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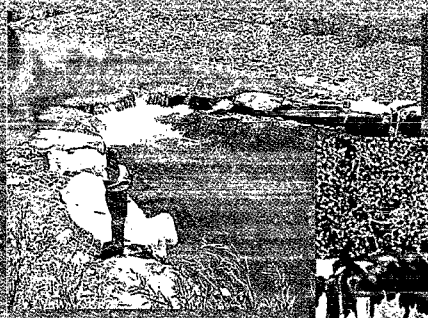
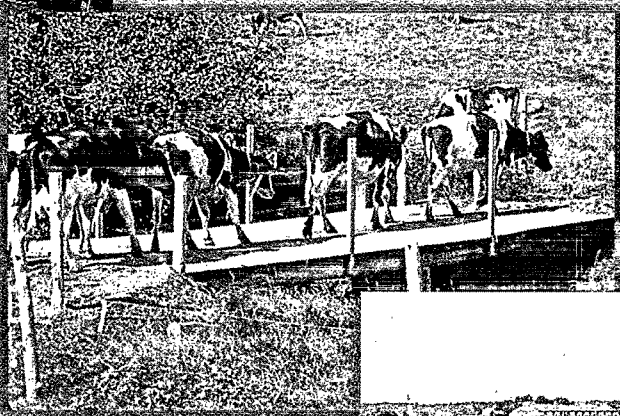
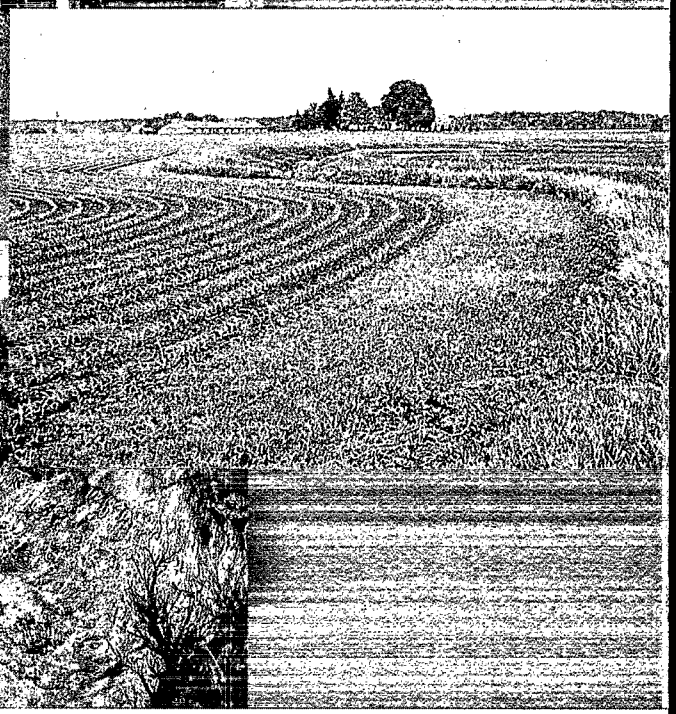
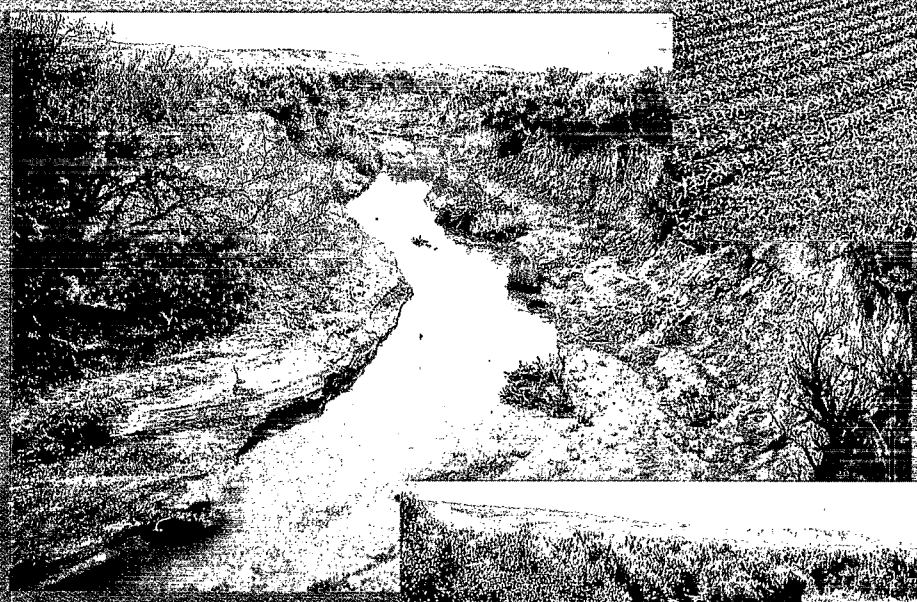
The Successful Implementation of the Clean Water Act's Section 319 Nonpoint Source Pollution Program









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Section 319 Success Stories Volume III:

The Successful Implementation of the Clean Water Act's Section 319 Nonpoint Source Pollution Program

United States Environmental Protection Agency
Office of Water
Washington, DC

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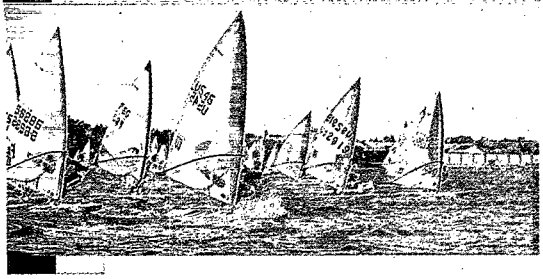


Section 319 Success Stories:

The Successful Implementation of the Clean Water Act's Section 319 Nonpoint Source Pollution Program

This document is the third volume of *Section 319 Success Stories*, the first volume of which was published in November 1994 and the second in October 1997. The first document illustrated the states' achievements in their initial efforts to implement their nonpoint source programs under section 319 of the Clean Water Act. The second volume demonstrated the maturation of the state programs and was replete with many examples of the documented water quality improvements, improved fisheries, reduced loadings, and increased public awareness that are a result of the many projects that have received section 319 funding.

Success Stories: Volume III contains approximately two new stories per state, highlighting some of the additional successes achieved since the 1997 publication. These stories demonstrate better-defined water quality improvements, as well as growing partnerships and funding sources, as state 319 programs expand and states learn increasingly more from past 319 demonstration projects. Collectively, they represent only a fraction of the section 319 project successes.

Nonpoint source pollution

After Congress passed the Clean Water Act in 1972, the Nation's water quality community placed a primary emphasis on addressing and controlling point source pollution (pollution coming from a discrete conveyance or location, such as industrial and municipal waste discharge pipes). Not only were these sources the primary contributors to the degradation of our nation's waters at the time, but the extent and significance of nonpoint source pollution was also poorly understood and overshadowed by efforts to control pollution from point sources.

Today, nonpoint source pollution remains the Nation's largest source of water quality problems. It is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into groundwater. Nonpoint source pollution also includes adverse changes to the hydrology of water bodies and their associated aquatic habitats.

The most common nonpoint source pollutants are soils and nutrients that storm water runoff picks up as it flows overland to rivers and streams; for example, runoff from agricultural land and other treated open spaces, urban developments, construction sites, roads, and bridges.

Other common nonpoint source pollutants include pesticides, pathogens (bacteria and viruses), salt, oil, grease, toxic chemicals, and heavy metals.

The most recent *National Water Quality Inventory* (1998) indicates that nonpoint sources constitute the leading sources of water pollution in the United States today. States and other jurisdictions reported agriculture as the most widespread source of pollution in assessed rivers, streams, and lakes, with hydromodification and urban runoff following as the second and third leading sources of pollution.

Nonpoint source pollution causes or contributes to beach closures, destroyed habitat, unsafe drinking water, fish kills, and many other severe environmental and human health problems. It also spoils the beauty and important functions of clean, healthy water habitats.

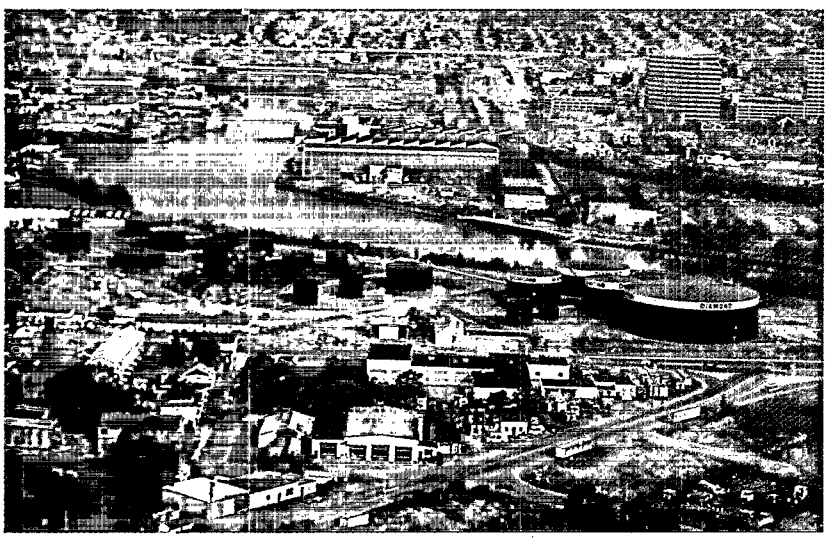
Nonpoint source program—Section 319 of the Clean Water Act

Congress established the national nonpoint source program in 1987 when it amended the Clean Water Act with section 319, "Nonpoint Source Management Programs." States were to address nonpoint source pollution by

- *Conducting statewide assessments of their waters* to identify those that are impaired (do not fully support state water quality standards) or threatened (currently meet water quality standards but are unlikely to continue to meet water quality standards fully) because of nonpoint sources.
- *Developing nonpoint source management programs* to address the impaired or threatened waters identified in nonpoint source assessments.
- *Implementing their EPA-approved nonpoint source management programs* over a multiyear time frame.

All states and territories and, as of September 2001, more than 70 tribes (representing over 70 percent of Indian Country) now have EPA-approved nonpoint source assessments and management programs.

In 1995, recognizing the growing experience of states, tribes, and localities in addressing nonpoint source pollution and the fact that state, tribal, and local nonpoint source programs had matured considerably since enactment of section 319 in 1987, representatives of EPA and the states, under the auspices of the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), initiated joint discussions to develop a new framework for further strengthening state nonpoint source programs. These discussions continued for more than a year, spanning fiscal years (FY) 1995 and 1996, and resulted in new national section 319 program and grant guidance that EPA signed and ASIWPCA endorsed. This May 1996 guidance reflected the states' and EPA's joint commitment to upgrade



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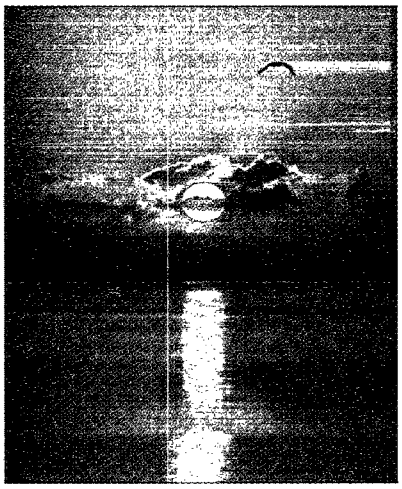


The stories highlight the range of best management practices, training programs, and other acitivites implemented to achieve measurable improvements in water quality.

state nonpoint source management programs to incorporate nine key program elements designed to achieve and maintain beneficial uses of water.

The guidance also provided for discontinuing competitive award of a portion of each state's annual section 319 grant award, thereby ensuring a firm annual planning target for each state at the outset of each annual award cycle, reducing the amount and frequency of administrative oversight and reporting, and offering greater flexibility for the states and territories in establishing priorities for the use of these funds. Additionally, a state that incorporates all nine key elements into its revised nonpoint source management program and has a proven track record of effective implementation of its nonpoint source programs is formally recognized by the Regional Administrator and the Assistant Administrator for Water as a Nonpoint Source Enhanced Benefits State. Nonpoint Source Enhanced Benefits States are afforded substantially reduced oversight and maximum flexibility to implement their state programs and to achieve water quality objectives. Thus, although EPA greatly streamlined the section 319 grants program for all states, it also provided further flexibility to the Nonpoint Source Enhanced Benefits States with complete programs and proven track records.

The nine key elements that form the core of the states' upgraded nonpoint source management programs are the following:

1. Short- and long-term goals and objectives.
2. Strong working partnerships with all key stakeholders.
3. Balanced approach emphasizing statewide and watershed-level programs.
4. Plans to abate known impairments and prevent significant threats to water quality.
5. Identifying and progressively addressing impaired or threatened waters.
6. Establishing flexible, targeted, iterative approaches.
7. Identifying federal programs that are not consistent with state programs.
8. Efficient and effective program management and implementation.
9. Periodic review and evaluation of program success at least every 5 years.

All states and territories will have approved, upgraded nonpoint source management programs by the end of 2001.

Responsibility and funding for the 319 Program

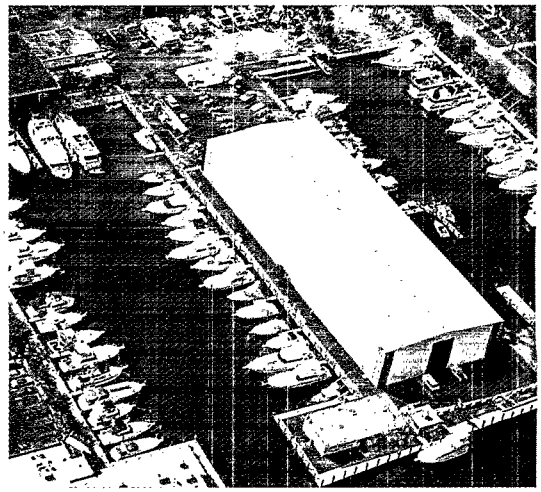
EPA is divided into 10 regions, with offices in Boston, New York City, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco, and Seattle. Each EPA region has a Nonpoint Source Coordinator, who is familiar with the nonpoint source programs in each of the states, territories, and tribes in that region and the 319 funding process that supports them. In turn, each state has a designated Nonpoint Source Coordinator responsible for managing the state's nonpoint source activities and funds. For specific EPA regional and state NPS Coordinators, see EPA's web site at www.epa.gov/owow/nps/contacts.html. In most states, this Coordinator is located in the state's water quality agency. In several states, however, the NPS Coordinator is located in the state's conservation agency, health agency, or agricultural agency. Increasingly, deci-

sions about funding and program priorities are made by a broad-based NPS Task Force representing not only state agencies but also other stakeholders at the state and local levels.

EPA awards grants to states using an allocation formula based on population, cropland acreage, critical aquatic habitats, pasture and rangeland acreage, forest harvest acreage, wellhead protection areas, mining, and pesticide use to determine the amount to be awarded to each state. Each year, the congressional appropriation for section 319 is multiplied by the applicable percentage based on the formula to determine each state's allocation for that year. Each state or tribe is required to provide a 40 percent nonfederal dollar match.

From FY 1990 through 2001, EPA awarded an aggregate of more than $1.3 billion to states and territories under section 319. Funds available for grants in FY 2001 alone have increased to more than $237 million, which is nearly double the FY 1998 appropriation. A small portion of the annual section 319 appropriation, one-third of 1 percent, is by statute set aside for Indian tribes. In FY 2000 and FY 2001, Congress authorized EPA to award grants to Indian tribes under section 319 in an amount that exceeds the statutory cap, recognizing that the tribes need and deserve increased financial support to implement their nonpoint source programs. EPA's long-term goal is that the one-third of 1 percent cap on tribal nonpoint source grants will be permanently eliminated.

Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants and deposits them into rivers, lakes, and coastal waters or introduces them into groundwater.



Nonpoint source pollution is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough for fishing or swimming.

Future of nonpoint source programs

With all state 319 programs upgraded by the end of 2001, EPA and ASIWPCA have established a new state/EPA Nonpoint Source Management Partnership to support states in the implementation of their upgraded programs. The partnership consists of a state/EPA Steering Committee and seven workgroups to help identify and solve states' highest-priority nonpoint source needs. The seven workgroups cover issues relating to

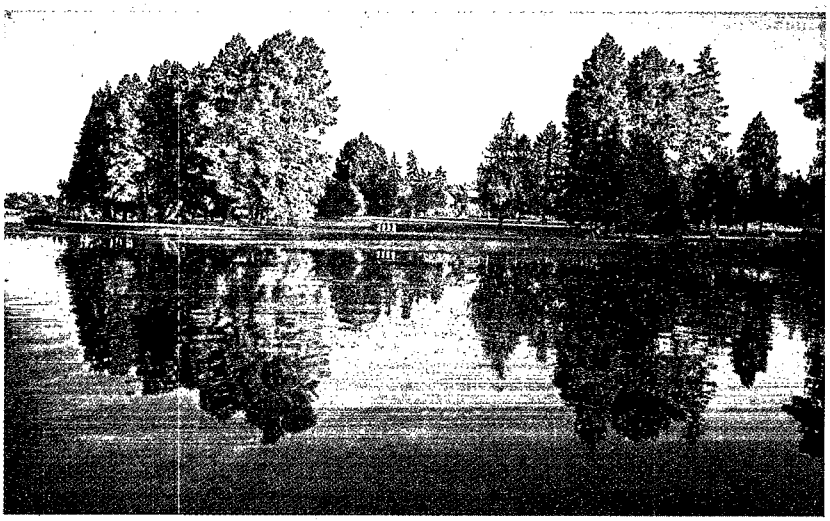
1. Watershed planning and implementation.
2. Rural nonpoint sources.
3. Urban nonpoint sources.
4. Nonpoint source grants management.
5. Nonpoint source capacity building and funding.
6. Information transfer and outreach.
7. Documenting nonpoint source results.

This new partnership provides an excellent framework for the states and EPA to work to-

gether cooperatively to identify, prioritize, and solve nonpoint source problems. For more detailed information on particular workgroup activities, see EPA's web site at www.epa.gov/owow/nps/partnership.html.

Defining success

Many of the projects contained in *Success Stories: Volume III* directly address the Clean Water Act's goal of achieving water quality standards by restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. The "state-by-state showcase" stories primarily demonstrate water quality improvements, a return to water quality standards, or other objective evidence of improvement in the water or in the habitat associated with the water. Many of the stories also document specific pollutant reductions or other measurable improvements attributed to the 319 project, such as increased shade for temperature-impaired waters and improved streamside habitat. The stories highlight the range of best management practices, training programs, and other activities implemented to achieve these successes, as well as the funding sources and other partners that contributed to the successful project.



The Clean Water Act's goal is to achieve water quality standards by restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters.

Although stories contained in *Success Stories: Volume III* emphasize "on-the-ground" projects to solve nonpoint source problems, many states also have created special programs and authorities to prevent nonpoint source problems. Interested readers should refer to two research studies published by the Environmental Law Institute (ELI) for general background on state authorities to address nonpoint source pollution—*Enforceable State Mechanisms for the Control of Nonpoint Source Water Pollution* (1997) and *Almanac of Enforceable State Laws to Control Nonpoint Source Water Pollution* (1998). Of special interest is an ELI study on how eight states in particular are using a combination of authorities and on-the-ground programs to achieve their nonpoint source goals of both remediation and protection (see *Putting the Pieces Together: State Nonpoint Source Enforceable Mechanisms in Context* [2000]). More details about ELI's research studies can be found on EPA's web site at www.epa.gov/owow/nps/pubs.html.

Four "special feature" sections are also included in this document, highlighting especially innovative state programs, information and education programs, state funding programs, and tribal 319 projects.

For more information

The stories in this document are abbreviated, nontechnical reviews that reflect only a small portion of each project's larger purposes. For further information on a particular project, call the state or local contact listed with the story. You may also contact EPA Headquarters' Nonpoint Source Control Branch at 202-260-7100 or find EPA on the Internet at www.epa.gov/owow/nps.

Contact:
Brad Bole
Project Coordinator
3120 Highway 36 West
Hartselle, AL 35640
256-773-6543 (ext. 107)
bbole@al.nrcs.usda.gov

Primary Sources of Pollution:
- agriculture (dairy)

Primary NPS Pollutants:
- nutrients
- fecal coliform bacteria

Project Activities:
- agricultural BMPs (dry stacks, dead bird composters, no-till farming, heavy use areas for feeding, stream crossings)
- riparian zone management
- outreach

Results:
- decrease in fecal coliform counts, nitrate concentrations, turbidity, and ammonia concentrations
- decline in duckweed/ algae blooms

Flint Creek Watershed Project:
Multiagency Effort Results in Water Quality Improvements

Lawrence and Morgan Counties, Alabama

The Flint Creek watershed is in southeast Lawrence County and western Morgan County in Alabama. The creek is listed as a priority water body for agricultural nonpoint source pollution and is documented as having at least 25 miles of impaired surface water due to nutrients, organic enrichment, and pathogens originating from animal holding and management areas, feedlots, dairies, and other nonpoint sources. The water quality problems were so severe that a local water supply on Flint Creek was forced to abandon an intake and water treatment facility as a result of excess nutrients.

Multiagency effort

The Flint Creek Watershed Project is a multiagency cooperative effort led by local leaders and watershed residents. In 1994 a Watershed Conservancy District was established, and plans were developed with the assistance of five federal agencies, five Alabama state agencies, and three local soil and water conservation districts. Sources of funding for the project activities included section 319 grants, U.S. Department of Agriculture programs such as the Environmental Quality Incentive Program and the Water Quality Incentive Program, Soil and Water Conservation District cost-share funds, and corporate donations.

A variety of projects were implemented in the watershed, including poultry, beef cattle, and cropland demonstrations; well sampling programs; on-site wastewater demonstrations; and riparian zone management efforts. Agricultural best management practices implemented included installing dry stacks and dead bird composters, promoting no-till farming and heavy use areas for feeding, and constructing stream crossings for cattle.

Outreach activities were conducted frequently in the watershed. The annual Flint Creek Wet & Wild Festival, for example, brought together more than 800 students in 1999. Other projects included a household hazardous waste day, pesticide amnesty day, and volunteer monitoring programs.

Water quality improvements

Improvements in fecal coliform counts have been documented at 11 of the 13 sampling sites. In addition, nitrate concentrations have decreased over time at three sites, turbidity has decreased at two sites, and ammonia concentrations have decreased downstream of a sewage lagoon. Although no benefit to dissolved oxygen has been documented to date, the decline of duckweed and algae blooms in Flint Creek demonstrates that the health of the watershed is improving.

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Primary Sources of Pollution:
- agriculture (farming)
- failing septic systems

Primary NPS Pollutants:
- pesticides
- herbicides
- fecal coliform bacteria

Project Activities:
- aquifer assessments
- education/outreach programs

Results:
- assessment of all 14 water systems
- outreach to more than 3 million people

Tuscumbia-Fort Payne Aquifer Protection Program:
Multiagency, Cooperative Approach Protects Aquifer

Tennessee River Valley, Alabama

One of the fastest-growing regions in Alabama is the Tennessee River Valley. This area is also one of the state's most rapidly developing areas in agricultural production (cotton and corn), recreation, and industry. The expanding economic base has led to suburban expansion into rural areas, resulting in more diverse nonpoint sources of pollution and more land coverage by impervious surfaces. As a result, one of the state's major aquifers, the Tuscumbia-Fort Payne Aquifer, was showing signs of stress due to contamination from surface sources.

The Highland Rim Physiographic Region of the state, in which the aquifer is located, includes six counties with roughly 4,500 square miles within the Tennessee River drainage basin. About 1.3 million pounds and 146,102 gallons of pesticides and herbicides are applied in the area yearly, causing major concern about the drinking water supplies throughout the region. Sampling results indicate that there is localized contamination in the Highland Rim Physiographic Region: 33 percent of wells and 32 percent of springs tested positive for pesticides, indicating that pesticides are entering the subterranean channel system that discharges into surface water bodies. Fecal coliform bacteria from poorly maintained on-site wastewater treatment systems are also a concern.

Multiagency project

The Tuscumbia-Fort Payne Aquifer Protection Program involved a multiagency cooperative approach. Alabama's Department of Environmental Management (ADEM) received partnership support from the Geological Survey of Alabama, the Alabama Department of Agriculture and Industries, the Alabama Soil and Water Conservation Commission, the Natural Resources Conservation Service (NRCS), the Alabama Cooperative Extension Service, the Alabama Department of Public Health, EPA, and the Tennessee Valley Authority, as well as 17 municipal and 6 county governments. Financial support for the program came from EPA's 319 grant program, which funded all aspects of the program.

The purpose of the aquifer protection program was to create a comprehensive program that would provide the maximum aquifer protection, given the regulatory limitations of community and county authorities. The program incorporated various state programs and developed a strategy for groundwater protection through cooperative efforts. The strategies for aquifer protection were to technically assess the aquifer and its characteristics, to assess the nonpoint sources of contamination (such as agricultural applications of chemicals and improperly maintained septic systems), and to create educational programs based on the technical data.

Technical strategy

Madison County's Wellhead Protection Program provided a framework for the technical strategy. That program had previously delineated recharge areas for 6 of the 14 water systems in the Highland Rim Region. The Geological Survey of Alabama delineated the recharge areas for the remaining eight water systems in the study area.

Water level and geologic field mapping, as well as dye tracing studies, were used to determine the flow boundaries and characteristics of each well or spring. After the recharge areas were identified, a comprehensive potential contaminant source inventory was conducted to identifiy all potential or existing sources of point and nonpoint contamination that could impair groundwater quality. Nonpoint sources of particular importance are sink holes, abandoned wells, residential septic systems, and agricultural fields under production.

Based on the potential contaminant inventory, the University of West Alabama conducted a pilot study in Lauderdale County to determine the relationship between on-site sewage treatment systems and bacteria in well water. One hundred homeowners voluntarily participated in a survey that collected information on characteristics and maintenance of the on-site system, factors related to water usage, and environmental information that could be related to fecal coliform contamination. Of the 100 wells and springs examined, 32 percent were found to contain fecal coliform bacteria. An examination of well depth indicated a possible relationship to the probability of contamination. It was found that 56.3 percent of the shallow wells were contaminated and that there was a very high probability of contamination (83 percent) when drainfield lines ran toward the well as compared to 23 percent probability for drainfield lines that ran away from the well.

Educational campaign

The foundation for protection of the aquifer and the identified recharge areas was a regional educational campaign developed to create public and private partnerships and instill a sense of responsibility for their drinking water quality in the local residents.

A pilot Groundwater Festival was held in Madison County in 1998, and more than 1,200 fourth-grade students participated. Following the successful pilot, festivals were held in three other counties. Each festival was unique, depending on the needs of the county and its schools. The festival organizing committees consisted of public water system personnel, Cooperative Extension agents, NRCS agents, regional planning and county commission representatives, local nongovernmental organizations, and school system representatives. The county organizing committees remain intact, and the festivals have continued annually. In spring 2000 approximately 5,000 fourth graders and their teachers attended a Groundwater Festival in the Tennessee Valley area.

A Cooperative Extension outreach program was also designed to introduce both urban and rural residents to the source of their drinking and irrigation water, as well as programs and practices that can protect groundwater. The Cooperative Extension System worked with ADEM and NRCS to implement the program. Public presentations and public service announcements were the primary methods of presenting information. Other materials created for the effort included a slide show, a tabletop display, brochures, a karst groundwater flow model, and questionnaires similar to the Farm, Home, and Business*A*Syst Program questionnaires.

Over the span of 3 years, the agents published 24 newspaper articles and aired 31 radio spots and 7 TV programs. A 30-minute program

describing the Wellhead Protection Program was aired on the local CBS station. Presentations were made at farmers' meetings such as the annual cotton and corn producers meetings, the county fair, Master Gardener classes, Pesticide Safety Programs, Rotary clubs, home and garden shows, and 4-H clubs. In addition, self-help booklets and questionnaires were distributed to businesses and organizations. The Cooperative Extension System estimates that more than 3 million people were reached during the 3 years of the media campaign.

The aquifer protection program showed what can happen when many agencies join forces to protect a vulnerable groundwater resource. State, federal, and local agencies collaborated to define the aquifer characteristics and flow conditions in the area and to use this information to build successful educational and outreach programs.

ALASKA

www.state.ak.us/local/akpages/ENV.CONSERV/dawq/nps/319pn.htm

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Primary Sources of Pollution:
- streambank degradation from recreational fishing

Primary NPS Pollutants:
- sediment

Project Activities:
- streambank restoration (soil bags, root wads, coir logs, sod layers, dormant willow cuttings)

Results:
- restored more than 7,700 feet of riverbanks

Restoration Work on the Kenai:
Section 319 Funds Are Key to Youth Restoration Corps's Success

Kenai River, Alaska

Alaska's rivers and streams are increasingly being affected by recreational use. People from around the world come to fish in some of Alaska's fabled waters and often return home with incredible stories and pictures. But all of that fishing is starting to exact a price. One of Alaska's most famous rivers, the Kenai, has been particularly hard hit, resulting in the closure of 22 miles of the river to bank fishing because of concerns regarding the natural habitat. People trampling its banks have caused severe damage that threatens the riverine habitat and causes erosion. Many efforts are under way to prevent further damage and restore the banks where damage has already occurred.

One of the most successful efforts has been the work of the Youth Restoration Corps (YRC), a nonprofit organization established in 1997 to promote environmental stewardship in youth while restoring riparian habitat along anadromous (salmon) streams on public lands. YRC has received 319 funding for its activities since its inception.

The Sanctuary Project is one of many efforts to restore eroded streambanks like this one at the mouth of the Russian River.

Restoration on the Russian River

In 1997 YRC established its first program on the Russian River, a tributary of the Kenai. The youth restored 2,219 linear feet of riparian habitat, using soil bags, root wads, coir logs, sod layers, and dormant willow cuttings. YRC has continued its restoration work on the Kenai and its tributary Russian River every year, and to date has worked

on more than 7,700 feet of some of the most heavily impacted riverbanks in Alaska. As a result, a river once in decline is now a river in recovery.

Fostering environmental stewardship and partnerships

In addition to helping restore Alaska's streams, YRC has also passed along its environmental stewardship ethic to young people. Each summer, kids aged 16 to 19 from local communities participate in this work and education program. They receive invaluable education on watersheds, healthy habitat, and the inhabitants that depend on a healthy ecosystem. YRC's motto is "We are building partners to build environmental ambassadors for the next generation."

Casey and Ivy (right) work on an undercut bank as Dean Davidson, Assistant Director, and Vera Group instruct youth on proper use of erosion mat.

YRC has also played a critical role in bringing together stakeholders from across the spectrum. Many other agencies and groups have partnered with YRC, including the Alaska Department of Environmental Conservation, Fish and Game and Natural Resources; the National Guard; the Forest Service; the US Army; the Natural Resources Conservation Service, and others. Local governments, as well as local, national, and international private businesses and organizations, have also partnered with YRC.

YRC's work has been well publicized each year by a professionally produced educational video on youths' participation in the program and successful completion of each project, which has been aired several times on statewide and national television. YRC has received many state and national awards and recognition for its work.

Although YRC has garnered many matching funds and in-kind matches from other organizations and businesses, 319 funds have been key to its success. The 319 funds have totaled less than $100,000, but other funds and in-kind match and value of the project work have been contributed at the rate of 5 to 1.

www.state.ak.us/local/akpages/ENV.CONSERV/dawq/nps/319pn.htm

ALASKA

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Primary Sources of Pollution:
- inadequate culverts
- forest roads

Primary NPS Pollutants:
- sediment

Project Activities:
- comprehensive evaluation of stream crossings/fish passage

Results:
- database on inadequate culverts
- leveraged funding for remediation

Road and Stream Crossing Project in Tongass National Forest:
New Data Help Identify Needed Fish Habitat Restoration

Tongass National Forest, Alaska

The Tongass Road and Stream Crossing Project is a 3-year cooperative effort by the U.S. Department of Agriculture Forest Service and the Alaska Department of Fish and Game (ADF&G) to identify and correct fish passage problems in the Tongass National Forest in southeast Alaska. ADF&G's participation was partially funded through section 319 grants. The project evaluated fish passage and sources of sediment from nonpoint source pollution along 60 percent of the miles of permanent (system) roads on the Tongass National Forest; the remaining 40 percent of the permanent roads, as

well as all of the temporary roads, will have the road condition survey completed in 2001.

The project involved inspecting all stream crossings and sources of sediment along the 2,153 miles of roads. There were 273 anadromous fish stream culverts and 662 resident fish stream culverts evaluated for passage. Adequate fish passage requires that the weakest-swimming fish present in a watershed can pass both ways through a culvert at all flow levels. Although some culverts are complete barriers to both adults and juveniles, many restrict movement of juvenile fish only during periods of high stream flow.

Velocity is the most common cause of fish passage restriction in culverts. If a culvert is installed at too steep a gradient or the culvert width is significantly narrower than the streambed width, the water velocity is increased within the culvert. Very slight changes in the slope of a culvert and the roughness of the substrate in the culvert can significantly change velocity and the ability of fish to pass through the culvert during all of the times of year when they normally move upstream or downstream. Other frequent causes of fish passage problems are perching of the culvert outlet above the water surface, blockage by excessive substrate or woody debris within the culvert, and structural damage to the culvert. In most cases, multiple factors interact to restrict fish passage.

Project results

Preliminary results indicate that 66 percent of the culverts across salmon streams in the Tongass National Forest are inadequate for fish passage. Eighty-five percent of the culverts across trout streams might also be inadequate.

The resulting database will be used to maintain historical information on roads, identify existing and potential risks to fish habitat and passage, and prioritize and estimate the costs of needed road maintenance and fish habitat restoration. The Forest Service has been using the data from this collaborative project to identify needed fish habitat restoration work. The data have already helped them obtain an additional $500,000 in annual road maintenance funds for the Tongass for the past 2 years.

AMERICAN SAMOA

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Primary Sources of Pollution:
- storm water runoff

Primary NPS Pollutants:
- litter

Project Activities:
- refuse collection
- public education programs

Results:
- absence of trash from coastlines

Nu'uuli Pala Lagoon Restoration Project:
Efforts Spread to Other Island Villages

Nu'uuli Village, American Samoa

American Samoa's Governor proclaimed "Paradise 2000," with the goal of American Samoa being the cleanest island in the South Pacific by the year 2000. In support of this goal, American Samoa initiated the restoration of the Pala Lagoon wetland area, a lagoon with an important nursery and spawning ground for fish and invertebrates. Restoration activities included identifying and developing best management practices to control nonpoint source pollution and supporting public education programs on wetlands and nonpoint source pollution.

A major effort in this project involved establishing trash stands in public areas surrounding the wetlands and hiring a contractor to collect and properly dispose of the refuse. As a result, refuse is nearly absent from all of the coastline. Public education about the lagoon and its resources was also considered integral to this project's success. A number of signs and posters were produced, and a wetlands fair was held in the lagoon area, emphasizing the functions and values of wetlands. Work continues to clean up and restore two major streams that discharge into the lagoon. Through the combined efforts of the American Samoa Environmental Protection Agency (ASEPA), American Samoa Coastal Management Program (ASCMP), Americorps volunteers, American Samoa Community College, Department of Public Works, and village volunteers, solid waste is being cleared from the streams and streambank habitat is being restored over an estimated few hundred feet (out of a thousand).

Restoration efforts have spread to other island villages, and ASEPA now plans to work with area businesses to continue the momentum. A contractor has completed a hydrologic assessment of the areas, and ASEPA has completed an initial assessment of storm water control problems. ASEPA, in cooperation with the ASCMP wetlands program and the village mayor, will continue to monitor the Nu'uuli village wetland areas to assess whether improper solid waste disposal remains a problem. American Samoa is committed to rectifying any problems identified through enforcement under American Samoa's new water quality standards.

www.adeq.state.az.us/environ/water/non/index.html

ARIZONA

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Primary Sources of Pollution:
- grazing
- channel degradation

Primary NPS Pollutants:
- sediment

Project Activities:
- restoration of the riparian zone
- improved grazing management practices
- increased irrigation efficiencies

Results:
- reduced sedimentation
- improved wetland habitat
- projected increases in ranching economics

Restoration in Nutrioso Creek:
Successful Results Beginning to Show

Apache County, Arizona

Nutrioso Creek is located in the Little Colorado River Basin in southern Apache County along the eastern border of Arizona. It is a 27-mile-long tributary to the Little Colorado River. Historical livestock activity caused a loss of riparian vegetation, such as willows, which has resulted in exposed streambanks aggravated by continued large ungulate grazing (cattle and elk). Riparian vegetation is necessary to help stabilize banks, dissipate stream energy, reduce erosion, and naturally filter sediment to reduce turbidity.

