologic monitoring;
- To use the water quality and habitat monitoring data interactively with implementation programs to aid targeting of best management practices (BMPs), and for public education to expand awareness of the need for NPS pollution prevention by farmers; and
- To provide Iowa and the USEPA with needed documentation for measures of success of NPS control implementation (Seigley et al., 1992).

Specific quantitative water quality goals need to be developed that are directly related to the water quality impairment and the primary pollutants being addressed by the land treatment implemented through the USDA projects.

Modifications Since Project Initiation

None.

Project Time Frame

1991 - unknown
(approximately 10 years, if funding allows)

Project Approval

1992

PROJECT AREA CHARACTERISTICS

Project Area

The watershed drains an area of 22,780 acres directly into the Upper Mississippi River Wildlife and Fish Refuge and part of Effigy Mounds National Monument.

Relevant Hydrologic, Geologic, and Meteorologic Factors

Average yearly rainfall in the area is 30.6 inches.

The creeks are marked by high proportions (70-80% or more of annual flow) of ground water base flow, which provides their cold water characteristics. Hence, ground water quality is also important in the overall water resource management considerations for area streams.

The watershed is characterized by narrow, gently sloping uplands that break into steep slopes with abundant rock outcrops. Up to 550 feet of relief occurs across the watershed. The landscape is mantled with approximately 10-20 feet of loess, overlying thin remnants of glacial till on upland interfluves, which in turn overlie Paleozoic-age bedrock formations. The bedrock over much of the area is Ordovician Galena Group rocks, which compose the Galena aquifer, an important source

of ground water and drinking water in the area. Some sinkholes and small springs have developed in the Ordovician-age limestone and dolomite.

The stream bottom of Sny Magill and its tributaries is primarily rock and gravel with frequent riffle areas. Along the lower reach of the creek where the gradient is less steep, the stream bottom is generally silty. The upstream areas have been degraded by sediment deposition.

Land Use

The entire watershed is agricultural, with no industry or urban areas. There are no significant point sources in the watershed. Sixty-five percent of the cropland is corn, with the rest primarily in oats and alfalfa in rotation with corn. There are about 140 producers in the watershed, with farm sizes averaging 275 acres.

Land use is variable on the alluvial plain of Sny Magill Creek, ranging from row cropped areas, to pasture and forest, to areas with an improved riparian right-of-way where the IDNR owns and manages the land in the immediate stream corridor. The IDNR owns approximately 1,800 acres of stream corridor along approximately eight miles of the length of Sny Magill and North Cedar creeks. Some of the land within the corridor is used for pasture and cropping through management contracts with the IDNR.

Row crop acreage planted to corn has increased substantially over the past 20 years. Land use changes in the watershed have paralleled the changes elsewhere in Clayton County, with increases in row crop acreage, fertilizer and chemical use, and attendant increases in erosion, runoff, and nutrient concentrations. Forest Service data show a 4% decline in woodland between 1974 and 1982. Much of this conversion to more erosive row crop acreage occurred without adequate installation of soil conservation practices.

Land Use	Sny Magill		Bloody Run	
	Acres	%	Acres	%
Rowcrop (for cropland)	5,842	25.9	9,344	38.6
Cover crop, pasture	5,400	23.9	6,909	28.5
Forest, forested pasture	11,034	48.9	7,171	29.6
Farmstead	263	1.2	415	1.7
Other	28	0.1	376	1.6
TOTALS	22,567	100	24,215	100

Source: Iowa Department of Natural Resources, 1994

Pollutant Source(s)

Sediment — cropland erosion, streambank erosion, gully erosion, animal grazing
Nutrients — animal waste from livestock facilities (cattle), pasture, and grazed woodland; commercial fertilizers; crop rotations
Pesticides — cropland, brush cleaning

Modifications Since Project Started

Funding to encourage BMP implementation was lost in 1993; however, applications for alternative funding sources were filed in 1994. Funding for sediment reducing practices, such as terraces, was secured through the Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, for Fiscal Years 1995-1997. An application for funding was filed through the USEPA Section 319 Program for animal manure structures, Integrated Crop Management (ICM), and streambank stabilization practices. At this time, the USEPA Section 319 application has yet to be approved; however, all indications would suggest that final approval will soon be granted.

INFORMATION, EDUCATION, AND PUBLICITY

The focus of information and education efforts in the watershed are:

- demonstration and education efforts in improved alfalfa hay management (to reduce runoff potential on hayland and increase profitability and acreage of hay production);
- improved crop rotation management and manure management (to reduce fertilizer and chemical use);
- implementation of the Farmstead Assessment System [NRCS, Iowa State University Cooperative Extension Service (ISU-CES)];
- woodland management programs (to enhance pollution-prevention efforts on marginal cropland, steep slopes, riparian corridors, and buffer areas in sinkhole basins);
- expand interest in the environmental and economic benefits of ICM, BMPs, and sinkhole and wellhead protection; and
- implementation of an educational program to bring information and results of the Sny Magill HUA project to the widest possible audience in the watershed and adjacent areas of the state.

Information is also disseminated through newsletters, field days, special meetings, press/media releases, and surveys of watershed project participants.

Additional resources for technical assistance and educational programs is provided in the area through the Northeast Iowa Demonstration Project, directed by ISU-CES, and the Big Spring Basin Demonstration Project, directed by IDNR.

Progress Towards Meeting Goals

Through FY94, the following have been completed in Sny Magill and North Cedar Creek watersheds:

- Various management plots, including manure, nitrogen, tillage, and weed, have been maintained for demonstration and educational purposes in the watershed area.
- Numerous field days were held at plot sites, and the plots were designed to be toured on a self-guided basis.
- A series of articles on wellhead protection was printed in local newspapers.
- A baseline survey of farming practices for farm operators in the Sny Magill Creek area was completed during the winter of 1992.
- ICM plans were developed for 44% of cropland in the project area through one-on-one meetings with farmers.
- An initiative was created to conduct a soil bioengineering demonstration on a stretch of Sny Magill Creek. The initiative centers on comparing the long-term stabilizing effectiveness of various lower cost, more aesthetically pleasing streambank stabilizing practices to traditional practices such as rip rap. The initiative will also serve as a training workshop for various agency personnel. Representatives from the NRCS Midwest Technical Center (Lincoln, NE) and the NRCS state office (Des Moines) provided technical support.
- Manure fertility demonstrations were conducted at seven new cooperator farms to try to get growers to take full nutrient credit for manure applied.

- A Family Education Fun Day was conducted in the watershed to give landowners in the Sny Magill watershed and the people living in the nearby town of McGregor a chance to meet agency representatives of the demonstration project and water quality monitoring project, learn more about each agency's involvement in the project, and to see what their neighbors are doing in order to improve the water quality of Sny Magill Creek.
- Transferring ICM to the private sector: training was provided by ISU-CES coordinator to ag-business firms and other individuals to develop ICM service providers. A major goal of the project is the development of ICM service providers to ensure that this management practice is available after the project is no longer directly providing the ICM service. There are now five ICM service providers as a result of this program; previously there were none.
- The media outreach program has included preparation of demonstration plot brochures, press releases, booklets for the "self-guided" tours, and articles for local newspapers. *Water Watch*, a bimonthly newsletter, is disseminated to over 1,750 subscribers. Article topics have included upcoming project activities, ongoing demonstrations and other conclusions or trends that develop from these efforts, chemical and biological rootworm control, well-water analyses, proper use of soil test, how various agronomic practices affect yields, water quality monitoring results, results of producer case studies where various ICM practices have been applied, farmstead assessment, and nutrient management of manure.
- The Clayton County Register, circulation 12,000, publishes an annual conservation issue. The 1994 issue centered on the various components of the Sny Magill HUA project activities. The subjects covered included: the ICM program, timber stand improvement practices, water monitoring programs, manure management techniques, and the proper handling and disposal of ag-chemicals and waste.
- Manure management workshop was conducted to assist interested producers in quantifying the potential nutrient benefits provided by the manure generated from their livestock operations. A manure management work sheet was developed as a simple method to determine how well manure nutrients are being credited and managed.
- Tours of the Sny Magill watershed and presentations on the Sny Magill Hydrologic Unit Area (HUA) have included information on the water quality monitoring, tillage and manure structures, ICM, manure management, and nutrient and pest management.
- Participation in the program "CONNECTIONS: Linking Science and Mathematics with Careers" (partnership between The University of Iowa Department of Pediatrics and the Cedar Rapids Community School District) led to the development of a video to help motivate high school girls and minorities to take more science and mathematics. In the video, several locations in both the Sny Magill and Bloody Run watersheds were included along with discussion about the design of the water quality monitoring project and the land treatment projects.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

The Sny Magill HUA has 10,468 acres of Highly Erodible Land (HEL), all of which have a conservation plan. Of these conservation plans, 7,303 acres, or 70%, are written to the Tolerable, or T, level. Conservation plans have been fully implemented on 3,660 acres, or 35% of the project area. There are 98 landowners in the Sny Magill HUA, of which 81% have chosen to participate in the HUA project.

The project is intimately connected to two ongoing land treatment projects in the watershed: the Sny Magill Hydrologic Unit Area project and the North Cedar Creek Agricultural Conservation Program - Water Quality Special Project. The HUA Project is a five-year project begun in 1991 and covering 19,560 acres (86%) of the Sny Magill watershed. The remainder of the watershed is included in the WQSP, which began in 1988. The purpose of these projects is to provide technical and cost sharing assistance and educational programs to assist farmers in the watershed in implementing voluntary changes in farm management practices that will result in improved water quality in Sny Magill Creek.

No special critical areas have been defined for the HUA Project. Highly erodible land has been defined and an attempt is being made to treat all farms, prioritizing fields within each farm to be treated first. Structural practices, such as terracing and a few animal waste systems, are being implemented, as well as a variety of management practices such as crop residue management and contour stripcropping. Extension staff are assisting farmers with farmstead assessment and with ICM, in the hope of reducing fertilizer and pesticide inputs by at least 25% while maintaining production levels.

The Water Quality Special Project (WQSP) has been completed. Practices implemented were primarily structural (terraces). No ICM or other information and education programs were implemented. Farmer participation was 80-85%.

The long-term sediment delivery reduction goal for Sny Magill Creek is 50%. Fertilizer and pesticide inputs are expected to be reduced by more than 25%.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

Through FY94, the following have been completed in North Cedar Creek and Sny Magill Creek watersheds:

- 269,685 feet of terraces
- 89 grade stabilization structures installed
- 32 water and sediment control basins installed
- 2 agricultural waste structures installed
- nitrogen, phosphorus, and pesticide management on 3,428 acres
- the more effective use or application of nitrogen, phosphorus, and pesticides in the Sny Magill watershed has resulted in a reduction of 78,105 pounds of total nitrogen, 40,905 pounds of total phosphorus, and a reduction in the amount of alachlor and atrazine applied
- water testing of 151 private wells
- Crop consultant model of ICM was implemented. The model included nutrient and pest management planning sessions with cooperators, intensive soil sampling, nutrient and insecticide application equipment calibration and maintenance, and regular field observations during the growing season to monitor insects, weeds, and crop development. Twelve cooperators enrolled 2,750 acres in 1994.

A coalition of various Federal, State, and County agencies has decided to work together to develop, install, maintain, and evaluate a series of diverse stabilization practices along certain stretches of the stream. The goal of this initiative is to pool our resources to develop more cost-effective, aesthetically pleasing, lower maintenance forms of streambank stabilization.

ISU-CES conducted a baseline survey of farming practices for farm operators in the Sny Magill Creek area in the winter of 1992. A mid-project survey of the farm operators was completed in the summer of 1994 as was an initial survey of farm operators in the Bloody Run Creek area ("control" watershed).

The IDNR-GSB has established a coordinated process for tracking the implementation of land treatment measures with NRCS, Consolidated Farm Service Agency (CFSA), and ISU-CES. NRCS is utilizing the "CAMPS" database to record annual progress for land treatment and may link this to a geographic information system (GIS), as well. ISU-CES conducts baseline farm management surveys and attitude surveys among watershed farmers and has implementation data from ICM - Crop System records. IDNR-GSB is transferring the annual implementation records to the project GIS, ARC/INFO, to provide the necessary spatial comparisons with the water quality monitoring stations.

Participating agencies meet in work groups as needed, typically on a quarterly basis, to review and coordinate needs and problems. Monitoring results are reviewed annually by an interagency coordinating committee to assess needed changes.

Funding restrictions in the Sny Magill HUA for FY94 affected cost-share funding to assist cooperating producers to install BMPs. The HUA was able to operate in FY94 on limited funding that remained from previous years. The full impact of this reduction will be felt in FY95. The project has applied for alternate funding to meet the unmet needs of producers to install BMPs.

WATER QUALITY MONITORING

Design

The Sny Magill watershed is amenable to documentation of water quality responses to land treatment. The cold water stream has a high ground water baseflow which provides year-round discharge, minimizing potential missing data problems. These conditions also make possible analysis of both runoff and ground water contributions to the water quality conditions. Because of the intimate linkage of ground and surface water in the region, the watershed has a very responsive hydrologic system and should be relatively sensitive to the changes induced through the implementation programs.

A paired watershed study compares Sny Magill watershed to the (control) Bloody Run Creek watershed (adjacent to the north and draining 24,064 acres). Watershed size, ground water hydrogeology, and surface hydrology are similar; both watersheds receive baseflow from the Ordovician Galena aquifer. The watersheds share surface and ground water divides and their proximity to one another minimizes rainfall variation. However, the large size of the two watersheds creates significant challenges in conducting a true paired watershed study. Land treatment and land use changes need to be kept to a minimum in the Bloody Run Creek watershed throughout the project period and for the first two years of water quality monitoring in the Sny Magill watershed.

Within the Sny Magill watershed, subbasins are compared using upstream/ downstream stations.

Modifications Since Project Started

None.

Variables Measured

Biological

Fecal coliform bacteria
Habitat assessment
Fisheries survey
Benthic macroinvertebrates

Chemical and Other

Suspended sediment (SS)
Nitrogen (N)-series (NO_3+NO_2-N, NH_4-N, Organic-N)
Anions
Total phosphorus (TP)
Biological oxygen demand (BOD)
Immunoassay for triazine herbicides
Water temperature
Conductivity
Dissolved oxygen (DO)
Turbidity

Explanatory Variables

Stream discharge
Precipitation

Sampling Scheme

Primary monitoring sites (SN1, BR1) (Figure 10) are established on both Sny Magill and Bloody Run. The sites are equipped with USGS stream gauges to provide continuous stage measurements and daily discharge measurements. Suspended sediment samples are collected daily by local observers and weekly by water quality monitoring personnel when a significant rainfall event occurs.

Monthly measurements of stream discharge are made at seven supplemental sites (NCC, SN2, SNT, SNWF, SN3, BRSC, and BR2).

Baseline data were collected during the summer of 1991. A report documenting these data was published (Seigley and Hallberg, 1994). The monitoring program as described below began in October of 1991.

Weekly grab sampling is conducted at the primary surface water sites (SN1, BR1) for fecal coliform bacteria, N-series (NO3 +NO2-N, NH4-N, Organic-N) anions, TP, BOD, and immunoassay for triazine herbicides.

Four secondary sites are monitored weekly (three on Sny Magill: SN3, SNWF, and NCC; and one on Bloody Run: BR2).* Grab sampling will be conducted for fecal coliform, partial N-series (NO3 + NO2-N, NH4-N), and anions.

Weekly sampling is conducted by the USNPS (weeks 1 and 3) and IDNR-GSB (weeks 2,4, and 5).

Three additional sites are monitored on a monthly basis (two on Sny Magill: SN2, SNT; and one on Bloody Run: BRSC).* These are grab sampled for fecal coliform, partial N-series, and anions.

Temperature, conductivity, dissolved oxygen, and turbidity are measured at all sites when sampling occurs.

An annual habitat assessment is conducted along stretches of stream corridor, biomonitoring of macroinvertebrates occurs on a bimonthly basis, and an annual fisheries survey is conducted.

* Note: Originally, site BRSC was monitored weekly and site BR2 was monitored monthly. However, after one water-year of sampling, the invertebrate biomonitoring group requested (in March of 1992) that the sites be switched. Thus, since October 1, 1992, BRSC is monitored monthly and BR2 is monitored weekly.

Monitoring Scheme for the Sny Magill and Bloody Run Watershed 319 National Monitoring Program Project

Design	Sites	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired watershed with upstream/ downstream stations (for each creek)	Sny Magill[T] and Bloody Run[C]	Habitat assessment Fishery survey Benthic macro-invertebrates Suspended sediment Nitrogen series Anions Total phosphorus* Biochemical oxygen demand* Triazine herbicides* Water temperature Conductivity Dissolved oxygen Turbidity Fecal coliform	Stream discharge (daily at sites SN1 & BR1; monthly at sites NCC, SN2, SNT, SNWF, SN3, BRSC, BR2) Stage (continuous at SN1, BR1) Precipitation	Weekly (for SN1, BR1, SN3, SNWF, NCC, BR2) Monthly (for SN2, SNT, BRSC)	Habitat and fisheries data collected annually. Macroinvertebrate data collected every two months.	1 yr pre-BMP 6 yrs BMP 2 yrs post-BMP

[T]Treatment watershed
[C]Control watershed
* These variables are only sampled at sites SN1 and BR1

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

Data Management

Data management and reporting is handled by the IDNR - GSB and follows the Nonpoint Source Monitoring and Reporting Requirements for Watershed Implementation Grants.

USEPA Nonpoint Source Management System (NPSMS) software is used to track and report data to USEPA using their four information "files": the Waterbody System File, the NPS Management File, the Monitoring Plan File, and the Annual Report File.

All water quality data is entered in STORET. Biological monitoring data is entered into BIOS. All U.S. Geological Survey (USGS) data is entered in WATSTORE, the USGS national database.

Data transfer processes are already established between USGS, UHL, and IDNR-GSB. Coordination is also established with NRCS and ISU-CES for reporting on implementation progress.

Data Analysis

For annual reports, data will be evaluated and summarized on a water-year basis; monthly and seasonal summaries will be presented, as well.

Statistical analysis and comparisons will be performed as warranted using recommended SAS packages and other methods for statistical significance and time-series analysis.

Paired watershed analysis has begun. In addition to the pairing between Sny Magill and Bloody Run, and the intra-basin watersheds, data is being compared with the long-term watershed records from the Big Spring basin. This provides a temporal perspective on monitoring and a valuable frame of reference for annual variations.

Significant differences in rainfall between water years 1992 and 1993 affected the monitoring components of the project, and made it difficult to assess whether any changes in water quality that did occur are attributable to improvements in farm management practices. Water Year 1993 was much wetter than 1992 and resulted in significant increases in stream discharge and suspended sediment concentration loads of both Sny Magill and Bloody Run creeks, as well as greater nitrate-N and triazine pesticide concentrations. For Sny Magill, annual mean discharge increased from 17.1 CFS (cubic feet per second) in 1992 to 36.6 CFS in 1993; Bloody Run discharge increased from 26.3 CFS to 42.1 CFS. Total suspended sediment discharge for Sny Magill increased from 1,940 tons in 1992 to 13,086 tons in 1993, and increased from 2,720 tons to 22,174 tons on Bloody Run. The number of benthic macroinvertebrate taxa sampled increased from 60 taxa in Water Year 1992 to 73 taxa in Water Year 1993. Based on the benthic macroinvertebrate data, the water quality in Sny Magill and Bloody Run watershed was rated "good" to "very good" for both years. Sites located on the tributaries to Sny Magill tended to have better water quality than the main stem sites on Sny Magill. Benthic data from 1993 suggests the water quality may have improved from 1992; however, this improvement is speculative because of the short period of record and the unusual climatic conditions. The fish assessment showed a decline from 1992 to 1993 in the number of fish sampled. This decline is considered a normal response to variations in precipitation, runoff, water clarity, and water stage. The fish sampled in both Sny Magill and Bloody Run creeks are fish typically found in coldwater streams. For both years, the fish population was dominated by a single species, the fantail darter. The habitat assessment for Water Year 1993 reflected the above normal rainfall conditions of that year. Stream flow, stream width, and stream depth measurements were higher during Water Year 1993 than during Water Year 1992. Noticeable silt deposition and scouring had occurred along many of the stream reaches in response to the above normal rainfall during Water Year 1993.

NPSMS Data Summary

Monitoring Station Parameters Report

STATION TYPE: Control Station

CHEMICAL PARAMETERS

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FECAL COLIFORM, MEMBR FILTER, M-FC BROTH, 44.5 C	S		275	85	10
FLOW, STREAM, MEAN DAILY, CFS	S	CFS	28	24	20
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	S		<0.1	<0.1	<0.1
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	S		0.4	0.2	<0.1
PHOSPHORUS, TOTAL (MG/L AS P)	S		0.2	0.1	<0.1
PRECIPITATION, TOTAL (INCHES PER DAY)	S		0.03	0	0
TEMPERATURE, WATER (DEGREES CENTIGRADE)	S		14	10	5

STATION TYPE: Study Station

CHEMICAL PARAMETERS

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FECAL COLIFORM, MEMBR FILTER, M-FC BROTH, 44.5 C	S		300	110	18
FLOW, STREAM, MEAN DAILY, CFS	S	CFS	18	15.5	13
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	S		<0.1	<0.1	<0.1
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	S		0.2	0.2	<0.1
PHOSPHORUS, TOTAL (MG/L AS P)	S		0.2	<0.1	<0.1
PRECIPITATION, TOTAL (INCHES PER DAY)	S		0.03	0	0
TEMPERATURE, WATER (DEGREES CENTIGRADE)	S		15	10	5

Annual Reports Detail **Year: 1995**

Water Quality Parameter	State Type	Parm Type	Exp Var	Units	SEASON 1 <-High		Low->		SEASON 2 <-High		Low->		SEASON 3 <-High		Low->		SEASON 4 <-High		Low->	
FECAL COLIFORM, MEMBR FILTER, M-FC BROTH	CNTL	S	N			1	12		1		11		6	2	5		5	6	2	
FLOW, STREAM, MEAN DAILY, CFS	CNTL	S	Y	CFS	62	23	5	2	12	27	21	30	9	33	44	5	13	28	50	
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	CNTL	S	N		13				13				13				13			
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	CNTL	S	N		2	3	8		1	3	9		1	7	5		1	5	7	
PHOSPHORUS, TOTAL (MG/L AS P)	CNTL	S	N		3		10		3	5	5		4	3	6		1	2	9	
PRECIPITATION, TOTAL (INCHES PER DAY)	CNTL	S	Y		15	77			21	69			24	67			26	66		
TEMPERATURE, WATER (DEGREES CENTIGRADE)	CNTL	S	N			3	8	2		2	4	7	9	2	1		11	2		
FECAL COLIFORM, MEMBR FILTER, M-FC BROTH	STDY	S	N			1	8	4			2	11	4	1	6	2	8	3	2	
FLOW, STREAM, MEAN DAILY, CFS	STDY	S	Y	CFS	82	4	5	1	44	15	27	4	78	13			56	20	16	
NITROGEN, AMMONIA, TOTAL (MG/L AS N)	STDY	S	N		13				13				13				13			
NITROGEN, ORGANIC, TOTAL (MG/L AS N)	STDY	S	N		7		6		2		11		5		8		5		8	
PHOSPHORUS, TOTAL (MG/L AS P)	STDY	S	N		1	12			2	10			4	9			2	10		
PRECIPITATION, TOTAL (INCHES PER DAY)	STDY	S	Y		15	77			21	69			24	67			26	66		
TEMPERATURE, WATER (DEGREES CENTIGRADE)	STDY	S	N			3	8	2		1	2	10	8	3	2		12	1		

Modifications Since Project Started

None.

Progress Towards Meeting Goals

The nonpoint source monitoring and reporting requirements for watershed implementation grants have been completed for the data from Water Years 1992 and 1993. A technical report on data from water years 1992 and 1993 has been completed (Seigley et al., 1994).

TOTAL PROJECT BUDGET

Estimated budget for the Sny Magill Watershed National Monitoring Program project for the period FY91-94:

Project Element	Funding Source ($)			
	Federal	State	Local	Sum
I &E	210,000	105,000	NA	315,000
LT (cost share)	533,604	NA	NA	533,604
LT (technical assist.)	395,000	NA	NA	395,000
WQ Monit	*274,700	NA	NA	274,700
TOTALS	1,413,304	105,000	NA	1,518,304

* from 319 funds
Source: Lynette Seigley (personal communication, 1995)

Modifications Since Project Started

Funding restrictions in the Sny Magill HUA for FY94 affected cost-share funding to assist cooperating producers to install BMPs. The HUA was able to operate in FY94 on limited funding that remained from previous years. The full impact of this reduction will be felt in FY95. The project has applied for alternate funding to meet the unmet needs of producers to install BMPs.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

Please refer to the section entitled Nonpoint Source Control Strategy.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

Agencies participating in the Sny Magill Watershed Nonpoint Source Pollution Monitoring Project and their roles are listed below:

- Clayton County USDA Consolidated Farm Service Agency Committee
- Iowa State University Cooperative Extension Service
- Iowa Department of Agriculture and Land Stewardship: Participate in program reviews and provide funding to aid in BMP installation
- Iowa Department of Natural Resources
- Iowa Department of Natural Resources: Preventive Medicine - Analytical
- Natural Resources Conservation Service
- University Hygienic Laboratory
- U.S. Forest Service

- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- U.S. National Park Service
- U.S. Environmental Protection Agency: Funding to aid in BMP installation

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Maryland

Warner Creek Watershed
Section 319
National Monitoring Program Project

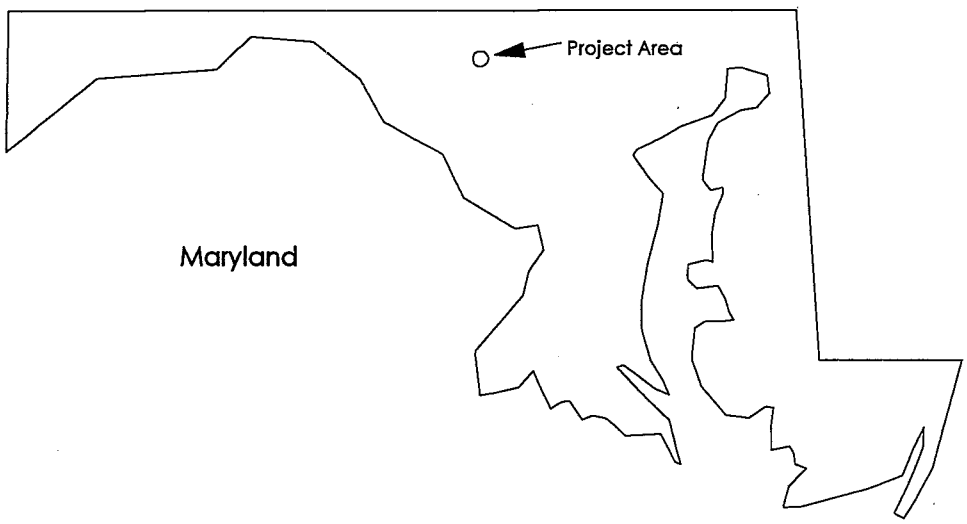

Figure 11: Warner Creek (Maryland) Watershed Project Location

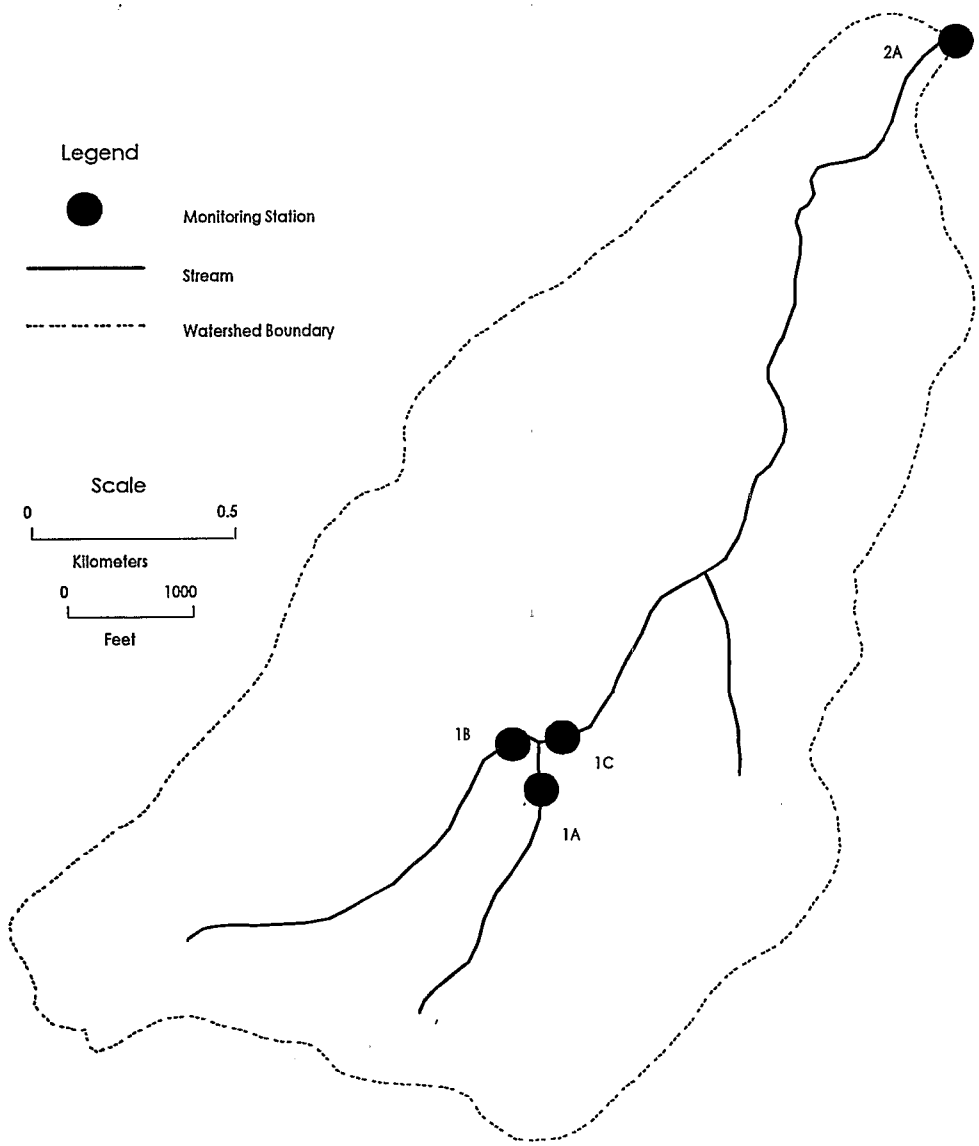

Figure 12: Water Quality Monitoring Stations for Warner Creek (Maryland) Watershed

PROJECT OVERVIEW

The Warner Creek watershed is located in the Piedmont physiographic region of northcentral Maryland (Figure 11). Land use in the 830-acre watershed is almost exclusively agricultural, consisting of beef and dairy production and associated activities.

Agricultural activities related to dairy production are believed to be the major nonpoint source of pollutants to the small stream draining the watershed. This situation is particularly apparent in one of the headwater subwatersheds, which will be compared to the other subwatershed that primarily contains beef farms.

Proposed land treatment includes conversion of cropland to pasture, installation of watering systems, fencing to exclude livestock from tributary streams, and the proper use of newly constructed manure slurry storage tanks.

Water quality monitoring involves both paired watershed and upstream/downstream experimental designs. Sampling will occur at the outlets of the paired watersheds (stations 1A and 1B) and at the upstream/downstream stations (1C and 2A) once per week (Figure 12). Storm-event sampling by an automatic sampler will occur at station 2A. Water samples will be analyzed for sediment, nitrogen, and phosphorus.

Monitoring data will be used to evaluate the suitability of a modified version of the CREAMS and/or ANSWERS model for its application in the larger Monocacy River basin.

PROJECT DESCRIPTION

Water Resource Type and Size

Warner Creek is a small stream with a drainage area of about 830 acres, all of which are included in the study area. Its average discharge is 30 gallons per minute.

Water Uses and Impairments

The project is more of a watershed study than an implementation project; therefore, the water resource has no significant use, except for biological habitat.

Pre-Project Water Quality

Seven weeks of pre-project water quality monitoring at four stations yielded the following data:

Nitrate (mg/l)	Nitrite (mg/l)	Ammonia (mg/l)	TKN (mg/l)	TKP (mg/l)	Orthophosphorus (mg/l)
3.3-6.7	.01-.05	0-23.0	0-73.0	0-6.7	0-3.6

Source: Shirmohammadi and Magette, 1993

Current Water Quality Objectives

The objectives of the project are to:

- develop and validate a hydrologic and water quality model capable of predicting the effects of agricultural best management practices (BMPs) on water quality, both at the field and basin scales;
- collect water quality data for use in the validation of the basin-scale hydrologic and water quality model; and

- apply the validated model to illustrate relationships between agricultural BMPs and watershed water quality in support of the Monocacy River demonstration project.

Project Time Frame May, 1993 - June, 1997

Project Approval June, 1993

PROJECT AREA CHARACTERISTICS

Project Area Approximately 830 acres.

Relevant Hydrologic, Geologic, and Meteorologic Factors The watershed is in the Piedmont physiographic province. Geologically, bedrock in this area has been metamorphosed. Upland soils in the watershed belong to the Penn silt loam series with an average slope of three to eight percent. Average annual rainfall near the watershed is 44-46 inches.

Land Use Land use in the upper part (upstream of 1C) of the watershed is mostly pasture and cropland, with a few beef and dairy operators. The subwatershed upstream of station 1B contains a dairy operation, and a recent survey indicated that about sixty-five percent of the land was used for corn silage production. Downstream of station 1C, land use is also mostly pasture and cropland, which is used to support dairy and beef production.

Pollutant Source(s) The major sources of pollutants are thought to be the dairy operations and the associated cropland. Pastures in which cows have unlimited access to the tributary streams also contribute significant amounts of pollutants.

INFORMATION, EDUCATION, AND PUBLICITY

The project will draw support from the University of Maryland Cooperative Extension Service (CES) agents, the Natural Resources Conservation Service (NRCS) District office in Frederick, Maryland, and project specialists located in the Monocacy River Water Quality Demonstration office. Several of the office's personnel have already established lines of communication between watershed farmers and the local personnel of the relevant USDA agencies. Education and public awareness will be accomplished through the CES in the form of tours, press releases, scientific articles, and oral presentations.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

Upstream/downstream Study Area (1C and 2A):
BMPs planned for this area include construction of watering systems for animals, fencing animals from streams, and the proper use of newly constructed manure slurry storage tanks. Conversion of cropland to pasture is also anticipated in this area.

Paired Watershed (1A and 1B):
The implementation of BMPs in the treatment (1B) paired watershed is uncertain; however, a concerted effort will be made to install an animal waste management system and cropland conservation practices in this watershed.

WATER QUALITY MONITORING

Design

The water quality monitoring component incorporates the following two designs:

- Upstream/downstream on Warner Creek
- Paired watersheds in the uppermost areas of the watershed

Variables Measured

Chemical and Other

Ammonia (NH_3)
Total kjeldahl nitrogen (TKN)
Nitrate/nitrite (NO_3+NO_2)
Nitrite (NO_2)
Orthophosphorus (OP)
Total kjeldahl phosphorus (TKP)
Sediment

Explanatory Variables

Rainfall
Discharge: instantaneous (1A, 1B and 1C) continuous (2A)

Sampling Scheme

Upstream/Downstream Study Area (1C and 2A) (Figure 12):
Type: grab (1C and 2A) automated storm event (2A)
Frequency and Season: weekly from February to June and biweekly for the remainder of the year

Paired Watershed (1A and 1B) (Figure 12):
Type: grab (1A and 1B)
Frequency and season: weekly from February to June and biweekly for the remainder of the year

Monitoring Scheme for the Warner Creek Watershed 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired		Ammonia Total Kjeldahl nitrogen	Rainfall discharge	Weekly Feb. to June and bi-weekly the remainder of the year.		? yrs. pre-BMP ? yrs. BMP ? yrs. post-BMP
Upstream/ downstream	Warner Creek	Nitrate/nitrite Nitrite Orthophosphorus Total Kjeldahl phosphorus Sediment				

Water Quality Data Management and Analysis

Monitoring data are stored and analyzed at the University of Maryland. In addition, data will be entered into the STORET data base and reported using the Nonpoint Source Management System (NPSMS) software.

TOTAL PROJECT BUDGET

Project Element	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Monitoring						
Personnel	41,600	32,500	45,000	49,000	51,500	54,500
Equipment	10,000	3,000	NA	NA	NA	NA
Other	26,733	35,938	37,140	34,190	35,215	36,445
TOTALS	78,333	71,438	82,140	83,190	86,715	90,945

Source: FFY94 Work Plan (6/23/94).

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The USDA Monocacy River Demonstration Watershed Project will facilitate the dissemination of information gained from the project and help provide cost-share funds for implementing BMPs.

OTHER PERTINENT INFORMATION

None.

PROJECT CONTACTS

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Michigan

Sycamore Creek Watershed
Section 319
National Monitoring Program Project

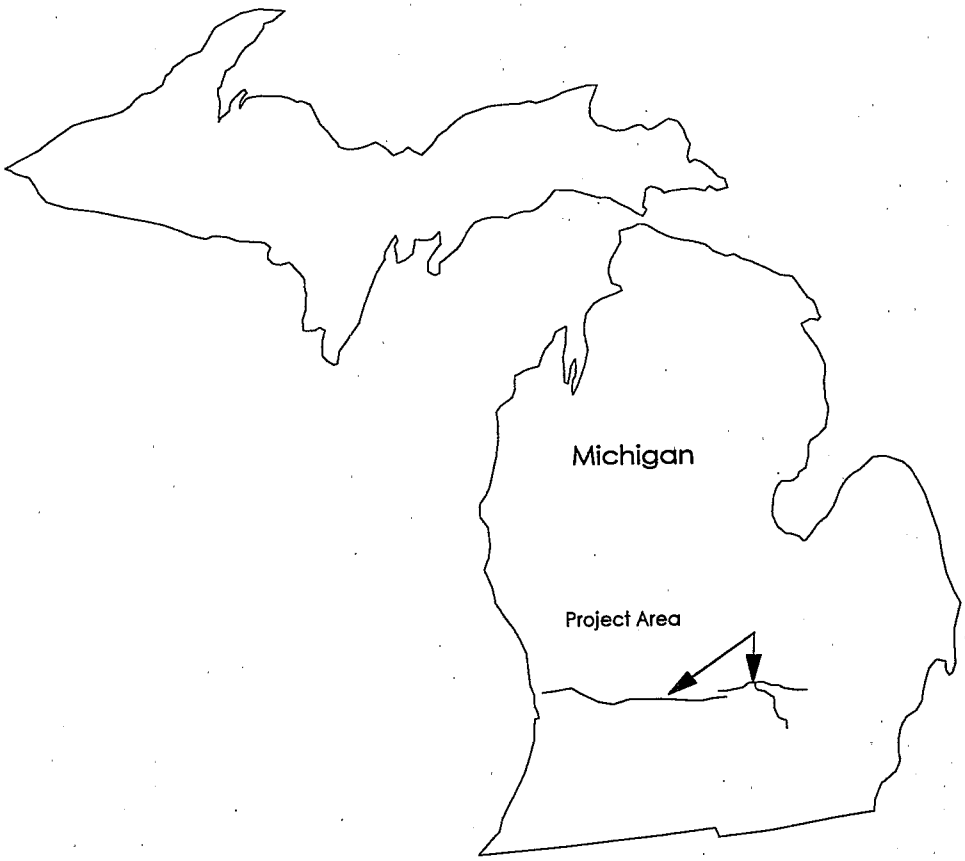

Figure 13: Sycamore Creek (Michigan) Project Location

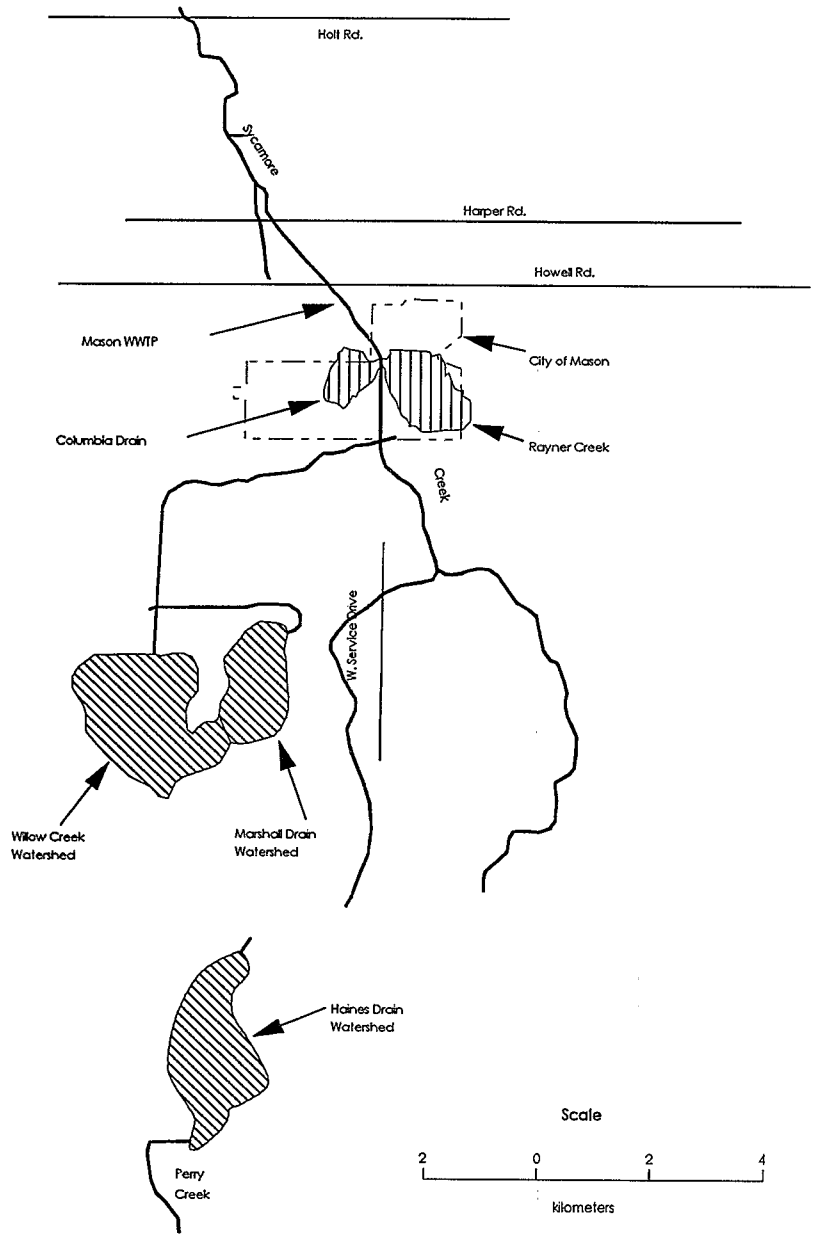

Figure 14: Paired Water Quality Monitoring Stations for the Sycamore Creek (Michigan) Watershed

PROJECT OVERVIEW

Sycamore Creek is located in southcentral Michigan (Ingham County) (Figure 13). The creek has a drainage area of 67,740 acres, which includes the towns of Holt and Mason, and part of the city of Lansing. The major commodities produced in this primarily agricultural county are corn, wheat, soybeans, and some livestock. Sycamore Creek is a tributary to the Red Cedar River, which flows into the Grand River. The Grand River discharges into Lake Michigan.

The major pollutants of Sycamore Creek are sediment, phosphorus, nitrogen, and agricultural pesticides. Sediment deposits are adversely affecting fish and macroinvertebrate habitat and are depleting oxygen in the water column. Sycamore Creek has been selected for monitoring, not because of any unique characteristics, but rather because it is representative of creeks throughout lower Michigan.

Water quality monitoring occurs in three subwatersheds: Haines Drain, Willow Creek, and Marshall Drain (Figure 14). The Haines subwatershed, where best management practices (BMPs) have been installed, serves as the control and is outside the Sycamore Creek watershed. Stormflow and baseflow water quality samples from each watershed are from March through July of each project year. Water is sampled for turbidity, total suspended solids, chemical oxygen demand (COD), nitrogen (N), and phosphorus (P).

Land treatment consists primarily of sediment-and-nutrient-reducing BMPs on cropland, pastureland, and hayland. These BMPs are funded as part of the U.S. Department of Agriculture (USDA) Sycamore Creek Hydrologic Unit Area (HUA) project.

PROJECT DESCRIPTION

Water Resource Type and Size

Sycamore Creek is a tributary of the Red Cedar River. The Red Cedar River flows into the Grand River, which flows into Lake Michigan.

Water Uses and Impairments

Sycamore Creek is protected by Michigan State Water Quality Standards for warm-water fish, body contact recreation, and navigation. Currently the pollutant levels in the creek are greater than prescribed standards. In particular, dissolved oxygen levels (the minimum standard level is 5 milligram per liter) are below the minimum standard, primarily because of sediment but also, in some cases, nutrients (Suppnick, 1992).

Pre-Project Water Quality

The primary pollutant is sediment. Widespread aquatic habitat destruction from sedimentation has been documented. Nutrients (nitrogen and phosphorus) are secondary pollutants. Pesticides may be polluting ground water; however, evidence of contamination by pesticides is currently lacking. Low levels of dissolved oxygen in the creek are a result of excess plant growth and organic matter associated with the sediment.

Sediment and Phosphorus Content of Sycamore Creek Under Routine (dry) and Storm (wet) Flow Conditions:

Dry P mg/l	Wet P mg/l	Dry Sediment mg/l	Wet Sediment mg/l
0.01-0.09	0.04-0.71	4-28	6-348

Source: NRCS/CES/CFSA, 1990

A biological investigation of Sycamore Creek, conducted in 1989, revealed an impaired fish and macroinvertebrate community. Fish and macroinvertebrate numbers were low, suggesting lack of available habitat.

Channelization of Sycamore Creek is causing unstable flow discharge, significant bank-slumping, and erosion at sites that have been dredged.

Current Water Quality Objectives

The water quality objective is to reduce the impact of agricultural nonpoint source (NPS) pollutants on the surface and in ground water of Sycamore Creek.

The goal of the project is to reduce sediment delivery into Sycamore Creek by 52%.

Modifications Since Project Initiation

None.

Project Time Frame

Monitoring is conducted for a minimum of six years, contingent upon federal funding.

Project Approval

1993

PROJECT AREA CHARACTERISTICS

Project Area

The project, located in southcentral Michigan, includes 67,740 acres.

Relevant Hydrologic, Geologic, and Meteorologic Factors

The geology of the watershed consists of till plains, moraines, and eskers (glacially deposited gravel and sand that form ridges 30 to 40 feet in height). The Mason Esker and associated loamy sand and sandy loam soil areas are the major ground water recharge areas for Ingham County residents. Eskers are the predominant geologic feature near the stream. These grade into moraines that are approximately one-half to one mile in width. The moraines have sandy loam textures with slopes of 6 -18%. The moraines grade into till plains. Interspersed within the area, in depressional areas and drainageways, are organic soils.

Land Use

Approximately 50% of the land in this primarily agricultural watershed is used for crops, forage, and livestock.

Critical areas for targeting BMPs are agricultural fields (cropland, hayland, or pasture) within one-half mile of a stream.

Major BMPs already implemented in the project area are pasture and hayland planting, pasture and hayland management, diversions, cover and green manure crops, critical area plantings, conservation tillage, grade stabilization structures, grassed waterways, and integrated crop management.

Crop and residue cover are recorded on a 10-acre cell basis in each of the three monitored subwatersheds.

Land Use	Acres	(%)
Agricultural	35,453	52
Forest	8,017	12
Residential	9,336	14
Business/Industrial	2,562	4
Idle	6,381	10
Wetlands	2,324	3
Transportation	1,349	2
Open land	826	1
Gravel pits and wells	806	1
Water	359	0.5
Other	325	0.5
Total	67,738	100

Source: NRCS/CES/CFSA, 1990

Pollutant Source(s)

Streambanks, urban areas, agricultural fields

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

The Ingham County Cooperative Extension Service (CES) is responsible for all information and education (I&E) activities within the watershed. These I&E activities have been developed and are being implemented as part of the Sycamore Creek HUA project. Activities include public awareness campaigns, conservation tours, media events such as news releases and radio shows, display set-ups, work-shops, short courses, farmer-targeted newsletters, homeowner-targeted newsletters, on-farm demonstrations, meetings, and presentations. Ingham County CES assists producers with nutrient management plans and integrated pest management.

Progress Towards Meeting Goals

1994 activities include:

- ten on-farm demonstrations;
- one watershed tour;
- one watershed winter meeting;
- monthly newsletters for area farmers;
- one homeowners' newsletter; and
- twenty-five farm plans for nutrient and pesticide management.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

The Sycamore Creek U.S. Environmental Protection Agency (USEPA) Section 319 National Monitoring Program project is nested within the Sycamore Creek HUA project. The nonpoint source control strategy includes: 1) identification and prioritization of significant nonpoint sources of water quality contamination in the watershed and 2) promotion of the adoption of BMPs that significantly reduce the affects of agriculture on surface water and ground water quality.

Selection of the BMPs depends on land use: cropland, hayland, pasture land, or urban land. BMPs for the cropland include conservation tillage, conservation cropping sequence, crop residue use, pest management, nutrient management, waste utilization, critical area planting, and erosion control structures. Hayland-area BMPs consist of conservation cropping sequence, conservation tillage, pest management, nutrient management, pasture/hayland management, and pasture/hayland planting. BMPs to be utilized on pastureland are conservation cropping sequence, conservation tillage, pasture/hayland management, pasture/hayland planting, fencing, waste utilization, filter strips, and critical area planting. The following practices are eligible for ACP funding:

- Permanent Vegetative Cover Establishment
- Diversions
- Cropland Protective Cover
- Permanent Vegetative Cover on Critical Areas
- Sediment Retention Erosion or Water Control Structure
- Sod Waterways
- Integrated Crop Management

Practice installation and the effect on water quality is tracked using the database ADSWQ (Automatic Data System for Water Quality). The EPIC model (Erosion Productivity Index Calculator) is being used to estimate changes in edge-of-field delivery of sediment, nutrients, and bottom of root zone delivery of nutrients resulting from BMP implementation.

Modifications Since Project Started

None.

Progress Toward Meeting Goals

The Ingham County Drain Commission has received an implementation grant under Section 319 of the Clean Water Act for the installation of streambank stabilization in Willow Creek. A variety of vegetative and structural BMPs are considered and used to see which work best to stabilize streambanks. Work will be concentrated upstream of the Michigan Department of Natural Resources (DNR) monitoring station, and is scheduled to begin in September of 1995.

WATER QUALITY MONITORING

Design

A paired watershed design is used to document constituent changes in Sycamore Creek. Two subwatersheds within the project, Willow Creek and Marshall Drain, have been compared to a control subwatershed, Haines Drain, that is outside the boundaries of the project (Figure 14). BMPs were installed in the Haines Drain prior to the commencement of water quality monitoring in 1990.

The Willow Creek and Marshall Drain subwatersheds were selected among all subwatersheds in the Sycamore Creek watershed because they contained the most excessive sediment loads and the largest percentage of erodible land within one-quarter mile of a channel.

Modifications Since Project Started

An additional station was added in 1995 at the United States Geological Survey gauging station at Holt Road. Sampling is conducted year round using a flow stratified strategy. The purpose of this station is to determine the annual load of pollutants near the mouth of the stream and compare these loads with various

models for estimating pollutant loads in the watershed. Automatic sampling equipment is used to collect samples and the USGS flow data are used to determine loads. The parameters tested for are the same as the other three stations.

Variables Measured

Biological

None

Chemical and Other

Total suspended solids (TSS)
Turbidity
Total phosphorus TP)
Total Kjeldahl nitrogen (TKN)
Nitrite (NO_2-N) + Nitrate (NO_3-N)
Chemical oxygen demand (COD)
Orthophosphorus (OP)
Ammonia (NH_3)

Explanatory Variable(s)

Rainfall
Flow
Erosion-intensity index

Sampling Scheme

Sampling during storm events is conducted from after snow melt (ground thaw) through the appearance of a crop canopy (sometime in July). Samples are collected every one to two hours. For each location and storm, six to twelve samples are selected for analysis. Automatic stormwater samplers equipped with liquid level actuators are used.

Twenty evenly spaced weekly grab samples are also taken for trend determination. Sampling begins in March when the ground thaws and continues for the next 20 weeks.

A continuous record of river stage is being obtained with Isco model 2870 flow meters. The river stage converts to a continuous flow record using a stage discharge relationship already determined by field staff of the Land and Water Management Division of the Michigan Department of Natural Resources.

One recording rain gauge is installed in each agricultural subwatershed (Figure 14).

Monitoring Scheme for the Sycamore Creek 319 National Monitoring Program

Design	Sites*	Primary Variables**	Covariates***	Frequency of WQ Sampling	Duration
Three-way paired	Willow Creek[1]	Total suspended solids Turbidity Total phosphorus Total Kjeldahl nitrogen Nitrite + nitrate Chemical oxygen demand Orthophosphorus Ammonia	Rainfall flow Erosion-intensity index	Weekly for 20 samples starting after snow melt	6 yrs pre-BMP 1 yr BMP 1 yr post-BMP
	Haines Drain[C]				
	Marshall Drain[T]			Storm sampling (from after snow melt until canopy closure)	3 yrs pre-BMP 3 yrs BMP 1 yr post-BMP

[T] Treatment watersheds
[C] Control watershed

Modifications Since Project Started

Prior to 1993, weekly grab samples were not collected, but occasional grab samples during base flow were collected.

Water Quality Data Management and Analysis

Preliminary exploratory analysis includes a linear regression of control values versus target values for storm loads, storm event mean concentrations, storm rainfall amounts, storm runoff volume, and storm runoff coefficients. Storm loads were also compared to the AGNPS model for the first two years of data. Land use and cover data are recorded each year on a 10 acre grid scale.

NPSMS Data Summary

A summary of quartile data through 1993 is presented in the table below. These summaries include all data including storm event data for 1990-1993, base flow grab samples for 1990-1992, and weekly sampling in 1993. Differences can be seen among the watersheds such as the stable flow and NO_2+NO_3 levels in Willow Creek compared to the other stations and the higher flows in Haines Drain compared to the other stations.

Monitoring Station Parameters Report

CHEMICAL PARAMETERS

STATION NAME: Haines Drain (Control; 848 acres) **YEAR:** 1990

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	85	8	6	2
SUSPENDED SOLIDS	mg/l	84	38	15	7
TOTAL PHOSPHORUS	mg/l	84	0.196	0.107	0.048
$NO_3 + NO_2$	mg/l	84	3.8	3.5	2.9
COD	mg/l	84	35.5	29	22

STATION NAME: Haines Drain (Control; 848 acres) **YEAR:** 1991

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	44	8	5	4
SUSPENDED SOLIDS	mg/l	43	147	46	20
TOTAL PHOSPHORUS	mg/l	45	0.64	0.34	0.178
$NO_3 + NO_2$	mg/l	45	36.	3.3	3
COD	mg/l	15	55	36	29

STATION NAME: Haines Drain (Control; 848 acres) **YEAR:** 1992

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	31	14	6	0.9
SUSPENDED SOLIDS	mg/l	31	270	95	24
TOTAL PHOSPHORUS	mg/l	31	0.8	0.47	0.126
$NO_3 + NO_2$	mg/l	31	4.2	3.4	2.9
COD	mg/l	31	59	37	20

STATION NAME: Haines Drain (Control; 848 acres) **YEAR:** 1993

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	67	8.3	2	1
SUSPENDED SOLIDS	mg/l	66	91	45	15
TOTAL PHOSPHORUS	mg/l	67	0.48	0.24	0.105
$NO_3 + NO_2$	mg/l	66	7.4	2.9	1.82
COD	mg/l	66	45	31	23

STATION NAME: Marshall Drain (Target; 422 acres) **YEAR:** 1990

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	44	0.5	0.4	0.2
SUSPENDED SOLIDS	mg/l	44	98.5	29	16.5
TOTAL PHOSPHORUS	mg/l	44	0.059	0.04	0.029
$NO_3 + NO_2$	mg/l	36	5.8	2.55	1.9
COD	mg/l	44	19	16	14

STATION NAME: Marshall Drain (Target; 422 acres) **YEAR:** 1991

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	40	2	1	0.8
SUSPENDED SOLIDS	mg/l	39	115	29	17
TOTAL PHOSPHORUS	mg/l	41	0.35	0.118	0.062
$NO_3 + NO_2$	mg/l	41	7.5	6.4	5
COD	mg/l	23	40	31	17

STATION NAME: Marshall Drain (Target; 422 acres) **YEAR:** 1992

Parameter Name	Reporting Units	N	QUARTILEVALUES -75-	-50-	-25-
FLOW,CFS	cfs	23	5	0.9	0.3
SUSPENDED SOLIDS	mg/l	23	100	30	7
TOTAL PHOSPHORUS	mg/l	23	0.4	0.152	0.046
$NO_3 + NO_2$	mg/l	23	6.2	4.8	2.4
COD	mg/l	23	49	26	16

STATION NAME: Marshall Drain (Target; 422 acres) **YEAR:** 1993

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	52	4.87	0.57	0.32
SUSPENDED SOLIDS	mg/l	52	60	26	7
TOTAL PHOSPHORUS	mg/l	52	0.27	0.177	0.06
$NO_3 + NO_2$	mg/l	51	12	3.9	3
COD	mg/l	52	32	22	12

STATION NAME: Willow Creek (Target; 1087 acres) **YEAR:** 1990

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	83	5	4	3
SUSPENDED SOLIDS	mg/l	82	44	32	18
TOTAL PHOSPHORUS	mg/l	83	0.075	0.055	0.036
$NO_3 + NO_2$	mg/l	83	2.7	2.4	2.1
COD	mg/l	83	31	24	18

STATION NAME: Willow Creek (Target; 1087 acres) **YEAR:** 1991

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	47	4	4	3
SUSPENDED SOLIDS	mg/l	47	197	80	44
TOTAL PHOSPHORUS	mg/l	50	0.36	0.137	0.066
$NO_3 + NO_2$	mg/l	50	3	2.3	2.3
COD	mg/l	21	67	51	32

STATION NAME: Willow Creek (Target; 1087 acres) YEAR: 1992

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	37	6	4	3
SUSPENDED SOLIDS	mg/l	37	150	70	28
TOTAL PHOSPHORUS	mg/l	37	0.26	0.135	0.052
$NO_3 + NO_2$	mg/l	37	3.5	1.94	1.75
COD	mg/l	37	82	45	27

STATION NAME: Willow Creek (Target, 1087 acres) YEAR: 1993

Parameter Name	Reporting Units	N	QUARTILE VALUES -75-	-50-	-25-
FLOW,CFS	cfs	74	7.36	4.98	4.14
SUSPENDED SOLIDS	mg/l	74	130	80	40
TOTAL PHOSPHORUS	mg/l	73	0.21	0.128	0.069
$NO_3 + NO_2$	mg/l	72	2.5	2.2	1.9
COD	mg/l	74	76	49	33

Modifications Since Project Started

None.

Progress Towards Meeting Goals

Six years of sampling have been completed in the paired watersheds.