Nutrioso Creek was listed as an impaired water for violating the turbidity standard for aquatic and wildlife cold water streams. The entire 27-mile reach of Nutrioso Creek was listed on the state's 303(d) list, requiring the development of a Total Maximum Daily Load (TMDL) for the watershed. The TMDL Report, issued in July 2000, focused recommendations on 3 miles of private property and 4 miles of property owned by the U.S. Forest Service. The turbidity impairment in Nutrioso Creek is a result of suspended

solids in the form of excessive sediment. The excess sediment comes from the banks of the stream itself, which is incised in some areas because of channel degradation. This downcutting of the channel created a loss in floodplain for the stream, resulting in higher stream velocities during high flows. The higher velocities increased the shear stress/force acting on the streambanks and thus increased erosional forces.

A local model of success

Restoration of Nutrioso Creek is occurring as a result of the cooperative efforts of area landowners.

Turbidity data were collected throughout the restoration project to determine the project's effectiveness.

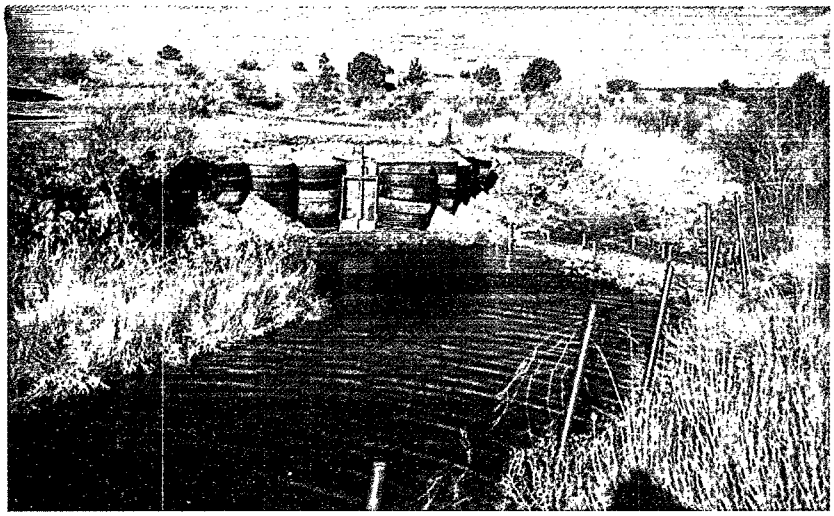
One landowner, Jim Crosswhite, has undertaken efforts to implement water quality practices while at the same time improving ranching economics. In 1996 Crosswhite purchased the 275-acre EC Bar Ranch, which included 1½ miles of riparian zone within the 3 miles recently recommended for water quality improvements. During 2000 Crosswhite purchased 115 acres from two neighbors, including another mile of the riparian corridor downstream. He now owns about 390 acres, including 2½ miles of the riparian zone being restored.

Crosswhite has changed range management practices and has been actively seeking grant monies to protect the riparian corridor, help restore the stream, and implement best management practices (BMPs). He has used a combination of 319 funding and grants obtained through the Environmental Quality Incentive Program, Arizona Stewardship Incentive Program, Arizona Water Protection Fund, and Arizona Game and Fish Department. He receives continued technical assistance from the Natural Resources Conservation Service (NRCS).

In 1997, at Crosswhite's request, the NRCS prepared a Conservation Plan for the EC Bar Ranch. The plan recommended a number of conservation practices designed to restore the riparian zone, improve grazing management of livestock, and increase irrigation efficiencies. In 1998 the riparian corridor was fenced to limit livestock grazing to dormant winter months, restore the wetland habitat, and raise the water table to increase off-channel forage production. A plan has been followed to eradicate rabbitbrush because it causes erosion into the creek and consumes vast quantities of subsoil moisture that could otherwise be used by productive grasses and crops. Improvements are under way to increase the efficiency of an irrigation system using water from Nutrioso Creek. Portions of 20,000 feet of earth irrigation ditches are being replaced with permanent and temporary pipe. Water is stored in a 250,000-gallon tank to supply a 1,500-gallon-per-minute pump to deliver water to traveling gun sprinklers covering 100 acres of upland pastures and 2 miles of the riparian zone. A significant portion of the 100 million gallons previously lost due to seepage and evaporation in earth ditches will now remain in the creek to help reduce turbidity, increase wetland habitat, and improve forage production for dormant season grazing; it can also be applied to upland pastures to help reduce erosion and improve crop production.

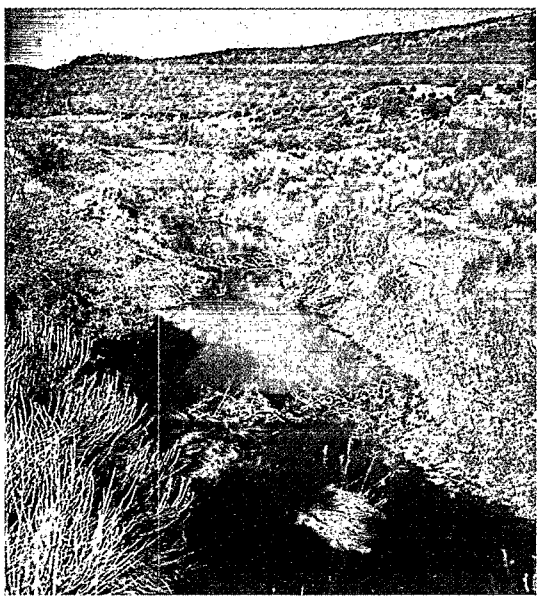
Improvements in water quality and ranching economics

Successful results are already beginning to show. In a study in 1996, the Bureau of Land Management, using the Proper Functioning Condition (PFC) score, rated the 1½ miles of riparian corri-



Controlled burns were used to slow the spread of rabbitbrush and stimulate the growth of new vegetation.

dor on the EC Bar Ranch as "non-functional" in places and "functional-at-risk with a downward trend" in other places. In 1999, after implementation of some BMPs, the same area was found to be "functional-at-risk with an upward trend." In 2000 one reach was found to be in "proper functioning condition." Turbidity and flow monitoring by the Arizona Department of Environmental Quality over high- and low-water flow events between October 1999 and April 2001 indicated that the level of turbidity has stabilized at 9 NTU, while flows have reached 50 percent above historical high levels. In another vegetative study performed during a severe drought in September 2000, the creek was dry upstream and downstream of the 2 miles located on the EC Bar Ranch where water quality improvement practices had been implemented.



Through the implementation of BMPs, streams in the riparian corridor have been returned to "proper functioning condition."

This created a stable wetland habitat for the threatened Little Colorado River spinedace and other fish.

Ranching economics are beginning to improve through a combination of conservation practices. A new Livestock Management Plan (LMP) places emphasis on producing forage during the growing season, assessing forage availability in the fall, and then acquiring stockers to be sold in January to March. This LMP will increase gross revenues, reduce year-round feeding expenses, allow wetlands to reach PFC, and permanently reduce turbidity.

Ongoing TMDL Implementation in Nutrioso Creek

Implementation of the Nutrioso Creek TMDL is ongoing, with a 5-year estimated time frame (and a 5- to 20-year time frame to meet turbidity standards). Primary goals of TMDL implementation include

- Increased education and public awareness.
- Decreased stream velocities using willows and streambed vegetation, stream grade stabilization structures, and increased floodplains.
- Decreased sheet flow and wind erosion contributions to the creek with removal of rabbitbrush and increased density of grasses as land cover.
- Arresting the downcutting of the stream channel to promote stabilization through BMPs, revegetation of the stream channel, and elimination of large ungulate (cattle and elk) grazing. With strong partnerships and the support of area landowners, restoration of Nutrioso Creek is guaranteed.

For more information on the project, go to www.ecbarranch.com.

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Primary Sources of Pollution:
- erosion from lack of vegetation

Primary NPS Pollutants:
- sediment

Project Activities:
- sediment retention structures

Results:
- reduction in sediment of 4 tons per acre per year

Sediment Reduction at Hackberry Ranch:
Reduction of 4 Tons Per Acre Realized

Stafford, Arizona

Hackberry Ranch is located east of the Whitlock Mountains 20 miles south of Safford, Arizona. The area is composed of wide and comparatively flat valleys between narrow, rugged mountains that generally run northwest-southeast. Vegetation is primarily desert scrub or desert grassland type. Most of the rain received (about 9.5 inches per year) is from intense thunderstorms in the summer, resulting in heavy runoff into the San Simon River, which discharges sediment into the Gila River. Winter rains are usually gentle, but they can also result in heavy runoff after the soil is saturated. Sampling results from the Arizona Department of Environmental Quality revealed that water quality standards, particularly turbidity standards, were being exceeded in the Gila River.

A solution: sediment retention structures

Through a 319 grant of $65,530, Boy Scouts and Americorps employees installed sediment retention structures on grazing land in the Whitlock Valley watershed, which drains to the Gila River. The structures were installed to trap sediment and slow runoff, thereby allowing the establishment of vegetative growth. Sediment is trapped behind structures to reduce the discharge into the San Simon. Structures were installed on two different range sites—a limey upland with predominately creosote bush cover, and basalt hills with grass over malpai. The structures were constructed of rock and/or brush. They were expected to improve conditions on some 300 acres of grazing land and reduce water erosion by around 95 percent.

Improved vegetative condition and sediment reduction

The project's 540 small sediment reduction structures are reported to have reduced erosion by an estimated 4 tons per acre per year. Photo monitoring also reveals that the sediment retention structures are capturing sediment. Some vegetation (primarily grasses) is beginning to grow in the newly captured sediments. Improved grazing management is increasing the amount of ground cover in the watershed and also reducing sediment. The success of the project will be demonstrated with a video, which will compare pre- and post-project conditions. Educational materials and events such as a slide show, photo monitoring, range transect information, sediment accumulation measurements, a fact sheet, a brochure, and a field day are being developed.

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Primary Sources of Pollution:
- agriculture (confined animal operations)

Primary NPS Pollutants:
- nitrogen
- phosphorus
- fecal coliform bacteria

Project Activities:
- revised storm water diversions and waste collection systems
- revised operational practices (changes in phosphorus application practices and on-site storage capacity)

Results:
- 90 percent decrease in nutrient concentrations

Buffalo National River Watershed Partnerships:
Partners Improve Swine Waste Management

Buffalo River Watershed, Arkansas

The Buffalo River watershed in north-central Arkansas covers 860,000 acres. From the headwaters in the Boston Mountains, the Buffalo River flows unobstructed for 150 miles eastward to the confluence with the White River. Because of the unique scenic and scientific features associated with the free-flowing river, Congress established the Buffalo National River Watershed in 1972 to preserve this national treasure for future generations. The federal and state governments own 40 percent of the watershed, primarily in the headwaters and along a narrow riparian corridor of the river. About 60 percent of the basin is privately owned, including most of the larger tributaries.

The Arkansas Department of Environmental Quality (ADEQ) has designated the Buffalo River an Extraordinary Resource Water and a Natural and Scenic Waterway, the highest water quality designation given by the state. Although the water quality in the Buffalo River at present is very good, several tributaries have been affected or threatened by agricultural activities. In 1992 there were 39 confined animal operations within the watershed, including 12 swine farrowing operations, one broiler operation, and 26 dairy facilities. All of the swine operations and 10 of the dairy facilities had Liquid Animal Waste Management Systems (LAWMS). At that time, the ADEQ Water Division received notice of intent from a watershed farmer to construct a 540-sow/pig farrowing operation adjacent to National Park property and less than a mile from the river. Manure land application sites for the proposed swine facility were as close as ¼ mile to the river. All of the existing watershed swine operations were located on the southern edge of the drainage basin in an area underlain by sandstone and shale. If the proposed swine facility was built, it would be the first swine operation located in such close proximity to the river and within a karst terrain.

Both citizens and resource agencies expressed concern over the construction and operation of a confined swine facility so close to the river. Personnel from the ADEQ Water and Environmental Preservation Divisions performed an investigation of confined animal operations within the watershed, visiting and evaluating 16 swine and dairy operations. Results of the watershed investigation showed that most LAWMS were not being operated and maintained in a manner that would eliminate or minimize the amount of waste leaving the farms. Subsequently, the ADEQ secured grant money to further study the problems revealed during the watershed investigation.

Project goals and methodology

The Buffalo River Swine Waste Demonstration Project was initiated in 1995 with the primary goal

of protecting the high-quality water in the Buffalo National River watershed by working with the local farmers and government agencies to identify and address the problems associated with the LAWMS. This 5-year, 319-funded project evaluated existing swine liquid waste management practices and demonstrated the benefits of new or improved best management practices (BMPs) in protecting water quality. The project objectives included evaluating the effectiveness of existing LAWMS BMPs (including design, training, and management aspects) by monitoring water quality and waste management practices at cooperating farms, improving existing BMPs or implementing new BMPs, and evaluating changes in the water quality and the operation of the LAWMS as a result of improved or new BMPs implemented at cooperating farms.

Other project goals included demonstrating to farmers and various government agencies the effectiveness of proper waste management at confined animal operations in protecting water quality. Nutrient loads in surface water were estimated before and after BMP implementation. Storm water runoff studies also were conducted to document nutrient loss from manure land application sites. In addition, waste management practices were documented before and after BMP implementation through frequent site visits and farm management surveys.

Waste management and water quality improvements

New or modified BMPs were implemented at the six cooperating farms based on site-specific problems and included the following:

- Storm water diversions were improved or installed.
- All-weather access to LAWMS was improved or installed.
- Storage capacity for liquid waste was increased.
- Waste collection systems were repaired.

New or modified BMPs associated with operational practices were also implemented and included decreasing fresh water usage; performing routine manure solids removal; and improving overall farm nutrient management by using a waste pumping service for solids handling, properly sampling manure holding structures to determine nutrient content, reducing phosphorus application rates, and increasing available acres for land application. In addition, 91 percent of the watershed's farmers had accumulated solids removed from the LAWMS, reestablishing the maximum available manure storage capacity at their facilities.

As a result of the new or modified BMPs, substantial improvements were documented in waste management practices. Free-board problems associated with waste storage ponds were reduced by 66 percent at cooperating farms. Overall, farmers began to manage the manure generated at their facilities for its fertilizer value, which reduced the time and expense associated with the LAWMS. Using water quality monitoring data collected on a stream (less than 1 square mile drainage area) adjacent to a poorly operated swine facility, preliminary estimates indicated that 3,000 pounds of total nitrogen and 400 pounds of total phosphorus were lost to the stream on an annual basis. Following BMP implementation, preliminary estimates indicated that nutrient loads in the stream were decreased by approximately 90 percent.

Partnerships to solve complex problems

This project involved building working relationships with watershed swine farmers, the swine industry, local Natural Resources Conservation Service staff, the Newton County Conservation

District, and the Environmental Preservation, Water, and Technical Services Divisions of ADEQ to improve LAWMS operation and swine manure management. All of the partners in the project cooperated to evaluate the data generated on LAWMS and to develop BMPs. New or improved BMPs were installed by extending cost-share programs and working one-on-one with individual farmers to ensure that all aspects of the waste system were understood. Emphasis was placed on finding economical solutions to waste management problems. Other groups, such as the Arkansas Soil and Water Conservation Commission, the Arkansas Pork Producers, and the University of Arkansas, contributed a considerable amount of time, resources, and technical expertise to help make this project a success.

Swine farmers in the Buffalo River watershed have successfully changed their waste management practices and are using the fertilizer benefit of the manure generated at their facilities while minimizing their impact on the environment. Information gained from this project has been presented at farmer training meetings and has helped swine producers statewide to improve their manure management practices. All of the partners participating in the project received an EPA Region 6 Partnerships for Environmental Excellence Award in 1998. The award acknowledged the contribution of each partner in cooperating to solve complex environmental problems.

www.state.ar.us/aswcc/NPS_Webpage/Mgmnt.html

ARKANSAS

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Primary Sources of Pollution:
- agriculture (dairy waste)

Primary NPS Pollutants:
- nutrients
- bacteria

Project Activities:
- dairy manure management practices
- manure clean-out service
- comprehensive nutrient management planning

Results:
- comprehensive local watershed assistance program

A Community Approach to Managing Manure in the Buffalo River Watershed:

Local Watershed Assistance Program Helps Dairy Farmers

Buffalo River Watershed, Arkansas

The Environmental Preservation Division of the Arkansas Department of Environmental Quality (ADEQ) was awarded a section 319 grant in 1997 to evaluate the effectiveness of "dairy manure management alternatives," designed for facilities with 100 cows or fewer, in minimizing nutrient and bacteria loads leaving farm sites. The dairy 319 project worked with dairy farmers and government agencies in the Buffalo River watershed, as well as with state and federal agencies, to develop and implement solutions to better manage manure in the watershed.

From the beginning of the dairy 319 project, the ADEQ project staff sought out cooperation with other agencies, the dairy cooperative, and dairy farmers in the Buffalo River watershed by forming a task force with representatives from all interested parties. Key relationships were devel-

oped between the ADEQ project staff and the Conservation District Boards, Natural Resources Conservation Service staff, and the dairy farmers in the watershed.

Most of the dairy farm owners in the Buffalo River watershed volunteered to participate in the dairy 319 project. The Buffalo Conservation District staff contacted farmers and requested individual meetings with them at their farms. During these meetings, the project staff explained the project to the farmers and requested their participation on a voluntary basis. In exchange for participation in the study, farmers hoped that the project would result in developing better information regarding the operation of manure management systems or finding a source of funding for improving their manure management systems.

Dairy operations and manure management

In 1994 there were 27 dairy facilities operating in the Buffalo River watershed. Recent financial difficulties have taken their toll on Arkansas dairy farmers, and today only 18 dairy facilities still operate in the watershed. Finding economic solutions to improve manure management at these small dairy facilities continues to be a challenge.

After an exhaustive investigation into the manure management practices of the dairy industry in the Buffalo River watershed, it became apparent that the 18 watershed farmers did not have the specialized equipment required to handle the different waste streams generated from the confinement of the cows at their farms. Although several individual problems were identified, such as ineffective fertilizer utilization and improper land application practices that increase the potential for contaminants to be transported in storm runoff, all of these problems originate from the lack of adequate manure handling equipment in the watershed. Therefore, the funding set aside for implementing best management practices (BMPs) in the watershed as part of the dairy 319 project was focused on solving identified manure handling problems.

Local watershed assistance program

To help accomplish the dairy 319 project goal of improving dairy manure management, partnerships were formed among the ADEQ, local NRCS, and the Buffalo Conservation District to develop a local watershed assistance program (LWAP). The program is administered through the Buffalo Conservation District office. It has been designed to provide a low-cost, effective solution to the manure handling problems identified throughout the watershed. In addition, the program will enable farmers to receive the maximum fertilizer benefits of their dairy manure while minimizing farm impacts on the environment. The LWAP includes the development of a local clean-out service, long-term clean-out scheduling, initial cost-share assistance, and comprehensive nutrient management planning.

As part of the LWAP, the Buffalo Conservation District provides a manure clean-out service for dairy farmers and an operator to maintain and operate the equipment. Easily transportable equipment for manure removal, including a side-discharge manure spreader, submersible pump, and pit agitator, will be purchased as part of the LWAP. This service provides dairy farmers in the Buffalo River watershed with a method to handle dairy manure without having to purchase and maintain specialized and seldom-used equipment. Additionally, by providing an operator, the program allows the dairy farmer more time to spend on milk production and other farm management responsibilities.

With the hope of increasing participation, up to 75 percent of the cost-share money will initially be available for watershed dairy farmers who use the program's manure handling service. To be

eligible for the program, the farmer is required to develop a long-term clean-out schedule for the dairy facility. ADEQ and NRCS staff will assist participating dairy facilities with the development of the 12-month clean-out schedules. This will ensure that solids are removed within the designed storage time for each manure management system.

Meetings were held to present the results of the dairy 319 project and introduce the LWAP, and they were attended by most of the dairy farmers in the watershed. Farmers in the Buffalo River watershed understand the importance of preserving water quality and were receptive to the LWAP. They realize that the program can help them economically manage and utilize dairy manure while protecting water quality in the watershed in which they live.

www.coastal.ca.gov/nps/npsndx.html

CALIFORNIA

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Primary Sources of Pollution:
- agricultural drainage

Primary NPS Pollutants:
- selenium

Project Activities:
- establishing selenium discharge caps
- instituting tradable loads program

Results:
- reductions in selenium load discharges

Grassland Bypass Project:
Economic Incentives Program Helps to Improve Water Quality

Grassland Drainage Area, California

Agricultural runoff is one of the primary sources of discharge to rivers and streams that do not meet water quality standards, affecting 70 percent of these impaired waters. This problem is particularly challenging in the western United States, where roughly 50 million acres of land are devoted to irrigated agriculture and where agricultural drainage and runoff provide a significant proportion of river flows during dry seasons.

The Grassland Drainage Area is an agricultural region on the west side of California's San Joaquin Valley. The agricultural land there is productive, but the soil contains a high level of selenium, a naturally occurring trace element. Selenium accumulates in the agricultural drainage water that collects in the tiles installed to drain excess water from the fields. In 1983 this problem received national attention when deaths and deformities in wildlife at the Kesterson Reservoir were attributed to selenium-contaminated drainage from outside the Grassland Drainage Area. In the early 1990s, selenium-laden drainage from the Grassland Drainage Area was still being discharged into other federal and state wildlife refuges, threatening important ecosystems and associated fish and wildlife.

An innovative tradable loads program

The Grassland Bypass Project is an innovative program designed to improve water quality in the channels used to deliver water to wetland areas. In 1996 several irrigation and drainage districts formed the "Grassland Area Farmers," a regional drainage entity that includes some 97,000 acres of irrigated farmland.

The group's initial goal was to use the San Luis Drain, owned by the federal Bureau of Reclamation, as an outlet for agricultural drainage. To do so, they entered into a Use Agreement with Reclamation, incorporating monthly and annual selenium load limits. A procedure was included in the Use Agreement to assess incentive fees if the monthly or annual load limits were exceeded. In addition, a maximum cap was established on the total amount of selenium that the Grassland Area Farmers could discharge. The Use Agreement for the project continued until September 2001, at which time development of a long-term plan began.

To meet the selenium load limits, the Grassland Area Farmers have implemented a wide variety of practices, including formation of a regional drainage entity, newsletters and other communications with the farmers, a monitoring program, an active land management program to use subsurface drainage on salt-tolerant crops, installation of improved irrigation systems, installation and use of drainage recycling systems to mix subsurface drainage water with irrigation supplies under strict limits, and tiered water pricing.

Additionally, with support of section 319 funding, the Grassland Area Farmers developed and adopted a "tradable loads" program to help achieve regional water quality targets. To date, pollution trading policies have been designed for trades between point sources, such as factories, and trades between point sources and nonpoint sources, such as farms. This project is unique in that it also establishes a trading program between nonpoint sources.

Under the tradable loads program, the total allowable regional selenium load is allocated among the member irrigation and drainage districts. The districts can then either meet their load allocation or buy/trade selenium load allocation from other districts. The theory is that the region will meet its selenium load target at the lowest possible cost because reduction measures will be taken where they are cheapest to achieve. In addition, the program should spur innovation by bringing selenium reduction decisions to a more localized level. Finally, the tradable loads program aims to distribute the costs of selenium discharge reduction equitably among the districts.

Environmental benefits

The environmental benefits of the project to wetland areas, including state and federal refuges, are significant. Drainage water has been removed from more than 93 miles of conveyance channels, allowing for delivery of fresh water to the wetland areas. Good-quality water from areas upslope of the Grassland Drainage is now separate from selenium-contaminated drainage water and can be put to use in the Grassland Water District and in the state and federal refuges.

Compared to data on preproject conditions observed in 1996, year 2000 data reflect that drainage volume has been reduced 41 percent; selenium load, 54 percent; salt load, 29 percent; and boron load, 14 percent. With the exception of the very wet year 1998, data show a continuous reduction in selenium discharge since 1995—reductions from 16 ppb to 2 ppb in some channel segments and reductions from 55.9 ppb to an average of 2 ppb in others. Selenium load targets were met every month in 1999 and 2000 and have been met every month to date in 2001. Selenium loads in 1999 and 2000 were the lowest ever discharged from the drainage in the past 15 years.

Other related efforts

The tradable loads program works together with other policies in place in the Grasslands Drainage Area. Many of the programs designed to encour-

age water conservation through irrigation efficiency also decrease selenium discharge. For example, one of the member districts of the Grassland Area Farmers pioneered a tiered water pricing policy in which increasing block-rate pricing motivates the use of water conservation practices. Other districts in the Grassland Drainage Area have followed suit by implementing their own tiered water pricing policies.

Additional incentive-based water conservation programs in the Grassland Drainage Area include low-interest State Revolving Fund loans and land management incentives. Irrigation system improvements in the Grassland Drainage Area include quarter-mile furrows, gated pipe, sprinklers, and drip irrigation systems. Districts are also pursuing methods aimed directly at selenium reduction.

In addition to providing local water quality benefits, this project provides valuable insight for controlling agricultural nonpoint source discharges elsewhere. Through a combination of quantitative discharge limits and economic incentives, a model that provides for direct accountability within a system that is locally controlled is emerging. In the long term, the use of economic incentives might enhance implementation by promoting cost-effectiveness and preserving farmers' flexibility to choose the most appropriate pollution reduction practices.

www.coastal.ca.gov/nps/npsndx.html

CALIFORNIA

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Primary Sources of Pollution:
- over-logging
- overgrazing

Primary NPS Pollutants:
- sediment

Project Activities:
- restored natural drainage
- new channel construction
- re-watering of meadow

Results:
- Increased stream flows, 18 acre-feet or more of water each year
- eliminated flooding

Turning History Around:
Stream Restoration Reclaims a Meadow While Helping to Control Floods

Feather River, California

Some of the worst floods in California have occurred where the Feather River, draining out of the Western Sierra Nevada Mountains, meets the Sacramento River in the Sacramento Valley of Northern California. Contributing to these major floods, as well as to localized flooding, the East Branch of the North Fork of the Feather River and its tributaries drained a land that had been over-logged and overgrazed for hundreds of years. Erosion and downcutting characterized the landscape, not only contributing to the flooding problem but also sending tons of sediment downstream, impairing water quality and fishery habitat.

Cottonwood Creek was one such tributary. The creek drained almost 11,000 acres of Big Flat Meadow, which was once covered with forage grasses and sedges. But all that had changed with a combination of livestock grazing, fire, and timber harvesting, leading to the channel's downcutting, a lowered water table, and a sagebrush wasteland where once lush grasses had flourished. Cottonwood Creek began to dry up in the summer, adversely affecting the fishery.

A headcut had created an incised gully that cut across the meadow. Over the years, the gully had downcut 15 feet and captured the flow from

Cottonwood Creek, the meadow's natural drainage channel. Before restoration, the downcut channel functioned like a fast-flowing drain, carrying off rainfall and snowmelt so quickly that the meadow was completely dewatered.

Restoring natural drainage

With 319 funding, the Feather River Coordinated Resource Management (CRM) team began work, with the goal of restoring the natural drainage regime, re-watering the meadow, and regaining wet meadow grasses and sedges. The restoration strategy was to construct a new channel on top of the meadow at the same location where the creek's historic channel had been and to fill the gully. Dirt from the newly constructed creek channel was used to fill the gully. At the same time, a number of intermittent ponds were left open within the former gully for the use of waterfowl.

Impressive results

The restoration process, dubbed "pond and plug," was so successful it is being used to restore other meadows in the area. With the meadow floodplain restored, floodflows now remain in the meadow long enough to percolate to the underground aquifer. Because they are saved and released as baseflow later in the year, they no longer add to downstream floods.

Data show the meadow is storing and later releasing about 18 acre-feet of water a year. For many years previous to 1997, the stream usually had stopped flowing by the first of July. In 1997 water flowed year-round, providing cool-temperature flows for a restored fishery.

Leveraging additional restoration

The Big Flat Meadow restoration is part of a larger vision of Plumas Corporation, a nonprofit economic redevelopment firm that coordinates the CRM projects. Plumas is promoting the natural water storage concept to attract restoration dollars from downstream water contractors, proclaiming that such meadow restoration projects can provide water that otherwise would run off as winter flood flows. This water is then available later in the season, when it is most in demand for delta fisheries and urban and agricultural communities south of the delta. Plumas now has four additional meadow restoration projects in progress. In one of the projects, Plumas is experimenting with a cost-cutting strategy that allows for the stream to build its own channel after they plug and pond the gully. This is a slower process, but much less expensive, and so far it's working.

Through the CWA section 319(h) grant program, the State Board helped fund many of the early Plumas County projects that paved the way for the restoration successes enjoyed today. The most recent project to be funded is development of a stream restoration guidance document that will document what has been learned from the many projects implemented.

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Primary Sources of Pollution:
- hard-rock mining
- acid mine drainage

Primary NPS Pollutants:
- zinc
- cadmium

Project Activities:
- diversion of mine works drainage into constructed wetland
- underground diversion/ earthen dam to segregate contaminated flows

Results:
- surface diversion moved recovery zone upstream from 12 miles to 4 miles below the mining activity
- underground diversion decreased dissolved zinc flows from 5,000 mg/L to 250 mg/L

Mining Remediation in the Chalk Creek Watershed:
Project Demonstrates Exciting Possibilities

Chalk Creek Watershed, Colorado

Hard-rock mining in the Chalk Creek watershed of central Colorado was extensive, continuing on and off from the late 1870s into the 1950s. Chalk Creek and its tributaries drain the eastern slopes of the Collegiate Range, and the creek enters the Arkansas River 10 miles south of Buena Vista. The Colorado Division of Wildlife maintains the Chalk Cliffs Fish Rearing Unit in the lower reaches of the creek.

The single greatest contributor of heavy metals to the creek is the Mary Murphy Mine, located 1 mile above the town of St. Elmo. The Mary Murphy developed steeply dipping gold-silver deposits and lead-zinc sulfide fissure-vein deposits through extensive underground workings on 14 different levels in the Tertiary-aged Mount Princeton quartz-monzonite. The two lowest adit levels, the 2200 level Golf Adit (10,400-foot elevation) and the 1400 level Main Adit (11,200-foot elevation), continue to discharge at a rate of 222 gallons per minute (gpm), contributing 66.2 pounds per day of zinc to Chalk Creek at high flow. Chalk Creek was identified on Colorado's 1998 303(d) list as impaired due to zinc; the TMDL is scheduled for completion in 2006.

The watershed first came under scrutiny in 1986 after a fish kill at the rearing unit. The kill was attributed to elevated concentrations of metals in Chalk Creek during spring runoff. Water quality sampling at that time found zinc and cadmium at levels exceeding state water quality standards. The effects were reduction of the number of brown trout and elimination of young fish for a 12-mile stretch below the mining district. Metal concentrations in Chalk Creek peaked in the vicinity of the Mary Murphy Mine and the Iron Chest tailing piles. At that time it was suspected that interaction between mine drainage, creek flows, and the tailings piles contributed most of the metals in the stream.

Diversion to reduce metal loadings

A 319 project in 1991 consolidated five tailings piles to a location just below the Mary Murphy mill ruins. The consolidated tailings were stabilized and revegetated with grasses, forbs, and trees. The drainage from the mine works was diverted around the consolidation pile into a constructed wetland between the consolidated tailings and Chalk Creek.

Biotic sampling conducted by the Division of Wildlife in 1994 and 1997 found the recovery zone had moved upstream, from 12 miles to approximately 4 miles below the mining activity. Greater numbers of individuals, greater species diversity, and more diverse age classes are now

represented in the creek. However, despite the impressive reductions in metal loadings from the now-reclaimed tailings sites, zinc loads still exceed state water quality standards.

Underground approaches to control continued discharges

The Colorado Division of Minerals and Geology (CDMG) completed hydrologic characterization at the Mary Murphy Mine in 1997. This work suggested that most of the flow coming from the adit portals was groundwater intercepted at discrete fault/fracture structures within the mine workings. Based on this work, underground inspection of the Golf Adit workings, and historical records of mining activity, an underground source-controls approach was developed and proposed, through the 319 NPS program and two other Clean Water Act grant sources.

In 1998 CDMG received $310,000 through three separate grants—$98,000 in 319 funds, $62,400 in 104(b)(3) funds, and $150,000 in an EPA multimedia grant—to implement underground flow characterization and control work over a 3-year period. This project was designed to demonstrate the source control approach, on a pilot scale, in only one level of the underground mine. This effort would essentially "untangle the plumbing" of the underground metals sources by determining where the groundwater was interacting with mineralized rock.

A loading analysis developed from flow and metals concentration data showed that 85 percent of the metals load exiting the Main Adit was attributed to one inflow from the north drift on the Mary Vein. The inflow constituted only 1.5 percent of the total discharge from the adit, but at high flow it had a total zinc concentration of 190,200 micrograms per liter (mg/L). The contaminated inflow was traced back to an ore chute on a high-sulfide stope on the north vein, which drained 15 gpm. This same high-concentration source also accounts for 70 percent of the zinc load discharging from the Golf Adit.

Flow measurements taken along the cross-cut adits of the Main level and Golf level indicated that clean groundwater inflows intercepted by the workings downstream from the contaminated stope inflow accounted for 70 percent of the total mine discharge volume. This proved that, at a minimum, it is possible to segregate the clean groundwater inflows from the mine discharge, reducing the total discharge needing treatment from the 90 to 222 gpm (low flow–high flow) range to the 5 to 20 gpm range. At these low volumes and high concentrations, many more passive or semipassive treatment options are available.

Success realized

CDMG conducted a demonstration of an underground diversion to control metals loading on the Main Adit level. A temporary, underground earthen dam was constructed by hand to divert the high-concentration flow. Subsequent sampling showed this diversion reduced dissolved zinc in the Main Adit flow from 5,000 mg/L to 250 mg/L, essentially eliminating the need for a treatment alternative at the 11,200-foot elevation site.

This project demonstrated exciting possibilities for addressing acid mine drainage. If clean inflows can be segregated, the volume of contaminated flows is greatly reduced and the scale of treating the remaining waste stream is greatly reduced. It now appears technically feasible to isolate underground sources of pollution to such an extent that it might be possible to eliminate 80 percent of the pollution source within a mine, rather than having to treat the discharge in perpetuity.

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Primary Sources of Pollution:
- stream-flow diversion

Primary NPS Pollutants:
- sediment
- high water temperature

Project Activities:
- hydrologic modifications
- bank stabilization

Results:
- increased pool depth and water levels
- well-defined channel
- increased fish population

The J-hook in the foreground is typical of the structures installed in the river. It directs stream flow toward the thalwag and away from the banks.

Rio Blanco Restoration:
Adopted Rocks and Homemade Jelly Help Fund Demonstration Project

Rio Blanco River, Colorado

The Rio Blanco, a tributary to the San Juan River, originates at the Continental Divide in Archuleta County, Colorado. Elevation ranges from more than 13,000 feet to around 6,400 feet at the confluence with the San Juan River. Land ownership is mixed: the headwaters lie within the Southern San Juan Wilderness area, and the confluence is on the Southern Ute Reservation. Private land is interspersed, but primarily in the lower 12 miles. The river runs about 30 miles from source to confluence. The watershed averages about 250 inches of snow in the winter and 13 inches of rain in the summer.

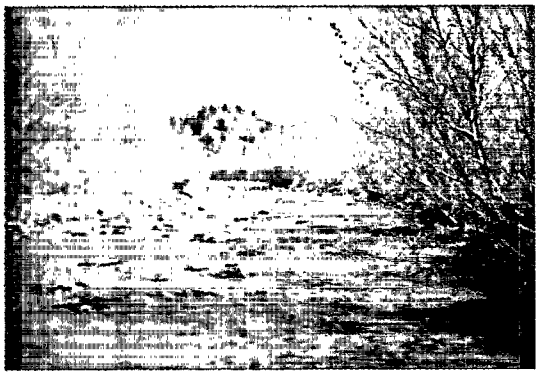
In the 1950s Congress appropriated funding to construct the San Juan–Chama Diversion Tunnel. The tunnel would take water from the Rio Blanco, which is part of the Colorado River Basin, under the Divide into the Rio Grande Basin for use in New Mexico. The diversion is located about 12 miles from the confluence.