TOTAL PROJECT BUDGET

The estimated budget for the Sycamore Creek Watershed National Monitoring Program project for the life of the project is:

Project Element	Funding Source: ($) Federal	State	Local	Sum
Project Mgt	129,370	122,000	3,130	254,500
I & E	159,900	NA	9,935	169,835
LT	1,078,300	NA	500,751	1,579,051
WQ Monit	285,000	222,000	NA	507,000
TOTALS	1,652,570	344,000	513,816	2,510,386

Source: John Suppnick (Personal Communication), 1993

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The funds for the 319 project provide for the water quality monitoring in the HUA project area. The county Consolidated Farm Service Agency Committee has agreed to use Agricultural Conservation Program (ACP) funds for erosion control, water quality improvement, and agricultural waste management.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

Agency responsibilities are as follows:

- Consolidated Farm Service Agency (CFSA)
- Michigan State University Extension - Ingham County
- Ingham County Health Department (Environmental Division)
- Ingham Conservation District
- Landowners within the Sycamore Creek Watershed
- Michigan Department of Natural Resources

PROJECT CONTACTS

Land Treatment

Bob Hicks (Land Treatment for the HUA Project)
Ingham County District Conservationist
USDA-NRCS
521 N. Okemos Rd.
P.O. Box 236
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(517) 676-5543

Ruth Shaffer
USDA-NRCS
State Office
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East Lansing, MI 48823-5202
(517) 337-6701, Ext. 1216; Fax (517) 337-6905

Water Quality Monitoring

John Suppnick
Department of Natural Resources,
Surface Water Quality
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Lansing, MI 48909
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Information and Education

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Mason, MI 48909
(517) 676-7207; Fax (517) 676-7230

Nebraska

Elm Creek Watershed
Section 319
National Monitoring Program Project

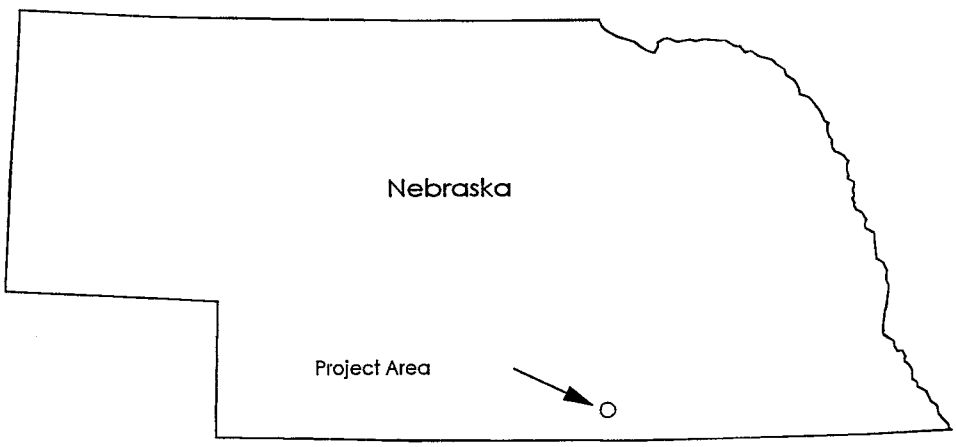

Figure 15: Elm Creek (Nebraska) Watershed Project Location

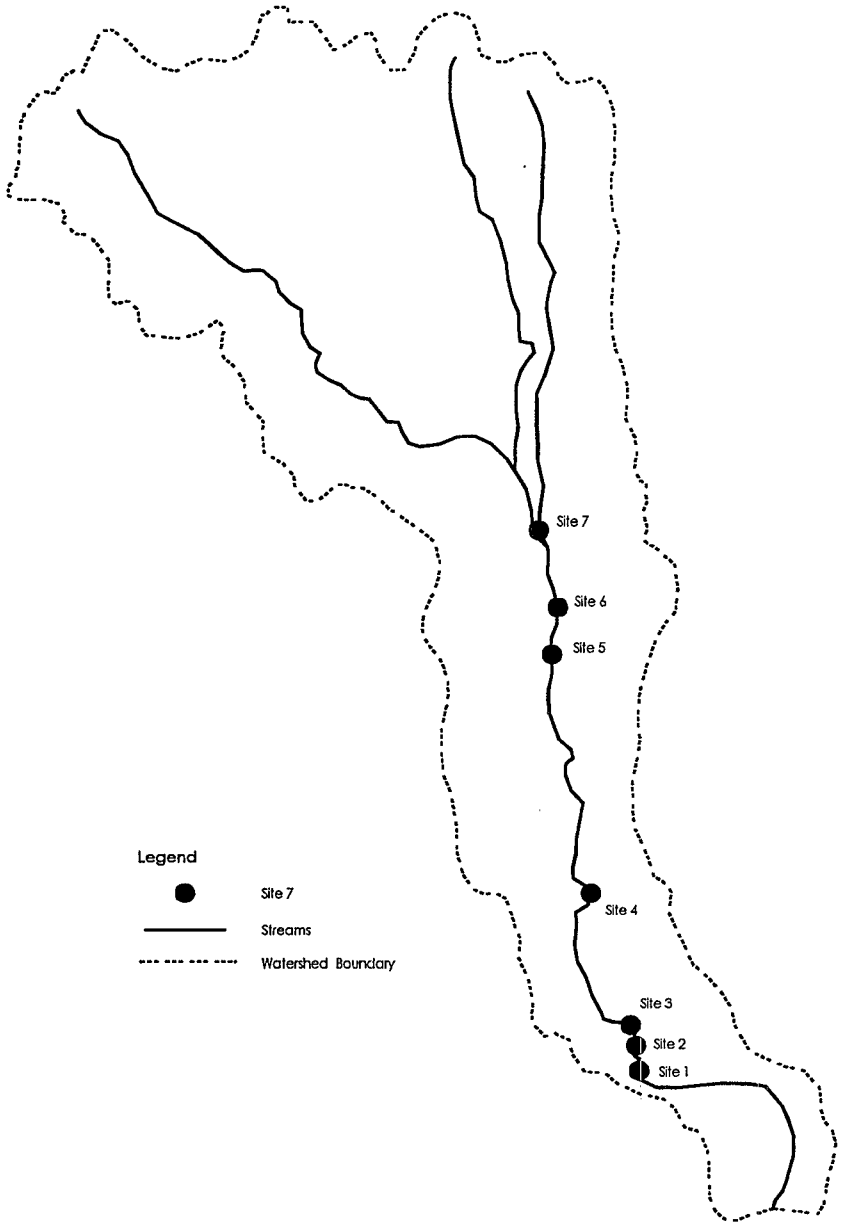

Figure 16: Water Quality Monitoring Stations for Elm Creek (Nebraska) Watershed

PROJECT OVERVIEW

Elm Creek is located in southcentral Nebraska, near the Kansas border (Figure 15). The creek flows in a southerly direction through agricultural lands of rolling hills and gently sloping uplands. The creek has a drainage area of 35,800 acres, consisting mainly of dryland crops of wheat and sorghum and pasture/range lands with some areas of irrigated corn production.

A primary water use of Elm Creek is recreation, particularly as a coldwater trout stream. Sedimentation increases water temperatures and high peak flows thus impairing aquatic life by destroying habitat, which reduces the creek's recreational use due to lowered trout productivity.

Land treatment for creek remediation includes non-conventional best management practices (BMPs), water quality and runoff control structures, water quality land treatment, and conventional water quality management practices (see section on nonpoint source control strategy). Many of these BMPs are being funded as part of the U.S. Department of Agriculture (USDA) Hydrologic Unit Area (HUA) Project. Land use is being inventoried. Cropland and BMP implementation is being tracked. Additionally, land treatment monitoring will include tracking land use changes based on the 40-acre grid system of the Agricultural Nonpoint Source (AGNPS) model at the end of the project.

Water quality monitoring includes an upstream/downstream design as well as a single station downstream design for trend detection. Grab samples are collected weekly from March through September to provide water quality data. Additional biological and habitat data are being collected on a seasonal basis.

PROJECT DESCRIPTION

Water Resource Type and Size

Elm Creek flows through cropland and pasture/range into the Republican River. Flow in the creek is dominated by inflow springs. The average discharge of Elm Creek is 21.4 cubic feet per second and the drainage area is 56 square miles.

Water Uses and Impairments

Elm Creek is valued as a coldwater aquatic life stream, as an agricultural water supply source, and for its aesthetic appeal. It is one of only two coldwater habitat streams in southcentral Nebraska. Sedimentation, increased water temperatures, and peak flows are impairing aquatic life by destroying stream habitat of the macroinvertebrates and trout. These negative impacts on the stream result from farming practices that cause excessive erosion and overland water flow.

Pre-Project Water Quality

A thorough water quality analysis of Elm Creek conducted in the early 1980s indicated that the water quality of Elm Creek was very good. There was, however, short-term degradation of water quality following storm events. The coldwater habitat use assignment of Elm Creek appeared to be attainable if it was not impaired by nonpoint source (NPS) pollution, particularly sedimentation and scouring of vegetation during storm events.

Current Water Quality Objectives

The NPS management objective in the Elm Creek watershed is to implement appropriate and feasible NPS control measures for the protection and enhancement of water quality in Elm Creek. Project goals are to:

- Reduce maximum summer water temperature,
- Reduce in-stream sedimentation,
- Reduce peak flows, and
- Improve in-stream aquatic habitat.

Modifications Since Project Initiation

None.

Project Time Frame

Monitoring is being conducted from April, 1992 through 1996. Two additional years of monitoring have been planned, contingent upon availability of funding.

Project Approval

1992

PROJECT AREA CHARACTERISTICS

Project Area

The project area, in southcentral Nebraska, consists of 35,800 acres of rolling hills, gently sloping uplands, and moderately steep slopes.

Relevant Hydrologic, Geologic, and Meteorologic Factors

Elm Creek, which receives 26.5 inches of rainfall per year, lies in a sub-humid ecological region. Seventy-five percent of this rainfall occurs between April and September. The average temperature is 52 degrees Fahrenheit with averages of 25 degrees in January and 79 degrees in July. The soils are derived from loess and the predominant soil types are highly erosive.

Land Use

Wheat and sorghum are the primary dryland crops produced. Corn is the primary irrigated crop. Range and pasture dominate the more steeply sloping lands.

Land Use	Acres	%
Agricultural		
Dryland	14,630	42
Irrigated	2,680	7
Pasture/Range	16,170	44
Forest	650	2
Other	1,670	5
Total	35,800	100

Source: Elm Creek Project, 1992

Pollutant Source(s)

Streambank erosion, irrigation return flows, cattle access, cropland runoff

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

Information and education (I&E) activities have been developed and are being implemented as part of the Elm Creek HUA Project. The University of Nebraska and Cooperative Extension in Webster County are in charge of I&E activities. I&E activities include: newsletters, an NPS video, slide shows, programs, questionnaires, fact sheets, demonstration sites, field days, and meetings.

Progress Toward Meeting Goals

The process of addressing nonpoint source issues in the Elm Creek watershed through information and education activities has been coordinated by the University of Nebraska Cooperative Extension as part of the USDA Hydrologic Unit Area (HUA) effort. In addition to those activities listed below, a newsletter promoting implementation of NPS pollution prevention practices continues to be developed and delivered to owners/operators in the watershed.

I&E activities implemented in the Elm Creek watershed include the following:

- Seven producers have agreed to host field days and BMP demonstration plots. To encourage no-till practices, a no-till drill is available for rent at $8.00 per acre.
- A videotape on no-till crop planting practices is currently being produced.
- Two newsletters are currently being produced for the project. One newsletter is sent to all landowners and operators in the project area and includes articles on BMPs, cost share funds available, and updates on project progress and upcoming events. In addition, a quarterly project newsletter detailing relevant project activities (i.e., budget, progress, etc.) is mailed to all cooperators.
- A series of educational programs have been held to provide producers with background information to encourage the adoption of BMPs. Other program topics included: New Tools for Pasture Production, Rotational Grazing Tour, and a Prescribed Burn Workshop.
- An Ecofarming Clinic was held where no-till drills were demonstrated. Topics of discussion for the program included: winter wheat production and weed control, diseases, cultivar selection, insect control, and soil fertility.
- Eight demonstration plots exhibiting various BMPs are currently being used as an educational tool. Practices being demonstrated include: Nitrogen Management, Integrated Crop Management - Irrigated, Integrated Crop Management - Dryland, No-till Milo Production, No-till Wheat Production, Conservation Tillage Wheat Production, Cedar Revetments for Streambank Protection, and Sediment Retention Basin Restoration.
- Twenty-two news stories, articles, meeting announcements and updates have been printed in local newspapers.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

Sediment-reducing BMPs are being installed. These BMPs have been divided into four BMP types, which will include upland treatment measures and riparian and in-stream habitat management measures.

<u>Non-conventional</u>

Vegetative Filter Strips
Permanent Vegetative Cover on
Critical Areas
Streambank Stabilization
Livestock Access & Exclusion
Ground Water Recharge
Abandoned Well Plugging
Trickle Flow Outlets
Sediment Barriers
Grade Stabilization

Water Quality & Runoff Control Structures

Water Quality Land Treatment

Tree Planting
Permanent Vegetative Cover
Terraces
Stripcropping

Conventional Water Quality Management Programs

Irrigation Management
Conservation Tillage
Range Management
Integrated Pest Management

Non-conventional BMPs are being funded under the U.S. Environmental Protection Agency (USEPA) Section 319 grant. Other BMPs will be funded with 75% cost share funds from the HUA Project. Finally, selected BMPs will be cost shared at 100% [75% from the Section 319 grant and 25% from Lower Republican Natural Resource District (LRNRD)]. The number and types of BMPs implemented will depend on voluntary farmer participation.

Land use will be inventoried. Cropland and BMP implementation will be tracked over the life of the project. Tracking will be based on the 40-acre grid system used for AGNPS modeling.

Modifications Since Project Started

As originally proposed, land use and BMP implementation were to be tracked based on a 40-acre grid system of the Agricultural Nonpoint Source (AGNPS) model. This scheme was to be used since a pre-project inventory of current land uses had been completed by the NRCS to run the AGNPS model. The goal was to then rerun the model with updated land use and BMP implementation data during the projects. However, once the Section 319 and HUA projects were initiated, it was quickly realized that annual tracking of land use changes and BMP implementation on a 40 acre basis in such a large watershed could not be accomplished with the resources available. The NRCS plans to rerun AGNPS with the updated information once the projects are complete.

Progress Towards Meeting Goals

Currently, 52 applications have been processed for USEPA 319 funds. Since January 1, 1994, 25 cooperators have requested HUA technical funds. From 1991 through 1993, the practices and activities outlined in the following table have been implemented primarily for erosion control in the Elm Creek Watershed. Modeling of erosion in the watershed has been completed using the AGNPS model. Another model run, again with AGNPS, will be done at project's end. Most goals have been met, but more work must be done with rotational grazing, livestock exclusion, and no-till and stubble mulch wheat.

Application of Practices/Activities for Erosion Control in the Elm Creek Watershed.

NRCS PRACTICE/ACTIVITY AND I.D. #	UNITS	NUMBER INSTALLED
Conservation Cropping Sequence (328)	acres	5,369
Conservation Tillage (329)	acres	3,904
Contour Farming (330)	acres	2,496
Critical Area Plantings (342)	acres	25
Crop Residue Use (344)	acres	1,739
Deferred Grazing (352)	acres	169
Diversion (362)	feet	4,236
Pond (378)	number	9
Fencing (382)	feet	35,768
Field Border (386)	feet	32,977
Filter Strip (393)	acres	5
Grade Stabilization Structure (410)	number	5
Grassed Waterway (412)	acres	5.3
Irrigation Water Management (449)	acres	2,260
Livestock Exclusion (472)	acres	199
Pasture and Hayland Management (510)	acres	176
Pasture and Hayland Planting (512)	acres	78
Pipeline (516)	feet	1,400
Proper Grazing Use (528)	acres	3,314
Range Seeding (550)	acres	93
Planned Grazing System (556)	acres	1,635
Streambank and Shoreline Protection	feet	280
Terrace (600)	feet	116,892
Tree Plantings (612)	acres	4
Trough or Tank (614)	number	11
Underground Outlet (620)	feet	2,325
Well (642)	number	6
Wildlife Upland Habitat Management (645)	acres	89

Significant strides have also been made in implementing NPS control measures throughout the watershed (see following table).

Though significant progress has been made, a few problems have also been identified with monitoring efforts. Preliminary evaluation of the project monitoring design (upstream-downstream and single downstream) and water quality data tend to suggest that the large watershed size above the upstream monitoring station (approximately 31,142 acres) inhibits documenting water quality improvements. More specifically, this problem can be attributed to the variability associated with regional and watershed conditions. The majority of non-structural BMPs recommended by the Natural Resources Conservation Service (NRCS) which have been implemented in the Elm Creek watershed, are designed only to control up to one-in-ten year storm events. When these types of storm events occur in the watershed, water quality (including in-stream habitat) remains good. However, with such a large watershed area above the perennial stream reach (which starts within a mile above the upstream monitoring station), even slightly larger storm events generally contribute to high flows, which degrade water and habitat quality, making it difficult to detect improvements.

WATER QUALITY MONITORING

Design

Upstream/downstream: The two sampling sites (sites 2 & 5) are located two miles apart (Figure 16)
Single downstream for trend detection (site 5) (Figure 16)

Variables Measured

Biological

Qualitative and quantitative macroinvertebrate sampling
Fish collections
Creel survey

Chemical and Other

Water temperature
Dissolved oxygen (DO)
Substrate samples (% Gravel, % Fines)
Total suspended solids (TSS)
Atrazine/Alachlor
Stream morphological characteristics (width, depth, velocity) and habitat
Continuous recording thermograph (June - September)

Explanatory Variables

Rainfall (recording rain gauge): April - September
Stream discharge (United States Geological Survey gauging station)

Modifications Since Project Started

Future use of artificial salmonid redds will be discontinued. Initial monitoring results indicate substrates are not suitable for salmonid spawning.

Sampling Scheme

(See Figure 16 for sampling site locations.)

Qualitative and quantitative macroinvertebrate sampling spring, summer, fall, and winter at sites 2 and 5.

Fish collections spring and fall at sites 1, 2, 3, 4, 5, 6.

Artificial salmonid redds (sites 2, 4, 5).

Creel survey (passive).

Dissolved Oxygen (DO) (sites 2, 5): Weekly grab samples from April through September. Monthly samples from October through March.

Substrate samples spring and fall at sites 2, 4, 5.

Total Suspended Solids (TSS) (sites 2,5): Weekly grab samples from April through September and monthly samples, October through March. Selected runoff samples are collected April through September.

Atrazine/Alachlor (sites 2,5): Grab and runoff samples are analyzed selectively in the spring for these pesticides.

Stream morphological characteristics (width, depth, velocity) and habitat: spring/ summer at sites 2, 5.

Rainfall (recording rain gauge): The main rain gauge will be placed in the upper or middle part of the watershed. A volunteer network for recording rainfall amounts has also been established.

Continuous recording thermograph (hourly water temperatures for at least 60% of the period June through September and at least 80% of the period July through August) at sites 2 and 5.

Monitoring Scheme for the Elm Creek 319 National Monitoring Program Project

Design	Sites	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Upstream/ downstream	2, 5	Macroinvertebrate survey	Stream discharge		4 times/yr spring & fall	0 yrs pre-BMP
	1, 2, 3, 4, 5, 6	Fish survey			passive	5 yrs BMP
Single downstream		Creel survey				3 yrs post-BMP
	2, 5	Water temperature				
	2, 4, 5	Substrate samples		Spring & fall		
	2, 5	Dissolved oxygen		Weekly (April-Sept.) & monthly (Oct.-March)		
	2, 5	Total suspended solids		Spring & fall		
	2, 5	Atrazine/alachlor		Spring		
	2, 5	Stream morphological characteristics		Spring/summer		
		Continuous recording thermograph				

Modifications Since Project Started

Plans to place a recording rain gauge in the Elm Creek watershed have been cancelled because of the variability associated with its large size. For the same reason, the volunteer network for recording rainfall amounts has also been discontinued.

Water Quality Data Management and Analysis

Ambient water quality data is entered into USEPA STORET. Biological data is stored in USEPA BIOS. Other data will be stored and analyzed using Microsoft Excel 5.0 spreadsheet program and USEPA NonPoint Source Management System (NPSMS). Water quality data is being analyzed using SAS statistical software. These data are being managed by the Nebraska Department of Environmental Quality (NDEQ).

Data assessment and reporting consists of quarterly activity reports, yearly interim reports focusing on BMP implementation, and a final report that will assess and link water quality and land treatment results.

NPSMS Data Summary

Monitoring Station Parameters Report

PERIOD: 1993
STATION TYPE: Upstream Station

CHEMICAL PARAMETERS

Parameter Name	QUARTILE VALUES -75-	-50-	-25-	Counts/Season:	1	2	3	4
FLOW, STREAM, INSTANTANEOUS, CFS	13.3	12.0	10.7	Highest	24	6	0	0
				High	2	0	0	0
				Low	0	0	0	0
				Lowest	0	0	0	0
OXYGEN, DISSOLVED (METER)	8.7	7.75	6.9	Highest	13	6	0	0
				High	6	0	0	0
				Low	3	0	0	0
				Lowest	3	0	0	0
SUSPENDED SOLIDS, TOTAL	51.0	16.5	2.0	Highest	8	1	0	0
				High	9	2	0	0
				Low	8	3	0	0
				Lowest	0	0	0	0
TEMPERATURE, WATER (DEGREE CENTIGRADE)	15.7	14.3	11.5	Highest	8	0	0	0
				High	3	0	0	0
				Low	9	0	0	0
				Lowest	5	6	0	0

BIOLOGICAL PARAMETERS (Non-Chemical)

Parameter Name	INDICES Fully	Threatened	Partially	Scores/Values	1	2	3	4
INDEX OF BIOLOGICAL INTEGRITY	30	--	22		33	--	29	--
INVERTEBRATE COMMUNITY INDEX	31	--	17		--	24	38	--
TROUT HABITAT QUALITY INDEX	--	--	--		--	--	4.1	--

STATION TYPE: Downstream Station

CHEMICAL PARAMETERS

Parameter Name	QUARTILE VALUES -75-	-50-	-25-	Counts/Season:	1	2	3	4
FLOW, STREAM, INSTANTANEOUS, CFS	13.3	12.0	10.7	Highest	24	6	0	0
				High	2	0	0	0
				Low	0	0	0	0
				Lowest	0	0	0	0
OXYGEN, DISSOLVED (METER)	9.9	8.85	8.5	Highest	8	6	0	0
				High	10	0	0	0
				Low	3	0	0	0
				Lowest	4	0	0	0
SUSPENDED SOLIDS, TOTAL	65.3	20.75	6.0	Highest	8	2	0	0
				High	10	0	0	0
				Low	7	2	0	0
				Lowest	1	2	0	0
TEMPERATURE, WATER (DEGREE CENTIGRADE)	16.6	14.8	11.2	Highest	9	0	0	0
				High	3	0	0	0
				Low	9	0	0	0
				Lowest	5	6	0	0

BIOLOGICAL PARAMETERS (Non-Chemical)

Parameter Name	INDICES Fully	Threatened	Partially	Scores/Values	1	2	3	4
INDEX OF BIOLOGICAL INTEGRITY	30	--	22		29	--	29	--
TROUT HABITAT QUALITY INDEX	--	--	--		--	--	2.2	--

Modifications Since Project Started

Quartile data for all chemical and physicochemical parameters indicate water quality conditions are relatively good. The values presented are accurate for water quality under baseflow conditions, but not necessarily reflective of impacts caused by runoff events. After heavy rainfall events, the stream is often subject to high flows and the associated NPS pollutants seemingly have only a short-term degrading impact on the in-stream chemical and physiochemical water quality. However, long lasting impacts not reflected in the data are the scouring and sedimentation resulting from these events which impair designated aquatic life uses.

Metrics comprising the biological indices used to assess aquatic communities are currently being refined for the State of Nebraska. Once this process is complete, more definitive conclusions can be drawn from the data collected in Elm Creek.

Progress Towards Meeting Goals

The following water quality monitoring goals have been met:

- Ambient water quality data is currently being entered and stored in USEPA STORET.
- Biological data is currently being entered and stored in USEPA BIOS.
- Quarterly and yearly interim reports have been developed as planned.

TOTAL PROJECT BUDGET

The estimated budget for the Elm Creek Watershed National Monitoring Program project for the life of the project is:

Project Element	Funding Source ($)			
	Federal	State	Local	Sum
Proj Mgt	11,200	0	0	11,200
I&E	0	0	3,400	3,400
Reports	6,300	0	0	6,300
LT	375,000	0	101,600	476,600
WQ Initiative Program (WQIP)	30,000	0	0	30,000
WQ Monit	100,000	0	15,000	115,000
TOTALS	*522,500	0	120,000	642,500

* $290,000 from HUA Project funds, $232,500 from 319 project funds
Source: Elm Creek Project, 1991

Time frame for funding sources:

- Local/Section 319 — April, 1992 to October, 1996
- HUA — May, 1990 to October, 1997 (The HUA project was scheduled to end in September, 1995, but has received a three year extension)
- WQIP - Contracts were written for cropping years 1992, 1993, and 1994. All funds were allocated in 1992.

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

This USEPA 319 National Monitoring Program project provides the water quality monitoring for the area HUA project. Agricultural Conservation Program (a USDA program) funding will be used for approved, conventional BMPs.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

The HUA activities are jointly administered by the University of Nebraska Cooperative Extension and the USDA Natural Resource Conservation Service (NRCS). Employees of these two agencies will work with local landowners, Consolidated Farm Service Agency (CFSA) personnel, personnel of the NDEQ, and personnel of the LRNRD. Section 319 project activities are administered by the NDEQ.

Agencies or groups involved in the project are listed below:

- CFSA (Consolidated Farm Services Agency)
- Landowners
- Lower Republican Natural Resources District: Monitoring
- Little Blue Natural Resources District
- Nebraska Game and Parks Commission
- NRCS (Natural Resources Conservation Service)
- Nebraska Department of Environmental Quality
- Nebraska Natural Resources Commission
- U.S. Geological Survey
- University of Nebraska Cooperative Extension
- United States Environmental Protection Agency
- Webster County Conservation Foundation (WCCF)
- Future Farmers of America Chapters and 4-H Clubs
- Center for Semi-Arid Agroforestry and Nebraska Forest Service
- Webster County Board of Commissioners

PROJECT CONTACTS

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North Carolina

Long Creek Watershed
Section 319
National Monitoring Program Project

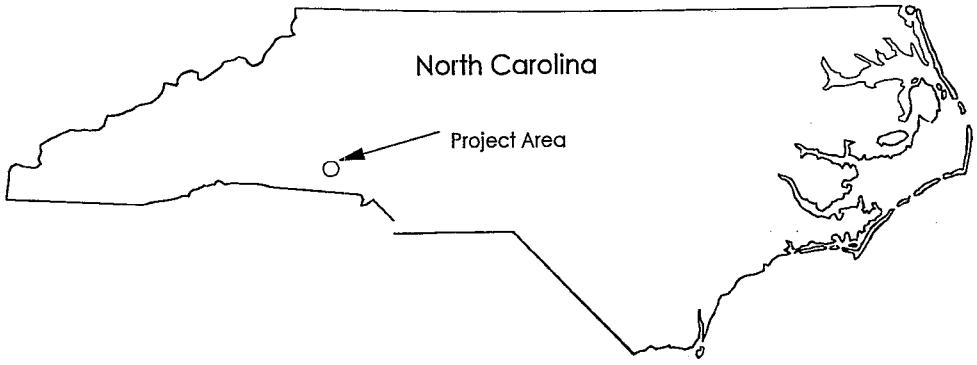

Figure 17: Long Creek (North Carolina) Watershed Project Location

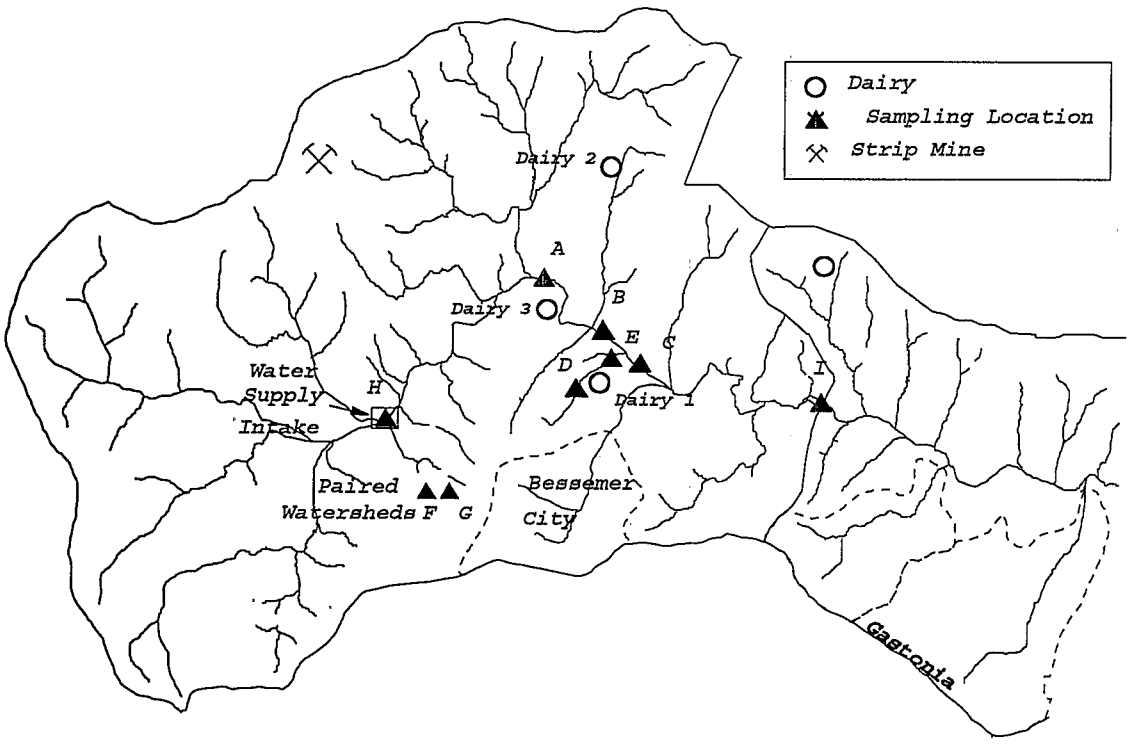

Figure 18: Water Quality Monitoring Stations for Long Creek (North Carolina) Watershed

PROJECT OVERVIEW

The Long Creek Watershed Section 319 National Monitoring Program project (28,480 acres), located in the southwestern Piedmont of North Carolina, consists of an area of mixed agricultural and urban/industrial land use (Figure 17). Long Creek is a perennial stream that serves as the primary water supply for Bessemer City, a municipality with a population of about 4,888 people (1994 estimate).

Agricultural activities related to crop and dairy production are believed to be the major nonpoint sources of pollutants to Long Creek. Sediment from eroding cropland is the major problem in the upper third of the watershed. Currently, the water supply intake pool must be dredged semiannually to maintain adequate storage volume. Below the intake, Long Creek is impaired primarily by bacteria and nutrients from urban areas and animal-holding facilities.

Proposed land treatment upstream of the water supply intake includes implementing the land use restrictions of the state water supply watershed protection law and the soil conservation provisions of the Food Security Act.

Below the intake, land treatment will involve implementing a comprehensive nutrient management plan on a large dairy farm and installing fence for livestock exclusion from a tributary to Long Creek. Land treatment and land use tracking will be based on a combination of voluntary farmer record-keeping and frequent farm visits by extension personnel. Data will be stored and managed in a geographic information system (GIS) located at the county extension office.

Water quality monitoring includes a single-station, before-and-after-land treatment design near the Bessemer City water intake (Figure 18), upstream and downstream stations above and below an unnamed tributary on Long Creek (B and C), stations upstream and downstream of a dairy farmstead on an unnamed tributary to Long Creek (D and E), and monitoring stations on paired watersheds at a cropland runoff site (F and G). Storm-event and weekly grab samples are being collected at various sites to provide the chemical, biological, and hydrologic data needed to assess the effectiveness of the land treatment program.

PROJECT DESCRIPTION

Water Resource Type and Size

The study area encompasses approximately seven miles of Long Creek (North Carolina stream classification index # 11-129-16). Annual mean discharges at the outlet of the study area (I) range between 17 and 59 cubic feet per second over a 40 year period of record.

Water Uses and Impairments

Long Creek is the primary water supply for Bessemer City. Water quality impairments include high sediment, bacteria, and nutrient levels. The stream channel near the water supply intake in the headwaters area requires frequent dredging due to sediment deposition. The section of Long Creek from the Bessemer City water supply intake to near the watershed outlet sampling station (Figure 18) is listed as support-threatened by the North Carolina Nonpoint Source Management Program. Biological (macroinvertebrate) habitat is degraded in this section due to the presence of fecal coliform, excessive sediment, and nutrient loading from agricultural and urban nonpoint sources.

Pre-Project Water Quality

Water quality variables change with time and location along Long Creek, but generally are close to the following averages:

Fecal Coliform #/100ml	BOD (mg/l)	TSS (mg/l)	TKN (mg/l)	NO_3-N (mg/l)	TP (mg/l)
2100	2	14	0.35	0.41	<0.17

Note: These average values were computed from the analyses of twelve monthly grab samples taken from three locations along Long Creek.

Current Water Quality Objectives

The objectives of the project are to quantify the effects of nonpoint source pollution controls on:

- Bacteria, sediment, and nutrient loadings to a stream from a working dairy farm;
- Sediment and nutrient loss from a field with a long history of manure application; and
- Sediment loads from the water supply watershed (goal is to reduce sediment yield by 60 percent).

In addition, biological monitoring of streams will attempt to show improvements in biological habitat associated with the implementation of nonpoint source pollution controls.

Modifications Since Project Initiation

None.

Project Time Frame

January, 1993 to September, 2001

Project Approval

1992

PROJECT AREA CHARACTERISTICS

Project Area

About 44.5 square miles or 28,480 acres

Relevant Hydrologic, Geologic, and Meteorologic Factors

The average annual rainfall is about 43 inches. The watershed geology is typical of the western Piedmont, with a saprolite layer of varying thickness overlaying fractured igneous and metamorphic rock. Soils in the study area are well drained and have a loamy surface layer underlain by a clay subsoil.

Land Use

Land Use	Acres	%
Agricultural	6,975	24
Forest	15,289	54
Residential	3,985	14
Business/Industrial	1,842	6
Mining	516	2
Total	28,607	100

Source: Jennings et al., 1992

Pollutant Source(s)

The monitored area contains the following four dairy farms:

Dairy Name	Cows (#)	Feedlot Drainage
Dairy 4	125	Open lot into holding pond
Dairy 3	85	Open lot across pasture
Dairy 1	400	Under roof and open lot across grass buffer

Source: Jennings et al., 1992

Modifications Since Project Started

Dairy 2 went out of business and was purchased by Gaston County for conversion to a biosolids application area.

INFORMATION, EDUCATION, AND PUBLICITY

Cooperative Extension Service (CES) personnel conducts public meetings and media campaigns to inform the general public, elected officials, community leaders, and school children about the project and water quality in general. In addition, project personnel make many one-to-one visits to cooperating and non-cooperating farmers in the watershed to inform them of project activities and address any questions or concerns they may have.

Progress Towards Meeting Goals

An education plan for Gaston County has been developed that includes activities in the Long Creek watershed. Also, a Watershed Citizens Advisory Committee has been formed to: 1) educate other watershed residents and 2) participate in citizen monitoring. Project overviews continue to be presented at state, local, and regional water-related conferences.

The Gaston Conservation District is continuing an extensive natural resources education outreach program to local schools. Eighty-five percent of schools (100% of elementary and junior high) located in the Long Creek Watershed participate in District programs.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

Water Supply Watershed (site H):
Bessemer City has recently purchased 13 acres of cropland immediately upstream of the intake with the intention of implementing runoff and erosion controls. Also, to comply with the North Carolina Water Supply Watershed Protection Act, land use requirements are implemented on land within one-half mile of and draining to the intake; less strict requirements such as the conservation provisions of the Food Security Act are implemented in the remainder of the watershed.

Up/downstream of Dairy 1 Tributary on Long Creek (sites B and C):
In addition to the best management practices (BMPs) planned for the dairy 1 farmstead, the control strategy is to design and implement a comprehensive nutrient management plan on the land between the sampling stations.

Dairy 1 Farmstead (sites D and E):
A larger waste storage structure has been constructed. After April, 1995, improved pasture management, livestock exclusion from the unnamed tributary, and stream bank stabilization between sites D and E will be implemented.

Paired Cropland Watersheds (sites F and G):
The control strategy on the paired watersheds involves implementing improved nutrient management on the treatment watershed while continuing current nutrient management and cropping practices on the control watershed. The number and types of BMPs implemented depends on voluntary farmer participation.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

Work has begun on developing farm plans for more than 20 farms within the watershed. Twenty-five Water Quality Incentive Project (WQIP) applications have been submitted by landowners in the Long Creek Watershed. Eight plans have been prepared representing more than $50,000 of BMP installations to control NPS pollution on these sites.

Water Supply Watershed (site H):
A land use survey of the agricultural portion of the water supply watershed has been completed. This data was then used by the North Carolina Division of Soil and Water Conservation to develop a Watershed Management Plan. Along with developing the plan, data from 1984 and 1994 were used to estimate erosion and sediment delivery rates in the watershed. The comparison indicated a 52% reduction in estimated annual erosion and a 51% reduction in sediment delivery to stream channels. However, visual inspection of the watershed tributaries indicates that considerable work remains in controlling stream channel erosion. This will be the emphasis of future NPS control efforts.

Dairy 1 Farmstead (sites D and E):
The Conservation District and the landowner completed the installation of a Waste Holding Pond in September, 1993. North Carolina Agriculture Cost Share Funds were utilized for this project. In addition, an underground main and hydrant with a stationary gun for applying waste effluent on the pasture/hayland areas was installed in July, 1994.

A solid waste storage structure was completed in July, 1993. North Carolina Agricultural Cost Share Funds were utilized for the construction of this project. A Resource Management System Plan was completed for the Kiser Dairy Farm to control nonpoint pollution sources and enhance the natural resources. As part of the plan, watering system and stream bank restoration projects will begin this fall.

WATER QUALITY MONITORING

Design

The water quality monitoring effort incorporates the following three designs:

- Single downstream station at water supply intake and watershed outlet
- Upstream/downstream design on Long Creek and unnamed tributary
- Paired watersheds on Dairy 1 cropland

Modifications Since Project Started

None.

Variables Measured

Biological

Percent canopy and aufwuchs (organisms growing on aquatic plants)

Invertebrate taxa richness: ephemeroptera, plecoptera, trichoptera, coleoptera, odonata, megaloptera, diptera, oligochaeta, crustacea, mollusca, and other taxa

Bacteria: Fecal coliform and Streptococci

Chemical and Other

Total suspended solids (TSS)
Total solids (TS)
Dissolved oxygen (DO)
Biochemical oxygen demand (BOD) (1991-92)
pH
Conductivity
Nitrate-nitrogen + nitrite-nitrogen (NO_3-N+NO_2-N)
Total Kjeldahl nitrogen (TKN)
Total phosphorus (TP)

Physical stream indicators: width, depth and bank erosion

Explanatory Variables

Rainfall, humidity, solar radiation, air temperature, and wind speed
Discharge rate of Long Creek and a tributary
Rainfall at paired watersheds and Dairy 1 farmstead

Sampling Scheme

Water Supply Watershed (Figure 18):
Type: grab (site H)
Frequency and season: weekly from December through May and monthly for the remainder of the year for total solids (TS), total suspended solids (TSS), fecal coliform, fecal streptococci, temperature, conductivity, dissolved oxygen (DO), pH, and turbidity; occasional storm event sampling for total sediment

Upstream/downstream of Dairy 1 Tributary on Long Creek (Figure 18):
Type: grab (sites B and C)
Frequency and season: weekly from December through May and monthly for the remainder of the year for fecal streptococci and coliforms, temperature, pH, conductivity, turbidity, dissolved oxygen (DO), total suspended solids (TSS), total phosphorus (TP), total kjeldahl nitrogen (TKN), and nitrate + nitrogen (NO_2+NO_3)

Annual biological survey for sensitive species at station C only

Dairy 1 Farmstead Storm Event:
Type: grab (sites D and E)
Frequency and season: weekly all year for fecal streptococci and coliforms, temperature, pH, conductivity, dissolved oxygen (DO), total suspended solids (TSS), total solids (TS), total kjeldahl nitrogen (TKN), nitrate + nitrogen (NO_2+NO_3), and total phosphorus (TP); storm events for total suspended solids (TSS), total solids (TS), total kjeldahl nitrogen (TKN), nitrate + nitrogen (NO_2+NO_3), and total phosphorus (TP)

Paired Cropland Watersheds (Figure 18):
Type: storm event (sites F and G)
Frequency and season: stage-activated storm event for runoff, total suspended solids (TSS), total solids (TS), total kjeldahl nitrogen (TKN), nitrate + nitrite (NO_2+NO_3), and total phosphorus (TP)

Single Downstream Station at Watershed Outlet (Figure 18):
Type: grab (site I)
Frequency and season: weekly from December through May and monthly for the rest of the year for temperature, pH, conductivity, turbidity, dissolved oxygen (DO), total suspended solids (TSS), total phosphorus (TP), total kjeldahl nitrogen (TKN), nitrate + nitrite (NO_2+NO_3), and fecal streptococci and coliforms; annual biological for sensitive species

Monitoring Scheme for the Long Creek 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Single downstream	Water supply watershed	Total solids Total suspended solids Fecal coliform Fecal streptococci	Discharge (weekly)	Weekly (Dec.-May) Monthly	Annually	2 yrs pre-BMP 6 yrs BMP
Upstream/ downstream	Dairy 1 Tributary in Long Creek	Total phosphorus Nitrate + nitrite Total Kjeldahl nitrogen Total suspended solids Fecal coliform Fecal streptococci	Discharge (weekly)	Weekly (Dec. - May) Monthly (June-Nov.)	Annually (downstream)	2 yrs pre-BMP 4 yrs BMP 2 yrs post-BMP
Upstream/ downstream	Dairy 1 Farmstead	Total phosphorus Nitrate + nitrite Total solids Total suspended solids Fecal coliform Fecal streptococci	Discharge (continuous) Rainfall	Weekly and storm event		2 yrs pre-BMP 2 yrs post-BMP
Paired	Paired cropland watershed	Total phosphorus Nitrate + nitrite Total solids Total Kjeldahl nitrogen	Discharge (continuous) Rainfall	Storm event		2 yrs pre-BMP 6 yrs post-BMP
Single downstream	Watershed outlet	Total phosphorus Nitrate + nitrite Total Kjeldahl nitrogen Total suspended solids Fecal coliform Fecal streptococci	Discharge (continuous)	Weekly (Dec.-May) Monthly (June-Nov.)	Annually	2 yrs pre-BMP 6 yrs BMP

Modifications Since Project Started

In May - June, 1994, four monitoring wells were installed at the paired watershed to gain a better understanding of ground water movement. Approximately 16 wells above Site B are also being installed on a Biosolids Application site.

Progress Towards Meeting Goals

The water quality monitoring stations have been established and two years of data have been collected. Also, climatic and flow measurements are being made at several points in the watershed.

Water Quality Data Management and Analysis

Data are stored locally at the county Extension Service office. The data are also stored and analyzed at North Carolina State University using the U.S. Environmental Protection Agency's (USEPA) NonPoint Source Management System software. The North Carolina Division of Environmental Management will also store the water quality data in the USEPA STORET system. Data will be shared among all participating agencies for use in their data bases. Data analysis will involve performing statistical tests for detection of long term-trends in water quality.

NPSMS Data Summary

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3600	1700	810
Fecal Streptoccoci 9230C	U	CFU/100ML	3700	1400	270
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	.53	.49	.45
Nitrogen, Kjeldahl, Total (MG/L as N)	S		.3	.22	.15
Phosphorus, Total (MG/L as P)	S		.3	.18	.1
Total Suspended Solids (2540c 17th SMEWWW)	U	MG/L	8	5.0	4.0

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3400	1350	940
Fecal Streptoccoci 9230C	U	CFU/100ML	4150	1650	495
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	.56	.51	.46
Nitrogen, Kjeldahl, Total (MG/L as N)	S		.35	.22	1.7
Phosphorus, Total (MG/L as P)	S		.29	.2	.13
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	11	7	3

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	81000	31000	7700
Fecal Streptoccoci 9230C	U	CFU/100ML	28000	10000	2600
Flow, Stream, Instantaneous, CSF	S	CFS	.169	.04	.018
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	2.7	2.085	1.405
Nitrogen, Kjeldahl, Total (MG/L as N)	S		3.2	1.3	.615
Phosphorus, Total (MG/L as P)	S		.745	.45	.285
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	145	102	90
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	44.5	12.5	2

NPSMS Data Summary (Continued)

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	485000	60000	21000
Fecal Streptoccoci 9230C	U	CFU/100ML	215000	42500	8150
Flow, Stream, Instantaneous (CFS)	S	CFS	.171	.075	.042
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	3.275	1.925	1.28
Nitrogen, Kjeldahl, Total (MG/L as N)	S		12.00	2.80	1.65
Phosphorus, Total (MG/L as P)	S		2.865	.815	.59
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	309	139	114
Total Suspended Solids	U	MG/L	71.5	13	3

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	910	630	270
Fecal Streptoccoci 9230C	U	CFU/100ML	1300	360	100
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	75	68	61
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	8	5	3

Modifications Since Project Started

Several ground water monitoring wells have been added. Beginning in the spring of 1996, selected grab samples will be analyzed for cryptosporidium, giardia, and E. coli.

TOTAL PROJECT BUDGET

The estimated budget for the Long Creek Watershed National Monitoring Program project for the life of the project is:

Project Element	Funding Source ($) Federal	State	Local	Sum
Proj Mgt	340,300	147,360	98,240	585,900
I & E	0	20,000	80,000	100,000
L T	0	370,000	80,000	450,000
WQ Monit	561,186	0	12,000	573,186
TOTALS	901,486	537,360	270,240	1,709,086

Source: Jennings et al., 1992

Modifications Since Project Started

A 319(h) grant has been awarded to provide cost share for BMP implementation.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

State (and probably federal) USDA - Agricultural Conservation Program cost share programs will be essential for the implementation of BMPs. The provisions of the North Carolina Water Supply Watershed Protection Act (see section below) and the threat of additional regulation will motivate dairy farmers to implement animal waste management and erosion control BMPs.

OTHER PERTINENT INFORMATION

The North Carolina Water Supply Watershed Protection Act, as applied to this class of watershed, requires that 1) agricultural activities within one-half mile and draining to the water intake maintain at least a 10-foot vegetated buffer or equivalent control and 2) animal operations of more than 100 animal units must use BMPs as determined by the North Carolina Soil and Water Conservation Commission. Other regulations in the Act apply to activities such as forestry, transportation, residential development, and sludge application.

Project contributors are listed below:

- Landowners
- North Carolina Cooperative Extension Service
- Gaston County Cooperative Extension Service
- Natural Resources Conservation Service (NRCS)
- Gaston Soil & Water Conservation District
- North Carolina Division of Soil and Water Conservation
- United States Geological Survey
- Gaston County Quality of Natural Resources Commission
- North Carolina Division of Environmental Management
- Consolidated Farm Service Agency (CFSA)

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Oklahoma

Peacheater Creek
Section 319
National Monitoring Program Project

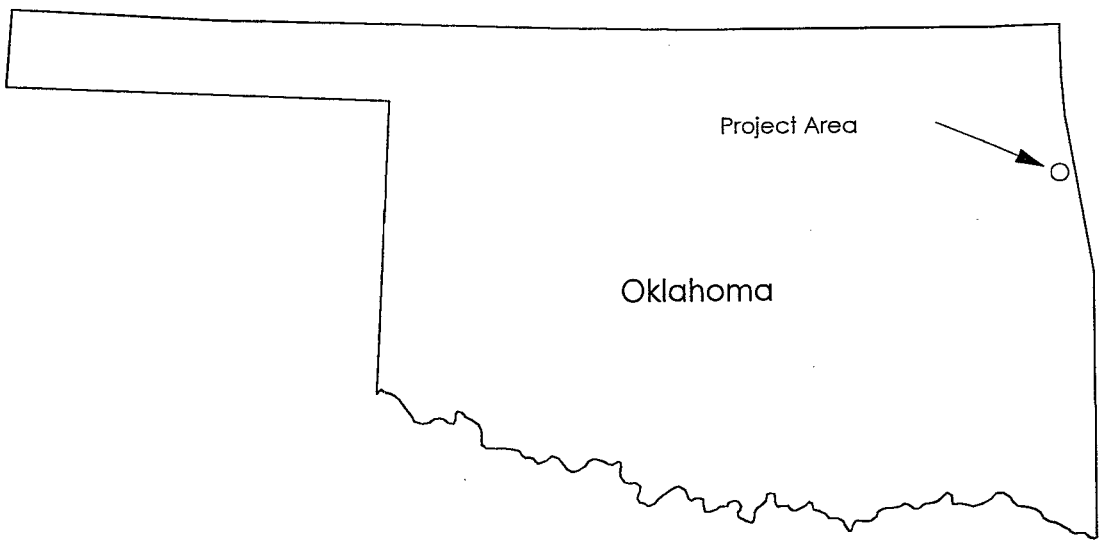

Figure 19: Peacheater Creek (Oklahoma) Project Location

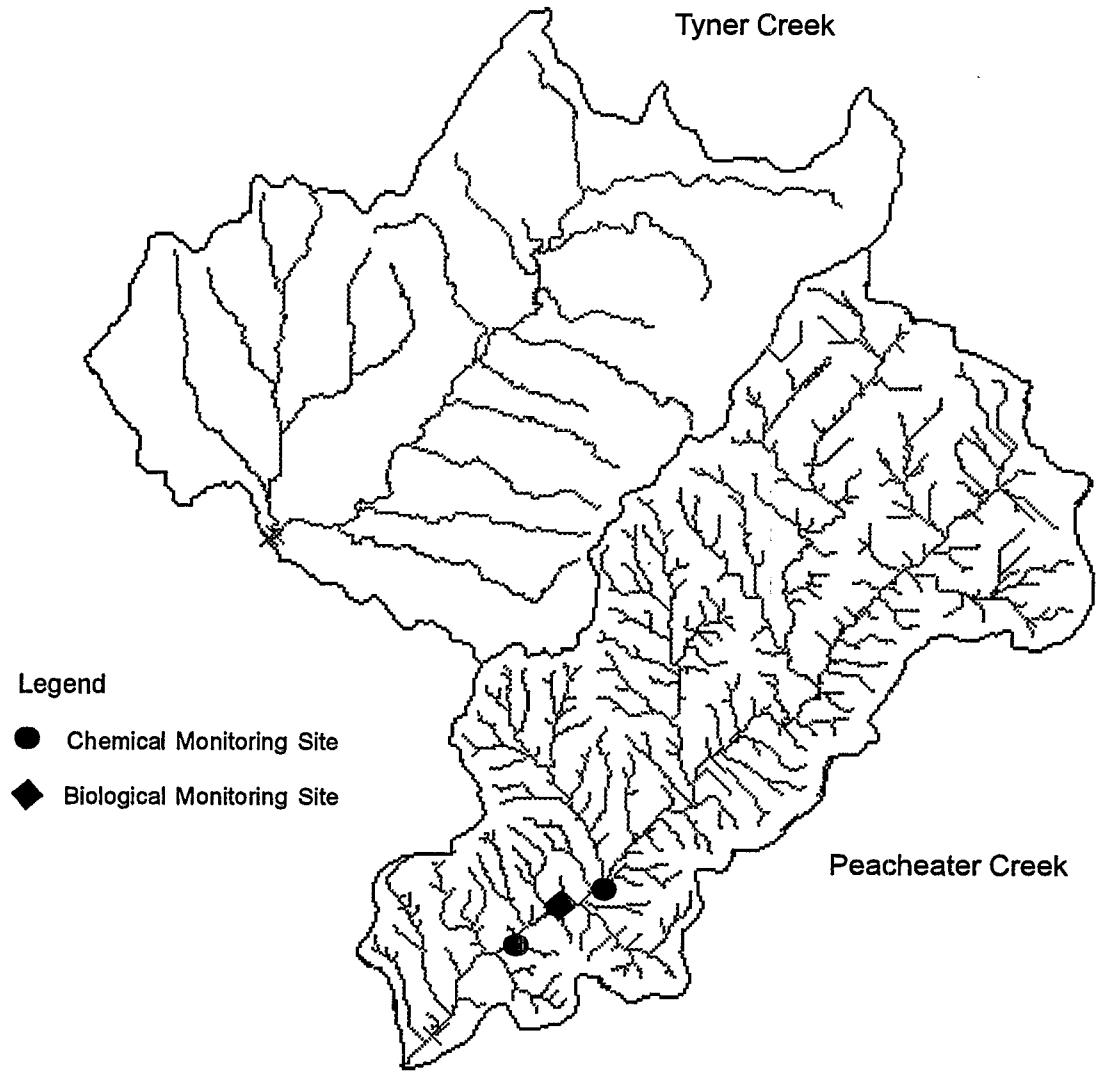

Figure 20: Water Quality Monitoring Stations for Peacheater Creek (Oklahoma) Watershed

PROJECT OVERVIEW

Peacheater Creek is located in eastern Oklahoma. The watershed is primarily pastureland and forestland with little cropland and rangeland. There are 51 poultry houses and 9 dairies in the watershed, along with 1200 beef cattle. Fish and macroinvertebrate habitat quality is impaired by large gravel bars generated from streambank erosion. Cattle traffic and forestry activities are thought to be major contributors to streambank erosion. Baseflow monitoring shows intermittent nutrient levels that contribute to creek eutrophication. Eutrophication impacts downstream of Peacheater Creek include nuisance periphyton growth in the Illinois River and phytoplankton blooms in Lake Tenkiller.

The project has completed an extensive natural resource and stream corridor inventory. Data from the inventory has been digitized and mapped in a geographic information system. A distributed parameter watershed model has been used for determining critical areas for treatment. Critical areas are pasturelands, riparian areas, and dairies. Nutrient management planning is underway to improve poultry and dairy waste utilization on cropland and pastureland. A paired watershed study is planned using chemical variables. Biological and habitat monitoring is planned for tributaries and the main stem stream.

PROJECT DESCRIPTION

Water Resource Type and Size

Water resources of concern are the Illinois River and Lake Tenkiller, a downstream impoundment of the river. The project water resource is Peacheater Creek, a fourth order stream, with baseflow ranging from 5 to 10 cubic feet per second. Peacheater Creek flows into the Illinois River upstream of Lake Tenkiller.

Water Uses and Impairments

Peacheater Creek is used for recreation and aquatic life support. Such use of Peacheater Creek is impaired by nutrient enrichment and loss of in-stream habitat. The Illinois River has been degraded by loss of water clarity and nuisance periphyton growth. Lake Tenkiller has had phytoplankton blooms and the hypolimnion becomes anoxic during the summer.

Pre-Project Water Quality

Baseflow monitoring for both Peacheater Creek (treatment watershed) and Tyner Creek (control watershed) for 1990-1992 shows that dissolved oxygen levels are high (e.g. generally well above 5 mg/l), indicating little concern about oxygen demanding pollutants. Turbidity was very low, with all samples taken less than 8 NTU. Specific conductivities range from 120 to 183. Nitrate-nitrogen concentrations for Peacheater Creek range from 0.82 mg/l to 3.4 mg/l. Nitrate-nitrogen levels, if near 3 mg/l, may be considered elevated if significantly above background for the area. Total Kjeldahl nitrogen (TKN) levels range from the detection limit of 0.2 mg/l to 1.5 mg/l. Eleven of the thirty TKN observations were equal to or greater than 0.3 mg/l, which is sufficient organic nitrogen to promote eutrophication. Generally, total Kjeldahl nitrogen (TKN) concentrations for Tyner Creek were lower than for Peacheater Creek. Three of the thirty baseflow samples showed total phosphorus (TP) levels were above 0.05 mg/l, which may be considered a minimum level for eutrophication. Storm sample TP concentrations are likely to be higher.

Both Peacheater and Tyner Creeks have poor in-stream habitat. Large chert gravel bars cover expansive portions of the streambed in Peacheater Creek. These gravel bars continue to grow and shift after major runoff events. The gravel covers natural geologic and vegetative substrates, reducing habitat quality for macro-

invertebrates and fish. Peacheater Creek has extensive streambank erosion due to forestry activities and cattle traffic.

Current Water Quality Objectives

Restore recreational and aquatic life beneficial uses in Peacheater Creek and minimize eutrophication impacts on the Illinois River and Lake Tenkiller.

Project Time Frame

1995 to 2000

Project Approval

Approved October, 1995

PROJECT AREA CHARACTERISTICS

Project Area

The Peacheater Creek watershed area is 16,209 acres. The creek drains to the Illinois River which then becomes Lake Tenkiller.

Relevant Hydrologic, Geologic and Meteorological Factors

Average baseflow for Upper Tyner and Peacheater Creeks is 5-10 cubic foot per second.

Rocks in the project area are chert rubble. Surface rocks are from the Boone Formation, the Osage Series, and the Mississippian Age.

Project area soils are generally sandy loams and silt loams with high infiltration rates. Typical slopes range from 2-5%, and a large portion of the watershed is steeply sloped land.

Land Use

Land Use	%
Forest land	36
Pastureland	14
Brushy pastureland	40
Cropland	3
Rangeland	7
TOTAL	100

Pollutant Source(s)

Primary sources of pollution include poultry houses and dairies in the treatment and control watersheds. Other sources of nutrients could be from septic systems by private residents. Peacheater Creek has 51 poultry houses and 9 dairies, along with 176 private residences. Upper Tyner Creek has 65 poultry houses, 7 dairies, and 150 private residences.

INFORMATION, EDUCATION, AND PUBLICITY

Several methods are being used to educate the general public and the agricultural community about pollution control and water quality management. A primary concern in the watershed is animal waste and nutrient management. Producer meetings are used to provide updates on regulations for concentrated animal feeding operations, which includes egg laying poultry operations. Records must be kept on waste cleanout operations and litter applications. Cooperative Extension Service and the US Department of Agriculture Natural Resources Conservation Service are working together to promote the use of waste holding ponds for dairies in the watershed. Soil nutrient sampling is free and is conducted to identify fields with excessive phosphorus levels. Litter testing is also available for broiler and laying operations. Litter application demonstrations are being used to illustrate nutrient management principles on bermuda grass and fescue.

Rainfall simulator studies and demonstrations have been held to show the effect of cropland best management practices (BMPs) on water quality. The effect of nutrient application rate and filter strips was demonstrated during a summer field day. Future rainfall simulator study demonstrations are planned.

Newsletters provide general information on agriculture and selected water quality topics. Producers in the watershed receive newsletters from the Adair County Extension Service and the Oklahoma Cooperative Extension Service Unit.

Annually, a three-day summer youth camp is planned to provide water quality education. An inner tubing excursion was used to show the extent and effect of streambank erosion on stream habitat quality. Youth camp participants also tested the chemical quality of Peacheater Creek using portable kits.

NONPOINT SOURCE CONTROL STRATEGY

Description

Land treatment plans include a description of BMPs already in place and the BMPs being planned for installation. Practices for dairies, poultry operations, beef operations, riparian areas, and home sites are described below.

In total, the eight dairies in the Peacheater Creek watershed have approximately 800 cows. Seven of the eight dairies have animal waste management plans. A total of seven waste management systems, including waste storage structures, are recommended, and three have been installed to date. Eight planned grazing systems have been recommended, and one planned grazing and one cell grazing system have been adopted.

There are 60 poultry houses in the watershed with a total of approximately 1,300,000 birds. Types of poultry grown in the watershed include broilers, layers, pullets, and breeder hens. Seventy five percent of the producers have current Conservation Plans of Operation. Fifteen mortality composters have been recommended and five have been installed. Buffer zones along streams have been recommended to reduce nutrient runoff from land applied manure. The current extent of buffers in the watershed is not reported. For the sole layer operation, a waste holding pond has been recommended but has not yet been constructed. Short term storage for litter is recommended when poultry house cleaning occurs during wet weather or outside the crop growth season.

There are approximately 1,200 beef cattle in the watershed. Best management practices recommended include planned grazing systems, cell grazing systems, buffer zones adjacent to streams, watering facilities, critical area vegetation, and soil testing to support nutrient management planning in pastures receiving land applied litter.

Twelve critical riparian areas have been identified. Streambank erosion has been caused by riparian area forestry practices, cattle traffic, and cattle grazing in riparian areas. Best management practices recommended include fencing, no land application of litter in riparian areas, off-site watering systems, and vegetative establishment.

WATER QUALITY MONITORING

Design

Monitoring will be done at the outlet of one control watershed (Tyner Creek) and one treatment watershed (Peacheater Creek). The chemical variable monitoring design at Peacheater Creek is the paired watershed and single outlet (before and after). Biological monitoring of both streams will be used to assess subwatershed impact and recovery. Bank erosion will be monitored on the entire length of each stream.

Variables Measured

Biological

Periphyton productivity
Fisheries survey
Macroinvertebrate survey
Intensive and extensive habitat assessment
Bank erosion and soil bank sampling

Chemical

Dissolved oxygen (DO)
Specific conductance (SC)
pH
Alkalinity
Turbidity
Total Kjeldahl nitrogen (TKN)
Nitrate + nitrite nitrogen (NO_2 and NO_3)
Total phosphorus (TP)
Total suspended solids (TSS)
Sulfate
Chloride
Hardness

Explanatory Variables

Stream discharge
Precipitation

Sampling Scheme

Chemical variables will be monitored weekly from July through January, monthly during February through June, and during storm events, for a duration of 20 weeks. Storm event monitoring is stage-activated and samples are taken on the rising and falling limbs of the hydrograph. Concentration samples are flow-weighted composites.

Biological monitoring varies considerably with assemblage being sampled. Periphyton productivity will be measured in the summer and the winter. Macroinvertebrates will be monitored twice per year; once in the summer and once in the winter. Fish will be monitored once per year. Intensive habitat will be monitored annually. Extensive habitat will be monitored on alternate years. Bank erosion and bank soil sampling will be monitored on alternate years.

Monitoring Scheme for the Peacheater Creek 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired	Tyner Creek[C] Peacheater Creek[T]	Periphyton productivity Fisheries survey Macroinvertebrate survey Habitat assessment Bank erosion	Stream discharge Precipitation		Summer / winter Yearly Summer / winter Alternate years Alternate years	1995-2000
		Turbidity Dissolved oxygen Total Kjeldahl nitrogen Nitrate + nitrite nitrogen Total phosphorus Total suspended solids		Weekly (July-Jan.) Monthly (Feb.-June) Storm event		

[C]Control watershed
[T]Treatment watershed

Water Quality Data Management and Analysis

Chemical variables will be entered into the U.S. Environmental Protection Agency (USEPA) STORET system, the Oklahoma Conservation Commission (OCC) Fox Pro Water Quality Data Base and OCC office library. Biological variables will be entered into the OCC Fox Pro Water Quality Data Base, the collections at the Oklahoma Museum of Natural History, and archived in the BIOS data base.

NPSMS Data Summary

The OCC will prepare data and summary statistics for entry into the USEPA Nonpoint Management System Software (NPSMS).

TOTAL PROJECT BUDGET

Currently unavailable.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

Currently unavailable.

OTHER PERTINENT INFORMATION

None.

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Pennsylvania

Pequea and Mill Creek Watershed
Section 319
National Monitoring Program Project

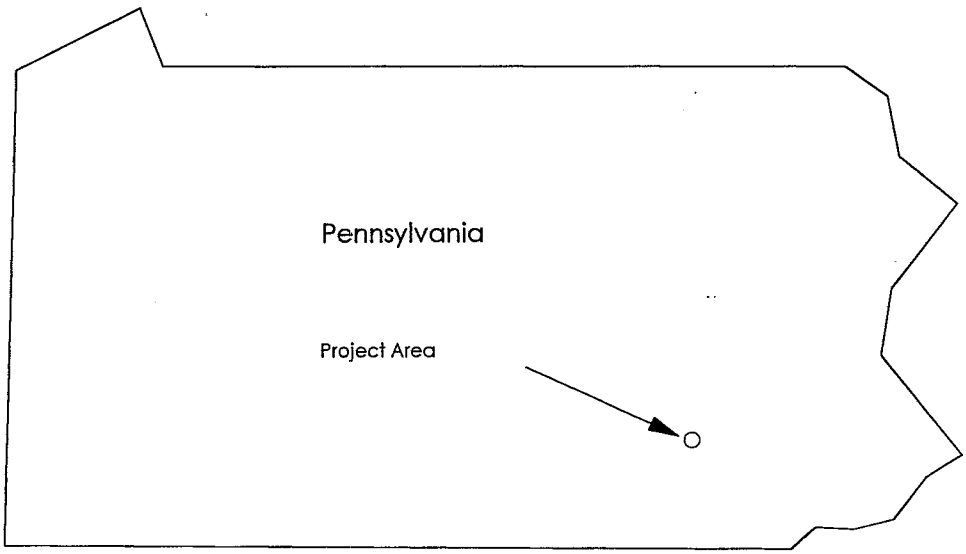

Figure 21: Pequea and Mill Creek (Pennsylvania) Watershed Project Location

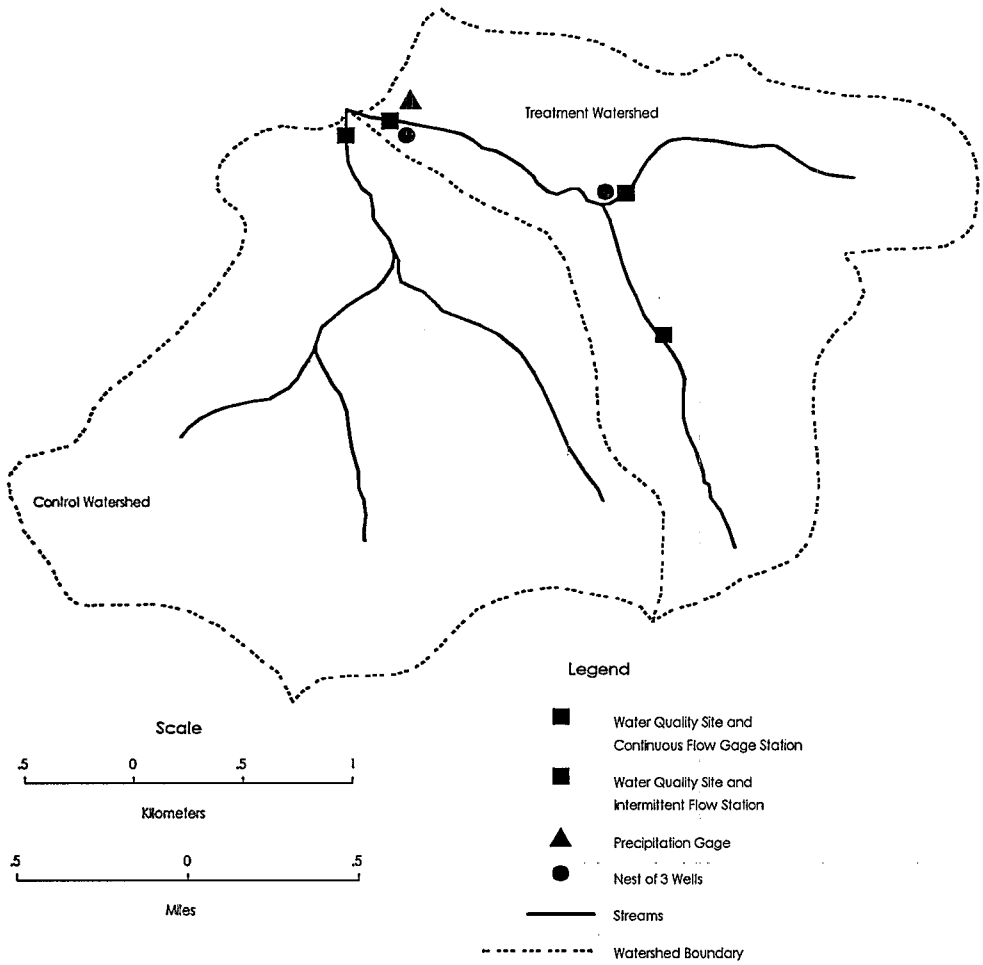

Figure 22: Water Quality Monitoring Stations for Pequea and Mill Creek (Pennsylvania) Watershed

PROJECT OVERVIEW

The Big Spring Run is a spring-fed stream located in the Mill Creek Watershed of southcentral Pennsylvania (Figure 21). Its primary uses are livestock watering, aquatic life support, and fish and wildlife support. In addition, receiving streams are used for recreation and public drinking water supply. Sampling of benthic macroinvertebrate communities indicated poor water quality at five of six sites. Other stream uses (recreation and drinking water supply) are impaired by elevated bacteria and nutrient concentrations.

Uncontrolled access of more than 220 dairy cows and heifers to each of the two watershed streams is considered to be a major source of pollutants. Pastures adjacent to streams also are thought to contribute significant amounts of nonpoint source (NPS) pollutants. Therefore, proposed land treatment will focus on streambank fencing to exclude livestock from streams. This will allow a natural riparian buffer to become established, which will stabilize streambanks and potentially filter pollutants from pasture runoff.

Water quality monitoring employs a paired watershed design in which the proposed NPS control is to implement livestock exclusion fencing on 100 percent of the stream miles in the treatment subwatershed (Figure 22). Grab samples are collected every 10 days at the outlet of each paired subwatershed from April through November. Storm event, ground water, biological, and other monitoring is planned to help document the effectiveness of fencing in the treatment subwatershed.

PROJECT DESCRIPTION

Water Resource Type and Size

The study area encompasses about 2.8 and 2.7 miles of tributary streams in the treatment and control subwatersheds, respectively. Onetime measurements of summer base flow documented discharges of 0.81 and 2.24 cfs at the outlets of the treatment and control subwatersheds.

Water Uses and Impairments

Sampling of benthic macroinvertebrates at three sites in each subwatershed indicated poor water quality (organic enrichment) except for the most upstream site in the treatment subwatershed. The subwatershed streams have relatively high nutrient and fecal coliform concentrations that contribute to use impairments of receiving waters.

Pre-Project Water Quality

Onetime baseflow grab sampling at four and seven locations in the control and treatment subwatershed are presented in tabular form:

	Fecal coliform	TP (mg/l)	OP (mg/l)	TKN (mg/l)	NO_3+NO_2 (mg/l)
Treatment	1,100-38,000	.06-.25	.03-.15	.3-1.6	10-18
Control	10,000	.02-.04	.01-.03	.1-.3	4-12

Current Water Quality Objectives

The overall objective is to document the effectiveness of livestock exclusion fencing at reducing NPS pollutants in a stream. Another objective is to reduce annual total ammonia plus organic nitrogen and total phosphorus loads from the project watershed by 40 percent.

Modifications Since Project Initiated

None.

Project Time Frame

October, 1993 to September, 1998-2003

Project Approval

July, 1993

PROJECT AREA CHARACTERISTICS

Project Area

Total area is 3.2 square miles (mi^2); Control = 1.8 mi^2; Treatment = 1.4 mi^2

Relevant Hydrologic, Geologic, and Meteorologic Factors

The average annual precipitation is 43 inches. The watershed geology consists of deep well-drained silt-loam soils underlain by carbonate rock. About five percent of each subwatershed is underlain by noncarbonate rock.

Land Use

Type	Control Watershed		Treatment Watershed	
	Acres	%	Acres	%
Agricultural	922	80	762	85
Urban	150	13	116	13
Commercial	80	7	18	2
Total	1152	100	896	100

Source: *Pequea and Mill Creek Watersheds Project Proposal*, 1993.

Pollutant Source(s)

The primary source of pollutants is believed to be pastured dairy cows and heifers with uncontrolled access to stream and streambanks. Approximately 260 and 220 animals are pastured in the treatment and control watersheds. It is estimated that grazing animals deposit an average of 40 pounds of nitrogen and 8 pounds of phosphorus annually per animal.

Other (commercial and urban) sources of pollutants are considered insignificant.

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

The Lancaster Conservation District and the Pennsylvania State University Cooperative Extension Service maintain active information and education (I&E) programs in the area. Also, as part of the Pequea-Mill Creeks Hydrologic Unit Area (HUA), the landowners in the watersheds will receive additional efforts.

Progress Towards Meeting Goals

The Pennsylvania State University Cooperative Extension Service has produced an educational video which includes information about the project and participating farmers.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

The control strategy involves installing streambank fencing on 100 percent of the pasture land adjacent to the stream draining the treatment subwatershed. All of the farmers in this watershed have agreed to install fencing. A stabilizing vegetative buffer is expected to develop naturally soon after the fencing is installed.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

The project is still in pre-BMP phase.

WATER QUALITY MONITORING

Design

The water quality monitoring effort is based on a paired watershed experimental design (Figure 22).

Modifications Since Project Started

None.

Variables Measured

Biological

Habitat survey
Benthic invertebrate monitoring

Chemical and Other

Suspended sediment (SS)
Total and dissolved ammonia plus organic nitrogen
Dissolved ammonia (NH_3-N)
Dissolved nitrate + nitrite (NO_3-N + NO_2-N)
Dissolved nitrite (NO_2-N)
Total and dissolved phosphorus (TP)
Dissolved orthophosphorus (OP)
Fecal streptococcus bacteria (only during base flow)

Explanatory Variables

Continuous streamflow
Continuous precipitation
Ground water level

Sampling Scheme

Continuous Streamflow Sites (3):
Type: grab and storm event composite
Frequency and season: grab every 10 days from April through November. Monthly grab December through March. Ten to 15 composite storm flow samples per year will also be collected.

Partial Streamflow Site (1):
Type: grab
Frequency and season: every 10 days from April through November. Monthly grab December through March.

Ground Water:
Type: grab
Frequency and season: monthly and analyzed for nitrate.

Habitat and benthic invertebrate surveys are conducted twice per year, preferably during May and August, at the outlet of each subwatershed and at points upstream in the treatment subwatershed.

Continuous streamflow at watershed outlets and one tributary site and partial streamflow at one upstream site.
Continuous precipitation amount is recorded at one site.
Additionally, ground water level is continuously monitored in four to eight wells.

Monitoring Scheme for the Pequea and Mill Creek 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired watershed	Treatment watershed Control watershed	Habitat survey Benthic invertebrate survey Suspended sediment Total organic nitrogen Ammonia Nitrate + nitrite Nitrite Total phosphorus and Dissolved phosphorus Orthophosphorus Fecal streptococcus bacteria	Discharge (continuous) Precipitation Ground water level	Sampling every 10 days from April to November Storm event samples (2-15)	Twice per year (May & August)	3 yrs pre-BMP 5 yrs post-BMP

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

Data are stored and maintained locally by U.S. Geological Survey (USGS), entered into the USGS WATSTORE database and STORET. Data will also be entered into the U.S. Environmental Protection Agency's (USEPA) NonPoint Source Management System (NPSMS) software and submitted to USEPA Region III.

NPSMS Data Summary

STATION TYPE: Control Station **PRIMARY CODE:** 01576521

CHEMICAL PARAMETERS

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FECAL, STREP KF AGAR	S	COLS/100ML	5,720	3,580	2,190
FLOW, STREAM, INSTANTANEOUS, CFS	S	CFS	2.2	1.8	1.4
NITROGEN, AMMONIA+ORGANIC DISSOLVED	S	MG/L AS N	0.30	<0.20	<0.20
NITROGEN, KJEDAHL, TOTAL	S	MGL/ N	0.05	0.04	0.02
NITROGEN, NITRITE DISSOLVED	S		0.40	0.30	<0.20
NITROGEN, $NO_2 + NO_3$ DISSOLVED	S	MG/L AS N	0.04	0.03	0.02
NO. COWS IN PASTURE PER 24 HRS PER ACRE	U	COWDAY/AC			
OXYGEN, DISSOLVED	S	MG/L	10.8	10.1	9.4
PASTURE STREAM MILES FENCED	U	MI	0	0	0
PHOSPHORUS, DISSOLVED	S	MG/L AS P	0.04	0.03	0.02
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE	S	MG/L AS P	0.03	0.03	0.02
PHOSPHORUS, TOTAL	S	MG/L AS P	0.08	0.04	0.03
PRECIPITATION, TOTAL (INCHES PER DAY)	S		0.64	0.31	0.11
SUSPENDED SEDIMENT	S	MG/L	107	84	20
TEMPERATURE, WATER (DEGREES CENTIGRADE)	S		15.9	15.2	12.5
TOTAL ALKALINITY AS CALCIUM CARBONATE	S	MG/L CAC03			
TOTAL NITROGEN APPLICATION/ACRE TO WATERSHED	U	N/ACRE			
TOTAL P APPLICATION/ACRE FOR WATERSHED	U	P/ACRE			
TURBIDITY, HACH TURBIDIMETER (FORMAZIN TURB UNIT)	S				

STATION TYPE: Study Station **PRIMARY CODE:** 01576529

CHEMICAL PARAMETERS

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
FECAL, STREP KF AGAR	S	COLS/100ML	98,320	10,880	1,710
FLOW, STREAM, INSTANTANEOUS, CFS	S	CFS	1.5	0.9	0.6
NITROGEN, AMMONIA+ORGANIC DISSOLVED	S	MG/L AS N	0.42	0.30	0.20
NITROGEN, AMMONIA, DISSOLVED	S	MG/L AS N	0.06	0.035	0.03
NITROGEN, KJEDAHL, TOTAL	S	MG/L AS N	0.70	0.55	0.38
NITROGEN, NITRITE DISSOLVED	S	MG/L AS N	0.07	0.06	0.05
NITROGEN, $NO_2 + NO_3$ DISSOLVED	S	MG/L AS N	12.2	11.0	9.4
NO. COWS IN PASTURE PER 24 HRS PER ACRE	U	COWDAY/AC			
OXYGEN, DISSOLVED	S	MG/L	12.4	11.4	9.8
PASTURE STREAM MILES FENCED	U	MI	0	0	0
PHOSPHORUS, DISSOLVED	S	MG/L AS P	0.06	0.025	0.02
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE	S	MG/L AS P	0.05	0.025	0.02
PHOSPHORUS, TOTAL	S	MG/L AS P	0.10	0.06	0.04
PRECIPITATION, TOTAL (INCHES PER DAY)	S		0.64	0.31	0.11
SUSPENDED SEDIMENT	S	MG/L	54	26	6
TEMPERATURE, WATER (DEGREES CENTIGRADE)	S		20.5	18.7	13.0
TOTAL ALKALINITY AS CALCIUM CARBONATE	S	MG/L CAC03			
TOTAL NITROGEN APPLICATION/ACRE TO WATERSHED	U	N/ACRE			
TOTAL P APPLICATION/ACRE FOR WATERSHED	U	P/ACRE			
TURBIDITY, HACH TURBIDIMETER (FORMAZIN TURB UNIT)	S				

NPSMS Data Summary (Continued)

STATION TYPE: Control Station PRIMARY CODE: 01576521

BIOLOGICAL PARAMETERS (Non-Chemical)

Parameter Name	Parm Type	Reporting Units	Expl. Var.	INDICES Fully	INDICES Threatened	INDICES Partially	Max. Pot.	Reason. Attn.	Ref/ BPJ
EPT INDEX	U	SCORE	N	6	4	1	11.00	6.00	B
EPT/CHIRONOMIDE ABUNDANCE	U	RATIO	N	2.0	0.6	0.2	13.00	2.00	B
HILSENHOFF BIOTIC INDEX (HBI)	U	SCORE	N	0.00-6.5	6.51-8.5	8.51-10	0.00	5.00	B
PERCENT DOMINANT TAXA	U	PERCENT	N	20	35	50	10.00	20.00	B
SCRAPERS/FILTER COLLECTORS	U	RATIO	N	0.8	0.4	0.2	3.00	0.80	B
SPECIES RICHNESS	U	COUNT	N	20	11	10	30.00	20.00	B

STATION TYPE: Study Station PRIMARY CODE: 01576529

BIOLOGICAL PARAMETERS (Non-Chemical)

Parameter Name	Parm Type	Reporting Units	Expl. Var.	INDICES Fully	INDICES Threatened	INDICES Partially	Max. Pot.	Reason. Attn.	Ref/ BPJ
EPT INDEX	U	SCORE	N	6	4	1	11.00	6.00	B
EPT/CHIRONOMIDE ABUNDANCE	U	RATIO	N	2.0	0.6	0.2	13.00	2.00	B
HILSENHOFF BIOTIC INDEX (HBI)	U	SCORE	N	0.00-6.5	6.51-8.5	8.51-10	0.00	5.00	B
PERCENT DOMINANT TAXA	U	PERCENT	N	20	35	50	10.00	20.00	B
SCRAPERS/FILTER COLLECTORS	U	RATIO	N	0.8	0.4	0.2	3.00	0.80	B
SPECIES RICHNESS	U	COUNT	N	20	11	10	30.00	20.00	B

Modifications Since Project Started

None.

Progress Toward Meeting Goals

1994 water quality data has been entered into WATSTORE and NPSMS software.

TOTAL PROJECT BUDGET

Project Element	Funding Required 1993	1994	1995
Personnel	$ 57,508	$ 91,970	$ 67,656
Equipment and Supplies	20,300	5,600	5,020
Contracted Services	16,200	14,200	6,200
USGS (lab and gauging)	25,100	38,800	40,770
USGS Overhead	115,192	139,834	109,214
Other	2,000	2,000	3,000
TOTAL*	$236,300	292,404	231,860

*50% of total funds are USGS matching funds

Source: *Pequea and Mill Creek Watersheds Project Proposal*, 1993.

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The Chesapeake Bay program, which has set a goal of a 40% reduction in annual loads of total ammonia plus organic nitrogen and total phosphorus to the Bay, should have a significant impact on the project. The Bay program is expected to provide up to 100% cost-share money to help landowners install streambank fencing.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

None.

PROJECT CONTACTS

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Vermont

Lake Champlain Basin Watersheds
Section 319
National Monitoring Program Project

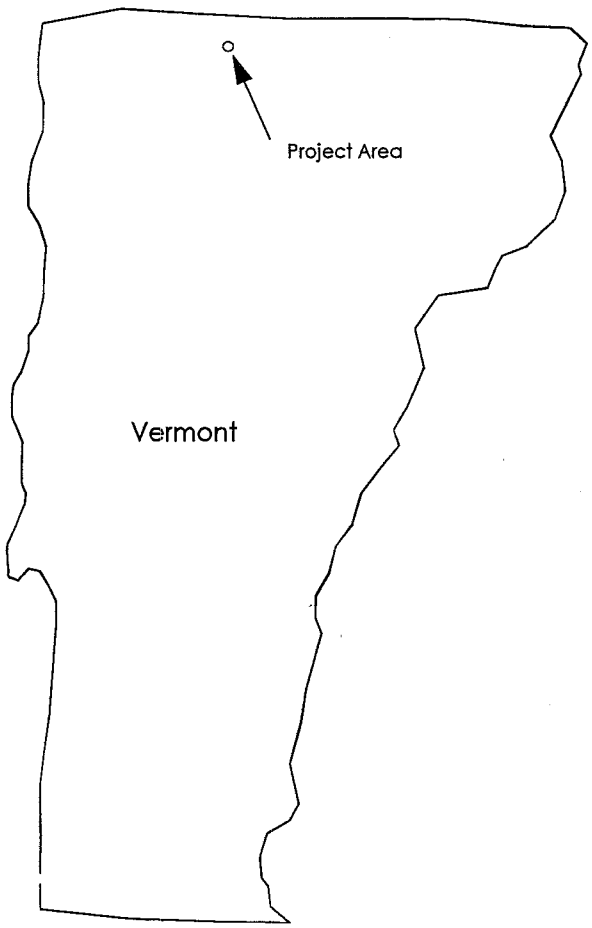

Figure 23: Lake Champlain Basin (Vermont) Watersheds Project Location

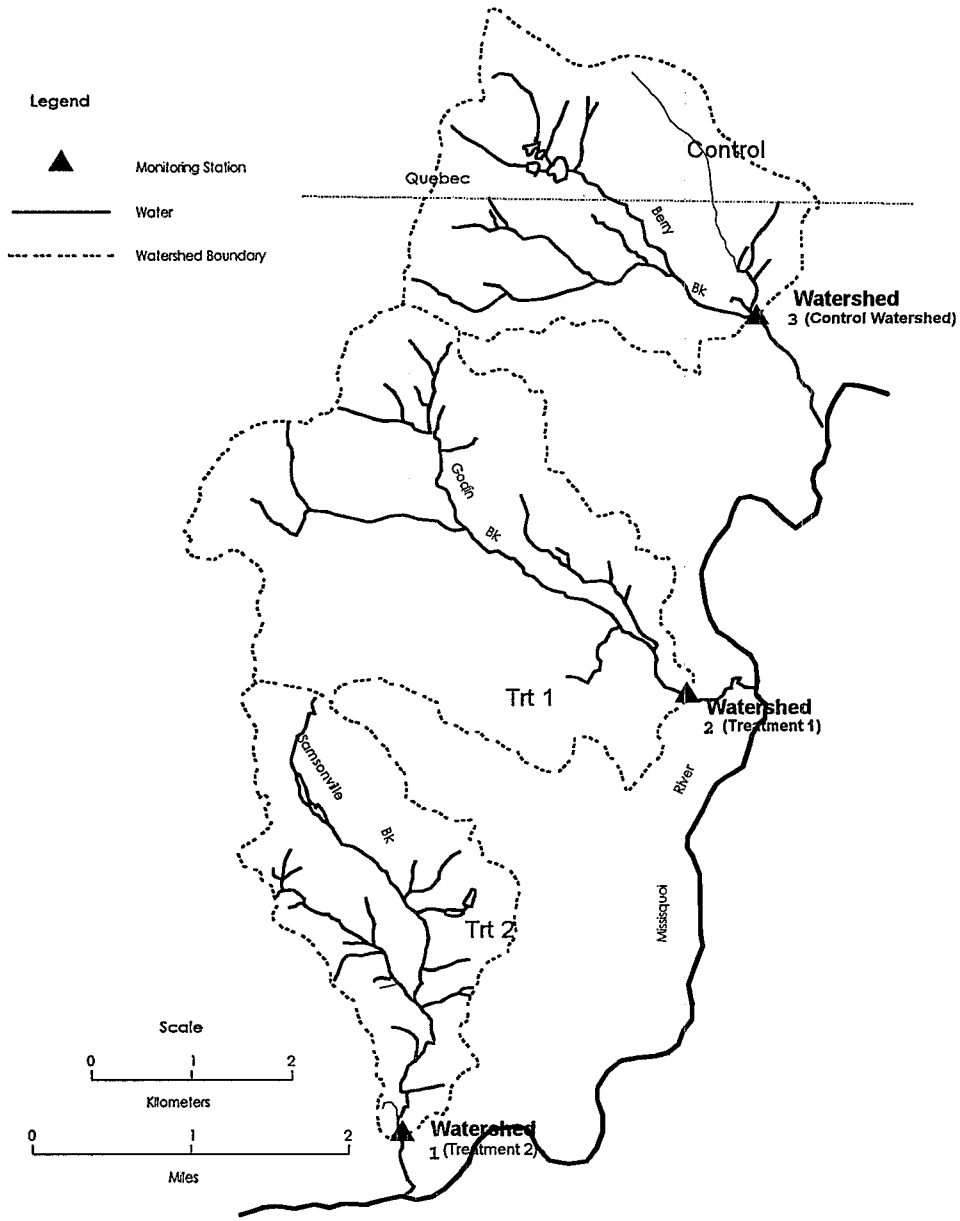

Figure 24: Water Quality Monitoring Stations for Lake Champlain Basin (Vermont) Watersheds

PROJECT OVERVIEW

The Lake Champlain Basin Watersheds Section 319 National Monitoring Program project (also known as the Lake Champlain Agricultural Watersheds Best Management Practice Implementation and Effectiveness Monitoring Project) is located in northcentral Vermont in an area of transition between the lowlands of the Champlain Valley and the foothills of the Green Mountains (Figure 23). Agricultural activity, primarily dairy farming, is the major land use in this area of Vermont.

The streams in these watersheds drain into the Missisquoi River, a major tributary of Lake Champlain. The designated uses of many of the streams in this region are impaired by agricultural NPS pollution. The pollutants responsible for the water quality impairment are nutrients, particularly phosphorus, E. coli, fecal streptococcus, fecal coliform bacteria, and organic matter. The source of most of the agricultural NPS pollution is the manure generated from area dairy farms, livestock activity within streams and riparian areas, and crop production. The Missisquoi River has the second largest discharge of water and contributes the greatest nonpoint source (NPS) load of phosphorus to Lake Champlain.

The Lake Champlain Basin Watersheds' 319 National Monitoring Program project is designed to evaluate two treatments to control the pollutants generated by agricultural activities. Treatment #1 is a system of best management practices (BMPs) to exclude livestock from selected critical areas of streams and to protect stream crossings and streambanks. Individual BMPs for treatment #1 include watering systems, fencing, the minimization of livestock crossing areas in streams, and the strengthening of the necessary crossing areas. Treatment #2 implements intensive grazing management through planned rotation of multiple pastures.

The water quality monitoring is a three-way paired design: there is one control watershed and two treatment watersheds (treatment #1 and #2) (Figure 24). The watersheds are monitored during a two-year calibration period prior to BMP implementation. Implementation monitoring will occur for one year and posttreatment monitoring will extend for three years.

Biological, chemical, and explanatory variables are being monitored during all three monitoring phases. Fish, macroinvertebrates, fecal streptococcus, fecal coliform, and E. coli bacteria are the monitored biological variables. The chemical variables monitored are total phosphorus, total Kjeldahl nitrogen, total suspended solids, dissolved oxygen, conductivity, and temperature. Two explanatory variables, precipitation and continuous discharge, are also being monitored.

Nutrients and sediment are monitored weekly in a flow-proportional composite sample. Bacteria grab samples are collected twice weekly, with concurrent in-situ measurements of temperature, dissolved oxygen, and conductivity. Macroinvertebrate communities are being sampled annually and fish are evaluated twice each year. Invertebrate and fish monitoring are also being conducted at an unimpaired reference site.

PROJECT DESCRIPTION

Water Resource Type and Size

The study streams are small second- or third-order permanent streams that drain to the Missisquoi River, a major tributary of Lake Champlain. The streams are generally 10-15 feet wide at the monitoring stations. Historical stream flow data do not exist for these streams; discharge has ranged from 1-288 cubic feet per second (cfs) since May, 1993.

Water Uses and Impairments

Because of their size, the study streams themselves are subject to very limited use for agricultural purposes (livestock watering) and recreation (swimming and fishing). No historical data exist to document support or nonsupport of these or other uses. Initial project data indicate that Vermont water quality (bacteriological) criteria for body contact recreation are consistently violated in these streams.

Early biological data for fish and macroinvertebrates indicate moderate to severe impact by nutrients and organic matter. These particular small watersheds were selected to represent agricultural watersheds in the Lake Champlain Basin, which often violate state water quality criteria (Clausen and Meals, 1989; Meals, 1990; Vermont RCWP Coordinating Committee, 1991) and contribute nutrient concentrations and areal loads that generally exceed average values reported from across the United States (Omernik, 1977) and in the Great Lakes Region (PLUARG, 1978).

The receiving waters for these streams - the Missisquoi River and Lake Champlain - have very high recreational use that is being impaired by agricultural runoff (Vermont Agency of Natural Resources, 1994). The Missisquoi River is the second largest tributary to Lake Champlain in terms of discharge (mean flow =1450 cfs) and contributes the highest annual NPS phosphorus load to Lake Champlain among the major tributary watersheds (75.1 mt/yr) (VT and NY Departments of Environmental Conservation, 1994). Lake Champlain currently fails to meet state water quality standards for phosphorus, primarily due to excessive nonpoint source loads (Vermont Agency of Natural Resources, 1994). About 66% of the NPS phosphorus load to Lake Champlain is attributed to agricultural land (Budd and Meals, 1994).

Pre-Project Water Quality

No historical physical/chemical data exist for the study streams. Early pretreatment monitoring data show the following ranges:

E. Coli	Fecal Coliform (#/100 ml)	Fecal Strep.
10 - 66,000	2 - 49,000	10 - 200,000

TP (mg/l)	TKN (mg/l)	TSS (mg/l)
0.05 - 1.05	0.32 - 2.08	2 - 150

(Note: these values represent the range observed in May, 1994 - June, 1995.)

Current Water Quality Objectives

The overall goal of the project is a quantitative assessment of the effectiveness of two livestock/grazing management practices in reducing concentrations and loads of nutrients, bacteria, and sediment from small agricultural watersheds. Major water quality objectives are to: 1) Document changes in sediment, nutrient, and bacteria concentrations and loads due to treatment at the watershed outlets; and 2) Evaluate response of stream biota to treatment.

Modifications Since Project Initiation

None.

Project Time Frame

September 1993 - September, 1999 (Approximate)

Project Approval

September 1993

PROJECT AREA CHARACTERISTICS

Project Area

1705 ac (WS 1) + 3513 ac (WS 2) + 2358 ac (WS 3) = 7576 ac

Relevant Hydrologic, Geologic, and Meteorologic Factors

The project area is in northcentral Vermont (Franklin County) in an area of transition between the lowlands of the Champlain Valley and the foothills of the Green Mountains. Average annual precipitation is about 41 inches; average annual temperature is about 42°F. Frost-free growing season averages 118 days.

Most of the watershed soils are till soils, loamy soils of widely variable drainage characteristics. There are significant areas of somewhat poorly drained silt/clay soils in the lower portions of the watersheds.

Land Use

The three watersheds are generally similar in land use:

	WS1		WS2		WS3	
Land Use	Acres	%	Acres	%	Acres	%
Corn/hay	369	22%	860	25%	569	24%
Pasture/ hay-pasture	60	4%	426	12%	167	7%
Forest	1135	67%	2118	60%	1408	60%
Other	141	8%	110	3%	213	9%

Source: 1993 CFSA aerial photography, unverified

Pollutant Source(s)

Nonpoint sources of pollutants are from streambanks, degraded riparian zones, and dairy-related agricultural activities, such as field-spread and pasture-deposited manure and livestock access. Some agricultural point sources such as milkhouse waste or corn silage leachate are thought to exist.

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

Pre-project activity included letters to all watershed agricultural landowners followed by small "kitchen table" meetings with farmers in each watershed. The purpose of these meetings was to assess landowner interest and acceptance of the project.

Two articles have been published in the weekly county newspaper concerning the project. A semiannual project newsletter was initiated in the summer of 1995.

In July, 1994, a monitoring station "open-house" was held to present the project, monitoring hardware, and some early monitoring results.

The first annual winter lunch meeting was held in February, 1995, where watershed farmers discussed the project and heard a talk by a local farmer engaged in rotational grazing.

The project includes a Project Advisory Committee with representatives from United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), Extension, Vermont Dept. of Agriculture, Vermont Dept. of Environmental Conservation, Vermont Natural Resources Conservation Council, U.S. Fish and Wildlife Service, the Vermont Pasturelands Outreach Program, and a watershed dairy farmer. The committee meets quarterly to review progress and assist in program direction.

Progress Towards Meeting Goals

Because the project is in the beginning of a two-year pretreatment calibration phase, information and education efforts will focus on laying the groundwork for treatment by presenting demonstrations and information concerning rotational grazing and livestock access control. Additional contact with farmers will occur through routine collection of agricultural management data.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Design

The project is designed to test two treatments: 1) livestock exclusion/streambank protection, and 2) intensive grazing management. In the first treatment watershed, work will focus on selective exclusion of livestock from the streams, improvement or elimination of heavily used stream crossings, and revegetation of streambanks. This treatment requires fencing, watering systems, minimizing livestock crossing areas, and strengthening necessary crossing areas.

In the second treatment watershed, intensive rotational grazing management is being implemented as a means to minimize the time spent by livestock in or near the streamcourse without complete exclusion.

During the two years of pretreatment monitoring, treatment needs are being assessed, specific plans and specifications are being developed, and agreements with landowners are being pursued. It is anticipated that the project will provide 100% cost support for cooperating landowners. Agricultural management activity - both routine and treatment implementation - are monitored by farmer record-keeping and semiannual interviews.

It is also anticipated that some work will be done as necessary on agricultural point sources if and when such pollutant sources are identified.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

The water quality monitoring component of the project is fully operational and is currently meeting project goals. A severe drought and elevated temperatures during June and July, 1995 have slightly interfered with chemical and physical monitoring, and may have some lasting influence on biological communities in the monitored streams.

Land use/agricultural activity monitoring is lagging somewhat behind schedule. A baseline farm inventory has been completed and the watersheds were flown for aerial videography in June, 1995 to update land use/land cover and to assess and classify stream corridors as part of an evaluation of treatment needs. The process of identifying specific treatment needs, designs, and negotiating agreements with landowners will begin in the fall of 1995.

The principal impediment to project progress is funding, both mechanism and quantity. While in principle, Section 319 National Monitoring Program funding is intended to be set up for the entire project period, this has not been the case in this project. The requirement to renew funding each year causes significant problems, including accounting confusion over fiscal vs. project vs. monitoring "years", inefficient expenditure of staff time, and, most importantly, difficulty in accounting for and documenting required match. This is a particular problem in the implementation budget, since actual implementation (and associated match) will not take place until project year 3, while funds have been allocated in project year 1 and 2 budgets. Budgeting over the entire project lifetime would substantially alleviate these problems.

The other financial impediment to the project involves significant increases in charges for sample analysis from the state Department of Environmental Conservation (DEC) laboratory. These costs have increased dramatically (on the order of $11,000 - $16,500 per year) since the first funding year and, with no corresponding increase in overall funding, other budget categories have had to be cut. In the current FY96 budget, this has required elimination of all nonsignificant principal investigator support, limiting available time commitment to the project. The increase in analytical costs also reduces the previous match contributions from DEC. Annual funding from U.S. Environmental Protection Agency (USEPA), however, has been essentially level and nonnegotiable for the last two years. Some flexibility in funding, i.e. increasing USEPA funding to cover such cost increases, would be helpful.

WATER QUALITY MONITORING

Design

The study is based on a three-way paired watershed design, with a control watershed and one watershed for each of the two treatments to be evaluated (Figure 24). The design calls for two years of pretreatment calibration, one year of implementation, and three years of posttreatment monitoring.

Modifications Since Project Started

None.

Variables Measured

Biological

E. coli bacteria
Fecal coliform bacteria
Fecal streptococcus bacteria
Macroinvertebrates
Fish

Chemical and Other

Total phosphorus (TP)
Total Kjeldahl nitrogen (TKN)
Total suspended solids (TSS)
Dissolved oxygen (DO)
Conductivity
Temperature

Explanatory Variables

Precipitation
Discharge (continuous)

Sampling Scheme

Automated sampling stations are located at three watershed outlets for continuous recording of streamflow, automatic flow-proportional sampling, and weekly composite samples for sediment and nutrients. The watersheds are as follows: WS1 is the rotational grazing (treatment #2), WS2 is the streambed protection (treatment #1), and WS3 is the control (Figure 24). Twice-weekly grab samples for bacteria are collected. Concurrent in-stream measurement of temperature, dissolved oxygen, and conductivity also occur at the same time that the grab samples are collected. Three precipitation gauges have been installed. All monitoring systems operate year-round.

The macroinvertebrate community at each site and a fourth "background reference" site are sampled annually using a kick net/timed effort technique. Methods and analysis follow USEPA's Rapid Bioassessment Protocols (Protocol III). Fish are sampled twice a year by electroshocking and evaluated according to Rapid Bioassessment Protocols Protocol V.

Physical habitat assessments are performed during each sampling run.

Monitoring Scheme for the Lake Champlain Basin Watersheds 319 National Monitoring Program Project

Design	Site or Activities	Primary Variables	Covariates	Frequency of WQ Sampling	Frequency of Biological Assessment	Duration
Three-way paired watershed	Samsonville Brook[T] Godin Brook[T] Berry Brook[C]	E. coli bacteria Fecal coliform Fecal streptococcus Macroinvertebrates Fish survey Total phosphorus Total Kjeldahl nitrogen Total suspended solids Dissolved oxygen Conductivity Temperature	Precipitation Discharge (continuous)	Weekly except bacteria temperature, dissolved oxygen, and conductivity which will be twice weekly	Fish sampled twice per year Macroinvertebrates sampled once per year	2 yrs pre-BMP 1 yr BMP 3 yrs post-BMP

[T]Treatment watershed
[C]Control watershed

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

Primary data management is done by an in-house spreadsheet system. The USEPA Nonpoint Source Management System (NPSMS) software will be used to track and report data to USEPA when it is upgraded to handle three watersheds and a version provided that runs on the available PC. Requisite data entry into STORET and BIOS has been completed through file transfer. Biological data are being formatted for transfer to BIOS.

Water quality data are being compiled and reported for quarterly project advisory committee meetings, including basic plots and univariate statistics. For annual reports, data is analyzed on a water-year basis.

Data analysis is being performed using both parametric and nonparametric statistical procedures in standard statistical software.

NPSMS Data Summary

Monitoring Station Parameters Report

DATE: 08/04/95 PERIOD: 5/94 - 6/95

STATION TYPE: Treatment Watershed #1 (Samsonville Brook)

CHEMICAL PARAMETERS

Parameter Name	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
CONDUCTANCE	uS/CM	120	95	80
E. COLI	CFU/100ML	200	120	24
FECAL COLIFORM	CFU/100ML	180	82	26
FECAL STREPTOCOCCUS	CFU/100ML	1040	300	60
FLOW, STREAM, WEEKLY MEAN	CFS	3.7	2.3	1.4
OXYGEN, DISSOLVED	MG/L	13.0	11.8	9.9
PRECIPITATION, TOTAL	IN/WEEK	0.58	0.29	0.07
NITROGEN, TOTAL KJELDAHL	MG/L	1.24	1.00	0.69
PHOSPHORUS, TOTAL	MG/L	0.160	0.076	0.052
TEMPERATURE, WATER	oC	0.8	9.1	17.1
TOTAL SUSPENDED SOLIDS	MG/L	59.6	26.8	13.8

STATION TYPE: Treatment Watershed #2 (Godin Brook)

CHEMICAL PARAMETERS

Parameter Name	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
CONDUCTANCE	uS/CM	139	117	90
E. COLI	CFU/100ML	4500	610	39
FECAL COLIFORM	CFU/100ML	4450	600	41
FECAL STREPTOCOCCUS	CFU/100ML	1200	520	50
FLOW, STREAM, WEEKLY MEAN	CFS	7.7	4.8	3.1
OXYGEN, DISSOLVED	MG/L	13.1	11.5	9.7
PRECIPITATION, TOTAL	IN/WEEK	0.76	0.40	0.09
NITROGEN, TOTAL KJELDAHL	MG/L	1.15	0.89	0.66
PHOSPHORUS, TOTAL	MG/L	0.185	0.088	0.037
TEMPERATURE, WATER	oC	18.0	10.4	2.3
TOTAL SUSPENDED SOLIDS	MG/L	36.0	14.4	5.2

NPSMS Data Summary (Continued)

STATION TYPE: Treatment Watershed #3 (Berry Brook)

CHEMICAL PARAMETERS

Parameter Name	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
CONDUCTANCE	uS/CM	130	111	94
E. COLI	CFU/100ML	3850	490	33
FECAL COLIFORM	CFU/100ML	2800	630	31
FECAL STREPTOCOCCUS	CFU/100ML	1900	405	60
FLOW, STREAM, WEEKLY MEAN	CFS	9.2	5.9	3.7
OXYGEN, DISSOLVED	MG/L	12.6	10.6	9.2
PRECIPITATION, TOTAL	IN/WEEK	0.75	0.48	0.12
NITROGEN, TOTAL KJELDAHL	MG/L	1.06	0.77	0.68
PHOSPHORUS, TOTAL	MG/L	0.179	0.058	0.040
TEMPERATURE, WATER	oC	17.4	10.6	2.7
TOTAL SUSPENDED SOLIDS	MG/L	31.0	8.6	5.0

Modifications Since Project Started

None.

Progress Towards Meeting Goals

PROJECT BUDGET

The estimated budget for the Lake Champlain Basin Watersheds National Monitoring Program project for years 1-3 is:

Project Element	Funding Source ($) Federal	State	University	Sum
LT	106,100	3,400	22,400	131,900
WQ Monit	273,400	85,500	75,600	434,500
TOTALS	379,500	88,900	98,000	566,400

Source: Don Meals (Personal Communication), 1994
(Dollar figures are rounded.)

Modifications Since Project Started

Project budget continues to be renewed yearly.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The project area is within the area of the Lake Champlain Basin Program (a program modeled after the Chesapeake Bay Program), directed toward the management of Lake Champlain and its watershed. Considerable effort on agricultural NPS control is associated with this program, including funding for pollution control/prevention demonstration projects.

Additionally, the state of Vermont's phosphorus management strategy calls for targeted reductions of phosphorus loads from selected subbasins of Lake Champlain.

Because this 319 National Monitoring Program project contributes to two ongoing projects (the Lake Champlain Basin Program and the phosphorus reduction program), it is anticipated that some support - technical assistance, funding, or other - will be actively sought from these programs.

Modifications Since Project Started

Two other activities may contribute to this project. The U.S. Fish and Wildlife Service has an active riparian zone restoration program, *Pastures for Wildlife,* in the area. The UVM Extension Pasturelands Outreach Program is engaged in active promotion and technical assistance in implementing rotational grazing in northern Vermont. Individuals from other programs serve on the Project Advisory Committee.

OTHER PERTINENT INFORMATION

None.

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Washington

Totten and Eld Inlet
Section 319
National Monitoring Program Project

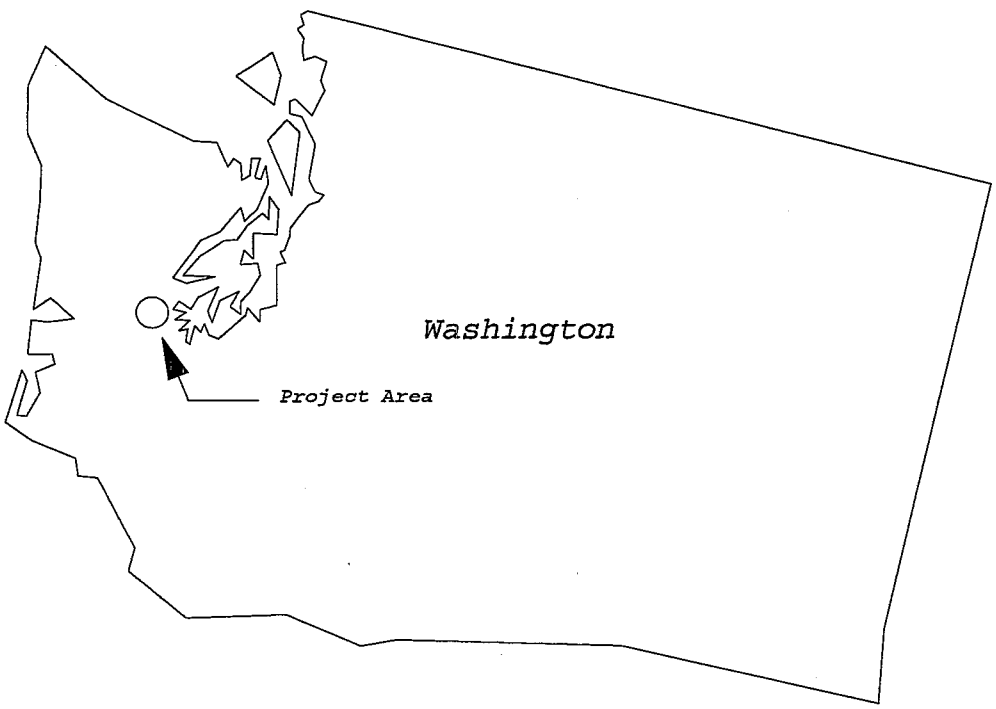

Figure 25: Totten and Eld Inlet (Washington) Project Location

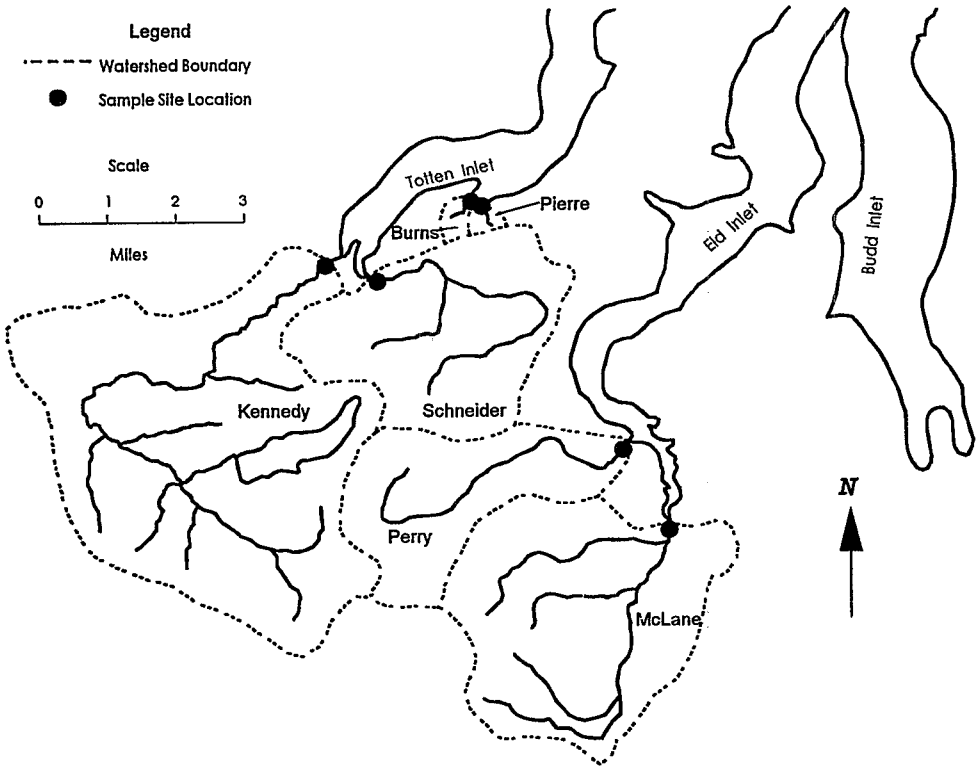

Figure 26: Water Quality Monitoring Stations for Totten and Eld Inlet (Washington)

PROJECT OVERVIEW

Totten and Eld Inlets are located in southern Puget Sound (Figure 25). These adjacent inlets are characterized by enriched marine waters that make them exceptional shellfish production areas. The rural nature of the area makes it an attractive place in which to live. Consequently, stream corridors and shoreline areas have experienced considerable urban, suburban, and rural growth in the past decade. Located in the area are many recreational, noncommercial farms that keep varying numbers of large animals (primarily horses). Upland and lowland areas are highly productive forest lands.

The most significant nonpoint source pollution problem in these inlets is bacterial contamination of shellfish production. Totten Inlet is currently classified as an approved shellfish harvest area but is considered threatened due to bacterial nonpoint source pollution. The southern portion of Eld Inlet is currently classified as conditional for shellfish harvest. This conditional classification means shellfish may not be harvested for 3 days following rain events that are greater than 1.25 inches in 24 hours. The major sources of fecal coliform (FC) bacteria are failing on-site wastewater treatment systems and livestock-keeping practices along stream corridors and marine shorelines.

The Totten and Eld Inlet Clean Water Projects have evolved from the combined efforts and resources of local and state government. Watershed action plans were completed in 1989 for both Totten and Eld Inlet. While a significant level of public involvement and planning has occurred, material resources for implementing on-the-ground best management practices (BMPs) have been scarce. In 1993, substantial funding from property assessments and grants provided funds to implement remedial actions in targeted areas within these watersheds. The goal of the remedial efforts is to minimize the impacts of nonpoint source pollution by implementing farm plans on priority farm sites and identifying and repairing failing on-site wastewater treatment systems. These focused efforts are expected to last into 1999.

In 1993, a water quality monitoring program was started to evaluate the effectiveness of remedial land treatment practices on water quality. This monitoring effort was formalized in 1995 into a U.S. Environmental Protection Agency (USEPA) Section 319 National Monitoring Program project. The monitoring effort targets six sub-basins within the larger Totten and Eld Inlet watersheds. The goals of water quality monitoring are to detect, over time: 1) trends in water quality and implementation of land treatment practices, and 2) associated changes in water quality to changes in land treatment practices. A paired watershed design is being used for two basins while a single site approach will be used for four basins. Water quality monitoring has been and will continue to be conducted from November to April on a weekly basis for at least 20 consecutive weeks each year. Fecal coliform bacteria, suspended solids, turbidity, flow, and precipitation are the main variables of interest. Best management practices are also being tracked.

PROJECT DESCRIPTION

Water Resource Type and Size

Totten/Little Skookum and Eld Inlets are estuaries separated by peninsulas in southern Puget Sound. The total drainage basin for the two inlets is approximately 67,200 acres. Six sub-basins have been selected for this monitoring project. They are as follows:

Burns	150 acre single site
Kennedy	13,000 acre paired site
Pierre	80 acre single site
Schneider	4,000 acre paired site
McLane	9,600 acre single site
Perry	4,000 acre single site

Water Uses and Impairments

Important beneficial uses of the Totten and Eld Inlet marine waters include shellfish culturing, finfish migration and rearing, wildlife habitat, and primary and secondary contact recreation.

Important beneficial uses of the freshwater streams that drain into the Totten and Eld Inlets include: finfish migration, spawning, and rearing; domestic and agricultural water supply; primary and secondary contact recreation; and wildlife habitat.

Pre-Project Water Quality

Three of the six project streams (Burns, Pierre and Schneider) failed to meet water quality standards for fecal coliform bacteria for the 1992-93 and 1993-94 monitoring seasons. The water quality standard for fecal coliform (FC) bacteria for these streams requires that the geometric mean value not exceed 50 cfu/100 mL and that not more than 10% of samples exceed 100 cfu/100 mL.

Site	Class	GMV		Part 1 meet standard?		% samples greater than Part 2 of standard		Part 2 meet standard?	
		92-93	93-94	92-93	93-94	92-93	93-94	92-93	93-94
Burns	AA	94	206	No	No	35	74	No	No
Kennedy	AA	5	6	Yes	Yes	0	0	Yes	Yes
Pierre	AA	52	55	No	No	22	42	No	No
Schneider	AA	24	17	Yes	Yes	17	11	No	No
McLane	A	37	27	Yes	Yes	4	4	Yes	Yes
Perry	A	14	10	Yes	Yes	0	0	Yes	Yes

Class AA Standard: Part 1—geometric mean value (GMV) shall not exceed 50 colonies/100mL. Part 2—not more than 10% of the samples used for calculating the GMV shall exceed 100 colonies/100mL.

Class A Standard: Part 1—geometric mean value shall not exceed 100 colonies/100mL. Part 2—not more than 10% of the samples used for calculating the GMV shall exceed 200 colonies/100mL.

Current Water Quality Objectives

Pierre Creek

- reduce median FC concentration by 69% (reduce to 10 cfu/100mL)

Burns Creek

- reduce median FC concentration by 63% (reduce to 20 cfu/100 mL)

Schneider Creek

- reduce median FC concentration by 50% (reduce to 10 cfu/100 mL)

McLane Creek

- reduce median FC concentration by 44% (reduce to 22 cfu/100 mL)

Project Time Frame

1993 to 2002

Project Approval

1995

PROJECT AREA CHARACTERISTICS

Project Area

The Totten and Eld Inlets Section 319 National Monitoring Program project area consists of six sub-basins within the Totten and Eld Inlets. The Totten watershed is approximately 44,300 acres and the Eld Inlet watershed is approximately 22,900 acres.

Relevant Hydrologic, Geologic and Meteorologic Factors

The topography of the project area includes the rugged Black Hills area southwest of the city of Olympia, upland prairies, fresh and estuarine wetlands, high and low gradient stream reaches, and rolling hills. Pleistocene glacial activity was the most recent major land forming process.

The predominant till formations generally consist of compact silts and clays.

Wet, mild winters and warm, dry summers are characteristic of the Puget Sound region. The climate and precipitation of the project area are similar. Rainfall ranges from about 50 to 60 inches per year, depending on elevation and longitude. The precipitation received in the areas mostly occurs between October and April.

Land Use

Land Use	Totten/Little Skookum Inlet	Eld Inlet
Forest	82.0%	63.0%
Residential	4.3%	6.3%
Agriculture	5.0%	5.1%
Public Use	0.3%	5.1%
Undeveloped	7.5%	19.8%
Other	0.9%	0.7%

Pollutant Source(s)

The major sources of fecal coliform bacteria are failing on-site wastewater treatment systems and livestock-keeping practices along stream corridors and marine shorelines. Wet season (October-April) soil saturation hampers the ability of many on-site systems to operate correctly. Saturated soils and stormwater runoff also contribute to water quality problems associated with overgrazed pastures, manure-contaminated runoff, and livestock access to streams. The major source of pollution in the monitoring sub-basins is considered to be animal-keeping practices.

INFORMATION, EDUCATION, AND PUBLICITY

There are a variety of educational and informational activities within the project counties (Thurston and Mason Counties) that address land and water stewardship. Local and state initiatives over the past six years have resulted in stewardship activities that cover the spectrum of personal commitment activities, including awareness, learning, experience, and personal action programs. Many educators involved with these activities share ideas, resources, and programs through a stewardship-focused Regional Education Team.

A Section 319 Clean Water Act grant funded a watershed resident survey in August, 1994. The survey explored public awareness and opinions regarding water quality and environmental issues. The survey targeted the Totten and Eld Inlet watersheds in southern Puget Sound as well as northern Puget Sound watersheds in Whatcom, Skagit, and Snohomish counties. Approximately 1300 residents responded to the mail survey. The survey was designed to help state and local governments evaluate levels of public awareness and effectiveness of current educational programs, and determine where educational efforts, and efforts to involve the public, should be directed (Elway Research, 1994).

The objective of the project's public involvement and education component is to participate in and lend support to established public information and education activities addressing environmental stewardship in the project areas and in the larger South Puget Sound area.

NONPOINT SOURCE CONTROL STRATEGY

Description

The nonpoint source treatment in the project area is designed to minimize the impacts of nonpoint source pollution by repairing failing on-site wastewater treatment systems and implementing farm plans on priority farm sites. Priority farm sites are those farms that potentially threaten the quality of a receiving water due to a variety of physical and managerial properties such as closeness to stream, numbers of animals, and lack of pollution prevention practices. The nonpoint source control strategy involves surveying all potential pollution sources in critical areas, estimating the water quality impact, and finally planning and implementing corrective actions.

Resource management plans (farm plans) are developed cooperatively by the landowner and local conservation districts. The farm planning process identifies potential water quality impacts and recommends BMPs to mitigate those impacts. District staff and the landowner discuss implementation costs and schedules of BMPs and cost-share opportunities. The landowner then chooses what he or she is willing to implement and agrees to implement the plan as funding allows. Specific BMPs most likely to be employed for nonpoint source control in project watersheds include pasture and grazing management, stream fencing, stream buffer zones, rainwater and runoff management, livestock density reduction, and animal waste management. Monies from the Farm Service Agency, State Revolving Fund, U.S. Fish and Wildlife Service, and other sources may be available for cost-share or low interest loan contracts.

Voluntary participation (due to education/outreach activities and local ordinances) is anticipated to be the major mechanism for implementation of farm plans. Farm owners who have impacts on water quality and do not comply with local ordinances become involved in a formal compliance procedure, which is outlined by a memorandum of agreement between the Ecology Water Quality Program and each conservation district. Legal recourse is seldom needed.

WATER QUALITY MONITORING

Design

A paired watershed approach is being used for the Kennedy/Schneider sub-basins to document the change in water quality as a result of BMP implementation. Kennedy is a background (control) sub-basin, while Schneider is the treatment basin (Figure 26). A single site approach will be used for Burns, Pierre, Perry and McLane sub-basins (Figure 26).

Variables Measured

Chemical and Other

Biological

Fecal coliform

Explanatory Variables

Conductivity
Daily precipitation
Flow
Temperature
Total suspended solid (TSS)
Turbidity

Sampling Scheme

Water quality monitoring is conducted from early November through mid-April. Grab samples will be collected on a weekly schedule (Tuesdays) for at least 20 consecutive weeks each year of the project. Up to six additional samples will be collected each season during runoff events at each site. The rain-event sampling is based on the criterion of previous 24-hour precipitation amounting to greater than 0.2 inches. The sample sites are located at the mouth of each stream. Historically, sampling has occurred at this location.

The Puget Sound Protocols for freshwater and general quality assurance/quality control (Tetra Tech, 1986) will be followed for water sample collection, identification, preservation, storage, and transport. Replicate samples (two samples taken from the same location at nearly the same time) for at least 10% of the total number of laboratory samples will be taken and analyzed each week. All sample sites are represented every sampling season.

Monitoring Scheme for the Totten and Eld Inlet 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of Primary Variable Sampling	Duration
Single downstream	Burns Pierre Perry McLane	Fecal coliform	Conductivity Daily precipitation Flow Temperature Total suspended solids Turbidity	Weely (Nov. to mid-April) during storms	Schneider Burns Pierre: 1 yr. pre-BMP 3 yrs BMP 2 yrs post-BMP Perry: 3 yrs pre-BMP 3 yrs BMP 1 yr post-BMP McLane: 1 yr pre-BMP 5 yrs BMP 1 yr post-BMP
Paired watershed	Kennedy/ Schneider	Fecal coliform			

Water Quality Data Management and Analysis

Water quality data will be stored and managed in spreadsheet formats and later transferred to USEPA's STORET and NonPoint Source Management System (NPSMS) databases. Other reporting formats for the Ecology Water Quality Program and local use may involve spreadsheet tabulation and graphic presentations. Data evaluation and analysis strategies include:

- Determining statistically significant temporal trends in water quality by comparison of 95% Confidence Interval about seasonal medians using notched boxplots (single site approach); linear regression of monthly or seasonal medians over time, and the significance of slope tested to indicate a decreasing trend of FC concentrations over time (single site approach); change in linear relationship of FC concentrations between paired basins (paired watershed approach); and, comparison of frequencies of water quality standards violations between years.
- Determining temporal trends in BMP implementation by: bar graph of BMPs (individual or grouped) implemented over time; and plot of cumulative histogram of BMPs implemented over time (individual measures or groups of measures).
- Evaluating combined water quality and BMP trends by: linear regression of FC as a function of BMPs (individually or grouped) such as livestock management, acres treated, farm plans implemented, and streambank protected; and, graphical expression of water quality and BMP information plotted over the same time scale (e.g. seasonal median FC values with cumulative histogram of fully implemented farm plans).

NPSMS Data Summary

Currently unavailable.

TOTAL PROJECT BUDGET

The estimated budget for the Totten and Eld Inlet National Monitoring Program project for the period of FY 1993 - 1999 (six years):

Project Element	Funding Source ($)			
	Federal	State	Local	Total
Proj Mgt	NA	NA	NA	NA
I&E	NA	NA	NA	NA
LT	NA	300,000	100,000	400,000
WQ Monit	250,000	50,000	NA	300,000
TOTALS	250,000	350,000	100,000	700,000

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

In response to increased and persistent closures of shellfish harvest areas and threats to close additional areas, state and local groups developed the Shellfish Protection Initiative (SPI). This program provides $3 million from State Referendum 39 funds for implementing BMPs in targeted watersheds. The Totten Basin, a targeted watershed, will receive $1.3 million in grant funds as part of the SPI. Eld Inlet, although not selected as an SPI project, will receive $260,000 from the SPI program to augment ongoing NPS control efforts in specific areas. In addition, $331,000 will be targeted for farm planning and implementation activities in the Eld watershed from 1996 to 1999.

OTHER PERTINENT INFORMATION

None.

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Wisconsin

Otter Creek
Section 319
National Monitoring Program Project

Figure 27: Otter Creek (Wisconsin) Project Location

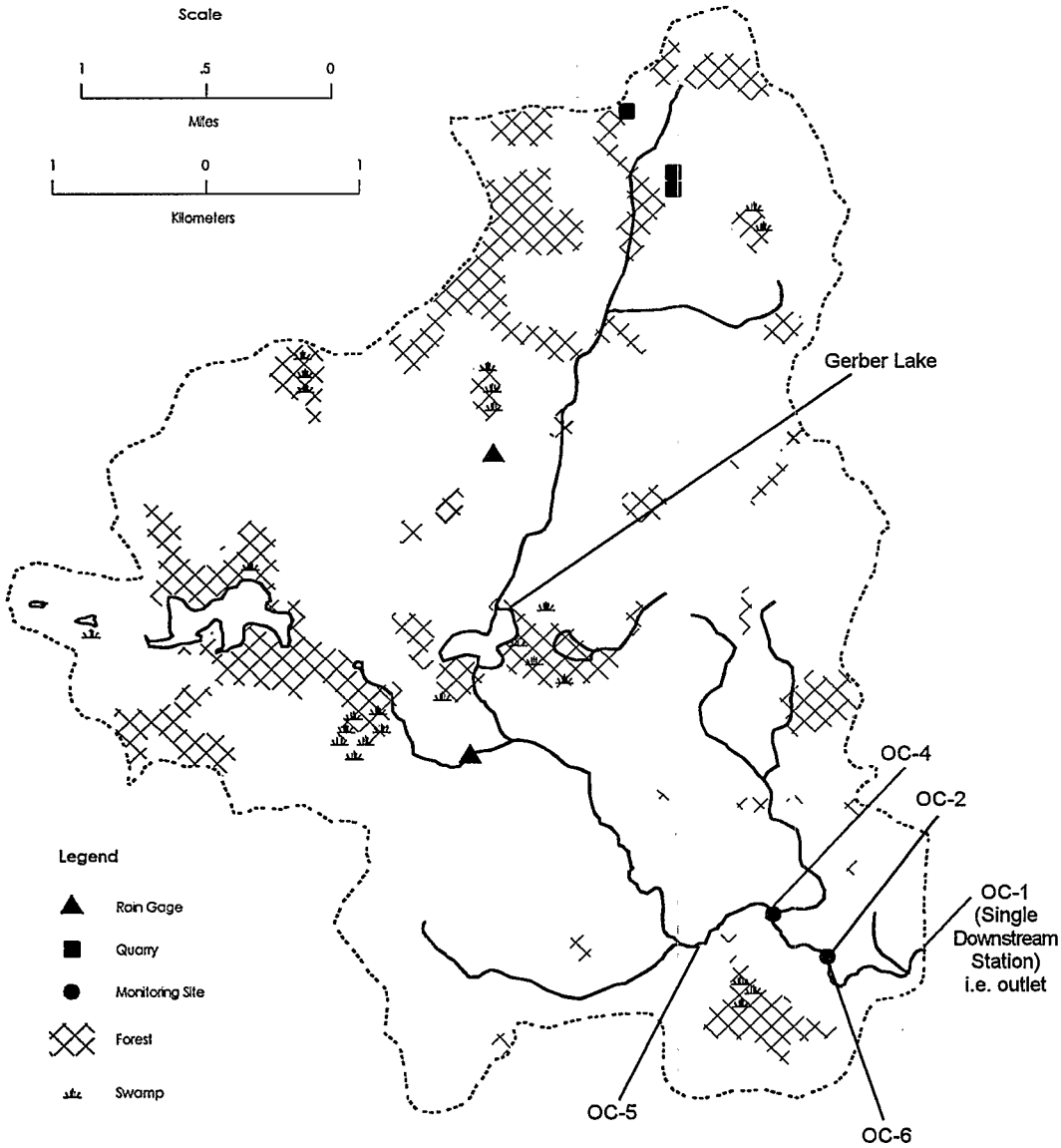

Figure 28: Water Quality Monitoring Stations for Otter Creek (Wisconsin)

PROJECT OVERVIEW

The Otter Creek Section 319 National Monitoring Program project is in east central Wisconsin (Figure 27), with a project area of 11 square miles. Otter Creek drains into the Sheboygan River, which then drains into Lake Michigan. Land use mainly consists of dairies and croplands.