The system began operation in 1971 and diverted approximately 70 percent of the in-stream flow of the Blanco. A basin summary prepared in 1990 by the U.S. Forest Service found that

- Fish habitat was poor.
- Sediment loads were high because of flow changes and streambank erosion.
- Sediment supply was greater than stream transport capacity.
- Water temperatures were high.
- Diversion and land use practices had created a wide, shallow stream with little pool and cover habitat.

The Rio Blanco is classified as an Aquatic Life Cold Water Class 1, Recreation Class 1 stream. Those uses, however, are not attained, resulting in the river's being listed on Colorado's 1998 303(d) list for sediment. A Total Maximum Daily Load (TMDL) is scheduled for June 30, 2006. Colorado also holds an in-stream flow water right that provides for 29-cubic-foot-per-second (cfs) flows from May 1 to September 30 and for 20-cfs flows from October 1 through April 30. The right was appropriated in 1974 to protect fish and aquatic life in the river; however, the physical structure of the river precluded adequate habitat under those flows.

The diversion had created a completely new flow regime in the river. The principle being applied in Colorado's Nonpoint Source Management Program for Hydrologic Modification is to make the best use of the water remaining in the stream and to restore the stream to its designated uses.



The diversion altered the river's natural flow regime and adversely affected fish habitat.

Hydrologic modification projects

In 1997 the San Juan Water Conservancy District and Colorado Water Conservation Board initiated a demonstration project under Colorado's Nonpoint Source Management Program for hydrologic modification. The goal of the project was to improve stream water quality and aquatic habitat through (1) reducing low-flow water temperatures by narrowing and deepening the channel and creating overhead and in-stream cover and (2) reducing sediment loading by stabilizing banks and enhancing sediment transport capacity by increasing the stream width/depth ratios.

A total of $96,000 of 1997 section 319 funds were used in the demonstration. Matching funds totaling more than the required $64,000 were provided by contributions from the San Juan Water Conservancy District, Southwest Water Conservation District, Colorado Division of Wildlife, Colorado Water Conservation Board, Archuleta County Commissioners, Pagosa Public Schools, Wetlands Hydrology, Lower Blanco Property Owners Association, and local landowners.

Aquatic habitat was improved by adding a drop structure. The pool in this area is 7 feet deep and supports trout.

Match contributions were collected in unique ways, including an "Adopt a Rock" campaign that allowed people to sponsor a rock for use in the restoration. Also, the local homeowners association sold homemade chokecherry jelly, offering the proceeds as match. The Bureau of Reclamation provided a significant contribution by providing staff and equipment to haul large boulders to strategic sites along the river.

Early signs of restoration

The project overcame considerable opposition on the part of some adjacent landowners, who feared the reconstruction would adversely affect the water level in their alluvial wells. The project was finally constructed in fall 1999 over 1.1 miles of the river below the San Juan/Chama diversion. Some of the early observations include the following:

- Pools within the river are now nearly 7 feet deep; previously, they were nonexistent or less than 2 feet deep.
- The channel is well defined and meanders, instead of braiding through the width of the riverbed.
- Water levels in alluvial wells have increased by 7 to 10 inches.
- Within a week of the completion of construction, children were again catching 10- to 16-inch fish in this segment of the river.

These observations are particularly notable because the river was at its lowest flow of the year, approximately 17 cfs, when data were collected. Data collected after construction are still being evaluated.

The goal for the Rio Blanco has now expanded from demonstration to full restoration of the impaired segment of the river. An application has been made for FY2001 319 funding to complete the next 2.2 miles, with the intent of restoring the entire 12-mile segment.

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Primary Sources of Pollution:
- urban storm water runoff

Primary NPS Pollutants:
- sediment
- nutrients
- trash

Project Activities:
- trash rack
- sedimentation forebay
- dredging of pond

Results:
- debris and duckweed blooms eliminated
- return of fishery
- 1,200 cubic yards of sediment removed in 1998

Center Springs Pond Restoration Project:
Skaters and Fish Return to Pond

Manchester, Connecticut

Center Springs Pond is the central feature of a 55-acre urban park in the center of Manchester, Connecticut, in the Hockanum River watershed. Center Springs Park and its pond are valued resources, providing residents with a variety of recreational opportunities. The pond has a surface area of 6.1 acres and is fed by Bigelow Brook. From the late 1920s through the mid-1970s, the pond was a popular site for skating and fishing, attracting people from all parts of Manchester. In addition, during the warm weather people were drawn to the area to enjoy picnic lunches or simply to sit by the pond and enjoy the scenery.

Environmental problems

Bigelow Brook, which feeds Center Springs Pond, runs through a heavily urbanized area. As a result, the brook receives high volumes of storm water runoff. This storm water carries with it pollutants such as sediment (from road sanding and construction activities), nutrients (from atmospheric deposition, septic systems, and lawn fertilizer), and trash (everything from common litter to shopping carts).

The filling of the pond with sediment and nutrients contributed to weed growth and increased water temperatures by allowing sunlight to penetrate to the pond's bottom. The combined effect of the sediments, increased temperature, and die-off of the algae and weeds consumed oxygen and led to low-dissolved-oxygen conditions. These impacts rendered the pond inhospitable to most species of fish and too shallow for ice-skating. The trash, bottles, cans, plastic containers, tires, lumber, logs, shopping carts, and even a doghouse made the park a less appealing place to visit.

The solution

The goals of the Center Springs Pond Restoration Project were to improve water quality in the pond and to reestablish the pond and surrounding area as a focal point for recreational activity in the town of Manchester.

The project's design was based on the recommendations of a diagnostic/feasibility study conducted by the Connecticut Department of Environmental Protection (CT DEP) Lakes Management Program on behalf of the Town of Manchester. It included the following components:

- *Installation of a trash rack upstream of the pond.* A trash rack collects large debris before items enter the pond. The trash is held in areas easily cleaned by the town maintenance crew.
- *Construction of a sedimentation forebay at the eastern end of the pond.* The forebay accumulates sediment entering from Bigelow Brook in a confined area for easy removal. The forebay is separated from the main

pond by a gabion wall/weir. The wall/weir directs the flow to the southern end of the forebay and extends the detention time, allowing sediments to settle before water enters the main body of the pond. The town also developed and has implemented a pond maintenance plan, which includes periodic sediment removal.

- *Dredging of the pond.* Approximately 25,000 cubic yards of material was removed. The pond was excavated to the bottom of the soft sediment, and the materials were trucked to a landfill. At the landfill, the material was stockpiled, dewatered, and then used as landfill cover.

Project partners and funding

This project was a combined effort by the Town of Manchester, the CT DEP, U.S. Environmental Protection Agency (EPA), and several private consultants and contractors. The total cost of the project was $342,900 (including construction of buildings and other park infrastructure). It was covered by $250,000 from CT DEP special bond act funds authorized by the state's General Assembly, $62,900 from federal Clean Water Act section 319 funds, and $30,000 from Town of Manchester capital improvement funds.

Section 319 funds were dedicated to nonpoint source controls in and around the pond, and other watershed management activities. Nonpoint source controls included the construction of the trash rack and the sedimentation forebay. As a condition of the section 319 grant, CT DEP and EPA required the town to conduct watershed management activities, including a review of street sweeping programs, a public education program (in the form of mailed pamphlets and newspaper articles), and an investigation of high-nutrient-loading areas.

Promising results

The Center Springs Pond Restoration Project was completed in 1995. Since then, there have been many noticeable changes. The most obvious of these is the improved appearance of the pond and the park. Before the restoration project, Center Springs Pond's extensive duckweed growth rendered the pond unattractive for recreation and unsuitable for most fish. Since the project was completed, the duckweed blooms have been eliminated. Floating debris has been brought to an end by the trash rack and watershed management activities. Watershed residents have done their part by responding to public education and helping to reduce the amount of litter and other household and yard pollutants.

Before the project, sedimentation of the pond and winter draw-downs for weed control had reduced the surface area, greatly limiting ice-skating for the past 20 years. Now the pond once again is used for skating. Perhaps the most astonishing change is the return of fishing as a viable recreational opportunity. Before the restoration project, the town's annual fishing derby, which usually attracts 600 to 700 people each spring, was held at other ponds in the region. Since the project was completed, the annual fishing derby has been held at Center Springs Pond, which is stocked with trout and bass.

The Town of Manchester now has a regular maintenance program for the pond and park that includes weekly litter pickup and periodic dredging of the sedimentation forebay. Other amenities have been added since the completion of the restoration project, including a fishing pier/lookout point on the gabion wall and a picnic area.

Future plans

Future plans for Center Spring Pond include regular maintenance of the immediate park

grounds. There are also plans to rebuild a picnic pavilion/observation deck over the foundation of the old skating lodge, which burned down. A concrete fishing pier, which is present in addition to the recently added pier, will be "dressed up" to match the décor of the new skating lodge.

Also proposed are stone dust trails throughout the park and a picnic pavilion at the top of the sliding hill. It is easy to see that, through the Center Springs Pond Restoration Project, this picturesque place in Manchester has been restored as an important recreational resource for the community.

www.dep.state.ct.us/wtr/nps/npsplsum.htm

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Primary Sources of Pollution:
- agriculture (dairy farm)

Primary NPS Pollutants:
- nutrients

Project Activities:
- farm waste management (waste collection, storage, and upland spray-irrigation)

Results:
- reductions in nutrients (phosphorus) and bacteria, allowing compliance with water quality standards

Lake Waramaug Watershed Agricultural Waste Management System:
One Farm Can Make a Difference

Washington, Warren, and Kent, Connecticut

Lake Waramaug is in the Housatonic River watershed in northwestern Connecticut in the towns of Washington, Warren, and Kent. This deep, 680-acre lake is the scenic center of the area's tourism business and is used for a variety of recreational activities, including boating, fishing, and swimming. Waramaug is the second largest natural lake in the state. The lake's 14.3-square-mile watershed is largely forested, with land use consisting of low-density residential development and several farms. Much of the lake's shorefront is developed with large-lot, single-family homes. Two state parks are located on and near the lake, Lake Waramaug State Park and Mount Bushnell State Park.

Problems caused by overenrichment

Twenty-five years ago, thick mats of algae covered the surface of Lake Waramaug, causing serious concern among property owners and local businesses. Dead fish washed ashore and became food for seagulls, raccoons, and other wildlife. The cause of the problem was overenrichment caused by runoff of phosphorus and other nutrients from farms, lawns, roads, and septic systems. These nutrients are considered a significant nonpoint source problem in the Housatonic River watershed.

The nutrients fed the growth of algae, which turned the lake's surface green every summer. When the algae died and sank to the bottom, the decomposition of the organic material consumed the oxygen that the fish and other aquatic life needed to survive. The algae also prevented sunlight from reaching native aquatic plants, which were both a food source and refuge for aquatic organisms.

By the mid-1990s, many of these problems had been solved through the joint efforts of the three watershed towns, area residents, and state and federal government agencies. However, water quality monitoring in Sucker Brook, which feeds the lake, was still finding elevated levels of nutrients and bacteria. Stream monitoring determined that a single dairy farm was the largest remaining source of nutrients in the watershed. This farm houses 255 cows, heifers, and calves, and the milking room,

corn bunker silos, and barnyards are located uphill and adjacent to Sucker Brook. Runoff from the farm, containing high concentrations of nutrients and bacteria, entered the stream, which transported the pollutants to the lake.

Solving the problems

One of the first steps to solving Lake Waramaug's problems was the formation of the Lake Waramaug Task Force in 1975. In 1978 the Task Force, with assistance from federal and state agencies and a private consultant, completed the *Lake Waramaug Management Plan*, which contained recommendations on how to restore and protect water quality. Major in-lake management projects include a 2.0 million-gallon-per-day "withdrawal-treatment-reinjection system"; two-layer aeration systems that mix the top water with the mid depths of the lake to create a large zone of cold, well-oxygenated water; construction of a channel through the delta formed at the Sucker Brook outlet to direct cold, well-oxygenated stream flow to the oxygen-depleted bottom waters; and several in-stream sediment collection basins. Numerous watershed nonpoint source controls were also established, including streambank and lakeshore erosion stabilization projects, a dairy farm manure storage system, and a vineyard wine waste lagoon.

As described previously, however, one major pollution source remained unchecked. To address this problem, in 1999 the farmer requested technical assistance from the Litchfield County Soil and Water Conservation District and the U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service (NRCS) to plan, design, and build a farm waste management system. The Task Force raised private funds and, through the conservation district, also solicited financial assistance from the towns that border the lake and the Connecticut Department of Environmental Protection (CT DEP). The CT DEP subsequently applied for and received section 319 funds from EPA. The farmer applied for funds through the USDA Farm Services Agency and the Connecticut Department of Agriculture and a loan from the Lake Waramaug Task Force.

Monitoring results

Water quality monitoring data collected since completion of the project indicate that the waste management system has significantly reduced pollution levels in Sucker Brook and in Lake Waramaug. Nutrient levels (especially phosphorus) in the stream have been drastically reduced. Before the waste management system was constructed, the farm was contributing more than 20 percent of the total phosphorus entering Lake Waramaug. Now, instead of flowing into Sucker Brook and Lake Waramaug, the nutrient-rich runoff from the farm area is collected, stored, and spray-irrigated on farm fields located hundreds of yards from Sucker Brook. This allows the nutrients to become incorporated into the soil, supporting plant growth on the farm rather than algae growth in the lake. Bacteria levels are also lower than before the water management system was installed, allowing the lake to meet state water quality standards for swimming and other primary-contact recreation.

Continuing the success

To ensure the future protection of water quality, the farm waste management system needs to be regularly inspected and maintained. It is expected that the dairy farm (with the assistance of local conservation organizations) will continue to take measures necessary to protect water quality in Sucker Brook and Lake Waramaug by following through with a new operation and maintenance plan established for the farm. The Lake

Waramaug Task Force and local health departments will continue to monitor the lake and its feeder streams to determine whether the farm waste management system and other best management practices are working to maintain and improve water quality. As a Task Force member noted in a recent local newspaper article, "This is a success story, but it wouldn't take much to turn it around. There has to be constant monitoring, constant improvement. Everything has to be kept working, brought up to date . . . ." (The *New Milford Times*, July 21, 2000).

Project Partners and Funding

This project was a combined effort by LCSWCD, CT DEP, USEPA, USDA, Lake Waramaug Task Force, and the dairy farmer. The total cost of the project was $211,864. Funding was provided by the following organizations:

$33,000 from an EPA Clean Water Act Section 319 grant awarded by CT DEP
$35,000 from the USDA Farm Service Agency (Agricultural Conservation Program)
$40,000 from the Connecticut Department of Agriculture
$61,864 from the farm through a loan agreement with the Lake Waramaug Task Force
$642,000 from the USDA NRCS for in-kind and technical services

www.dnrec.state.de.us/DNREC2000/Library/NPS/NPSPlan.pdf

DELAWARE

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Primary Sources of Pollution:
- failing septic systems

Primary NPS Pollutants:
- ammonium
- nitrate
- phosphorus

Project Activities:
- upgraded septic systems and wells

Results:
- upgraded 100 septic systems and more than 50 wells

Partners Upgrade Septic Systems in Coverdale Crossroads:
Quality of Life Improved for Residents

Sussex County, Delaware

The Coverdale Crossroads Community is in Sussex County, Delaware. Failing septic systems were resulting in contaminated drinking water wells and nutrient loss to surface water and groundwater supplies. Prior to restoration, most residents utilized a cesspool, a failed septic system, or no system at all.

Septic system upgrade

In October 1997 the Delaware Department of Natural Resources and Environmental Control (DNREC) entered into a 3-year partnership with the Coverdale Crossroads Community and First State Community Action to upgrade septic systems and wells. Greenwood Trust Bank and the Sussex Conservation District provided matching funds.

During the first year of implementation, the project had to overcome a number of unanticipated obstacles, resulting from some members of the community living in substandard housing. An upgraded septic system and well are of little use without electricity and plumbing. Near the end of the first year, DNREC joined forces with the Delaware Housing Authority, and donated homes were provided to those in need.

The local Prison Boot Camp and Work Release Program provided laborers for demolishing the substandard homes and clearing debris and trees to make way for subsequent installation of new septic systems and wells. Residents contributed by helping to remove debris and by providing temporary housing for those displaced. The final

year has added a partnership with the Resource Conservation and Development Council, which is lending its support in coordinating the last year of project implementation and installation of new housing.

Most of the replacement systems are gravity systems, with the exception of a few low-pressure pipe systems. Follow-up education on maintenance of the system is provided to each homeowner after installation.

Benefits to water quality and residents

By the end of September 2000, about 100 septic systems and more than 50 wells had been upgraded. Based on studies conducted in the Inland Bays watershed, the gravity systems have an efficiency rating for nutrient removal as follows: ammonium, 25 percent; nitrate, 35 percent; and total phosphorus, 90 percent. The efficiency rating for the low-pressure pipe systems is as follows: ammonium, 94 percent; nitrate, 66 percent; and total phosphorus, 90 percent.

Before the failing systems were replaced, remediation of nutrient loads was negligible. Through partnerships, this project has provided direct environmental benefits to groundwater and surface waters while improving the standard of living for many residents of Coverdale Crossroads.

DISTRICT OF COLUMBIA www.environ.state.dc.us/watershed/

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Primary Sources of Pollution:
- wetlands dredging/filling

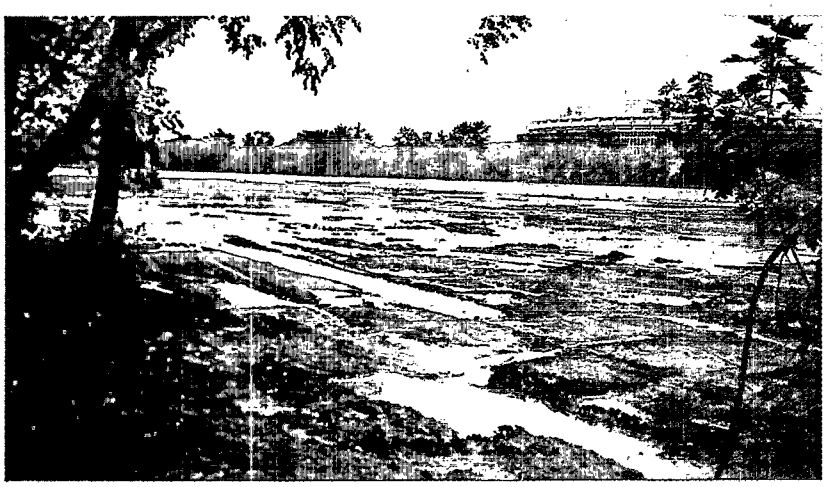
Primary NPS Pollutants:
- sediment

Project Activities:
- wetland restoration
- recreational/habitat enhancements

Results:
- mudflat transformed into wetland
- monitoring in progress

Marsh Restoration and Island Enhancement Projects at Kingman Lake:
Tidal Wetland Habitats Re-created

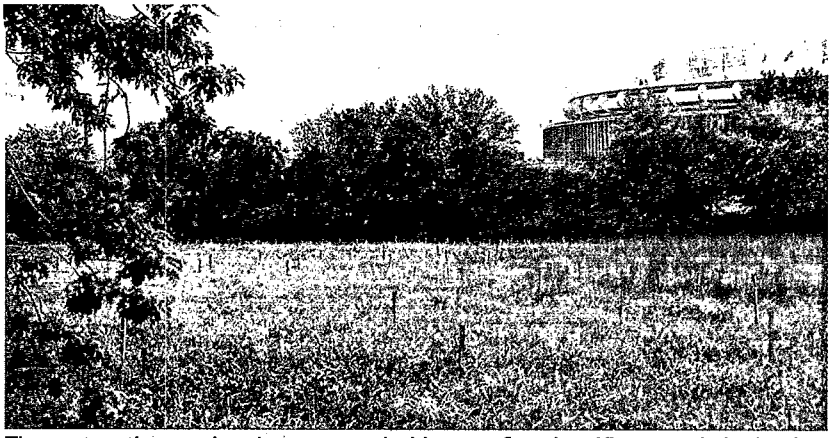
Anacostia River, District of Columbia



Years of sedimentation had turned Kingman Lake, once a tidal marsh, into a mudflat.

Kingman Lake is not a true lake, but a 110-acre tidal freshwater impoundment created during the 1920s and 1930s to provide a recreational boating area for District of Columbia residents. The lake is connected to the tidal Anacostia River by two inlets located at the northern and southern ends of Kingman Island, a wooded 94-acre dredge/fill-created island that separates the lake from the river.

Historically, the area emerged as an expansive freshwater tidal marsh, renowned for its migratory sora rail population. As wetlands were dredged and filled, many such migratory birds stopped coming. The open water tidal "lake" gradually



The restoration project has succeeded in transforming Kingman Lake back into a marsh.

filled with sediment until the dominant low tide feature was a mudflat. Because of the lack of suitable substrate elevation, most species of emergent marsh vegetation have not been established over the existing mudflats.

From mudflats to wetlands

With support of section 319 funding, in 2000 the U.S. Army Corps of Engineers, Baltimore District, led the restoration of 42 acres of the freshwater tidal emergent wetland in Kingman Lake. Other key partners included the U.S. National Park Service, the D.C. government, and neighboring Prince George's County in Maryland. The primary goal of the restoration plan is to restore historically significant wetlands, thereby enhancing the habitat diversity and structure of an area currently dominated by unvegetated tidal mudflats.

To re-create vegetated tidal wetland habitats, the morphology of the lake was altered by filling and grading existing lake mudflats with Anacostia River dredge material. Establishing new (higher) substrate levels on Kingman mudflats was key to creating an environment suitable for the growth of emergent wetland macrophytes, which can tolerate only moderate levels of tidal inundation.

Approximately 700,000 emergent wetland plants were planted in the newly elevated and graded mudflat areas. It was soon discovered that goose exclusion fencing would be necessary to prevent the plants from becoming a "free lunch" for the lake's resident Canada goose population. The fencing will allow the plants to gain a foothold during their first crucial growing season.

In concert with the wetland restoration work, Kingman Island is also being restored. The restoration primarily involves the removal of materials that historically have been dumped on the island. A number of low-impact actions are also under consideration, including the removal of invasive exotic plants. Also being considered is the construction of ramps and a floating boat dock for canoes and kayaks, as well as an interpretive nature trail for the recreational enjoyment of District residents. Enhancement of habitat for resident and migrating wildlife is also considered a priority. It might take the form of bird boxes, nesting areas for ospreys and eagles, and bat boxes, as well as artificial deadfalls and snags for species-specific nesting.

Ongoing monitoring

A prerestoration study will establish a baseline data set of aquatic biota and water quality parameters by collecting monthly water quality data and conducting a multiyear summer seasonal assessment of the benthic macroinvertebrate, fish, plankton, and bird communities living in or using Kingman Lake. After restoration is complete, the study will continue for 5 years to determine the relative impact of the restoration efforts on the water quality and the aquatic community.

Implementing these two significant restoration projects in the main stem of the Anacostia River is important not only for the improvements to wildlife habitat or water quality. The projects also demonstrate the success of large-scale environmental restoration projects involving multiple federal and local government agencies and funding sources.

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Primary Sources of Pollution:
- urban runoff
- sewer overflows

Primary NPS Pollutants:
- fecal coliform bacteria
- sediment
- nutrients

Project Activities:
- streambank stabilization
- education/outreach

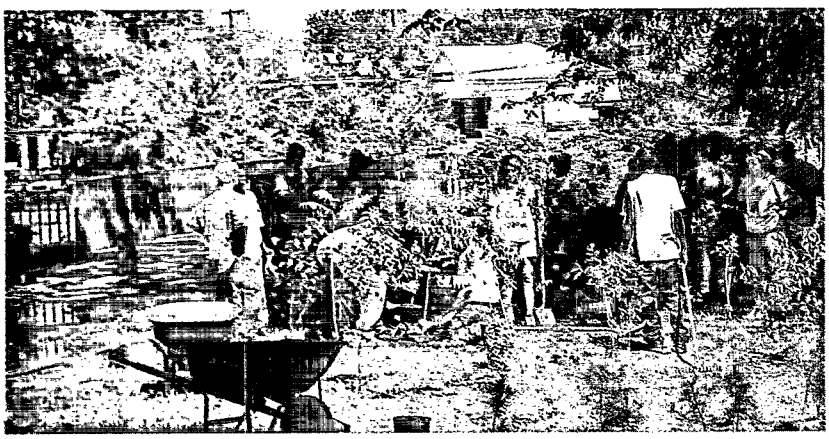
Results:
- monitoring in progress
- riparian buffers established (1,600 plants)

The Watts Branch Initiative:
Community Involvement Key to Success

Anacostia River, District of Columbia

Watts Branch is the largest and one of the most polluted tributaries of the Anacostia River. It flows from Maryland into the District of Columbia for 4 miles. About 80 percent of the stream's watershed is urban residential and commercial property; less than 15 percent is forested. Because of its location, the stream corridor is affected by runoff from a primarily impervious area. It is plagued by trash and debris dumped into the stream by local and upstream residents and businesses. The tributary is also a source of excessive fecal coliform bacteria loadings attributed to overflows from faulty sewers.

The Environmental Health Administration of the District's Department of Health established the Watts Branch Task Force to coordinate restoration of the Watts Branch watershed. The Task Force created the multiphased Watts Branch Watershed Initiative, which includes streambank stabilization and restoration, education and community outreach, and a strategy to prevent illegal dumping.



Many young people from the District helped plant trees throughout the Watts Branch watershed.

Public-private partnerships

The success of the Watts Branch Task Force has primarily been the result of its ability to effectively create partnerships between the public and private sectors and promote a high level of community involvement. Some 1,600 native trees, shrubs, and plants have been established to create and extend the Watts Branch riparian buffer. Through the efforts of the Task Force, in partnership with the Anacostia River Business Coalition and the Earth Conservation Corps, the work was funded largely through a section 319 grant. Section 319 funding also supported streambank stabilization efforts in the spring of 2001, in partnership with the U.S. Department of Agriculture's Natural Resources Conservation Service.

Money from Washington, D.C.'s Summit Fund supported the purchase of three surveillance cameras that are now being used by the Environmental Crimes Unit of the Metropolitan Police Department to monitor illegal dumping in and around Watts Branch. A grant from the Summit Fund also supported a community education day in the park, which helped to spread the word about illegal dumping, nonpoint source pollution, and the importance of riparian buffer plantings to the stream.

Plans for the future

Future work will address riparian and aquatic habitat concerns, as well as water quality impacts from sediment and nutrients. The U.S. Fish and Wildlife Service will provide monitoring assistance and will use the information it gathers to develop designs for areas still in need of stream restoration. The projected completion date for the stream restoration work is October 2004. The District of Columbia anticipates that continued stream restoration work will be funded through the District's 319 nonpoint source program.

www.dep.state.fl.us/water/slerp/nonpoint_stormwater/319h/documents/npsmgmtpln2000/npsmgmtprog2000.pdf

FLORIDA

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Primary Sources of Pollution:
- roads (timber, recreational)

Primary NPS Pollutants:
- sediment

Project Activities:
- road stabilization
- redirection of water flow

Results:
- reduced sediment delivery

Blackwater River Restoration:
Project Demonstrates Mechanics of Erosion and Effectiveness of BMPs

Santa Rosa and Okaloosa Counties, Florida

Ever know of a natural area that the users "loved to death"? The Blackwater River and the adjacent Blackwater State Forest in the Florida panhandle are good examples. Primitive roads created for and by the timber industry and by recreational users, including canoeists, tubers, horse riders, and hunters, have led to serious soil erosion problems in the forest. Roads leading to or along the river and its tributaries have caused erosion in the sandy, exposed soils of the watershed and along the shoreline, resulting in heavy sedimentation to the river.

Stabilization project

The Florida Division of Forestry treated 17 roads on the river's south side, closing 14 and repairing 3. Methods of closing and repairing the roads varied depending on the slope, likelihood of continued traffic, natural stabilization mechanisms in place, sources of water creating the erosion, and suitability of the best management practices (BMPs). The objective in each case was to remove or redirect the source of water flow causing the problem and to stabilize the soil. The overall project cost was $55,928, of which $25,268 was provided by a section 319 grant to the Florida Division of Forestry.

Encouraging results

Despite willful damage to treated areas by locals (subsequently repaired), the project was considered a success because sediment production from the roads was reduced and the restored areas were returned to timber production. The project taught the forest staff that soil cover is the key to reducing soil loss. The cover can be in the form of erosion fabric, vegetation, or mulch. Permanent native vegetation is expensive to procure, especially for large restoration areas. To continue this type of work on a forest-wide basis and make a significant impact on the soil erosion problems at a reasonable cost, some other means of revegetation will need to be used. The forestry staff believes transplanting forest materials will be one of the solutions.

This demonstration project helped state foresters better understand the causes and mecha-

nisms of erosion and sedimentation. Just as important, the project allowed the foresters to learn more about the effectiveness of BMPs that can be used to minimize erosion problems and where various BMPs work best. Consequently, state foresters have developed a management plan to continue addressing the erosion problems resulting from dirt roads and gullies that are negatively affecting the quality of the Blackwater River, an Outstanding Florida Water. Implementation of the management plan is proceeding using a variety of funding sources, including section 319 grants from the Florida Department of Environmental Protection, state funds, user fees, and in-kind contributions by forest users.

FLORIDA www.dep.state.fl.us/water/slerp/nonpoint_stormwater/319h/documents/npsmgmtpln2000/npsmgmtprog2000.pdf

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Primary Sources of Pollution:
- urban storm water runoff

Primary NPS Pollutants:
- sediment
- nutrients
- metals
- suspended solids

Project Activities:
- (Indialantic storm water retrofitting) baffle boxes in storm drain pipes
- (Indialantic) wet detention pond
- (Micco area retrofitting) exfiltration trenches
- (Micco) inlet system

Results:
- (Indialantic) 67 cubic meters of sediment removed per year
- (Indialantic) 60 percent less discharge of pollutants
- (Micco) 14,076 pounds of sediment removed
- (Micco) 80 percent less discharge of pollutants

Brevard County's Urban Storm Water Retrofitting Projects:
Lessons Learned About Design, Location, and Monitoring

Brevard County, Florida

With the implementation of the state storm water rule in 1982, Florida became the first state in the country to require that storm water from all new development be treated. However, reducing the pollutant loadings discharged from older drainage systems is also essential to the protection and restoration of water bodies throughout Florida. The Indian River Lagoon, an estuary of national significance and a water body of importance to both Florida and Brevard County, has been adversely affected by storm water discharges from older drainage systems. Fortunately, Florida's Surface Water Improvement and Management program, in conjunction with the Indian River Lagoon National Estuary Program, has developed a comprehensive watershed management plan to restore this important water body. A significant component of this plan is the implementation of urban storm water retrofitting projects through partnerships between the Florida Department of Environmental Protection, the St. Johns River Water Management District, and local governments.

Retrofitting Project Costs

Project	Drainage area	Cost
Alamanda	1.8 acres	$14,376
Cedar Lane	0.9 acres	$25,027
Franklin (2)	36 acres	$33,362
Indialantic I	25 acres	$13,580
Monaco	54 acres	$32,835
Pinetree	134 acres	$33,925
Puesta Del	2.2 acres	$25,181
Rivershore	7.2 acres	$ 9,463
Riverside	161 acres	$24,944
Sunset Park	24 acres	$23,422

Brevard County has implemented a storm water utility fee to help fund retrofitting projects, and its storm water program has initiated several

projects leading to a reduction in the pollutant loadings discharged to the lagoon. The county has received a number of section 319 grants to assist in funding these projects. The costs of the retrofitting projects are provided in the table.

Indialantic area retrofitting

Several storm water retrofitting projects have been conducted in the town of Indialantic to reduce pollutant discharge to the Indian River Lagoon. The first phase of retrofitting involved the installation of numerous baffle boxes (sediment boxes) at the end of existing storm drain pipes to capture sediment before it is discharged. The frequency of cleanout depends on rainfall frequency, land use, and drainage basin size but has averaged six cleanouts per baffle box per year. The maintenance records for 24 baffle boxes show that 202 cubic meters of sediment were removed from these boxes over a 3-year period.

Later phases of retrofitting in this area focused on treating storm water from an urbanized residential watershed of 120 contributing acres. The best management practices installed to correct storm water quality and quantity problems included construction of an exfiltration trench that discharges to a wet detention pond. The pond was planted with cordgrass and pickerelweed to provide nutrient removal and cattail control. The new sideslope Geo Web cells were planted with blanket flowers and sunflowers for additional erosion control.

Based on Florida's rainfall records and the design treatment volume of the exfiltration system, it is removing about 60 percent of the pollutants that would have been discharged. Water quality sampling of several storm events showed that the pond is providing significant treatment of storm water pollutants through settling and biological processes. Overall, the treatment system appears to be removing most nutrients, metals, and suspended solids from the storm water before discharge to the Indian River Lagoon.

Micco area retrofitting

The Micco area of Brevard County is an urbanized single-family residential area that was built before the storm water treatment requirements. The area's existing storm water system provided no treatment of the area's runoff, which was discharged to the Sebastian River and ultimately to the Indian River Lagoon. Prior to this project, Main Street ran directly down to its lowest point at a boat ramp. Because there were no curbs or gutters, storm water ran down the edges of the pavement, causing considerable erosion and transporting a lot of sediment into the river.

To arrest the direct discharge of storm water, the county developed a trench system designed to remove sediments. The county installed 1,536 linear feet of exfiltration trenches down the center of the road along with asphalt curbing to direct flow to inlets installed along the road's edge. The trenches capture 0.39 inch of runoff from the 15.5-acre watershed, and pretreatment is provided by sumps and skimmers at the inlets.

For a variety of reasons, monitoring on this project proved to be problematic. However, maintenance activities were able to document the effectiveness of the trench system in removing sediments. The inlet system was cleaned twice during the postconstruction monitoring period, and a total of 14,076 pounds of sediment was removed. In addition, based on Florida's rainfall patterns and the diversion of runoff into the trenches, it is estimated that the system removes 80 percent of the pollutants that previously were discharged to the Sebastian River.

Lessons learned

Many valuable lessons were learned from this project related to design, location, and monitoring. Brevard County staff are applying this information to current and future projects designed to address water quality and quantity problems throughout the Micco watersheds. Other local governments in Florida also are benefiting from the project as they develop and implement storm water master plans to reduce storm water pollution.

GEORGIA

www.dnr.state.ga.us/dnr/environ/

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Primary Sources of Pollution:
- erosion

Primary NPS Pollutants:
- sediment

Project Activities:
- tree revetment

Results:
- decreased sediment loads
- monitoring in progress

Broad River Streambank Stabilization Project:
Tree Revetments Rescue Eroding Banks

Northeastern Georgia

Streambank erosion on the streams and rivers of Georgia continues to be a growing problem. Erosion is particularly evident in the Broad River Watershed District of northeastern Georgia. The accepted consensus is that it is much easier, and more cost-effective, to prevent erosion before it occurs than to restore streambanks after the damage has been done. However, because in many cases erosion already exists, new and better ways of solving the problem are being explored.

One of the methods being tried in the Broad River watershed is the technique of installing "tree revetments." New to Georgia, this technique is relatively inexpensive when compared to other types of streambank stabilization techniques currently in use.

Demonstrating the technique

The Chestatee-Chattahoochee Resource Conservation and Development Council, through a 319 grant from the Georgia Department of Natural Resources, Environmental Protection Division, is implementing a project designed to demonstrate to landowners the positive effects of tree revetments on eroding streambanks. The project calls for 15 tree revetment sites, plus additional best management practices, to be installed on selected streams throughout the Broad River watershed.

A tree revetment is a bioengineering method that uses whole trees cabled tightly together in giant bundles. These bundles are then secured to the eroded streambank in a shingling effect, just like the shingles on a roof, through an anchoring system of cables. The trees used in the installation are selected by the contractor with assistance from an Natural Resources Conservation Service specialist or by the participating landowner from the landowner's own property. The streambank height should usually be 6 feet or more, with a steep incline; revetments can't be constructed on gradually sloped streambanks.