Otter Creek has a warmwater forage fishery. The fish community is degraded by lack of cover, disturbed streambanks, and siltation. Fecal coliform levels frequently exceed the state standard of 400 counts per 100 ml, and dissolved oxygen often drops below 2 mg/l during runoff events. Otter Creek delivers high concentrations of phosphorus and fecal coliform to the Sheboygan River. These pollutants then travel to the near shore waters of Lake Michigan, which serves as a water supply for municipal use and also supports recreational fisheries.

Streambed sediments originating from cropland erosion, eroding streambanks, and overgrazed dairy pastures are reducing the reproductive potential for a high quality fishery with abundant forage fish. Otter Creek is further degraded by total phosphorus and fecal coliform export from dairy barnyards, pastures, cropland, and alfalfa fields. The mean concentration of 22 runoff events is 104 mg/l for suspended solids and 0.39 mg/l for total phosphorus.

Critical area criteria are being used to reduce phosphorus and sediment loading to project area streams. Five of the six dairy operations in the project area were classified as critical; two of the five critical dairy operations spread enough manure that their cropland was classified as critical. Streambank critical areas are the 6,200 feet of streambank trampled by cattle.

Land treatment design is based on the pollutant type and the source of the pollutant. Upland fields will be treated with cropland erosion control practices to reduce sediment loss. Streambanks are being fenced to limit cattle access, and barnyard structural practices are being installed to reduce nutrient runoff into Otter Creek.

PROJECT DESCRIPTION

Water Resource Type and Size

Otter Creek is 4.2 miles long with an average gradient of .0023 ft/ft or 12.4 ft/mile (Figure 28). The creek flows into and out of a small spring-fed lake called Gerber Lake.

Water Uses and Impairments

Otter Creek is used for fishing and for secondary body contact recreation. The fishery is impaired by degraded habitat, while contact recreation is impaired by high fecal coliform counts. Both uses are also impaired by eutrophic conditions.

Pre-Project Water Quality

The Otter Creek project area is part of the larger Sheboygan River watershed, identified as a Priority Watershed in 1985. The watershed is characterized by streambank degradation due to cattle traffic. Excessive phosphorus, fecal coliform, and sediment runoff originate from manure spreading and cropland. Fisheries are impaired because of degraded aquatic habitat that limits reproduction. Recreation is limited by degraded fisheries and highly eutrophic and organically enriched stream waters.

Current Water Quality Objectives

The Otter Creek project water quality objectives are to:

- Increase the numbers of intolerant fish species by improving the fish habitat and water quality.
- Improve the recreational uses by reducing the bacteria levels.
- Reduce the loading of pollutants to the Sheboygan River and Lake Michigan by installation of best management practices (BMPs) in the Otter Creek watershed.
- Improve the wildlife habitat by restoring riparian vegetation.

Modifications Since Project Initiation

None.

Project Time Frame

Spring, 1994 through Spring, 2001

Project Approval

July, 1993

PROJECT AREA CHARACTERISTICS

Project Area

The Otter Creek watershed area is about 11 square miles. The Meeme River is the control watershed, and its area is about 16 square miles.

Relevant Hydrologic, Geologic, and Meteorological Factors

Average annual precipitation is 29 inches. Fifteen inches of rain falls during the growing season between May and September. About 42 inches of snow (five inches of equivalent rain) falls during a typical winter.

The topography of the watershed ranges from rolling hills to nearly level. The soils are clay loams or silty clay loams that have poor infiltration and poor percolation but high fertility. Soils are glacial drift underlain by Niagara dolomite.

Land Use

Land Use	%
Agricultural	72
Forest	13
Suburban	11
Wetland	3
Water	1
Total	100

Best management practices are being installed on critical dairies. Livestock exclusion practices are also being installed.

Source: Wisconsin Department of Natural Resources, 1993a

Pollutant Source(s)

There are five critical dairy operations that serve as important pollutant sources. Trampled streambanks and cropland and pastureland receiving dairy manure are also critical sources. Some critical area cropland is in need of erosion control practice installation.

Modifications Since Project Started

None.

INFORMATION, EDUCATION, AND PUBLICITY

The Sheboygan County Land Conservation Department has developed and implemented an effective educational program to reach project dairymen. Project personnel have achieved a high level of participation through education, technical assistance, effective communication, and cost-share assistance.

Progress Towards Meeting Goals

- A watershed tour was held for landowners.
- Watershed newsletters were sent to landowners.
- The watershed advisory committee meeting was held.

NONPOINT SOURCE CONTROL STRATEGY AND DESIGN

Description

Streambank erosion and cattle access practices include shoreline and streambank stabilization; barnyard management includes barnyard runoff management and manure storage facilities; and cropland practices include grassed waterways, reduced tillage, and nutrient and pesticide management.

Modifications Since Project Started

None.

Progress Towards Meeting Goals

Five critical barnyards have installed runoff controls.

WATER QUALITY MONITORING

Design

There are three monitoring studies being conducted in the Otter Creek National Monitoring Program project. They include a paired watershed study, a single downstream station, and an above and below study (Figure 28).

There are six sampling sites on Otter Creek, and one site each at the outlet of the Meeme and Pigeon River watershed. One of the sampling sites on Otter Creek is also an outlet station that serves as the site for the single station before and after monitoring site. There are two mainstem sites above and below a critical area dairy.

The above and below watershed study is being conducted using stations OC2 and OC4. Station OC2 is below the dairy where BMPs are being installed. Station OC4 is above this dairy. Station OC5 is a background station, and station OC6 is below a dairy where BMPs are being installed.

The paired watershed study is being conducted using stations OC1 and MR1. Station OC1 is the outlet of the Otter Creek Watershed where animal waste management and nutrient management BMPs are being installed. It also serves as the monitoring site for a single downstream station study. The only station not shown on Figure 28 is MR1, which is the outlet for the Meeme River watershed. MR1 is being used as the control site for the paired watershed study.

The paired watershed study is used to assess the overall impact of best management practices on water quality. The treatment watershed is 11 square miles and is being monitored at station OC1. The control watershed area is 16 square miles of the Meeme River with monitoring station MR1. Biological, bacterial, and chemical variables are primary variables and precipitation and water discharge are covariates for the paired watershed study.

The following table provides details on the sampling design for the paired study, the upstream/downstream and the single downstream station. The monitoring sites are listed for reference. The primary variables are very similar for each study except for methods used for macroinvertebrates. The frequency of sampling, the covariates, and the duration of each study are also listed.

Modifications Since Project Started

None.

Variables Measured

Biological

Fisheries survey
Macroinvertebrate survey
Habitat assessment

Chemical

Total phosphorus (TP)
Dissolved phosphorus (DP)
Total Kjeldahl nitrogen (TKN)
Ammonia-N (NH_3-N)
Nitrogen series (NO_2-N and NO_3-N)
Turbidity
Total suspended solids (TSS)
Dissolved oxygen (DO)
Fecal coliform bacteria (FC)

Explanatory Variables

Stream discharge
Precipitation

Sampling Scheme

Automatic, continuous water chemistry sampling occurs on an event basis. The schedule for chemical grab sampling and biological and habitat monitoring varies by station and by year. Chemical grab sampling occurred at a time characterized as midsummer-fall for 1990 and 1994 and during spring-midsummer in 1991. Future plans are for spring-midsummer monitoring in 1995 and 1999 and mid-summer-fall monitoring for 1998. Fisheries, macroinvertebrate, and habitat monitoring has been scheduled for midsummer in 1990, 1994, and 1998, and for the spring of 1991, 1995, and 1999.

Fisheries monitoring includes sampling fish species, frequencies, and biomass. Fisheries data are summarized and interpreted based on the Index of Biotic Integrity (Lyons, 1992). Macroinvertebrate monitoring criteria includes macroinvertebrate species or genera and numbers. Macroinvertebrate data are summarized and interpreted using the Hilsenhoff Biotic Index (Hilsenhoff , 1987). Habitat variables include riparian buffer width, bank erosion, pool area, stream width to depth ratio, riffle-to-riffle or bend-to-bend rating, percent fine sediments, and cover for fish. Habitat information is rated using the fish habitat rating system established for Wisconsin streams by Simonson et al. (1994).

Grab and continuous samples are being used for water chemistry monitoring. Variables sampled include total phosphorus, fecal coliform bacteria, dissolved oxygen, and suspended sediments.

Monitoring Scheme for the Otter Creek 319 National Monitoring Program Project

Design	Sites or Activities	Primary Variables	Covariates	Frequency of Primary Variable Sampling	Duration
		Biological			
Paired watershed design	Otter Creek[T] OC1 Meeme River[C] MR1	Fisheries index Macroinvertebrates[H] Habitat **Bacterial & Chemical** Fecal coliform bacteria Total phosphorus Dissolved phosphorus Total Kjehldahl nitrogen Ammonia nitrogen Nitrate nitrogen Nitrite nitrogen Turbidity Total suspended solids Dissolved oxygen	Precipitation discharge	Annually Annually Annually 30 samples per monitoring season; weekly April-Oct.	1990-1999
Upstream/ downstream	Above Dairy[C] OC[4] Below DairyT OC[2]	Fisheries index Macroinvertebrates[F] Habitat Same bacterial & chemical variables as paired watershed study	Precipitation discharge	Annually Annually Annually 30 samples per monitoring season; weekly April-Oct.	1990-1999
Single downstream	Otter Creek OC[1]	Fisheries index Macroinvertebrates Habitat Same bacterial & chemical variables as paired watershed study	Precipitation discharge	Annually Annually 30 samples per monitoring season; weekly April-Oct.	1990-1999

Treatment Area[T]
Control Area[C]
Hilsenhoff Biotic Index level; kick samples[H]
Family level; kick samples[F]

Modifications Since Project Started

None.

Water Quality Data Management and Analysis

All water chemistry data is being entered into the Wisconsin DNR data management system, WATSTORE (the U.S. Geological Survey national database), U.S. Environmental Protection Agency's Nonpoint Source Management System software (NPSMS), and STORET.

NPSMS Data Summary

Not available.

Modifications Since Project Started

None.

Progress Toward Meeting Goals

The water quality data is being collected and will be added to STORET.

TOTAL PROJECT BUDGET

The total estimated cost of needed land treatment practices is $221,000. Funds through the state of Wisconsin Nonpoint Source Program will be used to fund cost-share practices. The estimated budget for the Otter Creek National Monitoring Program project for the period FY94-FY95 (2 years) is:

Project Element	Funding Source($)			
	Federal	State	Local	Total
Proj Mgt	NA	30,000	NA	30,000
LT	NA	221,000	NA	221,000
I&E	NA	2,000	NA	2,000
WQ Monit	120,000	NA	NA	120,000
TOTALS	120,000	253,000	NA	373,000

Source: Wisconsin Department of Natural Resources, 1993a (M. Miller, Personal Communication, 1994)

Modifications Since Project Started

None.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

State grants are being provided to cover the cost of land treatment technical assistance and information and educational support.

Modifications Since Project Started

None.

OTHER PERTINENT INFORMATION

Cooperating agencies include the Wisconsin Department of Natural Resources, Department of Agriculture, Trade, and Consumer Protection, Sheboygan County Land Conservation Committees, and the U.S. Geological Survey.

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Chapter 3

Proceedings of the Third Annual Section 319 National Monitoring Program Conference

Linking Land and Water: Third National Nonpoint Source Watershed Monitoring Workshop

October 2-6, 1995
Seattle, Washington

Co-sponsored by
U.S. Environmental Protection Agency
State of Washington Department of Ecology
State of Washington Water Research Center
USDA - Natural Resource Conservation Service

In cooperation with
North Carolina State University
Oregon State University

SESSION A
PROJECT PLANNING AND MANAGEMENT

Iowa's Approach to Project Planning and Management

Lynette Seigley
Iowa Department of Natural Resources-Geological Survey Bureau

Since 1991, the Sny Magill Creek Watershed has been the focus of an interagency effort to encourage landowner adoption of a wide variety of Best Management Practices and to monitor and measure the resulting improvement in water quality. The following have made the Sny Magill Project work: the interagency approach, flexibility/creativity, and communication/communication/communication.

Interagency Approach: During the planning stages of the project, all the necessary players were identified. Each agency identified resources they could and would contribute to the program. Currently, 15 agencies are involved in the project.

- Shared resources and budgets have enhanced project efforts more than individual resources or budgets would have allowed.
- An interagency approach has brought a variety of expertise to the project.
- A common message needs to be communicated by all agencies. The interagency effort to monitor a watershed forces individual agencies to think beyond their normal agency confines and to understand the project goals and how their information contributes to the big picture.
- When managing large interagency projects, it is important to give credit where credit is due.
- Acknowledge the efforts of others.

Flexibility/Creativity: Iowa State University Extension developed the phrase "Manure Happens, Take Credit" as part of their manure management program. When it comes to project planning and management, the phrase could be modified to read "Manure Happens, Make the Most of It."

- Allow for flexibility in the project. Despite the best-laid efforts in planning, not everything was anticipated and not everything has gone as planned.
- There isn't always adequate time when initially developing a project. Understand what didn't happen in the initial stages of the project that should have. How can the project implementation be adjusted?
- Allow for creative solutions to your problems. What can be tried that wasn't considered in the initial work plan? What can be done in response to the unforeseen changes that have occurred to the project?

Communication/Communication/Communication: Limit surprises.

- Good communication is needed both within the interagency group and with those outside the interagency group.
- As with coordination, communication has taken an enormous amount of time, but it is time that needs to be invested for project success.
- Stress the importance of presenting project information so that others can understand it. The message means little if its significance is not understood.
- Communication involves both talking and listening.

Further Discussion:

- Give credit where credit is due for work performed: When a collaborating agency had done an extremely good job, project personnel designed and presented a special award to the agency.
- Be sure to distribute the work load throughout the agencies and personnel.
- Continual education of locals plus other agency personnel is essential in order to maintain the momentum of the project.

- Be sure to communicate deadlines to all project personnel.
- To gain volunteer participation, use hands-on workshops. In this project, project personnel were able to train interested citizens and other agency personnel in streambank stabilization techniques. The course participants installed streambank stabilization devices within the project area and received training at the same time.
- A family education day was used to gain stakeholder support of project activities.
- To overcome producer resistance to state agency intrusion, the Iowa Department of Natural Resources has conducted residential well testing. This allowed producer and agency personnel to establish communication and begin to build trust.

General Discussion:

- Projects have learned that in some cases agencies are willing to work without funding to minimize unforeseen land use changes.
- The presenter described how a road crew had cleaned the stream near a monitoring site. When asked how this activity could have been prevented, the presenter stressed the importance of including all players that work within the boundaries of the watershed.

Successful Watershed Project Management: Lessons Learned in Long Creek

Gregory D. Jennings and Martha Burris
North Carolina State University and North Carolina Cooperative Extension Service

The Long Creek Watershed Project in Gaston County, North Carolina, is directed by a team of researchers, educators, government officials, and private interests. Since the project began in 1992, we have learned several valuable lessons about project management. Among these are:

- Teamwork. The project team must include all interested parties, including local landowners. It must work together as a unit to meet common objectives. This is sometimes difficult due to conflicting priorities among team members. The team must reach consensus on project objectives, team member roles, and operating procedures early in the project. The Long Creek Project Steering Committee has evolved into an effective management team as members have become more comfortable with their own and others' roles and abilities.
- Project Leadership. The leader must be organized, motivated, respected, responsible, team-oriented, and an excellent communicator. The leader should have local ties to the project and general knowledge of all aspects of the watershed project. The Long Creek Project Leader is Will Harman, a County Extension Natural Resources Agent. He is an effective leader because of his dedication and willingness to improve his leadership abilities.
- Objectives and Scope. These must be clearly defined and understood by all team members at the beginning of the project. Team members must know their responsibilities in meeting the objectives. The Long Creek Project team has worked to overcome early difficulty agreeing on project objectives and scope.
- Work Plan. The plan must define measurable units of work, assign responsibilities, and provide a schedule of expected accomplishments. The work plan must be flexible to account for unexpected changes in watershed land use weather conditions or project team membership. In Long Creek, we have experienced delays and problems resulting from an unclear project work plan.
- Budget. One team member must be responsible for tracking expenditures and reporting on the budget. Full funding to meet all project objectives in monitoring, land treatment, and education must be available from the beginning of the project. In Long Creek, we have spent considerable time and energy seeking additional funding to meet objectives identified by team members since the beginning of the project.
- Communication. The project leader must facilitate open communications so that team members know what is expected of them and so that problems can be addressed efficiently and effectively. The Long Creek project team communicates via bimonthly meetings, teleconferences, electronic mail discussions, and newsletters.
- Quality. Team members and funding agencies must expect quality results from the project. Members should seek expert assistance from public agencies and private sources to make the project as successful as possible. Because of the high level of government, industry, and media interest in the Long Creek Project, we have worked hard to ensure quality control in all of our efforts.

Further Discussion:

- The Long Creek project grew from a local concern about degradation of environmental quality.
- The project is managed at the local level by a steering committee. This keeps the perspective local. It took a long time to coalesce the committee into a functional group. At the beginning of the project, each agency brought their own agenda into the committee. It has taken over two years to clarify project goals in order to focus people on the project and not the needs of their agencies.
- In order to reduce the time it took for the steering committee to coalesce as a group, the decision making processes should have been formalized at the start of the project.
- Subcommittees were tried and failed because everyone needed to be part of the decision making process and to have a stake in the project's success.

General Discussion:

- Most project personnel in the audience admitted that they are still struggling with BMP implementation and farmer cooperation.
- An audience participant stated that although you can't control the land use activities in your watershed, you must be very certain that you document the activities so you can explain your data.
- Most conference participants agreed that the 25% producer cost share contribution for BMPs is too expensive for producers to justify.

Experiences from the Elm Creek (HUA) Project

Scott Montgomery
Natural Resource Conservation Service-Nebraska

Achievements:

- Local Coordinating Committee (LCC) was established to provide a Local input process.
- Elm Creek Hydrologic Unit Area Project developed a Watershed Land Treatment Plan. The Elm Creek Watershed Land Treatment Plan was provided to the Lower Republican Natural Resources District (LRNRD) for implementation.
- The primary agencies (i.e. Lower Republican Natural Resource District, Nebraska Department of Environmental Quality, Natural Resource Conservation Service, Cooperative Extension, Consolidated Farm Service Agency, Local Coordinating Committee) requesting this Project reached consensus on nonpoint source pollution & runoff treatment goals and objectives. Elm Creek Watershed Land Treatment Plan was a document established through team building among agencies and consensus planning.
- Almost all the funds targeted to the Elm Creek Watershed have been obligated to install conservation practices.

Challenges:

- The lack of timely and adequate staffing continues to hamper project management and conservation land treatment efforts.
- Lack of proper Local Coordinating Committee function, because only land owners with vested interests in the Project participated.
- "Strings attached" to various funds targeted to the Elm Creek Watershed. Many owners are not willing to "jump through the hoops" to get cost-share assistance, thus limiting nonpoint source treatment opportunities.
- Time limitations on how long targeted funds were/are available has lead to cost-share assistance being provided for the installation of conservation practices that cost more and yield lessor NPS pollution reduction benefits.
- Elm Creek Hydrologic Unit Area land owners, operators, and area citizens still do not recognize that Elm Creek is a very unique resource that needs protection. Local "Buy-In" has not significantly occurred.
- Continued insufficient funding to fully implement the Elm Creek Watershed Land Treatment Plan.
- Area citizens continue to ask me "Is the water quality improvement worth what it will cost to make Elm Creek trout habitat "clean?" Agricultural production "pays the bills" and keeps the local economy going; thus many

agricultural producers in the Elm Creek Watershed have expressed concerns that this project has wasted tax money (especially if they have not received cost-share assistance).

- Various institutional pressures against the application of appropriate and cost effective conservation (i.e. CAB's, production financing, property taxes, producer's attitude, etc.).

Further Discussion:

- Local buy-in is essential and the local buy-in is usually based on the local population recognizing the value of the water resource. In this project, the designated water use of the stream, cold-water fishery, is not valued by the local population.
- Elm Creek is a large watershed and, therefore, it has been difficult to show results. The Nebraska Department of Environmental Quality stated that a smaller watershed should have been chosen.
- The lack of a designated project leader from the start of this project has been problematic to the success of the project.
- There is no violation of water quality standards in Elm Creek; therefore there is no impetus for producers to participate in the project. The incentive that project personnel have used to increase participation is a 75% - 100% cost share for BMP implementation from national and local sources.
- When the project started, the local coordinating committee was composed largely of a diverse representation of the county population. Over time, only persons that had vested interests in the watershed continued to participate in the local coordinating committee activities. In order for the community to become vested in conserving the stream, the committee needed to be rediversified.

SESSION B
INSTITUTIONAL AND SOCIAL ISSUES

Combining of Resources to Maximize Efforts

Rick Mollahan
Illinois Environmental Protection Agency

In spite of all good intentions on the part of local interests, financial resources are limited due to overall community needs and the political acceptability of increased fees on consumers. To maximize resources, the City of Pittsfield, Illinois (City), the Illinois Environmental Protection Agency (Illinois EPA), Consolidated Farm Service Agency (CFSA), and Pike County Soil and Water Conservation District (SWCD) combined efforts in a single watershed.

Lake Pittsfield was originally constructed under P.L. 566 as a flood control structure. It later served as the City's water supply as well as a recreational area. The City of Pittsfield performed a Diagnostic Feasibility Study under Section 314 of the Clean Water Act. The Illinois EPA contacted the Pike County SWCD and the City to consider a holistic approach to lake protection restoration and watershed management. Utilizing the water quality data provided in the Section 305(b) Report prepared by the Illinois EPA, the parties applied for a Section 319 grant for construction of 37 detention basins throughout the watershed, and a Section 314 grant for in-lake implementation. The Illinois EPA presented the watershed as a candidate for Water Quality Incentive Payments through the CFSA. Based on the involvement of the other organizations, the documentation of the water quality issues, and the strong local support, funding was obtained.

The City and the SWCD have also committed resources to this effort. At a cost of approximately $1 million, the City will be dredging the existing lake to remove in-place contaminants and reestablish capacity. The SWCD has committed staff time and facilities to work with the landowners in the development of extended operation and maintenance agreements with the landowners. The Natural Resource Conservation Service is preparing the designs for the detention basins, and is assisting the SWCD where needed.

Coordination of these organizations and their resources has assured a blanketed approach to correction and management of the total watershed resource concerns. Execution of operation and maintenance agreements to assure proper function of the systems will hopefully instill responsibility for the continued care of the system as well as promote positive communication between the urban and rural community.

Further discussion:

- Sediment from cropland erosion and in-stream erosion impacts roadways and recreation areas greatly.
- Soil types, slope, and land use practices were taken into consideration as decisions were made about placement of retention basins.
- The project offers 100% funding for BMP implementation (sediment retention basins). Landowners signed 10 year agreements to maintain the basins and to install and pay for the fencing. Farmers have finished installing all sediment basins except the largest basin upstream of the lake.
- Raw water samples, taken from the deepest lake station, near the water intake are also analyzed for Atrazine, along with other chemicals. To date, the dredging of the Lake has not occurred.
- Blue Creek - Due to the construction of sediment basins and the resulting reduction of sediment loads, some bottom scouring and streambank destabilization has been noticed in the main tributaries. Due to the stream dynamics, it is not yet known if fixing one problem has created another. Further analysis of the project will answer whether corrective actions will be necessary within the watershed.

General Discussion:

- Project personnel are modeling the watershed to look at hydrological changes resulting from the decreased sediment load. They are looking at pool riffling as a way of addressing the hydrological changes.
- What has the effect of the hydrological changes been on the aquatic community in stream? The focus has been on water chemistry. They haven't yet looked at the biological communities. Upland streams are zero flow streams. Main stem has some water flow. They are waiting for the new system to equilibrate and then will study the biological communities.
- The question of long-term management of the retention basins was raised. Farmers have signed 10 year agreements to maintain stable banks and intact fencing. At 10 years, the project team intends to reevaluate functional capabilities of the basins. Basins are designed for a 20 year life by Natural Resource Conservation Service. The state can recover the full costs of BMP installation from landowners if the basins are not maintained for 10 years.

Citizen Monitoring and Urban BMP Evaluation

Joan Drinkwin
Texas Watch Program

Texas Watch is the volunteer environmental monitoring program of the Texas Natural Resource Conservation Commission, supporting more than 5,000 citizen monitors throughout the state. The program was developed as an EPA approved Quality Assurance Project Plan which calls for standardized equipment, training, quality control checks, and data checks. The program recently ventured into nonpoint source pollution monitoring and is currently implementing five projects funded through Section 319.

The East Bouldin Creek BMP Implementation and Demonstration Project entails implementing non-structural BMPs, such as community education, as well as citizen monitoring. The goal of the project is to decrease the NPS pollutant load entering Town Lake from East Bouldin Creek in Austin, Texas. Citizen monitors are being trained specifically to evaluate whether these goals are being met by implementation of BMPs. Throughout the project, volunteer monitors will sample for benthic macroinvertebrates on a quarterly basis and chemical and physical variables on a weekly basis. A paired watershed design is being employed.

Working with the City of Austin is a critical element in the success of this project. While Texas Watch has been successful coordinating with the city's own monitoring program, there remain differences in monitoring techniques which will hamper data analysis. Coordinating with other city departments has been more challenging. It has been

difficult, for example, to coordinate with various city departments regarding community education and BMP construction. These challenges represent institutional barriers inherent in implementing a project in an urban area.

Texas Watch has learned that you can train volunteers to conduct water quality monitoring for either community education or good water quality monitoring data. The Texas Watch program has always been focused on good water quality data.

One powerful technique for community education is using the media to get the message across. The conflict that arises is the need to promote the project in the treatment area, but not have an impact on the control area. Because of this contradiction, it is necessary to clearly explain to citizens in both control and treatment watersheds the philosophy behind the experimental design and the importance of having a control. Through successful documentation of BMP effectiveness, which requires a treatment and a control, we can gather sufficient evidence to support requests for funds for treatment in all watersheds.

Implementation of BMPs by other agencies before the calibration period for a water quality monitoring project has been completed is a problem that has been raised. Joan noted that the Texas Watch had been able to coordinate with the city's professional monitors for adequate historical data for the calibration phase. A participant noted the importance of pre-project coordination among agencies before any of the agencies implements anything in the project area. It was noted that it is important to emphasize educating the community and agencies about the value of pre-BMP monitoring.

General Discussion:

- Texas Watch has learned that you can train volunteers to conduct water quality monitoring for either community education or good water quality monitoring data. The Texas Watch program has always been focused on good water quality data.
- One powerful technique for community education is using the media to get the message across. The conflict that arises is the need to promote the project in the treatment area, but not have an impact on the control area. Because of this contradiction, it is necessary to clearly explain to citizens in both control and treatment watersheds the philosophy behind the experimental design and the importance of having a control. Through successful documentation of BMP effectiveness, which requires a treatment and a control, we can gather sufficient evidence to support requests for funds for treatment in all watersheds.
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Farmers and Cows

Summary of presentation made by
Patricia Lietman, U.S. Geological Survey
(summary prepared by Judith A. Gale and Janet M. Young, NCSU Water Quality Group)

Synopsis of the Pequea-Mill Creek Basin Project (Pennsylvania)

The Big Spring Run is a spring-fed stream located in the Mill Creek Watershed of south central Pennsylvania. Its primary uses are livestock watering, aquatic life support, and fish and wildlife support. In addition, receiving streams are used for recreation and public drinking water supply. Sampling of benthic macroinvertebrate communities indicated poor water quality at five of six sites. Other stream uses are impaired by elevated bacteria and nutrient concentrations.

Land use in the project area is primarily agricultural. Uncontrolled access of more than 220 dairy cows and heifers to each of the two watershed streams is considered to be a major source of pollutants. It is estimated that grazing animals deposit an average of 40 pounds of nitrogen and 8 pounds of phosphorus annually per animal. Pastures adjacent to streams also are thought to contribute significant amounts of nonpoint source pollutants. Therefore, proposed land treatment will focus on streambank fencing to exclude livestock from streams. This will allow a natural riparian buffer to become established, which will stabilize stream banks and potentially filter pollutants from pasture runoff.

Water quality monitoring will employ a paired watershed design in which the proposed nonpoint source control approach is implementation of livestock exclusion fencing on 100% of the stream miles in the treatment subwatershed. Grab samples will be collected every 10 days at the outlet of each paired subwatershed from April through November. Storm event, ground water, biological, and other monitoring is planned to help document the effectiveness of fencing in the treatment subwatershed.

The Chesapeake Bay program, which has set a goal of a 40% reduction in annual loads of total ammonia plus organic nitrogen and total phosphorus to the Bay, should have a significant impact on the project. The Pennsylvania State Chesapeake Bay Program is expected to provide up to 100% cost-share money to help landowners install streambank fencing.

General Discussion:

The project team is facing challenges posed by land use changes in both the control and treatment watersheds. These changes include changes in cow numbers, changes in land ownership or tenancy, an unexpected housing development, and changes in length of pasture rotations.

- In response to the land use changes, the project team has installed an additional water quality monitoring station below the housing development and has negotiated the placement of 30-foot buffers around the development, in the hope that the buffers will reduce the impact of the development on water quality data. The team considered adding an extra year to the pre-BMP (best management practice) monitoring period, but was not convinced that lengthening both the pre- and post-BMP periods of monitoring would improve the water quality data, since additional land use changes are likely to take place during the post-BMP period.
- The team is considering stratifying the water quality data to allow analysis of early pasture season data separately from late pasture season data. This may help decrease the impact of the changes in pasture rotations, which have generally involved some farmers not pasturing their cows until later in the summer.
- The possibility of placing another new monitoring station above the housing development was discussed, but would probably not be feasible (lack of funds) or necessary, since there are no cows in the subwatershed above the housing development.
- The differences in fecal strep data from one time to another have been as great as three orders of magnitude, making the data hard to interpret.
- The possibility of switching from a paired watershed to an upstream-downstream before-after design was discussed. It was noted that some of the land use changes may not create data analysis problems because of the built-in redundancy of the monitoring design, which includes both paired watersheds and upstream-downstream sampling.

SESSION C
THE COOPERATIVE EFFORT

Common Ground on Private Land - Is It Possible?

Rick Hafele
Oregon Department of Environmental Quality

The Grande Ronde River is a 5,265 square mile watershed in the northeastern tip of Oregon. As in most basins in Eastern Oregon, the major land uses are logging, grazing, and agriculture. In 1992, an NPS assessment and restoration project began on five tributaries to the upper Grande Ronde River. Stream and site selection followed a combination of the paired watershed and upstream-downstream approaches.

Land ownership in the selected tributaries covers both U.S. Forest Service and private ranches, with Forest Service land making up most of the upper timbered portions of the watersheds and private land comprising lower elevation pasture and rangeland. Because important areas of the streams, as well as the greatest restoration opportunities, are on private land, cooperation of private landowners is critical to the overall success of the project.

What have been the critical issues in dealing with the landowners? First, there are typically very different perceptions between landowners and agencies about basic ideas such as:

- Who does the land really belong to?
- What is the land used for?

Secondly, there are often differences in the levels of trust and cooperation between old landowners and new landowners. Finally, some of the basic questions and problems that have come up include many common sense, issues that are not easily addressed. For example:

- How many agencies does a landowner want to deal with?
- Clear communication of study objectives is important so that landowners understand them.
- Watersheds are generally owned by more than one owner and not all are willing to participate. Thus, entire watersheds cannot be studied and treated, and control of problems is only partial.
- Maintaining consistent land use activities in study areas throughout the life of the project is difficult since scientific controls are not considered by landowners.
- Lengthy turnaround of data and results is difficult for landowners to understand.
- What do you do when you find an endangered species?

The long term success of most NPS projects is dependent upon the attitude and cooperation of private landowners. Failure to start on the right foot can create years of difficulty and ultimately lead to a lack of improvements in land use or stream conditions.

The speaker noted the difficulty of making water quality improvements with the cooperation of landowners when upstream landowners are not interested in working on repairing the stream.

Issues

Landowners:

- Lack of consistency within and between agencies
- Too many agencies
- Too much red tape
- Data analysis takes too long to be completed and reported
- Don't trust data or recommendations
- Landowners don't trust Agencies (hidden agenda)

Agencies:

- Changing objectives and funding
- Who takes the lead (the level of communication among agencies needs to be quite sophisticated so that the objectives of each agency are articulated by the lead agency, which has direct contact with the landowner)
- Complex criteria for funding
- Land use changes take too long
- Don't trust commitment to land use changes
- Agencies don't trust landowners (hidden agenda)

Communication is the key issue for building trust between landowners and agencies. In order to successfully involve landowners, it is important to first identify and agree on problems. Once problems are agreed upon, it is easier to identify and agree on solutions.

The Cooperative Effort: Working With Producers

Randy Brooks
University of Idaho

The Idaho Snake River Plain Water Quality Demonstration Project staff works with over 30 producers/cooperators involved in production agriculture. Many diverse crops are produced in the project area. Excessive irrigation, a common practice in the area, creates the potential for nitrate and pesticide leaching and/or runoff. Groundwater monitoring indicates the presence of elevated nitrate levels in the shallow aquifer underlying the project area. The NPS control strategy focuses on voluntary implementation of nitrogen, pesticide, and irrigation water management BMPs that will reduce the amount of nutrients and pesticides moving into surface water groundwater. Project objectives are to demonstrate these BMPs so producers will voluntarily adopt them. Getting producers to adopt BMPs on a voluntary basis, without any guarantee that the BMPs will not adversely affect yields, can be challenging. To date, this has been accomplished through cost-share incentives for record keeping. Producers are required to act on uncontrollable events which hamper the logistics of rigidly scheduled sampling activities. The number and arrangement of field instrumentation has complicated production field work as producers are forced to manipulate production equipment around monitoring instrumentation. One of the biggest obstacles to overcome while monitoring the effectiveness of implemented BMPs has been changes in the types of crops produced and the production methods employed. Scheduled crop rotations designed to monitor BMP effectiveness have been changed spontaneously to meet commodity market demands. Finally, one of the largest obstacles to overcome when working with producers has been the existence of long established traditions.

While there have been several challenges to overcome, there have also been numerous achievements. The greatest advancements have come in the area of record keeping and irrigation water management. With advances being made in those areas, a trend towards reductions in agri-chemical use has been noted. A trend towards reductions in groundwater nitrate concentrations has also been observed in conjunction with this. Current demonstrations and I&E efforts conducted by project staff has heightened water quality awareness not only among producers, but among the urban populations as well.

Further Discussion:

- Barriers to technology transfer include: water cost, availability, and delivery schedule.
- Barriers to technology adoption include: landowner or farm manager attitudes and the level of cost-share funds available.
- Gains have been made in the Snake River Plain project in:

  1 - Irrigation scheduling: irrigating on basis of soil moisture.
  2 - Recordkeeping.
  3 - Reduction in water usage.
- For a farmer, in order for a practice to be a BMP, it has to be technically feasible, economically feasible, and socially acceptable.

Benefits and Disadvantages of Coordinating University Environmental Science Students for the Collection and Analysis of Water Monitoring Samples

Robin Woods
Northern Arizona University

This presentation will discuss the benefits and disadvantages of coordinating University Environmental Science students for the collection and analysis of water monitoring samples for the Oak Creek National Water Monitoring Project versus using trained professionals.

The discussion will focus on three key issues:

1. Properly trained and supervised students in the collection and analysis of water monitoring sampling provides the Oak Creek National Water Monitoring Project with accurate and reliable data.
   - In August of 1994, Arizona Department of Environmental Quality engaged in split sampling procedure with the students of the National Water Monitoring Team and the results of this procedure were a 95% confidence interval.
   - Data collected by Northern Arizona's National Water Monitoring Team can be used to draw correlations among the seasons, high-use periods, and a rise in pathogens.
2. Who benefits from using students as a resource for the Oak Creek National Water Monitoring Project?
   - The project benefits because a dependable trained team is created to do the sampling and analysis at a minimum of the cost.
   - The students benefit because they can receive one or all of the following benefits: the opportunity to "network" with agency representatives and receive "hands-on training" which they do not receive in classroom or lab environments; development and polishing of their skills in their selected profession; and provision of a possible stepping stone for their future careers.
3. What are the controversies over using students rather than trained professionals for the Oak Creek National Water Monitoring Project, and what tools are used to ensure that students are capable, competent, and performing to their full capacity?
   - Undoubtedly, there is a learning curve. Students have to have strict supervision and guidance. At all times there is at least one paid Graduate Research Assistant or a University Professor either present or available during sample collection and analysis.
   - There is doubt about the competency of the students because they are students rather than trained professionals. To ensure competent students are participating on the project we provide a mandatory Sampling Training Workshop in conjunction with ADEQ, we select students who have been recommended by Professors, and our Quality Assurance/Quality Control plan was designed in anticipation of using students.

General Discussion:

General discussion covered ways of addressing skepticism about student-collected data. One suggestion made was to include skeptics in the training sessions for the students so that the skeptics can be more aware of the quality of the training. Another participant noted that there is a double standard in this sense, because industries are allowed to conduct self-monitoring without being required to attend training sessions. The presenter followed this statement by noting that the same professional water quality sampling training workshops that are conducted for volunteers are also provided for homeowners and land facilitators, who live and work in the project area.

General discussion regarding Concurrent Session C, *The Cooperative Effort*, is listed below:

- Get cooperators involved early in the planning process.
- Be flexible in terms of integrating cooperator comments into your monitoring plan.
- Threat of regulatory action can provide motivation for landowners or stake holders to participate in a project.

- Correspond frequently with the landowners. Share results with landowners because if you don't, they may suspect you're building a case against them.
- Sharing results with landowners helps educate them about the limitations of scientific studies and what we can realistically expect to learn from water quality data.
- Results of data analysis should be used as part of a feedback loop for refining and improving a water quality monitoring plan.
- Don't change the sampling program too quickly before you are sure that you have enough data to detect a trend, if there is one.

SESSION D
WATER QUALITY AND DATA EVALUATION

Interstitial Loadings of Fecals in the Cold Water Lotic Ecosystem of Oak Creek in Sedona, Arizona

Daniel Salzler
Hydrologist/Environmental Program Specialist
Arizona Department of Environmental Quality

The study area of the Oak Creek National Monitoring Program includes the upper reaches of Oak Creek Canyon and the cold water lotic ecosystem of Oak Creek. This 12 mile stretch of the canyon is one of Arizona's most popular recreational areas. Approximately 7,000,000 automobiles travel this scenic highway through the canyon every year. At Slide Rock State Park and the US Forest Service's Grasshopper Point water recreation areas, approximately 550,000 people pay to enjoy the recreational experiences Oak Creek has to offer. It is estimated that another 700,000 enjoy the cold waters from junctures along the highway.

The Oak Creek National Monitoring Program has measured significantly higher levels of ammonia downstream of the water recreation area of Slide Rock State Park than upstream levels. This has been attributed to human excretions of urine. Fecal coliform levels are also higher downstream than upstream. Parallel complementing research has revealed significantly large numbers of fecal coliform colony forming units within the sandstone/basalt sediments of Oak Creek. The interstitial zone of the sediments appears to be the breeding ground for fecal coliforms that enter a suspended state when stirred by human activity or natural storm events.

The method of determining the source of fecal coliform continues to be researched. Possible sources are warm blooded animals that live within the watershed of the canyon, human excretion by recreationists, human excrement dumped by RV tourists, and septic systems. Discussion will be centered on research findings and a theory of fecal coliform reproduction.

Further Discussion:

- Project personnel have found increases in fecal coliform from May through the swimming season.
- There are several potential sources of fecals: septic systems in adjacent residential areas, a herd of elk, intentional recreational-vehicle septic discharge, diaper disposal, recreationists relieving themselves, and dog feces.
- Project personnel have found that ammonia levels increase from upstream to downstream, thus suggesting direct ammonia input into the stream by swimmers.
- Project personnel efforts to explain fecal coliform data have lead them to the supposition that the fecal coliform are using nutrients within the interstitial zones of the sediment to grow or possibly reproduce.
- If the supposition is true, then how do you treat the interstitial growth of fecal coliform within the stream sediments? It was suggested that limiting nutrients would limit fecal coliform growth. However, the data does not consistently show a correlation between high nutrient concentrations and fecal coliform spikes. Project personnel have tried to reduce nutrients by educating recreationists, upgrading the bathroom facilities, and other types of activities.

- Lab experiments performed using sediments from Oak Creek demonstrated continuous growth of the fecal coliform for more than 150 days. These results suggest that sediments may serve as an on-going source of fecal coliform.
- It was suggested by a conference participant that the project verify the presence of human pathogens and another participant suggested that they determine whether the fecal coliform was derived from an animal or human source.

Chumash and Walters Creek Stormwater Analysis Morro Bay Watershed, California

Karen Worcester
Regional Water Quality Control Board
San Luis Obispo, CA
and
Dave Paradies
Bay Foundation of Morro Bay
Los Osos, CA

Storm water data was collected by Cal Poly State University over a two year baseline period (1993-94 and 1994-95) at Chumash and Walters creeks in the Morro Bay watershed, San Luis Obispo County, California. Establishing baseline flow and water quality relationships between the two creeks is a critical component of the "paired watershed" study design, and must be developed prior to implementation of Best Management Practices on the treatment watershed. In this paper, we examine the relationships between the two creeks defined by this data set, and consider the question, "How much data is enough?"

Because of low rainfall during 1993-94, only one storm data set was collected. Flow data was not yet available at the time of this storm, so data from this year is incomplete and of limited usefulness. Fortunately, the winter of 1994-95 was an extremely wet one, and provided a considerable amount of data on storms of varying intensities.

Water quality samples were collected at 30-minute intervals when flow levels rose high enough to trigger activation of automated sampling devices. Flows were also measured at 30-minute intervals, and precipitation data was collected at 5-minute intervals. Samples were analyzed for total filterable solids, turbidity, and conductivity.

Although 784 30-minute interval data records were collected in total, only 139 time based pairs could be developed between the two creeks. This resulted for a variety of reasons, including flume design errors, equipment failure, and differing equipment activation thresholds between creeks. Flow data lost when the Chumash Creek flume overtopped was simulated using the regression relationship between the two creeks ($y= 0.6958x - 2.18$; $r^2= 0.84$); 36 data pairs were recovered in this fashion. Because of the flow activated data collection strategy, lack of sample time synchronization, and loss of data records, the data stream used for analysis contains a number of time interval gaps.

A "storm event delimiter" algorithm was developed to define storm events in the data stream in a repeatable, non-subjective way. Flow, turbidity and sediment data from the control watershed were utilized in the algorithm to establish the boundaries between flow events.

Data was examined in various ways to evaluate the relationships between flow, turbidity and sediment concentration in the two creeks. Double mass curves were developed both for the entire paired data set and for individual storm events. A variety of statistical analyses were performed in order to characterize the distinction between variability in the data resulting from watershed to watershed differences versus storm to storm differences. Prior to initiating BMP treatments on the treatment watershed, we will utilize the results of these analyses to determine whether the existing data collected to date contains enough information to serve as a baseline characterization.

Further Discussion:

- The statistical analyses that were performed on the paired watershed data demonstrated a consistent performance between the two watersheds in terms of discharge, sediment, and turbidity. Additional sensitivity analyses need to be performed in order to confirm the suitability of the pairing.
- BMP implementation is occurring in the treatment watershed due to grant obligations to spend out the money. An additional year of baseline water quality monitoring would have been useful to establish a stronger relationship between the paired watersheds.
- The use of several statistical software packages has made data analyses difficult. Project personnel will be trying to standardize their statistical software.

Evaluating Barnyard Best Management Practices in Wisconsin Using Upstream-Downstream Monitoring

Todd D. Stuntebeck
U.S. Geological Survey

This presentation discusses the results of a study by the U.S. Geological Survey, in cooperation with the Wisconsin Department of Natural Resources, to evaluate water-quality improvements that result from implementation of Best Management Practices (BMPs) at barnyards. Automated water-quality sampling equipment was used to collect discrete water samples during 10 storms at stations on Otter Creek and Halfway Prairie Creek before BMPs were implemented. On each stream, one sampling station is located upstream from a single barnyard-runoff source and the other station is downstream from that same source.

Continuous streamflow and instantaneous water-quality data were used to estimate event-mean concentrations for individual storms. Event-mean concentrations of total phosphorus, ammonia nitrogen, and biochemical oxygen demand (BOD) downstream from the barnyard at Otter Creek and Halfway Prairie Creek were generally higher than event-mean concentrations upstream from each barnyard. Paired Student's *t*-tests performed on these data indicate that average downstream event-mean concentrations of total phosphorus, ammonia nitrogen, and BOD were significantly greater than average upstream event-mean concentrations at the 95-% confidence level for both creeks. Using the pre-BMP data, an equation was developed to estimate the minimum amount of change in post-BMP average downstream event-mean concentrations necessary to be considered statistically significant. For Otter Creek, this "minimum detectable change" is 50 % for total phosphorus and ammonia nitrogen and 40 % for BOD. Minimum detectable changes of 10, 30, and 40 percent were estimated for Halfway Prairie Creek, respectively. The pollutant reductions expected from BMP implementation at each site are greater than the changes needed to observe a statistically significant improvement in water quality.

Further Discussion:

- Upstream pollutant sources may mask the barnyard sources. A good sampling design is necessary to detect water quality changes, because the upstream/downstream design is not very sensitive.
- However, for this barnyard, there is a visual difference between the upstream and downstream samples: the downstream samples were much darker.
- The time at which sampling is initiated is extremely important to distinguish between the upstream water quality and barnyard runoff into the stream.
- If sampling is initiated by stage, it is important to use a sufficiently low threshold to capture high initial barnyard inputs downstream. Later, downstream constituent values may be swamped by upstream concentrations. Statistical analyses were done by taking the difference between downstream and upstream water quality for all storms and determining significance. A statistical difference for phosphorus, ammonia-nitrogen and biological oxygen demand was detected.

SESSION E
POLLUTION SOURCES-NONPOINT

Thurston County Intensive Dye-Trace Method for On-Site Sewage System Evaluation

Linda Hofstad and Sue Davis
Thurston County Environmental Health Division
Olympia, WA

Effluent from failing on-site sewage systems is one of the primary sources of nonpoint pollution along the shorelines of Thurston County, Washington. Located at the southern terminus of Puget Sound, Thurston County has an abundance of natural resources which includes a valuable shellfish resource—both commercial and recreational. These resources depend upon excellent water quality in order to be safe for consumption. Nonpoint pollution sources, primarily storm water, agricultural runoff, and failing on-site sewage systems, threaten these areas. As part of the coordinated effort with Conservation Districts and others to remediate the nonpoint sources, the Health Department has focused on identifying the failing on-site sewage systems, getting the systems repaired, and providing the homeowner with information on how to properly operate and maintain their systems. Blatant failures of septic systems are easy to find with most any method of sanitary survey. The intermittent and seasonal failures caused by system component problems and general subsurface failure are much more difficult, if not impossible, to find.

However, in order to address nonpoint pollution remediation, these failing systems need to be identified, evaluated and repaired. Thurston County has developed an intensive sanitary survey procedure which includes a dye-trace method using small mesh charcoal-filled packets placed in probable pathways of surfacing effluent. The fluorescent dye used to establish the hydraulic pathway of effluent is absorbed onto the charcoal in the packets if the effluent surfaces. Dye concentration is measured and then fecal coliform sampling is done to confirm the presence of sewage. This method has been used in over 1600 surveys and has been proven to be a sensitive test which identifies failing sewage systems. Statistical analysis of the survey results has shown that there is little to no correlation of failure with age, type, or distance from water of the systems. A special study was conducted during the wet season 1994-95 which looked at correlations between dye concentrations and fecal coliform levels from identified failing systems. The study also considered additional parameters (nitrates, ammonia, total dissolved phosphorus, chlorides, and specific conductance) which might be better indicators of failing systems. Preliminary results will be presented at the conference.

Further Discussion:

- The study concentrated on systems within 200 feet of the shoreline. No correlation was found between septic system failure and either distance from the shoreline or antecedent rainfall. The conclusion was that nutrients were not going to help define further failures.
- The speaker indicated that types of support needed for this type of program include: a clear definition of system failure, political support, legal support, and a specific staff person assigned to follow-up with homeowners.

Challenges of Monitoring Bacteria

Thomas D. Harrison
Northern Arizona University

A spate of biological pollution incidents have occurred in numerous water recreation areas located on the southern Colorado Plateau region (AZ, NV, UT) during the past two seasons. In 1994 the Bull Head City lake area was closed because of high fecal coliform counts. One hundred and forty-three rafters developed intense gastrointestinal illness in the Grand Canyon area of the Colorado River. Nineteen Las Vegas residents died from cryptosporidia from drinking "purified" Lake Mead water. This past summer, Bull Head City was closed as was the Utah northern shore of Lake Powell as a result of high fecal coliform counts. The Oak Creek Canyon National Monitoring Project falls into this general pattern. Slide Rock State Park, the most popular water recreation area, was closed for three weeks in late

summer, 1994, when fecal coliform counts reached 3400 cfu/100ml. Warning signs were posted in the same area over the July 4th holiday. Coconino County Environmental Health Department closed off Grasshopper Point, a smaller water recreational area in the Canyon, on September 7, 1995.

Using the Arizona Project as a case study, this discussion focuses on basic issues entailed in attempts to remediate and to prevent these incidents from recurring:

Identifying biological pollution sources. In the case of Slide Rock, a significant amount of previous research—to a person—assumed that the water recreationists themselves were the pollution source. Results from Year I baseline study strongly suggest that:

- Fecal coliforms are introduced into the system in significant numbers above Slide Rock State Park; and
- High downstream fecal coliform counts may be the result of roiled sediment transported downstream to Slide Rock during the rainy "monsoon" season.

Is the fecal coliform a valid and reliable indicator organism of the presence of other water borne pathogens? EPA selected fecal coliform as a standard indicator organism under the assumption that the organism multiplies only in the intestines of warm blooded animals.

- One season of sediment research calls this assumption into serious question.
- NAU is currently conducting experiments designed to determine if fecal coliforms do multiply in sediments under certain conditions.
- Using state-of-the-art equipment, Northern Arizona University is attempting to rapidly and reliably identify water borne pathogenic bacteria.

How does the Arizona project balance the responsibility to inform the public of potential health risks with these uncertainties?

- There are those who have financial risk in closure—concessionaires, local business people, and even state managers; others tend to overreact to a degree bordering on hysteria.

Further Discussion:

- The goals of the Oak Creek Canyon project are to show success in reducing fecal coliform counts and to apply data to other problems arising in the future.
- Participants pointed out that fecal coliform counts can be high due to waterfowl and other natural sources. The consensus was that much more research is needed on 1) the use of fecal coliform as an indicator variable, 2) distinguishing between human and nonhuman fecal coliform, and 3) the means by which fecal coliform multiply.

Biological Monitoring in Otter Creek, Wisconsin

Roger Bannerman
Wisconsin Department of Natural Resources

Otter Creek is a low gradient warmwater forage fishery located in east central Wisconsin. Dairy farming and cash grain crops are the main landuse activities in the watershed. These activities have impacted the biological integrity of Otter Creek by degrading the stream habitat and causing excessive growth of aquatic plants. Evaluation monitoring of Otter Creek began in 1990, and is expected to be completed in 2001. Methodologies have been developed for sampling fish habitat and communities that provide a good balance between the precision needed to see change and the amount of field time required to collect each sample. We have published manuals describing these fish habitat and community sampling protocols. A Before-After-Control Impact (BACI) experimental design is being used to determine the effect of the BMPs in Otter Creek. The specific design is called a "beyond" BACI design because multiple control sites (eight) are being used for the five test sites on Otter Creek. The paired and regional control sites are located on four streams. Most of the sites have a poor to fair Index of Biological Integrity (IBI) value, while the habitat ratings are more variable and they range from fair to good. Control and test sites will be compared using a two way analysis of variance having site type (control vs. test) and time period (before and after) as the main effects. To date, best management practices have been installed at all critical barnyards in the Otter Creek watershed. Completion of the upland erosion control practices will mark the start of the "after" watershed monitoring period.

Further Discussion:

- Heavy macrophyte growth is being caused by excess fertilization on surrounding land. Another problem is highly degraded habitat caused by siltation and bank erosion. Sources of sediment include cows in the stream and upland erosion.
- The experimental design includes five treatment sites in the Otter Creek Watershed and eight reference sites within the same ecoregion. A before and after / control and impact (BACI) design is being used with treatment and control sites.
- A fish habitat assessment protocol has been established based on the following considerations: spatial scale (including field trials to determine sampling size); sampling effort (to determine how many transects and how long a reach should be sampled); and accuracy and precision (visual measurement was determined to be acceptable in terms of accuracy).
- Quality control procedures are being critically evaluated.

SESSION F
SPATIAL ANALYSIS OF DATA

Spatial Analysis of Data: Tracking Agricultural Activity

William A. Harman III
Associate Extension Agent, Natural Resources
NC Cooperative Extension Service

The Long Creek National Nonpoint Source Monitoring Program Project is near completion of the two year background monitoring phase. Thus far, spatial analysis has included targeting critical areas for BMP installation. A few achievements are listed below. As we move into the BMP installation and post BMP monitoring phase, new opportunities and challenges arise as to tracking these BMPs and relating them to improvements in water quality.

Achievements:

- Base maps have been digitized into Atlas GIS, Strategic Mapping, Inc. including watershed boundaries, monitoring sites, soil surveys, streams, roads, land use (limited) and topography (limited).
- Implementation of the Universal Soil Loss Equation in a GIS. A graduate student from UNCC worked on this project for her MA degree in Geography. She used one of our project watersheds for a case study, providing us with a watershed scale prediction of agricultural field erosion.
- Targeting Critical Areas with Pollutant Runoff Models and GIS. The AGNPS model was used to determine critical and near critical NPS pollution source areas. AGNPS output was imported into Atlas GIS for display and georeferencing.
- GIS Procedures for the Analysis of Fecal Coliform Bacteria Transport and Fate. A Ph.D. student from NCSU is working in Long Creek to understand the mechanisms which contribute to bacterial fate (die off) and transport in the terrestrial environment, which will help in the interpretation of water quality indicators. A geographic information system (GIS) model will be used to determine the effect of temperature, exposure , rainfall, and soil type on die off and transport of bacteria.

Challenges:

- Cooperating agencies use different GIS systems, i.e. Atlas GIS, Arc-Info, Intergraph and Microstation, which can make data analysis and transfer difficult.
- Land use data at multiple scales (field to large watershed scale). What is the best source of data? How do you track detailed land use changes at a large watershed scale?
- Using GIS to integrate land use changes with BMP installations and water quality changes (spatially and temporally).
- GIS model validation. Does this map mean anything?

Further Discussion:

- How do you monitor a watershed with rapidly changing land use patterns? No one in the audience had an answer to this problem.
- You must field verify your data. For example, a piece of land on which a building is identified is insufficient data. The use of the building must be known in order to interpret the data correctly.
- Project personnel have found that fecal coliform was found to survive for up to three months in the soil system, making it difficult to track.
- Everyone agreed that tracking land applications of commercial fertilizers, manure, and pesticides is very difficult. Different projects use different sources to determine land application of commercial fertilizers and pesticides: some projects use consulting agencies, some use farmer surveys, some use averaged county data, some use commodity organizations.
- How do you monitor dynamic land use changes, such as cows with free access to the stream? When the cows are in the stream there is a direct correlation with water quality parameters.

Geostatistical Sampling and Assessment of Nitrate in an Agricultural Environment

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Dr. Stanley M. Miller
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College of Mines and Earth Resources
University of Idaho
Moscow, Idaho

Geostatistics is an applied statistical method used to measure spatial dependence and to make spatial predictions of an attribute of interest. Geostatistical methods are being used to describe nitrate occurrence in the vadose zone at an agricultural demonstration project in southern Idaho. The goal is to assist in evaluating the effectiveness of management practices, as related to irrigation and fertilizer application, for mitigating high nitrate levels in subsurface waters. Geostatistical tools provide a means to assess the hypothesis that nitrate concentrations are spatially dependent in the vadose zone across the study site.

The initial phase of the investigation consisted of the development of a geostatistically based sampling network of lysimeters for obtaining soil-water samples, subsequent installation of the monitoring network, and collection of monthly nitrate data over the four-month growing season in 1994. Results indicated that nitrate concentrations as sampled in August and September, 1994, did exhibit some spatial dependence. The existing sampling network then was modified to better define that spatial dependence. Nitrate samples collected thus far in 1995 show some spatial dependence in July, as well as a notion of spatial anisotropy in the nitrate levels measured in the vadose zone.

Geostatistical spatial simulation procedures have been used to describe the spatial distribution of nitrate concentrations across the study site. This description includes contour maps of expected mean values of nitrate and of the probability of exceeding any specified threshold value. The overall study illustrates that the effectiveness of a geostatistical investigation depends on both the number of, and the locations of, sampling points. A multi-phase sampling program allows the development of an efficient and rationally based monitoring network conducive to an appropriate description of the spatial attribute.

Further Discussion:

- Geostatistics is being used to help evaluate BMP's for agricultural water and fertilizer applications based on improved spatial sampling design.
- Soils in the unsaturated zone across the study site were sampled for particle-size characteristics, and then geostatistical criteria were used to assign locations for lysimeters used to sample soil water at a depth of 1 m below the ground surface.
- Initially, there were just barely enough lysimeters to obtain the desired spatial information, so additional lysimeters were installed for the second field season.

- Geostatistical simulations based on the field measurements of nitrate concentration verify the heterogeneity of nitrate across the site; these simulation also were used to generate exceedance probability maps for nitrate concentrations in soil water. Such information will be compared to groundwater nitrate levels measured in monitoring wells at the site.

Techniques for Quantifying Nonpoint Sources of Pollutants and Tracking Land Treatment Practices

Kerry F. Rappold
U.S. Geological Survey

Landuse and land treatment practices can have a significant effect on the water quality of agricultural watersheds. Quantifying and tracking these effects is a key element of the Otter Creek (Wisconsin) National Monitoring Program project. The Otter Creek project area is part of the larger Sheboygan River watershed, which has been included in Wisconsin's Priority Watershed Program since 1985.

Constituent loadings from agricultural nonpoint sources of pollutants were quantified by a variety of techniques. These techniques rely on collection of site-specific nonpoint-source pollutant data and computation of pollutant loads from simple equations or models. The constituent-load data are used to identify critical sites that require the implementation of best management practices (BMP's). Nonpoint-source pollutant data were collected primarily by local Land Conservation Department (LCD) staff; sources not quantified by local staff or in need of updating were compiled by activities of the monitoring team.

Land-treatment practices are tracked through a cooperative effort between the monitoring team and the local LCD staff. BMP's funded by state and federal agencies are updated in the spring and fall. Maintenance of accurate and timely information on BMP implementation is crucial to interpretation of existing and new water-quality data.

The data collected on nonpoint sources of pollutants and land treatment practices are maintained in a geographic information system (GIS). Spatial-data layers created within the GIS include the basin boundary, nonpoint sources of pollutants, hydrologic features, land-treatment practices, soil types and topographic features. The GIS provides a useful tool for updating information and presenting graphical depictions of the current conditions and changes occurring within the Otter Creek project area.

Further Discussion:

- Project personnel inventoried barnyard runoff, manure spreading, streambank, and gully erosion.
- Barnyard data was collected by the local LCD and estimates of pollutants were generated. They were able to estimate phosphorus deposition based on manure spreading locations.
- The LCD inventoried agricultural land use and modeled sediment deposition delivery.
- Currently the monitoring team is updating sediment delivery using a new model that allows for both in-stream sediment delivery and deposition.
- Other data collected by the monitoring team demonstrated that there are insignificant gulley erosion sites.
- Few conservation practices have been implemented in the upland regions of the watershed, which is the primary source of sediment.
- The land survey must be updated because some of the information and models are outdated.
- Techniques for tracking land use consist of biannual updates of BMP implementation and field surveys.
- Tabular and spatial data are used in graphical representation, water quality modeling and statistical analysis.
- The inventory has allowed pollution sources to be identified and BMPs tracked. However, there is some field level information not inventoried (i.e. pesticide and nutrient application). Project personnel also have problems with incompatible data and old information.

SESSIONS G1 AND G2

Use Of Spatial Data - GIS Tools

Walter Bremer
Landscape Architecture Department
Cal Poly, San Luis Obispo, CA

Session Overview

This session will familiarize participants with the use of spatial data and geographic information system (GIS) tools for manipulating and displaying spatial data related to watershed monitoring. GIS tools are becoming more and more important to watershed activities. They provide a different look at the watershed and bring many disciplines together to understand and solve problems.

This session will use lecture/demonstration and discussion, together with some "hands on" interaction with GIS technology. The session will also take a peek into the future to see what new data and ways of working with data are just around the corner.

Organization

The sessions will be broken into four topics:

1. Introduction - GIS for data management and use in NMP. How can GIS be used?
2. Organization of GIS data - Spatial and database organization
3. GIS Data - Representation, structure, automation, precision, display
4. GIS Tools - Overview of systems, ArcView 2.1 to access and represent data, the future

The sessions will use watershed data from the San Luis Obispo County area on the central coast of California to illustrate concepts. The watersheds include the Morro Bay Watershed and San Luis Obispo Creek Watershed, both of which have numerous ongoing projects at this time.

Group Participation

Although the format will be primarily lecture/demonstration and discussion, there will be four computers with software and data to provide an opportunity for the participants to try out the technology and to use "real" data. The computers should also be available during the breaks. The "hands on" experience will help participants to more fully understand the information.

Additional information provided by the speaker

WHAT IS A GIS?

A *Geographic Information System* is a form of Information System utilizing geographic data.

- System - group of components working together, e.g.., stereo components forming a system
- Information System - set of processes (components) executed on raw data to produce information useful in decision making

GIS - uses geographically referenced and non-spatial data and includes operations for spatial analysis to:

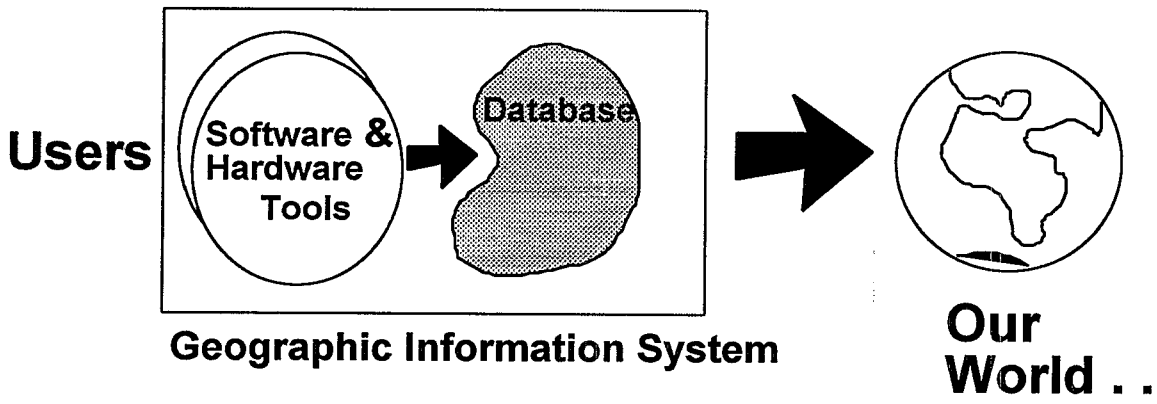
aid in decision making, managing land resources, transportation, oceans, anything spatially distributed...

A GIS System is:

An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently
capture,
store,
update,
manipulate,
analyze, and
display
all forms of geographically referenced information." Environmental Systems Research Institute

or

"A computer system capable of holding and using data describing places on the earth's surface." Environmental Systems Research Institute



WHY IS GIS IMPORTANT?

"GIS technology is to geographical analysis what the microscope, the telescope, and the computer have been to other sciences.... (It) could therefore be the catalyst needed to dissolve the regional-systematic and human-physical dichotomies that have long plagued geography" and other disciplines which use spatial information." Dangermond

GIS:

- integrates spatial and non-spatial data into one system
- enables us to look at data geographically, and gain new insights, explanations, connections
- enables us to look at geographic proximities, i.e. what land uses are within 1/4 mile of Diablo Canyon

Why are computers used for GIS?

- computers are fast
- computers are accurate
- computers are able to store lots of information, efficiently

Types of questions GIS can answer:

- location - What is at...?
- condition - Where is it...?
- trends - What has changed since ....?
- patterns - What spatial patterns exist...?
- modeling - What if...?

*A **GIS** is not:*

- just a system for making maps
- just a system for storing conventional maps

Types of databases:

- environmental/ natural resources
- land records
- transportation facilities
- military
- etc.

GIS IS AN INTERDISCIPLINARY ACTIVITY

Traditional disciplines are brought together. The related disciplines offer the techniques which make up GIS technology: some emphasize data gathering, others analysis.

GIS brings together disciplines by emphasizing:

- integration
- modeling
- analysis
- display/ communication

DATA IN GIS

SAMPLING DATA

- The world is infinitely complex.
- The database represents a particular view of the world.

Representing Reality

- A database consists of digital representations of discrete objects.
- Many features on a map are fictitious and do not exist in the real world.
  boundaries, contours, direction of slope, etc.
- Contents of the database include:
  digital versions of real objects, e.g. roads
  digital versions of artificial map features, e.g. contours
  artificial objects created for purposes of the database e.g. cells

Spatial Data

- Geographic phenomena can be observed on 3 "modes" or can have 3 characteristics:
  Spatial (locational) characteristic
  Descriptive (attribute) characteristic
  Temporal (time) characteristic

Types of Geographic Data

- Line, point, area

Measurement Scales

- It is important to recognize scales of measurement used in GIS to determine the kinds of mathematical operations which can be performed.

- Scales of Measurement
  - **Nominal**
    - name, establish identity
  - **Ordinal**
    - numbers establish order
  - **Interval**
    - the intervals or difference between numbers is significant
    - subtraction makes sense but division does not
  - **Ratio**
    - measurement has an absolute zero, and the difference between numbers is significant
    - division makes sense

Errors and Accuracy

- There is a tendency to lose sight of errors when any data are in digital form
- Types of errors
  Original Sin
    - errors in sources of the data; maps, etc.
  Boundaries
    - lakes fluctuate, soil boundaries are transition zones, etc.
  Classification errors
    - wrong attributes, particularly in tabular data
  Data capture errors
    - manual data input can induce error, e.g. in digitizing

DATA INPUT

- Data input is the largest task (time & $) in the application of GIS technology
- Costs can consume 80% or more of project costs
- Data input is labor intensive and prone to error
- Activities include encoding of both locational (spatial) and descriptive (attribute) data
- Modes of data input:
  keyboard - usually only attribute data but also some coordinate entry
  manual locating devices - digitizing
  automated devices - scanning
  conversion - from other digital sources, e.g. magnetic tape

Digitizing

- uses cursor
- points interpreted as x and y coordinates
- table uses grid of wires to generate electromagnetic field, detected by cursor
- $500 - $5,000
- process:
  map taped to table
  three or more control points digitized
  stream mode - points captured at set time interval
  point mode - operator identifies points to be captured; most common mode
- time/cost - industry "rule-of-thumb" is *one boundary* (polygon) *per minute*

Scanning

- Video scanners - *(the kind we will use)*
  - black and white, or color
  - fast and inexpensive - $500 - $10,000
  - typically have poor geometrical and radiometrical characteristics

- Electromagnetic scanners
  - accurate and expensive $6,000 - $100,000
  - resolution of up to 25 microns
- Requirements for scanning
  - clean documents
  - lines at least 0.1 mm wide, and crisp
  - contours cannot be broken with text

Other Sources of Data

- USGS digital products
  - DLG's Digital Line Graphs - roads, hydrography, boundaries
  - DEM's Digital Elevation Models - elevation
- DIME & TIGER - census data
- CAD/ CAM systems (DXF, IGES)
- LANDSAT, SPOT satellites
- Other GIS products

DATA STRUCTURES - GRID & VECTOR

- A GIS database consists of digital representations of discrete objects
- Current GIS's differ in the way they organize reality
- Through the **data model - GRID/RASTER or VECTOR** - each type of model tends to fit certain types of data and applications
  - A **GRID/RASTER** model indicates *what occurs at each place* in the geography (landscape) - occupies space
    - A grid can be thought of as
      a special case of point sampling where the points are regularly spaced
      a special case of the same size zones
  - A **VECTOR** model indicates *where every object occurs* in the geography (landscape) - location of objects

GRID Data Model

- Process for converting data map into GRID format:
  1. Overlay uniform grid (cells) registered to the earth
     - high resolution means small cells and large grid (overall grid)
  2. Assign values
     values representing measurements, i.e. elevation
     values as "pointers", (e.g. 1 = deciduous forest; 2 = grassland
     usually one value per cell)
  3. Arrange in map layers - THEMES *(from other readings)*
- Cell Size
  Resolution of data
  Types of analysis and modeling
  Personnel and equipment limitations
- Coding Rules
  Predominant type
  Presence/ absence
  Percent
  Centroid

VECTOR Data Model

- Based on vectors, with the fundamental unit as a point *(a primitive)*
- Points are connected with straight lines
- Areas are defined by sets of lines
- Process for entering VECTOR data
  1. Georeference with coordinates (x, y)
  2. Map is digitized by recording points and lines to define general data types:
     - points
     - lines
     - areas *(polygons)*
  3. Edit line work
  4. Label, or attach attribute data to points, lines, areas
- Types of storage:
  1. "POLYGON" Storage
     - every polygon stored as sequence of coordinates - all internal shared polygon boundaries digitized twice, once for each adjacent polygon
     - used in some current GIS's, many automated mapping packages
  2. "ARCS" Storage
  - "smart" - have attributes which identify polygons on either side
  - digitizing *direction* is important
  - areas "built" by linking arcs, calculating the relationships between points, lines, areas and to the RDBMS (e.g. INFO, Oracle)
  - only one version of internal shared boundary is input and stored
  - used in most current vector-based system
- Database
  - Attribute data - description of what the points, lines, and areas represent
  - Often a RDBMS - relational data base management system

MAP PROJECTIONS

A map projection is a system in which locations on the curved surface of the earth are displayed on a flat sheet or surface according to some set of rules

Relevance to GIS

Maps are a common source of data input
Often the size of our study site is large enough that the earth's curvature is significant

Distortion Properties

- angles, areas, directions, shapes and distances will become distorted when transformed from sphere to a plane, to a flat map
- map projections attempt to represent these surfaces but a single projection cannot keep all properties undistorted
- usually, a projection can keep one property from being too distorted but the other properties become very distorted

Universal Transverse Mercator (UTM)

- UTM provides georeferencing at high levels of precision for the entire globe
- established in 1936 by the Union of Geodesy and Geophysics
  - adopted by the US Army in 1947
  - adopted by many national and international mapping agencies, including NATO
  - is commonly used in thematic and topographic mapping, for referencing satellite imagery

Transverse Mercator Projection

- results from wrapping a cylinder around poles rather than the equator
- the central meridian is where the cylinder touches the sphere

Zone System
- to reduce distortion, 60 zones, 6 degrees of longitude wide
- each zone is further divided into 8 degree strips of latitude

Coordinates
- coordinates in meters
- eastings (x) are displacements eastward
- northings (y) are displacements northward

- advantages
  UTM is frequently used
  consistent for the globe
  a universal approach to accurate georeferencing

- disadvantages
  full georeferencing requires zone, easting, northing
  adjacent zones are skewed with respect to each other

State Plane Coordinates (SPC)

- SPC's are individual coordinate systems adopted by the US state agencies
- each state's shape determines the projection
- projections are chosen to minimize the distortion
- units are in feet
- advantages
  SPC may give better representation than UTM for the state's area
  coordinates may be simpler than UTM
- disadvantages
  SPC are not universal from state to state
  problems may arise at the boundaries of projections

North American Datum

- NAD 27 - 1927
- NAD 83 - 1983 (current datum for many projects)

THE FUTURE

Although there are many changes or trends in GIS in the near future, the following are some related to watershed monitoring projects.

GPS - Global Positioning Systems
quicker and more accurate determination of locations

More Network Access
acquisition to existing data (World Wide Web - WWW)
provide access to information by others

3D Visualization
visual understanding and display of phenomenon

Multilayer Views Of Data
better understanding of complex systems

More Portable/Laptop Support
better field access to GIS

Better, Easier To Use GIS Tools
better user interfaces
easier to use modeling and display tools

Access To GIS By Non-Technical Users

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SESSIONS H1 AND H2

BIOLOGICAL MONITORING TO PROTECT WATER RESOURCES

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Since the Clean Water Act amendments of 1972, federal and state agencies have been mandated to monitor the chemical, physical and biological integrity of rivers and streams. The emphasis until recently has been on chemical criteria such as nitrogen, phosphorous, and dissolved oxygen. Continued loss of aquatic species and degradation of aquatic resources has shifted the focus of monitoring to biological criteria.

To assess the biological integrity of Northwestern streams, we collect benthic invertebrates to evaluate the species richness and composition of the biota. Sites with high numbers of mayfly, stonefly, and caddisfly taxa, for example, indicate excellent in-stream conditions. These invertebrates require conditions that are also favorable to salmon—cool, clean, fast-moving water with complex cobble substrates. Juvenile salmon also favor these organisms in their diet. Stream sites that have been damaged by timber harvest, grazing, and urbanization have higher proportions of tolerant organisms such as soft-bodied flies (tipulids and simuliids), worms, some snails, and small crustaceans (amphipods). We evaluate attributes of invertebrate (or fish) assemblages and score them in reference to minimally disturbed sites. Attribute scores are then integrated into an overall numeric index, the index of biotic integrity (IBI), that is used to rank streams or stream reaches according to their biological condition. IBI scores reflect, for example, logging and road building in forested watersheds, the effects of impervious surface area in urbanized watersheds, and agricultural practices in agricultural landscapes.

Participants in this workshop will evaluate data from Puget Sound lowland streams. We will construct testable hypotheses about how invertebrates respond to human-induced degradation and test them with real data. We will construct an index and test its relationship with impervious surface area. In conclusion, we will present evidence of IBI's ability to respond to other types of degradation.

Additional information provided by the speakers

Existing water-quality programs have made substantial progress in improving the quality of water resources in the United States, especially in controlling point sources of contamination. But inadequacies in analysis of the effects of nonpoint sources, and in their management, result in continued degradation of water resources. The most important gap between accomplishments and legislative intent is in the area of biological integrity.

Three problems are responsible for the gap; all deserve increased attention. First, we have used a conceptual framework to control contamination based on point-source strategies that is not effective in controlling nonpoint sources. Second, the primary focus on chemical water quality has allowed other factors responsible for water resource degradation to go unchecked. Third, we undervalue the importance to society of healthy biological systems and, as a result, biological integrity continues its steep decline.

A broader conceptual framework is needed if we are to attain the goals of the Clean Water Act because biological resources are not being protected by current programs.

Humans influence the biological integrity of water resource systems by altering: 1) water quality, 2) habitat structure, 3) energy sources, 4) flow regime, and 5) biotic interactions. Biological integrity is the sum of the elements of biologi-

cal systems (biodiversity) and the biological processes that generate and maintain those elements. Until programs to protect and improve the quality of water resources focus on all those factors, water resource degradation seems inevitable.

Several years ago EPA called for states to develop narrative and numeric biocriteria. Substantial progress has been made by some states but others are just initiating biocriteria programs. Early efforts to focus on rapid assessment are changing. Effectiveness rather than speed should be the core of biological monitoring. Costs of implementation of biocriteria are very competitive with chemical evaluations and they provide a more comprehensive assessment of resource condition.

Bioassessment can be accomplished using any major taxonomic group (e.g., fish, benthic invertebrates, algae). The primary limiting factor is the nature of the ecological insight that goes into the study design, data analysis, and project synthesis. In the Pacific Northwest, we focus on invertebrates, but earlier work in the Midwest concentrated on fish. Salmon, or other fish, may be the primary focus of society but invertebrates provide a better approach to evaluate biological condition in Northwest streams because they are resident year around, are easier to sample, and are present in a diverse array of species. In addition, the process involved in obtaining sampling permits is simplified with invertebrates relative to the many endangered stocks of salmonid fishes.

Both managers and researchers have successfully used biological monitoring and assessment to evaluate the condition of water resources. Ohio EPA uses both invertebrates and fish in their monitoring programs while other states use only one or the other. Linda Deegan at Woods Hole has developed a prototype IBI for estuarine environments, and John Lyons has adapted the fish IBI for use in Wisconsin. Many other water resource managers and scientists have developed approaches that are reliable in their regions.

An early step in the design of an effective program is to generate hypotheses about the relationship between human actions and the condition of the aquatic biota. Work throughout North America has demonstrated the generality of patterns, such as the total number of taxa and the number of stonefly taxa decline as human actions increase within a watershed. We have used a variety of measures of human influence: percent impervious area in urban environments; grazing intensity in rangeland; percent of watershed logged in forested areas; and condition of riparian corridors in a number of areas. By plotting, for example, taxa richness (number of kinds of fish or invertebrates in a stream sample) against a measure of human influence (% impervious area) one can document very robust indicators of water quality.

The following metrics work well in the Northwest as measures of biotic integrity of streams:

Metric	**Response**
Taxa Richness	
Total number of taxa	decrease
Number of Ephemeroptera taxa	decrease
Number of Plecoptera taxa	decrease
Number of Trichoptera taxa	decrease
Number of long-lived taxa	decrease
Number of intolerant taxa	decrease
Number of sediment intolerant taxa	decrease
Community Structure	
Percent predator individuals	decrease
Percent tolerant individuals	increase
Percent sediment tolerant individuals	increase
Percent dominance (3 most common species)	increase

Workshop participants were given sample data (benthic invertebrate samples) from six lowland streams in Puget Sound. Streams were selected to represent the range from the best to worst streams in the region along a gradient of urbanization. The metrics listed above were calculated for each station and scoring criteria were developed to define each site based on the range of values within the data set. These metrics are essentially hypotheses about the effects of human activities on invertebrate assemblages. After each site was evaluated and scored for each metric, an IBI was calculated for each stream and the ranking of streams was compared to the conditions within each watershed (as ranked by % impervious area). This IBI is referred to as B-IBI (benthic IBI) to distinguish it from the original IBI

based on fish assemblages. B-IBI values were ranked according to impervious area, indicating the ability of biological data to reflect watershed condition.

Although the influence of human activities varies from watershed to watershed in the region, analysis of invertebrate data demonstrates that diverse human actions (e.g., forestry, grazing, urbanization, and the cumulative impacts of these and other actions) have predictable and easily detected influences on benthic organisms. Conversely, sampling aquatic organisms provides a convenient and reliable evaluation of the condition of streams and the landscapes they drain. Biological integrity varies in predictable ways with measures of the extent of human influence within a watershed (e.g., percent impervious area, percent of watershed logged, grazing intensity, or chlorine concentration in effluent water). Other factors that also influence biotic integrity include time since logging, drainage from mined lands, presence of wetlands or intact riparian areas, and number of stream crossings by roads in areas involving timber harvest.

Some states begin by establishing a set of reference stations to define reference condition. We do not begin with reference streams per se. Rather, we identify and sample the full range of stream conditions in the sample region. By sampling the best and worst and a range of intermediate streams, we can observe which biological attributes vary as a function of intensity of human activity, that is, along a gradient of human influence. One cannot discover how biology changes (i.e., which components of biology provide signal about biological integrity) by only measuring reference streams. By integrating the results of studies in grazed, logged, and urbanized landscapes, biologists can develop a general B-IBI useful in watersheds with diverse cumulative impacts.

Success in use of the multimetric IBI has changed the framework of monitoring and analysis of water resource condition in many states. Use of biological monitoring has been limited in the past, in part because of the following factors: 1) dominance of water pollution engineers; 2) lack of a defensible definition of biological integrity; 3) lack of standardized field methods; 4) lack of indexes successful in measuring attainment of biological integrity; and 5) misconceptions about the cost of biological monitoring. The development of multimetric approaches like IBI clearly demonstrates that these problems have been overcome.

Societal well-being has long been evaluated by examination of the health of individual humans. In recent decades, economic health has been the focus of efforts to assess societal well being. IBI provides a way to assess ecological or environmental health, upon which both human health and economic health ultimately depend.

SESSION K1 & K2

APPLYING THE PAIRED-WATERSHED AND UPSTREAM-DOWNSTREAM MONITORING DESIGNS

Moderators: Pat Lietman, U.S. Geological Survey, Lemoyne, PA
Jean Spooner, NCSU Water Quality Group, Raleigh, NC
Jack Clausen, University of Connecticut, Storrs, CT

Paired Watershed Study Design

Jack Clausen, University of Connecticut, Storrs, CT

The criterion of a paired watershed study design will be described. Jack's own *Fruit-of-the-Loam* presentation will be included. Statistical analysis approaches will be summarized. An example from a conservation tillage paired watershed site in Vermont will be used.

Discussion:

Experimental Designs

Single Station Design: a single station below the treatment area compares baseline and post-treatment data. The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to climatic factors.

Above and Below — Before and After: analysis can be similar to the paired watershed design.

Above and Below Design: monitoring occurs on receiving waters both above and below the treatment area. The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to inherent differences in the watershed between above and below positions (e.g., geology). The exception to this is the case of above and below design with both before and after sampling, allowing two periods of comparison.

Two Different Watersheds: comparison of two watersheds with different land uses (e.g., agriculture and forestry), where one receives BMP implementation and the other remains the same. The major disadvantage is that the cause of water quality changes can't be isolated; results may be due to BMPs or to the inherent differences in the watersheds. There are many examples of these flawed studies in the literature.

Paired Watershed Design: two similar, nearby watersheds are used. A calibration period occurs where the watersheds are treated the same in terms of land use and management. From this a regression relationship is developed for their hydrology. The watersheds do not need to be identical, they just need to respond similarly to rainfall. Regression relationships are compared between the two watersheds before and after land treatment, based on slope and intercept.

The advantage of this method is that rather than performing a comparison of absolute parameter values, changes in the relationship of values between the two watersheds are analyzed. The method factors out confounding variables, narrowing the cause of water quality changes more closely to the treatment BMPs. One weakness of this method is the lack of replication (such as is used in plot- or field-scale efforts).

Nested Watershed Design: this method is useful where there are distinct geological zones within a basin (e.g., coastal plain, piedmont, and montane). Analysis is similar to the paired watershed design. The treatment area is a subwatershed in the head waters. The larger watershed outlet is monitored to evaluate relative change in the smaller subwatershed.

Multiple Watershed Design: the use of numerous watersheds within a basin allows a substantive understanding of the basin-wide big picture.

Paired Watershed Issues

The prior existence of water quality-oriented BMPs in the control watershed should not be considered a disqualifying factor. Prior level of BMP use is not as important as a lack of change in BMPs in the control watershed during the 6 to 10 year monitoring period. This feature is attributable to the comparison of relationships between watersheds, not simply values. Ideally, both watersheds should have the same land uses, but they can be different provided land uses don't change during the project. Watersheds with significantly different land uses will show different hydrologic responses, but as long as the relationship between them is established, the design can be workable.

In an above/below — before/after watershed design, the control watershed may be more desirably located up- or downstream, depending on the treatment. For example, the "anti-BMP" of spreading manure on frozen ground should be done downstream from the control, whereas restoration of riparian areas should occur upstream of the control.

A completed case study of a paired watershed in Starksboro, VT was presented. The project evaluated the effects of conservation tillage on pesticide movement in surface water. Conservation tillage was defined in terms of residue management, the leaving of at least 30 % residue on the surface. The design actually used paired fields of approximately 2 ha in size. H-flumes collected surface runoff. In evaluating pesticides, the desired focus is on the decay in pesticide movement in runoff over time following application. Use of paired watersheds allows this comparison of temporal effects because the effect occurs on both watersheds. The calibration period was 19 months, the treatment period 30 months. A useful method of evaluating the data involved generating plots of residual errors for the treatment vs. the control. In this example, plots represented the observed deviations from predicted total mass export of atrazine based on the control watershed, and provided a visual illustration of the change in that deviation over the project's lifetime. The individual errors in these plots could be summed to give the total reduction in mass export of atrazine for the given time period due to the treatment.

Downstream-Upstream Study Design - Long Creek Watershed, 319 NMP, North Carolina Case Study

William A. Harman, North Carolina Cooperative Extension Service - Gaston County, Dallas, NC
Jean Spooner, NCSU Water Quality Group, Raleigh, NC

Monitoring data from a management area of the Long Creek, NC project, which has an upstream-downstream monitoring design, are presented to illustrate various aspects of water quality data analysis. One of the preliminary, but important, steps in the analysis of monitoring data is to plot the data in different ways such as upstream parameters versus downstream parameters, all parameters versus covariates, and all parameters versus time. Plots of the data from our project indicated that concentrations of total Kjeldahl nitrogen (TKN), nitrite+nitrate (NO_2+NO_3), total phosphorus (TP), and levels of fecal coliform bacteria (FC) were generally greater at the downstream (site E) compared to the upstream (site D) sampling station; however, considerable variability was apparent.

Observation and then regression analysis showed a relatively strong (r^2=0.64) linear relationship between upstream and corresponding downstream concentrations of NO_2+NO_3. Further statistical analysis will be discussed to test sample frequency requirements, minimum detectable change that will be required in the post-BMP period to document a change in water quality, length of pre-BMP monitoring, and usefulness of storm water samples for trend analysis.

Workshop Discussion:

Long Creek drains a 28,500 ac mixed agriculture/urban watershed in southwestern piedmont North Carolina, and serves as the primary water supply for a small city of 5,000. Water quality problems include high sediment, bacteria, and nutrient levels, and sections of the Creek are listed as support-threatened.

The study was designed as an upstream-downstream study. The upstream watershed contains pastures, single family homes, and apartments. Extreme bank and bed erosion is occurring within upstream pasture area that supports 300-400 dairy cows. Major sediment transport action causes filling in behind the weir that was established for the upstream sampling site, compromising stage-discharge relationships. The weir is a v-notch to allow accurate gauging of low flows, but it also lends to sediment accumulation. The downstream or treatment watershed contains a milking barn and a loafing area which receives heavy use. Land management focuses on reducing erosion, largely from streambanks, by providing alternative watering sites and by fencing and restoring riparian corridors.

The current dilemma is two-fold: 1) whether to approach the project as a paired watershed design with the control upstream instead of as an upstream-downstream arrangement, and 2) whether to fence the entire study area stream corridor, both up- and downstream, or fence only the treatment area corridor. On the first question, a paired design could give more valuable results. On the latter question, there is a concern that sediment loading from the upstream watershed is so great and highly variable that it will not only compromise the stage-discharge relationship at the upstream weir, but also that sediment values at the downstream station will be swamped.

The concern was expressed that changing practices upstream by fencing the riparian area, while acceptable for upstream-downstream design, would nullify a paired approach. Given that results under any approach might be difficult to interpret if upstream fencing doesn't occur because of swamping of downstream values, some felt that upstream-downstream and complete fencing was a good alternative. Mr. Harman pointed out that considering practical realities, the farmer would very likely want to fence all of the corridor, given the short-term availability of 75% cost-share. While discussing the experimental design concerns and the fact that most of the pollutant source was below the upstream and downstream monitoring locations, the general consensus was to minimize treatment above upstream site D and to maximize treatment below the 2 monitoring locations.

A separate issue involves an inconsistent relationship among the nitrate data. At low flows, downstream values are lower than upstream, while at high flows, downstream values become higher. Some discussion focused on minimizing variability in the data. The suggestion was made to stratify the data seasonally, and to factor out flow. The upstream weir was identified as another potential source of data variability; under high flows it could become a sediment source as opposed to a sink at low flows.

Changes to the upstream weir design were discussed, such as modification to a rectangular notch with a v-cut, to allow sediment to pass while retaining the ability to gauge low flows for a rating curve and mass load calculations. The use of different upstream (weir) and downstream (culvert) structures was identified as undesirable and a potential source of data variability. The upstream weir could actually act as a BMP. As long as there were no significant defined inputs between up- and downstream, and given the relatively short flow distance of approximately two hundred yards between sampling sites, it was suggested that the downstream stage relationship be used for the upstream site as well, and that the upstream weir be removed.

Paired Watershed Study Design - Sny Magill Watershed, 319 NMP, Iowa Case Study

Lynette Seigley, Geological Survey Bureau, Iowa City, IA

Data from the paired watershed study in the Sny Magill Watershed, Iowa project will be examined. Two large watersheds are being used for the paired watershed study. Sny Magill watershed consists of 22,780 acres; the Bloody Run Creek watershed is adjacent and drains 24,064 acres. Preliminary data analysis will be presented, using one year as the pre-BMP data set and two years as the post-BMP data set. The challenges and benefits of utilizing a short pre-BMP period and having large watersheds will be discussed.

Workshop Discussion:

Sny Magill is a paired watershed design, with Bloody Run as the control. This example illustrated the issues of appropriate watershed size (keeping them as small as possible) and minimum sufficient baseline data. At 34 and 27 mi^2, respectively, both Bloody Run and Sny Magill watersheds are extremely large, and therefore hard to control in terms of unwanted land use changes during the study. Implementation of BMPs over a significant portion of the treatment watershed is a real challenge. Also, 70 to 80% of the flow out of the watersheds is base flow.

Another complicating factor was the ability to collect only one year of baseline data before BMPs had to be implemented due to time limitations on the HUA cost-share moneys. Regarding the question of minimum sufficient baseline data, Jack Clausen provided some guidelines. He stated that the calibration period ends when:

- a significant regression relationship is obtained. It may not be obtained for all constituents, and it may be obtained for mass load but not concentration. While the F statistic is important, a reasonable r^2 for water quality work was felt to be in the .6 to .7 range;
- regression errors are less than BMP effects. Two means of measuring this are confidence intervals and minimum detectable concentration;
- there is a sufficiently large sample size; and
- the full range of anticipated values for each parameter has been spanned by data points (the high end being of concern).

Jack Clausen also gave some guidance on improving the correlation coefficient of regressions to improve baseline calibrations:

- paired observations may not show a significant relationship in concentration, but be acceptable in terms of mass load;
- perform flow adjustment of concentration, if concentration varies in some way with flow;
- aggregate the data. Use means or totals, use weekly or monthly aggregation;
- stratify the data - by season (e.g., 4 seasons, or ice and non-ice, or planting and non-planting) or by process period (e.g., separate initial spike in values due to ephemeral flushing associated with BMP installation from later stabilization of values);
- use multivariate regression and add explanatory variables (covariates).

Sharing the Paired Watershed Experience

All session participants will be encouraged to briefly describe problems and success with their paired watershed studies. Pat Lietman, of USGS (PA), shared the results of her study with the group, as summarized below:

This is a paired watershed design with watersheds of 1.48 and 1.8 mi2, much smaller and more manageable than the Sny Magill areas. Pat Lietman made a brief presentation to illustrate the effects of sampling design on parameter values obtained. Graphs of various parameters were shown, obtained from time-based (@10 day intervals) instantaneous samples contrasted with those obtained from composite grab samples. Significant differences were apparent in concentration between the two methods for all constituents. Poor regression relationships existed for the time-based composite data, while the storm composite sample regressions showed r2 values in the 0.6 to 0.7 range. She then illustrated use of the EPA factsheet, *Paired Watershed Study Design*, on the Mill Creek site.

SESSIONS I1 AND I2

LAND TREATMENT MONITORING: DATA NEEDS, COLLECTION, AND MANAGEMENT

Jack Clausen, University of Connecticut
Kathleen Kilian, NRCS Liaison to EPA Region 10

Objectives

1. Participants will be able to develop a land use monitoring plan.
2. Participants will interact with others having similar issues in land use monitoring.

Process

This session is intended to give hands-on experience in developing a land use monitoring plan for water quality monitoring projects. The session will be highly participatory and involve group activities.

Agenda

I. Facilitators give lecturette on land use monitoring (30 min.)
II. Facilitators divide the entire group into smaller groups of five members each with similar interests. (15 min.)
III. The groups will begin the first of three exercises. (30 min.)
IV. Groups will report their findings.
V. Break
VI. Groups will begin the second of three exercises.
VII. Groups complete the exercises.
VIII. Groups present results of their plans.

Group Findings

A land use monitoring program for a watershed project was developed by each group. The following information was compiled:

Information Needed
- Base map
  - hydrology: surface and groundwater; soils; cover type
- Current and projected land use
- Historical data - water quality and biological
- Water quality standards: criteria and biological
- Inventory of farm practices
- Runoff
- Upstream contributions
- Manure (nutrient) application
  - timing of application
  - location of application
  - rate of application
- Crop type and rotations
- BMPs
- Irrigation methods
- Spatial land use / cover
- Critical site selection
- BMPs (current and historic) data
- Determine the water use
- Characterize leachate
- Soil type / leaching interactions
- Names of land managers and operators
- Current list of management units
- BMPs applied
  - EIS documents
  - Consult literature reviews, theses, and on-line computer data
  - Pump logs (existing monitoring wells and ground water data)
  - Determine leachate
  - Select pilot project sites

Method
- Personal observation of site characteristics
- Field logs
- Stream monitoring data
- Conservation districts, NRCS
- Field surveys
- Operator interviews
- Remote sensing: NRCS, FSA
- On-site visits
- Previous data - USGS
- Other agency files and data
- Field logs
- Follow-up with personal interviews
- Follow-up with agencies
- Personal contact with the county government (tax lots), NRCS, FSA
- Ground tracking - interview local specialists
- Build on existing data
- Quad maps - USGS
- Contact the Forest Service, local universities, and data archives
- Build trust through personal contact: interview local agencies
- Time log
- Cost vs. benefits

Data Management
- Dedicated staff
- Dedicated resources
- Dedicated technology (spreadsheets, Access databases)
- Photographs
- Spreadsheets
- GIS and AutoCad
- Acetate overlays
- BIA GIS for existing physical and chemical characteristics, and monitoring well and pilot project locations
- Personnel
- Existing university agencies
- Communities
- Coordinators
- GIS - store spatially and temporally
- Contractor for format (in-out), trend analysis, evolution of data
- GIS - Macintosh software
- Buy information
- ArcInfo

SESSIONS J1 AND J2

LINKING LAND TREATMENT WITH WATER QUALITY AT THE WATERSHED LEVEL

Don Meals, University of Vermont

OPENING DISCUSSION (first 20-30 minutes of J1)

I. Spatial and temporal issues at the landscape/watershed level
   A. Scale issues: edge-of-field vs. watershed
   B. Factors influencing pollutant delivery to watershed outlet
      1. Hydrologic system
         a. Where do pollutants come from? Possibilities include highly erodible land, areas that receive manure, and riparian zones.
         b. How do pollutants get there? Variable Source Areas - runoff contributing areas (consider rainfall and soil conditions for surface water) and ground water flow systems.
         c. How long do pollutants take to get there? Consider ground water time of travel.
      2. Pollutant behavior
         a. Nutrients - phosphorus sorption to soil or sediment particles, erosion transport, bioavailability
         b. Bacteria - sources; die-off
         c. Pesticides - toxicity, partition/leaching potential, persistence
      3. Flow collector processes
         How do pollutants get from where they are generated to the stream?
      4. In-stream processes
         How are materials processed (physical, biological processing of nutrients) once they are in the stream?
      5. Management
         What actions are taken to influence supply, availability, and losses?
         What BMPs are used to manage these sources? NOTE: Management is only **one** factor influencing what you see at the watershed outlet.
         Good news: most other factors are relatively constant, within some bounds.
         Bad news: other factors are often unknown or unknowable.

II. Measures of land treatment/management to relate to water quality
   A. What are the independent variables of interest? They are not the amount of dollars spent or the number of structures built, but are the activities that affect pollutant inputs, generation, availability, transport, or delivery.
   B. Arithmetic measures - variable selection exercise:
      1. Hypothesize potential relationships
      2. Hypothesize mechanisms
      3. Select variables and measurement scales
   C. Spatial measures
      1. Cookie-cutters (e.g. all corn land, 100 m. buffer around streams, aquifer recharge area)
      2. Runoff contributing areas
      3. GIS applications
         a. Designation of Hydrologic Response Units - land areas having similar response to precipitation/snowmelt based on combination of physical properties (e.g. altitude, slope, aspect, soil, cover, and climate).
         b. Mapping critical areas (e.g. erosion rates as a function of a soil and cropping system).
         c. Integrating distance/attenuation factors regarding pollutant export.
         d. Riparian condition map based on slope, vegetation, and bank conditions.
         e. Air video and GIS for mapping watersheds and identifying riparian condition.
   D. Temporal measures
      1. Timing of management activities
      2. Timing of storms
      3. Trends through time

III. Linking land treatment and water quality
  A. Constraints
    1. Differences in scale/precision of data
    2. Confounding interactions
      a. Obvious: hydrologic variations, e.g. precipitation, seasonal differences.
      b. Subtle: weather vs. agricultural activities, e.g. manure vs. spring runoff, bacteria vs. pasture season or temperature.
    3. Unknown landscape-level influences
      a. How does position affect influence on water quality?
      b. Landscape level processes - phosphorus and nitrogen attenuation, wetlands, storage.
  B. Possible approaches
    1. If variables and covariates are chosen carefully, association will equal correlation and regression.
  C. Examples of success and failure
    1. Success: TVA Watershed Index of Pollution, Pennsylvania RCWP lag, Vermont RCWP (animals and bacteria)
    2. Failure: Manure applications and phosphorus, pasture and bacteria

GROUP EXERCISE (remaining time of J1 and continuing through J2)
Participants divided up into groups of 6 to 10 people
Each group was provided with a unique scenario, including:

- watershed baseline description
- water quality problem statement
- water quality monitoring system
- hypothetical "rules" governing pollutant behavior, land treatment, practice efficiency, hydrologic system, etc. in their watershed
- limited amount of money

Each group did the following:

1. Sketched out their land treatment program and land treatment monitoring program.
2. Formulated their hypothesis on the effect(s) of their land treatment program on water quality.
3. Bought land treatment implementation and positioned it within the watershed (within the typical limitations and constraints of a voluntary program).
4. Bought land use/land treatment information/data.
5. Bought analytical tools such as maps, spreadsheets, and GIS.
6. Made choices regarding measures of management to use, how to quantify and display, and how to relate to water quality.
7. Reported back to entire group.

Team Project Reports

Team #1:

- Planning process: This project team operated at the direction of watershed people. They collected, reviewed, and analyzed information related to watershed. Problems were identified and water quality monitoring information, land use, and existing farm practices were reviewed.
- Goal and objective: To improve and enhance the water quality of the watershed. The main focus was on the lower portion of the watershed and on direct BMP application. Prioritization of actions and educational development was also important.
- Specific project elements: A map was developed, indicating the problem areas treated. Farm practices were focused upon. All money was spent on implementation and restoration activities. It was discovered that the main contributor to load degradation was livestock. One-hundred % of the problem areas received BMP implementation. Two stream crosses were eliminated and ten crossings were armored. All pastureland and those areas with degraded streambanks were fenced. There was intensive management on pasturelands. An educational outreach program was implemented, with the hope of changing cultural viewpoints of current residents and those arriving in new housing developments. There was enough funding to complete stream restoration on three kilometers of degraded streams.

- Team summary: The requirements for monitoring effectiveness became academic. A windshield survey was implemented, all farmers complied, and there was a 90% reduction of loadings, 75% reduction in phosphorus and 90% reduction of e. coli.

Team #2:

- This group focused on fencing units, armored crossings (eliminating one), and stabilizing streambanks.
- Land use monitoring: By looking at discharge and storm events, it was determined that the sources identified would not account for loads. Farmer log books, interviews, photographs, and windshield surveys were used to get information about potential sources in the watershed. A GIS approach was used for analyses (ARCINFO, SAS, etc.).
- Effectiveness: Calculations showed a 20% reduction in phosphorus.

Team #3:

- Goals were discussed as to reduce or eliminate impairment for fishing, swimming, and aesthetics. The major pollutants were sediment, phosphorus, and e. coli.
- BMPs: Cost, effectiveness, and land use considerations were discussed. There were correlations among land use, riparian conditions, and targeted areas where BMPs should be implemented. It was decided that BMPs would not be used for corn land. While looking at the upstream distribution of stream crossings, it was determined that one stream with less priority should be eliminated. A secondary targeting process began, based on BMP effectiveness. Two additional crossings were eliminated, nine crossings were armored, and four kilometers of fencing, six rotational grazing packages, and two kilometers of streambank restoration packages were purchased.
- Budget: The allotted money was spent first and documented later. Site specific and overall reductions of parameters were made. There was an eight percent reduction in phosphorus and a ten percent reduction in e. coli. Focus was aimed on smaller areas of the watershed. In some areas, loading was reduced by 100%.
- Monitoring plan: The money was targeted on aerial photography, GIS, and education and outreach. The photography was downloaded into GIS and used as an educational tool.
- One farmer pulled out of the program. The remaining money was used to bring the farmer back to make the program more effective and to expand the outreach program to other farmers. A conclusion was not drawn on how to quantify the level of treatment because the team believed the data to be insufficient.

Team #4:

- Total suspended solids, total phosphorus, and e. coli loadings were calculated by adding stream meters on a map.
- The allotted funds were spent on eliminating 2 allowable crossings and armoring 11 others, fencing 5.6 kilometers of streambank, stabilizing 4 kilometers of streambank, and converting 8 pastures to rotation grazing. ArcInfo was also purchased.
- The group was successful in reducing pollutants. One armored crossing was lost, and one farmer dropped out. Extra efforts were made to have close farmer contact for cooperation.

Team #5:

- Budget: The allotted money was primarily used on streambank fencing. Armored crossings were installed and one was eliminated. All riparian areas were fenced.
- Education in the watershed: GIS and ArcInfo were used to generate reports to show farmers that their actions benefited the entire watershed. These reports would be presented annually. Log books were provided for the farmers, aerial photographs were taken, and annual interviews were done. The aerial photographs were used to show where fencing was in place.
- After data analysis, the group discovered that total suspended solids were reduced by 85%, total phosphorus by 55%, and e. coli by 80%.

Session Leader's Observations:

- Goal setting and assessments were utilized, prioritizing the target, and pollution reduction percentages were targeted. Information on how to measure the extent of land treatment and how it affected water quality was not presented.

- For future use, it should be noted, with emphasis, that not every problem has a regulatory or mandatory solution. Perhaps some loaded questions should be included, but don't include all information.

SESSIONS L1 AND L2

STATISTICS: CONCEPTS AND APPLICATIONS

Pete Richards, Heidelberg
John McCoy, Maryland Department of Natural Resources

The title first suggested for this session was "Statistics Made Easy", but we decided that statistics really cannot be made easy, and we might just as well admit it. In fact, applying formal statistics correctly is difficult without advanced training, and knowing that you've applied statistics correctly is even more difficult. Most of us do not have that level of training, and should acknowledge this reality and consult with experts when we need to.

One thing that is considerably easier to do without advanced training is to explore your data and find many of the patterns in it. Once the patterns are discovered and documented graphically, formal statistical treatment may not be necessary. Or, if it is, the appropriate techniques will be more apparent, and consultation with a "real" statistician will be more efficient. Throwing statistical tests at a data set without a prior notion of what the patterns are and what you want to evaluate is like fishing without bait - it's usually not very successful, and if you do come up with something, it may well not be what you were after!

We support the two-step approach first suggested by Tukey: exploratory data analysis followed by confirmatory analysis. Exploratory analysis seeks to identify patterns and leads to the generation of hypotheses; confirmatory analysis applies formal statistical testing to evaluate the probability that the patterns represent something real, rather than being a result of random variation alone. Many programs for exploratory data analysis are now available for personal computers, offering a number of features which make the exploration process an easy and powerful one. Most programs also offer formal statistical tests.

This session will be an introduction to techniques of exploratory data analysis on personal computers, using a MacIntosh program as an example of the kind of tools available. We will present a step-by-step approach to exploring a data set, seeking whatever stories it may have to tell. After a short introductory presentation, we will interactively explore three data sets, at least two of them from NMP projects, and including ground and surface water data. In the second half, we will explore another NMP data set, and consider some of the special issues related to load estimation and working with Biomonitoring results. **Audience participation is expected and will help make this session successful as well as take it in directions where it can do participants the most good.**

Some Useful References:

Helsel, D.R. and R.M. Hirsch. 1992. *Statistical Methods in Water Resources.* Elsevier Studies in Environmental Science 49. (Exploratory data analysis, non-parametric statistics, and other novel approaches applied specifically to water resources questions. A very valuable guide, worth even Elsevier's price.)

Hoaglin, D.C. and D.S. Moore, Eds. 1992. *Perspectives on Contemporary Statistics.* Mathematical Association of America Notes #21. (See especially Chapter 2 on Data Analysis. You'll recognize the source of some of our introductory remarks.)

Hoaglin, D.C., Mosteller, F., and J.W. Tukey, Eds. 1983. *Understanding Robust and Exploratory Data Analysis.* John Wiley & Sons. (The basic introduction to exploratory data analysis approaches, more technical and theoretically oriented than the other two references.)

(The following pages are copies of overheads used during this presentation.)

STATISTICS: CONCEPTS & APPLICATIONS

aka

~~Statistics Made Easy~~
Approaches to Data Analysis

R. Peter Richards • Heidelberg College Water Quality Laboratory

"We got all this data and
we gotta
do some statistics on it..."

NMP Project Director?
I hope not...

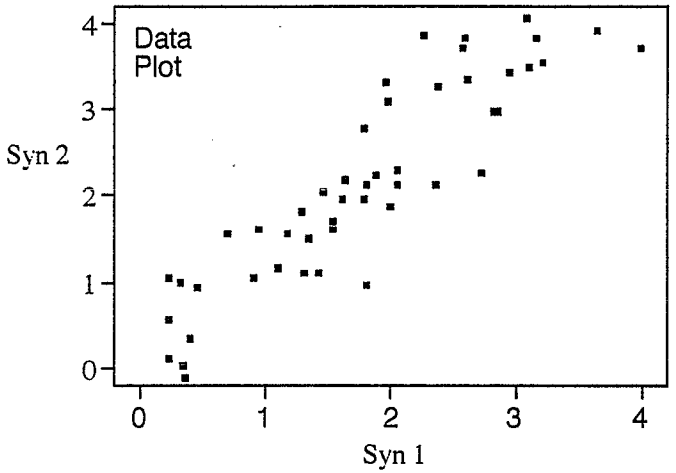
Philosophy I:
What is "Doing Statistics"?

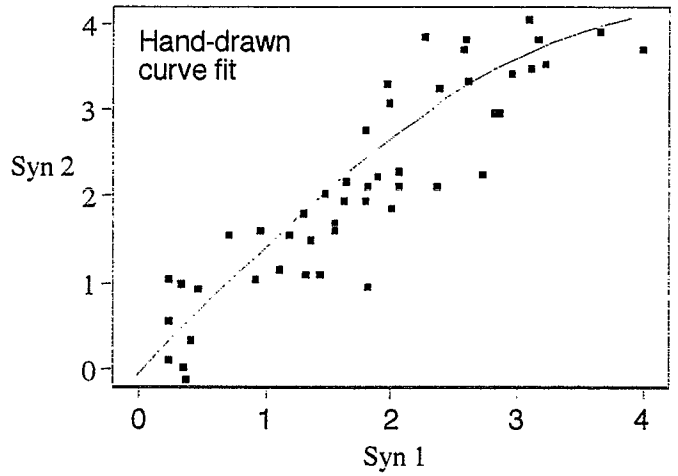
Is this?

Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174

Philosophy I:
What is "Doing Statistics"?

Is this?





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Philosophy I:
What is "Doing Statistics"?

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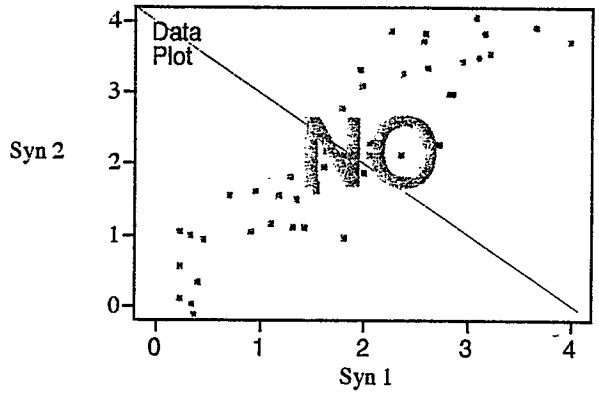
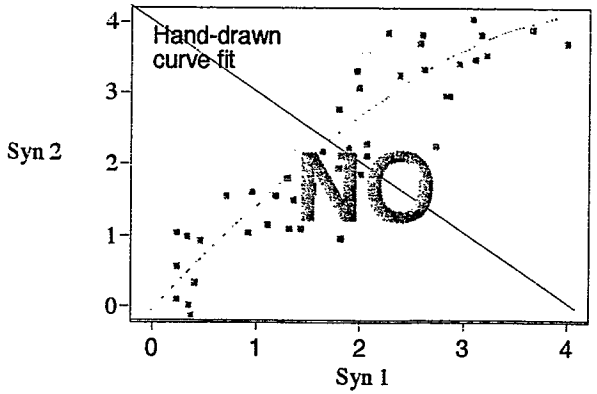
Syn 2	50	2.087	1.174

YES





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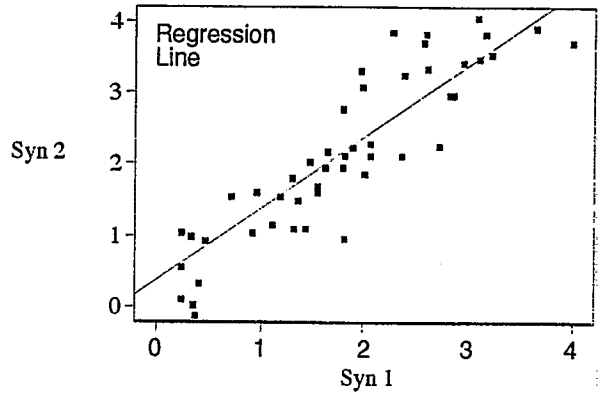

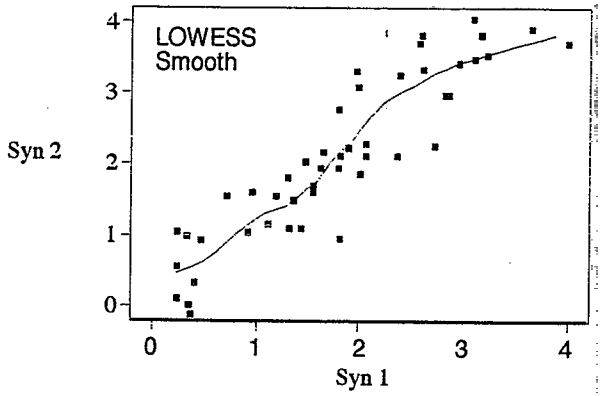

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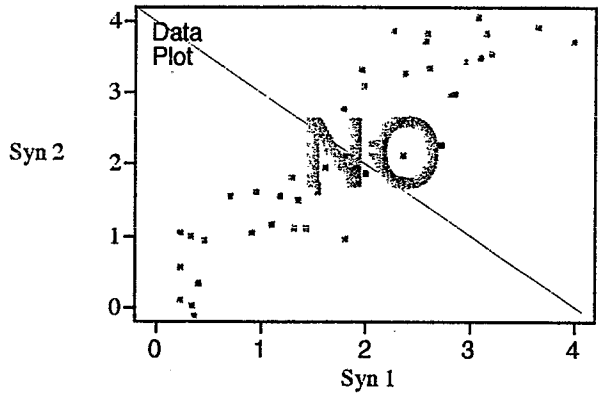
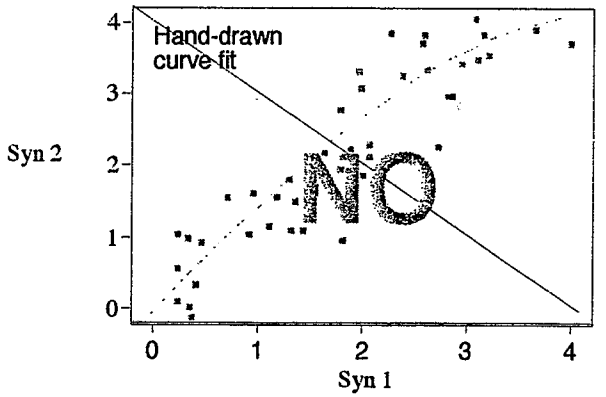
Philosophy I:
What is "Doing Statistics"? And WHY?

Var	n	mean	std dev
Syn 1	50	1.703	1.050
Syn 2	50	2.087	1.174

YES





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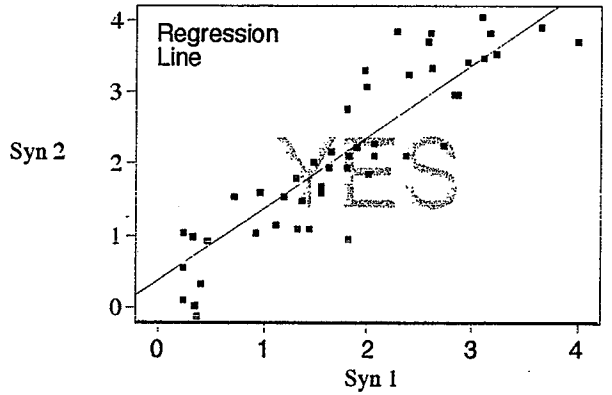

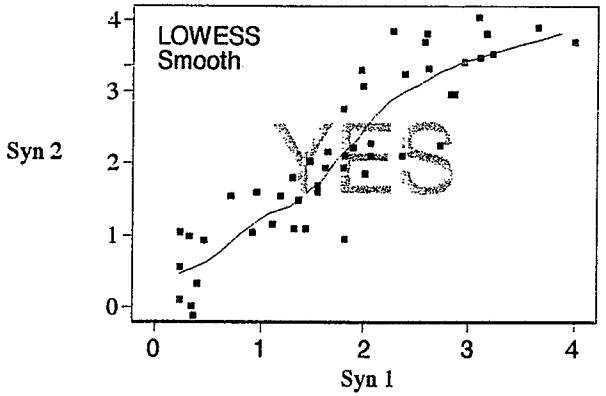

"Doing Statistics" is...

... applying any of a number of objective procedures to:

- describe one or more sets of data,
- usually to make inferences about the total of all possible observations of which the actual data is a part, and
- often to evaluate the probability that two or more sets of data are from different populations or universes.

Fundamental Choices for Confirmatory Statistics

Parametric, Non-Parametric, Parametric on Ranks

To Transform or Not To Transform...

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Different Uses of Statistics

- Characterize the center and spread of a set of data.

- Make inferences about the "universe" of possible data of which our particular data is a sample

- Test hypotheses about one or more sets of data:
  - these two samples are different (trivial),
  - these two samples are drawn from different universes
  - there is a (linear) relationship between these two samples

- Extrapolate/interpolate from existing data
  - trend studies
  - modeling

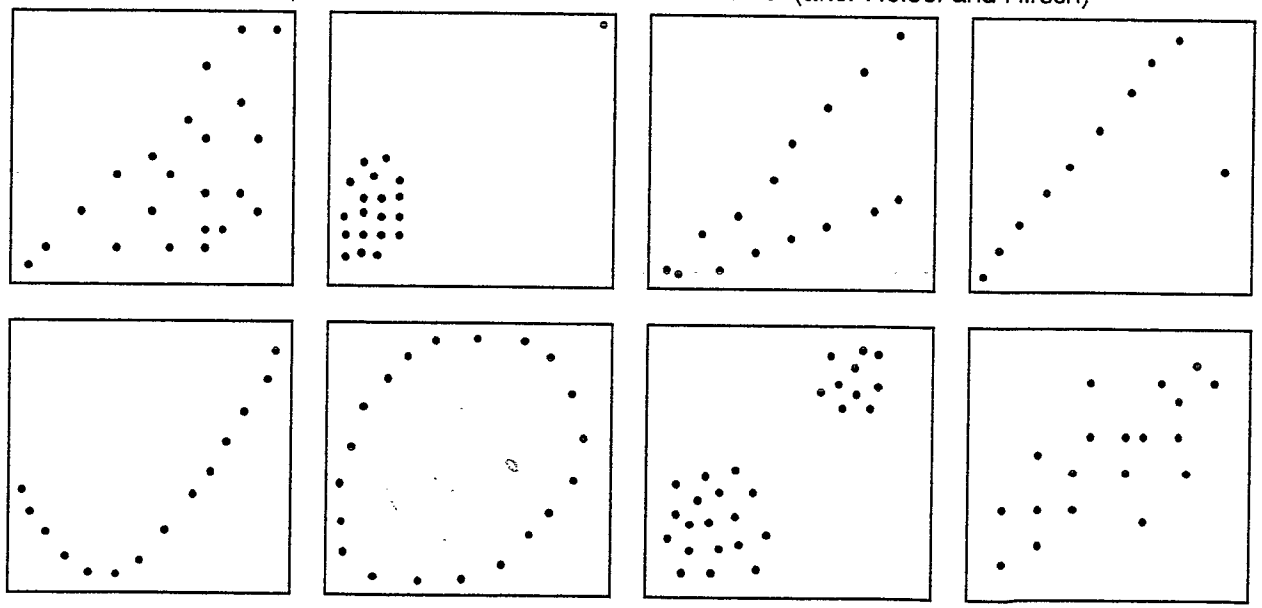
Philosophy II: The Appropriate Use of Statistics…

- is **NOT** to grope blindly for some order in all that data
- is **NOT** to mine a data set in the search for something (anything...) impressive to put in a report
- **IS** to evaluate objectively whether an expected (hoped for?) relationship actually exists in the data, and not by chance
- **IS** to formalize a subjective understanding of a relationship perceived in the data
- **IS** to evaluate how confident we can be of a perceived relationship (if at all)
- **IS** to evaluate whether the relationship is likely to hold for the universe of which we have a sample, not just for the sample itself - i.e. separate "real" from "coincidental"

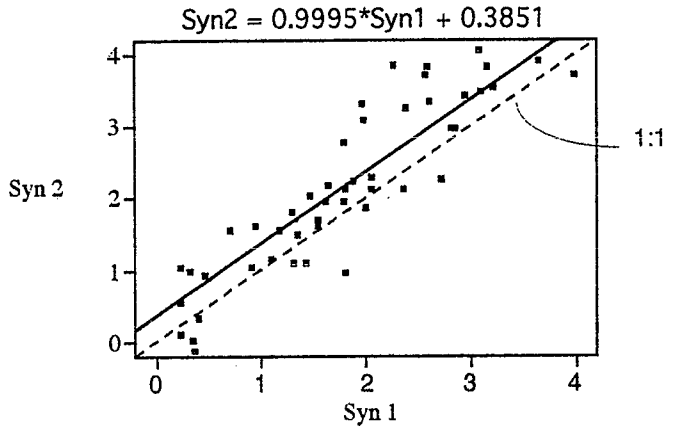
Common Pitfalls

- Can't show sameness, only difference: Cigarettes and cancer
- Correlation and causality: The Methodist Minister Syndrome and "lurking variables"
- Can get misleading results if data are not distributed as assumed

Eight scaterplots, all with correlation coefficient 0.70 (after Helsel and Hirsch)



Statistical Significance vs Environmental Importance



- Statistical significance reflects how certain we are of a difference

- Statistical significance does not indicate how big or how important the difference is

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The Tukey Paradigm for Data Analysis

Exploratory Data Analysis
(do it yourself)

Confirmatory Statistics
(get help)

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Philosophy III: The Perspective of Exploratory Data Analysis

- We seek not just to answer questions, but to develop better questions, and maybe even new, unexpected ones. We ARE prepared to mine the data, and to let it tell its own story.

- PLOT THE DATA!

- We are probably most interested in the story that the majority of the data is telling. Remove usual observations (temporarily) and concentrate on the main pattern. Then go back and figure out what the outliers are telling us.

- Hypotheses are to be used flexibly for guidance, not tested rigidly as the goal of the process. Velleman and Hoaglin: "We prefer approximate answers to the right question over exact answers to the wrong question"

- Conventional statistics tends to be end-oriented: is the test significant or not, awready? EDA is process- and progress-oriented: try a bunch of approaches and see what you can learn. Use what you learn to guide what you do next. "Unpeel the onion".

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Characteristic Aspects of Modern Exploratory Data Analysis

- EVERYBODY PLOTS THE DATA!

- Use of interactive computer programs which allow multiple graphs which are hot-linked and self-updating.

- The four R's:
  - -Revelation: display the data in a variety of ways so that it can reveal unexpected patterns.
  - -Residuals (= data - model): remove perceived patterns and examine what remains for further patterns.
  - -Re-expression: use a scale or transformation for each variable which simplifies the analysis e.g. log transform
  - -Resistance: use approaches which are resistant to the effects of unusual observations, including removing them.

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Exploratory Data Analysis: A Sequential Approach

0. Make a list of things you'd like to know from the data, but remain open to finding things in the data you didn't expect.

1. Maximize Data Quality

2. Explore distribution properties of the data, consider transformations for convenience and enhanced display properties.

3. Look at subgroups of individual variables e.g. seasonality, different years, etc.

4. Look for relationships among variables e.g. flow & concentration, ss & tp, etc.

5. PLAY with the data - explore effects of removing extreme points, of transforming variables, of adjusting variables for the effects of other variables, etc. If there is a cluster of unusual points in one plot, see where they lie in other plots.

6. When you think you have some good understandings of what's in the data, use formal statistics to test these understandings.

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Let's Do It!!!

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SESSIONS M AND N

DECISION CASE: THE WATERING TROUGH

Jack Clausen, University of Connecticut
Don Meals, University of Vermont

"The Watering Trough" is a real Decision Case that brings out the issues of water quality monitoring to document the changes associated with BMP implementation in an agricultural watershed. A facilitator will lead a discussion of the Case. Participants will be given a few minutes to read the information presented, including a description of the Case, maps, tables, and figures.

This session will be highly participatory and will serve as a summary to most aspects of water quality monitoring, including linkages between water quality and land treatment. Participants will apply knowledge regarding water quality monitoring to a real situation and discuss alternatives.

Case Study: The Watering Trough

by John C. Clausen, University of Connecticut

It was another one of those meetings. Rob, who works for EPA, had just gotten off another road trip. He had a pile on the desk, including three letters to write for members of Congress. That project from Vermont had come in for some additional RCWP funding. They had a slick presentation with lots of slides and some pretty hot GIS maps. The room was starting to fill up. There were people from Extension, NRCS, CFSA. as well as EPA. Together that group comprised the RCWP National Coordinating Committee. They would make the decision on funding, but Rob was unsure whether to support the request. There were some competing projects for the money, including one from Rob's home state. Everyone pretty much knew everyone else there. Bill from CFSA introduced the project people; there was Dick from the SCS state office and Jack and Don from the University. Oh-oh, someone invited the staffer from Sen. Leahy's office.

Dick led it off. He began, "Good morning and thank you for the opportunity to discuss the St. Albans Bay Watershed project." Dick went on to explain that they were in the tenth year of the project. The St. Albans Bay watershed is 32,000 acres in area, 65% of which is agricultural, consisting of corn, hayland, and pasture (**Exhibit 1**). Dairy operations (102 farms) dominate the agriculture. St. Albans Bay is eutrophic due to phosphorus loading from a WWTP and agricultural runoff. In addition, high bacteria counts in the Bay closed a State swimming beach. Best Management Practices (BMPs) have been established on 76% of the critical acres in the watershed, involving 61 farms, which exceeds the original project goals. Most of the targeted farms were on contract. He showed a pretty slick GIS map of the locations of farms with BMPs, but it looked like they were scattered all over the watershed (**Exhibit 2**). The primary BMP is animal waste management, although other practices were used, including nutrient management, streambank protection and conservation cropping (**Exhibit 3**).