Tree revetments have been shown to greatly slow the stream current along an eroding bank, decreasing erosion and allowing sediment to be deposited in the tree branches of the revetment. The deposited sediment forms an excellent seed-

bed in which the seeds of riparian trees such as sycamores and maple, as well as other plants, can sprout and grow. The resulting growth spreads roots throughout the revetment and into the existing streambank. In addition to slowing streambank erosion, tree revetments also provide excellent habitat for birds, fish, and other forms of wildlife.

Continuing efforts

As of August 2001, seven revetment demonstration sites had been installed throughout the watershed. An additional five sites will be installed through the end of 2001, as weather permits. The progress of these sites will be monitored over the next 2 years.

www.dnr.state.ga.us/dnr/environ/

GEORGIA

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Primary Sources of Pollution:
- urban storm water runoff

Primary NPS Pollutants:
- nutrients
- metals
- oil
- grease

Project Activities:
- constructed wetland system

Results:
- reduction of storm water constituents

North Griffin Storm Water Detention Pond Project:
Constructed Wetland System Protects Water, Wins Award

Griffin, Georgia

An important function of wetlands is their role in maintaining and enhancing water quality. Urban storm water contains a variety of constituents, such as nitrogen, phosphorus, metals, oil, and grease, that can contribute to nonpoint source pollution. Because many complex chemical and biological processes that affect water quality occur in wetlands, a vegetated wetland system can incorporate and transform many of these storm water constituents through biological breakdown by microorganisms or vegetative decomposition. In addition to providing water quality-enhancing attributes, constructed wetland systems offer other potential advantages, including comparatively simple operation with low maintenance, process stability under varying environmental conditions, and low construction and operating costs when compared with traditional water treatment facilities. Additionally, the introduction of emergent wetland species not only provides several benefits for water quality enhancement but also results in improvement of wildlife habitats.

Comprehensive watershed management

In 1997 the City of Griffin began a comprehensive watershed management program by implementing a Storm Water Utility to address the city's aging infrastructure and improve the quality of storm water runoff. One of the first projects successfully completed under the management program was construction of the North Griffin Regional Detention Pond (NGRDP). This regional pond was designed for flood control and to enhance and preserve water quality in Shoal Creek and Wildcat Creek of the Flint River Basin.

The NGRDP features a drainage channel, a regional detention pond, and two constructed wetland areas for storm water filtration. The pond and wetland areas use natural filtration and other biological processes, rather than traditional mechanical means, to improve the quality of storm water runoff. The pond serves as a comprehensive storm water management system that eliminates flooding problems in a 180-acre area of North Griffin while enhancing water quality.

Evaluating the performance of the NGRDP

To determine the overall performance of the wetland system, an evaluation of water quality was performed by collecting and laboratory testing storm water samples from locations upstream of, within, and downstream of the detention pond. A baseline sampling protocol was developed to establish the initial quality of storm water runoff from the North Griffin Drainage Basin.

Review of the monitoring data for the first 21 months (between January 1999 and September 2000) indicates that the actual removal efficiencies are showing significant reductions for the constituents listed (see table). The City of Griffin anticipates that the future monitoring results for the mature site will be comparable to the theoretical removal efficiencies documented. Wetland maturation should result in utilization and transformation of these constituents through biological breakdown by microorganisms and vegetative decomposition.

The American Consulting Engineers Council awarded the City of Griffin and Integrated Science & Engineering the 2000 Engineering Excellence Award for this project.

Monitored Removal Efficiencies

This table shows the removal efficiencies for several constituents that are currently being monitored. The table represents data collected between January 1999 and September 2000 by the City of Griffin, Georgia.

Constituent	Station 1 (influent)	Station 3 (effluent)	Average removal efficency	Theoretical removal efficiency
Total suspended solids	42.86 mg/L	36.71 mg/L	14%	65% to 80%
Total Kjeldahl nitrogen	4.53 mg/L	1.76 mg/L	61%	60% to 80%
Total phosphorus	0.17 mg/L	0.10 mg/L	41%	25% to 50%
Chemical oxygen demand	52.00 mg/L	31.86 mg/L	39%	35%
Total lead	BDL	BDL	0%	50%
Total zinc	0.13 mg/L	0.07 mg/L	46%	60% to 70%
Fecal coliform bacteria	25,457 no/100 mL	8,169 no/100 mL	68%	NCLI

Note: BDL – below detection limits; NCLI – no comparison level identified.

GUAM

www.gepa.gov.gu/programs/water/poll.html

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Primary Sources of Pollution:
- soil erosion

Primary NPS Pollutants:
- sediment

Project Activities:
- planting native acacia trees

Results:
- 50,000 acacia tree seedlings planted in a 50-acre area
- projected to reduce turbidity and improve drinking water supply

Ugum Watershed Project:
Students Plant Acacia Seedlings to Help Restore Watershed

Ugum Watershed, Guam

The Ugum watershed is one of Guam's last relatively pristine natural areas. It has been identified as one of Guam's highest-priority watersheds in the island's Unified Watershed Assessment. The watershed consists of 19 square kilometers of lush vegetation, productive wetlands, savanna grasslands, and badlands with numerous springs and feeder streams. Located in the southern part of Guam, it is home to wild pigs, deer, and carabao, as well as many birds, some of which are endangered.

The Ugum Water Treatment Plant on the Ugum River supplies drinking water to southeastern island villages. Soil erosion and increased turbidity levels in the Ugum River have been adversely affecting water quality and drinking water supplies.

Acacia tree planting

In 1999 Guam's Water Planning Committee (WPC), composed of a broad spectrum of government agencies and other stakeholders (including Department of Agriculture, Division of Forestry; Aquatic and Wildlife Resources; Department of Commerce; Guam Environmental Protection Agency; Natural Resources Conservation Service; University of Guam; Guam Waterworks Authority; Department of Defense; and Bureau of Planning), initiated the watershed action plan for one of its highest-priority watersheds. The WPC determined that the most effective means of preventing and minimizing soil erosion was to encourage actions that maximize vegetative cover, particularly forest.

To achieve this, section 319 funding was used to plant a 50-acre area within the Ugum watershed with some 50,000 trees. One hundred students from Guam's southern schools helped plant the seedlings. The WPC goals were to conserve and protect the ravine forest, revegetate badlands within the savanna grasslands, minimize fires, increase public involvement and education, and obtain special recognition and standing that support the Ugum watershed as a priority watershed.

Reforestation of Ugum watershed

Once established, the acacia trees will allow the opportunity for native trees to restore the area to its native state. This is the beginning of a long-term program of forestation of the watershed.

Another sign of success is the WPC's development of a Watershed Executive Order, which the Governor signed in August 1999. The Executive Order affirms the WPC's work on watersheds, gives direction for agency leaders, and emphasizes a watershed protection approach involving multiple ownership and use perspectives.

www.state.hi.us/dbedt/czm/6217.html

HAWAII

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Primary Sources of Pollution:
- erosion from alien coastal plants

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- removal of alien plants
- planting of native species

Results:
- projected decrease in sediments and nutrients

He'eia Coastal Restoration Project:
Thousands of Volunteers Replace Alien Plants with Native Species

Kaneohe Bay, Hawaii

Friends of He'eia State Park is a nonprofit educational institution that offers interpretive programs in the sciences and Hawaiian culture. The park sits on an elevated peninsula on the shores of Kaneohe Bay. Bordering the park are a unique fringing reef, a mountain stream, and an ancient Hawaiian fishpond. This project was part of a larger master planning effort to rehabilitate portions of the entire He'eia watershed.

The state's Department of Health has designated Kaneohe Bay a Water Quality Limited Segment because of the nonpoint source pollution, specifically sediments and nutrients. Kaneohe Bay and He'eia Stream are part of

Koolaupoko watershed, designated a priority watershed in need of restoration by Hawaii's Unified Watershed Assessment Plan. Alien coastal plants were causing problems by preventing adequate filtering of waters that emanate from the watershed above before they entered the bay.

Replacing alien plants with native species

The major goal of this project was to expand and enhance the He'eia Stream and coastal area by replacing existing alien coastal plants with native strand species. The area was surveyed, and plans were developed for the removal of the alien plants. Two 40-square-foot test plots were identified to be cleared and planted with native species. Some of the trees removed were 60 feet tall with 16-inch diameters. The trees were cut at the top of the prop roots so the remaining roots could serve as traps or filters.

The project was very successful in removing alien flora from the streambanks and in planting native species such as milo, naupaka, kukui, kou and puhala in their place. The native species are expected to provide continuous protection to Kaneohe Bay by filtering the waters that come from the watershed above. Thousands of people from community groups, schools, service clubs, businesses, and prison work teams provided labor for the project.

Benefits to waters and the community

Students and professors from Windward Community College monitored the water quality of He'eia Stream at five sites in the watershed. The community benefited from this project through the many formal presentations made to the public and from the Hawaiian Lecture Series, which focused on the cultural relationship of the land to the sea. The success of this project has given Friends of He'eia State Park a huge boost in their continuing efforts throughout the watershed.

The total cost of this project was $155,000; funding included $60,000 in 319 grant funds.

HAWAII

www.state.hi.us/dbedt/czm/6217.html

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Primary Sources of Pollution:
- aquaculture
- taro production

Primary NPS Pollutants:
- dissolved chemical fertilizers
- high-nutrient-content aquaculture effluents
- sediment
- total dissolved solids
- pesticides

Project Activities:
- integration of aquaculture with taro production

Results:
- reduced levels of ammonia, nitrate, phosphate, and BOD

Integration of Aquaculture with Taro Production:
Nonpoint Source Pollutants Reduced in Demonstration Project

Niumalu, Hawaii

Both aquaculture and taro production play important roles in the Hawaiian culture but can sometimes result in significant nonpoint source pollution. Puali Stream and Nawiliwili Bay have been particularly affected by agricultural discharges of dissolved chemical fertilizers, high-nutrient-content aquaculture effluents, sediment, total dissolved solids, and pesticides.

Hawaii initiated a 319 project to demonstrate that the integration of aquaculture with taro production systems can significantly reduce nonpoint source water pollution. The goal of the project was to demonstrate that the application of various best management practices (BMPs) to integrated aquaculture (fish)–agriculture (taro) production systems can result in significant eco-

logical and economic advantages, including, ultimately, the reduction of nonpoint source pollution. Equally important was the goal that the project result in the improvement of the social and economic conditions of taro growers and aquaculturists throughout the state.

New approaches to production

The project involved stocking four pairs of fish tanks with both tilapia and Chinese catfish. Each taro treatment then received the effluent from two fish tanks. Each pair of tanks that discharged into each loi (pondfield) was integrated with four treatment taro pondfields planted with lehua maoli, which then drained into adjacent fields planted with bun long. Two taro controls were integrated with, and discharged into, a wastewater polyculture pond. One was solarized and one was not. The polyculture pond was stocked with fish, taro, and aquatic plants, dependent on waste products from the two controls for their nutritional needs. The system was expected to control eutrophication, recycle organic and inorganic wastes, decrease soil erosion, and abate water pollution.

Quantitative water quality data were collected bimonthly with the use of a Hydrolab and other water quality testing equipment to monitor the following parameters: dissolved oxygen, percent saturation, pH, conductivity, temperature, turbidity, total dissolved solids, total nitrate, total phosphate, total ammonia, and biological oxygen demand (BOD). The purpose of the monitoring was to assess which BMPs and integrated methods are most effective as pollution abatement techniques.

Increased water quality without affecting crop yields

This project was successful in demonstrating that the traditional Hawaiian cultural practice of taro production can efficiently meet today's standards of water quality without affecting taro yield. Although the growth rate of the tilapia and Chinese catfish were considered relatively slow, it must be considered that two crops (fish and taro) are being grown and the goal is to optimize the production of both while at the same time protecting the quality of receiving waters. The taro functioned well as a "biofilter" to recover nutrients in aquaculture effluent. Overall levels of ammonia, nitrate, phosphate, and BOD were significantly reduced after the aquaculture effluent flowed through the taro loi.

www2.state.id.us/deq/water/nps/nps.htm

IDAHO

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Primary Sources of Pollution:
- nonirrigated cropland (headwater sites)
- rangeland (grazing activities)
- surface mining operations
- streambank erosion

Primary NPS Pollutants:
- sediment
- nutrients
- high water temperature

Project Activities:
- landowner education
- streambank stabilization structures

Results:
- 20 tons per acre per year reduced erosion from erosion control structures
- 7 tons per acre per year reduction from sheet and rill erosion control practices
- 20 percent reduction in use of pesticides and fertilizers
- increased trout density

Conservation in Hatwai Creek:
Partners Work Together on Four Successful Projects

Nez Perce County, Idaho

Hatwai Creek is 3 miles east of Lewiston, Idaho. Its watershed consists of 19,785 acres of cropland (56 percent), rangeland (31.5 percent), pasture/hayland (5 percent), riparian areas (2.5 percent), roads (2 percent), forestland (1 percent), mining (1 percent), and farms and

suburban areas (1 percent). The watershed elevation ranges from 775 feet to 2,964 feet. Annual precipitation ranges from 10 inches at lower elevations to 22 inches at higher elevations.

The watershed was listed on Idaho's 303(d) list and also listed as critical habitat for steelhead salmon. The National Marine Fisheries Service (NMFS) listed steelhead as threatened in Hatwai Creek. The creek's beneficial uses are agriculture water supply, secondary contact recreation, and salmonid spawning. The nonpoint source pollutants include sediment, nutrients, and high water temperature. The primary sources of such pollutants are nonirrigated cropland (headwater sites), rangeland (grazing activities), surface mining operations, and streambank erosion.

Combined resources to address watershed

In the early 1990s the Nez Perce Soil and Water Conservation District (NPSWCD) organized local, state, and federal stakeholders to address water quality and fishery concerns. The watershed plan resulting from that partnership consisted of four separate projects to address water quality and fisheries issues: an EPA 319 project, a U.S. Department of Agriculture Water Quality Incentives Project, a riparian demonstration project funded by the Idaho Soil Conservation Commission, and a USDA Environmental Quality Incentives Program project.

The Idaho Department of Environmental Quality (DEQ) funded a sediment and nutrient reduction project through section 319 funding. The project included landowner education for watershed management and nonpoint source pollution. Many structural conservation practices were installed, including 12 water and sediment control basins, nine grade stabilization structures, two ponds, one off-site water development, eight sediment basins, 8,000 linear feet of terrace, and 5,400 linear feet of riparian improvement practices (brush mattresses, pole plantings, and revetments).

The USDA Water Quality Incentive Program project provided incentive payments for nutrient and pest management and for well testing. Thirty-five landowners participated and received training on soil testing, nutrient budgets, Integrated Pest Management practices, and wellhead protection practices. More than 11,000 acres were treated through this program.

The riparian demonstration project began in 1993 and will be completed in 2001. The primary areas of focus are grazing management on riparian and upland areas, enhancement of the riparian areas, streambank stabilization, and fish habitat improvement.

In June 1999 a special project for reducing sheet and rill erosion on cropland was initiated through the support of the Natural Resources Conservation Service's (NRCS) Environmental Quality Incentives Program. Conservation practices will focus on the implementation of direct seeding systems, a new technology for this area, and there is a possibility of reducing sheet and rill erosion by as much as 25 percent.

Success of cooperative efforts

The Idaho Department of Fish and Game collected fish data in Lower Hatwai Creek, monitoring the responses of wild trout, natural rainbow trout, and steelhead trout. Monitoring results for the 1995 to 1998 period indicate that the trout density increased annually throughout the length of the demonstration project. Trout density in the project area increased from 0.32 per 100 square meters in 1995 to a high of 13.24/100 m^2 in 1998; in the control area, on the other hand, trout density was only 0.87/100 m^2 in 1996, 3.00/100 m^2 in 1997, and 3.06/100 m^2 in 1998. This improvement is attributed to improved riparian health,

including improved streambank, increased canopy cover, and decreased stream temperatures.

Nineteen erosion control structures were installed, reducing concentrated-flow erosion of sediment by an average of 20 tons per acre per year. Installing sheet and rill erosion control practices on 10,000 acres of nonirrigated cropland resulted in a reduction of 7 tons per acre per year. Installing 9,000 acres of pest and nutrient management practices produced a 20 percent reduction in the amount of pesticides and fertilizers applied.

The NPSWCD also completed a landowner survey to document technology adoption. Eighty-five percent of those surveyed had participated in at least one of the four projects, and 69 percent confirmed that they would participate again in a similar project if given the opportunity. Fifty-four percent of those surveyed were willing to participate in watershed advisory groups. Nineteen different types of conservation practices were installed on more than 14,000 acres of land, representing about three-fourths of the total watershed acreage.

Success is the result of the cooperative efforts of landowners, the public, and various agencies. Groups assisting included DEQ, EPA, Idaho Department of Fish and Game, Idaho Soil Conservation Commission, Nez Perce County Commissioners, Lewiston Senior High School, Lewiston Retired Senior Volunteer Program, Idaho Department of Lands, Idaho Department of Water Resources, NRCS, University of Idaho, local Boy Scout groups, NMFS, and the NPSWCD.

www2.state.id.us/deq/water/nps/nps.htm

IDAHO

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Primary Sources of Pollution:
- agriculture
- urban wastewater
- channelization
- streambank erosion

Primary NPS Pollutants:
- sediment
- nutrients
- high temperatures
- pathogens
- ammonia

Project Activities:
- remeander channel segments
- restore floodplains
- revegetate riparian areas
- stabilize streambanks
- construct wetlands
- conduct community education

Results:
- projected decreases in sediment, nutrients, high temperatures
- projected 1.5-foot drop in flood elevations

Restoring the Paradise Creek Watershed:
Phased Approach Implemented to Address Pollution and Flooding

Moscow and Pullman, Idaho

Paradise Creek originates on Moscow Mountain (elev. 4,356 feet) and then flows in a southwesterly direction for 20 miles, through Moscow, Idaho (elev. 2,520 feet), ultimately entering the South Fork of the Palouse River in Pullman, Washington. The creek drains 34 square miles and consists of 55 stream segments, 49 of which flow through agricultural fields. Wetlands associated with riparian areas along Paradise Creek are in poor condition because of past and present management activities such as draining and tiling.

Today, Paradise Creek is a simplified ecosystem adversely affected by habitat destruction, excessive sediment, nutrients, high temperatures, altered flow, pathogens, and ammonia, which in combination have significantly decreased its biological integrity. Cropland is the most prevalent land use (about 73 percent) in the Paradise Creek watershed but provides the least diverse plant community type. Historically, Paradise Creek supported cold water fisheries; currently, the creek supports only limited nongame fish species. Be-

cause negative impacts on the stream continue to increase along with growth in the urban areas of Moscow and Pullman, it is becoming even more difficult for the creek to repair itself.

A multiphase approach

For the past decade, the Palouse-Clearwater Environmental Institute (PCEI), a 501(c)(3) nonprofit organization, has directed watershed restoration projects in Paradise Creek. From 1994 to the present, PCEI has led a seven-phase comprehensive watershed restoration approach in the Paradise Creek watershed. In addition to 319 funding, support for this project was provided by a multitude of partners, including Moscow School District No. 281; numerous private individuals and businesses; City of Moscow; Latah Soil and Water Conservation District; University of Idaho; Palouse Conservation District in Whitman County, Washington; City of Pullman, Washington; Idaho Department of Fish and Game; Idaho Department of Water Resources; Idaho Department of Lands, Soil Conservation Commission; U.S. Army Corps of Engineers; U.S. Department of Agriculture's Natural Resources Conservation Service; and U.S. Fish and Wildlife Service.

Phase 1 of the project began in fall 1995, and the project continues today with restoration efforts in Phase 7. Most of the activities have involved floodplain and wetland restoration, streambank stabilization and revegetation, and relocation of the previously straightened stream channel to its natural pattern in the Paradise Creek watershed. These efforts have involved the cooperation and participation of both public and private landowners along the Paradise Creek corridor, dealing with various contributors of nonpoint source pollution.

In 1995 Phase 1 began with the restoration of a floodplain and streambanks at a site owned by the Moscow School District. Before the restoration project, this section of Paradise Creek was channelized with unstable banks. The riparian zone was farmed, and plant diversity along the stream channel was low. Phase 1 involved efforts to remeander 1,200 feet of stream channel, as well as streambank stabilization practices, including the planting of more than 750 native plants on some 3,000 square feet of streambank and 5 acres of floodplain.

Also in 1995, the commencement of Phase 2 involved the development of wastewater treatment wetlands with the help of local community volunteers and students, who planted the newly constructed cells with 23,860 native herbaceous wetland plants. The wetlands were completed in 1998, and PCEI has given tours of the site to classes from universities and to local groups like the Native Plant Society.

In 1996 Phase 3 projects were aimed at floodplain restoration, streambank stabilization, and the remeandering of a 1,250-foot segment of the creek owned by the University of Idaho that had previously been channelized. The creek's path had been tamed, but it had little value for flood control, aesthetics, or wildlife. The floodplain was therefore revegetated with a native riparian plant community, and a sinuous, low-flow channel with bioengineered bank stabilization and habitat structures was constructed. In addition, biofilters, including grassy swales and "pocket" wetlands, were installed to treat storm water runoff from a planned parking lot. Models of the completed project showed a drop in flood elevations of up to 1.5 feet.

The Phase 4 projects, begun in 1999, focused on streambank and floodplain restoration in private backyards along Paradise Creek. Need for this project was high, as demonstrated by one landowner's loss of a 60-square-foot strip of her backyard to streambank erosion. Interested landowners provided buffer strips. The widths of their strips varied based on the erosion potential of their reach of Paradise Creek.

Restoring riparian areas on agricultural land along Paradise Creek was the goal for Phase 5. Before restoration, the stream channel had been straightened and acted as a drainage ditch for active agricultural land directly adjacent to the stream. As part of the restoration project, 3,600 feet of stream channel was relocated to follow its estimated historical path. Vulnerable banks were stabilized, and two new wetlands were excavated to act as a flood storage and groundwater recharge area and to provide habitat for wildlife. In spring 2000 PCEI and the landowner planted a 150-foot-wide buffer strip with a mix of native woody plant species.

Phase 6 involved the urbanized riparian floodplain and associated wetlands on public land along Paradise Creek within Moscow. Work took place along two reaches of the creek, resulting in the revegetation of more than 4,000 feet of stream by fall 2000.

Phase 7 of the project is under way, focusing on the implementation of nonpoint source controls to achieve Total Maximum Daily Load allocations. The project includes construction of animal waste biofiltration swales and treatment wetlands, revegetation of riparian areas, streambank stabilization, and agricultural land restoration activities in association with other local agencies.

www2.state.id.us/deq/water/nps/nps.htm

IDAHO

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Primary Sources of Pollution:
- agriculture
- stream channelization
- streambank modifications

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- streambank stabilization
- fencing

Results:
- decreased sedimentation—more than 200,000 cubic feet of sediment retained on streambank

Streambank Stabilization in the Thomas Fork Watershed:
Photo Monitoring Sells Landowners on Bank Stabilization

Thomas Fork Watershed, Idaho

The Thomas Fork watershed covers 150,100 acres, with 39 percent in Bear Lake County, Idaho, and 61 percent in Lincoln County, Wyoming. The watershed is near where the states of Idaho, Wyoming, and Utah meet and is a subwatershed of the Bear River Basin. Because of the latitude and elevation of the watershed, the area typically has short, cool summers and long, cold winters. The watershed receives about 50 percent of its annual precipitation during the winter months. Most of this precipitation falls as snow and is stored in the snowpack at higher elevations for spring and summer runoff.

Thomas Fork is a tributary to the Bear River and is upstream from the point where the Bear River is diverted into Bear Lake. Bear Lake, which is half in Idaho and half in Utah, is a unique body of water with about 110 square miles of surface area. It contains five endemic fish species. In Idaho the lake has been designated a Special Resource Water.

The designated uses of Thomas Fork are cold water biota and salmonid spawning. The stream is listed among Idaho's 303(d) "water quality limited stream segments." The pollutants the state has identified as contributing to the watershed's water quality problems are sediment, nutrients, and habitat alteration. The primary nonpoint sources of pollutants to surface water are cropland and rangeland, animal feeding areas, riparian areas, stream channelization, and streambank modification.

Streambank stabilization

The Bear Lake Regional Commission, a bistate organization, worked in partnership with the Bear Lake Soil and Water Conservation District, U.S. Department of Agriculture's Natural Resources Conservation Service, and local landowners to reduce the pollutant loading to Bear Lake that comes from the Bear River and Thomas Fork. The Soil Conservation District developed a watershed management plan, funded through an Idaho state agricultural water quality project.

The plan identified 12 critical areas needing treatment. Remediation activities for the first area selected focused on riparian and streambank problems and encompassed 100,842 linear feet. This area was further refined to a 20,000-foot segment of high streambank erosion in the Idaho portion of the Thomas Fork watershed.

The Bear Lake Regional Commission received 319 funding to install a series of best management practices, in partnership with area landowners. The types of practices employed included rock stream barbs, bank shaping and reseeding, tree revetment, rock riprap, channel armoring, fencing, and animal water gaps. The project was successful in treating 4,767 linear feet of streambank, installing 41 rock stream barbs, and installing 2,000 linear feet of permanent fencing.

Decreased sedimentation

The stabilization work resulted in a marked decrease in the amount of sediment entering Thomas Fork. Three types of monitoring techniques were used to measure the results of the stabilization work: photo points, water chemistry, and surveyed stream transects. The stream transects have revealed that for each foot of treated streambank as compared to an untreated site, 50 cubic feet of streambank material was retained on the banks over a 3-year period. This quantity of retained material per foot, when expanded to the entire treated area, amounts to more than 200,000 cubic feet of material retained.

Photo monitoring helped demonstrate the rewards of bank stabilization work to other landowners. As a result, another 4,000 linear feet of streambank is scheduled for remediation in 2001.

ILLINOIS

www.epa.state.il.us/water/watershed/nonpoint_source.html

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Primary Sources of Pollution:
- agriculture (farming operations)

Primary NPS Pollutants:
- sediment

Project Activities:
- sediment-reducing practices (installation of water and sediment control basins, conservation tillage, integrated crop management, livestock exclusion, filter strips, terraces, wildlife habitat management)

Results:
- 90 percent reduction in sediment loading

Lake Pittsfield Project:
Ninety Percent Reduction in Sediment Loading Achieved

Pittsfield, Illinois

Lake Pittsfield was constructed in 1961 to serve as a flood control structure and as a public water supply for the city of Pittsfield. Pittsfield is a western Illinois community of some 4,500 people. The Blue Creek watershed, a 7,000-acre watershed draining into Lake Pittsfield, is predominantly agricultural, consisting primarily of rotational corn and soybean cropland.

Sedimentation was a major water quality problem affecting Lake Pittsfield. Sediment from farming operations, gullies, and shoreline erosion had decreased the capacity of the lake by 25 percent over the past 33 years.

Project design

Based on a thorough analysis of lake problems and pollution control needs conducted under the Clean Lakes Program, project coordinators developed a strategy to reduce sediment transport into Lake Pittsfield. The keystone of the land management strategy was the construction of 29 water and sediment control basins (WASCOBs) throughout the watershed, including a large basin at the upper end of the lake. Funds from the U.S. Department of Agriculture's Environmental Quality Incentive Project, Illinois's Conservation Practices Program, and the Illinois EPA 319 Program supported installation of additional sediment-reducing practices such as conservation tillage, integrated crop management, livestock exclusion, filter strips, terraces, WASCOBs, and wildlife habitat management. Land-based data and a geographic information system (GIS) were used to develop watershed maps of sediment sources and sediment yields.

Monitoring conducted

In 1994 the project was approved for the section 319 National Monitoring Program. Money has been approved until 2004, allowing monitoring to continue for 9 years past installation of the sediment retention basins.

The objective of the Lake Pittsfield section 319 project was to evaluate the effectiveness of WASCOBs in reducing sediment delivery into the lake. Water quality monitoring consisted of tributary sampling after rainstorms to determine sediment loads, pre- and post-project lake water quality sampling (104 Clean Lakes Phase I and II Assessments) at three lake sites to determine trends in water quality, and lake sedimentation rate monitoring to determine changes in sediment deposition rates and patterns.

Key successes and lessons learned

A 90 percent reduction in sediment loading to Lake Pittsfield was achieved through the installation of water and sediment control basins. The large sediment basin covering 147 acre-feet upstream of the lake was more effective, in general, than the smaller basins upstream. The effectiveness of the 29 smaller upland basins was dependent on watershed geology and basin position.

Stream stabilization of Blue Creek was an important component of the overall program to reduce sediment loading to Lake Pittsfield. Installing low stone weirs prevented further channel incision and mass wasting of streambanks.

Strong local partnerships, along with interagency corporation, were key to achieving the desired success of this project.

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Primary Sources of Pollution:
- land development
- channelization
- urban runoff

Primary NPS Pollutants:
- sediment

Project Activities:
- detention basin retrofit
- wetland swale
- sand filters
- shoreline and streambank stabilization
- stream corridor restoration
- native plant installation

Results:
- no impairments due to NPS pollution on 2000 Illinois Water Quality Report

Restoration of the Flint Creek Watershed:
Restoration Partnership Completes Multiple Projects

Lake and Cook Counties, Illinois

The Flint Creek watershed covers approximately 28 square miles of Lake and Cook Counties in northeastern Illinois. The watershed includes several high-quality wetlands and lakes, as well as Flint Creek. The creek was listed in the Illinois Water Quality Report (1994–1995) as being impaired, in part, due to nonpoint source pollution from land development, channelization, and urban runoff. Problems in the watershed included shoreline erosion, streambank erosion, and debris blocking areas of the stream.

In spring 1996 the first of many projects using section 319 funding began in the Flint Creek watershed. The approach of the restoration partnership was to implement several projects to make a difference in the quality of water and aquatic habitats in the watershed. The planners also wanted to involve the community through information and education. The restoration partnership consisted of the Northeastern Illinois Planning Commission, Illinois Environmental Protection Agency, U.S. Environmental Protection Agency, Village of Barrington, Village of Lake Zurich, Lake County Forest Preserve District, Good Shepherd Hospital, Natural Areas Ecosystem Management, Applied Ecological Services, and Citizens for Conservation, a local citizens group.

Urban runoff BMPs

The project involved retrofitting outdated practices and installing new practices to deal with urban runoff. One component involved retrofitting an outdated basin that was no longer effective at handling runoff. Different pools of water were created for settling, as well as a shallow marsh for filtering. An installed walkway created an opportunity for a nearby elementary school to use the basin as a "living classroom," with a place to view aquatic plant and animal life.

A wetland swale was created to remove pollutants and reduce the flow rate of runoff coming from an auto repair shop, landscape nursery, office buildings, and roads. The swale was constructed in a long, linear shape with a forebay where heavier solids would be captured. Sand filters, which were effective in achieving pollution control, were constructed using PVC piping and standard manhole structures connecting the settling chamber and sand filter.

In addition, 250 feet of shoreline and 5,600 feet of streambank were stabilized using a combination of bioengineering techniques such as A-jacks, lunker structures, coir fiber rolls, brush layering, willow staking, and native plant installation. Lunker structures, made of real or recycled plastic lumber, were used to form artificial undercut banks. These structures stabilized the toe of

the streambank and were found to be effective at creating a cover for aquatic habitat. A vegetative zone was created by using A-jacks to stabilize the shoreline and fiber rolls to reduce the effects of wave action. Native plants were then installed in the fiber roll and the newly created zone.

Many impediments to fish migration, including debris blockages and logjams, were removed. Riffles were installed to dissipate stream energy and improve aquatic habitat. Through prairie and savanna restoration, native deep-rooted vegetative communities were used to stabilize the soil and enhance infiltration.

Nonnative woody vegetation had been growing along the banks of Flint Creek, allowing an undercover that was not effective in stabilizing the banks to grow. A combination of techniques, including physical removal, herbicide treatment, and burning, was used to remove the nonnative vegetation. Native plants were installed, and some subsequent reinstallation was necessary. These efforts resulted in stable slopes, vegetated mostly with native species.

The Flint Creek projects were completed at the end of 1999 and will continue to be monitored and maintained. The goals of the restoration planners have been accomplished, and the result is evident in the water quality of Flint Creek. The Illinois Water Quality Report (2000) now lists Flint Creek as having no impairments due to nonpoint sources. Successful restoration came about with the help of both municipalities, as well as some landowners who continue the projects in the watershed. The Flint Creek watershed restoration is an example of how completing multiple projects and educating communities can make a difference in the quality of a watershed today and in the future.

www.state.in.us/idem/owm/planbr/wsm/watershed/NPSplan/NPSManagementPlan.pdf

INDIANA

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Primary Sources of Pollution:
- deforestation for row crops
- livestock access

Primary NPS Pollutants:
- nutrients
- sediment
- high water temperature

Project Activities:
- riparian reforestation

Results:
- planted nearly 300 acres of riparian buffer

Blue River Riparian Reforestation:
The Nature Conservancy Gets Landowners Involved

Washington, Crawford, and Harrison Counties, Indiana

The Blue River originates in Washington County, Indiana, and flows south to form the natural boundary between Crawford County, Indiana, and Harrison County, Indiana, continuing south to the Ohio River. The Blue River has been designated a State Natural and Scenic River and is a favorite recreation site in Indiana. The river is home to many globally rare fish and mussels. The southern fork of the Blue River flows through the Harrison Crawford State Forest, and the river also flows near Wyandotte Caves. Much of the northern part of the river was located in a primarily agricultural area, which was cleared of riparian forest to make way for row crops and livestock access. The problems that resulted include reduced bank stabilization and lack of filtration of nutrients. The lack of shading and higher turbidity have also caused the temperature of the water to rise.

Role of The Nature Conservancy

In 1997 the state of Indiana provided $34,865 of section 319 dollars to The Nature Conservancy to replant the riparian forest and to educate the community on its purpose, progress, and results. The Nature Conservancy brought a large group together for the project, including landowners, Friends of the Blue River, Harrison County Cattlemen's Association, U.S. Department of Agriculture's Natural Resources Conservation Service, Washington County Farm Bureau, Indiana University Southeast, University of Louisville, and Indiana Department of Natural Resources Division of Forestry. This group began in 1994 to coordinate a comprehensive river conservation approach.

The Nature Conservancy placed the project in the hands of a coordinator, Allen Pursell, with the goals of aiding landowners in riparian reforestation, teaching reforestation best management practices, and publicizing its work. The group advertised its intent to aid landowners in reforesting portions of their land through local papers, a field day, and one-on-one contact with landowners. Personal contact proved to be the most successful method, and seven landowners agreed to implement riparian reforestation.

By the end of the contract, The Nature Conservancy, with the help of the seven landowners and a professional forester, had planted 72.1 acres along the corridor of the Blue River with 56,000 trees. These acres translated to 3.1 miles of corridor reforestation. Tree species planted included bur oak, shumar oak, black walnut, yellow-poplar, swamp white oak, white ash, and black cherry. The landowners agreed at the start of the contract to enroll each area as a Classified Forest if it qualified for the program; of the seven, five have qualified.

Sharing lessons learned

During the course of this first grant, The Nature Conservancy learned the best ways to involve landowners, to plant trees at a high density for best results, and the importance of keeping weeds out of seedling areas. They have shared this knowledge with many other groups with interest in riparian reforestation. They also shared their lessons learned by sponsoring a field day on tree planting for government and private sector conservation practitioners. All attendees planned to begin a riparian tree planting program in their areas.

Indiana has given The Nature Conservancy a second 319 grant for Blue River riparian reforestation. Under this new grant, which started in August 1999, The Nature Conservancy has signed on 13 landowners. They have also planted 103 acres of riparian buffers, representing 4.3 miles of riparian zone. All planted lands have completed or are going through the process of enrollment in the Classified Forest or Classified Riparian Land program, which allows landowners tax breaks and periodic free inspections by a professional forester on at least 10 acres of private land that has been left or restored to forest. In Washington County, 4,000 feet of fencing was placed on a dairy farm to exclude the livestock from the Blue River. The riparian area just outside the fence was planted with native hardwoods and is going through the classification process. To date, a total of almost 300 acres of land has been planted.