Jack described the water quality monitoring program. The paired watershed study is located within the project area and is aimed at evaluating the effects of best manure management on phosphorus export. Two small watersheds, nested with each other, are being used for the study. He mentions that the farmer could not get manure out of the pit in the winter to spread it and they had to buy some manure.

At that point Rob started to take notice. Jack went on and explained the intricacies of the paired watershed approach. Rob had trouble staying focused on what was going on and began drafting one of those letters for the Senator's constituent.

Jack also reported on the St. Albans Bay monitoring stations. There are four levels of monitoring. Level 1 is sampling within the Bay (**Exhibit 4**). Besides chemical monitoring at the four Bay stations, plankton and chlorophyll 'a' samples are taken. Once a year macrophytes are surveyed in the Bay. Level 2 is tributary monitoring and the WWTP. Level 3 is the paired watershed study. Level 4 is the random sampling. Jack indicated that the Level 4 sampling had been terminated. They are using three times per week composite samples made up from 8 hour composites for the

chemical and physical monitoring, which includes suspended sediment and total phosphorus analysis. Fecal coliform bacteria are sampled during a weekly grab sample. Benthic macroinvertebrates are sampled at the stream stations at the beginning of the project, during the middle of the study, and at the end of 10 years. Rain gauges are located in the watershed and discharge is recorded continuously at the level 2 stations.

Don stood up to explain the results from the project. Bacteria standard violations have declined in the Bay, he stated. In the tributary streams, bacteria abundance has also declined significantly. Suspended solids has declined in the streams, but there has been no reduction in phosphorus concentrations in the streams or the Bay or phosphorus loading to the Bay during the past 10 years (**Exhibit 5**). This includes the period following the treatment plant upgrade to tertiary treatment in 1987. The Bay itself continues to be eutrophic.

One of the NRCSers asked if the locations of the BMPs made a difference. Don indicated that based on the current study design, it was difficult to evaluate that question.

Jack went on to discuss the paired watershed results. He indicated that during the calibration period when both watersheds were in best manure management, significant regressions were obtained between the control and treatment watersheds for discharge, and suspended sediment and phosphorus concentrations and mass exports. Winter spreading of manure was found to significantly increase phosphorus concentrations but discharge decreased due to a mulching effect.

One of the biological types asked about the macroinvertebrates. Jack indicated that the organisms present in the tributary streams are indicative of highly polluted waters. The number of organisms have declined during the project but the species have pretty much remained the same. He also mentioned that the methods varied somewhat during the three sampling years. The biologist followed up by asking what the indices showed. Jack stated that the indices did not show any clear trends (Exhibit 6).

The guy from Extension asked what was the effect of the WWTP upgrade on St. Albans Bay. Don stood up and said that although the plant has been upgraded to tertiary treatment, and the phosphorus load from the WWTP declined by over 95%, no change in phosphorus in the Bay has been seen.

Rob wondered why the nutrients didn't change in 10 years. That is such a long time. He asked why the BMPs weren't effective. Jack got up and indicated that they didn't know if the lack of change was due to whether the BMPs were not effective or if enough time hadn't been allowed to flush out the watershed. Somewhat humorously, he added that "Ethan Allen started farming in this watershed over 200 years ago. Why would we expect change in just 10?"

The staffer from Leahy's office indicated that the Senator had been watching this project closely and saw it as a landmark project in the country. He also mentioned that local residents in the Bay have seen a return of the smelt fishery to the Bay.

Dick took over the meeting again, indicating that they would like to continue the project for five more years and need additional RCWP money to do that. They also would like to add some additional BMPs and perhaps saturate one watershed with BMPs. One of the additional BMPs could be riparian buffer zones. They could also further limit the timing of manure applications. Dick mentions that a proposal outlining the extended project has been submitted to the RCWP Coordinating Committee.

Rob looked up from his notes and wondered whether to support their request for funding. Recently there had been increasing pressure to show results from the RCWP to Congress. Can this project do it? Why haven't they done it already? If we give them the money what should they do?

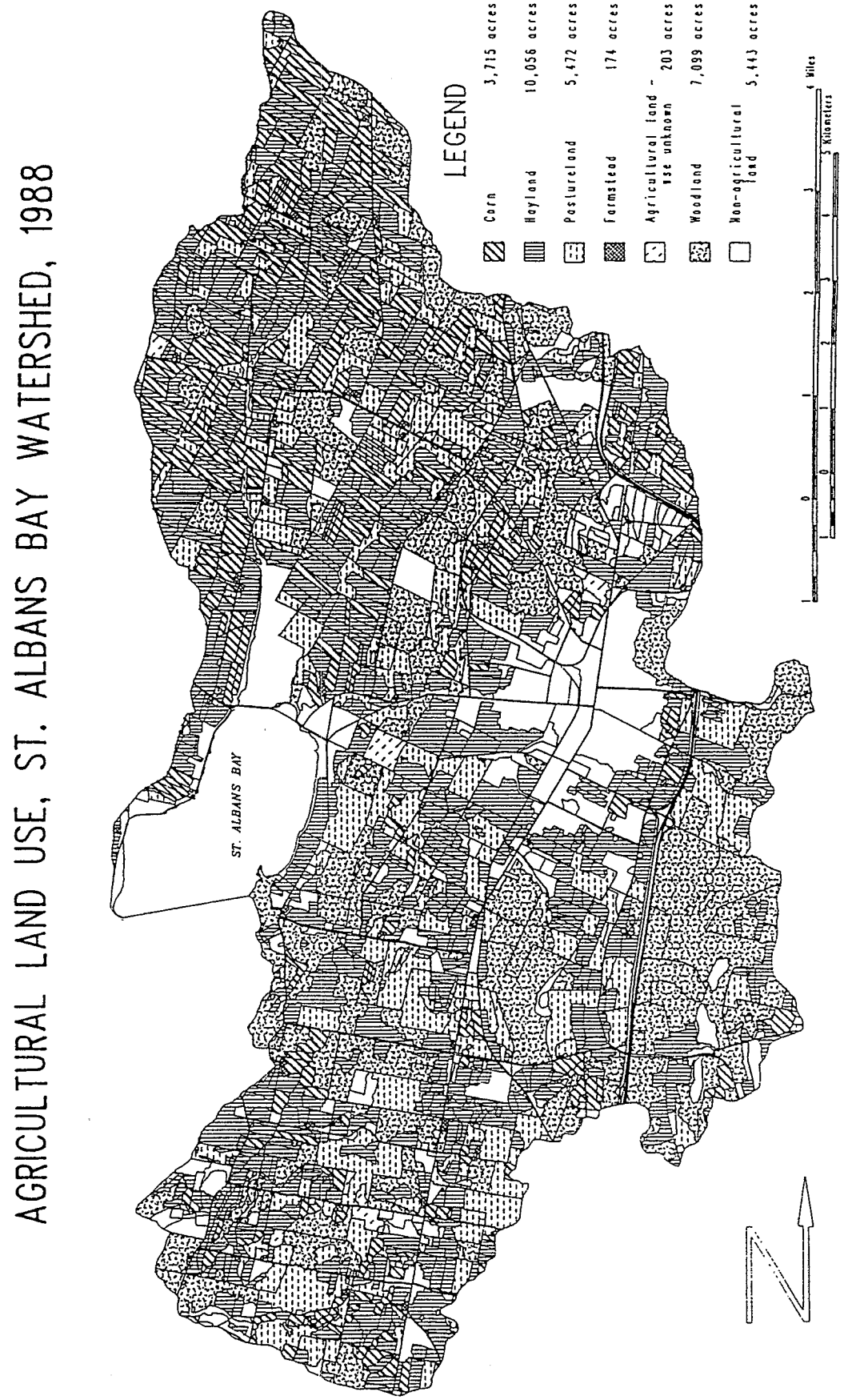
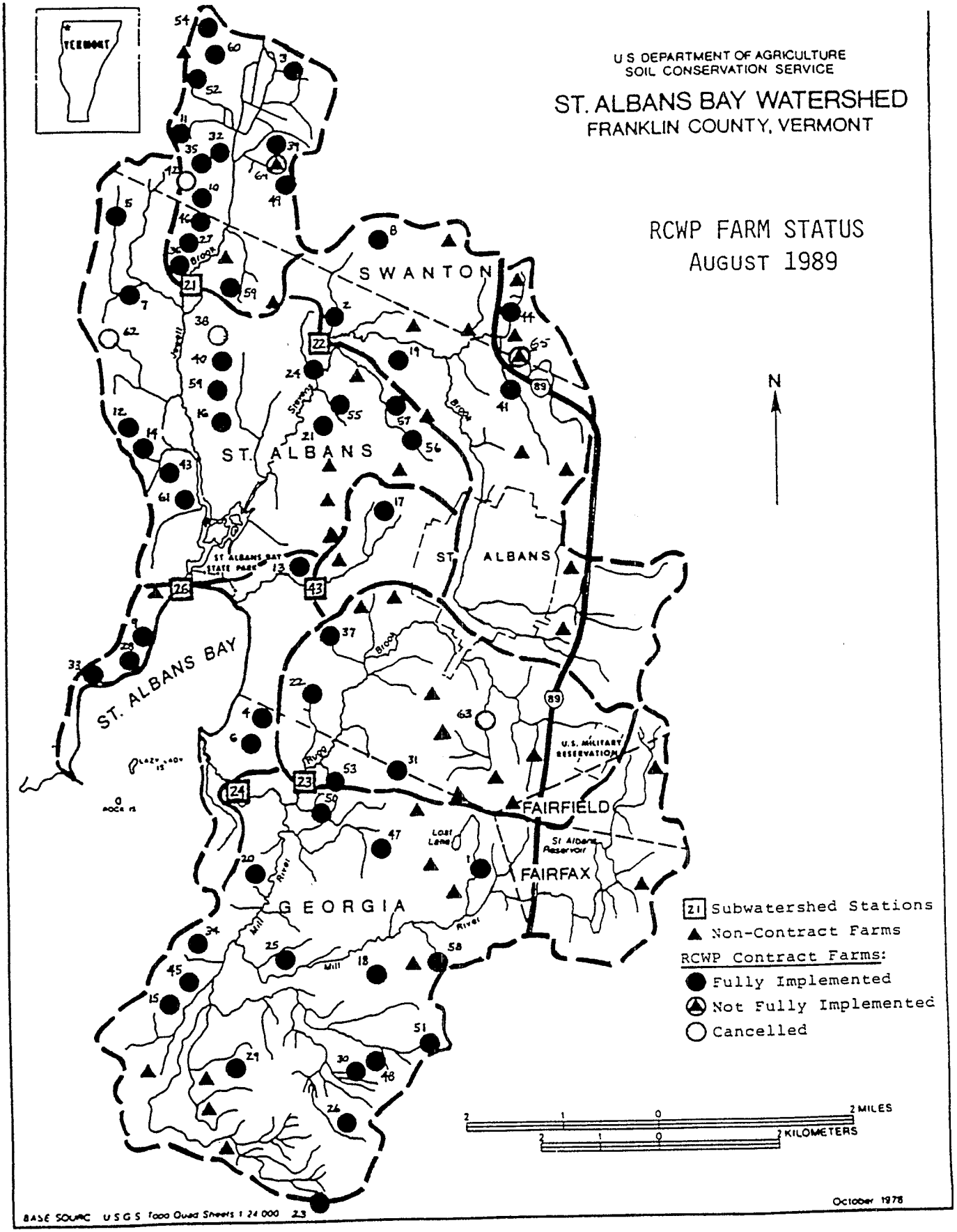

AGRICULTURAL LAND USE, ST. ALBANS BAY WATERSHED, 1988
LEGEND
Corn 3,715 acres
Hayland 10,056 acres
Pastureland 5,472 acres
Farmstead 174 acres
Agricultural land - use unknown 203 acres
Woodland 7,099 acres
Non-agricultural land 5,443 acres
ST. ALBANS BAY
4 Miles
3 Kilometers
N

Exhibit 1


VERMONT
U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ST. ALBANS BAY WATERSHED
FRANKLIN COUNTY, VERMONT
RCWP FARM STATUS
AUGUST 1989
N
SWANTON
ST. ALBANS
ST. ALBANS
ST. ALBANS BAY
FAIRFIELD
FAIRFAX
GEORGIA
ST. ALBANS BAY STATE PARK
U.S. MILITARY RESERVATION
St Albans Reservoir
Lost Lake
Stevens Brook
Rugg Brook
Mill River
Mill River
21 Subwatershed Stations
Non-Contract Farms
RCWP Contract Farms:
Fully Implemented
Not Fully Implemented
Cancelled
2 1 0 2 MILES
2 1 0 2 KILOMETERS
October 1978
BASE SOURCE USGS 1000 Quad Sheets 1 24 000

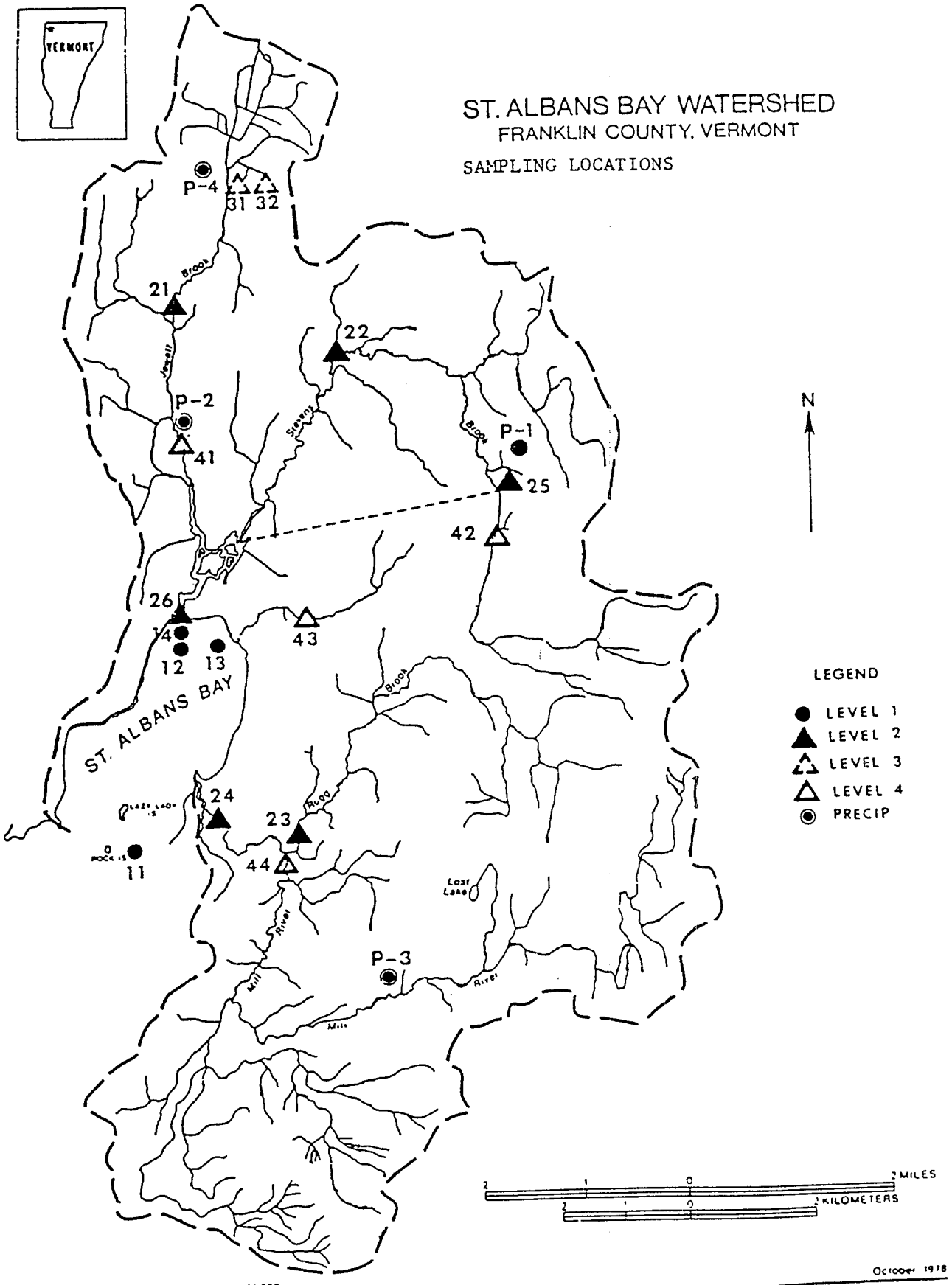
Exibit 2

St. Albans Bay Watershed
RCWP Goals, Accomplishments, and Projections
August 1989

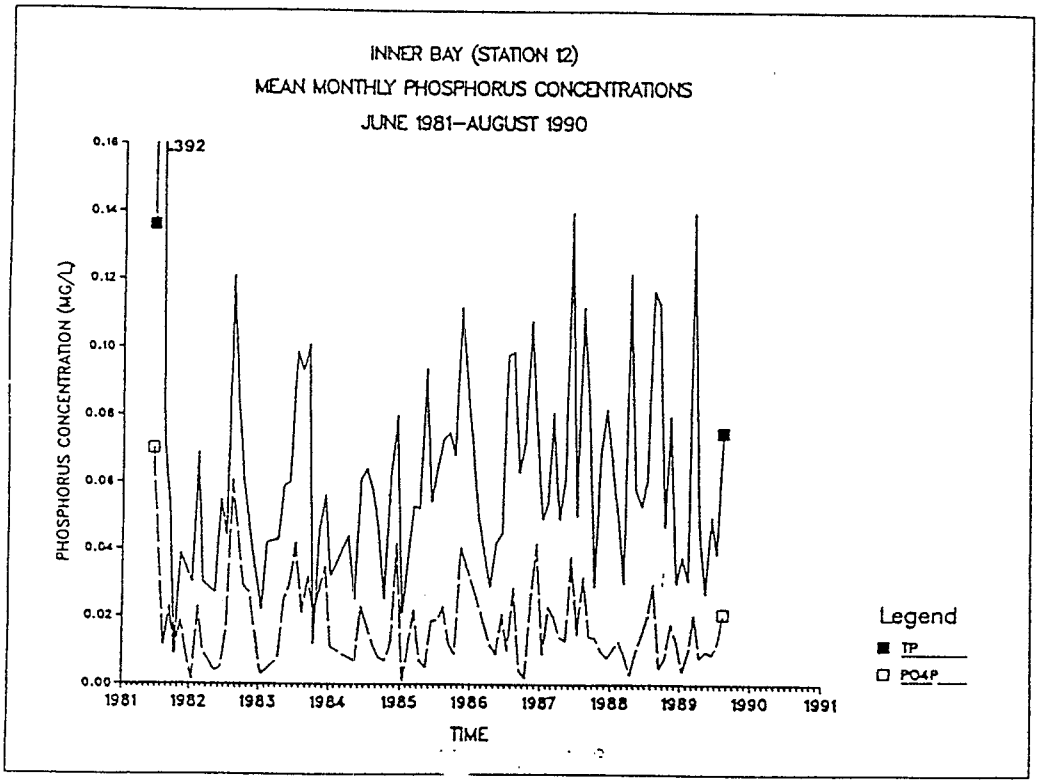
	Units	Goals	Under Contract	Completed	Projected (1990)
Critical Acre Treatment	Ac.	11,443	11,277	10,101	11,277
Critical Source Treatment	No.	64	61	62	61
BMPs					
1. Permanent Vegetative Cover	Ac.	4,500	4,021	4,021	4,021
2. Animal Waste Mgmt System	No.	70	66	66	66
.	A.S.	—	9,397	9,397	9,397
3. Stripcropping System	Ac.	—	0	0	0
4. Terrace System	A.S.	—	—	—	—
5. Diversion System	A.S.	25	25	25	25
6. Grazing Land Protective System	No.	6	6	6	6
7. Waterway	A.S.	15	132	132	132
8. Cropland Protective System	Ac.	6,400	7,074	6,867	7,074
9. Conservation Tillage System	Ac.	10	10	10	10
10. Stream Protection System	A.S.	500	483	483	384
11. Permanent Vegetative Cover on Critical Areas	Ac.	75	63	63	63
12. Sediment Retention, Erosion or Water Control Structures	No.	50	55	52	55
14. Tree Planting	Ac.	—	—	—	—
15. Fertilizer Management	Ac.	7,000	7,610	7,610	7,610

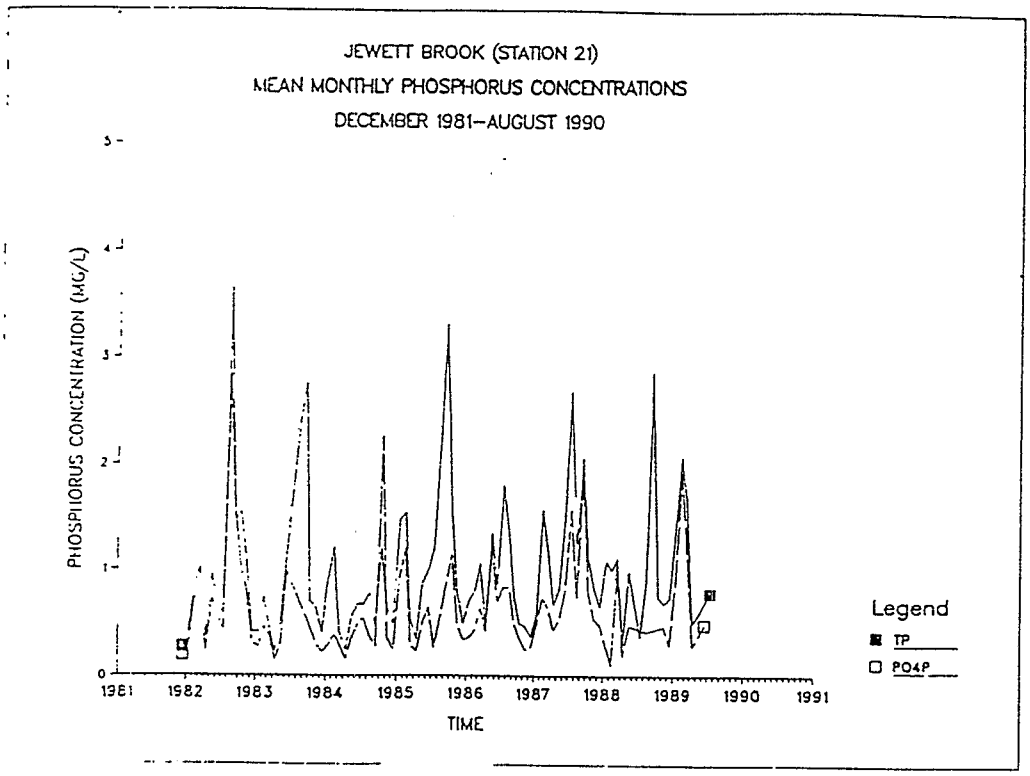
*A.S. = Acres Served

Exhibit 3


VERMONT
ST. ALBANS BAY WATERSHED
FRANKLIN COUNTY, VERMONT
SAMPLING LOCATIONS
P-4
31
32
21
Brook
Jewett
22
P-2
41
Stevens
Brook
P-1
25
42
N
26
14
12
13
43
ST. ALBANS BAY
Brook
LEGEND
LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
PRECIP
24
23
Brook
Lazy Lady
Rock Is
11
44
Lost Lake
River
P-3
Mill
River
Mill
2 1 0 2 MILES
2 1 0 2 KILOMETERS
October 1978
BASE SOURCE: U.S.G.S. 1:000 Quad Sheets 1:24 000

Exibit 4


INNER BAY (STATION 12)
MEAN MONTHLY PHOSPHORUS CONCENTRATIONS
JUNE 1981–AUGUST 1990
PHOSPHORUS CONCENTRATION (MG/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
TIME
Legend
TP
PO4P


JEWETT BROOK (STATION 21)
MEAN MONTHLY PHOSPHORUS CONCENTRATIONS
DECEMBER 1981–AUGUST 1990
PHOSPHORUS CONCENTRATION (MG/L)
5
4
3
2
1
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
TIME
Legend
TP
PO4P

Exibit 5

Table 2 Mean benthic macroinvertebrate density, biomass, and number of taxa from three samples taken at each site in the spring of 1983 and 1986. * = significant yearly difference (alpha = .05). i = significant year by site interaction (alpha = .05).

		Mill		Rugg/Mill		Jewett		Overall	
Spring		1983	1986	1983	1986	1983	1986	1983	1986
Density	Pool	13,017	3,789	34,905	2,339	25,877	1,536	24,600	2,555
	Riffle	8,041	492*	9,390	2,045*	441	2,716	5,957	1,751*I
Biomass (g/sq m)	Pool	3.57	1.72	13.69	1.25*	4.65	0.99*	7.31	1.32*
	Riffle	2.48	0.34*	3.87	0.66*	0.55	0.82	2.30	0.61*I
# Taxa	Pool	18	4*	29	10*	13	3*	20	6*
	Riffle	32	12*	28	17	7	10	22	13*I

Table 5 Values of diversity indices for fall invertebrate collections in 1982 and 1986. Each is the average of three samples. ND= No Data * = significant yearly difference (alpha = .05)
i= Significant year by site interaction (alpha = .05)

Fall		1982	1986	1982	1986	1982	1986	1982	1986
Shannon-Wiener H'	Pool	1.11	0.89	1.52	1.01	0.81	1.32	1.15	1.07
	Riffle	1.37	1.04	1.17	1.98	ND	ND	1.27	1.51
Simpson's D	Pool	0.47	0.54	0.34	0.50	0.58	0.41	0.46	0.48
	Riffle	0.41	0.46	0.53	0.18	ND	ND	0.47	0.32
Evenness, J	Pool	0.46	0.58	0.60	0.64	0.58	0.62	0.55	0.61
	Riffle	0.45	0.61	0.42	0.80*	ND	ND	0.43	0.71*

Exhibit 6

After the participants read the case study the question was asked, "should funding of this project be continued?"

Questions and comments by the audience fell into four major categories: the political/policy realm, unanswered questions that must be addressed before proceeding with project funding, concrete suggestions for improving the water quality monitoring design, and technical considerations.

Political/Policy Considerations

- It appears that Senator Leahy's staff has better information on the impaired use of Lake Champlain, and since it seems that the Senator would support additional funding, the water quality monitoring should continue.
- Many decisions are based on the politics of the situation, not the facts. Therefore, the political climate ought to be considered when making the decision about continued funding.
- The project team needs to make a better case for the public benefit of continued funding.

Answer Unanswered Questions Before Funding is Continued

- Rob can't decide because he has insufficient information.
- Monitoring should continue, but it should be targeted toward answering the unanswered questions.
- The project needs better data on pollution sources if a case is to be made for continued funding.
- Before funding the project further, wait and see or do more investigation before the water quality monitoring work is continued.
- More information is needed on the actual BMP compliance by the producers. Also, information is needed on whether or not BMPs are effective in reducing the loading of phosphorus into the streams.
- The role of non-contract farms in phosphorus loading should be determined before further money is spent on monitoring activities.
- It is important to determine whether land treatment goals (75% of the critical area) are sufficient for the change that was expected.
- It is difficult to tell if the project has met its goal of decreasing phosphorus, because the project never established a numerical value for a decrease in phosphorus concentrations. Before proceeding any further, project personnel should establish numerical goals for lowering phosphorus concentrations.
- Monitoring results so far suggest a potential ground water role in stream recharge because, although fecal coliform and total suspended solids are declining, the nitrogen concentrations are increasing. Determine the contribution of ground water to the stream system before proceeding.

Improving Water Quality Design

- Water quality monitoring should continue but focus only on the wet season.
- More intensive biological monitoring is needed, although the project had no goals related to habitat improvement nor any baseline habitat information. Further, more work needs to be done in order to determine why the macroinvertebrate community isn't thriving.
- Continue to monitor the water quality, but concentrate activities on first and second order streams.
- The water quality monitoring should be scaled back to a subwatershed scale and focused on a pollutant source assessment.

Technical Considerations

- Because of the phosphorus attached to the sediments in Lake Champlain and the associated wetland, it is unrealistic to expect to see a decrease in lake phosphorus concentration. In order to detect changes in phosphorus concentrations, long-term lake monitoring will be necessary.
- An immediate downward response in fecal coliform amounts and total suspended sediments has been seen. The lack of phosphorus response suggests that the residual phosphorus response is slower.
- Additional farms should be treated with BMPs, and monitoring should continue. However, if additional funding is approved, a better watershed plan should be developed that contains regulations for noncompliance by producers.

- After comments and questions had been received from the audience, participants were encouraged to present concrete suggestions for continuing or discontinuing funding of water quality monitoring activities. Five suggestions were received from the participants and then the proposals were voted on. Based on the vote, the audience recommended that funding be continued, but with some modifications to land treatment and water quality monitoring.
- Continue monitoring but at a reduced level of effort. The monitoring should focus on a smaller land area. More project effort should be placed on information and outreach to landowners to ensure BMP implementation and compliance. (Received 17 votes)
- Continue monitoring at same level but redirect funds for monitoring to unanswered questions, such as how much of the phosphorus is derived from lake sediments. (Received 18 votes)
- Allocate one-half million dollars for short-term data collection. Convene a conference in November of 1996 to discuss the collected data and determine the future monitoring strategy for the project. (Received 2 votes)
- Minimize the size of the watershed, in order to better control variables and continue to monitor. This smaller watershed should contain old monitoring sites in order for the project to maintain historical data. The focus of the land treatment for this project should be on new BMPs. All monitoring efforts in the Bay should cease. (Received 16 votes)
- Discontinue the monitoring for a period of time and then start monitoring again in order to quantify the water quality changes that have happened over time without any additional interventions. (Received 2 votes)

Chapter 4

Rural Clean Water Program Technology Transfer Fact Sheets

Contributions and Successes of The Rural Clean Water Program

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U.S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered to producers as incentives for using or installing BMPs.

The Rural Clean Water Program

In 1980, the U.S. Congress established an experimental program to address agricultural nonpoint source (NPS) pollution in watersheds across the country. The experiment was called the Rural Clean Water Program, usually referred to as the RCWP.

The objectives of the RCWP (45 Federal Register 14006, March 4, 1980) were to:

- Achieve improved water quality in the most cost-effective manner possible;
- Assist producers in reducing agricultural NPS water pollutants; and
- Develop and test programs, policies, and procedures for controlling agricultural NPS pollution.

Each of the 21 RCWP projects involved: 1) the implementation of best management practices (BMPs) to reduce NPS pollution and 2) water quality monitoring to evaluate the effects of the land treatment. BMP installation or adoption (often referred to as land treatment) was targeted to land areas or sources of NPS pollutants identified as having significant impacts on the impaired or threatened water resource. These areas are referred to as critical areas.

Contributions and Successes

The experience gained through the RCWP projects provides valuable information for personnel involved in NPS control programs and projects. The RCWP projects made significant contributions to the body of knowledge about NPS pollution, NPS pollution control technology, agricultural NPS pollution monitoring design and data interpretation, and the effectiveness of voluntary cost-share programs designed to assist producers in reducing agricultural NPS pollution (Gale et al., 1993). The purpose of this fact sheet is to present some of the many contributions and successes of the RCWP projects.

The Taylor Creek - Nubbin Slough RCWP Project demonstrated that a large project can be successful if well organized, tightly managed, and well funded. Fencing, water management, and animal waste management systems in the Taylor Creek-Nubbin Slough project reduced phosphorus levels in water entering Lake Okeechobee by more than 50%. Cost-share incentives helped operators comply with stringent state regulations.

Florida: Taylor Creek - Nubbin Slough Project

The Taylor Creek-Nubbin Slough Basin, located in southern Florida directly north of Lake Okeechobee, covers 120,000 acres of flat, poorly drained land. Beneficial uses of the lake include drinking and irrigation water, flood protection, commercial and sport fishing, and wildlife habitat. High phosphorus concentrations in runoff to the lake promote eutrophic conditions, resulting in algal blooms and low levels of dissolved oxygen.

Land use is primarily agricultural, characterized by intensive dairy and beef cattle farming. The critical area (63,109 acres) included dairy farms, drained and fertilized pastures, and areas close to a waterway. The project water quality goal was a 50% reduction in phosphorus and nitrogen concentrations in water flowing into Lake Okeechobee. BMPs installed included stream protection systems, reduction of barn waste, animal waste management, diversions, grazing land protection, permanent vegetative cover, sediment retention structures, and water control structures.

An intensive water quality monitoring program was undertaken to evaluate the effectiveness of BMPs in reducing phosphorus loads to the lake. The monitoring program was designed to facilitate comparison of water quality data collected before, during, and after BMP implementation. Accounting for changes in animal density, ground water table depth, and upstream phosphorus concentrations during the project period facilitated documentation of the effects on water quality of BMPs installed. Land treatment tracking (recording BMP implementation and location in relation to water bodies) aided in the determination that changes in water quality resulted from BMP implementation. The project exceeded its phosphorus reduction goals, despite substantial increases in animal density.

By decreasing commercial fertilizer applications, expanding acreage under no-till, and improving animal waste management, farm operators in the Appoquinimink River RCWP Project significantly decreased sediment and phosphorus reaching critical water bodies. The project combined excellent inter-agency cooperation, an effective information and education program, and a high rate of farmer participation.

Delaware: Appoquinimink River Project

The Appoquinimink River watershed (30,762 acres) lies in the Atlantic Coastal Plain. The 16-mile stream meanders through tidal marsh and is linked to several ponds and lakes. Two-thirds of the watershed is agricultural land planted in corn and soybeans.

High nutrient concentrations in runoff from agricultural land in the watershed were causing advanced eutrophication in several lakes and ponds used for primary and secondary contact recreation, such as swimming, boating, and fishing. Also affected were maintenance and propagation of fish and aquatic

life, industrial and agricultural water supply, drainage, navigation (in the tidal portion of the river), and passage of anadromous fish. Problems included bacterial contamination, fish kills, and algal growth.

The objective of the RCWP project was to reduce cropland erosion and nutrient transport, decrease nutrient applications, and properly manage animal waste. The BMPs emphasized were no-till, pesticide and fertilizer management, cover crops, grassed waterways, and filter strips.

Producer participation was high and BMPs were applied to over 85% of the 13,000-acre critical area. No-till acreage increased from 50% of the cropland to 90%. Improved fertilizer management cut the pre-project phosphorus application rate in half. In one pond, sediment and phosphorus declined by 90% and 65%, respectively. Suspended solids in the river decreased by 60%.

The project combined excellent inter-agency cooperation and an effective information and education program. Benefits spread beyond the project area. By the end of the 10-year project, most farmers in the county had voluntarily adopted no-till techniques, although its use in corn production has since decreased as a result of slug damage.

Water management and sediment control BMPs reduced sediment and phosphorus in return flows from irrigated land in the Rock Creek RCWP Project. Monitoring of in-stream habitats, benthic organisms, and fish populations was used to document improvements in the ability of the stream to support designated uses, such as fishing and fish spawning. Innovative techniques to evaluate trout spawning habitat by directly measuring substrate oxygen were developed by the RCWP project team.

Idaho: Rock Creek Project

The Rock Creek RCWP Project covered 45,000 acres within a 198,400-acre watershed in south central Idaho. Agriculture includes irrigated pasture and cropland and rangeland. Irrigation water diverted from the Snake River is delivered to farms through a network of canals. Return flows empty into Rock Creek, which discharges into the Snake River.

Poor water quality impairs recreation, salmon spawning, and fishing. Rock Creek delivers a disproportionate load of sediment to Snake River. NPS pollutants are sediment, phosphorus, and nitrogen from irrigation return flows, streambank erosion, and animal waste.

The project objective was to reduce sediment, phosphorus, and nitrogen discharging into Rock Creek. All irrigated cropland and animal operations were considered part of the critical area (28,159 acres). Land treatment to prevent sediment from entering irrigation drains by controlling erosion and trapping sediment was implemented on 75% of the critical area. BMPs included sediment retention structures, irrigation water management, vegetative filter strips, cover crops, conservation tillage, and animal waste management.

The objectives of the water quality monitoring program were to document: 1) changes in sediment and nutrient concentrations and 2) beneficial use improvements. Water quality was monitored both upstream and downstream of significant NPS

pollutant sources before, during, and after BMP implementation. Effectiveness of individual BMPs was measured in this RCWP project.

Improvements in the ability of the stream to support designated uses were documented through monitoring of in-stream habitats, benthic macroinvertebrates, and fish populations. Innovative techniques to measure trout spawning habitat by directly measuring substrate oxygen were developed in the course of the project.

Management practices, such as conservation tillage and water management, were found to be the most cost-effective BMPs for reducing sediment loss on a per-acre basis. BMPs implemented through the RCWP project decreased sediment and phosphorus delivery to the river by 75% and 68%, respectively. In addition, fish populations in Rock Creek below agricultural areas appeared to improve during the course of the project.

Vermont: St. Albans Bay Project

The St. Albans Bay RCWP Project employed a paired watershed study to document the pollutant export reduction associated with changing from the common practice of spreading manure on frozen ground to the manure management BMP, which allowed controlled timing of application during the growing season.

St. Albans Bay of Lake Champlain is located in northwestern Vermont. The watershed draining to the Bay encompasses over 32,000 acres of mostly agricultural land. Bacteria, sediment, and nutrients from dairy farms were causing high bacterial counts, algal blooms, and prolific aquatic plant growth, resulting in beach closings, decreased shoreline property values, and declining recreational use.

The RCWP project was aimed at reducing agricultural NPS pollution by implementing BMPs on 15,000 critical acres. Through the project, 74% of the critical area and 76% of the manure were treated with cropland protection and animal waste management system BMPs.

The extent and location of BMP implementation and land use were tracked using a geographic information system. Pertinent farm data, such as the quantity and timing of manure application and the number of cows under BMP manure management, were also recorded. These data were used to correlate land treatment to water quality on a subwatershed scale. The strongest correlation was between an increasing proportion of animals under BMP manure management and decreasing bacterial contamination in streams. Sediment and bacteria decreased in most of the monitored streams feeding the Bay. During the last three years of the project, bacterial counts near the public beach (along the northern shore) of the bay decreased to below state standards for swimming.

A productive shellfishing resource in northern Oregon was threatened by fecal coliform in runoff from surrounding dairy farms. The strategy adopted by the Tillamook Bay RCWP Project team and critical area dairy farmers was to keep the water off the manure and keep the manure from entering the streams. Innovative practices, including roofed and guttered manure storage areas, were developed to reduce runoff under extremely high rainfall conditions (annual rainfall ranging from 90 to 150 inches). By the end of the project period, the number of shellfish beds closed to commercial and recreational harvesting had been reduced.

Oregon: Tillamook Bay Project

Tillamook Bay, bounded by the Coast Mountain Range and the Pacific Ocean, receives drainage from five watersheds (363,520 acres). Water quality is impaired by high fecal coliform levels caused by manure in runoff from dairy farms, which produce 322,500 tons of manure annually. Coliform levels threatened public health and resulted in closure of commercially important shellfish beds.

The RCWP project objective was 70% reduction in fecal coliform levels in the Bay. Farmers were highly motivated to participate, both out of concern for the shellfish resource and because of their awareness of the potential for state regulation if the problem could not be solved through voluntary NPS control measures. Manure storage and management BMPs were installed on 96% of the farms in the watershed. Innovative animal waste management practices developed for this high rainfall area (such as roofed and guttered manure storage areas) reduced bacterial contamination of the Bay. As a result, the number of shellfish beds closed to harvesting was reduced.

Stream protection using cedar revetments was an innovative practice implemented in the Long Pine Creek RCWP Project. Farmers participating in the project: 1) reduced sedimentation from cropland erosion by implementing irrigation water management BMPs and 2) reduced streambank erosion by installing cedar revetments and fencing. This combination of BMPs significantly reduced the sediment load to a trout stream.

Nebraska: Long Pine Creek Project

The Long Pine Creek RCWP Project area lies on the northeastern edge of the Nebraska Sandhills in north central Nebraska. The Sandhills rest upon the Ogallala Aquifer, a 200-mile wide corridor of ground water extending south through Kansas, Oklahoma, and Texas. The aquifer is used for irrigation, stock watering, and water supply. The watershed is drained by Long Pine Creek, the longest self-sustaining trout stream in Nebraska, which supports contact recreation, fishing, and three threatened fish species.

Sediment, bacteria, and nutrients impair recreation and fishing. The primary sources of sediment are intensive grazing in riparian areas, streambank erosion, and irrigation return flows. Animal feedlots and a sewage treatment plant contributed to high bacteria and nutrient levels.

A system of erosion control and stream protection BMPs was implemented on 71% of the critical area (60,242 acres), which was defined on the basis of high erosion rates and proximity to waterways. Irrigation water management was used to minimize total water usage, thereby reducing pollutants entering streams and ground water. Installation of irrigation tailwater re-use systems and construction of a secondary water storage reservoir, which reduced irrigation water use, were major components of the management program. An effective information and education program resulted in reduced fertilizer and pesticide use.

An innovative practice implemented by Long Pine Creek Project participants was stream protection using cedar revetments. Dried cedar trees were secured with cable and steel fence posts along the edge of the stream to stabilize the streambank and reduce erosion. In combination with grazing land protection and fencing, the revetments decreased streambank erosion.

Significant reductions in sediment delivery were achieved. Trout habitat was improved and the creek's trout-carrying capacity increased. Comparison of pre-, during-, and post-project water quality data is ongoing. The length of the monitoring record (15 years) and a high level of land treatment in the critical area provide the potential for documenting the effectiveness of BMP systems.

Reference

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Planning and Managing a Successful Nonpoint Source Pollution Control Project

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

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Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered as incentives.

Significant progress has been made in reducing water pollution caused by point sources since the Clean Water Act was passed. However, much work remains to be done to reduce nonpoint source (NPS) pollutants that impair the quality of streams, rivers, lakes, ground water, and other bodies of water throughout the United States.

Many local government officials, as well as citizens, are becoming increasingly interested in taking action to address local water quality problems caused primarily by nonpoint source pollutants. There is also a heightened awareness that water quality problems do not occur in isolation; many activities within a watershed affect the quality of water resources. Surface and ground waters are frequently connected, so management strategies aimed at protecting water quality must often be designed to address the impacts of human activities on a watershed basis for both surface water and ground water.

This fact sheet is designed to provide information to local and state government officials and staff, concerned citizens, educational and technical assistance agencies, landowners, and farmers interested in protecting or restoring water quality. Specific steps are outlined for:

- Deciding whether a water quality project is viable, based upon available information,
- Documenting the water quality problem and its source,
- Defining specific project objectives and goals,
- Involving potential participants and other community members in planning and implementing the project,
- Securing funding,
- Clarifying agency roles and organizing a project,
- Defining the critical area,
- Choosing a land treatment approach, and
- Designing a monitoring and evaluation plan.

CAUSES OF WATER QUALITY PROBLEMS

Most watersheds encompass many land uses (farms, homes, industries, forests). Each land use has an impact on water quality. Even in uninhabited watersheds, natural sources of pollution exist. These include sediment from streambank erosion and bacteria and nutrients from wildlife.

Water pollution caused by human activities results from *point sources* or *nonpoint sources*. These terms indicate how pollutants are released to surface water or ground water.

A *point source* is a single identifiable source of pollution, such as a pipe through which factories or treatment plants release water and pollutants into a river. Point source pollution is often controlled through water quality standards and programs requiring a permit, which establish limits on the kind or amount of pollutants each point source may discharge into a body of water.

***Nonpoint sources* are activities that take place over a broad area and result in the release of pollutants from many different locations. Agriculture, forestry, and residential or urban development are examples of nonpoint sources. Common pollutants include:**

- ***Sediment* from cropland, forestry activities, roadways, construction sites, streambank erosion**
- ***Nutrients* from cropland, lawns and gardens, livestock operations, wildlife, septic systems, and land receiving waste application**
- ***Bacteria* from livestock, wildlife, septic systems, land receiving waste application, urban runoff**
- ***Man-made chemicals* from roadways, mining operations, cropland, lawns and gardens, forestry activities.**

Designing a Successful Voluntary Nonpoint Source Pollution Control Project

Choose a Viable Project

The first step in planning a successful nonpoint source pollution control project is to identify a water resource with water quality needing restoration or protection. Focus on a water resource that is valued by the community and a problem that is neither too complex nor too difficult to solve in a reasonable amount of time. Talk to or formally survey community members who live and work in the vicinity of the water resource. Find out whether they believe that there is a water quality problem and if it is of concern to them. For example, find out if the water quality problem impairs recreational uses, such as fishing, swimming, or boating, or aesthetic enjoyment of the water resource.

If the source of the water quality problem is not clear, or if the source is one that cannot be affected by changes in project participants' behavior (for example, if the source is a point source versus agricultural runoff), there may be dissension within the community about the cause of the problem, how best to resolve it, or the value of a NPS pollution control project. Documentation of the problem and its source can help a community come together to support a project designed to address a water quality problem (see next section). If, however, consensus about the existence of a problem cannot be reached, or agencies cannot work effectively together, a project is unlikely to be successful. In such cases, limited resources for addressing water quality problems may be better spent on a different project or program.

If project funds are restricted to one source of nonpoint source pollutants, such as agricultural sources, avoid choosing a watershed that contains major point sources or other nonpoint sources. Pollutants from point sources can mask improvements in water quality brought about by implementation of best management practices (BMPs) aimed at reducing NPS pollution, thus making it difficult to document the benefits of a nonpoint source pollution control project. Other approaches designed to reduce both point and nonpoint source pollutants, such as total watershed management, can be very effective if adequate technical and financial resources are available.

Select a watershed of a size that matches the level of available funding for the project; if funds for installing BMPs are limited, treating most or all of a small watershed (or a subwatershed within a large watershed) will likely result in greater water quality improvements than treating a small land area in a large watershed.

Document the Water Quality Problem

Clearly document the water quality impairment or threat, and the source(s) of the problem. For example, a popular swimming beach at the community lake may have algal blooms (rapid growth of algae) at certain times of year. The results are color changes, odor, and fish kills, which impair swimming and other uses of the lake for recreation. To plan an effective approach to this problem, the specific pollutant(s) causing the blooms must be identified and the source(s) determined. Are nutrients causing the problem? If so, is there too much nitrogen or phosphorus? After identifying the pollutant, find out where it is coming from. Possible sources of nutrients include runoff from animal operations, over-application of fertilizer, septic tank drain fields, sediments in the lake bottom, or discharges from a treatment plant or industry. The source(s) of the water quality problem must be identified before action is taken, so available resources can be targeted to the critical area. Trying to address a problem without knowing the source can result in wasting limited funds and human resources and losing support for future projects.

Existing water quality and other relevant data, such as soils, geology, land use, and weather (and assistance in interpreting such data), should be requested from appropriate agencies, such as the state water quality agency; U.S. Geological Survey; local health department; county planning department; and U.S. Department of Agriculture (USDA) - Natural Resource Conservation Service, USDA - Consolidated Farm Services Agency, USDA - Extension Service, National Oceanic and Atmospheric Administration, and Soil and Water Conservation District.

If adequate information about the problem and its source(s) has not already been collected, seek technical and financial assistance in designing a water quality monitoring program. Relevant state and federal programs are discussed in the section entitled *Obtain Funding*.

An effective approach to identifying the exact nature of the problem and its source(s) is to implement a problem identification and assessment monitoring program lasting from six to 18 months. Monitor sites suspected of contributing pollutants or stressors during both baseflow and storm conditions, especially during the seasons when the highest amount of the pollutant enters the water and during the season when water quality problems have been noticed. For example, in winter and spring there is often a great deal of runoff which carries nutrients, sediment, and other pollutants. A walk through the watershed may help identify problem areas with regard to habitat. Creel surveys can identify fishery problems.

Before initiating a project, write a problem statement that: 1) states what the impaired water use is, 2) identifies the location of the problem, 3) specifies the pollutant(s) or stressor(s), and 4) identifies the major or suspected source(s). A written problem statement documents the problem for future reference and clearly conveys the problem and source to participants and community members, thereby contributing to consensus about the problem and the approach being taken to resolve it.

Define Objectives and Goals

Well-defined objectives and goals clearly convey the purpose of the project to potential participants and the public. Objectives and goals also provide a basis for evaluating the project.

Objectives define the overall direction or purpose of the project. Establish objectives that focus the project on achieving water quality changes or meeting water quality standards. Be sure that objectives are measurable and achievable. For example, a workable objective might be "re-opening shellfish beds in Green Creek estuary by 1998."

Goals provide milestones to be met during the course of a project. Establish quantitative goals that provide a way to measure progress. For example, progress toward the goal "reduce the phosphorus load to Blue Reservoir by 45%" can be measured, while achievement of the goal "reduce pollution in the reservoir" is more difficult to evaluate. Set specific goals early with assistance from local agencies, project participants, and community representatives.

Objectives and goals must be tailored to available resources and to the nature of the problem. For example, expecting to reduce eutrophication in a reservoir when the project watershed supplies only 10% of the phosphorus load is unrealistic, as is a goal of reducing nutrient loss from a 500,000-acre watershed with 1,200 producers when resources consist of a $50,000 budget and two staff members.

Involve the Community

Public support and a high rate of participation are key in voluntary nonpoint source projects because of the widespread nature of NPS pollution. The following actions can increase participation:

- Educate potential participants and the community. They need to agree that there is a water quality problem, that it is important to solve it, and that the project will help do so.
- Encourage potential participants to accept responsibility for their contribution to the problem. Ongoing education about land use impacts on water quality is important, as awareness does not necessarily translate into problem ownership or changes in behavior.
- Involve potential participants early in the planning process; involvement fosters a feeling of ownership which often increases participation.
- Find out if federal, state, local, or private funds are available. Financial assistance, such as cost-share funding, is necessary to enable many potential participants to implement BMPs.
- Recommend the lowest cost BMPs that can effectively reduce the pollutant(s) of concern.
- One-to-one contact between project personnel and potential participants is much more effective than mass media for gaining cooperation in a project. Because of their importance in encouraging participation, information and education efforts should be initiated early.
- Provide technical assistance valued by participants, such as soil testing and assistance in designing site-specific affordable BMPs.
- Ask participants to talk with their neighbors about the project and why they decided to become involved.
- Where relevant, notify potential participants that regulations may be instituted if voluntary measures do not improve water quality. This knowledge can provide an incentive for participation.

Obtain Funding

Obtain funds to support *each* aspect of the project. Cost-share funds that can be used to assist participants in installing BMPs are often critical to the success or failure of a voluntary nonpoint source project. Funding for pre-, during-, and post-implementation water quality monitoring and educational activities is also important.

State cost-share funds may be available to support implementation of agricultural or forestry BMPs for nonpoint source pollution control. Federal programs offering cost-share funds for forestry or agricultural BMPs may be available through the USDA - Consolidated Farm Services Agency. Section 319 funds allocated to each state by the U.S. Environmental Protection Agency (EPA) may be available from a state's water quality agency (nonpoint source program) to support nonpoint source pollution control projects.

Several EPA publications provide information on federal programs for watershed protection (EPA, 1993) and how state and local governments have funded nonpoint source pollution control programs (EPA, 1992).

Clarify Agency Roles and Administer the Project Effectively

Cooperation and coordination among local, state, and federal agencies are essential. Potential participants within the project area must receive clear messages about the project, its purpose, and its value. Conflicting messages from local, state, or federal agencies participating in a project can result in a low rate of participation. Clearly define each agency's role and how agencies will interact to avoid confusion, duplication of efforts, or competition. Urge agency administrators to support the project and encourage inter-agency cooperation. If key agencies cannot agree on the value of a proposed project, or if turf battles seem unresolvable, consider an alternative project choice.

Designate a project manager to coordinate the project and assess progress. Ideally, the project manager should have a background in water resources and project management.

Establish a local coordinating committee, consisting of project participants, agency personnel, and community leaders, to support the project. The committee should set direction, set objectives and goals, assure adequate public involvement, enlist agency assistance, oversee information and education activities, determine priorities for water quality monitoring, and develop plans for critical area selection, choice of BMP systems, and linkage of land treatment and water quality data.

LAND TREATMENT AND BMP SYSTEMS

Water quality best management practices (BMPs) are designed to control the generation and delivery of pollutants from land use activities to water resources and to prevent impacts to the physical and biological integrity of surface and ground water. BMPs can be either structural (such as detention basins, broad-based dips, waste lagoons, terraces, sediment basins, and fencing) or managerial (such as rotational grazing, pre-harvest planning for silvicultural operations, rapid vegetation of construction sites, no-wake zones for boating, fertilizer and pesticide management, and conservation tillage).

Any two or more BMPs used together to control a pollutant from the same source constitute a BMP system. A BMP system can be tailored for a specific pollutant, source, geographical location, and cost requirement.

Systems of BMPs are more effective at controlling nonpoint source pollution than individual BMPs because systems can minimize the impact of the pollutant at several points: at the source, during transport from the source to the water body, and at the water body.

Systems of BMPs, however, are just part of a land treatment strategy to reduce nonpoint source pollution. In addition to selection of a BMP system that will effectively address the primary pollutant(s), project managers must be sure that BMPs are placed in the correct locations in the watershed (critical areas contributing the most pollutants) and that a sufficient amount of land treatment is implemented to achieve the desired water quality improvement.

Define the Critical Area

Apply BMP systems to those areas where land treatment will have the greatest effect. Where available, pre-project water quality monitoring and modeling can be used to identify or refine the critical area — the land area contributing most to the problem. In the absence of such resources, critical areas can be roughly defined based on distance to the water body and its tributaries, or other location or land use characteristics. Within the critical area, significant pollutant sources (such as animal operations, farm fields, or forestry operations) can be prioritized for BMP installation based on the expected impact of each source on the water body.

Choose a Land Treatment Approach

Encourage participants to implement systems of BMPs. Systems of practices often control loss of a pollutant from the critical area more effectively than a single BMP. Resources for assistance in identifying systems to effectively address a particular water quality problem and source include Extension Service, Natural Resource Conservation Service, and Soil and Water Conservation Districts staff.

Design a Water Quality and Land Treatment Monitoring and Evaluation Plan

Water quality and land treatment monitoring and evaluation provide essential tools for assessing project effectiveness. Team members who will conduct and interpret the monitoring effort must be involved from the beginning of the project, not added as an afterthought.

When limited resources are available for monitoring BMP effectiveness, visual observations such as fewer algal blooms, clearer water, or increased recreational use can be helpful in assessing the effectiveness of the project. Monthly monitoring of a few key factors (such as dissolved oxygen or chlorophyll *a*) can provide useful information.

When funds are available for more extensive water quality monitoring, essential tasks and elements include:

- Developing a monitoring plan based on clearly stated water quality monitoring objectives. Include in the plan: monitoring design, agency roles, laboratory and quality assurance and control procedures, data storage plans, reporting requirements, personnel needs, and costs.
- Collecting sufficient pre-, during -, and post-project data to document water quality changes. In large watersheds with lakes, water quality changes often occur gradually and monitoring for five to 10 years, or longer, may be required to confirm changes that can be linked to land treatment.

KEYS TO SUCCESS

Choose a Viable Project

- **Choose a water resource that needs restoration or protection and is valued by community members.**

Document the Problem

- **Document the water quality problem and its source.**

Define Objectives and Goals

- **Define obtainable objectives and goals.**

Involve the Community

- **Involve potential participants and the community early in project planning.**

Obtain Funding

- **Obtain funding for all project aspects.**

Clarify Roles and Administer Effectively

- **Clarify agency roles.**
- **Designate a project manager.**
- **Form a local coordinating committee.**

Define the Critical Area

- **Define the critical area where treatment will have the most impact.**

Choose a Land Treatment Approach

- **Apply BMPs that will address the water quality problem.**
- **Encourage participants to implement systems of BMPs.**

Monitor and Evaluate

- **Design a water quality and land treatment monitoring and evaluation program, when possible, to document the effects of BMPs installed.**

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This fact sheet is one of a series of RCWP Technology Transfer fact sheets prepared with support from the Extension Service, U.S. Department of Agriculture (Cooperative Agreement No. 93-EXCA-3-0241). Copies of the fact sheet series may be requested from: NCSU Water Quality Group, Dept. of Biological and Agricultural Engineering, Box 7637, North Carolina State University, Raleigh, NC 27695-7637, Tel: 919-515-3723.

Assessing Project Effectiveness

Evaluate data with project objectives and goals clearly in mind. A consistent improving trend in water quality after BMP system implementation may provide evidence needed to attribute water quality improvements to land treatment.

Consider interviewing (pre- and post-project) participants and people who were eligible but chose not to participate in the project to assess the effectiveness of education efforts.

Report successes and failures periodically to provide feedback to project participants and agency staff on the results of their efforts. Make results available to the community to enhance public education and contribute to more effective management of water quality problems in the future.

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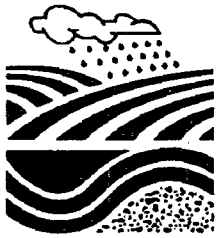

Selecting an Agricultural Water Quality Project

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered as incentives.

Restoring or protecting water resources from nonpoint sources of pollution is critical for good water quality. Watershed-level projects are ideal for improving or protecting a water resource from a total watershed perspective. However, controlling nonpoint source (NPS) pollution generally requires funding from public appropriations. To assure the best use of scarce financial resources, it is important to select NPS pollution control projects that are the most viable and can succeed in either protecting threatened or restoring impaired water resources.

A successful NPS pollution control project does not happen randomly. Nonpoint source pollution control project selection is a difficult and time-consuming task. Projects need to be selected carefully based on an analysis of the technical and social factors within the watershed of concern. Because encouraging feedback is essential to project participants, the watershed community, and policy makers, watershed projects that have a high probability for reversing a water quality use impairment, or that contain highly valued water resources threatened by NPS pollution, should be given high priority. The technical factors involved in the planning and completion of a successful project include:

- Accurate identification and documentation of the water quality problems or impairments;
- Analysis of the appropriate types and quantities of land-based treatment in the critical areas (areas contributing the most pollutants);
- Selection of a water quality problem on which significant progress can realistically be achieved within the time frame and monetary constraints of the project; and
- Monitoring to document changes in land treatment and water quality.

Social factors that influence the effectiveness of any NPS pollution control project include:

- Commitment by the community and producers to controlling NPS pollution;

- Implementation strategies selected by the sponsoring agencies and the agencies' ability to work together; and
- Multi-year funding sufficient to offer technical assistance, information and education, and cost-share for best management practice (BMP) implementation to ensure a high level of participation in the critical areas.

Many of the 21 projects that participated in the Rural Clean Water Program (RCWP) were successful in reducing the impacts of NPS pollution (Gale et al., 1993). Each of these successful projects was able to uniquely combine the necessary technical and social factors that comprise an effective NPS pollution control project. Specific examples and lessons learned from RCWP on the selection of workable NPS pollution control projects are presented below, along with examples of specific RCWP projects.

Water Resource Impairment and Water Quality Objectives and Goals

One of the most critical factors in the evaluation of a potential NPS pollution control project is the development of a well-defined water quality problem statement. In order to write a problem statement, the water quality problem must be correctly identified and clearly documented. A water quality problem statement should describe, at a minimum, the following:

- The water resource(s) of concern;
- The water use impairment(s) or threatened impairment(s); and
- The pollutant or pollutants, the sources of each pollutant, and the magnitude of the pollutant(s) causing the water use impairment.

A water quality problem statement should be used as the basis for selecting NPS pollution control projects. If all factors of the water quality problem statement are not clearly delineated, then the project should not be chosen.

Clearly defined and realistic water quality objectives and goals improve a project's probability of success. The water quality problem statement should be used as the basis for setting objectives and goals for both water quality and land treatment. The goals and objectives should be directly related to the water quality impairment or conditions threatening designated uses of the water resource.

WATER RESOURCE IMPAIRMENT AND WATER QUALITY OBJECTIVES AND GOALS

RCWP Project Examples

A well-defined water quality problem statement was used to select the Taylor Creek - Nubbin Slough (Florida) RCWP project. The statement is: Lake Okeechobee (the water resource of concern), a multi-purpose freshwater lake, received excessive quantities of phosphorus-laden runoff from dairy farms (the pollutant source) located on the Taylor Creek - Nubbin Slough tributaries. High phosphorus (P) inputs (the magnitude of the pollutant) from agricultural areas were causing eutrophication (the water use impairment) of Lake Okeechobee. Lower dissolved oxygen contents and increased plant growth were affecting the acceptability of water use for drinking water, the use of the lake for recreation, and the quality of aquatic habitats in the lake.

Based on the water quality problem statement, an effective land treatment strategy was designed with a quantitative goal of reducing by 50% P concentrations in water entering Lake Okeechobee from the watershed. The goal was achieved through implementation of best management practices.

In the Massachusetts RCWP project, the water quality problem statement did not clearly state and document the source of the fecal coliform contamination (runoff from dairy farms or leakage from septic systems), so farmers were reluctant to accept their role in causing the water quality problem and thus were not motivated to participate in project activities. Because of poor participation, no improvement in the water quality of the estuary was achieved.

RCWP Project Examples

BMP IMPLEMENTATION STRATEGY

Bacteria, sediment, and nutrients from dairy farms in the St. Albans Bay (Vermont) project were enriching the bay; causing high bacteria counts, large algal blooms, and prolific macrophyte growth; and resulting in beach closings, decreased shoreline property values, and overall declining recreational use of the bay. Dairy production was the dominant land use. The land treatment strategy was to treat 75% of the critical area, defined as farmsteads delivering excessive phosphorus (P) and fecal coliform (FC) to the bay. Critical farms were identified based on distance from a watercourse, amount of manure produced, manure management practices, and manure-spreading rates. The BMP system chosen emphasized reducing P and FC from animal operations and cropland. As a result of targeting appropriate farms and application of effective BMPs, decreasing trends in fecal coliform and fecal strep. bacteria have been documented in bay tributaries.

WATER QUALITY PROBLEM THAT CAN BE ADDRESSED

Lake Tholocco, a 600-acre recreational lake, was closed to contact water sports due to high fecal coliform levels, the source of which was surrounding area hog operations. During the RCWP project, most of the hog-producing farms were treated with animal waste management practices and some of the animal-producing operations closed. As a result of treating the animal waste and a decline in animal numbers, fecal coliform counts dropped and the lake was reopened to swimming.