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Primary Sources of Pollution:
- agriculture (spray irrigation of lagoon water, agricultural cultivation, chemical application to crop field, storm events)

Primary NPS Pollutants:
- nitrates
- phosphorus
- total suspended solids

Project Activities:
- constructed wetland system

Results:
- reduction of more than 60 ppm in nitrate concentrations
- improved wildlife habitat

Little Pine Creek and Indian Watersheds:
Constructed Wetland System Averts Agricultural Nonpoint Source Pollution

Tippecanoe County, Indiana

Throughout the Indian and Little Pine Creek watersheds, the concentrations of nitrates, phosphorus, and total suspended solids in the stream water are among the highest in the nation. The largest inputs of chemicals to streams occur from March through June, corresponding to spray irrigation of lagoon water, agricultural cultivation, chemical application to crop fields, and storm events. Because these pollutants reach agricultural ditches via overland flow and tile drain systems, best management practices that can reduce pollutant levels without significantly interrupting drainage of cropland or converting cropland to other uses are needed.

Filtering pollutants

In 1999 the Department of Forestry and Natural Resources at Purdue University used 319 funding provided by Indiana to construct an experimental wetland system to remove nonpoint source pollutants from agricultural ditches before the pollutants reached the more natural parts of Little Pine Creek and the Wabash River. Agricultural ditch water is pumped through a series of wetlands to filter out the pollutants and is then returned to the ditch.

Monitoring results

Although the effectiveness of this wetland system in reducing nonpoint source pollution is still being assessed, follow-up monitoring results are variable but promising. Preliminary results show a reduction of more than 60 parts per million in nitrate concentration in the water treated by the system after an intense rain event. The reduction in nitrate concentration varies depending on spray irrigation timing and rainfall. Monitoring the success of this project in terms of the nonpoint source pollution mitigation continues. Various wildlife species, including reptiles and amphibians, birds, and mammals, have colonized the wetlands, showing their value as habitat.

This project has been successful in another important way—increasing the awareness of the public and the next generation of environmental stewards about nonpoint source pollution. Since its inception, the project has provided many opportunities for individuals and classes to get involved in designing and constructing the wetlands and evaluating their effects on water quality, habitat, and wildlife.

www.state.ia.us/epd/wtrq/npsource/nonpt/nps_0900.htm

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Primary Sources of Pollution:
- agriculture
- cattle watering

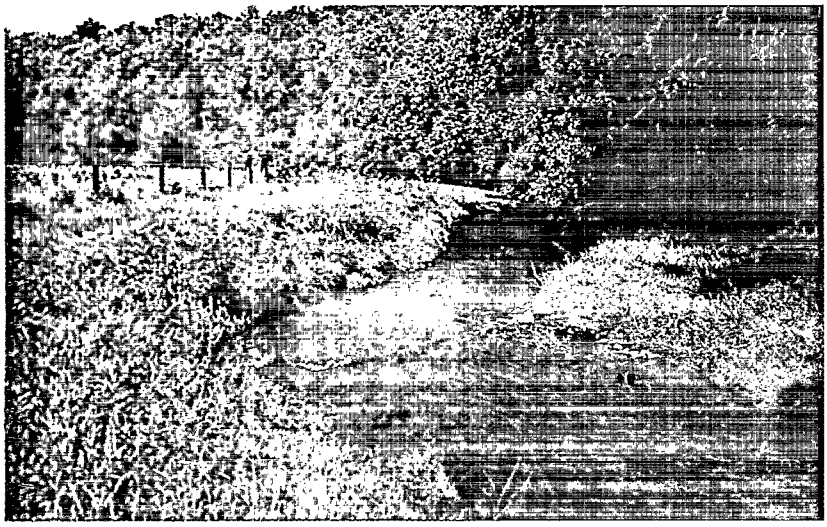
Primary NPS Pollutants:
- sediment

Project Activities:
- cattle exclusion
- stream corridor improvements
- sediment basins
- innovative farming practices

Results:
- reduction of 12,285 tons of soil delivery into Bigalk Creek (projected future reductions of 5,000 tons/year)
- livestock manure reduced by 50 percent
- rebound of rainbow trout population, including natural reproduction

Bigalk Creek Watershed Project:
Rainbow Trout Population Rebounds

Howard County, Iowa



A stream corridor restoration and watershed improvement project reduced nutrient and sediment delivery to Bigalk Creek.

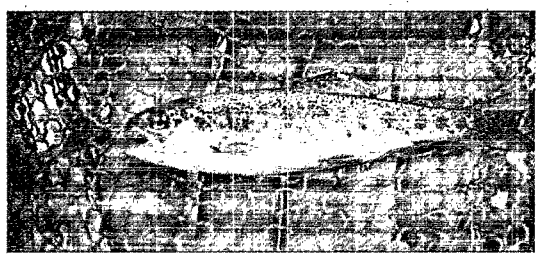
Bigalk Creek in northeast Iowa historically has been used for watering cattle. As a result, streambanks along the creek were severely degraded, causing extremely high sediment delivery from streambank erosion.

The Iowa Department of Natural Resources (using section 319 funds), the Iowa Department of Agriculture and Land Stewardship, and the Natural Resources Conservation Service partnered in a 5-year effort (from 1995 to 1999) to reduce erosion in the watershed, hoping to also increase the rainbow trout concentration.

Cattle exclusion and BMPs to reduce soil erosion

The first major step in the Bigalk Creek watershed project involved fencing cattle off a primary stretch of the stream where most of the trout stocking takes place. Nose pumps were used to provide water for the cattle while keeping them away from the streambank. The project then focused on a subwatershed of 3,140 acres closest to the 1.2 miles of stockable stream and complete restoration of the stream corridor by the Iowa DNR, which included reshaping the streambank, installing rock riprap, constructing fish hides, and reseeding the bank.

Improvements to the stream corridor were augmented by preventive measures in the watershed to reduce erosion. Practices used to achieve sediment delivery reduction goals included grade and stream stabilization, strip cropping, sediment basins, no-till, grass waterways, and grass/legume



A naturally spawned rainbow trout from Bigalk Creek. Iowa DNR fisheries biologists now consider the creek Iowa's most productive stream in terms of natural rainbow trout reproduction.

rotation. These practices are targeted at protecting the integrity of stream restoration work accomplished.

Rebounding trout population

The Bigalk Creek project demonstrated the feasibility of several new and innovative resource management systems. Major accomplishments include reducing sediment delivery to the creek by 50 percent, reducing the amount of livestock manure reaching the stream by 50 percent, and reducing the amount of sediment from streambank erosion by 60 percent. Erosion was reduced by 12,285 tons of soil in the Bigalk Creek watershed during the project. It is estimated that if current sediment control structures remain in place, erosion will be reduced by more than 5,000 tons a year in the future.

The rainbow trout population has also made a comeback. Bigalk Creek has now become only the third stream in Iowa with documented natural reproduction of rainbow trout.

www.state.ia.us/epd/wtrq/npsource/nonpt/nps_0900.htm

IOWA

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Primary Sources of Pollution:
- agriculture
- failing septic systems

Primary NPS Pollutants:
- sediment
- pesticides
- nutrients
- bacteria

Project Activities:
- agricultural BMPs
- sediment control basins, ponds, and constructed wetlands
- septic system upgrades

Results:
- sediment reduced by 60 percent
- nutrients, pesticides, and organic materials reduced by 50 percent
- bacteria reduced by 50 percent

The Lake Fisher Water Quality Project:
Chipped Tires Help Protect Public Water Supply

Bloomfield, Iowa

When the 100-acre Lake Fisher reservoir was constructed in 1936 as a Works Progress Administration (WPA) Project, it was to serve a purely functional purpose as a water supply for local residents. Today, that reservoir has the capacity to hold 326 million gallons of water, making Lake Fisher the primary source of drinking water for the 3,100 residents in and around the city of Bloomfield in southeast Iowa. Over time, Lake Fisher has also become a notable fishery and home to Iowa's state record largemouth bass.

Originally 12 to 15 feet deep, the southwest leg of the lake is now only 3 to 5 feet deep because of soil erosion from the lake's watershed. This portion of the lake has silted so extensively that it can no longer handle drainage from the land above it. During heavy precipitation, this portion of the lake fills until water spills onto the road, closing South Lake Fisher Drive. The water draining from 1,380 acres of land in Lake Fisher's watershed deposits an estimated 2,100 tons of sediment each year to the reservoir.

Treating the public water supply also is becoming more challenging because of the sedimentation of Lake Fisher. Often attached to the particles of dirt are pesticides and nutrients that can degrade the quality of water in the lake. Water quality is also hampered by the presence of bacteria from private sewage disposal systems that simply don't work as well as intended because of the soil characteristics of the watershed.

Tom Sperfslage, Lake Fisher Watershed Project Coordinator, handles chipped tire used to upgrade 19 private household septic systems in the watershed.

Partnership for land management

The Lake Fisher project is a partnership that provides governmental funding and assistance to local farmers, landowners, and residents who want to improve the quality of their drinking water supply now and in the future. Beginning in 1998, the 3-year watershed protection project has used funding from various sponsors (including 319 funding, the Water Protection Fund administered by the Iowa Department of Agriculture and Land Stewardship, and the City of Bloomfield) to fund structural improvements on properties designed to reduce the amount of sediment flowing into the lake.

Project activities include treating more than 900 acres of agricultural land with a combination of terraces, water and sediment control basins, ponds, and constructed wetlands. The project also includes nutrient management, whole farm planning, manure management, bank stabilization, and abandoned well plugging.

An innovative approach to upgrading private septic systems was also used, resulting in 19 of the 22 failing systems (86 percent) in the watershed being improved to meet the Iowa Administrative Code. Although the original goal of the project was to upgrade five systems during the life of the project, this number was greatly increased because of a grant of nearly $83,000 from the Waste Management Division of the Iowa Department of Natural Resources. Through this grant, chipped tires were used as aggregate in the secondary treatment portions of the new systems installed. In all, more than 300 tons of chipped tires were used as part of the project for septic systems. Monthly samples are being collected over the next 2 years to measure the treatment efficiency of the chipped tire medium.

Results of project activities

Preliminary results show that all three of the project's original goals have been met. As a result of implementing agricultural best management practices, the sediment load reaching Lake Fisher has been reduced by 60 percent. The amount of nutrients, pesticides, and organic materials flowing into the lake has been reduced by 50 percent. As a result of septic system improvements, the amount of bacteria delivered to the lake has also been reduced by 50 percent. Meeting these objectives will improve the quality of Lake Fisher for the more than 3,100 people who rely on it for drinking water.

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Primary Sources of Pollution:
- agriculture

Primary NPS Pollutants:
- sediment

Project Activities:
- dredging
- soil conservation BMPs

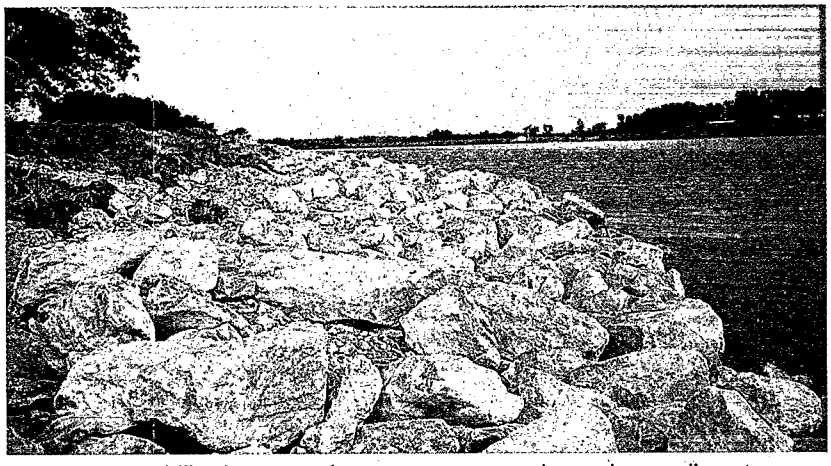
Results:
- sediment delivery reduced by 66 percent
- life expectancy of lake extended by more than 100 years

Pine Creek Water Quality Project:
Life Expectancy of Pine Lakes Extended

Hardin County, Iowa

By the early 1990s, the water in the Pine Lakes might have been murky, but the eventual fate of the two lakes was unmistakably clear. If nothing was done, the Hardin County lakes created more than a half century ago by impounding water from Pine Creek would eventually choke to death on the rich Iowa soil of the watershed. The degradation had even reached the point where it could be quantified on the 75-acre Upper Pine Lake: in 1991 studies indicated that Upper Pine Lake would be completely filled with sediment in less than 45 years. Lower Pine Lake, Iowa's first man-made, state-owned lake, had also lost nearly half of its original volume.

Doing nothing was not an option. The Pine Lakes and the surrounding 572-acre state park draw some 500,000 visitors annually.

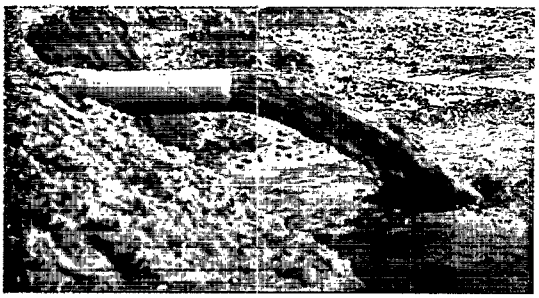


Streambank stabilization was a key component used to reduce sediment delivery at Pine Lakes.

Combined efforts to reduce sediment delivery

From 1993 to1998, the Pine Creek Water Quality Project, through the leadership of the Iowa Department of Natural Resources (DNR), undertook a monumental effort to reduce sediment in the Pine Lakes. Through intensive dredging of the Lower and Upper Pine Lakes, DNR set out to increase the volume of the lakes and restructure the bottom for better fishing habitat. In 1997 DNR removed more than 179,000 cubic yards of sediment from the two lakes. Dredging increased the average depth of 5 to 7 feet in Upper Pine Lake to 12 to 14 feet throughout a large portion of the lake. Lower Pine Lake now has a depth of approximately 15 feet in its west end, compared to 8 to 10 feet before the dredging.

Dredging alone, however, would result in treating only a symptom of the overall problem. The effort to take accumulated sediment out of the lakes would be worthwhile only if the amount of soil coming in could be significantly reduced. By implementing a variety of soil conservation measures on their land, farmers in the watershed have helped to reduce the amount of sediment flowing into the Pine Lakes. Practices like streambank stabilization, terracing, no-till and contour farming, and critical area seeding have all made a positive difference in the watershed.



A total of 180,000 cubic yards of sediment was dredged from Pine Lakes as part of a comprehensive project that targeted watershed protection and lake renovation.

Extended life expectancy

Overall, the Pine Creek Water Quality Project has reduced the amount of sediment coming into the lake by more than 4,000 tons per year, a 66 percent reduction. Not only is the water cleaner for swimming and fishing, but the watershed improvements and dredging have also extended the life expectancy of Upper Pine Lake alone by more than 100 years.

The Pine Lakes are an excellent example of a combined resource enhancement and protection effort by the Iowa DNR. But the success of this project would not have been possible without the work and commitment of dedicated landowners in the watershed. In addition to 319 support, project sponsors included the Iowa Publicly Owned Lakes Program, U.S. Department of Agriculture Water Quality Incentive Program, Iowa Financial Incentive Program, Emergency Conservation Program, Section 314 Clean Lakes Program, and local Friends of Pine Lake organization; Marine Fuel Tax funds were also used to support the project.

KANSAS

www.kdhe.state.ks.us/nps/index.html

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Primary Sources of Pollution:
- golf course maintenance
- urban storm water

Primary NPS Pollutants:
- pesticides
- nutrients

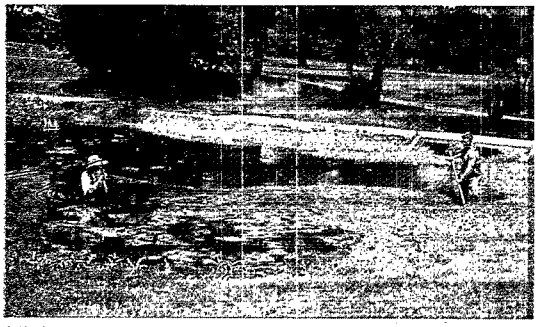
Project Activities:
- modified chemical applications
- buffers
- rerouting drainage patterns

Results:
- pesticides eliminated
- reductions in nitrates (80%) and total phosphorus (40-60%)
- improvements in macroinvertebrates

Braeburn Golf Course Project:
Nitrates Reduced by More Than 80 Percent

Wichita, Kansas

Improving the water quality at Braeburn Golf Course began as part of a larger project looking at urban runoff and its effects on nonpoint source pollution. This 319-funded project was initiated through an agreement between the Kansas Department of Health and Environment and Wichita State University (WSU). The project commenced in 1997 with sampling of water quality conditions at 13 sites, including public parks, urban lawns and streets, a row crop agricultural site, and two golf courses, one of which was Braeburn. The objective was to identify areas with contaminated runoff coming from them and then implement best management practices (BMPs) to determine the BMPs' effectiveness in reducing nonpoint source pollution. A number of parameters commonly associated with urban storm water, including pesticides and nutrients, were the focus of monitoring.



High nutrient levels cause algae blooms, which reduce the amount of dissolved oxygen available to fish and other aquatic creatures.

Of all the sites tested, Braeburn Golf Course showed the most significant contamination and presented itself as an optimal site for BMP implementation. Excessive amounts of nutrients in the

Wetlands were created to catch runoff water and reduce the nutrients entering the ponds.

form of nitrates and total phosphorus were found in the ponds, prompting the growth of excessive aquatic vegetation and algae blooms. The golf course superintendent had reported fish kills in the past, likely due to the biodegradation and subsequent oxygen depletion caused by these algae blooms. Periods of elevated pesticide contamination were evident, typically in the spring and early summer during major application times, and herbicides had caused violations of water quality criteria during those times. In addition, the algaecide copper sulfate was being used to control algae blooms. Copper sulfate can have extremely toxic effects on aquatic organisms, especially when found in combination with various pesticides. An assessment of macroinvertebrates revealed that only a few tolerant organisms inhabited the ponds.

Alterations in golf course maintenance

Because of these circumstances, researchers at WSU selected Braeburn as the site for BMP implementation. In cooperation with golf course superintendent Kent Trexler, various alterations to golf course maintenance procedures were imposed. Chemical application procedures were modified, using slow-release fertilizers and applying chemicals at a reduced rate. Thirty-foot buffer zones in which no chemicals were applied were established around the perimeters of the ponds on the golf course, increasing grass density and biomass to aid filtration of runoff. The use of copper sulfate for algae control was discontinued; instead, biological controls (grass carp), as well as aquatic dye to act as a photoinhibitor to the algae, were used. Rainwater drainage patterns also were changed to route runoff into filtration areas, not directly into the ponds as done previously.

Water quality improvements

Post-BMP water sampling, conducted for more than a year in two ponds at Braeburn, revealed that nitrates were reduced by more than 80 percent and total phosphorus values dropped by 40 percent and 60 percent in the two ponds. In addition, contamination from pesticides was all but eliminated. An assessment of macroinvertebrates showed an increase from 5 families collected before BMP implementation to 16 families sampled following BMPs, along with a shift from tolerant organisms to those more sensitive to water quality such as mayfly, butterfly, dragonfly, and damselfly larvae. These improvements in macroinvertebrate family richness provide biological evidence that BMPs are improving water quality conditions on the golf course.

A backhoe removed accumulated sediment from the pond in an effort to improve aquatic habitat and control future algae blooms.

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Primary Sources of Pollution:
- failing on-site wastewater treatment systems

Primary NPS Pollutants:
- nutrients
- fecal coliform bacteria
- total suspended solids (TSS)

Project Activities:
- constructed wetlands

Results:
- decreased concentrations of TSS, fecal coliform bacteria, biochemical oxygen demand, ammonia, phosphorus

On-site Sewage Disposal on Difficult Sites:
Special Conditions Demand Alternative Response

Southeastern Kansas

Many of the soils in Kansas present challenges to the on-site disposal of domestic wastewater. When site evaluations reveal shallow or heavy clay soils, bedrock close to the surface, or other limiting conditions, alternatives to conventional septic tank lateral fields are needed to provide adequate treatment and disposal of the wastewater. Constructed wetlands are a relatively inexpensive technology to achieve this. Although constructed wetlands have been successfully used in other states, the Kansas Department of Health and Environment (KDHE), which is responsible for the on-site wastewater program, funded the installation of some demonstration systems that were monitored for 2 years to verify their effectiveness in the midwestern climate.

In cooperation with the See-Kan Resource Conservation and Development District, which covers nine counties in southeastern Kansas, three home sites with failing wastewater systems were identified. The sites were characteristic of the shallow, heavy clay soils that predominate in the area, and the homeowners were willing to participate in the demonstration with the hope that the data would assist others having similar problems. KDHE designed the constructed wetlands systems, which were installed in spring 1994. The design and construction included easily accessible sampling ports to monitor the quality of the effluent at various locations throughout the treatment cell.

Evaluation of monthly sampling results, conducted for 2 years by students from Pittsburg State University, showed significant reductions in all of the parameters analyzed. As a result of this demonstration project, additional constructed wetlands have been installed throughout the state. Several hundred people, including sanitarians, homeowners, conservation district personnel, contractors, and other interested parties, have attended tours of the sites to observe the systems firsthand. Two manuals have been written: *Rock-Plant Filter Design and Construction for Home Wastewater Systems* and *Rock-Plant Filter Operation, Maintenance, and Repair*. Now in operation for 6 years, the original demonstration projects are all thriving and the homeowners are thrilled to have solved their wastewater disposal problems.

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Primary Sources of Pollution:
- agriculture (livestock)

Primary NPS Pollutants:
- sediment
- nutrients
- pathogens

Project Activities:
- alternative livestock exclusion practices (pumps, electric fencing)

Results:
- monitoring in progress

Elkhorn Creek BMP Demonstration Project:
Farmers See Water Supply Alternatives in Action

Fayette, Franklin, Scott, and Woodford Counties, Kentucky

Elkhorn Creek drains 311,000 acres in Fayette, Franklin, Scott, and Woodford Counties in Kentucky. At one time, the stream was ranked among the best in the nation for smallmouth bass fishing. It continues to be a valuable recreational resource and has provided an emergency source of drinking water during prolonged summer droughts.

The Elkhorn Creek watershed has been identified as impaired due to sediment, nutrient, and pathogen loading from nonpoint and point sources of pollution. Livestock production is important in the watershed and potentially contributes a significant part of the nonpoint source pollutant loading. Direct access of livestock to streams in the watershed contributes to the stream degradation. This degradation affects water quality, aquatic habitat, and recreation activities. Primary contact recreation (swimming) and warm water aquatic habitat uses are being adversely affected in much of the watershed.

Livestock management alternatives

Often, traditional methods of excluding livestock from streams and providing livestock water supply are not cost-effective or practical. However, promising fencing systems and water supply alternatives are available. The principal objective of this project is to demonstrate to farmers four alternatives for managing livestock: the ram pump; the pasture pump (cattle-activated pump); the solar-powered water pump; and use of limited-access watering points, using modern electric fencing components.

The solar-powered livestock watering system excludes livestock from the stream by using a solar-powered electric fence charger. So far, solar pump system performance has been very good. In full sunlight, the system pumps about 180 gallons per hour. The pasture pump (or nose pump) is a cow-activated diaphragm pump, reputed to be quite dependable. Use of this pump is limited, however, because the pump can't be used when temperatures are below freezing. Another demonstration farm uses a limited access watering point, using modern electrified water gaps. This type of system reduces but does not eliminate livestock access to a stream.

These systems have the potential to protect stream quality while providing a cleaner, safer water supply for livestock. To facilitate acceptance of the new management practices, four demonstration farms were located in the watershed. Because this project emphasizes use of nontraditional best management practices (BMPs), the use of field days as an educational tool is very important and is an integral part of the project.

Results in progress

Monitoring of changes in water quality and habitat resulting from the use of BMPs is ongoing. One year of stream data was collected for each of four demonstration farm sites before installation of BMPs, and 2 years of post-BMP data are to be collected. Parameters measured include total Kjeldahl nitrogen, NO_2-NO_3 nitrogen, ammonia, total phosphorus, water pH, temperature, conductivity, turbidity, and fecal coliform bacteria. Monitoring is conducted at upstream and downstream stations at each site.

The demonstration sites have provided opportunities for local farmers to share their experiences with alternative technologies for providing livestock water and to encourage their neighbors to consider the benefits of reducing livestock access to riparian areas. The use of local examples has proven very effective in promoting nontraditional farm practices. The project is already considered a success in that it has resulted in more adoption of rotational grazing and livestock exclusion from the creeks in the project area and even outside the project area.

LOUISIANA

http://nonpoint.deq.state.la.us/nonpoint.html

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Primary Sources of Pollution:
- agriculture (croplands)

Primary NPS Pollutants:
- sediment
- organic loads

Project Activities:
- GIS map of land use classifications

Results:
- agricultural watershed model to identify "hot spots" of high pollutant loading and predict BMP effectiveness

Bayou Plaquemine Brule:
Louisiana Applies Satellite Imagery to Watershed Planning and Management

Bayou Plaquemine Brule, Louisiana

As states continue to implement watershed planning and management strategies, several analytical tools are necessary to classify the types of land use present in each watershed. One tool that has become important for Louisiana's Nonpoint Source Management Program is satellite imagery. The images provide so much detail on the watershed that the people involved with developing management strategies, educational programs, monitoring designs, or mathematical models can clearly see what needs to be done. The maps are also very important for educating farmers, landowners, and public officials about what a watershed is and the complexity of land use patterns. The visual image seems to provide a basis for all of the people involved in watershed planning and management to begin to understand what steps will be necessary to implement best management practices (BMPs) and reduce nonpoint source pollution loads that are affecting water quality.

Pilot watershed project

The pilot watershed project where this geographic information system (GIS) tool was initially used was Bayou Plaquemine Brule, a bayou that flows through the Mermentau River Basin in southwestern Louisiana. This is rice and crawfish country, rich in Cajun heritage and traditions that have existed since the 1700s. Bayou Plaquemine Brule is on the state's 303(d) list of impaired waters and is not meeting the designated uses for fishing or swimming. The high sediment and organic loads that enter the water body each spring affect the dissolved oxygen concentrations and cause the water body to fail to meet water quality standards. The Louisiana Department of Environmental Quality (LDEQ) prioritized the Bayou Plaquemine Brule for a Total Maximum Daily Load (TMDL) in 1998 and completed all of the sampling and modeling involved to develop the

TMDL by December 1999. The results of the TMDL study indicated that a 50 percent nonpoint source load reduction was needed in the upper tributaries of the bayou and a 30 percent load reduction was needed in the main stem.

Application of GIS to land use classification

To allocate this pollutant load to the various types of land uses or crops in the watershed, more detailed information was needed on land use patterns. LDEQ's GIS Center agreed to tackle this complicated task by purchasing and classifying Landsat 5 Thematic Mapper satellite imagery of Bayou Plaquemine Brule. Before the imagery could be classified, a multi-temporal data set had to be created from three separate scenes of source satellite imagery. The resultant data set was classified, producing a map of Bayou Plaquemine Brule that contains land use data for all of the major crops grown in the watershed during the 1998 growing season. This map was the result of a year of coordinated effort among numerous individuals and included extensive amounts of both lab and fieldwork. Furthermore, interagency cooperation was essential to the success of this project and resulted in a maximization of all available resources. Agencies involved included the Louisiana Department of Environmental Quality; the Louisiana Department of Agriculture and Forestry, Office of Soil and Water Conservation; the U.S. Department of Agriculture (Farm Service Agency and Natural Resources Conservation Service [NRCS]); the Acadia Parish Soil and Water Conservation District; and the St. Landry Soil and Water Conservation District.

Watershed modeling and monitoring

Once the land use classification was completed, LDEQ's Nonpoint Source Unit began work with the NRCS and the Agricultural Research Service on an agricultural watershed model called AnnAGNPS. *This watershed model is being used* to predict the amount of water and sediment transported through the watershed and to assist in identifying "hot spots" of high pollutant loading. The model also allows LDEQ to predict the effectiveness of BMPs that have been recommended for reducing pollutant loads to the bayou from rice, sugarcane, and crawfish farms. The result is that LDEQ is now working with Louisiana State University's Agricultural Center, NRCS, and the local Soil and Water Conservation District on a comprehensive watershed implementation strategy that will be implemented over the next 3 years. The water bodies will be carefully monitored as BMPs are implemented to track the water quality response to implementation of the practices. As these data are collected, they will be shared with the farmers so that they can know whether their efforts have been successful. Local meetings with the farmers are being held to inform them of the watershed effort and ask for their support.

Future activities

LDEQ has prioritized five additional watersheds for this type of intensive watershed planning and management. Each of the watersheds is in a different part of the state, where the soils, hydrology, land use patterns, and water bodies function differently. The goal is to have a broad database that can be used throughout the state and guide future watershed planning and management in each of the watersheds where the water body is not fully supporting the designated uses. This type of comprehensive watershed planning effort requires many partners, including local universities, educators, landowners, and resource agencies, but it results in an effective process for understanding how watersheds function and how water bodies can be improved through long-term management.

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Primary Sources of Pollution:
- agriculture (cropland, pastureland)

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- grade stabilization structures

Results:
- soil loss savings of 4,120 tons

Flat River and Red Chute Bayou Watersheds:
BMPs Reduce Soil Loss

Flat River/Red Chute Bayou, Louisiana

Land use in the Flat River and Red Chute Bayou watersheds consists of 25,515 acres of agricultural cropland, 29,348 acres of pastureland, and about 50 farms with an average size of 200 acres. The 1998 National Water Quality Inventory (305(b) report) indicates that the two waterbodies only partially meet their designated uses because of nutrients, siltation, organic enrichment, habitat alteration, and pathogen indicators. Soil erosion is a major problem in the watershed, as well as nutrients related to fertilizer usage.

A 319 project was initiated in the watershed to address the impacts of soil erosion. For this project, 1,100 acres of pastureland and 600 acres of row cropland were selected to install grade stabilization structures and implement best management practices (BMPs). Education regarding land-use practices was also emphasized through field days, agency cooperation, and spreading the word through the farm community to influence other landowners in the watershed to use these practices.

Installing grade stabilization structures and implementing BMPs have significantly reduced soil loss to the watershed. The reduction of soil loss for this project was calculated using the Revised Universal Soil Loss Equation. The result was a soil loss savings of 4,120 tons. Stabilization structures alone saved 595.4 tons of soil; 2,589 tons of soil were saved on pastureland; and 936 tons of soil were saved on the row cropland.

The project will continue until September 2001 and will add four new grade stabilization structures and BMPs on more pastureland and cropland. In addition to the 319 project, other programs have addressed environmental concerns in the watersheds. The Environmental Quality Incentives Program (EQIP) encompasses 5,077 acres, and the Wetlands Reserve Program (WRP) encompasses 3,500 acres in the watersheds. These two watersheds are scheduled for data collection through the 5-year basin cyclic monitoring program in 2002.

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Primary Sources of Pollution:
- urban runoff
- erosion

Primary NPS Pollutants:
- phosphorus
- sediment

Project Activities:
- erosion control training and BMPs

Results:
- reduction of 14.3 pounds of phosphorus in the first year

Highland Lake Watershed Project:
Hotspots Model Links Land Use and Water Quality

Bridgton, Maine

Like many lakes in southern Maine, Highland Lake has experienced a long history of adverse watershed development patterns. Highland Lake is a picturesque, blue water lake in the foothills of the White Mountains of western Maine. The 1,300-acre lake is the centerpiece for the town of Bridgton, Maine. The watershed was developed in stages: the expansive farm fields of the 1800s gave way to reforestation and second homes in an odd combination of old land uses and new development patterns. Since the early 1900s, 10 miles of shoreline frontage have been developed. Access roads were designed and built at a time when eroding roads were not believed to be pollution sources. Although much of the land remains forested, geographic information system (GIS) studies showed that existing developed areas accounted for 70 percent of the phosphorus reaching the lake.

The development patterns have affected the lake's water quality. Currently, the Lakes Environmental Association (LEA), a nonprofit conservation group, considers the lake at risk for developing algae blooms. Long-term monitoring data indicate the lake is threatened with gradual declines in water clarity and dissolved oxygen. A persistent loss of oxygen would reduce or eliminate trout habitat. In the lake's deeper waters, phosphorus is recycling in the bottom sediments. Increases in phosphorus levels could lead to significant declines in water quality and aquatic habitat. Reductions in water quality could lead to financial problems as well: recent studies by the University of Maine and the Maine Department of Environmental Protection (DEP) show a direct relationship between high lake water clarity and higher property values. Concerns have been raised that property values along Highland Lake's shoreline, currently valued at $17 million, could decrease if the lake's water quality worsens.

Reducing phosphorus and sediment

These concerns prompted LEA to carry out an intense, 3-year section 319 project (January 1997 to March 2000) to control and reduce pollution impacts on the lake. As a first step, LEA used DEP's phosphorus loading methodology to determine a phosphorus reduction goal for the watershed. It was estimated that a reduction of 50 pounds of phosphorus per year would result in a noticeable improvement in water quality.

LEA then used GIS technology and its "Phosphorus Hotspots Model" to assess the watershed. The model overlays land use information (GIS coverage) with phosphorus export coefficients for each land use, adjusted for soil type, slope, and zones of proximity to the lakeshore or shorelines of tributaries. "Our model represents an automated way of applying common sense principles of phosphorus

export in order to better understand the effects of a watershed's land use patterns on water quality," explains Peter Lowell, Executive Director of LEA.

As an adjunct to this method, LEA conducted a field survey of secondary roads under deluge-like storm conditions. Observing areas under a worst-case scenario helped to identify erosion sites and offered ideas regarding which management practices would be most effective.

Throughout the project, LEA collaborated with volunteers and key organizations, especially Portland Water District and DeLuca-Hoffman Associates, along with the Town of Bridgton, the Town of Sweden, Maine DEP, and EPA. LEA worked with its partners to encourage, design, and construct "fixes" using a multifaceted approach.

Under the project's Clean Lakes Check-Up program, LEA assisted property owners with a wide range of storm water runoff and erosion problems. Upon request, LEA conducted site visits and developed field reports and detailed erosion control plans. In total, 42 Clean Lake Check-Ups were performed.

Erosion Control Workshops, focusing on camp road maintenance, shoreline buffer strips, and a wide range of erosion control techniques, were held over three seasons. LEA and Maine DEP staff also provided training on the latest erosion control techniques to earth-moving contractors, resulting in the certification of 17 contractors. In addition, LEA worked closely with the CEO from the Town of Bridgton to assist code enforcement officers in preventing and addressing shoreline violations. LEA worked closely with contractors on a variety of sediment problems related to roads and riparian buffers, resulting in the installation of best management practices (BMPs) at 19 key site locations.

Encouraging results

After the BMPs were installed, LEA recalculated the Hotspots maps in consultation with engineering staff from Deluca-Hoffman Associates. The difference between the preconstruction and postconstruction phosphorus export represented the reduction in phosphorus export as a result of BMP construction. It was found that the BMPs installed under this one project accounted for a reduction of 14.3 pounds of phosphorus. LEA will continue to work with the community on a long-term program to achieve phosphorus reductions closer to the 50 pounds per year goal.

LEA, Maine DEP, and EPA New England are encouraged by the overall results of the Highland Lake project. In April 2000 EPA New England presented LEA with an EPA Merit Award for its 30-year history of exceptional work and its efforts on the Highland Lake project. Peter Lowell recapped the project's success: "The project significantly raised awareness among all interest groups in the watershed. The ability to quantify the water quality impact of BMPs will continue to be a powerful tool in encouraging ongoing efforts to protect this lake and many others."

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Primary Sources of Pollution:
- agriculture (crops)
- farm access roads

Primary NPS Pollutants:
- sediment

Project Activities:
- erosion control/land use practices (diversion ditches, culverts, sediment pond, ditches/road improvements, buffers)

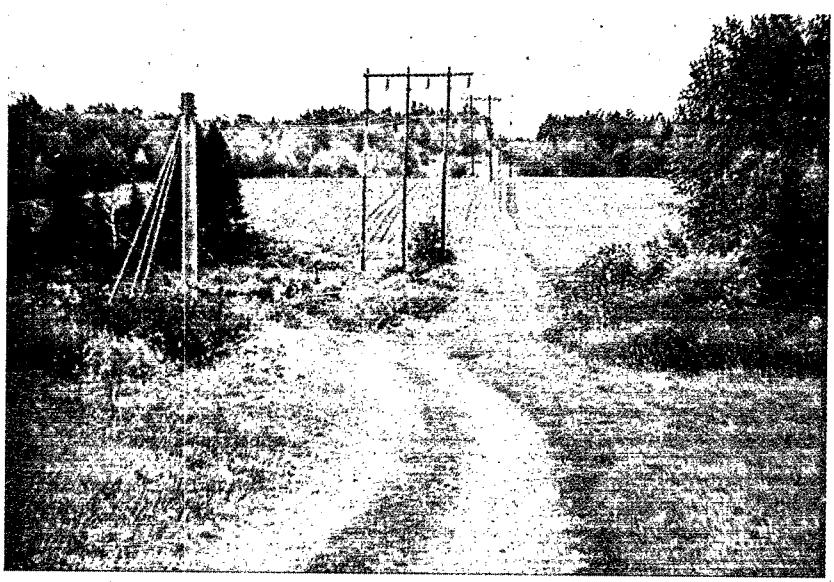
Results:
- decreased turbidity readings
- improved recreational opportunities
- improved native brook trout habitat

Silver Spring Brook Watershed Demonstration Project:
Landowners' Cooperation Plus Town's Commitment Equals Success

Limestone, Maine

The Silver Spring Brook watershed encompasses about 1,400 acres, 42 percent of which are cropland. The remaining acreage is either forested or in the Conservation Reserve Program. Over the years, the stream's water quality had become degraded to the point of being almost unusable. Field roads, ditches, stream crossings, and sections of some fields were identified as significant contributors to the stream's degradation.

Silver Spring Brook had threefold value to the town of Limestone: it was the town's drinking water supply, a cold-water habitat for native brook trout, and the feeder for the community swimming area. Heavy sedimentation resulted in high raw turbidity readings, exceeding federal drinking water standards, threatening the cold-water habitat for native brook trout, and endangering the town's only recreational swimming area.



Runoff from farm roads caused excess sediment to enter Silver Spring Brook.

Cooperation of landowners

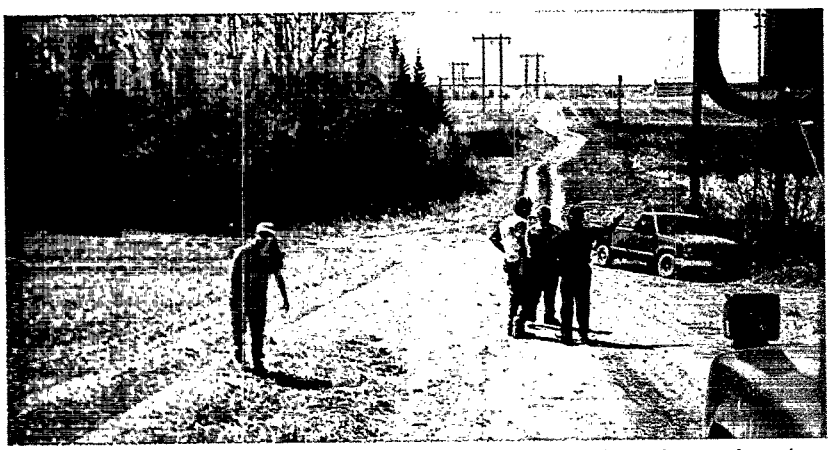
The Town of Limestone formed a partnership with the Central Aroostook Soil and Water Conservation District to plan and implement a 319 project, funded through the Maine Department of Environmental Protection (MDEP). The U.S. Department of Agriculture, Natural Resources Conservation Service, and MDEP were consulted on how best to solve the problem. There were two key components to the project's success. One was the cooperation of adjacent landowners—all farmers—and the other was the town's commitment of municipal staff and equipment to the installation of the farm road best management practices (BMPs).

A variety of erosion controls and land use practices were installed throughout the project area. Diversion ditches were constructed to divert the flow of water away from the brook, and turnouts were built to divert road flow into the woods. Culverts were replaced and new ones added, surrounded by riprap, to allow unimpeded stream flow. A sediment pond was also constructed to collect runoff from cropland.

The farm access road that crossed the stream was graded and crowned, and the stream crossing

was repaired and stabilized. Workers installed drain tile to control the water from a natural spring that had been causing erosion and deterioration of the farm access road. They reshaped and stabilized existing road ditches and constructed new ditches. Grass buffers were also established along the fields.

Several acres of highly erodible cropland were placed in conservation reserve, thanks to the cooperation of Glen Beaulieu, whose farm borders the brook on which most of the BMPs were constructed. "I couldn't cultivate that acreage during wet years," he explains, "and I was losing a lot of topsoil. I was happy to place that land into the Conservation Reserve Program." Beaulieu says that since the BMPs were installed, there have not been any washes, the diversion ditches are working, and the water looks much cleaner.



Farmers cooperated to install BMPs to divert runoff away from the creek and into the woods.

Decreased turbidity

Before the project, raw turbidity readings averaged 1.99 nephelometric turbidity units, or NTU (in 1995 and 1996), exceeding the federal drinking water standard of 1.6 NTU treated turbidity. Raw turbidity readings for the same period in 1997 and 1998 averaged 1.225 NTU—a 38 percent improvement even before fully establishing all the BMPs. A dry summer and a very wet fall, along with plantings of a potato crop (highly erodible), contributed to an increase in turbidity readings in 1999. Data have since become unavailable, however, because the town switched from a surface water source (using Silver Spring Brook) to a groundwater source after the new federal drinking water standard of 0.50 NTU treated turbidity was established.

The native brook trout habitat has significantly benefited from the decrease in murky conditions. Lower turbidity readings have also resulted in improved swimming conditions for the community, improving recreational opportunities. Although many seemingly inconsequential unstable land use practices can add up to water quality degradation, through the commitment of local people and agencies and effective teamwork, water pollution can be prevented and water quality restored.

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Primary Sources of Pollution:
- forestry

Primary NPS Pollutants:
- sediment

Project Activities:
- forestry BMPs
- paired watershed study

Results:
- stabilized stream temperature
- reduced suspended solid concentrations
- improved benthic macroinvertebrate populations

Evaluating the Effectiveness of Maryland's Forestry BMPs:
Paired Watershed Study Tests BMP Performance

Frederick County, Maryland

Forests cover about 2.7 million acres of Maryland, representing 40 percent of the state's total land area. Forest health is inextricably linked to healthy streams and a robust Chesapeake Bay. But many forest harvest activities, including poorly designed haul roads, skid trails, landings (loading areas), and stream crossings, can lead to significant inputs of sediment to stream channels, resulting in degradation of water quality and impacts on living resources. The removal of trees adjacent to streams can also cause elevated stream temperatures, reducing habitat quality for fish and benthic macroinvertebrate populations.

To assist loggers and landowners in meeting environmental requirements, the Maryland Department of the Environment and the Department of Natural Resources (DNR) have developed a number of forestry programs. Sediment control plans are required before undertaking major earth-disturbing activity; best management practices (BMPs) and streamside buffer zones are required when logging in nontidal wetlands; and a special "Timber Harvest Plan" must be approved before any timber may be harvested within 1,000 feet of the Chesapeake Bay. DNR's aggressive Stream Releaf Program even has a goal of establishing 600 miles of riparian forest buffer restoration plantings by the year 2010!

Testing BMPs

Although studies show that most Maryland loggers follow timber harvest BMPs, there have been no studies in the state reporting the effectiveness of these BMPs in protecting water quality under local conditions. Using 319 funding, a 4-year study was designed to test the hypothesis that forest harvest operations have no long-term significant impacts on stream benthos, temperature, and suspended sediment if forestry BMPs are implemented.

Two small forested watersheds, located on Sugarloaf Mountain in Frederick County, Maryland, were monitored from August 1995 until July 1999 as part of a paired watershed study to evaluate the effectiveness of Maryland's BMPs for timber harvest operations. One watershed, designated the "treatment" watershed, underwent a controlled level of timber harvesting with strict adherence to BMPs, while the "control" watershed remained unharvested.

A wide range of BMPs were installed in the treatment watershed, including a 20-foot-long portable timber bridge, a 21-inch-diameter stream-crossing culvert, streamside forest buffer (streamside management zone), drainage outsloping, broad-based dips, rolling dips, grade breaks and water bars, and the use of geotextile and stone for haul road stabilization. The logging contractors also complied with the BMPs by following marked skid trails and performing postharvest stabilization of roads, landings, and skid trails where required. On slopes over 10 percent, roads, main skid trails, and landings were seeded, limed, fertilized, and mulched.

Timber was harvested in 1997 on 73 acres of the treatment watershed, using a variety of silvicultural prescriptions. Monitoring of baseflow and stormflow suspended sediment samples, temperature, and benthic macroinvertebrates continued until July 1999.

Successful results

The results of this study indicate that the BMPs were effective in preventing significant impacts on stream water quality, biology, and habitat. There was no significant difference in total suspended solid concentrations or yields due to the harvesting activities. The harvesting also did not significantly affect stream habitat, benthic macroinvertebrate populations, or stream temperature. Most BMPs performed as intended, and none allowed observable sediment input into waterways. Logger awareness and training were also critical to effective use of BMPs because implementation and installation are ultimately under the loggers' control.

MASSACHUSETTS www.state.ma.us/dep/brp/wm/wmpubs.htm

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Primary Sources of Pollution:
- storm water runoff

Primary NPS Pollutants:
- suspended solids
- fecal coliform bacteria

Project Activities:
- infiltration structures

Results:
- 99.99 percent removal of fecal coliform bacteria
- 90 percent removal of fecal streptococcus bacteria
- elimination of petroleum hydrocarbons and zinc
- shellfish beds reopened

Broad Marsh River Storm Water Remediation Project:
Infiltration Structures Reduce Pollutants, Save Shellfish Beds

Wareham, Massachusetts

Over the past decade, the Town of Wareham, Massachusetts, has begun one of the Commonwealth's most complete programs to address the pollution problems caused by storm water discharges along the town's shoreline. Contamination from storm water runoff, particularly suspended solids and fecal coliform contamination, has forced many shellfish beds and public bathing beaches along Massachusetts' coast to close. The closures can range from periodic closure for a few days after heavy rainstorms to complete year-round closure due to nonpoint source contamination. Like many coastal communities, Wareham relies on fishing and tourism for its economic vitality. Faced with the prospect of losing its unique and valuable coastal resources, the town began to search for ways to address the contamination problem.

Selecting the right alternative

In 1993 the Town of Wareham and the Buzzards Bay Project received 319 funding to remediate

storm water discharges along the lower reaches of the Broad Marsh River. The goal was to reopen 64 acres of adjacent softshell clam and quahog beds. The project also intended to demonstrate that leaching catch basins could be an effective storm water remediation tool to reduce coliform contamination in the town's coastal waters.

During consultations with the U.S. Department of Agriculture's Natural Resources Conservation Service, several alternatives for treating storm water discharges were considered. The site conditions were difficult—a high ratio of impervious surface and areas of high ground water. Narrow roads, existing gas, sewer, and water lines, and groundwater close to the surface made designing the system challenging.

Because of land constraints, the final project design involved installation of "under-the road" infiltration structures along road rights-of-way. Two different types of infiltration structures were installed with the purpose of storing and treating the first ½ inch of rainfall. In areas with adequate separation from groundwater, 4-foot by 4-foot concrete leaching galleys were installed; in areas with shallower groundwater, shallower plastic infiltration chambers were installed. The infiltration structures were installed at 15 storm water discharge points along the banks of the lower Broad Marsh River. Instead of being discharged directly into the river through storm drainpipes, the storm water would be directed into infiltration structures, allowing for filtration of the pollutants.

Reopening the shellfish beds

Initial postconstruction monitoring data indicated that the infiltration systems were very effective in removing fecal coliform bacteria (99.99 percent removal) and fecal streptococcus bacteria (90 percent removal) from the storm water runoff. The infiltration systems were also quite effective in removing petroleum hydrocarbons and zinc. These pollutants were present at low levels in the storm water prior to the infiltration treatment; however, they were not detected during postconstruction monitoring.

Two and a half years after installation of the leaching catchment basins, Massachusetts Division of Marine Fisheries (DMF) announced that the shellfish beds in the Broad Marsh River would be reopened on a conditional basis. The beds continue to be temporarily closed after heavy rainfalls, but the large softshell clam and quahog resource is now open to shellfishermen most of the time.

Success inspires additional projects

Other successful 319 projects have since followed. A storm water treatment system was installed in the upper reaches of the Broad Marsh River, with the hope that over time water quality will improve to the point that the Broad Marsh River shellfish beds can be reclassified and opened without restrictions of any kind.

In addition to the continued storm water remediation work on the Broad Marsh River, town officials have set their sites on reopening the larger shellfish beds in Onset Harbor. Onset Harbor is larger and more open than the Broad Marsh River, and its watershed area is heavily developed and quite urban. The town now has two additional ongoing 319 grants that are being used to target the storm water discharges from these urbanized areas. In recent correspondence, Michael Parola, Harbormaster/Shellfish Constable for Wareham, confirmed that storm water remediation efforts have exceeded expectations. The town's current goal is to remediate "any and all active storm drains" because of their overall effect on water quality and on the town's shellfish beds. Parola believes that storm water remediation has been largely responsible for allowing the

Massachusetts Division of Marine Fisheries to upgrade miles of publicly accessible shoreline. The current remediation projects in Onset Bay and its tributary, the East River, have the potential to allow the DMF to upgrade fully half of Onset Bay's shellfish beds from their current classification, seasonally closed, to open and approved for shellfish harvesting.

Like so many coastal communities that rely on fishing and tourism for their livelihood, Wareham faced the loss of the coastal resources that make the town unique and vital. Wareham has taken full advantage of the opportunity that the 319 Program presented to address nonpoint source pollution problems and restore coastal resources for all to enjoy. Given the demonstrated success of the Marsh River Project in both reopening shellfish beds and inspiring a community to institute a phased, long-term storm water management program, the Massachusetts 319 Program should encourage other communities to do the same.

www.state.ma.us/dep/brp/wm/wmpubs.htm

MASSACHUSETTS

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Primary Sources of Pollution:
- storm water runoff

Primary NPS Pollutants:
- suspended solids
- fecal coliform bacteria

Project Activities:
- 12 first flush leaching basins

Results:
- 91 percent decrease in fecal coliforms
- 98 percent decrease in total coliforms
- elimination of oil, grease, barium, chromium, and lead
- shellfish beds remain open

Lake Tashmoo Storm Water Remediation Project:
First Flush Leaching Basins More Effective Than Expected

Town of Tisbury (Island of Martha's Vineyard), Massachusetts

Contamination from storm water runoff, particularly suspended solids and fecal coliform contamination, has forced many shellfish beds and public bathing beaches along the Massachusetts coast to close. The closures can range from a few days to the summer to the entire year, depending on the type and level of contamination. The town of Tisbury on the Island of Martha's Vineyard has numerous "hotspots" where access to shellfish beds and public beaches has been restricted because of storm water contamination. The residents of Tisbury rely on fishing and tourism for their livelihood, so it is imperative for the town to find ways to effectively treat storm water contamination.

At 1 mile in length, Lake Tashmoo is one of the larger of the saltwater lakes on the island that feed into the sea. It is an ideal habitat and breeding ground for oysters, scallops, clams, mussels, crabs, lobsters, and a variety of fish species that serve as the food source for larger fish, all of which are commercially harvested as the backbone of the island's fishing industry. In addition, the lake has a major beach area, a town dock, and boat moorings and is used for swimming, sailing, wind surfing, boating, and sportsfishing.

Before 1994 hard shell clam, mussel, and scallop beds near the storm water outlet were showing contamination from fecal coliform bacteria, heavy metals, and oil and grease. The Division of Marine Fisheries routinely closed the beds after large rainfall events because of fecal coliform

levels in the water. The contaminant levels were consistently high enough that the shellfish beds were on the verge of seasonal closure, which would have effectively put the resource off-limits to the local townspeople and to the large seasonal population that flocks to Martha's Vineyard during the summer months. Recreational use of the lake is a major tourist attraction, and the town considered maintaining the lake in a viable and usable state imperative.

Adding leaching basins

In 1994 Tisbury Waterways, Inc., and the Town of Tisbury received 319 funding to install a series of 12 "first flush" leaching basins along road drains to capture and treat the road runoff that was contributing to the contamination of highly productive shellfish beds at one end of Lake Tashmoo. The first flush basins, installed along a 1.6-mile stretch of road, were designed to treat the first ¼ inch of rainfall, which contains most of the contaminants.

Each basin consists of a 6-foot by 6-foot perforated cement vessel filled with limestone, surrounded by a gravel bed. The limestone in the basins is covered with hydrophobic, oil-absorbing pads, which help to separate the hydrocarbons from the runoff. The limestone in the pits raises the pH of the runoff, causing heavy metals to precipitate and accumulate in the pit. Finally, the first flush basins provide additional residence time for fecal coliform bacteria to oxidize and decay. The treated runoff then passes through the gravel surrounding the pits into the subsurface soil.

Exceeding expectations

Comparison of contaminant concentrations in Lake Tashmoo before and after installation of the basins showed significant improvement in water quality. Samples from Lake Tashmoo during rainfall events showed fecal coliform and total coliform levels going down by 91 percent and 98 percent. Oil and grease could not be detected in the treated effluent; barium, chromium, and lead, which had all been present before installing the basins, could no longer be detected in the effluent. The project was deemed a success and recommended as a model for other storm water hotspots around Tisbury.

The system is exceeding the town's initial expectations. Although it was designed to capture and treat the first ¼ inch of storm water runoff, the system appears to be capturing and treating the first ½ inch of runoff. The sandy soils that underlie the leaching catch basins allow the treated storm water to percolate into the ground more quickly than the designers anticipated, thus allowing the system to capture additional storm water.

As a result, since the basins were installed there has been no discharge at all to Lake Tashmoo during moderate rains. Even during heavy rainfall, less storm water is discharged into the lake and the water continues to be of significantly better quality than before the basins were added. The Massachusetts Division of Marine Fisheries has continued to monitor water quality at the shellfish beds. The beds have not been closed during the past several years, and there is no longer any thought of seasonal bed closure.

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Primary Sources of Pollution:
- agriculture (cropland)

Primary NPS Pollutants:
- sediment
- nutrients
- pesticides

Project Activities:
- conservation tillage

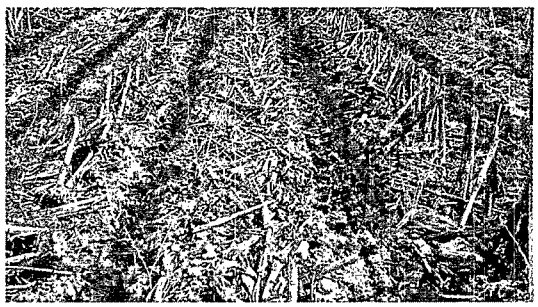
Results:
- reduced soil erosion (70 percent less from water and 60 percent less from wind)

Innovative Farmers of Michigan:
Blending Farm Profitability and Water Quality Protection

Huron, Tuscola, and Bay Counties, Michigan

The Saginaw Bay watershed is the largest watershed in Michigan, covering more than 8,700 square miles. The water quality of the bay is affected by sediment, nutrients, and pesticide inputs from runoff and wind erosion. Agriculture is the major land use in the Eastern Coastal Basin of the watershed (Huron and Tuscola Counties and part of Bay County), representing 95 percent of the land area. The major crops are dry beans, sugar beets, corn, and wheat.

The Innovative Farmers of Michigan is a group of agricultural producers, supported by more than 60 partners representing the agricultural industry, lenders, equipment companies, commodity groups, and federal, state, and local agencies. The group's two primary objectives are reducing the amount of sediment entering the Saginaw Bay and altering farming practices to reduce nutrient and pesticide runoff while retaining profitability for the farmer. "All my fields drain to large ditches, to larger ditches, and eventually to Saginaw Bay," says Pat Sheridan, Tuscola Innovative Farmers, "and I don't want my soil in the bay."



Crop residue forms a protective layer on the field that prevents soil from washing away during rainstorms.

So Sheridan joined the Innovative Farmers of Michigan, which was organized in 1994 in Huron, Tuscola, and Sanilac Counties. Members pay a $100 annual fee, entitling them to membership in the Michigan Agricultural Stewardship Association and subscriptions to *No-Till Farmer* and *Conservation Digest* magazines. In 1996 the Michigan State University Extension-Huron County received a section 319 grant of $71,863 for a 3-year Innovative Farmers project. The Innovative Farmers aimed to reduce soil erosion, improve soil health, and increase family farm income by using reduced tillage, cover crops, and a totally integrated system.

The emergence of dry beans is enhanced by using a spoke closing wheel on the planter.

Confronting traditional farming practices

Before the Innovative Farmers, reduced-tillage corn and soybean cropping systems had been successfully used throughout the Midwest. Michi-

gan farmers, however, were reluctant to use high-residue cropping systems for beans and sugar beets because such high-value crops would still make fall-spring tillage profitable. In addition, many farmers in the area assumed that it isn't possible to warm the soil in the spring, prepare a good seed bed in heavier soils, and achieve adequate weed control without tilling in the fall and the following spring.

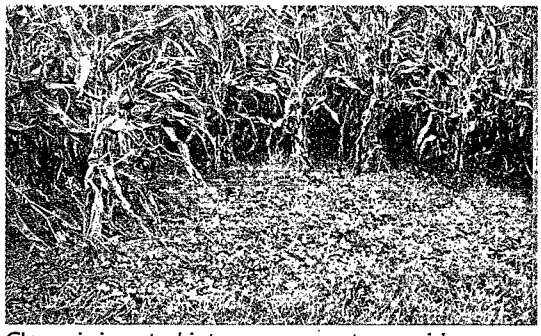
The key to the Innovative Farmers' success is that rather than relying on research and information provided by other sources, the group designed and conducted the studies themselves. In one of the first studies undertaken by the group, 14 producers collected 127 water samples from their tile outlets. Concentrations and flow rates were used to determine the extent of nutrients and the associated dollar loss from their fields. This activity helped producers better understand the nutrient and soil interactions, as well as the impacts on water quality.

Valuable findings

Studies conducted by the Innovative Farmers yielded many valuable findings for area farmers. Conservation tillage did not reduce yields of sugar beets, corn, and dry beans when compared to conventional tillage. In fact, corn yields significantly increased at one of the demonstration sites. Farmers also learned that the soil's capacity to supply nitrogen to a growing crop increases with conservation tillage. Athough phosphorus applications ceased for 6 years, the soil fertility levels did not decrease.

At the end of the project, the water holding capacity and water infiltration rates were also higher for the limited-tillage sites. Conservation tillage reduced the potential for soil erosion from water by up to 70 percent and from wind by up to 60 percent, as compared to conventional tillage.

These results are making a difference. Several farmers in the area have converted their operations to zone till in the past 2 years. (In zone till, only a small area is tilled at planting. The result is a conventional seedbed in the immediate seed zone while the rest of the field remains untilled and covered with residue to promote soil conservation.) Innovative Farmers members also report the increasing use of the chisel tillage system and cover crops by their neighbors. As these systems are used on a wider scale, others will adopt them as they see the success of fellow farmers. That is just what the Innovative Farmers hoped to accomplish.



Clover is inserted into corn crops to provide more cover and reduce erosion over the winter.

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Primary Sources of Pollution:
- agriculture (unrestricted livestock access, plowing)

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- agricultural BMPs (fencing, streambank stabilization, filter strip, sediment detention, wetland restoration)

Results:
- reduction of 19,852 tons of sediment, 19,706 pounds of phosphorus, and 39,321 pounds of nitrogen

Little Rabbit River Watershed Project:
One-to-One Approach Wins Landowners' Support

Allegan County, Michigan

The Little Rabbit River Watershed Project demonstrates the effectiveness of community-based watershed planning in addressing water quality issues. In 1995, through the efforts of local leaders and a broad conservation partnership, a section 319 watershed grant of $380,936 was awarded to the Allegan Conservation District. This grant began a 5-year program that built a team of proactive stakeholders to direct project activities, develop a watershed management plan, and implement best management practices (BMPs) to protect water quality.

The 30,850-acre Little Rabbit River watershed is in southwest Michigan, primarily in the northern section of Allegan County. A small portion lies in Byron Township in Southern Kent County. The Little Rabbit River flows southwesterly to the Rabbit River, a tributary of the Kalamazoo River.

The Little Rabbit River watershed project worked to gain the support of local landowners.

The dominant land use in the watershed is agriculture. Sediment, nutrients, and high flow are adversely affecting the Little Rabbit. Unrestricted livestock access, plowing up to the edge of the watercourse, and conventional fall plowing were commonly found throughout the watershed.

Partners and funding sources

The project's Steering Committee consisted of a broad range of active participants, including the County Drain Commissioner, County Road Commission, Natural Resources Conservation Service, Farm Service Agency, Michigan State University Extension, County Board of Commissioners, Dorr Township Parks and Recreation, other township officials, West Michigan Regional Planning Agency, and local residents and agricultural producers. In addition to 319 funding, other significant sources of funding included the U.S. Department of Agriculture's Environmental Quality Incentives Program (EQIP) and Michigan's Groundwater Stewardship Program.

The objectives of the project were to improve water quality by reducing the amount of sediment and nutrients entering surface water and promoting farmland preservation and controlled development. The Steering Committee decided that one key to the project's success would be to engage area landowners. The Steering Committee exceeded its goal of contacting 50 landowners, reaching 64 landowners to discuss their water quality issues.

A watershed logo, displayed on this cooperator's sign, created an identity for the watershed project.

A number of best management practices (BMPs) were installed as a result of the project, including

- Implementation of 3,000 acres of mulch-till and no-till.
- Installation of more than 12,000 linear feet of exclusion fencing.
- Installation of four stream crossings and a watering facility.
- 190 linear feet of streambank stabilization.
- Installation of 18 acres of filter strips.
- Addition of five animal waste storage facilities.
- Installation of two sediment detention and two erosion control structures.
- Restoration of more than 9 acres of wetlands.

Successful reduction of pollutants

The quantity of sediment and nutrients entering the Little Rabbit River was substantially reduced with the installation of water quality-protective BMPs. Pollution reductions were calculated for all erosion control BMPs. The total amount of pollutants prevented from entering the Little Rabbit River during the 3 years of project implementation was 19,852 tons of sediment, 19,706 pounds of phosphorus, and 39,321 pounds of nitrogen.

In addition, the awareness of water quality issues in the community increased. The local residents stated that the project newsletter was a primary source of conservation information. A watershed logo was developed for use on T-shirts, hats, and watershed cooperator signs, which created an identity for the watershed project.

The success of the project can be attributed largely to the emphasis on one-to-one meetings that built trust one person at a time. The watershed coordinator went to breakfast where the farmers ate, using the opportunity to interact in a relaxed social setting. The true partnership of the agencies involved was also instrumental in the project's success. Other agencies that had rapport with the agricultural community promoted the Little Rabbit River Watershed Project, too, helping to build credibility and trust.

Although the section 319 portion of the Little Rabbit River Watershed Project is complete, water quality improvement and protection efforts are continuing. EQIP funds are available for agricultural BMP implementation. Watershed planning and protection efforts have expanded to the Rabbit River watershed and adjoining watersheds (Macatawa, Gun River) as a direct result of the positive response from the local community.

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Primary Sources of Pollution:
- storm water

Primary NPS Pollutants:
- sediment

Project Activities:
- construction of multicell wetland treatment system

Results:
- storm water filtration
- increased wildlife and plant diversity
- education center, research site for invasive species studies

North St. Paul Urban Ecology Center:
Wetland Improvements Needed to Control Storm Water

North St. Paul, Minnesota

In 1994 the City of North St. Paul identified a potential wetland restoration project and nature center, the Urban Ecology Center. The project site was a 20-acre remnant of an old farm that had last been a sod farm in 1950. The area had once been part of a much larger area of seasonally wet wetland of approximately 150 acres.

Before the restoration effort, the site was a sod farm located on an area that had once been a seasonal wetland.

The Ecology Center site was also identified as a good location to provide water quality improvement for the 420-acre watershed, which had been severely affected by storm water leaving the site. In addition, project managers planned to include the restoration of a diverse wetland and upland plant and animal community that could be studied by students from the four area schools.

The project involved a unique partnership of local, regional, and state government that provided funding and technical assistance. The total cost of the 5-year project was about $397,000. The project was funded in part by $210,000 in grants from four different agencies. The remainder of the project funding was supplied by the City of North St. Paul and the Ramsey-Washington Metro Watershed District. The Minnesota Pollution Control Agency 319 Program provided a $40,400 grant in 1997.

Water quality improvement and environmental education

The restoration plan included modification to the existing wetland to construct a multicell wetland treatment system. The overall objective was not only to improve the quality of storm water leaving the site but also to design and develop the site as a wetland environmental learning center. Environmental changes would be monitored and information used to make future improvements on this site, as well as on other wetlands in the watershed. The project would serve as a model for other metro area communities and school districts.

Using city and District funds, two additional parcels of private land were acquired as essential environmental education and water quality elements of the project. A trailhead parking lot was constructed on one site, providing convenient access to the Urban Ecology Center for schoolchildren and other visitors. A wetland boardwalk, trails, and an educational display were constructed, providing information on the history of the site, water quality improvement, and habitat management. A section of the display was set aside for school classes to present their environmental monitoring and research results to the community.

District staff, school classes, and sentenced-to-serve crews completed restoration of all dis-

turbed areas with native vegetation. Some schools helped by growing some of the native grasses and wildflowers from seed in their classrooms.

Water quality improvements

Project leaders report a number of improvements as a result of the project. The first basin is collecting significant sedimentation, and the material is removed every 2 years. Site observations have documented a dramatic increase in use of the site by wildlife. Plant diversity also has increased, reflecting a good water quality condition.

Both plants and wildlife continue to thrive at the site, reflecting good water conditions.

Continuing benefits

Although completed in 1999, the project continues to involve several local governments and state agencies in management, monitoring, and research. The site is now being used for a research project on control methods for reed canary grass funded by the District, the Department of Natural Resources, the Minnesota Department of Transportation, and the University of Minnesota. Reed canary grass is an invasive plant that spreads very quickly in seasonally wet areas and crowds out most desirable plants. Reed canary grass is the dominant plant in the Urban Ecology Center. The primary challenge to increasing vegetative and wildlife diversity will be controlling the reed canary grass and successfully reestablishing a native habitat. This project will continue for several years.

www.pca.state.mn.us/water/nonpoint/mplan.html

MINNESOTA

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Primary Sources of Pollution:
- urban runoff (new development)
- agriculture

Primary NPS Pollutants:
- phosphorus

Project Activities:
- wetland restoration
- streambank stabilization
- storm water treatment systems

Results:
- removal of dissolved phosphorus

Prior Lake/Spring Lake Improvement Project:
Long-Term Implementation Strategy Off to a Good Start

Scott County, Minnesota

Over the years, a combination of factors had been compounding, relentlessly contributing to the water quality problems in the Prior Lake and Spring Lake Watershed District. In addition to the impacts of the agricultural community, new development was taking its toll, along with the constant adverse effects of failing septic systems in the watershed. Both Spring Lake and Upper Prior Lake were found to be hypereutrophic, while Lower Prior Lake was mesotrophic. A reduction in phosphorus levels was necessary to improve the quality of Spring and Upper Prior Lakes; phosphorus concentrations needed to be maintained at their existing levels to preserve the quality of Lower Prior Lake.

Based on the recommendations of a Clean Lakes Study completed in 1993, the Minnesota Clean Water Partnership Project commenced. The initial phase was designed to reduce nonpoint source

phosphorus loads to the lakes. Funding and implementation assistance for this 6-year effort were provided through the section 319 grant program.

Phase 1: A comprehensive approach to restoration

During the first phase of the project, a number of projects were successfully completed, while relationships were built with other agencies, citizens, and organizations. Several projects aimed at controlling storm water runoff were accomplished, including the construction of the Iron (Ferric Chloride) Runoff Treatment Facility and installation of storm water treatment devices with road improvements. Wetland restoration projects also occurred, including the construction of the Highway 13 treatment wetland and conversion of the Sand Point Park dry basin to a water quality pond. In an effort to control the increasing threat of sedimentation, several shoreline stabilization projects were conducted. Among them were projects to stablize the eroding channel in Fish Point Park and to improve the desiltation basin adjacent to Spring Lake. The community was also involved in septic system education workshops, yard waste management workshops, and soil testing programs. No-till farming assistance was provided to help encourage the adoption of such practices.

A successful first phase

Both citizen observations and monitoring data indicate that the water quality is improving. Monitoring data show that the ferric chloride system is operating as designed with respect to the removal of dissolved phosphorus. In recognition of these successes, the Minnesota Department of Natural Resources named the Prior Lake/Spring Lake Watershed District the 1998 Minnesota Watershed District of the Year. Most importantly, trust has improved between the agricultural constituents and the District.

These successes enabled the District to convene another partnership for the second implementation phase. This phase builds on lessons learned in the first phase, as well as some new efforts focusing more specifically on the lakes. Continuing efforts include providing incentive payments for conservation tillage and nutrient management, as well as conducting additional wetland restorations and constructing more water quality basins. In-lake efforts will aim to control internal recycling of phosphorus and manage submerged aquatic plants with changing water clarity.

Additional benefits

The project's initial successes have translated into water quality management efforts beyond those initiated by the grant program. These efforts include regulatory responses, such as the passage of a "no phosphorus fertilizer" ordinance by the local city, and revisions or improvements to the Watershed District's rules regarding new development and redevelopment. Agricultural improvements, participation in the cropland filter strip program and supplemental payments for participants in the Conservation Reserve Program and the Conservation Reserve Enhancement Program, continue. Wetland restoration efforts are ongoing, and sewer lines are now expanding into previously unsewered areas around the lakes. Efforts to sustain the progress continue, with completion of macrophyte surveys and whole lake management plans.

In for the long haul

Overall, the District is pleased with the results to date. Grant assistance allowed much more to be accomplished than the District could have achieved on its own. The District would have preferred more immediate visual improvements of the lake's water quality. However, scientists involved in the Clean Lakes Study had stated that

although only limited visual improvements would occur as a result of the first phase, these efforts were a necessary first step in achieving benefits in subsequent phases. The District and its partners realize that sustainable improvements will come from a long-term implementation strategy.

www.deq.state.ms.us/newweb/homepages.nsf

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Primary Sources of Pollution:
- agriculture (animal operations, crops)
- forestry

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- conservation tillage
- streambank stabilization

Results:
- retention of more than 3,500 tons of soil annually

Muddy Creek Watershed Demonstration Project:
BMPs Retain 3,500 Tons of Soil per Year

Tippah County, Mississippi

Winding its way through the northern part of Tippah County, Mississippi, Muddy Creek eventually flows into Tennessee. The creek's drainage area encompasses a total of 67,070 acres, of which approximately 42 percent is in cropland, 31 percent in pastureland, and 25 percent in forest. Four dairy, 300 timber, 100 livestock, and 20 swine operations are also in the watershed. The main agricultural products are soybeans and corn. Classified as a Fish and Wildlife area, Muddy Creek is designated as suitable for secondary contact recreation, such as wading and occasional swimming. Of primary concern to the local population and the neighboring population in Tennessee was the amount of sediment and nutrients emptied by this creek into the Hatachie River in Tennessee, designated as a Wild and Scenic River.

Water quality and land use assessments were performed in the watershed, and 3 of the 10 tributaries were identified as having the most agricultural operations. The land use assessment evaluated the average soil erosion rate and the magnitude of the animal operations in the watershed. The average soil loss from cropland and pastureland in the watershed was estimated at 12.2 tons per acre per year. This amount of sediment entering the watershed gave it a designation as a priority watershed on the state's priority watershed list for agricultural nonpoint source pollution.