BMP Implementation Strategy

Best management practices (BMPs) are essential for any nonpoint source pollution control project. One of the criteria for project selection should be the technical merits of the BMP implementation plan, which should be integrally tied to water quality impacts and project goals. Proposed plans must include critical area delineation within the watershed. A critical area should be delineated to identify and encompass the major pollutant sources that have a direct impact on the impaired water resource. Planned BMP implementation should be targeted to the critical area and primary pollutants. The BMPs proposed for the critical area should be selected so that the most effective system of BMPs to reduce a particular pollutant is chosen. The system of BMPs should address both source reduction from the major pollutant sources and pollutant delivery reduction by minimizing transport of the pollutant to the water resource of concern. The project team should also clearly state (set a goal for) the anticipated percent of BMP implementation (coverage) planned for the critical area. Selection of recommended BMP systems and estimation of the coverage necessary to accomplish a documentable water quality change are important for two reasons: 1) to estimate the effectiveness of the BMP systems to meet water quality goals and 2) to determine if proposed appropriations are sufficient to fund the necessary types and numbers of BMPs.

Water Quality Problems That Can Be Adequately Addressed

Several factors establish the economic and technical feasibility of controlling water quality problems: assessment of the size of the critical areas, sources of pollutants, extent of BMPs needed in the critical area, cost per participant, and cost per acre.

The size of the selected watershed project should allow for a large portion of the critical area to be treated. Small watersheds (critical area of roughly 30,000 acres or less) are easier to treat and monitor and should, therefore, be given special consideration in the selection process.

The project time frame must be long enough to facilitate adequate comparison between pre- and post-project conditions in order to evaluate the water quality improvements. Multi-year projects (usually 5 to 10 years) should be given priority in the project selection process.

Nonpoint source pollution programs restricted to addressing agricultural sources should avoid watersheds that contain significant non-agricultural nonpoint sources or point sources because

RCWP Project Examples

WATER QUALITY AND LAND TREATMENT MONITORING TO DOCUMENT CHANGES IN LAND TREATMENT, LAND USE, AND WATER QUALITY

The Rock Creek, Idaho RCWP project had a good monitoring design for documenting changes in water quality in subwatersheds and entire project areas. Land treatment and water quality monitoring occurred throughout the 10-year project time frame with consistent sampling before and after BMP implementation at multiple sites. Project personnel were able to isolate the effects of water management and sediment control BMPs by monitoring explanatory variables, including season, stream discharge, precipitation, and land use changes. Significant reductions in sediment and phosphorus concentrations in return flows from irrigated lands improved the ability of Rock Creek to support trout spawning and fish production.

PARTICIPATION AND COMMUNITY SUPPORT

Initially in Minnesota, only a few farmers volunteered to participate in a project to protect and restore a trout stream (Garvin Brook RCWP project). However, when the focus of the Minnesota RCWP project changed from restoration of a trout stream to protection of the drinking water resource (the ground water), many farmers chose to participate.

pollutant loadings from these other sources often mask water quality changes associated with NPS controls. Other approaches, such as total watershed management, which include treating both point sources and all major nonpoint sources of pollution, can be effective if adequate resources are available.

Monitoring to Document Changes in Land Treatment, Land Use, and Water Quality

Water quality and land treatment monitoring plans that are likely to result in adequate documentation of changes in land treatment, land use, and water quality should be among the most important selection criteria applied to experimental watershed projects, particularly when the goal of the project being selected is to document both water quality changes and an association between land management and water quality improvements. Water quality monitoring can provide important feedback on the effectiveness of nonpoint source control efforts to project participants, other citizens, and policy makers. The potential of the project for meaningful water quality monitoring, including two to three years of baseline data and evaluation feedback, should also be carefully considered as part of the project selection process.

Participation and Community Support

Assessing potential participation and community support is important when evaluating the viability of a NPS pollution control project. Adequate participation by landowners or farm operators is essential for project success.

Predicting the likely rate of landowner participation in advance of project activities, in order to select a NPS pollution control project, is a difficult task. One good indicator is how highly valued a water resource is by the community. Community support helps motivate potential participants to cooperate. To ensure project participation, the community and landowners must have a vested interest in solving the water quality problem. Such an interest is generally present when the water resource is valued, the pollutant source is understood, and participants recognize that they are part of the solution. Benefits from the project that can serve to increase public support for a project may include decreased human health threats, improved recreational use, or improved habitat or natural health of the water resource.

Another good indicator of potential project participation is the existence of ongoing (pre-project) grass-root efforts to protect the water resource.

RCWP Project Examples

PARTICIPATION AND COMMUNITY SUPPORT (continued)

Tillamook Bay, a shellfish-producing estuary in Oregon, was impaired by fecal coliform contamination, which caused closing of shellfish beds and reduced shellfish harvest. Prior to Tillamook Bay RCWP project activities, a citizen group, comprised of dairy farmers, fishermen, and business leaders, had been formed to protect the estuary. Almost 100% of area dairy farmers participated in the RCWP project. Peer pressure from the community (fishermen, bankers, the dairy cooperative) was essential in obtaining and maintaining project participation. Fecal coliform was reduced by over 50% and the majority of the shellfish beds were reopened for harvest.

INSTITUTIONAL ARRANGEMENTS

In the Oregon RCWP project, strong working relationships among the Oregon Department of Environmental Quality, the USDA Natural Resource Conservation Service, the USDA Consolidated Farm Services Agency, Oregon State University, and the local dairy cooperative were established before the project was initiated. These groups were already actively cooperating with each other to solve the problem of fecal coliform contamination of Tillamook Bay. Part of the success of the Tillamook Bay RCWP project was directly attributed by participating agency personnel to the strong institutional arrangements that had been forged prior to the initiation of RCWP project activities and that were maintained throughout the project period.

Institutional Arrangements

Institutional arrangements also affect the potential of a proposed NPS pollution control project for success. Projects that have a dedicated staff, positive interaction among agencies and other groups, cooperative attitudes, well-defined organizational strategies, and a long-term commitment to the project are generally more successful at gaining and maintaining producer and community participation and support. The organizational strategy should include strong inter-agency cooperation with clearly outlined roles for each agency. Although it is difficult to judge the effectiveness of institutional arrangements prior to project activities, pre-project institutional arrangements and inter-agency relationships can be useful indicators of future interactions and should be investigated prior to project selection.

Funding

Commitment of funds for the full project period is another important criterion for the selection of a NPS pollution control project. Nonpoint source pollution control projects need sufficient funds to effectively address the land treatment needs based on the size of the critical area and the severity of the water quality problem to be addressed. In the RCWP, the goal was to treat 75% of the critical area. For most of the 21 RCWP projects, funding was sufficient, regardless of the problem, to support this land treatment goal.

Reliable funding is needed to facilitate long-term planning and budgeting, both essential components of NPS pollution control watershed projects, which often require five or more years to implement. A short funding cycle that does not ensure full implementation of project activities reduces the effectiveness of projects. Sufficient time and funds should be allocated to pre-implementation planning and acquisition of pre-project data, development of compatible / consistent data management and evaluation procedures, and selection of the most appropriate monitoring and modeling activities.

Best management practices are often too expensive for most agricultural producers to implement. Cost-share funds ease the economic burden of adopting BMPs. Results from a farm operator survey (Gale et al., 1993) showed that access to cost-share money was the primary reason producers participated in the RCWP. Because the availability of cost-share funds significantly affects producer participation, one of the project selection criteria must include adequate funding or tax credits for BMP implementation.

RCWP Project Examples

FUNDING

Unlike most agricultural NPS pollution control projects, the RCWP was funded up-front, for a well-defined period of time (10 to 15 years). If all other selection criteria factors are equal, the project with the most reliable, long-term funding should be chosen. This allows multi-year project planning and continuity in project personnel.

Because technical assistance and information and education (I&E) activities are critical components of successful NPS projects, it is essential that potential NPS pollution control projects include sufficient funding for technical assistance and I&E. For example, in Alabama, an extension agent was credited with obtaining and maintaining support for the RCWP project from area farmers.

Participants in NPS pollution control projects need frequent advice about what type(s) of BMPs to use and how to implement and manage them. Without a strong technical assistance component, which includes information and education (I&E), NPS projects will fail. Although state extension agencies and the Natural Resource Conservation Service offer these technical services free of charge, the additional workload presented by a NPS project necessitates funding for technical assistance. Additional funds may also be required for I&E activities designed to inform and educate participants and citizens about the project. Technical and I&E services funded through the RCWP transferred important information to farmers, contributing significantly to project success.

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Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. *Evaluation of the Experimental Rural Clean Water Program.* NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, (published by U.S. Environmental Protection Agency) EPA-841- R-93-005, 559p.

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Identifying and Documenting a Water Quality Problem

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

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Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered to producers as incentives for using or installing BMPs.

One of the most critical steps in controlling agricultural nonpoint source (NPS) pollution is to correctly identify and document the existence of a water quality problem. The water quality problem may be defined either as a threat or impairment to the designated use of a water resource. The designated use of a water resource is set by each state's water quality agency and includes categories such as human consumption, agriculture, aesthetics, and recreation.

Proper identification and documentation of a water quality problem requires gathering existing data from past or ongoing water quality studies. If adequate water quality data are not available to clearly document the problem and its source, a water quality problem identification and documentation monitoring program should be initiated. Monitoring should include both storm and baseflow sampling of surface water over a 6-18 month period. Ground water monitoring may also be needed. Depending on the pollutant(s) of concern, water quality monitoring may require measurements of chemical, physical, and biological factors.

Clear problem identification and documentation should lead to a water quality problem statement that:

- defines the water resource of concern;
- delineates the water use impairment or threat of impairment and identifies its location and history; and
- states the pollutant(s), the pollutant sources, and magnitude of the sources.

Assumptions about the association between pollutants and impairments should be stated. In addition, any habitat attributes found to limit ecological health should also be included.

The water quality problem statement provides the basis for a strategy to effectively remediate, or prevent, a water quality impairment and enhance the designated water resource use. The strategy is used to guide the selection and placement of best management practices (BMPs) designed to reduce, remediate, or retard specific pollutants. A well-crafted water quality problem statement is also essential to ensure community consensus about the water quality impairment. Communities are generally unwilling to expend the money and time necessary to combat

THE IMPORTANCE OF A WELL-CRAFTED WATER QUALITY PROBLEM STATEMENT

The Florida RCWP project is an excellent example of how effective water quality problem identification and documentation can lead to improvements in water quality. Lake Okeechobee has been studied since the early 1940's by the U.S. Geological Survey. A 1969 study that assessed the nutrient status of the lake indicated eutrophic conditions (Fredrico et al., 1981). High nutrient levels, particularly phosphorus, were leading to excess water plant growth and depleted oxygen levels, which were impairing fish and migratory bird habitats. In addition to other limnological studies, the water quality of the tributaries that flow into the lake was monitored for seven years (1973-1980). One tributary, the Taylor Creek-Nubbin Slough, was contributing 28% of the total phosphorus but only 5% of the water into Lake Okeechobee (Allen et al., 1982).

Animal waste and fertilizer runoff from the large dairy farms (averaging more than 1,000 cows per herd) in the Taylor Creek-Nubbin Slough watershed were the primary sources of the phosphorus.

Land treatment consisted of an aggressive system of BMPs designed to reduce phosphorus runoff from manure and fertilizer. As a direct result of the BMPs implemented during the RCWP, phosphorus concentrations in the Taylor Creek-Nubbin Slough were decreased by more than 50% (Gale et al., 1993).

NPS pollution unless they are convinced that a significant problem or threat exists and that it can be rectified.

The Rural Clean Water Program (RCWP) (see sidebar on page 1) was a national program that demonstrated the importance of water quality problem identification and documentation to agricultural NPS pollution control projects. Lessons learned about problem identification and documentation from RCWP are presented in this fact sheet.

The Importance of Problem Identification and Documentation

The diffuse nature of NPS pollution, and its spatial and temporal variability, make it a difficult problem to treat. Pollutant sources can be difficult to identify and impacts may be subtle. Therefore, without adequate water quality problem documentation, NPS pollution cannot be successfully controlled.

Many of the projects selected to participate in the RCWP had thorough water quality impairment investigations prior to project selection (see sidebar). This allowed project teams to prepare well-crafted water quality problem statements that led to actions that enhanced water quality.

Gathering Existing Data for Water Quality Problem Identification and Documentation

The first step in identifying and documenting a water quality problem is to gather existing data on the water resource and the watershed. Water resource information includes past or ongoing water quality studies. Any additional water quality studies should also be reviewed and summarized. This existing information may be available from the state water quality agency, U.S. Fish and Wildlife Service, U.S. Department of Agriculture (USDA) - Forest Service, or U.S. Geological Survey.

Land use, soils, hydrologic, and climatic data should be compiled. A land use map is one of the most important tools for watershed managers. Land use classifications include agricultural lands, animal operations, residential areas, commercial and industrial facilities, mining operations, parks, forests, and wetlands.

Basic climatic information can be used to evaluate the times of the year when pollutant loads are greatest and when drought or other factors are affecting water resource data.

MONITORING COMPLEX HYDROLOGIC SYSTEMS

The water quality problem in the Oakwood Lakes - Poinsett RCWP project (South Dakota) initially seemed straightforward. Lake Poinsett and East & West Oakwood Lakes were found to be hyper-eutrophic by the U.S.EPA in 1977. The hyper-eutrophic conditions had occurred due to excess nutrient runoff from surrounding croplands and animal operations. Algae blooms, aquatic weeds, dissolved oxygen depletion, and fish kills were common in all of the lakes. Nutrient- and sediment-reducing BMPs and waste management BMPs were implemented on the watershed's critical areas. (Critical areas are those portions of the watershed that contribute disproportionate amounts of the pollutant(s) to the receiving water. A very comprehensive monitoring program was conducted to assess the water quality of the lakes, tributaries, ground water, and runoff from individual farm fields. Best management practices reduced sediment and nutrients associated with the sediment and from animal sources (Gale et al., 1993). However, in spite of a reduction in pollutants, there was no change in the trophic status of the lakes: they remained hyper-eutrophic. Further studies revealed that phosphorus is trapped and stored in lake sediments. This phosphorus is continuously released into the water column, promoting hyper-eutrophic conditions. Even without additional phosphorus inputs, the recycling of phosphorus will occur for many years and continue to impair water quality.

Although the project failed to reduce the phosphorus levels of the lakes, it did reduce the amount of phosphorus delivered to the lakes and provided information on the water quality problem and the eutrophication process in these prairie lake systems.

Data for the watershed analysis may be available from local health departments, county planning departments, state natural resource agencies, USDA - Natural Resource Conservation Service (state or local offices), USDA - Consolidated Farm Services Agency, National Oceanic and Atmospheric Administration, Soil and Water Conservation Districts, or county or regional Extension Service offices.

In cases where existing data are not adequate to identify or document a water quality problem, additional monitoring will be needed.

Monitoring for Problem Documentation

Program Design

The monitoring objective is to locate pollutant sources and ecological conditions contributing to the problem. The monitoring program must be designed such that at its conclusion a clear statement of the water use impairment(s), the primary pollutant(s), and the pollutant sources can be written.

The program should employ both ambient and stormwater quality monitoring. Baseflow monitoring of surface water documents ambient water quality conditions and problems. Storm sampling is useful for documenting the magnitude of hydrologic and pollutant impacts. If ground water monitoring is needed, specifically constructed monitoring wells generally yield more reliable data than existing domestic wells.

The categories (physical properties, chemical constituents, biological organisms, and habitat) and individual variables monitored will depend on the water quality impairment and the extent to which the water resource has already been studied.

Physical assessment monitoring includes such variables as water temperature, turbidity, sedimentation, and ground water elevation.

Chemical assessment consists of monitoring inorganic (nitrate, ortho-phosphate, metals) and/or organic constituents (pesticides, benzene).

Biological monitoring should be used to assess impacts on aquatic life, and may include monitoring variables such as coliform bacteria, benthic macroinvertebrates, and fish.

Habitat monitoring is important for characterizing the ecological integrity of the water resource as well as in explaining primary biological variation. Habitat monitoring variables include stream, lake, or reservoir macroinvertebrate and fish habitat.

Depending on the water resource being studied, to determine the water quality impairment and the primary pollutant, and

THE IMPORTANCE OF DETERMINING THE POLLUTANT SOURCE

Lake Reelfoot (Tennessee/ Kentucky), which supports commercial and sport fishing and migratory birds, is threatened by siltation. The water quality problem and primary pollutants were identified and documented correctly before the commencement of the Lake Reelfoot RCWP project. However, contributing pollutant sources were not sufficiently quantified (Gale et al., 1993). The two primary sources of sediment in the watershed are cropland and naturally occurring gullies. A sediment budget, indicating the relative contributions of each pollutant source, should have been completed prior to project implementation. A sediment budget would have assisted the project team in selecting the most effective placement of BMPs for reducing erosion.

Another study of the lake, conducted during the RCWP time frame, indicated that some small watersheds not originally targeted for BMP installation were contributing significant amounts of localized sediment and should have been included as part of the critical area. Later studies confirmed the need for winter cover crops that were not promoted as part of the RCWP project. Finally, results of a pollutant delivery study indicated that dechannelizing area streams and tributaries would have reduced sediment loading into the lake.

Had the studies mentioned above been conducted prior to the implementation of the RCWP project, a more complete water quality problem statement would likely have been written, leading to increased accuracy in critical area definition and more appropriate selection and placement of BMPS.

possibly the pollutant source, monitoring stations for surface water may be established at: edge of field; tributaries; main-stem streams; or estuaries, lakes, reservoirs or wetlands. For ground water, stations may be needed: aquifer-wide, in certain portions of an aquifer, at specific sites or locations where particular practices are in use, or at specific intervals within the aquifer.

Tributary stations are often useful for identifying pollutant sources and the magnitude (load) of the pollutant. Simply monitoring the main-stem stream (primary drainage channel or lake) may be inadequate to identify sources of pollutants because the receiving water dilutes and assimilates tributary inputs, making identification of specific sources difficult. Tributary stations should be located immediately above and below suspected NPS pollution discharge areas to facilitate pollutant source identification. For example, in the Oregon RCWP project, tributary stations were used to document the type(s) and magnitude of pollutants entering Tillamook Bay from individual dairy farms (see project example in the sidebar on next page).

Data collected at main-stem stream stations provide an aggregate of the water conditions upstream. The water quality variables measured at the main-stem stream station should match those monitored in the tributaries. In the Florida RCWP project, for example, phosphorus, the major pollutant of concern, was carefully monitored in both main-stem streams and tributaries.

Monitoring stations located in reservoirs, lakes, estuaries, or wetlands can provide useful information about the amount and fate of pollutants reaching the water resource. These stations should be strategically positioned to evaluate the impact of the pollutant on the designated water use. For example, in the Oregon RCWP project, estuarine monitoring stations were located in or near shellfish beds so that fecal coliform contamination could be monitored.

Monitoring Duration and Frequency

Monitoring aimed at problem identification and documentation should usually be conducted for at least 6 to 18 months. However, watersheds with complex hydrologic conditions may require more than 18 months of monitoring for adequate water quality identification and documentation (see project example in sidebar on page 3).

For continuous streams, monitoring of physical and chemical constituents should occur with sufficient frequency to ensure that water quality changes caused by climatic impacts and watershed activities can be accounted for in the analysis. The timing of biological monitoring should correspond to the type and stage of the organism being documented. Guidance on

THE ROLE OF A STRONG PROBLEM STATEMENT IN ASSURING COMMUNITY SUPPORT

Another RCWP project in which the water quality impairment was correctly identified and documented was the Tillamook Bay RCWP project. Tillamook Bay, located in northwestern Oregon, contains important commercial and recreational shellfish resources. Due to fecal coliform contamination originating from dairies located near the estuary, shellfish beds were frequently closed to harvesting. As part of the water quality planning for Section 208 of Public Law 95-217 (The Clean Water Act), studies conducted by the U.S. Food and Drug Administration, the Oregon Department of Environmental Quality, and U.S. Department of Agriculture (USDA) Natural Resource Conservation Service quantified bacteria counts and the timing of the contamination and delineated the major land areas that were the primary source of the bacteria.

Fecal coliform was reduced by over 50% in the estuary after BMPs were implemented on more than 80% of all dairy farms in the region (Gale et al., 1993). Detailed problem identification and documentation was instrumental in the construction of a good water quality problem statement. This statement was used to convince all segments of the community - dairy producers, concerned citizens, fishermen, dairy cooperative executives, lenders - that the fecal coliform water quality problem had to be solved by the dairy farmers, working in conjunction with federal, state, and local agencies, to reduce contamination of shellfish beds.

timing for biological monitoring should be available from the state water quality agency.

The timing of water quality monitoring activities should also be a function of the monitoring objective. For example, timing of storm sampling is critical if the project team is trying to determine load. Water quality samples should be taken during the rise, peak, and fall of stream level during runoff.

Pollutant Budget

Existing watershed data and additional monitoring may be insufficient to entirely clarify the exact nature of the water quality problem. In some NPS projects it may be necessary to quantify the relative proportion of the pollutant contributed by each source (create a pollutant budget). For example, in the Tennessee RCWP project, where several sources of sediment contributed to the siltation of Reelfoot Lake, a pollutant budget was not constructed for the lake (see sidebar on page 4). The consequence of this lack of information about the relative proportion of sediment entering the lake from the various sources was that critical areas contributing the greatest amount of sediment were not correctly identified and the most effective BMPs were not implemented.

The Importance of Preparing a Water Quality Problem Statement

After all pertinent preliminary water quality information has been obtained, water quality data have been collected, and a pollutant budget prepared (if necessary), a detailed water quality problem statement should be written. A comprehensive water quality problem statement describes the water resource; the water quality impairment or threat to designated use; habitat limitations; and the type, source, and magnitude of the pollutant(s). The problem statement is essential because it clearly states the water quality impairment and its source(s). The problem statement can be used by the project team as a guide in selecting and siting appropriate BMPs. A comprehensive water quality problem statement can also be useful because it provides a clear explanation of the water quality problem and its causes to community members. Consensus within the community about the water quality problem and the approach being taken to address the problem is essential to project success (see project example in the sidebar on page 5).

Sometimes the water quality problem statement is written correctly the first time. In other cases, the statement may have to be rewritten as additional information becomes available. In the Illinois RCWP project, for example, the project team

KEYS TO PROBLEM IDENTIFICATION AND DOCUMENTATION

- **Prioritize problem identification and documentation as a first step to designing an NPS pollution control project.**
- **Gather existing water quality data. This information should include a physical description of the water resource and the watershed, a designated use of the water resource, and water quality data that indicate a water quality impairment or potential threat to the water resource.**
- **Water quality monitoring for problem documentation should ensue if existing data are inadequate to identify and document the water quality problem.**
- **Water quality monitoring for problem documentation should include both storm and ambient flow.**
- **Variables monitored will depend on the suspected impairment.**
- **A clear water quality problem statement should be written.**
- **Well-crafted water quality problem statements should lead the project team toward the selection of the appropriate systems and locations of BMPs.**

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originally thought that excess lake turbidity was caused by general erosion (Gale et al., 1993). However, monitoring conducted during the project indicated that a particular type of soil (natric soils) was causing most of the turbidity because saline soil particles from the natric soils do not settle. Once the pollutant source was accurately determined, a new problem statement was written and land treatment efforts were redirected toward the natric soils.

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Critical Areas in Agricultural Nonpoint Source Pollution Control Projects

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered as incentives for using or installing BMPs.

A primary objective of a nonpoint source (NPS) pollution control watershed project is to protect or restore the designated use of a water resource by reducing pollutant delivery to the water resource. Because nonpoint sources of pollution are usually widespread, intermittent, and undefined, mitigating a water quality problem or potential problem caused by NPS pollution is often difficult. The task is further complicated when sufficient time and funding are not available to implement all the recommended best management practices (BMPs). For this reason, a land treatment strategy should be developed to guide the selection and implementation of BMPs. While strategies can vary widely depending on hydrologic, sociologic, and agronomic factors, a key component of the most effective strategies is identification and appropriate treatment of NPS areas contributing disproportionately to the water quality problem. Concentrating land treatment efforts on these critical areas, or sources, helps ensure that available resources are appropriated as efficiently as possible.

All Rural Clean Water Program (RCWP) projects were required to identify and treat critical areas. However, since explicit guidance was not provided, project critical area criteria varied widely from simply all land within a set distance from a water resource to a complex set of factors applied to individual farms. The experiences of the 21 RCWP projects provide the basis for the following discussion of critical areas.

Reasons to Identify Critical Areas

All nonpoint sources of pollution are not equal. Many nonpoint sources of pollution are insignificant , while other sources contribute substantially to water resource impairment. Topographic, hydrologic, and agronomic factors often combine to make some nonpoint sources more detrimental to the beneficial use of water resources than others. Therefore, a method or strategy to identify and prioritize for treatment NPS areas that are more detrimental than others is desirable. Identifying and treating, in order of priority, the sources that most adversely affect the water resource help speed up the restoration process and may save time and money by achieving the same pollutant reduction by treating fewer sources.

HYDRAULIC TRANSPORT OF POLLUTANTS TO THE WATER RESOURCE

- **Defining critical nonpoint source pollutant areas involves identifying major pollutant sources and assessing the hydrologic transport system from the source to the water resource.**

MAGNITUDE OF THE POLLUTANT SOURCE

- **A source area that contributes large amounts of pollutants to a waterway often has a significant impact on a water resource, regardless of the efficiency of the hydrologic system.**

TYPE OF POLLUTANT

- **Identifying the primary pollutant(s) facilitates the focusing of land treatment on the critical sources causing the water quality impairment.**

Important Factors in Identifying and Defining Critical Areas

Hydraulic Transport of Pollutants to Water Resource of Concern

Defining critical NPS areas involves identifying the major pollutant sources and assessing the hydrologic transport system from the source to the water resource of concern. The purpose of this assessment is to estimate the quantity of the pollutant(s) of concern that will actually affect the water resource. For example, if a pollutant source is on a small intermittent tributary that is slow moving and drains through a large wetland and several miles of stream before emptying into a lake, then the pollutant source may not be as critical as a similar source on a perennial stream within a mile of the lake. The difference in the efficiency of the hydrologic transport system makes the delivery of pollutants to the lake from one source much more likely than from the other. Therefore, although both pollutant sources should be treated, the source closer to the lake should be considered a higher priority.

The transport mechanisms by which pollutants are carried to a water resource help identify critical pollutant sources. Pollutants that are sorbed to sediment or organic matter are much less likely to be delivered to the water resource (because of settling or filtering en route) than are pollutants in the dissolved phase, such as nitrate.

Magnitude of the Pollutant Source

Another factor in determining critical sources is the magnitude of the source. A source area that contributes large amounts of pollutants to a waterway often has a significant impact on a water resource, regardless of the efficiency of the hydrologic system. A few sources of large amounts of pollutants can overload the filtering capability of natural waterways or, in the case of ground water, overlying soils, thereby creating chronic water quality problems. Thus, the magnitude of the source as well as the hydrologic transport system must be considered in determining whether the source is critical.

Type of Pollutant

Finally, the type of pollutant must be considered in critical area selection. Examples of pollutants include: fine sediment that causes turbidity, larger sediment that causes reduced reservoir-storage capacity, phosphorus that causes eutrophication, and microbial pathogens or pesticides that cause health risks. Identifying the primary pollutant(s) facilitates focusing of land treatment on the critical sources causing the water quality impairment. For instance, a single pollutant may be the primary cause of the impairment; therefore, it would not be necessary to treat source areas of other pollutants. For example, when bacte-

TYPE OF WATER RESOURCE

- **Critical areas for ground water versus surface water problems may differ because the pollutants causing the impairment, sources of pollutants delivered to the water resource, and hydrology of the recharge area or watershed are different.**

SEVERITY AND TYPE OF WATER QUALITY PROBLEM

- **The more severe the water quality problem, the greater the pollutant reduction and extent of land treatment required to reverse the problem.**
- **If peak concentrations are the problem, critical areas may be determined by the maximum pollutant delivery rate.**

METHODS FOR IDENTIFYING CRITICAL AREAS

- **Developing a set of scientific criteria facilitates systematic assessment of the factors involved in critical area identification.**

ria are causing the impairment, critical areas need include only those areas in which bacteria is a problem, such as in and around animal operations.

Type of Water Resource

Critical areas are also determined by the type of water resource that is impaired. Critical areas for ground water versus surface water problems may differ because the pollutants causing the impairment, sources of pollutants delivered to the water resource, and hydrology of the recharge area or watershed are different.

In the Minnesota RCWP project, the ground water recharge area was significantly different from the surface watershed and critical areas. The surface water resource, Garvin Brook, was a trout stream impaired by high sediment and nutrient loads. The surface watershed critical area was determined by distance to flowing water, sinkholes, and abandoned wells, then refined using the Agricultural Non-Point-Source Pollution Model (AGNPS) (Young et al., 1987). The impaired ground water resource was a shallow aquifer. The recharge area for the aquifer (critical area) extended outside the Garvin Brook watershed. Thus, source areas critical to one type of water resource may not be critical to another.

Severity and Type of Water Quality Problem

In general, the more severe the water quality problem, the greater the pollutant reduction and extent of land treatment required to reverse the problem. Also, the type of problem affects critical area selection. If peak concentrations or standard violations are the problem, critical areas may be determined by the maximum pollutant delivery rate. For example, surface drinking water supply impairments are often caused by peak pollutant concentrations. Conversely, critical area selection that minimizes pollutant accumulation can be important for addressing loss of reservoir storage capacity or destruction of benthic habitat.

Methods Used to Identify Critical Areas

Developing a set of scientific criteria facilitates systematic assessment of the factors involved in critical area identification. The ideal criteria incorporate the efficiency of the hydrologic system in pollutant transport, magnitude of the source, and type of pollutant into guidelines that can be applied throughout the watershed. However, due to the complexity of the task, criteria are often simplified to the point that they are of little value. One simple criterion used in the RCWP was to define as critical all cropland within a quarter mile of the water resource. This criterion ignored land use activities and potential pollutant loading from sources along tributaries. Another simple criterion,

METHODS FOR IDENTIFYING CRITICAL AREAS (continued)

- **The ideal criteria incorporate the efficiency of the hydrologic system in pollutant transport, magnitude of the source, and type of pollutant into guidelines that can be applied throughout the watershed.**

- **Critical area criteria for watersheds with animal waste problems are particularly complex because these watersheds often include two or more pollutants and various types of sources, such as land application of animal waste, untreated feedlots, and livestock lounging in streams.**

- **For watersheds in which eroding cropland contributes significant quantities of sediment-attached phosphorus runoff, the distance to the nearest waterway is also important.**

- **Other important criteria include cropping system, soil erodibility, land slope, waste application rate, soil fertility, and current management practice.**

- **Critical area criteria should be applied consistently throughout the project watershed.**

identifying the entire watershed as critical, is usually not feasible or efficient unless the project area is small and major pollutant sources are uniformly widespread. Pollutant transport, source magnitude, and pollutant type should each be addressed by the simplest set of criteria.

Critical area criteria for watersheds with animal waste problems are particularly complex because these watersheds often include two or more pollutants and various types of sources, such as land application of animal waste, untreated feedlots, and livestock lounging in streams. The major criteria used by several RCWP projects with animal waste problems are presented in Table 1. The presence of an untreated feedlot combined with its distance from a watercourse (column 2) was the criterion used most often to identify a critical pollutant source. Obviously, this criterion is important because untreated feedlots are sources of large quantities of nutrients and bacteria and, if untreated feedlots are near waterways, the probability of pollutant loading to the drainage system is high.

For watersheds in which eroding cropland contributes significant quantities of sediment-attached phosphorus runoff, the distance to the nearest waterway is also important. Other important criteria include cropping system, soil erodibility, land slope, waste application rate, soil fertility, and current management practice. Cropland receiving excess fertilizer may also be critical, depending on location. When nitrogen loading is a major problem, losses are usually not directly related to soil erodibility or sediment movement, but are more closely related to manure or fertilizer application rate and timing, soil type and texture, and area hydrology.

Critical area criteria should be applied consistently throughout the project watershed. Applying all the criteria to each area ensures not only that major pollutant sources receive priority for treatment, but also that landowners whose farms do not meet the criteria do not feel excluded from the program for non-scientific reasons.

Occasionally, identifying critical pollutant sources is simply a matter of observation. In the Utah RCWP project, a small critical area was defined within a large watershed by observing that animal holding corrals were located directly in or in close proximity to drainage ways and, therefore, obviously constituted high priority for treatment. However, critical pollutant source areas are usually not so obvious. Several RCWP projects developed methods for applying criteria to animal waste problems (Table 1). The Oregon and Vermont projects used rating systems based primarily on manure management practices and distance from a watercourse to prioritize farms for treatment. The Vermont project identified critical areas based on a phosphorus (P) load per farm considered treatable with BMPs.

For watersheds with complex hydrology and many different types of pollutant sources, sophisticated computer models may be needed to accurately identify critical areas. The Florida RCWP project used pre-project monitoring and the Chemicals,

METHODS FOR IDENTIFYING CRITICAL AREAS (continued)

- **For watersheds with complex hydrology and many different types of pollutant sources, computer models may be needed to accurately identify critical areas.**

- **Distributed parameter water quality models, such as AGNPS, are generally the most accurate tools for identifying critical pollutant sources short of actually monitoring the sources.**

Runoff, and Erosion from Agricultural Management Systems (CREAMS) model (Knisel, 1980) to identify critical sources of phosphorus. This method identified as critical: all dairy operations in the project area, all fertilized and extensively ditched beef cattle pastures, and all agricultural land within one-quarter mile of major streams, ditches, and channels (Stanley and Gunsalus, 1991). Other RCWP projects (Minnesota, Vermont, Illinois, Wisconsin) used computer models after implementing at least some BMPs to evaluate how well pollutant sources had been targeted, or to adjust critical areas.

Distributed parameter water quality models, such as AGNPS, are generally the most accurate tools for identifying critical areas short of actually monitoring the sources. However, considerable expertise and significant amounts of time and effort are required to assemble the necessary model input and to interpret the output. Often, this initial expense is worthwhile, considering the time and money required to design, cost share, and implement BMPs.

Spatial analysis of the watershed using land use survey and hydrologic data in a geographic information system is often useful as an initial estimate of critical areas and, when readily available, can reduce the number of source areas requiring further evaluation.

Table 1. Major Criteria Used By RCWP Projects With Significant Animal Waste Problems.

	Major Critical Area Criteria					
RCWP Project	Feedlots Without Treatment*	Feedlot Size	Waste Application	Cropland Erosion	Pasture Condition	Degree of Adherence to Criteria
Alabama	X			X		High
Delaware	X&D	X	X	X		Low
Maryland	X&D	X		X		High
Michigan	X&D		X&D	X&D		High
Utah	X&D					High
Vermont	X&D		X&D			High
Wisconsin	X	X&D		X&D		High
Florida	X&D				X&D	High
Minnesota	X&G	X			X	High
Oregon	X&D		X&D			High
Pennsylvania	X&G					Low
Virginia	X&D		X&D			Medium

* In many projects this was simply any animal operation without treatment.
X Indicates criterion used by project.
D Indicates distance to watercourse used in combination with major criterion.
G Indicates geologic criteria used in combination with major criterion.

METHODS FOR IDENTIFYING CRITICAL AREAS (continued)

- **Spatial analysis of the watershed using land use survey and hydrologic data in a geographic information system is often useful as an initial estimate of critical areas.**

- **Water quality monitoring is useful for identifying subwatersheds, tributaries, or land areas that contribute significant amounts of pollutants.**

SUMMARY

- **Proper identification, prioritization, and treatment of critical source areas will significantly improve the chances of mitigating a water quality impairment in a watershed project.**

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Water quality monitoring is useful for identifying subwatersheds, tributaries, or land areas contributing significant amounts of pollutants. The Florida and Nebraska RCWP projects used monitoring to document major sources of sediment and nutrients, which facilitated prioritization of critical subwatersheds. Monitoring to confirm critical areas can be relatively simple, such as collecting grab samples at a few key locations over several months.

Summary

Proper identification, prioritization, and treatment of critical areas will significantly improve the chances of mitigating a water quality impairment in a NPS pollution control watershed project. The Idaho, Florida, and Utah RCWP projects documented 40 to 90% reductions in pollutant concentrations by identifying and treating critical areas based on the methods outlined above.

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Systems of Best Management Practices for Controlling Agricultural Nonpoint Source Pollution

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Best management practices were used by producers to reduce NPS pollution from their farms. Since participation was voluntary, cost-share funds and technical assistance were offered as incentives.

A significant portion of all pollutants entering streams, lakes, estuaries, and ground water in the United States results from agricultural activities. In order to solve the water pollution problem, agricultural nonpoint source (NPS) pollution will have to be controlled. The solutions to the problem of controlling runoff will require an integrated effort on the part of the landowners, government, and private organizations responsible for protecting and restoring soil and water.

The first step in reducing agricultural NPS pollution is to focus on the primary water quality problem within the watershed: the water quality use impairment must be identified and the type and source of the pollutant(s) must be defined. Once the problem has been clearly defined and documented, the critical area (the area that contributes the majority of the pollutant to the water resource) can be identified. Land treatment should then be implemented on these critical areas.

Land treatment consists of the installation or utilization of best management practices (BMPs). Best management practices are used to control the generation or delivery of pollutants from agricultural activities to water resources and to prevent impacts to the physical and biological integrity of surface and ground water. BMPs can be either structural (for example: waste lagoons, terraces, sediment basins, or fencing) or they can be managerial (for example, rotational grazing, fertilizer or pesticide management, or conservation tillage). Both types of BMPs require good management to be effective in reducing agricultural nonpoint source pollution.

The installation or use of one structural or management BMP is rarely sufficient to control the pollutant of concern. Combinations of BMPs that control the same pollutant are generally most effective. These combinations, or *systems*, of BMPs can be specifically tailored for particular agricultural and environmental conditions as well as for a particular pollutant.

The Rural Clean Water Program (RCWP), a federally sponsored experiment in controlling agricultural NPS pollution conducted during the 1980s, demonstrated the impor-

BMP SYSTEMS

- **BMP systems, as opposed to individual BMPs, are almost always necessary for controlling nonpoint source pollution.**

- **A BMP system is two or more individual BMPs that are used to control a pollutant from the same critical source.**

- **If the pollutant is the same, but the sources of the pollutant are different, BMP systems must be designed for each source.**

- **Systems of BMPs must comprehensively address the pollution problem.**

(continued on page 4)

tance of using BMP systems to control agricultural NPS pollution (Gale et al., 1993). In the RCWP projects, systems of BMPs were used to control a range of pollutants, such as sediment, nutrients, and bacteria. The following discussion of BMP systems and their effectiveness is based on the knowledge gained through the efforts of the 21 RCWP project teams.

Systems of Best Management Practices

Systems of two or more BMPs are often required to effectively control pollutant sources in critical areas. A BMP system is any combination of BMPs that are used together to comprehensively control a pollutant from the same source. When a pollutant is coming from more than one source, a separate BMP system should be designed to reduce pollutant loss from each source.

In the Nebraska RCWP project, sediment in Long Pine Creek was impairing fish production. Excess sediment originated from streambank erosion, irrigation return flows, and intensive grazing in the riparian zone. Although the pollutant (sediment) was the same, the pollutant sources were different. Three BMP systems had to be devised: a BMP system to control streambank sediment, a BMP system to control sediment from irrigated farmland, and a BMP system to decrease sediment from riparian zone grazing lands. Several individual BMPs were combined into each of the three BMP systems for controlling sediment. Nine individual BMPs were combined for the streambank system, twenty-four BMPs were used for the irrigated croplands system, and ten practices were integrated for the grazing lands system (see Table 1). A total of 37 individual BMPs were used during the project. Some BMPs were specific for controlling sediment from a single source (such as diversions), while other practices controlled sediment from two or more sources (such as fencing).

A system of BMPs designed to address a specific pollutant from a particular source must comprehensively address the pollution problem. In coastal Oregon, where rainfall often exceeds 120 inches per year, dairy farmers installed animal waste management BMPs to reduce fecal coliform runoff into the nearby estuary. Although 12 individual BMPs comprised the animal waste management system (see Table 2), these installations did not qualify as an effective BMP system because they dealt only with manure storage and were not comprehensive in controlling both the pollutant source and delivery of the pollutant to the water resource of concern. Complete and effective control of the bacterial and nutrient contamination reaching Tillamook Bay required that waste

Table 1. Systems of Best Management Practices Used in the Nebraska RCWP Project

NRCS Code[1]	Individual Best Management Practices	BMP Systems		
		Farm Land	Grazing Land (Irrigation)	Stream-banks
428	Irrigation Water Conveyance	*		
430	Irrigation Water Conveyance Pipeline	*		
443	Irrigation System (surface/subsurface)	*		
447	Irrigation System (tailwater)	*		
441	Irrigation Water System (drip)	*		
449	Irrigation Water Management	*		
382	Fencing	*	*	*
612	Tree Planting	*		*
410	Grade Stabilization	*		*
587	Structures for Water Control	*		
350	Sediment Basins	*		*
638	Water and Sediment Control Basin	*		
342	Critical Area Planting	*		
484	Mulching	*		
329	Conservation Tillage	*		
344	Crop Residue Management	*		
330	Contour Farming	*		
328	Conservation Cropping	*		
340	Cover Crops and Green Manure	*		
412	Grassed Waterway	*		
362	Diversion	*		
620	Underground Outlet	*		
660	Subsurface Drain	*		
510	Pasture and Hayland Management		*	
512	Pasture and Hayland Planting		*	
550	Rangeland Seeding		*	
556	Planned Grazing		*	*
516	Pipeline		*	
614	Tank		*	
642	Well		*	
378	Pond		*	
574	Spring		*	
322	Channel Vegetation			*
382	Filter Strips			*
580	Streambank Protection			*
NC	Cedar Revetments			*

[1] NRCS = Natural Resources Conservation Service, U. S. Department of Agriculture
Source: NRCS, 1994

NC = No NRCS Code

BMP SYSTEMS (continued)

- **No single "best" BMP system to control a particular pollutant exists. Rather the BMP system should be determined based on the pollutant and its source; the agricultural, climatic, and environmental conditions; economic considerations; and the experience of BMP system designers.**

(continued on next page)

application management be employed: land application of manure had to be conducted at the appropriate season, time, and rate. It was also necessary to include waste utilization as part of the BMP system.

There is no single "best" BMP system to control a particular pollutant. Rather the BMP system should be determined by the type of pollutant; the source of the pollutant; the agricultural, climatic, and environmental conditions; the economic situation of the farm operator; and the experiences of the system designers. For example, a similar water quality problem existed in both the Massachusetts and Oregon RCWP projects. In both projects, shellfish production was impaired in an estuary by fecal coliform contamination caused by runoff from surrounding dairy farms. Animal waste management BMPs were installed, along with other types of BMPs. In the Oregon project, 12 individual BMPs were needed to control the animal manure in the barnyard area, whereas in Massachusetts only four were needed (see Table 2). However, both projects implemented the most appropriate set of BMPs for their environment. The regions where these two projects are located have different climatic and ecological characteristics, requiring different approaches to mitigate the animal waste problem. Some of the animal waste management BMPs installed in Oregon were designed to keep the rain off the manure (guttering and roofing). Because rainfall in Massachusetts is much lower, these types of structures were not needed. In addition, Oregon farmers had to install extremely large waste storage structures to contain the manure during continuous rain events. Because

Table 2. Animal Waste Management BMP Systems Used in the Oregon and Massachusetts RCWP Projects

NRCS Code[1]	Individual Animal Waste Management BMPs	Oregon	Massachusetts
313	Waste Storage Structure	*	*
312	Waste Management System	*	*
NC	Roofing	*	*
561	Heavy Use-Area Protection		*
NC	Guttering	*	
NC	Buried Main Line	*	
359	Waste Treatment Lagoon	*	
NC	Conduit	*	
NC	Curbing	*	
412	Grassed Waterway or Outlet	*	
607	Subsurface Drain	*	
608	Subsurface Drain, Main, or Lateral	*	

NC = No NRCS Code
1 NRCS = Natural Resources Conservation Service, U. S. Department of Agriculture
Source: NRCS, 1994

BMP SYSTEMS (continued)

- **Systems of BMPs can be designed to reduce the amount of pollutant, retard the transport of the pollutant, or remediate the pollutant, whereas individual BMPs can only affect one of these three mitigation mechanisms.**

- **Systems of BMPs can be measured for their effectiveness in reducing agricultural nonpoint source pollution.**

- **For maximum effectiveness, BMP systems must be selected correctly and placed in the critical pollutant source areas. The extent of land treatment must be sufficient to achieve water quality improvements.**

of the drier climatic conditions in Massachusetts, these large waste storage structures were not necessary. Even though the water quality problem was similar for the Oregon and Massachusetts RCWP projects, each project had to design a system of BMPs that was appropriate to the specific conditions encountered.

Transport of agricultural chemicals to surface and ground water can be controlled by reducing the pollutant load reaching the water resource; retarding the transport of pollutant (either by reducing water transported, and thus pollutant transport, or through chemical or biological transformation); or remediating the pollutant in the water system. An individual BMP can only control the pollutant at its source, during transport, or in the water. Systems of BMPs are generally more effective in controlling the pollutant since they can be used at two or more points in the pollutant delivery system. For example, the objective of the Iowa RCWP project was to reduce the loss of soil from cropland, which was resulting in sedimentation and turbidity in Prairie Rose Lake. A system of BMPs was designed not only to reduce soil detachment, thus reducing the potential for soil to erode, but also to retard off-site transport of eroded soil. Critical area planting (NRCS Code 342) and conservation tillage system (NRCS Code 329) were used to reduce the amount of on-site soil loss. Terraces (NRCS Code 600), underground outlets (NRCS Code 620), diversions (NRCS code 362), grassed waterways (NRCS code 412), and sediment retention basins (NRCS Code 350) were installed to slow sediment transport to the lake.

Systems of BMPs can be measured for effectiveness. In the Taylor Creek - Nubbin Slough RCWP project in Florida, greater than 50% reductions in total phosphorus concentrations were documented by water quality monitoring at the project outlet and in subwatersheds where many BMPs had been implemented. In contrast, water quality in subwatersheds with little BMP implementation or increased cattle densities showed increases in total phosphorus concentrations. These monitoring results supported the conclusion that the system of BMPs implemented was effective in reducing phosphorus delivery to Lake Okeechobee.

Conclusions

BMP systems are more effective at controlling agricultural nonpoint source pollution than individual BMPs because systems minimize the impact of the pollutant at several points: the source, the transport process, the water body. However, systems of BMPs are just part of the land treatment strategy. Properly designed BMP systems must also be placed in the correct locations in the watershed (critical

CONCLUSIONS

- **The placement of BMP systems in the watershed should be prioritized. Locations contributing the largest proportion of pollutant(s) from the critical area should be treated first with the appropriate system of BMPs.**

pollutant source areas) and the extent of land treatment must be sufficient to achieve water quality improvements.

Because financial resources are generally limited, BMP system implementation should be prioritized. Systems of BMPs should first be implemented at those locations in the critical area that contribute the largest proportion of pollutant(s). The remaining critical area locations can then be treated with BMP systems as feasible, given availability of funds.

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Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. *Evaluation of the Experimental Rural Clean Water Program.* National Water Quality Evaluation Project, NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, (published by U.S. Environmental Protection Agency) EPA-841- R-93-005, 559p.

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COLLEGE OF AGRICULTURE & LIFE SCIENCES

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The Role of Information and Education in Agricultural Nonpoint Source Pollution Control Projects

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U.S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered as incentives.

Designing an Information and Education Program for an Agricultural Nonpoint Source Pollution Control Project

Most farm operators are aware of water quality issues, but may not have all of the information they need to minimize agricultural nonpoint source (NPS) pollution. For this reason, information and education (I&E) programs are an essential component of any project aimed at reducing NPS pollution.

The information element of any I&E program should be used to share existing knowledge through the distribution of material. The education element, which requires the active participation of the audience, should be used to encourage participants to incorporate new information into behavioral choices that enhance water quality. Although the two I&E program elements have separate goals and functions, they are complementary. Transfer of information should heighten the awareness of water quality issues both within the agricultural community and among the general public, while education should encourage farmers to reduce agricultural NPS pollution through implementation of best management practices (BMPs).

The focus of I&E efforts often changes over the course of a project. Initial efforts develop general awareness of the water quality problem and public support and inform producers about NPS controls and why they should be implemented. Next, technical assistance is provided to the farmers in the management and maintenance of the implemented BMPs.

In agricultural NPS pollution control projects, I&E should be directed at a wide range of target audiences: producers, business persons, local government officials, community members, and school children. The overall I&E message should be the same for these groups and should address the following questions. What is NPS pollution? How do agricultural practices cause NPS pollution? What is the water quality problem of concern to the community? Why is it important to solve the water quality problem? What changes in individual and collective behavior or practices will result in a decrease in NPS pollutants in the water

DESIGNING AN INFORMATION AND EDUCATION PROGRAM

- **Educate the community about the project and seek widespread input into the project planning process.**
- **Identify the target audiences for I&E.**
- **Determine the I&E strategy for each audience.**
- **Tailor I&E activities and methods to each audience.**

PRODUCER PARTICIPATION

- **One-to-one contact between producers and I&E specialists is the most effective method to transfer information and increase participation.**
- **In order for one-to-one contact to be effective, land owners must believe there is a water quality problem that needs to be corrected.**
- **Effective educational programs encourage farm operators to accept responsibility for the effects of their farming operations on water quality.**

body of interest? What are the objectives of the NPS pollution control project? How will these project objectives be met?

Target audiences should be identified during the planning period before project implementation, and specific I&E strategies should be developed for each group based on its information needs. Particular I&E activities should then be tailored to each group. Farm operators must be educated about their role in causing NPS water pollution and informed about ways to prevent and solve the problem. Business leaders must be informed about ways in which they can support changes in agricultural practices that will enhance water quality. A better understanding of the sources and causes of NPS pollution can assist local government officials in making a wide range of governmental decisions.

Community members need I&E to be informed citizens and decision makers. Information about the impacts of land use on water quality can enhance citizens' awareness of and willingness to change behaviors that contribute to water quality degradation. Finally, the most lasting way to affect lifetime attitudes is to educate children. Information and education programs for children represent an investment in the future.

A national program that has clearly demonstrated the importance of I&E programs to the successful outcome of agricultural NPS pollution control projects is the Rural Clean Water Program (RCWP) (Gale et al., 1993). The I&E lessons presented below are drawn primarily from the RCWP experience.

The Importance of Information and Education for Producer Participation

The most effective I&E approach to gaining producer participation is one-to-one contact between project personnel and farmers. RCWP projects with successful I&E programs used on-farm contacts between producers and agency or business personnel to gain producer confidence and increase participation. In the South Dakota RCWP project, I&E funds were used to hire a technical planner to work on a one-to-one basis with farmers. His contact with producers resulted in an increase in participation from 6 farms and 2,132 acres before the planner was hired to 92 farms and 29,468 acres within one year after the planner began working with area farmers.

If, however, farmers do not support the objectives of a voluntary NPS pollution control project, one-to-one contact by agency personnel will not be sufficient to change farming practices and motivate farmers to participate in a water quality project. In RCWP projects where producers either did not believe that there was a water quality problem or were not convinced that the water quality problem was caused by agricul-

PRODUCER PARTICIPATION (continued)

- **Trusted local community members are often the most effective transmitters of I&E.**
- **I&E programs can be effectively delivered by government agencies.**
- **When I&E is delivered by several agencies, one agency should be designated as the lead agency, agencies must communicate with each other, and all agencies must deliver a uniform message to the producers.**
- **Private sector organizations can also make valuable contributions to I&E efforts.**
- **Farmers with large successful operations and full-time farmers are most easily reached through I&E activities.**
- **Different I&E strategies will have to be devised for more economically challenged farmers.**
- **Specific services or project support, such as machinery loans, nutrient management plans, and soil testing, should be provided to encourage producer participation and educate farmers about recommended practices and objectives.**

ture, one-to-one contact was only marginally effective in increasing producer participation.

Results of a survey of farmers who participated in the RCWP projects found that although most producers believed that a water quality problem existed, many did not feel that their farm was contributing to the problem (Gale et al., 1993). I&E programs must both educate producers about water quality issues and assist producers in recognizing the ways in which their farming practices contribute to the problem.

Information is often most successfully transmitted to producers by trusted members of the community. In some RCWP projects, producer participation increased when local community members were employed as I&E specialists. In other RCWP projects, the trusted community member was a county Extension Service or U.S. Department of Agriculture (USDA) - Natural Resource Conservation Service (NRCS) (formerly called the Soil Conservation Service) employee who had worked with the producers for years and had gained their trust.

Information and education programs can be effectively conducted by either the Extension Service or NRCS. Both agencies conducted successful I&E outreach programs in the RCWP projects, with the Extension Service taking the lead in most cases.

When several agencies jointly deliver I&E services, it is important that one agency is clearly identified as the lead agency, that personnel of all participating agencies communicate with each other, and that all agencies convey a consistent message to producers and the community. One RCWP project, for example, had a very effective I&E program until the Natural Resource Conservation Service and Extension Service stopped coordinating efforts. Another project never got off the ground, in part because farmers received conflicting messages about the value of the project and the source of the water quality problem from the staffs of two participating agencies.

Information and education can also be effectively delivered by private organizations. A local dairy cooperative representative was an important source of I&E in one RCWP project. In another project, the local fertilizer dealer was instrumental in extending information about fertilizer calibration and rates. Consulting firms that offered integrated pest management services were also used to promote I&E in some RCWP projects.

It is more difficult to extend I&E to some farmers than to others. In general, farmers who participated in the RCWP projects were full-time farmers and had more assets (land, machinery, and income) than farmers who were eligible but chose not to participate (Gale et al., 1993). Farmers who had to work off the farm to make ends meet and those with fewer assets were less likely to participate. Specific I&E strategies must be developed to target farmers who are more economically challenged, if NPS pollution is to be significantly reduced.

PRODUCER PARTICIPATION (continued)

- **I&E programs should use all information delivery methods, even those that may not be the most effective methods (letters, radio spots, newsletters, videos) but which serve as ongoing reminders of project activities.**

- **It is generally easier to motivate farmers to install structural BMPs than to use BMPs that require changes in farm management.**

- **I&E efforts must start in advance of other project activities.**

- **Producers and members of the community should be brought into the project planning process from the very beginning.**

- **I&E efforts must continue after the project ends to ensure that BMPs are continued and maintained.**

- **I&E programs must educate community members about agricultural NPS pollution and methods for controlling such pollution.**

A variety of techniques should be used to transfer technical information about BMPs. Most of the RCWP projects offered field or farm demonstrations of recommended practices. One project loaned no-till equipment to farmers who wanted to try conservation tillage before purchasing the necessary machinery. Some projects hired nutrient management specialists to assist farmers in utilizing animal manure as a source of fertilizer. Soil and manure testing were provided free of charge as an additional incentive to cooperating farmers.

All available media and forums should be used to extend information about a nonpoint source project to producers. Print media (newsletters and newspaper articles), electronic media (radio and TV), meetings, tours, videos, slide shows, and displays were used in many RCWP projects. Although farm magazines, USDA personnel, and newspaper articles provided the farmers with more information on water quality than the other sources (Gale et al., 1993), a combination of I&E techniques is most likely to be effective in any agricultural NPS pollution control project.

Introducing farmers to less familiar management practices requires a higher level of I&E effort than does education about structural practices. In most RCWP projects, terraces, animal waste management systems, and other structural BMP components were easier to "sell" to farmers than management practices such as soil testing, nutrient and pesticide management, rotational grazing, and conservation tillage. Although more difficult to sell, management practices are generally more cost-effective in reducing NPS pollution than are structural practices. Future agricultural NPS pollution control projects should focus more resources on promoting management practices that minimize NPS pollutants.

A successful I&E program must start in advance of project activities. RCWP project teams that involved producers and community members in planning a project before it started generally had a higher level of support and participation than those projects in which I&E was delayed until after the project was funded and initiated.

Once funding for an agricultural NPS pollution control project ends, I&E efforts must continue to ensure that the BMPs implemented are maintained. Agency personnel found that in several RCWP projects, I&E support to the farmers was just as important after the farmers implemented structures or learned management practices as it was during BMP implementation. For example, in several RCWP projects, farmers who had installed waste lagoons needed to learn how to maintain them effectively. This maintenance required follow-up I&E beyond that originally scheduled as part of the project.

INFORMATION AND EDUCATION IN THE COMMUNITY

- **I&E must inform the community about project objectives and progress.**
- **Specific groups within the community who will be instrumental in providing services and financing to project participants should be educated about the project so that they can support project objectives.**

EDUCATING THE NEXT GENERATION

- **Education of the next generation about water quality has long-term benefits and should be part of the I&E program for any NPS pollution control project.**
- **I&E programs should be developed for presentation in schools and youth organizations.**

The Role of Information and Education in the Community

The amount and types of I&E that should be extended to a community and to farm operators will vary from project to project, depending on project objectives, and will vary over time within a project. At a minimum, I&E was used in the RCWP projects to inform the community about project objectives and to update citizens on progress. Sometimes I&E was used to educate the community about NPS pollution in general.

Some RCWP projects went beyond general information transfer and educated specific community groups. In one project, contractors responsible for building the animal waste management systems were informed about the project. Better understanding on the part of contractors about the goals and technical requirements of the project resulted in construction of higher quality, more effective waste management systems. In this and another project, bank officials received information about the RCWP project to better understand and evaluate applications for loans to support BMP implementation. As a result, farmers were able to obtain loans more easily. Community groups that are perceived as instrumental for achieving project objectives should be targeted and specific I&E outreach approaches should be designed for these groups.

The Role of Information and Education Activities in Educating Children

One of the most effective ways to influence attitudes and behavior is to educate the next generation. Several RCWP projects specifically included outreach to children. Sometimes information about NPS pollution and the RCWP was delivered through school programs. Other times children were reached through information delivered to particular organizations, such as 4-H clubs. Information and education geared to children has long-range benefits and should be instituted as part of all agricultural NPS pollution control projects.

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Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. *Evaluation of the Experimental Rural Clean Water Program.* National Water Quality Evaluation Project, NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, (published by U.S. Environmental Protection Agency) EPA-841- R-93-005, 559p.

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Farmer Participation in Solving the Nonpoint Source Pollution Problem

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered as incentives for using or installing BMPs.

The Importance of Producer Participation in Voluntary Agricultural Nonpoint Source Pollution Control Projects

The success or failure of any agricultural nonpoint source pollution control project depends on the participation of many landowners or farm operators. These producers must install or utilize land-based treatments, or best management practices (BMPs), that minimize the movement of agricultural pollutants such as sediment, nutrients, and pesticides to water resources.

The degree of producer participation necessary to protect or remediate water quality will depend not only on the total number of land users employing BMPs in the watershed, but also on several other factors: the location of the producers' farms in the watershed, the types of BMPs selected, the extent of BMP implementation, and the type and severity of the water quality problem.

The first phase in a nonpoint source (NPS) pollution control project is to accurately identify and clearly document the water quality problem, the specific pollutant(s), and the sources of the pollutant(s). Based on the water quality problem assessment, the critical area (land area or areas contributing disproportionately to the water quality problem) should be identified. High-priority project participants are those producers who farm or raise livestock in the critical area of the watershed.

A primary goal of any voluntary NPS pollution control project is to engage a sufficient number of potential participants in the project. The Rural Clean Water Program (RCWP), a nationally recognized nonpoint source pollution control program conducted between 1981 and 1995, established a target voluntary producer participation rate of 75%. Many valuable lessons were learned from the RCWP about how to recruit and retain participants in voluntary NPS pollution control projects. The information presented in this fact sheet is based on these lessons learned.

SOCIO-ECONOMIC AND ATTITUDINAL FACTORS AFFECTING PARTICIPATION

- **Farmers who work solely on the farm or who receive most of their income from agricultural sales are most likely to participate in agricultural nonpoint source (NPS) pollution control projects.**
- **Project participants are generally more aware of water pollution than farmers who choose not to participate.**
- **Producers who receive most of their water quality and conservation information from government agencies and farm magazines are most likely to change agricultural practices that affect water quality.**

INCENTIVES TO PARTICIPATION

- **Financial incentives may be the most important factor in achievement of voluntary implementation of BMPs.**
- **Financial incentives include cost-share funds, tax relief, payment transfers, and government subsidies.**

Farm Structure and Producer Attitudes and Attributes that Affect Project Outcome

An extensive telephone survey of producers farming in the critical areas of the 21 RCWP projects was conducted to evaluate differences between farmers who chose to participate in the RCWP and those who did not (Gale et al., 1993). Farm structure, farm operator characteristics, and water quality awareness and attitudes were assessed.

Participation in RCWP projects was highly correlated with strong economic indicators, such as comparatively larger total acreage farmed, higher gross farm sales, and greater property and farm equipment values. Producers who were employed off-farm, or who received only part of their income from agriculture, were less likely to participate in NPS pollution control projects than were farmers who worked solely on the farm and earned most of their income from agriculture.

Water quality awareness and attitudes were also important in determining participation rates in the RCWP projects. Producers who were more aware of water pollution (in general, in the specific area, or on individual farms) participated in greater numbers than farmers who were less well informed. Producers who received most of their water quality and conservation information from government agencies and farm magazines were more likely to change agricultural practices that affected water quality than producers who did not receive information from these sources.

Many of the results of the farm operator survey were similar to conclusions of previous studies evaluating factors that influence conservation. Farmers who run large-scale operations, are better educated and more willing to take risks, and have access to government information generally participate at a higher rate in conservation programs than producers without these characteristics. Although farm structure and producer characteristics were important factors in determining which farmers chose to participate in the RCWP projects, external incentives also affected participation.

Incentives To Producer Participation

Economic Factors

Financial incentives are extremely important, and may be the most important factor, in obtaining voluntary implementation of BMPs. Financial incentives for voluntary environmental compliance include cost-share funds, tax relief, payment transfers, and government subsidies.