Installing best management practices

To address these concerns, the Muddy Creek Watershed Demonstration Project was initiated by establishing demonstration farms and agricultural best management practices (BMPs). Conservation tillage was widely promoted and accepted throughout the watershed. The purpose of conservation tillage is to reduce ground disturbance before crop planting, so that less soil and pollutants leave the field and enter the receiving stream.

Other BMPs included grade stabilization structures (pipes), a pond, more than 2,500 feet of diversion (a constructed ridge diverting the flow of water), fencing, critical area planting (pine trees), and streambank protection. Streambank stabilization BMPs included earthwork, vegetative cover, and rock riprap.

Dramatic reductions in erosion

As a result of the BMPs installed, more than 3,500 tons of soil is being retained on the land each year. The BMPs dramatically reduced the amount of annual soil erosion and the subsequent flow of sediment into the Muddy Creek watershed.

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Primary Sources of Pollution:
- agriculture (croplands)

Primary NPS Pollutants:
- sediment
- nutrients
- pesticides

Project Activities:
- grade stabilization structures

Results:
- retention of more than 4,950 tons of topsoil per year
- decreases in organic carbon, total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite, and total phosphorus

Roebuck Lake Demonstration Project:
Slotted-Board Risers Installed to Save Topsoil and Improve Water Quality

LeFlore County, Mississippi

Roebuck Lake is a 580-acre lake in the Bear Creek watershed in the central part of LeFlore County, Mississippi. Its watershed encompasses an area of 11,200 acres. Roebuck Lake has tremendous potential as a multiple-use recreational lake because some 101,500 people live within a 25-mile radius. In the past the lake was well known for water-skiing, swimming, boating, and fishing, but currently these uses have decreased.

The water quality in Roebuck Lake is degrading because of the inflow of pollutants from cropland fields. Drainage from approximately 8,100 acres of delta cropland flows into the lake, leaving deposits of silt, pesticides, and fertilizer and other plant nutrients. Erosion occurring from these erodible cropland acres is excessive, at an average rate of 8 tons per acre. Based on available data, the lake was designated in the state's 305(b) water quality report as only partially supporting its fish and wildlife classification because of agricultural nonpoint sources of pollution.

Installing slotted-board risers

A number of partners came together to address these concerns: the Mississippi Department of Environmental Quality; U.S. Department of Agriculture, Natural Resources Conservation Service; Mississippi Soil and Water Conservation Commission; Environmental Protection Agency; and Mississippi Cooperative Extension Service. The project included installing grade-stabilization structures called slotted-board risers (SBRs) on a selected cotton farm site. The practice involves placing a pipe at the edge of the field just after harvesting, with slotted boards placed in front of the pipe, and allowing the field to flood. Valuable topsoil and expensive nutrients are retained on the field, allowing them to be used during the next growing season

Significant reductions

During the winters of 1997 and 1998, automated storm water monitoring equipment was used to calculate the loading reductions resulting from the use of the SBRs. Because most of the rainfall runoff was contained on-site and did not produce a discharge, reduction percentages were high. Most of the trapped rainwater evaporated or was absorbed into the soil. The results included reductions of 99.8 percent total suspended solids, 89.4 percent total organic carbon, 100 percent total Kjeldahl nitrogen, 90.7 percent ammonia nitrogen, 96.3 percent nitrate/nitrite, and 97.1 percent total phosphorus. Overall, the grade stabilization structures are saving 4,950 tons of topsoil per year.

The SBR practice continues to prove that it is a very cost-effective approach to saving topsoil while at the same time improving the lake's water quality. Many farmers have installed SBRs on

their fields since the project was initiated. It is still too early to determine what long-term effects these best management practices (BMPs) will have on Roebuck Lake's water quality. It is hoped that through this demonstration and through subsequent field days, farmers and the public will take what they have learned and apply it to their lands. If this occurs, it is possible that Roebuck Lake could once again support its fish and wildlife designated use.

www.dnr.state.mo.us/deq/wpcp/wpcnpsmp.htm

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Primary Sources of Pollution:
- agriculture (crop fields)
- poor irrigation efficiency

Primary NPS Pollutants:
- nutrients
- pesticides

Primary NPS Pollutants:
- nutrients
- pesticides

Results:
- 20 percent to 50 percent water savings
- reduction in agricultural chemicals entering groundwater and surface water

Mississippi Delta Irrigation Water Management Project:
Irrigation Efficiency Improved

Six counties in the Missouri Bootheel

The Mississippi Delta of Missouri encompasses about 4,000 square miles, or 2.5 million acres, of prime agricultural land. Forests and swamps originally covered this region, but it has become intensively developed for agricultural production.

The Mississippi Delta 319 Irrigation Water Management Project was implemented in 1995 with the goal of maintaining and enhancing Missouri's portion of the Mississippi Delta alluvial aquifer. The project area and demonstration activities occurred within the 700,000 acres of irrigated lands in the Delta. The management complexities of the intensively irrigated lands in the project emphasize the need in the region for comprehensive nutrient and pesticide management plans and maximum-efficiency water delivery systems.

Targeting irrigation system efficiency

The project involved field-scale demonstrations of three best management practices (BMPs) targeting the improvement of irrigation system efficiency:

- Side-inlet flood irrigation of rice, which allows water to be applied to each basin independent of the water levels in other basins. Water is delivered to each basin through a pipeline or an irrigation canal. The system can be set so that all basins fill at the same time.
- Surge-furrow irrigation for crops, which is used to improve the uniformity of water entering the soil down a row in a furrow irrigation system. Water is introduced to one area of the irrigated field for a certain duration, then switched to a different irrigated area, then returned to the original area. Surge valves automatically switch the irrigation water. Switching back and forth is continued until the entire length of the furrow is watered. By pulsing, or surging, the water advances down the furrow faster than it would with the constant flow in a conventional furrow irrigation system. By decreasing the time needed to advance to the end of the furrow, deep percolation is reduced. This is particularly true in coarse-textured soils.

- Furrow flow rate uniformity improvements for row crops, which will enable furrow irrigation systems using lay-flat irrigation tubing to apply water uniformly to individual furrows as needed. In this recently developed technology, a computer program calculates the needed gradient of the crown end of a field to match energy losses within the pipeline to equalize furrow flow streams. The program selects hole sizes to help make existing systems operate more efficiently. Uniform furrow flow streams result in water conservation (from 1 to 10 inches per acre per year), reduced potential of surface water contamination through reduced irrigation tail water (from 1 to 6 inches per acre per year), and increased yields. Roughly 200,000 acres could be furrow-irrigated each year using the lay-flat irrigation tubing system.

Improving the efficiency of irrigation systems would reduce water loss due to deep percolation and runoff. Consequently, it would reduce the amount of water and agricultural chemicals entering groundwater and surface draining systems.

The three methods to be demonstrated were relatively unknown to Missouri farmers. The benefits of the side-inlet and surge-irrigation methods are well documented, and both methods are commonly used in other irrigated areas of the United States. The furrow flow uniformity improvement demonstration used technology recently developed in Missouri. It is especially important to southeast Missouri irrigators because it pertains to the use of lay-flat irrigation tubing. A higher percentage of southeast Missouri irrigators use lay-flat tubing than irrigators in any other irrigated area of the country.

Water savings and simpler management

For the eight side-inlet rice irrigation sites installed, the composite water savings consistently ranged from 30 percent to 50 percent on the fields. Another benefit of the side-inlet system expressed by producers was the simpler management. The producers believed that with side-inlet irrigation they experienced less wear on their levees, used fewer gates, did not have to adjust gates, and did not have to guess when to end their irrigation. Consequently, they had more time to take better care of their fields. Even without the water savings, producers felt the management aspect of the side inlet made it worthwhile to install.

For the six surge-valve/furrow-flow irrigation improvement sites, the surge systems averaged between 20 percent and 30 percent reduction in water use per irrigation, depending on soil type and system flow rate. The producers indicated they could also see a definite reduction in the pump times on their fields using the irrigation water management plans. In addition, they saw even application of water across their field as a benefit. In the case of soybeans, some farmers noted they did not see the damage that had previously occurred in oversaturated portions of their fields.

This project was also successful in transferring information after the completion of the demonstrations. At the time the project was proposed, there were few, if any, known producers in southeast Missouri using the side-inlet method of irrigating rice, as well as very limited use of surge/furrow-flow improvement systems. As of 2000 it is estimated that 20,000 to 30,000 acres of rice are being irrigated using the side-inlet method. Since the project's inception, an estimated 80,000 acres of irrigation water management have been put into practice, including 20,000 to 30,000 acres of surge irrigation. By comparison, in 1995 furrow flow improvement plans were used on fewer than 1,000 acres, surge irrigation plans were used on fewer than 100 acres, and there were no side-inlet rice irrigation plans.

These field-scale demonstrations were critical in establishing credibility among area producers and gaining their acceptance of the applicability of the BMPs. Equally important, the concentrated efforts of informing and educating producers about the successes of the project ensured continued use of these practices even after the project was completed.

www.dnr.state.mo.us/deq/wpcp/wpcnpsmp.htm

MISSOURI

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Primary Sources of Pollution:
- agriculture (dairy/beef operations)

Primary NPS Pollutants:
- nutrients

Project Activities:
- pasture management practices
- rotational grazing systems
- farmer education (workshops, manuals)

Results:
- average savings of $1/cow/day
- reduced labor
- less erosion and nutrient-contaminated runoff

Upper Niangua Grazing Demonstration Project:
Counties Unite to Start Demonstration Farms

Webster, Dallas, and Laclede Counties, Missouri

The Upper Niangua watershed encompasses 217,000 acres in Webster, Dallas, and Laclede Counties in southwest Missouri. Dairy and beef operations, with an emphasis on forage production, constitute a large component of the agriculture in the watershed. Through support of section 319 funding obtained through Southwest Missouri Resource Conservation and Development (RC&D), seven landowners from these three counties implemented management-intensive grazing systems to better manage their cattle, manure, and pastures. The project was funded from March 1,1994, through December 31, 1999.

The objectives of the Upper Niangua Grazing Demonstration Project included the following:

- Demonstrate best management practices for pastures and use of animal waste to prevent nonpoint source pollution.
- Inform local and regional landowners of the economic and ecological benefits of proper pasture management.
- Demonstrate riparian corridor protection as a part of the total farm system.

Implementing resource management systems

Seven livestock/dairy operations were selected to participate as model sites to demonstrate the effectiveness of grazing best management practices. Each producer was required to implement a total resource management system, and incentive payments were provided for participation.

Management-intensive grazing systems were installed and customized to each producer's operation. Management-intensive grazing is a goal-driven approach to grazing management, characterized by balancing animal demand with forage supply through the grazing season and allocating available forage based on the animal's requirements. Underlying the approach is a basic understanding of how soil, water, plants, and animals interact with each other as influenced by climatic conditions and management decisions. The four goals used in implementing a management-intensive grazing plan for each participant included financial or economic considerations, environmental concerns, lifestyle, and production goals.

Workshops were held at these demonstration farms in the spring and fall to provide training to

Recipe for Success in Missouri

Ingredient	Amount
• Farms	Seven
• Cattle	Match to forages
• Fencing	Enough to split each farm into eight or more paddocks
• Watering pipe	Enough to carry water to all paddocks
• Watering troughs	Enough to supply cool, clean water to cattle in each paddock
• Forages	Large variety of dense, palatable, high-quality grasses and legumes
• Manure	Distributed evenly in all paddocks
• Landowners	Seven progressive, open-minded farmers

Carefully split each farm into paddocks (pasture subdivisions) with the fencing. Insert watering troughs into each paddock, and connect them with pipeline. Keep cattle on one paddock at a time, rotating based on forage growth and availability. The variety of forages will increase the longer you cook this mixture. Let it rain on the mixture to moisten evenly. Ask the seven farmers to open the meal to anyone interested and share at "Pasture Walk" gatherings and workshops.

Delicious! (And guess what? Everyone wants the recipe!)

landowners and agency personnel working in the region. Highlighted were sessions on plant growth, plant management, soil fertility, species selection, livestock needs, water development, and other aspects of the management-intensive grazing system necessary to derive the economic and environmental benefits of participating. In addition, monthly Pasture Walks proved to the "Show Me" Missouri farmers the value of these systems.

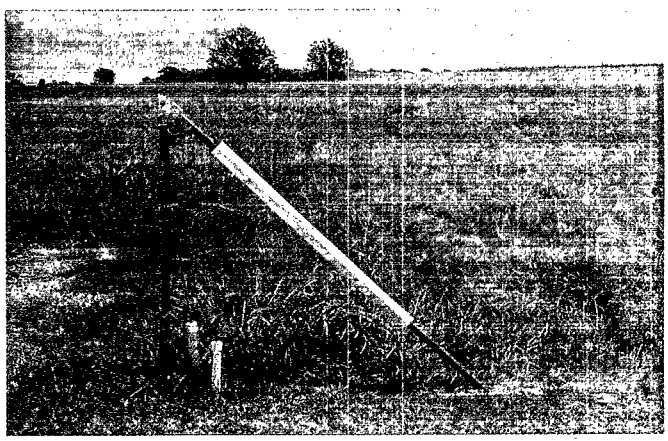
The University of Missouri Extension Service also published a valuable manual for dairy farmers called the *Missouri Grazing Dairy Manual.* The manual covers all aspects of pasture-based dairying in Missouri, including managing nutrients from manure and inorganic sources in pastures. The manual documents how the amount of phosphorus added to a stream when a cow defecates directly into it—just once—can be the same as the amount of phosphorus that runs off an acre of pasture in a single rain runoff event.

The final chapter in the manual highlights the economics of the pasture-based dairy. Missouri is fortunate to have at least 8 months during which pastures can be grazed. The diversification of pasture species that results from rotational grazing provides high-quality forage throughout that long grazing season. High-quality forages mean greater milk production, which in turn provides greater returns to the producer.

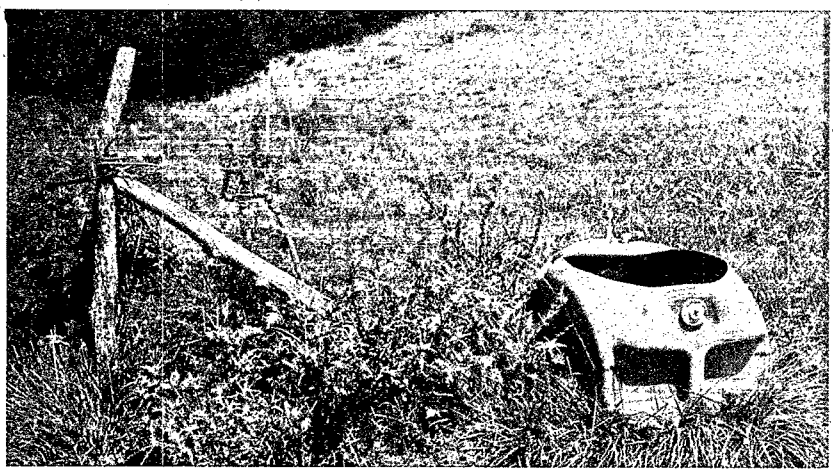
Results of pasture management

The producers in this project saved an average of $1 per cow per day by using pasture management practices. They also decreased labor because of the reduced time needed for harvesting forages and handling waste. This was evident to the landowners from Dallas County. The landowners with the management-intensive grazing systems were able to extend their grazing season and wait up to 2 months longer before feeding supplemental hay than some of their neighbors during an extensive period of drought.

Through this demonstration project, managed grazing strategies and riparian corridor protection reduced the quantity and improved the quality of the farmland runoff. As noted in the dairy manual, dairy cows excrete 70 percent of the



Splitting large fields into smaller fields (called paddocks) with electric fence allows for more efficient use of the pasture, healthier plants, and more plant diversity.



Water in every paddock allows for better manure distribution and nutrient recycling, reduces stress on animals, and reduces erosion.

nitrogen, 60 percent of the phosphorus, and 80 percent of the potassium they consume in their diets. In grazing systems, the nutrients that have been consumed are returned to the pasture through manure and then taken up again by the forage. This cycling of nutrients leads to a lower runoff of nutrients from pasture systems because fewer nutrients are imported to the pasture by heavy concentrate, or hay feeding. A greater number of rotations in a grazing system provides for more evenly distributed manure, so nutrients are not concentrated in only a few spots.

The demonstration project protected ground cover and provided more efficient forage production. The manual provided information showing that forages managed in grazing dairy systems in Missouri were of very high quality, with an average crude protein content of 21 percent from April through December. These forages also furnish vigorous ground cover, which helps reduce erosion and runoff compared to conventionally grazed pastures. Legume growth and reseeding are enhanced because of longer recovery periods for pastures in a rotation. The legumes can "fix" nitrogen in the soil so that less nitrogen needs to be applied to pastures. Water infiltration is increased because of improved soil structure, which reduces runoff. In addition, the extensive root system of healthy forages decreases the potential for leaching by trapping particles and by taking up water.

The Upper Niangua Grazing Demonstration was a success. This demonstration project had numerous partners: funding was provided by an Environmental Protection Agency grant through the Missouri Department of Natural Resources; the U.S. Department of Agriculture's Natural Resources Conservation Service, University of Missouri Outreach and Extension, Dallas County Soil and Water Conservation District (SWCD), Laclede SWCD, Webster SWCD, and Missouri Department of Conservation provided technical assistance.

The ongoing impact of the project in this Ozark region of Missouri, known for its clear lakes and streams, will be felt by all those who enjoy this area—visitors and residents alike.

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Primary Sources of Pollution:
- agriculture

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- agricultural BMPs (including fencing, rangeland management)
- reduced irrigation discharges

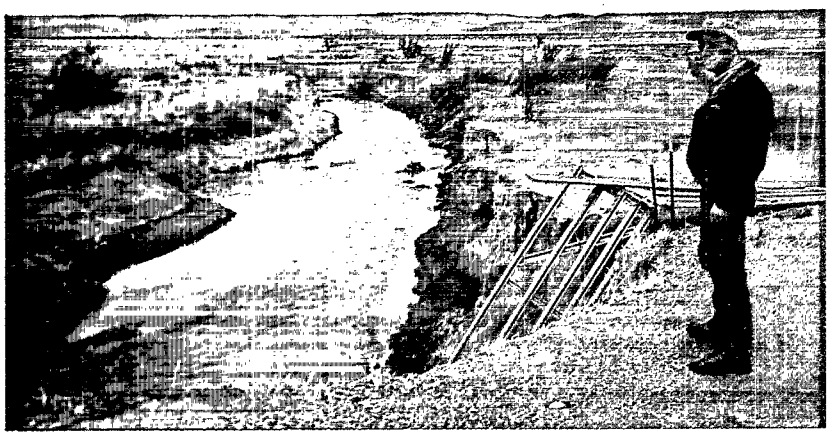
Results:
- 19 percent increase in riparian habitat
- 25 percent reduction in sediment delivery
- fish populations rebounded

Careless Creek Watershed Project:
Sediment Delivery Reduced by 25 Percent

Careless Creek, Montana

Local initiative and voluntary participation contributed to the success of the Careless Creek Watershed Project. Careless Creek is a 100-mile-long tributary to the Musselshell River in central Montana. Agriculture is the main economic activity and land use in the 500,000-acre watershed. About a quarter of the land in the stream corridor is irrigated; the rest is mostly forest and rangeland.

Lower Careless Creek was classified as "moderately to severely impaired" in the 1988 state water quality assessment. Sediment and salts from return irrigation flows and other agricultural activities were the main pollutants. Artificially high summer flows were causing severe streambank erosion.



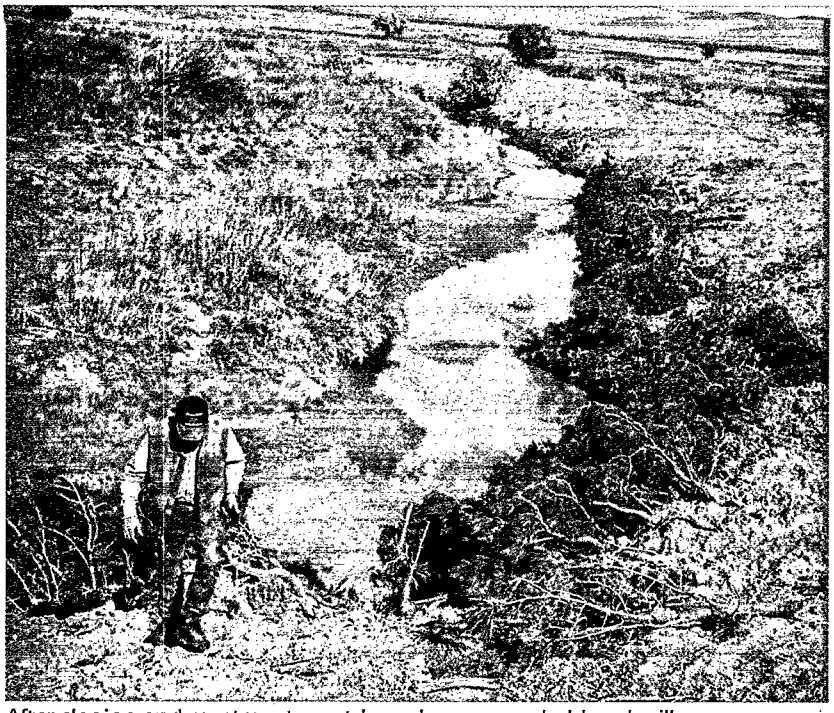
Severe bank cutting and loss of fencing were common on Careless Creek before streambank restoration.

Broad-based collaboration

Local landowners, working with the Lower Musselshell Conservation District, began a process to address local resource concerns. In 1990 a 319-funded study led to the formation of a local steering committee. The steering committee brought together a broad coalition of private landowners and water users; federal, state, and local agencies; and private organizations to address resource concerns in the watershed. Collaborators include the Lower Musselshell Conservation District; Musselshell and Golden Valley County Commissions; U.S. Department of Agriculture's Natural Resources Conservation Service; Deadman's Basin Water Users Association; Upper Musselshell Water Users Association; U.S. Bureau of Reclamation; Montana Watercourse; Deadman's Basin Cabin Owners Association; Montana's Fish, Wildlife and Parks Department, Department of Natural Resources and Conservation, and Department of Agriculture; local schools; and the Montana Conservation Corps.

The steering committee developed a number of restoration goals for Careless Creek, including the following:

- Reduce artificial flows down Careless Creek.
- Reduce streambank and channel erosion on the lower 7 miles of Careless Creek.



After sloping and revetments, outdoor classes were held and willows were planted at the site.

- Apply voluntary best management practices (BMPs) in the watershed above Deadman's Reservoir.
- Improve native fisheries in the lower watershed.
- Establish weed control plans for the watershed.
- Restore Franklin Lake to a wetland.

Remediation approaches

Local buy-in was crucial to the project's success. Complex resource issues, involving water rights and allocations, had the potential to create conflict within the community. The watershed committee emphasized a nonregulatory, collaborative approach that attracted the participation of a majority of landowners and interest groups. Irrigation discharges to Careless Creek were voluntarily limited to 100 cubic feet per second. This flow reduction was made possible by infrastructure improvements to the water delivery system.

A number of agricultural BMPs were also implemented, including the installation of 56,000 feet of fencing to manage livestock grazing in critical areas and the installation of a 15,195-foot pipe and two tanks to provide off-stream livestock watering.

Measurable results

At the outset the watershed group established a tracking program to monitor implementation. As of summer 2000, the project had resulted in the restoration of 37,000 feet of streambank and a 19 percent increase in riparian habitat. Fifty-four percent of the stream corridor is no longer eroding. So far, prescribed grazing practices have improved rangeland management on 18,000 acres. These restoration activities have reduced sediment delivery to the Musselshell River by 25 percent.

The comprehensive monitoring plan uses a combination of water chemistry analyses, biological indicators, and physical habitat evaluations to measure progress. One indication of progress is obvious: fish populations have rebounded in the first 5 years of the project.

Phase II

To further reduce nutrient and sediment delivery in Careless Creek and the Musselshell River, 319 funds are being used to restore another 14,632 feet of degraded streambank by improving livestock waste systems, moving corrals off the creek, developing alternative livestock watering systems (solar pumps), excluding livestock from damaged riparian areas, and continuing to plant willows and grass. Other contributors are the Montana Renewable Resources Grant and Loan Program, the Deadman's Basin Water Users Association, and the Department of Natural Resources and Conservation.

Widespread recognition of success

In 1995 the steering committee organized a "Know Your Watershed" workshop, which

marked the beginning of the committee's outreach and education program. The project's bimonthly newsletter, *Careless Creek Country*, won a state award for excellence. Other components of the outreach program have included outdoor classrooms and watershed tours.

Montana's governor and the Montana Watershed Coordination Council recognized this collaborative effort last summer with a Montana Watershed Stewardship Award. In November 2001 the project will receive a CF Industries National Watershed Award.

MONTANA

www.deq.state.mt.us/ppa/nonpoint/NonpointPlan.htm

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Primary Sources of Pollution:
- agriculture
- irrigation return flows

Primary NPS Pollutants:
- sediment

Project Activities:
- agricultural BMPs (including grazing management)
- reestablishing riparian vegetation
- increased irrigation efficiency

Results:
- 75 percent reduced sediment delivery
- reestablishing habitat

Restoration in Muddy Creek:
Will a Name Change Be Needed?

Muddy Creek, Montana

Muddy Creek was aptly named. Until recently, the small tributary was carrying 200,000 tons of sediment a year into the Sun River west of Great Falls, Montana. Irrigation return flows were increasing the normal seasonal stream flow tenfold and scouring a deep, steep-banked gully. Muddy Creek had the dubious distinction of being the most polluted stream in Montana. The creek drains about 314 square miles of farmland, and agriculture—both livestock grazing and crop production—was the primary contributor of nonpoint source pollutants.

Supported by 319 funding, local landowners, conservation districts, and other partners formed the Muddy Creek Task Force in 1994. By 1998 the Task Force had achieved three of the four goals it had established at the outset:

- *Goal 1: Reestablish riparian vegetation.*
  Watershed cooperators improved grazing management on 8 miles of stream corridor, installed 44,000 feet of riparian fencing, established six off-stream livestock watering systems, planted more than 8,000 willows and other trees and shrubs, and reestablished native grasses in riparian and upland zones.
- *Goal 2: Reduce irrigation return flows.*
  A public education effort that included brochures, newsletters, a video and slide show, a project display board, numerous watershed tours, and U.S. Bureau of Reclamation progress reports contributed to a 35 percent reduction in irrigation return flows. Most of the reduction was achieved by increasing irrigation efficiency.
- *Goal 3: Reduce sediment delivery to the Sun River and Missouri River.*
  More than 400 barbs were installed to reduce bank erosion, and 13 drop structures were built to slow flows and stop headcutting. Reduced sedimentation is also a product of the first two goals—reestablishing riparian vegetation and reducing irrigation flows. The original goal was to

reduce sedimentation by 75 percent in 5 years; the project did it in 4 years.

- *Goal 4: Improve fisheries in the Sun River watershed.*

  Although it is too soon to adequately document an improved fishery, anglers have noted that the improved water quality is allowing fish to migrate back to Muddy Creek.

And there are other documented improvements—increased waterfowl and wildlife habitats from improved riparian areas, reduction of flood potential, reduced cost for maintaining roads and railroads, and a reduction of land loss by several landowners along Muddy Creek.

Duplicating success in the Sun River watershed

The Muddy Creek Task Force's successes were contagious. Soon groups were working throughout the Sun River watershed. In 1996 the Sun River Project received a 319 grant of $198,140 to continue work on the Muddy Creek Project, complete a comprehensive resource inventory of the Sun River watershed, and enhance the water quantity and quality of the Sun River. This project funded stream work on 8,000 feet of Mill Creek, 4,000 feet of the Sun River, and 4,000 feet of Duck Creek. Supplemental 319 funding from the 1999 Clean Water Action Plan helped fund restoration work on several segments of Elk Creek, another tributary to the Sun. By 1999 the in-kind contributions of the various partners had exceeded $2 million.

The Sun River Project is now in its third phase. A $135,480 section 319 grant is targeted at reducing erosion and irrigation return flows on the Sun River and its tributaries. The project is continuing to restore riparian habitat and promote the implementation of best management practices.

Broad-based partnerships

The Sun River Project is known for its broad-based cooperation. Participating entities include Cascade County, Teton County, and Lewis and Clark County conservation districts; the Muddy Creek and Willow Creek task forces; U.S. Bureau of Reclamation, U.S. Department of Agriculture's Natural Resources Conservation Service, U.S. Forest Service, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Geological Survey; Montana Departments of Environmental Quality, Natural Resources and Conservation, Fish, Wildlife and Parks, and Agriculture, and Bureau of Mines and Geology; Greenfields and Fort Shaw irrigation districts; Medicine River Canoe Club, Missouri River Flyfishers, Audubon Chapter, Russell Country Sportsman Association; and many others.

The Sun River Project has won numerous awards, such as the Montana Watershed Coordinating Council's Watershed Stewardship Award, Clean Water Action Plan's Showcase Award, and CF Industries' National Watershed Award.

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Primary Sources of Pollution:
- agriculture
- construction site runoff

Primary NPS Pollutants:
- nutrients
- sediments

Project Activities:
- erosion control ordinance
- sediment retention basins
- streambank stabilization

Results:
- low total phosphorus concentrations and sediment delivery
- excellent habitat for new lake

Walnut Creek Lake Project:
Partnership Drives Watershed Protection

Papillion, Nebraska

The Walnut Creek Lake and Recreation Area, near Papillion, Nebraska, represents a new approach to reservoir development. Walnut Creek Lake planners, aware that Omaha area lakes suffer from excess sediment and nutrients, set out to prevent those problems from the start. The project partners were the Papio-Missouri River Natural Resources District, the City of Papillion, Sarpy County, University of Nebraska Cooperative Extension, the U.S. Department of Agriculture's Natural Resources Conservation Service, Game and Parks Commission, and Department of Environmental Quality (DEQ).

An initial accomplishment was the creation of a 15-member Clean Lakes Community Council consisting of area farmers, residents, and other private citizens. The Council's mission was to develop management goals for the lake watershed that would serve the needs and desires of the community and protect the lake from polluted runoff. The Council quickly established itself as the driving force for the project.

To protect against the high levels of erosion caused by commercial development around Walnut Creek Lake, strict erosion control standards were implemented around the lake.

Innovative approaches to protecting watershed

The Walnut Creek watershed was entirely agricultural and enjoyed an unusually high level of land treatment at the beginning of the project. The Council and project partners recognized, however, that creation of a lake would quickly attract residential and commercial development in the watershed and with it the excessive erosion characteristic of land development. To guard against this threat, the Council drafted a special ordinance for the lake watershed that requires a high level of erosion control on construction sites and provides for higher penalties than usual for violators of the ordinance. The City of Papillion subsequently adopted the ordinance within its jurisdiction of the lake's watershed. The practices required by the ordinance provide the first barrier to keep sediment on the development site and out of the lake.

Further protections were built into the design of the lake itself. The DEQ's Nonpoint Source Pollution Management Program provided funding through section 319 for outreach and installation of best management practices to reduce sediment and nutrient runoff into the lake. Islands and jetties dissipate wave action and prevent shoreline erosion, and sediment retention basins intercept sediment before it reaches the lake. Shoreline plantings stabilize soils, break up wave action, and provide food and habitat for aquatic organisms. Pallet stacks, tire reefs, and brush piles placed in

the bottom of the lake provide shelter for fish. Restrictions prevent boaters from generating destructive wakes that erode shorelines and disturb aquatic wildlife. The cost of installing these practices as preventive measures is a fraction of the cost of installing restorative measures after a lake has suffered degradation.

Water quality improvements

The goal of the project partners and the Community Council was to create a model lake designed to resist the pollutant pressures typical in eastern Nebraska and to meet or exceed its design lifetime. Early water quality data suggest that goal will be achieved. The initial water transparency of 61 inches is expected to stabilize in the long term to about 28 inches, well above the average of 22 inches for other area lakes. In-lake total phosphorus concentrations should stabilize at 0.07 milligram per liter (mg/L) from the current 0.05 mg/L; other area lakes average 0.08 mg/L total phosphorus. Sediment basins and other erosion controls will limit lake volume loss to 0.27 percent per year compared to the average 0.85 percent loss in other area lakes.

High water quality and habitat enhancements are expected to make Walnut Creek Lake the premier fishery among the Omaha area lakes. An added bonus of the project is that it leaves behind an energized group of watershed residents. The Clean Lakes Community Council is dedicated to ensuring that protective measures remain in place to protect the lake from polluted runoff.

DEQ has adopted a community-based approach to watershed planning for all nonpoint source priority watersheds, based on the experience with the Walnut Creek project. Formation of a Citizen Watershed Council to advise the agency's Technical Advisory Committee is a key feature of the process. A manual is being developed to guide the project sponsor, Watershed Council, and Technical Advisory Committee through the planning process. The process is being initiated or implemented in two watersheds where new reservoirs are being constructed and in six watersheds where reservoir renovations are planned or under way.

www.deq.state.ne.us/Priority.nsf/Pages/NNSMP

NEBRASKA

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Primary Sources of Pollution:
- abandoned wells

Primary NPS Pollutants:
- nitrates

Project Activities:
- plugging/capping abandoned wells

Results:
- closure of 37 abandoned wells
- projected decrease in nitrate levels

Wellhead Protection in Guide Rock:
Village Closes Abandoned Wells to Protect Water Supply

Guide Rock, Nebraska

Guide Rock, like many small towns and villages, recently found itself facing concerns about the community's environmental health. The south-central Nebraska village (1990 population 290) contacted the Department of Environmental Quality's (DEQ) Nebraska Environmental Partnerships (NEP) program to discuss its problems and concerns. NEP provided Guide Rock with a grant so the village could complete a community assessment and identify current or potential problems with its drinking water and wastewater systems.

The primary concern identified by the assessment was high nitrate levels in the village's public water wells. The nitrate levels had started to in-

crease gradually in 1995; by December 1997 they were above 10 parts per million, the maximum level of nitrates in drinking water considered safe for all consumers of the water. In October 1999 nitrate levels were 10.4 ppm and 9.4 ppm in the village's two wells.

Source of contamination

Because of concerns about the nitrate levels, the NEP team assigned to work with Guide Rock discussed the Wellhead Protection Area program with the village board. (The Wellhead Protection Area program assists communities and other public water suppliers in preventing contamination of their water supplies.) The board asked the DEQ's Ground Water Section to proceed with drawing a wellhead protection area map for Guide Rock's public water supply wells. A meeting was held for all village residents to discuss the proposed wellhead protection area in 1998, and the village board passed an ordinance to designate the protection area.

"The village board is to be commended, as it has been very supportive of these efforts and has been active in undertaking preventive activities," says M.J. Rose, Nebraska Environmental Partnerships program coordinator. "In particular, the village board is committed to providing the residents a good public water supply at the least possible cost to residents."

Staff of the Wellhead Protection Program identified abandoned wells as a probable major source of the contamination of Guide Rock's water supply wells and recommended closing any unused wells in the community and the wellhead protection area. Correctly plugging and capping abandoned wells can eliminate the risk of contamination of the groundwater aquifer. In April 1999 the village board contacted the Lower Republican Natural Resources District (NRD) regarding the District's abandoned wells program, which provides up to 60 percent of the cost of properly closing a well.

The village board then sought assistance from NEP for possible funding sources to assist in closing wells. NEP helped the community secure a section 319 Small Projects Assistance grant to develop a promotion campaign and pay the remaining 40 percent of closure costs. These two funding sources enabled the village to pursue the proper closing of abandoned wells at no cost to Guide Rock's residents.

Successful enrollment in abandoned well program

Village board members and the village clerk conducted a survey of properties in Guide Rock and the wellhead protection area to locate abandoned wells. Residents were given information about the abandoned well program and were encouraged to attend a September 1999 public meeting to discuss the program. The Lower Republican NRD, DEQ, and a local well driller presented information at the meeting. Residents had the opportunity to ask questions and to sign up for the program. Thirty-seven wells were signed up and have since been closed through the program.

"Guide Rock's drinking water supply will be much safer," says Rose. "Numerous potential sources of contamination have been eliminated. I'm glad that Nebraska Environmental Partnerships was able to assist in this process. Since there are additional abandoned wells in the village in need of proper closing, I hope that this initial success will encourage citizens to volunteer other wells for the program in the future."