The primary financial incentive in the RCWP projects was federal cost-share funding. Each producer could receive up to

ECONOMIC FACTORS

- **The cost of BMP installation and maintenance serves as a disincentive to BMP implementation.**

THE IMPORTANCE OF INFORMATION AND EDUCATION PROGRAMS

- **Information and education programs increase producer participation in agricultural NPS pollution control projects.**
- **Information heightens farmers' awareness of water quality problems and approaches to solving them.**
- **Education aids farmers in selecting appropriate BMP systems.**
- **I&E programs must begin prior to land-based project activities to facilitate development of a sense of problem and project ownership on the part of the potential participants.**

(continued on next page)

75% of the cost of each recommended BMP implemented (up to a maximum per farm of $50,000).

The cost-share rate for the Alabama RCWP project was originally set at 60%. Few farmers chose to participate until the cost-share rate was raised to 75%. Participation then increased to 100% of the producers in the critical area.

A significant barrier to implementation of BMPs is poor economic status of producers. The farm operator survey (Gale et al., 1993) found a lower rate of participation among farmers who had relatively lower economic indicators. During the early 1980s, many farmers in Oregon were unable to participate in the Tillamook Bay RCWP project because high interest rates limited cash flow, making it difficult for farmers to pay their portion of the cost of installing BMPs. Another hindrance is the high cost of some BMPs, such as animal waste management systems. For many dairy farmers, the maximum cost-share payment of $50,000 was insufficient to make the construction of animal waste storage units economically feasible.

State or local cost-share assistance was offered in some projects as a supplement to federal cost-share funds. To entice absentee landlords to participate in the RCWP, Tennessee and Kentucky officials added 25% to the federal 75% cost-share rate for seeding alfalfa. Producers also received an additional one-time payment of $75 per acre for converting cropland to pasture. Florida dairy farmers participating in the Lake Okeechobee RCWP project received substantial subsidies from the State of Florida to assist them in installing expensive animal waste management BMP systems.

Technology Transfer: The Importance of Information and Education Programs

Information and education (I&E) is an essential component of any agricultural NPS pollution control project. Information should heighten farmers' awareness of water quality problems and approaches to solving them. Education should increase project participation and assist farmers in selecting and maintaining appropriate BMP systems.

Strong and effective I&E programs in many of the RCWP projects (for example, Maryland, Alabama, Nebraska, Idaho, Utah, Vermont, Florida, and Oregon) contributed to high producer participation and, consequently, to water quality improvements.

I&E must begin prior to land-based project activities in order to foster a sense of problem and project ownership on the part of the potential project participants. Delaware and Iowa RCWP project personnel reported that both pre-project meetings to discuss the water quality problem and producer involvement in

project planning helped develop strong support for and participation in the project by area farmers.

The most effective way to increase producer participation is one-to-one contact between project personnel and farmers.

On-farm demonstrations can be used effectively to educate farmers about new technologies. Producer participation was increased in the Maryland RCWP project through on-farm demonstrations of BMP installation and maintenance.

To control agricultural runoff, producers must implement additional, often new, BMPs. Technical assistance must help participants with new BMPs, whether the BMPs are structural or managerial. In the Oregon RCWP project, Natural Resource Conservation Service personnel had to modify animal waste storage systems for high-rainfall conditions. Extension Service personnel in Pennsylvania developed nutrient management plans for individual farmers and taught them how to implement the plans. These technical assistance efforts resulted in more effective implementation and maintenance of BMPs. Technical assistance also served to strengthen producers' motivation to participate in the project.

Environmental Concerns

Like air pollution, water pollution from nonpoint sources is a complex issue. It is often difficult for land users to understand how an individual's daily activities can contribute to nonpoint source pollution. Producers are most likely to participate in solving water quality problems when they understand that their own agricultural practices affect the water quality of a local water resource. The farm operator survey showed that the major reason producers did not participate in the RCWP projects was that they did not believe water pollution was a problem. Conversely, twice as many RCWP participants as non-participants stated that they believed water quality was a problem.

Producer participation also depends on farmers valuing the impaired water resource. Because Iowa RCWP project participants valued a recreational lake that was decreasing in size and depth due to sedimentation caused by cropland erosion, they were willing to adopt new agricultural practices.

Environmental regulations, or the threat of regulation, can provide incentives for producers to participate in agricultural NPS pollution control projects. Farmers in the Chesapeake Bay drainage area face possible regulation if voluntary efforts fail to address the NPS pollution problem. As a result, over 50% of the farmers eligible to participate in the Virginia RCWP project were ready to get involved in the project as soon as cost-share funding became available.

THE IMPORTANCE OF INFORMATION AND EDUCATION PROGRAMS (continued)

- **One-to-one contact between producers and I&E specialists is the most effective method to transfer information and increase participation.**
- **New technologies can be effectively shared with producers through on-farm demonstrations.**
- **Technical assistance results in more effective BMP implementation and maintenance and better participation in NPS pollution control projects.**

ENVIRONMENTAL CONCERNS

- **Producers are most likely to participate in NPS pollution control efforts when they understand that their agricultural practices affect the water quality of a valued local water resource.**
- **Environmental regulations, or the threat of regulation, can motivate participation by producers in a NPS control project.**

COMMUNITY SUPPORT

- **The support of the entire community is required for NPS pollution control project to be successful.**
- **Community members can apply pressure to local farmers to adopt better agricultural practices.**

CONCLUSIONS

- **Water quality improvements occur as the result of many factors, including: identification of a water quality problem amenable to remediation, documentation of the source of the major pollutant(s), accurate definition of the critical area, correct selection and placement of BMPs, installation of sufficient land treatment in the critical area, and maintenance of BMPs.**
- **The rate of participation necessary to achieve water quality goals depends on the pollutant, agro-environmental conditions, and the magnitude of the water quality problem.**
- **The RCWP experience indicates that close to 100% participation is needed when animal operations are involved.**

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Community Support

An impaired or threatened water resource affects the entire community. Nonpoint source pollution control projects must have the support of the whole community. In Oregon, community support of the Tillamook Bay RCWP project was instrumental in achieving 96% participation of critical area dairy farmers. Pressure to participate in the project came from neighbors and a local business. Fecal coliform contamination of the bay, caused by runoff from dairies, threatened the local economy by reducing shellfish harvests. Many of the fishermen losing revenue were relatives and friends of local dairy farmers. These fishermen were able to exert peer pressure on dairy farmers to change their farming practices. In addition, all of the dairy farmers sold their milk to a local cheese-producing cooperative that reserved the right to discount milk prices paid to producers who did not install BMPs. This high level of community support played an important role in the achievement of a very high rate of project participation.

Conclusions

Water quality changes require implementation of BMPs by a large percentage of producers who farm in the critical area of a watershed. However, a high rate of participation does not automatically ensure water quality improvements. Improvements in a degraded water resource, or protection of a threatened water resource, occur as the result of the interaction of many factors: identification of a water quality problem amenable to remediation, documentation of the source of the major pollutant(s), accurate definition of the critical area, correct selection and placement of BMPs, installation of a sufficient number of BMPs in a substantial portion of the critical area, and maintenance of BMPs.

The absolute number of participants necessary to reduce pollutants by a stated amount will vary depending on the pollutant, agro-environmental conditions, and the magnitude of the problem. For some situations, almost 100% producer participation may be required to improve the water resource to its designated use. In the Oregon RCWP project, approximately 60 dairies were considered critical at the start of the project. Dairies having the greatest negative impact on water received cost-share funds to implement BMPs first; then other critical farms were added. However, the project goal of a 70% reduction in fecal coliform counts was not being met. Consequently, additional dairies were classified as critical. By the end of the project, BMPs to control dairy runoff had been implemented on 96% of 109 dairies defined as critical and the project's water quality goals were met. The experience of the Oregon, Florida, and Utah RCWP projects indicates that close to 100% participation is necessary in projects where the major source of the pollutants is animal operations.

CONCLUSIONS (continued)

- **Results from the RCWP suggest that an absolute minimum participation of 75% of critical area farmers is necessary.**
- **Financial incentives are extremely helpful in reducing the economic burden of BMP implementation.**
- **Environmental regulations or the threat of regulation tend to result in higher project participation.**
- **Technical assistance helps producers select, install, and maintain appropriate BMP systems.**
- **Information and education is an essential component of any NPS pollution control effort.**
- **Community support for the project is essential.**

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This fact sheet is one of a series of Rural Clean Water Program Technology Transfer fact sheets prepared by the NCSU Water Quality Group with support from the Extension Service, U.S. Department of Agriculture (Cooperative Agreement No. 93-EXCA-3-0241).

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Other RCWP projects successfully reduced pollutants with lower participation rates. In Idaho, installation of BMP systems on 75% of the critical area farms resulted in a 75% decrease in sediment and a 68% decrease in phosphorus entering Rock Creek, resulting in better habitat for fish.

While the amount of voluntary participation necessary to successfully address agricultural NPS pollution must be determined for each individual watershed, results from the RCWP suggest that an absolute minimum of 75% participation of critical area farmers is necessary.

Many factors interact to determine the ultimate number of producers who participate in a voluntary NPS pollution control project. Financial incentives are extremely helpful in reducing the economic burden of BMP implementation. Environmental regulations, or the threat of regulations, can also increase participation, although they are most often used as a last resort when voluntary measures have failed. Technical assistance is an important means for helping producers select, install, and maintain appropriate BMP systems. I&E is also an important means for achieving adequate participation and helping potential participants understand how their practices may degrade valuable local water resources. Finally, community support is essential for encouraging and sustaining producers throughout the project period.

Reference

Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. *Evaluation of the Experimental Rural Clean Water Program.* NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, EPA-841- R-93-005, 559p.

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Water Quality Extension Specialists
NCSU Water Quality Group

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Farmer Participation in Solving the Nonpoint Source Pollution Problem

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

The RCWP was administered by the U.S. Department of Agriculture - Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) in consultation with the U.S. Environmental Protection Agency. The Natural Resource Conservation Service (formerly Soil Conservation Service), Extension Service, Economic Research Service, Agricultural Research Service, U. S. Geological Survey, and many state and local agencies also participated.

The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered to producers as incentives for using or installing BMPs.

Changes in water quality resulting from the implementation of nonpoint source (NPS) pollution controls can be determined by monitoring the particular water resource of interest. Water quality monitoring along with a simple inventory of land use and land treatment (implementation of best management practices) is usually sufficient in most agricultural NPS projects, especially if the intent of a water quality project is merely to document water quality improvements. However, monitoring the water resource alone is insufficient to document a cause-and-effect relationship between changes in water quality and changes in land treatment or land use. To ascribe changes in water quality to land treatment and land use, it is often necessary to intensively monitor (track) and document both changes in water quality and changes in land use and land treatment over an extended period of time (at least four to eight years). Land-based data requirements include detailed, timely, and site-specific information about land treatment practices and land use changes.

Few agricultural NPS pollution control programs before the Rural Clean Water Program (RCWP) attempted to correlate water quality changes with the installation of land treatment practices and land use changes on a watershed scale (Gale et al., 1993). In several of the 21 RCWP projects, efforts were made to correlate land treatment with water quality changes.

Land Treatment Monitoring in the Rural Clean Water Program

One of the objectives of the RCWP was to document that NPS controls can reduce pollutant loss from agricultural land. Only a few RCWP projects participated in land treatment monitoring at a level sufficiently detailed to correlate land-based activities with water quality changes. Personnel in these projects had to design experimental protocols for correlating land treatment practices with water quality data. In addition, many of the technical tools (personal computers, geographic information systems, database software) that facilitate detailed land treat-

LAND TREATMENT MONITORING STRATEGY

- **Intensive land treatment and land use tracking is necessary if water quality changes are to be ascribed to changes in land-based activities.**

- **A well-designed land treatment monitoring strategy must include the variables to be monitored, the frequency with which each variable will be monitored, and the landscape scale of each monitored variable.**

- **The land-based variables to be monitored should correspond to the water quality problem.**

- **Monitoring frequency should be based on the specific characteristics of the variable being tracked.**

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ment and land use data analysis only became commercially available or affordable during the period of the RCWP (1980-1990). Many of the lessons that were learned about land treatment and land use monitoring during the RCWP are presented in this fact sheet. However, the science of land treatment monitoring is in its infancy and can be expected to continue to evolve for the foreseeable future.

Land Treatment Monitoring Strategy

A land treatment and land use monitoring strategy should specify the variables to be monitored, the monitoring frequency for each variable, and the landscape scale of each monitored variable.

Variable Selection

The land-based variables selected for monitoring should correspond to the identified water quality problem and should include static, temporal, and spatial variables. For example, if sediment deposition caused by cropland erosion is the water quality problem, the variables should include position of the field relative to the water resource, soil type, field slope, acres under various cropping systems, soil conservation practices, and timing of tillage activities. When the water quality problem is caused by runoff of nitrogen, rates and timing of commercial fertilizer and manure applications should be tracked.

Sample Frequency

The frequency with which a variable should be monitored depends on the specific variable and its characteristics. In general, monitoring should take place at the same time that land use or land management changes occur. For example, each fertilizer application during a given production season should be recorded by field. The number of applications will depend on management decisions made by the individual farm operator. Crop type should be tracked on a yearly basis.

LAND TREATMENT MONITORING STRATEGY (continued)

- **The landscape scale of the monitored variable will be determined by the pollutant and the source of the pollutant being monitored.**
- **Land-based activities in critical areas should be closely monitored.**
- **Critical area monitoring should include both project participants and non-participants.**

DATA COLLECTION

- **Careful data collection is essential for ensuring accuracy.**
- **More detailed tracking of land-based activities is necessary than what is provided by yearly USDA reporting requirements.**
- **Data should be collected and stored according to subwatershed boundaries to facilitate water quality data evaluation.**

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Landscape Scale

The appropriate landscape scale for each variable will be determined by the pollutant being monitored and its source. Land-based activities located within the delineated critical area (the land area contributing most to the problem) should be closely monitored for both project participants and non-participants. For example, since the Oregon RCWP project watershed was very large (363,520 acres), and the pollutant of concern was fecal coliform, the scope of the land treatment monitoring focused exclusively on the dairy farm operations that constituted 6% of the watershed and 100% of the critical area. Data should be collected by subwatershed in order to match land use and land-based information with the water resource of concern.

Data Collection

Careful data collection is essential to ensure accuracy. There are several ways to collect land-based data and the collection method should be determined based on the intended use of the data as well as the extent of financial and human resources available.

During the RCWP, most of the land-based data were collected by the U.S Department of Agriculture (USDA) - Natural Resource Conservation Service, Consolidated Farm Services Agency, and Extension Service as part of the agencies' annual reporting. These aggregated data included information on the types of crops produced, number of acres grown, number and types of animals in the watershed, and soil and water conservation practices installed under federal cost-share programs. Additional data on best management practices installed or utilized were collected for each RCWP project by agency personnel. Although this information provided an overall perspective on land treatment activities and land utilization, by itself the data were not sufficient to correlate changes in land-based activities and water quality.

Consolidated Farm Services Agency (CFSA) reporting formats allow description of annual aggregate agricultural information by county, but are simply not detailed enough to support reliable correlations between land-based activities and water quality changes that occur on a seasonal basis. The Idaho RCWP project enhanced the use of CFSA data by compiling the information contained in CFSA annual reports on a drainage basis by season. However, the drawback of this system was that detailed land use and management data were not available for landowners who did not accept cost share payments for best management practices (those who did not participate in CFSA-administered programs).

DATA COLLECTION (continued)

- **Producer log books are a useful land-based data collection tool.**
- **Personal interviews are an excellent source for collecting land-based data.**
- **Aerial photography can be used to monitor amounts and types of crops produced.**
- **Direct observation of the land-based activities may be necessary to identify water quality changes.**

Producer log books, called field logs, are useful tools for data collection. Using field logs for data collection increases the precision of the land treatment information. The quality of data collected through field logs, however, is dependent on each individual's ability and desire to use the field log. The Vermont RCWP project (one of only two RCWP projects that collected detailed land treatment data using log books) distributed field logs to all producers in a selected watershed, regardless of their project participation status. Although frequently difficult to obtain, land use data from non-cooperators within the watershed can provide valuable data to explain water quality trends as well as sociological information from farm operators who have decided not to participate in a project. An added advantage of using field logs is that further information can be obtained by project personnel who talk directly with farmers when collecting the field logs.

Land-based data can also be collected through personal interviews. Although the necessary data may be difficult to obtain through interviews with producers, the effort should be made. In the Vermont RCWP project, researchers found that two visits per year, timed during less busy seasons, were more effective than one annual visit at eliciting detailed land treatment information from farm operators. If a project is small enough, detailed land-based activity data can be collected by project personnel. All eight dairy farmers located in the lower Snake Creek drainage basin participated in the Utah RCWP project. Because it was feasible for project staff to visit this small number of farms frequently, project personnel remained well informed about land-based activities on all of the farms.

Aerial photography can be used to collect data about land use. Photography must be supplemented with additional information about land-based activities, such as fertilizer placement.

Sometimes direct observation is necessary. In the Alabama RCWP project, a spike occurred in the fecal coliform data for one of the tributaries to Lake Tholocco. Project personnel could not account for the spike on the basis of the land uses that surrounded the tributary. After walking along the tributary, project personnel discovered that the source of the fecal coliform was a new beaver colony. Without direct observation, project personnel would not have been able to identify the source of the pollutant.

DATA STORAGE, ANALYSIS AND REPORTING

- **Computerized spreadsheets and data bases are effective tools for storing land-based data.**

- **Geographic information systems applications used in conjunction with computerized data bases assist in the representation of land use practices and BMP implementation tracking; data accessibility, presentation, analysis, and reporting; and aggregation of land treatment and land use data.**

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Data Storage, Analysis, and Reporting

In the early 1980's, most land-based data were stored on paper and in files. The majority of data analyses and reporting was done manually. Personal computers have now simplified data storage, analysis, and reporting. A computerized spreadsheet or data base facilitates effective storage of data on a farm field and watershed or subwatershed basis. However, handwritten file sheets should be kept as back-up. Summaries of important land-based information, such as acres under conservation tillage within one-half mile of a stream, can be readily computed and reported using data base software. During the later stages of the RCWP, the Natural Resource Conservation Service introduced CAMPS, its computerized data base system, which significantly reduced the work associated with data storage, retrieval, and reporting.

Computerized data bases and systems that synthesize spatially referenced data (geographic information systems) facilitate representation of land use practices and tracking of best management practice implementation; data accessibility, analysis, and presentation; and aggregation of land treatment and land use data. Geographic information systems are useful tools for data display, analysis, and reporting. A few RCWP projects (Idaho and Vermont) digitized project data to make possible spatial representation of land treatment and land use practices over time.

For smaller projects, such as the Utah RCWP project, which included only eight dairy farms, spatially and temporally referenced data can be obtained manually. Large-scale maps can be utilized and updated regularly for spatial and temporal referencing of BMPs.

Reference

Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. *Evaluation of the Experimental Rural Clean Water Program*, National Water Quality Evaluation Project, NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, (published by U.S. Environmental Protection Agency) EPA-841- R-93-005, 559p.

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Linking Water Quality Trends with Lang Treatment Trends

The Rural Clean Water Program Experience

The Rural Clean Water Program (RCWP), a 15-year federally sponsored nonpoint source (NPS) pollution control program, was initiated in 1980 as an experimental effort to address agricultural NPS pollution problems in watersheds across the country. The RCWP is important as one of the few national NPS control programs to combine land treatment and water quality monitoring to document NPS pollution control effectiveness.

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The 21 experimental RCWP projects, representing a wide range of pollution problems and impaired water uses, were located in Alabama, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Oregon, Pennsylvania, South Dakota, Tennessee/Kentucky, Utah, Vermont, Virginia, and Wisconsin.

Appropriate best management practices (BMPs) were used by producers to reduce NPS pollution from their farms. Since participation in the RCWP was voluntary, cost-share funds and technical assistance were offered to producers as incentives for using or installing BMPs.

Land use and land management affect the type and amount of nonpoint source (NPS) pollution entering water bodies. Improvements in land management (also referred to as land treatment) are necessary to reduce the delivery of pollutants to impaired or threatened water resources. Documentation of the magnitude of water quality improvements from changes in land management, for at least a few projects in each part of the country, is essential to provide feedback to project coordinators and state, regional, and national policy makers. Such feedback enhances the development and implementation of land treatment programs that effectively reduce delivery of pollutants causing water quality impairment. In addition, demonstration that land treatment is effective in reducing NPS pollution and improving water quality tends to increase political and economic support for NPS pollution control measures.

Historically, it has been difficult to demonstrate the relationship between land treatment and water quality changes, at least in part because of a lack of well-designed water quality and land treatment monitoring efforts. Two goals must guide the design of monitoring networks and data analysis in programs and projects designed to link water quality changes with implementation of best management practices (BMPs): 1) detection of significant (or real) trends in both water quality and land treatment and 2) linking or associating water quality trends with land treatment trends.

This fact sheet outlines the principles for development of effective monitoring designs, and describes the land treatment and water quality monitoring elements necessary for linking land treatment or land use modifications with water quality changes. These monitoring elements are essential for successful experimental watershed projects designed to document the relationship between land treatment and water quality changes.

Many of the recommendations for monitoring discussed in this fact sheet are based on the 15-year Rural Clean Water Program (RCWP), an experimental, agricultural watershed, NPS pollution control program that combined land treatment and water quality monitoring in a continuous feedback loop to document NPS control effectiveness (Gale et al., 1993; Spooner and Line, 1993).

Documenting a Cause-and-Effect Relationship

Documenting that water quality changes at a watershed scale were caused by implementation of BMPs is difficult. Not only must a strong correlation be established, but the observed changes must be repeatable over time and space in an experimental manner. The only major changes made in the watershed during the evaluation period should be changes in land treatment. Observed changes in water quality should match predicted pollutant reductions based on the estimated land treatment effectiveness. Some projects have been able to document a strong relationship, increasing confidence that appropriate land treatment can result in (cause) improved water quality. The stronger the relationship, the more likely it is that a cause-and-effect relationship exists and that water quality changes are caused by changes in land treatment rather than other factors.

An association (statistically significant correlation or relationship) between land treatment and water quality changes is required to demonstrate a cause-and-effect relationship. As the implementation of land treatment (specifically BMPs) occurs, improvements in water quality are observed. However, an association by itself is not sufficient to infer a cause-and-effect relationship. Other factors not related to BMP implementation may be causing the changes in water quality, such as changes in land use or rainfall. If, however, the association is *consistent* and *responsive* and has a *mechanistic basis*, causality may be supported (Mosteller and Tukey, 1977).

Consistency means that the relationship between the measured variables (such as total phosphorus and acres treated with the nutrient management BMP) holds in each data set in terms of direction and degree. A consistent, multi-year, improving trend in water quality after BMP implementation provides evidence needed to attribute water quality improvements to land treatment. Improvements in multiple watersheds treated with systems of BMPs provide strong evidence that water quality improvements resulted from land treatment.

Responsiveness signifies that as one variable changes in a known, experimental manner, the other variable changes similarly. For example, as the amount of land treatment increases, further reduction of pollutant delivery to the water resource is documented.

Mechanistic means that the observed water quality change is that which is expected based on the physical processes involved in the installed BMPs. For example, based on knowledge of absorption and solubility of nutrients, greater reduction of nutrient delivery to the water resource might be predicted as the result of implementation of the manure management BMP than a soil erosion control practice alone.

Elements of Monitoring Needed to Link Land Management Modifications with Water Quality Changes

Experimental Designs for Water Quality and Land Treatment

An appropriate experimental design for water quality and land treatment monitoring is essential to document a clear relationship between land treatment and water quality changes. The best designs to demonstrate linkage are those that can isolate the effects of the land treatment from other land use and climatic changes. Such designs include: 1) *paired watershed* (Clausen and Spooner, 1993); 2) *upstream-downstream sites monitored before, during, and after land treatment*; and 3) *multiple watershed monitoring*.

The paired watershed design is the best method for documenting BMP effectiveness in a limited number of years (three to five). Two or more similar subwatersheds (drainage areas) are monitored before and after implementation of BMPs in one of the subwatersheds (the treatment subwatershed). Paired drainage areas should have similar precipitation and runoff patterns and should exhibit a consistent relationship in terms of the magnitude of pollutant losses with changes in hydrology and climate. Analysis of paired pollutant data from treatment vs. control areas should show a statistically significant correlation. Ideally, a paired watershed monitoring program is characterized by:

- Simultaneous monitoring at the outlet of each drainage area;
- Monitoring prior to land treatment to record the relative hydrologic response of each drainage area (calibration period);
- Calibration period of one to three years, depending on the consistency of the data relationships between drainage areas;
- Subsequent monitoring where at least one drainage area continues to serve as a control (that is, receives significantly less land treatment than the other drainage area); and

GOOD EXPERIMENTAL DESIGNS

RCWP Examples

In the Taylor Creek - Nubbin Slough (Florida) RCWP project, upstream and downstream stations were installed in multiple subwatersheds and at the watershed outlet to document water quality improvements resulting from BMP installation on dairy farms. Water quality monitoring conducted for five years before BMP implementation and five years after implementation documented a greater than 50% reduction in total phosphorus concentrations entering Lake Okeechobee from the watershed.

The St. Albans Bay (Vermont) RCWP project team found that the paired watershed design was the most effective design for documenting a linkage between land treatment and water quality changes in small watersheds over a relatively short time period. The paired watershed study confirmed that winter spreading of manure on corn land resulted in significantly higher nitrogen and phosphorus concentrations and loads in edge-of-field runoff compared to application of manure during the growing season only.

The Rock Creek (Idaho) RCWP project watershed contributed high sediment loads to Rock Creek, impairing salmonid spawning, contact recreation, and fishing. Critical sediment sources were the irrigated cropland and streambank erosion. The experimental design chosen for the chemical monitoring was an upstream/ downstream strategy with monitoring before, during, and after BMP implementation in multiple subwatersheds and on Rock Creek.

- Similar land management in both drainage areas both before and after BMP implementation (for example, similar crops), except for BMPs implemented in the treatment drainage area.

Land Management and Water Quality Monitoring Before and After BMP Implementation

Monitoring for several years both before and after BMP implementation is essential for documentation of water quality changes. The pre-BMP period is the time prior to installation of new land treatment practices. Monitoring of water quality and land use prior to BMP implementation is required to establish baseline data for statistical comparison with post-implementation data. The post-BMP period starts once BMPs have been implemented on critical areas and are reducing pollutant delivery to the water resource.

Sampling frequency and collection must be consistent across seasons and years. Year-to-year variability is often so large that at least two to three years each of pre- and post-implementation monitoring is required to indicate a consistent water quality change following implementation and maintenance of BMPs. Documentation of changes over multiple years increases confidence that observed water quality improvements are due to land treatment.

Short-term monitoring is seldom effective because climatic and hydrologic variability can mask water quality changes. However, in small watersheds affected by relatively few large pollutant sources, the monitoring period may be shorter. Longer duration monitoring is necessary where water quality changes are likely to occur gradually, such as large watersheds with lakes in which lag times may occur due to buffering effects of long hydraulic residence times and pollutant recycling.

Quantitative Monitoring of Land Management

The importance of recording the amount and type of land treatment cannot be overlooked when trying to establish documented water quality improvements. Best management practices must be targeted to treat specific sources of pollutants causing the water quality impairment; these pollutants, in turn, must be monitored in the water resource. A high level of appropriate NPS pollution control implementation in critical areas is usually required to achieve substantial water quality improvements.

Monitoring of land treatment and land use is needed to quantify the pollutant reduction impacts of BMPs. Quantitative monitoring of BMP implementation facilitates documentation of land treatment trends and is a necessary step in linking water quality to land treatment. Methods of reporting and quantifying land treatment and land use should be consistent throughout a project.

Careful planning is required to determine which land treatment variables should be monitored to best reflect the extent of actual

RCWP Examples

MULTIPLE YEARS OF MONITORING BEFORE AND AFTER BMP IMPLEMENTATION

In the Rock Creek (Idaho) RCWP project, irrigated cropland and streambank erosion were causing high sediment loads in Rock Creek, impairing salmonid spawning, contact recreation, and fishing. Ten-year monitoring encompassed pre-, during-, and post-BMP implementation periods in multiple subwatersheds and on Rock Creek.

Through its water quality monitoring program, the Taylor Creek - Nubbin Slough (Florida) RCWP project documented a greater than 50% reduction in total phosphorus concentration leaving the watershed. At least five years of biweekly water quality monitoring was collected for both the pre- and post-BMP periods.

QUANTITATIVE MONITORING OF LAND TREATMENT AND USE

In the Rock Creek (Idaho) project, land use (crop type) and BMPs were recorded in a data base for each farm field and each year. A rating system was used that ranked each BMP on a scale of 1 to 5 relative to its effectiveness in controlling sediment delivery to Rock Creek.

SPATIAL MATCHING OF LAND TREATMENT AND WATER QUALITY DATA

The Rock Creek (Idaho) project team collected annual land treatment and land use data on a subwatershed basis. These data were then summarized using a geographic information system, which facilitated spatial and hydrological linkage of land treatment and water quality monitoring data.

changes in agricultural practices. Land treatment data must be reported in quantitative units that reflect BMP effectiveness and changes from previous practices. Examples of quantitative units include: application method, tons of manure spread per acre, pounds of fertilizer applied per acre, acres served by each BMP, and acres served by each BMP system. The acres served unit includes all treated acres (those acres with actual implementation) plus all acres whose pollutant delivery is being reduced by the BMP. Documenting the assumptions used in calculating the acres served is important so that these units can be calculated consistently from year to year, thus ensuring valid year-to-year comparisons.

When reporting acres served, care should be taken to avoid double counting acres when multiple BMPs are serving the same acres, as this could artificially inflate the reported number of acres served. In addition, correction should be given for differences in the effectiveness of the BMPs in controlling pollutant delivery.

Operation, management, and maintenance of BMPs should be tracked because these factors affect BMP effectiveness and, therefore, the water quality impacts of the land treatment.

Changes in land use should be recorded to help isolate the water quality changes associated with the NPS controls from water quality changes due to other land use factors. Land use modifications that affect water quality include acres converted from row crops to pasture (permanently or based on rotation), set-aside acres, changes in the number of animals or animal units per acre, closure of animal operations, changes in impervious land areas, implementation of soil and water conservation practices not being recorded as part of the project, and changes in non-agricultural land uses.

Matching of Land Treatment and Water Quality Data on a Spatial (Drainage) Scale

Land treatment data must be collected on a hydrologic or drainage basis so that the land area being tracked corresponds to the drainage area served by each water quality monitoring station. Water quality and land treatment data must be matched if water quality changes are to be attributed to BMP implementation.

Linkage of land treatment and water quality impacts can be made at different spatial scales (such as farm field, subwatershed, or watershed). Spatial scale should be determined based on project goals and desired interpretations. In general, the larger the drainage area, the harder it is to identify and quantify a water quality - land treatment linkage. Water quality changes are more likely to be observed at the subwatershed than watershed level. Confounding effects of external factors, other pollutant sources, and scattered BMP implementation are minimized at the subwatershed level. If the goal is to document changes at the entire watershed level, a monitoring station must be located at the watershed outlet.

RCWP Examples

TEMPORAL MATCHING OF DATA

In the Taylor Creek - Nubbin Slough (Florida) project, a reduction in total phosphorus concentrations was documented following implementation of BMPs on dairy farms draining to tributaries of Lake Okeechobee. Fencing, shade, and alternative water facilities (to keep dairy cows from waterways), control of wastewater runoff from dairy barns, and nutrient management were the primary BMPs. BMP implementation and land use changes were documented annually on a subwatershed basis.

MATCHING MONITORED POLLUTANTS WITH TARGETED POLLUTANTS

The Taylor Creek - Nubbin Slough RCWP project documented a greater than 50% reduction in total phosphorus (P) concentrations entering Lake Okeechobee. Reduction of P was achieved through fencing, shade, and alternative water facilities (to keep dairy cows from waterways); control of wastewater runoff from barns; and nutrient management. The water quality monitoring program, in turn, incorporated measurement of P in tributaries to the lake.

Bacteria and nutrients from dairies and cropland were impairing recreationin St. Albans Bay (Vermont). The RCWP project focused on manure management and cropland protection BMPs. Manure logs and interviews with farmers were used to monitor land management and document reductions in nutrients and bacteria. Water quality monitoring data indicated a downward trend in stream bacteria counts with an increasing proportion of watershed animals under manure management BMPs.

Matching of Land Treatment and Water Quality Data on a Temporal Scale

Water quality and land treatment data should be collected during the same time periods so both data sets are temporally related. Actual implementation of land treatment needs to be recorded at least seasonally or annually. Land treatment data (such as timing of manure or commercial fertilizer applications, construction of a lagoon storage structure, or a dairy closure) should be collected more frequently than annually or seasonally if the effect on water quality is more short-term or has a large, immediate impact.

Water quality samples are usually collected weekly or biweekly. These data do not have to be summarized on the same time scale as the land treatment data; land treatment data can be added to the trend analysis as repeating explanatory variables. Alternatively, water quality data can be aggregated to the same time scale as the land treatment data for analysis. Data aggregation is particularly useful for plotting and explanatory data analysis.

Matching Monitored Pollutants with Pollutants Addressed by Land Treatment

Pollutants monitored at water quality stations must correspond to pollutant(s) being treated by the BMP systems implemented.

Monitoring Explanatory Variables

Accounting for all major sources of variability in water quality and land treatment data increases the likelihood of isolating water quality trends resulting from BMPs. Correlation of water quality and land treatment changes by itself is not sufficient to infer causal relationships. Other factors not related to BMPs may be causing water quality changes, such as changes in animal numbers, cropping patterns, land uses, known pollutant sources, or amount of impervious land surface; season; stream discharge; precipitation; ground water table depth; salinity; or other climatic or hydrologic variables. Factoring explanatory variables into trend analyses yields water quality trends closer to those that would have been measured had no changes in climatic or other explanatory variables occurred over time. Accounting for variability in water quality due to known causes also decreases variation in adjusted water quality data, facilitating documentation of statistically significant trends. Explanatory variables should be monitored at the same frequency as the principle water quality variables.

RCWP Examples

MONITORING EXPLANATORY VARIABLES

High sediment loads from irrigated cropland and streambank erosion were impairing salmon spawning and recreation in the Rock Creek (Idaho) project. Explanatory variables, monitored as part of the 10-year upstream/downstream monitoring program, included stream flow and precipitation. These variables were used in the analysis to adjust for climatic variability.

In the Taylor Creek - Nubbin Slough (Florida) RCWP project, changes in dairy cow numbers on a subwatershed basis, water table depth, and upstream phosphorus (P)concentrations were the most important explanatory variables. Water table depth measurements in poorly drained, coastal soils were responsive to antecedent rainfall. These measurements were especially useful in confirming that total P concentrations in tributaries increased as the water table rose to within two feet of the surface. Incorporation of explanatory variables in the analyses helped demonstrate that BMP implementation contributed significantly to the decreased P concentrations in tributaries draining into Lake Okeechobee.

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Copies of the fact sheet series may be requested from: Publications, NCSU Water Quality Group, Department of Biological and Agricultural Engineering, Box 7637, North Carolina State University, Raleigh, NC 27695-7637, Tel: 919-515-3723, Fax: 919-515-7448.

Summary

A good experimental design for water quality and land treatment monitoring is essential in order to provide clear documentation of the relationship between land treatment and water quality changes. The paired watershed monitoring design can best demonstrate the relationship between land treatment and water quality in the shortest period of time.

To determine if the trends in water quality match the mechanistic prediction of trends, pre- and post-BMP implementation monitoring and data analysis must combine water quality, land treatment, and land use data on suitable spatial and temporal scales. Incorporation of explanatory variables facilitates isolation of water quality changes that result from land treatment.

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Appendices

Appendix I

Minimum Reporting Requirements For Section 319 National Monitoring Program Projects

The United States Environmental Protection Agency (USEPA) has developed the NonPoint Source Management System (NPSMS) software to support the required annual reporting of water quality and implementation data for Section 319 National Monitoring Program projects (USEPA, 1991). The software tracks NPS control measure implementation with respect to the pollutants causing the water quality problem.

Currently, NPSMS can accept and track the following information (USEPA, 1991):

Management Area Description:

- State, USEPA Region, and lead agency.
- Watershed management area description (management area name, management area identification, participating agencies, area description narrative).
- 305(b) waterbody name and identification.
- Designated use support for the waterbody.
- Major pollutants causing water quality problems in waterbody and relative source contributions from point, nonpoint, and background sources.

Best Management Practices (BMPs) and Nonpoint Source (NPS) Pollution Control Measures:

- Best management practices (BMP name, reporting units, indication whether the life of the practice is annual or multi-year).
- Land treatment implementation goals for management area.
- Pollutant source(s) causing impaired use(s) that is (are) controlled by each BMP. Each control practice must be linked directly to the control of one or more sources of pollutants causing impaired uses.

Funding Information:

- Annual contributions from each funding source and use of funding for each management area.

Water Quality Monitoring Plan:

- Choice of monitoring approach (chemical/physical or biological/habitat).
- Monitoring design and monitoring station identification (paired watersheds, upstream-downstream, reference site for biological/habitat monitoring, single downstream station). The paired watershed approach is recommended; the single downstream station is discouraged.
- Drainage area and land use for each water quality monitoring station.
- Delineation of monitoring year, seasons, and monitoring program duration.
- Variables measured (variable name; indication if the variable is an explanatory variable; STORET, BIOSTORET, or 305(b) Waterbody System code; reporting units).
- Quartile values for chemical/physical variables. Quartile values are established cutoffs based on historical or first-year data for each season and monitoring station.
- Maximum potential and reasonable attainment scores for biological monitoring variables. Indices scores that correspond to full, threatened, and partial use supports are required.
- Monitoring frequency. Chemical/physical monitoring, with associated explanatory variables, must be performed with at least 20 evenly-spaced grab samples in each season. Fishery surveys must be performed at least one to three times per year. Benthic macroinvertebrates must be performed at least once per season, with at least one to three replicates or composites per sample. Habitat monitoring and bioassays must be performed at least once per season.

Annual Reporting:

- The NPSMS software is used to report annual summary information. The raw chemical/physical and biological/habitat data are required to be entered into STORET and BIOSTORET, respectively.
- Annual chemical/physical and explanatory variables. The frequency count for each quartile is reported for each monitoring station, season, and variable.
- Annual biological/habitat and explanatory variables. The scores for each monitoring station and season are reported.
- Implementation tracking in the watershed and/or subwatersheds that constitute the drainage areas for each monitoring station. Implementation reported corresponds to active practices in the reporting year and includes practices with a one-year life span and practices previously installed and still being maintained.

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Appendix II

Abbreviations

ACP	Agricultural Conservation Program
ADSWQ	Automatic Data System for Water Quality
AGNPS	Agricultural Nonpoint Source Pollution Model
ANSWERS	Areal Nonpoint Source Watershed Environment Response Simulation
ASCS	Agricultural Stabilization and Conservation Service, USDA
BMP(s)	Best Management Practice(s)
BIBI	Biological Index of Biotic Integrity
BIOS	USEPA Natural Biological Data Management System
BOD	Biochemical Oxygen Demand
Cal Poly	California Polytechnic State University
CES	Cooperative Extension Service, USDA
cfs	Cubic Feet per Second
CFSA	Consolidated Farm Service Agency
cfu	Colony Forming Units
COD	Chemical Oxygen Demand
CREAMS	Chemicals, Runoff, and Erosion from Agricultural Management Systems Model
DEC	Department of Environmental Conservation
DO	Dissolved Oxygen
DP	Dissolved Phosphorus
DNR	Department of Natural Resources
EPIC	Erosion Productivity Index Calculator
FC	Fecal Coliform
GIS	Geographic Information System
GMV	Geometric Mean Value
GRASS	Geographic Resources Analysis Support System

HEL	Highly Erodible Land
HUA	Hydrologic Unit Area
I&E	Information and Education Programs
IBI	Index of Biotic Integrity
ICM	Integrated Crop Management
IDNR	Iowa Department of Natural Resources
IDNR-GSB	Iowa Department of Natural Resources Geological Survey Bureau
ISU-CES	Iowa State University Cooperative Extension Service
ISUE	Iowa State University Extension
LRNRD	Lower Republican Natural Resource District
LT	Land Treatment
MCL	Maximum Contaminant Level
Mg/l	Milligrams Per Liter
N	Nitrogen
NA	Information Not Available
NCSU	North Carolina State University
NDEQ	Nebraska Department of Environmental Quality
NH_4	Ammonium - Nitrogen
NMP	National Monitoring Program
NO_2	Nitrite-Nitrogen
NO_3	Nitrate -Nitrogen
NPS	Nonpoint Source
NPSMS	NonPoint Source Management System
OCC	Oklahoma Conservation Commission
OP	Orthophosphorus
P	Phosphorus
Proj Mgt	Project Management
QA/QC	Quality Assurance/Quality Control
RCWP	Rural Clean Water Program
SCS	Soil Conservation Service, USDA
Section 319	Section 319 of the Water Quality Act of 1987
SPI	Shellfish Protection Initiative
SS	Suspended sediment
STORET	EPA STOrage and RETrieval Data Base for Water Quality
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus

TSS	Total Suspended Solids
UHL	University Hygienic Laboratory (Iowa)
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
VSS	Volatile Suspended Solids
WATSTORE	United States Geological Survey Water Data Storage System
WCCF	Webster County Conservation Foundation
WQIP	Water Quality Incentive Project
WQ Monit	Water Quality Monitoring
WQSP	Water Quality Special Project

Appendix III

Glossary of Terms

AGNPS (Agricultural Nonpoint Source Pollution Model) — an event-based, watershed-scale model developed to simulate runoff, sediment, chemical oxygen demand, and nutrient transport in surface runoff from ungauged agricultural watersheds.

Animal unit (AU) — One mature cow weighing 454 kg or the equivalent. For instance, a dairy cow is 1.4 AU because it weighs almost 1.5 times a mature beef cow. The animal units of smaller animals than beef cows is less than one: pigs = 0.4 AU and chickens = 0.033 AU.

Anadromous — Fish that return to their natal fresh water streams to spawn. Once hatched, these fish swim to the ocean and remain in salt water until sexual maturity.

Artificial redds — An artificial egg basket fabricated of extruded PVC netting and placed in a constructed egg pocket. Artificial redds are used to measure the development of fertilized fish eggs to the alevin stage (newly hatched fish).

Alachlor — Herbicide (trade name Lasso) that is used to control most annual grasses and certain broadleaf weeds and yellow nutsedge in corn, soybeans, peanuts, cotton, woody fruits, and certain ornamentals.

Atrazine — Herbicide (trade name Atrex, Gesa prim, or Primatol) that is widely used for control of broadleaf and grassy weeds in corn, sorghum, sugar cane, macadamia orchards, pineapple, and turf grass sod.

Autocorrelation — The correlation between adjacent observations in time or space.

Bedload — Sediment or other material that slides, rolls, or bounces along a stream or channel bed of flowing water.

Before-after design — A term referring to monitoring designs that require collection of data before and after BMP implementation.

Beneficial uses — Desirable uses of a water resource such as recreation (fishing, boating, swimming) and water supply.

Best management practices (BMPs) — Management or structural practices designed to reduce the quantities of pollutants — such as sediment, nitrogen, phosphorus, bacteria, and pesticides — that are washed by rain and snow melt from farms into nearby surface waters, such as lakes, creeks, streams, rivers, and estuaries. Agricultural BMPs can include fairly simple changes in practices such as fencing cows out of streams (to keep animal waste out of streams), planting grass in gullies where water flows off a planted field (to reduce the amount of sediment that runoff water picks up as it flows to rivers and lakes), and reducing the amount of plowing in fields where row crops are planted (in order to reduce soil erosion and loss of nitrogen and phosphorus from fertilizers applied to the crop land). BMPs can also involve building structures, such as large animal waste storage tanks that allow farmers to choose when to spread manure on their fields as opposed to having to spread it based on the volume of manure accumulated.

BMP system — A combination of individual BMPs into a "system" that functions to reduce the same pollutant.

Biochemical oxygen demand (BOD) — Quantitative measure of the strength of contamination by organic carbon materials.

Chemical oxygen demand (COD) — Quantitative measure of the strength of contamination by organic and inorganic carbon materials.

Cost sharing — The practice of allocating project funds to pay a percentage of the cost of constructing or implementing a BMP. The remainder of the costs are paid by the producer.

County ASC Committee — County Agricultural Stabilization and Conservation Committee: a county-level committee, consisting of three elected members of the farming community in a particular county, responsible for prioritizing and approving practices to be cost shared and for overseeing dissemination of cost-share funds by the local USDA-Agricultural Stabilization and Conservation Service office.

Critical area — Area or source of nonpoint source pollutants identified in the project area as having the most significant impact on the impaired use of the receiving waters.

Demonstration project — A project designed to install or implement pollution control practices primarily for educational or promotional purposes. These projects often involve no (or very limited) evaluations of the effectiveness of the control practices.

Designated use — Uses specified in terms of water quality standards for each water body or segment.

Drainage area — An area of land that drains to one point.

Ecoregion — A physical region that is defined by its ecology, which includes meteorological factors, elevation, plant and animal speciation, landscape position, and soils.

EPIC (Erosion Productivity Index Calculator) — A mechanistic computer model that calculates erosion from field-size watersheds.

Erosion — Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical or chemical forces.

Eskers — Glacially deposited gravel and sand that form ridges 30 to 40 feet in height.

Explanatory variables — Explanatory variables, such as climatic, hydrological, land use, or additional water quality variables, that change over time and could affect the water quality variables related to the primary pollutant(s) of concern or the use impairment being measured. Specific examples of explanatory variables are season, precipitation, streamflow, ground water table depth, salinity, pH, animal units, cropping patterns, and impervious land surface.

Fecal coliform (FC) — Colon bacteria that are released in fecal material. Specifically, this group comprises all of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 degrees Celsius.

Fertilizer management — A BMP designed to minimize the contamination of surface and ground water by limiting the amount of nutrients (usually nitrogen) applied to the soil to no more than the crop is expected to use. This may involve changing fertilizer application techniques, placement, rate, and timing.

Geographic information systems (GIS) — Computer programs linking features commonly seen on maps (such as roads, town boundaries, water bodies) with related information not usually presented on maps, such as type of road surface, population, type of agriculture, type of vegetation, or water quality information. A GIS is a unique information system in which individual observations can be spatially referenced to each other.

Goal — A narrowly focused measurable or quantitative milestone used to assess progress toward attainment of an objective.

Land treatment — The whole range of BMPs implemented to control or reduce NPS pollution.

Loading — The influx of pollutants to a selected water body.

Macroinvertebrate — Any non-vertebrate organism that is large enough to be seen without the aid of a microscope.

Mechanistic — Step-by-step path from cause to effect with ability to make linkages at each step.

Moraine — Glacial till (materials deposited directly by ice) which is generally irregularly deposited.

Nitrogen — An element occurring in manure and chemical fertilizer that is essential to the growth and development of plants, but which, in excess, can cause water to become polluted and threaten aquatic animals.

Nonpoint source (NPS) pollution — Pollution originating from diffuse areas (land surface or atmosphere) having no well-defined source.

Nonpoint source pollution controls — General phrase used to refer to all methods employed to control or reduce nonpoint source pollution.

NonPoint Source Management System (NPSMS) — A software system designed to facilitate information tracking and reporting for the USEPA 319 National Monitoring Program.

Objective — A focus and overall framework or purpose for a project or other endeavor, which may be further defined by one or more goals.

Paired watershed design — In this design, two watersheds with similar physical characteristics and, ideally, land use are monitored for one to two years to establish pollutant-runoff response relationships for each watershed. Following this initial calibration period, one of the watersheds receives treatment while the other (control) watershed does not. Monitoring of both watersheds continues for one to three years. This experimental design accounts for many factors that may affect the response to treatment; as a result, the treatment effect alone can be isolated.

Pesticide management — A BMP designed to minimize contamination of soil, water, air, and nontarget organisms by controlling the amount, type, placement, method, and timing of pesticide application necessary for crop production.

Phenolphthalein alkalinity — A measure of the bicarbonate content.

Phosphorus — An element occurring in animal manure and chemical fertilizer that is essential to the growth and development of plants, but which, in excess, can cause water to become polluted and threaten aquatic animals.

Post-BMP implementation — The period of use and/or adherence to the BMP.

Pre-BMP implementation — The period prior to the use of a BMP.

Runoff — The portion of rainfall or snow melt that drains off the land into ditches and streams.

Sediment — Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.

Sedimentation — Deposition of sediment.

Single-station design — A water quality monitoring design that utilizes one station at a point downstream from the area of BMP implementation to monitor changes in water quality.

Subbasins — One of several basins that form a watershed.

Substrate sampling — Sampling of streambeds to determine the percent of fine particled material and the percent of gravel.

Subwatershed — A drainage area within the project watershed. It can be as small as a single field or as large as almost the whole project area.

Tailwater management — The practice of collecting runoff, "tailwater," from irrigated fields. Tailwater is reused to irrigate crops.

Targeting — The process of prioritizing pollutant sources for treatment with BMPs or a specific BMP to maximize the water quality benefit from the implemented BMPs.

Total alkalinity — A measure of the titratable bases, primarily carbonate, bicarbonate, and hydroxide.

Total Kjeldahl nitrogen (TKN) — An oxidative procedure that converts organic nitrogen forms to ammonia by digestion with an acid, catalyst, and heat.

Total Kjeldahl phosphorus (TKP) — An oxidative procedure that converts organic phosphorus forms to phosphate by digestion with an acid, catalyst, and heat.

Tracking — Documenting/recording the location and timing of BMP implementation.

Upstream/downstream design — A water quality monitoring design that utilizes two water quality monitoring sites. One station is placed directly upstream from the area where the implementation will occur and the second is placed directly downstream from that area.

Vadose zone — The part of the soil solum that is generally unsaturated.

Variable — A water quality constituent (for example, total phosphorus pollutant concentration) or other measured factors (such as stream flow, rainfall).

Watershed — The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

Appendix IV

Project Documents And Other Relevant Publications

This appendix contains publication references for the Section 319 National Monitoring Program projects. Project document lists appear in alphabetical order by state.

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Appendix V

Matrix for Section 319
National Monitoring Program Projects

Section 319 National Monitoring Program Projects

PROJECT	BASIN SIZE	DESIGNATED BENEFICIAL USES	WATER QUALITY PROBLEM	SOURCE OF POLLUTANT	WATER QUALITY GOALS AND OBJECTIVES	WATER QUALITY MONITORING DESIGN
Arizona: Oak Creek Canyon	9 sq. miles	•Primary contact recreation •Aquatic life support •Drinking water supply	•Bacteria •Nutrients	•High-impact recreational campgrounds and swimming areas	•Reduce fecal coliform by 50% •Reduce nutrient levels by 20%	•2 Paired sites upstream / downstream
California: Morro Bay Watershed	76 sq. miles	•Endangered species habitat •Shellfish harvesting •Primary and secondary contact recreation •Esturine and fresh water habitat	•Accelerated sedimentation •Nutrients •Bacteria	•Cattle grazing •Roads •Cropland •Stream bank erosion and mass wasting	•Decrease sediment entering project streams	•1 Paired site •1 Single site •2 Upstream/downstream
Idaho: Eastern Snake River Plain	3,041 sq. miles	•Drinking water supply (ground water)	•Nitrates •Low-level pesticide concentrations	•Irrigated cropland	•Evaluate the effects of irrigation water management on nitrate-N ground water leaching •Evaluate the effects of crop rotation on nitrate-N ground water leaching •Decrease nitrate and pesticide concentrations	•2 Paired 5 acre plots
Illinois: Lake Pittsfield	11 sq. miles	•Drinking water supply •Primary and secondary contact recreation	•In-place contaminants •Nutrients	•Cropland •Small livestock operations	•Reduce sediment loads into lake •Evaluate the effectiveness of sediment retention basins	•7 Single stations •3 Lake stations
Iowa: Sny Magill Watershed	38 sq. miles	•Aquatic life support ("put and take" recreational trout fishing)	•Sediment •Nutrients •Animal wastes •Pesticides	•Cropland •Livestock operations •Streambank erosion	•Quantitatively document WQ improvements •Develop protocol and procedures for NPS monitoring •Develop capacity for rapid habitat and biologic monitoring •Reduce sediment by 50% •Decrease nitrogen, phosphorus, and pesticide loading by 25%	•Paired watersheds •Upstream/downstream on sub-basins
Maryland: Warner Creek Watershed	1 sq. miles	•Biological habitat	•Sediment •Nitrogen •Phosphorus	•Dairy operations	•Develop and validate a hydrologic and water quality model capable of predicting effects of BMP on WQ •Collect WQ data for use in model validation •Illustrate relationships between BMP and WQ	•Upstream/downstream on Warner Cr. •Paired watersheds
Michigan: Sycamore Creek Watershed	106 sq. miles	•Aquatic life support •Primary contact recreation	•Sediment •Dissolved Oxygen	•Streambanks •Urban areas •Cropland	•Reduce impact of agricultural NPS pollutants on surface and ground water on Sycamore Creek •Reduce sediment in Sycamore Creek by 52%	•Paired watersheds
Nebraska: Elm Creek Watershed	56 sq. miles	•Recreation •Aquatic life support (cold water trout habitat)	•Sediment •Increased water temperatures •High peak flows	•Cropland •Rangeland •Streambank erosion •Irrigation return flows and cattle access	•Implement appropriate and feasible NPS control measures for protection and enhancement of WQ •Reduce summer max. water temperature •Reduce instream sedimentation •Reduce peak flows •Improve instream aquatic habitat	•Upstream/downstream •Single station downstream
North Carolina: Long Creek Watershed	44 sq. miles	•Drinking water supply •Aquatic life support	•Sediment •Bacteria •Nutrients	•Cropland •Dairy operations •Pastures •Streambank erosion •Urbanization	•Quantify the effects of NPS pollution controls on: -Bacteria, sediment, and nutrient loading to a stream from a local dairy farm -Sediment and nutrient loss from field with a long history of manure application -Sediment loads from the water supply watershed •Reduce sediment yield by 60%	•Single downstream station •Upstream/downstream •Paired watersheds
Pennsylvania: Pequea and Mill Creek Watersheds	3.2 sq. miles	•Aquatic life support •Recreation •Drinking water supply	•Nutrients •Bacteria	•Dairy operations •Pastures	•Document the effectiveness of livestock exclusion fencing at reducing NPS pollution in a stream •Reduce annual total ammonia plus organic nitrogen and total phosphorus loads by 40%	•Paired watersheds
Vermont: Lake Champlain Basin Watersheds	12 sq. miles total	•Aquatic life support •Lake Champlain recreation and aesthetics (NPS pollutant loading)	•Nutrients (particularly phosphorus) •Bacteria •Organic matter	•Streambanks •Dairy operations •Livestock activity within stream and riparian areas •Cropland	•Quantitative assessment of the effectiveness of two livestock/grazing management practices •Document changes in nutrients, bacteria, and sediment concentrations and loads due to treatment •Evaluate response of stream biota to treatment	•Three-way paired watershed design
Washington: Totten and Eld Inlet Clean Water Projects	Totten= 69 sq miles Eld = 36 sq miles	•Shellfish harvesting	•Bacteria	•Livestock operations •Failing on-site sewage systems	•Reduce median 1992-93 fecal coliform values on: -Pierre Creek by 69% -Burns Creek by 63% -Schneider Creek by 50% -McLane Creek by 44%	•Paired watersheds •4 Single stations
Wisconsin: Otter Creek	11 sq miles	•Aquatic life support •Secondary contact recreation	•Sediment •Phosphorus •Bacteria	•Cropland •Dairy operations •Streambank erosion	•Increase numbers of intolerant fish species •Improve recreational uses •Reduce loading to the Sheboygan River and Lake Michigan •Restore riparian vegetation	•Paired watersheds •Above and below •Single station

Section 319 National Monitoring Program Projects

SAMPLING SCHEME	PRIMARY WATER QUALITY PARAMETERS	BMP	IMPLEMENTING INSTITUTIONS	PROJECT TIME FRAME
•Weekly grab samples from May 15 - Sept.15	Fecal Coliform, Nitrate, Orthophosphorus, TN, TP, Ammonia	•Enhance rest room facilities •Install showers •Enforce litter laws	•AZ Department of Environmental Quality •Northern Arizona University	1994 - 2001 319 Project Approval 1994
•Storm events (30 min. intervals) •20 Weekly grab samples (start Nov.) •Macroinvertebrate and habitat monitoring	Suspended Sediment, Turbidity, Nitrate, Fecal Coliform	•Riparian cattle exclusion •Riparian pasture development •Rotational grazing of pasture •Floodplain restoration	•California Polytechnic State University •Central Coast Regional Water Quality Control Board •USDA NRCS	1993 - 2003 319 Project Approval 1993
•Monthly groundwater grab samples •Growing season soil water samples	Nitrate, Organic Pesticides, DO	•Decrease water use •Pesticide management strategies •Fertilizer evaluations and recommendations •Irrigation management program	•Division of Environmental Quality •U. of Idaho Cooperative Extension Service •USDA NRCS (319 Project is part of the Hydrologic Unit Area Demonstration Project)	Oct. 1991 - Oct. 1997 319 Project Approval 1992
•Storm events (automatic samplers) •Base flow sampled monthly •Lake grab samples monthly from April - October	Orthophosphorus, TP, Ammonia, TKN, Nitrate+Nitrite, TSS, Suspended Sediments	•Sediment retention basins •Conservation tillage •Integrated crop management •Livestock exclusion •Filter strips •Wildlife habitat management	•IL Environmental Protection Agency •IL State Water Survey •Pike Co. Soil and Water Conservation District	1992-1995 319 Project Approval 1993
•Continuous stage, daily discharge and suspended sediment measurements •Weekly grab samples •Annual habitat assessment •Annual fisheries survey •Bi-monthly macroinvertebrates	Fecal Coliform, Habitat Assessment, Fisheries Survey, Benthic Macroinvertebrates Sediment, TP, Nitrogen (N) Series	•Structural erosion control practices •Farmstead assessment •Water and sediment control structures •Animal waste management systems •Education and assistance	•IA DNR-Geologic Survey Bureau •IA State University Extension •USDA NRCS (319 Project is part of the Sny Magill Hydrologic Unit Area Project and North Cedar Creek Ag. Conservation. Program-WQ Special Project)	1991-unknown (Approximately 10 yrs. with funding) 319 Project Approval 1992
•Automated storm event - weekly from Feb.-June; bi-weekly remainder of year •Grab - weekly from Feb.-June; bi-weekly remainder of year	Ammonia, TKN, Nitrate+Nitrite, Nitrate, Orthophosphorus, TKP, Sediment	•Conversion of cropland to pasture •Installation of watering systems •Fencing to exclude livestock from streams •Manure slurry storage tanks	•MD Department of the Environment •U. of Maryland Agricultural Engineering	May 1993 - June 1997 319 Project Approval 1995
•Storm events (1-2 hr. intervals) using automated samplers March - July •20 Evenly spaced weekly grab samples	Turbidity, TSS	•Diversions •Cropland protective cover •Reduced tillage •No-till systems •Water and sediment control structures	•Ingham Co. Health Dept.(Environmental Division) •Ingham County Cooperative Extension Service •Ingham Soil Conservation District •Michigan Department of Natural Resources •Michigan State University •USDA NRCS	1993 -1997 319 Project Approval 1993
•Weekly grab samples April - September •Seasonal biological, habitat data collection, and stream morphology	Qualitative and Quantitative Macroinvertebrate Sampling, Fish Collections, Creel Survey, Substrate Samples, TSS, Morphology Characteristics, Water Temperature	•Conventional BMP •WQ and runoff control structures •WQ land treatment •Conventional WQ management practices	•NB Department of Environmental Quality •USDA NRCS •Webster County Extension	April 1992 - 1996 (2 additional years contingent upon funding) 319 Project Approval 1992
•Weekly grab Dec.- May and monthly remainder of year •Stage activated storm event and weekly grab Dec. - May (year-round on trib.)	Percent Canopy and Aufwuchs, Invertebrate Taxa Richness, Fecal Coliform, Fecal Streptococci, TSS, Total Solids, DO, Nitrate+Nitrite, TKN, TP, Temperature	•Land use requirements upstream of intake •Comprehensive nutrient management •Waste holding structures •Pasture management and livestock exclusion	•Gaston Co. Cooperative Extension •NC Cooperative Extension Service •NC Division of Environmental Management •USDA NRCS	January 1993- Sept. 2001 319 Project Approval 1992
•Grab samples every 10 days April - Nov. •Monthly storm event composite •Monthly grab Dec. - March •Macroinvertebrate and habitat May and Sept.	Suspended Sediment, Total and Dissolved Ammonia plus Organic Nitrogen, Dissolved Ammonia, Dissolved Nitrate plus Nitrite, Dissolved Nitrite, Dissolved Orthophosphorus, Fecal Streptococcus, Total and Dissolved Phosphorus	•Streambank fencing on 100% of pasture land adjacent to the stream draining the treatment watershed	•PA Department of Environmental Protection-Bureau of Land and Water Conservation •USDA NRCS •USGS	October 1993 - Sept. 1998 -2001 319 Project Approval 1993
•Automated continuous sampling stations •Weekly flow-proportional sampling •Bi-weekly grab sampling	Fecal Coliform, Fecal Streptococcus, E. Coli Bacteria, Macroinvertebrates, Fish, TKN, TSS, TP	•Livestock exclusion/stream bank protection •Intensive grazing management	•Franklin County Conservation District •U. of Vermont School of Natural Resources •USDA NRCS •VT Department of Agriculture •VT Department of Environmental Conservation	Sept. 1993 - Sept. 1999 319 Project Approval 1993
•20 Weekly grab samples (starting Nov.) •6 Storm events	Fecal Coliform	•Repair failing on-site sewage systems •Implement farm plans on priority farm sites	•Department of Ecology •Thurston County Environmental Health Services •Thurston Conservation District •USDA NRCS	1993 - 2002 319 Project Approval 1995
•Event based automatic •Continuous chemistry sampling •Grab samples (various timing) •Fisheries •Macroinvertebrate and habitat monitoring	Dissolved Phosphorus, TKN, Ammonia-N, Nitrogen Series, Turbidity, TSS, DO, Fecal Coliform, TP	•Shoreline and streambank stabilization •Barnyard runoff management and manure storage facilities •Grassed waterways •Reduced tillage •Nutrient and pesticide management	•Sheboygan Co. Land Conservation Committees •U. of Wisconsin Extension •USGS •WI Department of Natural Resources	Spring 1994- Spring 2001 319 Project Approval 1993