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Primary Sources of Pollution:
- urbanization
- agriculture

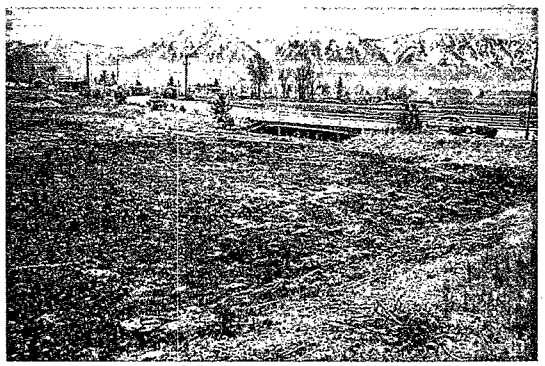
Primary NPS Pollutants:
- nutrients
- fecal coliform bacteria
- suspended solids
- metals

Project Activities:
- constructed wetland ponds
- realignment of slough downstream
- riparian restoration

Results:
- reductions in fecal coliform bacteria, phosphorus, ammonia, and heavy metals
- improved wildlife habitat

Martin Slough Water Quality Enhancement Project:
Water Quality Improves in the Upper Carson River Basin

Upper Carson River Basin, Nevada



In 1999 the pond at Gilman Avenue crossing was unhealthy and visually unappealing.

The Carson River in Western Nevada is a river in trouble. Natural phenomena like drought and flooding and human activities such as agriculture (irrigation return flows and livestock grazing), hydrologic modification (water diversion and channelization by the U.S. Army Corps of Engineers during the 1960s), habitat modification (removal of riparian vegetation), and urban runoff have contributed to degraded water quality, beneficial use impairment, and highly unstable, easily erodible banks. The river is listed on Nevada's 303(d) list for total phosphorus, suspended sediment, turbidity, and several metals. During the recent high water years of 1995 and 1997, hundreds of acres of land along the river were washed away. Not only were valuable land and riparian habitat lost, but the eroded material also degraded fish habitat downstream.

The towns of Minden and Gardnerville are located side-by-side in the heart of Carson Valley, Nevada, where ranching and associated irrigated agriculture dominate land use. The East and West Forks of the Carson River meet in the southern portion of the valley to form the main stem of the river. Scenic vistas surround the area: the Carson Range of the Sierra Nevada Mountains rises to the west, and the Pinenut Mountains border the eastern side of the valley. Through a public outreach process, Minden and Gardnerville have identified the Martin Slough as an important amenity to their communities.

The Martin Slough is a partially man-made waterway that flows through both communities before it joins the East Fork of the Carson River. Historically the slough was used to deliver irrigation water and collect return flow. However, because of rapid urbanization over the past decade, the Martin Slough has also become a conduit for increased amounts of urban runoff. Water quality monitoring has shown elevated levels of nutrients, fecal coliforms, suspended solids, and metals.

Joining forces to arrest runoff

In 1995 Minden and Gardnerville joined with the Douglas County Water Conveyance Advisory Committee, Douglas County School District, and local landowners to develop a plan to improve water quality, restore wetland and wildlife habitat, provide for ground water recharge and storm water storage and treatment, provide for public education, and preserve an open-space corridor through both communities.

The entire project consists of six phases. During Phase 1 of the project, completed in

The restoration project improved water quality, created wildlife habitat, and enhanced the visual appeal of the pond.

September 1999, two wetland ponds were constructed in the upper slough to provide for water treatment and sediment capture. Phase 2 was completed in April 2000 and consisted of realigning the slough downstream of Phase 1 and installing a trash rack and diversion structure. Phase 3 was completed in December 2000 and consisted of riparian restoration through planting of native trees and shrubs to provide for cooler water temperatures and further enhance wildlife habitat. In addition, an access road to provide for maintenance, water quality sampling, and flow monitoring was constructed. A flow-measuring device was installed downstream of the ponds.

Continued water quality improvement

Water quality monitoring sites were established upstream and downstream of the constructed wetland ponds. Preconstruction samples were collected from April through September 1999 to establish a baseline from which to measure the effectiveness of the project. Postconstruction sampling began in October 1999, and it is expected to continue for at least 10 years.

Current preliminary data suggest improved water quality and reductions in the levels of fecal coliform bacteria, phosphorus, ammonia, and heavy metals. Other immediate results of the project have been an increase in wildlife such as muskrat and deer in the area and a variety of birds, including herons, geese, ducks, blackbirds, and swallows. As indicated in the photo of the completed project, the results are aesthetically pleasing. Future phases will occur in the town of Minden and include plans for public parks, bike trails, bank stabilization, riparian restoration, and wildlife habitat enhancement.

Funding to date for Phases 1 and 2 includes $45,000 of section 319(h) funds and $86,745 in local matching funds.

http://ndwr.state.nv.us

NEVADA

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Primary Sources of Pollution:
- unstable stream banks

Primary NPS Pollutants:
- sediment

Project Activities:
- bank stabilization through vegetative treatment and redirection of flow away from unstable banks

Results:
- 74 percent average cover on all vegetative treatments
- 35 percent regeneration of willow clumps

Middle Carson River Restoration Project:
Bioengineering Used to Restore Unstable Banks

Middle Carson River, Nevada

In 1995 a group of ranchers and other concerned local citizens living along the Middle Carson River near Dayton, Nevada, formed the Middle Carson River Coordinated Resource Management Planning Committee to find ways to manage and restore the river. The effort was spearheaded by the Dayton Valley Conservation District (DVCD), with the support and cooperation of numerous

community groups and agencies, including the Carson Water Subconservancy District, Western Nevada Resource Conservation and Development, Natural Resources Conservation Service, and Lyon County. In 1996 the DVCD hired Kevin Piper as watershed coordinator.

The strength of the Middle Carson group is their ability to work together to implement "on-the-ground" projects. Under Piper's leadership, several bank stabilization projects have been completed, and the group supports education and outreach programs in coordination with local schools.

Restoring streambanks with bioengineering

Bioengineering, which uses vegetative techniques in addition to "hard" structures such as riprap, is the cornerstone of the bank restoration projects. Work began on the Glancy property near Dayton in 1998, with the construction of five stream barbs to redirect flow away from the unstable banks. The quiescent areas behind the structures collect sediment and allow natural regeneration of native vegetation. Several vegetative treatments, including brush mattress layering, brush trenches, juniper revetments, willow clump planting, and seeding, were used to provide bank stability, reduce erosion, trap sediment, provide shading, encourage natural plant growth, and restore wildlife habitat.

Monitoring to document improvements

A long-term monitoring program is being implemented to evaluate the effectiveness of the best management practices. Activities include aerial photography; annual survey of channel cross sections to determine the degree of accretion/degradation; monitoring of vegetation growth to assess changes in habitat; analysis of soil characteristics to document particle size, erodibility, and sediment transport potential; and hydraulic modeling to determine water surface elevations at specific recurrence intervals.

Monitoring conducted 9 months after project completion showed an average of 74 percent cover on all vegetative treatments, with about 35 percent regeneration of the willow clumps. A topographical survey indicated deposition of about 430 cubic yards of sediment between the stream barbs. Although sediment buried the lower half of many of the vegetative treatments, it provided a medium for natural cottonwood seeding. Channel cross sections showed that the low-flow channel has moved away from the bendway, suggesting the stream barbs are functioning as designed to deflect higher stream flow away from the bank.

As part of the public education component, bimonthly water quality monitoring of the Middle Carson River is conducted with the help of the River Wranglers. This volunteer group, coordinated by Lyon County teacher Linda Conlin, works with local schools to educate students about river and lake ecology. Students measure dissolved oxygen, pH, and turbidity in the field. Macroinvertebrate samples are collected and transported back to school, where students identify the number of mayflies, caddisflies, stoneflies, worms, and other aquatic organisms.

In July 2000 Kevin Piper and the Middle Carson River Coordinated Resource Management Group received the Wendell McCurry Excellence in Water Quality Award. The Nevada Division of Environmental Protection established this award to recognize individuals, firms, organizations, and governmental entities that have made significant contributions to improving the quality of Nevada's water resources.

Funding to date includes approximately $30,000 of section 319(h) funds and $30,000 in local matching funds.

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Primary Sources of Pollution:
- urban storm water runoff
- eroded ditches

Primary NPS Pollutants:
- phosphorus
- sediment

Project Activities:
- installed system of berms
- swales
- settling and filtering basins

Results:
- 82 percent reduction in phosphorus

Chocorua Lake Project:

BMPs Reduce Phosphorus by 82 Percent

Carroll County, New Hampshire

The Chocorua Lake Association (CLA) has been monitoring Chocorua Lake for more than 20 years. Recent trends showing declining water clarity prompted the CLA to request designation of the watershed as "Category I," a priority waterbody in need of restoration. Working with the Carroll County Conservation District, the North Country Resource Conservation and Development Area, Inc., and Natural Resources Conservation Service, a 319 project was developed and the New Hampshire Department of Environmental Services awarded grant funds in April 2000.

The Chocorua Lake watershed is 13.2 square miles in extent and well protected except for a few vulnerable areas. The U.S. Forest Service manages the south side of Mount Chocorua as a scenic view area. This management decision helped maintain more than half of the watershed as uncut forest. As a result of work begun in 1969 by the Chocorua Lake Conservation Foundation, about 95 percent of the land in the watershed is protected by conservation easements written into the property deeds of about 60 landowners. These easements have preserved woodland buffers all around the lake, except for a portion of the Route 16 highway corridor. The easements also require setbacks for housing and septic systems, beyond state regulation, and low-density housing. North of the lake are conservation lands owned by The Nature Conservancy and the Chocorua Lake Conservation Foundation. There are also several large wetlands in the watershed that act as natural filters to help treat the water before it enters the lake. Although the lake is protected in most areas of its watershed, it is a fragile lake. It has a maximum depth of 29 feet and an average depth of 12 feet. Because the lake is so shallow, sunlight reaches most of the water column. Even low concentrations of nutrients are readily available to algae and other plant life.

The CLA participates in the University of New Hampshire's Lakes Lay Monitoring Program, which determined that 15 percent of phosphorus input to the lake was coming from direct runoff from Route 16, a heavily traveled tourist road adjacent to the lake. Watershed surveys found several eroded ditches adjacent to Route 16 and across land providing beach access to the lake owned by the Chocorua Lake Conservation Foundation and the Town of Tamworth. In addition to the water quality problems, the CLA was interested in addressing traffic safety and noise problems caused by the highway.

Route 16 has grown enormously since it began as a dirt road next to the lake in the 1890s. In the early 1900s the road was tarred but left very close to the lake. In the 1950s the road was widened, straightened, and moved slightly away from the lake; however, Route 16 still runs close to the lake

for about 1 mile. The width and length of this impermeable surface next to the lake play a doubly negative role. First, the road's surface collects particulates from partially burned gas and diesel fuel, oil, and sand and salt. These residues typically contain high amounts of phosphorus, which are diluted and flushed into the lake. Second, during spring runoff and storm events, runoff from the impermeable surface creates surges of water, which flow to the ditches and culverts. High volumes and velocities of runoff scour the soil, adding to the phosphorus loading of the lake. Neither the highway residues nor the eroded soils have time to settle and filter before entering the lake.

The groups mentioned previously, along with the New Hampshire Department of Transportation (DOT) and the Town of Tamworth, initiated the "Berms and Swales Project." The best management practices (BMPs) installed include a system of berms, swales, and settling and filtering basins to control runoff, improve safety, and reduce noise.

BMP performance

Installation of the BMPs was completed on September 5, 2000. Since then the BMPs have been performing to design specifications. Water quality monitoring has shown an 82 percent reduction in phosphorus entering the lake. The CLA continues to monitor the BMPs, and the project team is now beginning Phase II of the Chocorua Lake project, which will address additional phosphorus sources in the watershed. The success of the project is mainly the result of the resources and energy brought to it by the numerous project partners. The project team hopes to formalize one aspect of the project in a Memorandum of Agreement drafted between the CLA and the New Hampshire DOT. The CLA will inspect the BMPs and report on their condition annually to DOT so that long-term maintenance can be planned. DOT will invite CLA's participation in planning future highway improvements in the Chocorua Lake watershed.

www.des.state.nh.us/waterdiv.htm

NEW HAMPSHIRE

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Primary Sources of Pollution:
- urban storm water runoff

Primary NPS Pollutants:
- sediment
- salt
- phosphorus
- oil and grease
- heavy metals
- bacteria
- nitrogen

Project Activities:
- bioengineered wetland
- redesigned boat-launch ramps
- vegetated buffers
- sediment basins
- regraded surface away from lake

Results:
- reduced sediment
- monitoring in progress

Lake Opechee Watershed Project:
City-State Partnership Takes on Multiple Pollutants

Laconia, New Hampshire

Lake Opechee has a very high use and visibility in the city of Laconia. The watershed is one of the city's smallest but most urbanized watersheds, with the heavily developed Lakeport and Union Avenue to the southeast, the fringes of downtown to the south, and residential development surrounding most of the westerly, northern, and easterly sides of the lake. The city's principal beach and recreation complex, Opechee Park, is located on the south westerly shore of this water body, and one of the city's best public beaches, Bond Beach, is located on its northeasterly shore.

Lake Opechee suffered from multiple nonpoint sources of pollution related to the use of land in the public domain. Opechee Cove is a particularly sensitive area in the lake because very little exchange or flushing takes place. Storm water discharge from adjacent streets, as well as several boat launching ramps around Lake Opechee, had been identified as contributing significant sediment and urban runoff to the lake. The city's uncovered sand and salt storage facility, as well as a nearby private parcel used as a snow dump site, were also significant contributors of pollutants to Lake Opechee.

These sources were determined to contribute significant pollutant loads to the lake and the connecting Winnipesaukee River system, including salt, fertilizer, phosphorus, sediment, and the wide gamut of pollutants contained in urban runoff, such as oil and grease, heavy metals, bacteria, phosphorus, and nitrogen. In addition, boat trailers would become mired in the ramps, which had inadequate base preparation, thus stirring up large quantities of bottom sediment.

Multifaceted project

To address these issues, in 1996 the New Hampshire Department of Environmental Services initiated a 3-year project with the City of Laconia. To provide overland treatment before storm water entered the lake, the city implemented diversion and swale improvements, creating a 0.5-acre wetland in Opechee Cove to treat and settle out pollutants before the storm water entered the lake. The city also wanted to prevent run off and sediment from leaving the boat-launching ramps and discharging into the lake. To accomplish this, the city selected two boat-launching ramps to test the construction and maintenance of innovative best management practices (BMPs). The city installed a prefabricated mat and cellular block system as part of each ramp. Vegetated swales and diversions were also installed along the lake edge of the boat-launching parking lot to prevent runoff from discharging directly into the lake.

To prevent the direct overland flow of sand and salt from the public works yard to the lake, the city installed a vegetated buffer strip along the shore, regraded the public works yard surface away from the lake, installed a sediment basin to trap salt brine and sediment from the work bays, and guttered all building outlets to a newly installed catch basin. To prevent runoff of salt- and sediment-laden snowmelt from directly entering Lake Opechee, the city constructed a berm with a 25-foot setback from the lake and regraded the site such that runoff flows away from the lake at the city's snow storage facility. The city also constructed a 150-foot-long sediment basin along the toe of the berm to trap any sediment before it was discharged into the lake.

Successful as project and as learning experience

Officials from the City of Laconia expressed that this project has been a great learning experience for them, from the design issues to the construction and maintenance of each BMP. The project involved five different city departments working together to meet the water quality goals. The design and implementation process raised the city's awareness of the water quality and land use issues that face the community. The city has also expressed how pleased it is with the physical outcomes of the project, including the bioengineered wetland in Opechee Cove and the resulting modern boat ramps.

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Primary Sources of Pollution:
- urban runoff

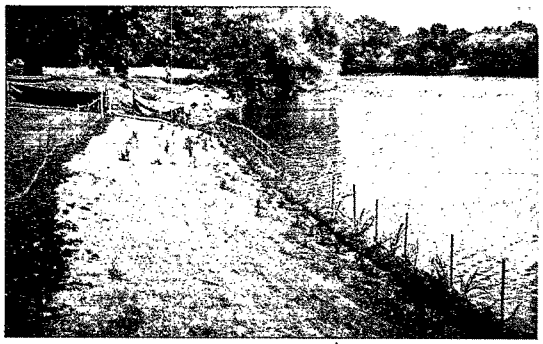
Primary NPS Pollutants:
- sediment
- phosphorus

Project Activities:
- streambank restoration
- construction of biofilter wetlands

Results:
- more than 4,000 feet of streambank stabilized
- monitoring in progress

Restoration of Strawbridge Lake:
Volunteers Assist in Stabilizing Shoreline and Constructing Wetlands

Moorestown (Burlington County), New Jersey



A coconut fiber roll and soil erosion blanket protected the bank until vegetation was established.

The Strawbridge Lake watershed comprises 12.6 square miles and encompasses portions of Moorestown, Mount Laurel, and Evesham Townships. Strawbridge Lake is surrounded by a park widely used by residents of Burlington and Camden Counties for activities like walking, biking, picnicking, fishing, and ice-skating. In addition to having a highly eroded shoreline, the lake receives numerous storm water discharges from the surrounding residential and commercial areas, as well as directly from State Route 38.

The lake itself has been listed by the New Jersey Department of Environmental Protection (NJDEP) as a water quality-limited water body. Sedimentation, elevated phosphorus, heavy macrophyte growth, and chlordane in fish tissue were identified as the water quality impairments at Strawbridge Lake.

Multiagency cooperation

NJDEP's NPS Grant Program provided 319 funding to help restore Strawbridge Lake in Moorestown, Burlington County. Additional funds were secured from the Township of Moorestown and the Eastgate Mitigation Fund, under the jurisdiction of the New Jersey Natural Lands Trust. Other cooperating entities included Omni Environmental Corporation and the Delaware Riverkeeper Network. In addition to the local schools, volunteers from AmeriCorps, Save the Environment of Moorestown (STEM), Moorestown Environmental Advisory Committee, and Strawbridge Lake Association assisted with the rehabilitation. Because of the efforts of these volunteers, about 80 percent of the 319 grant funds resulted in on-the-ground improvements.

More than 4,000 feet of eroding shoreline were stabilized using soil bioengineering techniques, which created a vegetative buffer, along with a "no mowing zone," along the lake's edge. The buffer ranged in width from 10 to 20 feet. Easy access areas, which were interspersed throughout the project, were created along the shoreline using red gravel bordered by large, flat stones. A total of 240 linear feet of shoreline was treated in this manner.

In addition to the shoreline restoration, biofilter wetlands (pocket wetlands) were constructed in the park area to treat seven storm water discharges into the lake. Four outfall structures were discharged into two pocket wetlands retrofitted to filter pollutants from the storm water. The last of these pocket wetlands was completed in

November 1999. Three of the discharges to the wetlands were retrofitted with sedimentation chambers to remove coarse sediment from the runoff from Route 38 before discharging the runoff to the lake. Volunteers participated in planting the biofilter wetland and installing the shoreline stabilization and vegetative buffer.

A model project

The Strawbridge Lake project is believed to be a great success. Other communities have used this project as a model. The project not only has enhanced the natural beauty of the lake and the surrounding park area for future generations but also has significantly improved the water quality of the lake.

NEW JERSEY

www.state.nj.us/dep/watershedmgt/nps_program.htm

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Primary Sources of Pollution:
- urban runoff

Primary NPS Pollutants:
- sediment

Project Activities:
- streambank restoration (bioengineering techniques and reforestation)

Results:
- more than 800 linear feet of streambank restored
- more than 10 acres of land reforested
- improved stream habitat
- monitoring in progress

The Stony Brook-Millstone Watershed Restoration Project:
Streamwatch Volunteers Monitor Success of Restoration Efforts

Mercer, Middlesex, Hunterdon, Somerset, and Monmouth Counties, New Jersey

Large-scale development is occurring at an accelerated rate in New Jersey's Stony Brook-Millstone watershed. As a result, runoff is passing over more areas of impervious surfaces. The increased flows during rain events are scouring streambanks, contributing sediment downstream, which clogs New Jersey's waterways, chokes aquatic life, and restricts plant growth by blocking sunlight.

Recognizing the impacts of urbanization in their watershed, the Stony Brook-Millstone Watershed Association (SBMWA) developed a 4-year project that involves general watershed restoration and reforestation projects with the main goal of stabilizing streambanks for erosion and sediment pollution control on various tributaries in the Stony Brook-Millstone watershed. The key to the SBMWA's current success is stakeholder and citizen involvement.

Three major activites

The project primarily focused on three activities to protect stream corridors: streambank restoration, bioengineering techniques, and reforestation. Training sessions in bioengineering and reforestation methods were offered to the public. The SBMWA also identified and convened stakeholders to ensure the success of the project. To determine whether the projects were successful, StreamWatch, SBWMA's volunteer monitoring program, will monitor the water quality at the restoration sites. StreamWatch volunteers chemically, biologically, and visually assess the environmental health of streams.

SBMWA also held educational sessions on what makes a stream healthy, the value of riparian corridors, and the role of trees in maintaining a healthy ecosystem. After this project, data gathered from Stream Watch will be evaluated and compared with previously collected data to determine the effectiveness of all these efforts.

Exciting results

From 1997 to 2000, more than 800 linear feet of streambank was restored, some 1,000 square feet

of lakeside hydric soils were planted, and 10.4 acres of land was reforested. The long-term educational benefits to the more than 1,200 volunteers who have participated in these efforts have been tremendous. Many groups return year after year to contribute to the project's success, as well as to observe days like Arbor Day, Earth Day, and Make a Difference Day.

With 2 years left on the project, the SBMWA is very excited about the success of these restorations. Severely eroding banks were regraded, revegetated, and stabilized to prevent additional sediment from entering the waterways. A new forest was planted, creating habitat and protecting the stream that runs through the former farm field. More important, volunteers and community representatives feel empowered by their ability to improve their environment.

www.nmenv.state.nm.us/swqb/NPS_Management_Plan-1999.PDF

NEW MEXICO

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Primary Sources of Pollution:
- degraded stream channel conditions
- road construction

Primary NPS Pollutants:
- sediment

Project Activities:
- road drainage improvements/outlets
- construction of sediment retention basins

Results:
- reduced sediment delivery
- improved turbidity readings

Lower Bitter Creek Restoration Project:
Sediment Loads Reduced by Implementing BMPs

Taos County, New Mexico

Bitter Creek is a perennial-to-intermittent stream that flows into the Red River, a major tributary of the upper Rio Grande system, in northern Taos County, New Mexico. The Bitter Creek subwatershed is immediately northeast of the town of Red River. Nonpoint source pollution, primarily from heavy sediment delivery, was identified as a significant contributor to water quality impairment of the Red River.

An interagency cooperative pollution prevention project was initiated with the Carson National Forest (CNF) Supervisor's Office, the Questa Ranger District (QRD), and the Town of Red River, with participation from local watershed residents. The project was designed to improve degraded stream channel conditions, correct road construction and maintenance practices, remedy illegal refuse disposal, and arrest the rapidly developing headcut impacts. The project also attempted to address the area's altered and mineralized volcanic geology input by mitigating the effects of unchecked erosion from a landslide/debris flow system overlooking the local Forest Service road and the Bitter Creek channel.

Arresting impacts of sediment delivery through BMPs

A number of best management practices (BMPs) were designed to reduce the impacts of turbidity and sediment delivery (with potential for heavy metal loading) in the watershed. A series of road drainage outlets and diversions were constructed to modify and improve drainage along the local forest system road. These outlets reduce the tendency for precipitation or snowmelt runoff to be confined to channelized road segments before

accessing degraded slopes via deep headcuts. Highly turbid road and headcut runoff is therefore prevented from delivering sediment directly to Bitter Creek.

In a particularly erodable stream segment known as "the Logjam," a set of energy dissipation and sediment aggradation measures have provided streambank and bed stability. The Town of Red River also constructed a series of in-channel sediment retention basins to slow flow, settle out suspended sediment, and allow channel bottom and floodplain aggradation. This approach aids in the development of a riparian plant community, creating an improved local habitat.

At the suggestion of the local residents, a sediment and runoff retention basin was constructed in the Bitter Creek Debris Flow. The Debris Flow is a surface feature formed by the

Bitter Creek Turbidity Sampling Before BMP Installation

Location	Date	Turbidity	Remarks
At Red River confluence	9/13/1988	110 NTU	
At Red River confluence	4/29/1992	125 NTU	
Upper Bitter Creek	7/24/1992	1.33 NTU	Headwaters
Above Two Lakes	8/31/1994	24.7 NTU	Turbidity measured above Two Lakes and debris flow reach
Above Red River	8/31/1994	1,000 NTU	Heavy rain event and runoff mobilizing abundant sediment
Below gravel pits	4/6/1999	21.7 NTU	
Below Logjam	4/22/1999	19.5 NTU	
At Red River culvert	4/22/1999	42 NTU	Turbidity sampled during local gravel sorting/hauling activities
Above Red River confluence	5/10/1999	231 NTU	Spring 1999 TMDL
Above Red River confluence	5/11/1999	85.2 NTU	Spring 1999 TMDL
Above Red River confluence	5/12/1999	40.3 NTU	Spring 1999 TMDL
Above Red River confluence	5/13/1999	48.3 NTU	Spring 1999 TMDL

Project Implementation Begins to Show Effects

Location	Date	Turbidity	Remarks
Below Scar Creek	5/21/1999	15.1 NTU	High flow (bankfull conditions thru Town of RR)
At Logjam	5/21/1999	16.8 NTU	High flow (bankfull conditions thru Town of RR)
At Red River confluence	5/21/1999	112.5 NTU	High flows mobilize sediment from gravel pits (clean upstream)
Above Logjam	5/26/1999	12 NTU	Low flow conditions resumed
Above gravel pits	5/26/1999	13 NTU	
Below gravel pits	5/26/1999	24.7 NTU	Gravel operations continue to impact stream flow
Above Red River confluence	8/17/1999	15.5 NTU	Summer 1999 TMDL
Above Red River confluence	8/18/1999	6.91 NTU	Summer 1999 TMDL
Above Red River confluence	10/25/1999	15 NTU	Fall 1999 TMDL
Above Red River confluence	10/26/1999	15.3 NTU	Fall 1999 TMDL
Above Red River confluence	10/27/1999	8.34 NTU	Fall 1999 TMDL
Above Red River confluence	10/27/1999	16 NTU	Fall 1999 TMDL
Above Town of RR basins	5/21/2000	88.3 NTU	Flow entering Town of RR basins from upstream.
Below Town of RR basins	5/21/2000	8.1 NTU	Settled base flow exiting sediment basins

Note: RR = Red River; NTU = nephelometric turbidity units

accumulation of landslide debris running off the Bitter Creek Scar's hydrothermally altered volcanic breccia that forms a high ridge overlooking the region. The favorable performance of the basin minimized the effects of outflow and runout for four large runoff events during 1999–2000, holding back most of the materials that would previously have affected the local road and restricted access into the Bitter Creek channel. This BMP implementation effort represents a temporary fix, and annual maintenance is necessary for this basin to continue to function. Convincing an agency or the local residents to take ownership of the BMP measure remains a target for this 319 project.

This project succeeded in identifying and mitigating a variety of nonpoint source impacts and in demonstrating effective approaches that land management agencies or local residents can adopt and maintain as they seek to preserve their environment and minimize the area's downstream effects. A series of measures were successfully implemented to reduce and control runoff from the roads and slope headcuts. The construction of in-channel revetments is aimed at long-term reduction of sediment loads from the stream system. Overall, the targeted decrease in turbidity of the flow that Bitter Creek delivers to its confluence with the Red River is being realized (see table). Lasting success at Bitter Creek, the Red River, and the Upper Rio Grande will require at least some level of continued monitoring and maintenance.

www.nmenv.state.nm.us/swqb/NPS_Management_Plan-1999.PDF

NEW MEXICO

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Primary Sources of Pollution:
- grazing
- fire suppression
- roads

Primary NPS Pollutants:
- sediment

Project Activities:
- establishment of public land grass bank program
- prescribed burning/ thinning

Projected Results:
- reduced erosion
- improved grasslands/ ecological diversity

Valle Grande Grass Bank Water Quality Improvement Project:
Success Breeds More Success

San Miguel County, New Mexico

Grasslands and meadows in northern New Mexico have been experiencing continued decline because of the combined effects of fire suppression and historical grazing. The loss of grass communities has diminished ecological diversity in the regional landscape and has contributed directly to high rates of soil erosion and consequent nonpoint source pollution throughout the region. It has also eroded the viability of northern New Mexico's small-scale Hispanic ranching community, which depends on the use of public lands throughout the region.

Nearly all of the ecological communities that support grazing in northern New Mexico depend on recurrent low-intensity fire to arrest the encroachment of trees and shrubs. It follows that a

central challenge in restoring grassland diversity and productivity is to restore fire to its natural role in structuring and renewing the regional landscape. Simply removing cattle from public lands will not restore environmental diversity and health because it will not bring the keystone process of fire back into the landscape.

Rise of the grass bank program

In 1996 The Conservation Fund (TCF), with the assistance of the Forest Service, studied the feasibility of establishing a public land grass bank in northern New Mexico. In 1997 the study led to the formation of a steering committee composed of representatives from the Forest Service, the Cooperative Extension Service, the Northern New Mexico Stockmen's Association, and The Conservation Fund. In August 1997 TCF acquired 240 acres of land on Rowe Mesa, south of the town of Pecos in San Miguel County, renaming it the Valle Grande Ranch. Purchase of the land qualified TCF to become the sole grazing permittee of the adjacent 36,000-acre Valle Grande grazing allotment within the Santa Fe National Forest.

The grass bank program allows participants (selected by the supervisor of the Santa Fe National Forest based on the steering committee's recommendation) to have cattle delivered to the Valle Grande allotment and placed in the care of a full-time cowboy and range rider provided by TCF. By placing their cattle on the grass bank, participating permittees rest their "home" allotments, allowing their pastures, for instance, to grow a crop of grass that will fuel a prescribed fire. Participation in the grass bank usually lasts several growing seasons, allowing desired vegetation to become resilient following restoration treatments.

The first cattle arrived on the Valle Grande Grass Bank in March 1998. By mid-summer, the ranch held 264 cows from four allotments. Gradually, the reputation of the grass bank grew. By January 1999 the steering committee had received applications from seven allotments requesting three times the amount of grazing than was actually available. During the summer of 1999, 346 cows and their calves, belonging to 19 permittees from three allotments, grazed on the Valle Grande Grass Bank.

Land treatment projects: a significant component

In fiscal year 2000, funding from the 319 program helped to support a composite of land treatment projects involving six grazing allotments and five New Mexico watersheds throughout the Santa Fe and Carson National Forests. The unifying purpose is to obtain improved grazing management and ecological restoration that will produce healthy watersheds and reduce nonpoint sources across a wide spectrum of northern New Mexico. Success on these allotments will ensure that permittees on other allotments will want to participate in the Valle Grande Grass Bank program or similar programs at a future date across a broad spectrum of watersheds.

Land treatment projects generally involve burning and thinning to reduce tree and brush densities and to increase effective vegetation ground cover, thus reducing soil erosion and offsite sedimentation and turbidity. Grass bank resting is also necessary to ensure maximum fine fuels prior to burns and to provide rest for establishing seedlings on projects that involve disturbed soil. Road projects are also implemented to improve drainage and appropriate channel crossings, and in some cases might also include closure. Ultimately, 5,800 acres will be burned; 1,475 acres will be thinned; 6 miles of fencing will be constructed; and 5 miles of road will be treated.

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Primary Sources of Pollution:
- agriculture (animal operations, vineyards, croplands)

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- revised fertilizer and pesticide management practices
- diversion ditches
- buffer strips
- alternative vineyard layout

Results:
- reduced erosion
- increased crop yields
- decreased applications of nutrients and pesticides

Keuka Lake Watershed:
Grape Growers Implement Soil Conservation Practices

Yates and Steuben Counties, New York

The Agricultural Environmental Management (AEM) Program has put New York State in the forefront of a national effort to help farmers identify and address agricultural nonpoint source pollution. New York's AEM Program is a statewide voluntary, incentive-based program. It provides cost-sharing and educational/technical assistance for the development and implementation of agricultural plans that enable farmers to remain good stewards of the land, maintain economic viability of the farm operation, and comply with federal, state, and local regulations relating to water quality and other environmental concerns. (*Refer to special feature section on Innovative State Programs for more information on New York's AEM Program.*)

The New York Department of Agriculture and Markets selected Keuka Lake as a pilot watershed to test some of the new Agricultural Environmental Management (AEM) concepts developed under "Whole Farm Planning" efforts under way elsewhere in the state. Keuka Lake is an outstanding natural and cultural resource, as well as a primary drinking water source for more than 20,000 people. The surrounding watershed, encompassing 99,700 acres of land that drains into the lake, supports a diverse and thriving agricultural community of about 34,000 acres of dairy/livestock, vegetable/cash crops, grapes, and fruit trees. Vineyards occupy one-quarter of this acreage. Grape production in the Finger Lakes area directly contributes $15 million per year to the regional economy, and associated services and tourism contribute even more to the local economy.

Soil and water conservation practices for vineyards

Grape growers have a history of good land stewardship and recognize the benefits of conservation practices for both environmental and economic reasons. Through the AEM program, grape growers are implementing a number of soil conservation practices to prevent contamination of lake water by soil, fertilizers, and pesticide residues. Diversion ditches are being constructed to collect water from slopes and divert it away from the vineyards and into natural drainageways; buffer strips are being added around the perimeters of vineyards; and alternative vineyard planting layouts and vineyard floor management options (including no-till seeding of row middles) are being implemented.

Grape growers are also adjusting their fertilizer and pesticide application practices through the AEM program. Practices used to manage fertilizer use with grapes include soil and petiole (stem) tests (to avoid deficiencies and excesses of nutrients needed for efficient production) and split nitrogen applications (with revised timing

periods for fertilizer applications). Growers are also using a variety of techniques under the umbrella of Integrated Pest Management to efficiently use pesticides only when they are economically justified: insect scouting is being conducted, resulting in revised spray schedules; disease forecasting is helping to define critical periods for applying fungicides to control diseases; and canopy management, which reduces shading, is resulting in better penetration of spray materials while enhancing the development of desirable flavors that contribute to wine quality.

Promising results

Soil conservation practices are yielding both environmental and economic benefits for grape growers. The construction of diversion ditches is reducing the amount of water running through vineyards by up to 80 percent. Using an alternative vineyard layout—planting vineyards so that the rows run across the slope rather than up and down the slope—is reducing erosion by up to 50 percent. Alternative floor management options, such as applying straw mulch to row middles, can directly increase yields by up to 20 percent on some sites.

Efficient use of fertilizer and pesticide inputs directly improves the bottom line. For a 100-acre vineyard operation, each spray applied to the vineyard represents an investment of $2,000 to $3,000—ample motivation for avoiding "recreational spraying." Revised spraying practices are resulting in documented reductions in the average number of insecticides applied, from three to four per year in the 1980s to an average of 1.3 per year in the most recent U.S. Department of Agriculture survey of New York grape growers.

Continued innovation by area growers and researchers will be a key factor in maintaining the economic viability of the industry and protecting soil and water quality in the Keuka Lake watershed.

NEW YORK

www.dec.state.ny.us/website/dow/index.html

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Primary Sources of Pollution:
- agriculture (animal operations, vineyards, croplands)

Primary NPS Pollutants:
- nutrients
- sediment

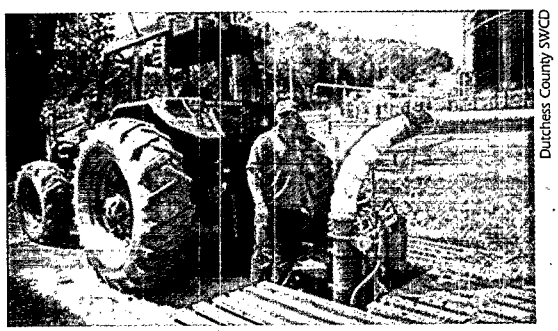
Project Activities:
- nutrient management practices
- Integrated Pest Management

Results:
- riparian protection on 3,000 acres

Wappingers Creek Watershed:
AEM Program Plays a Vital Role

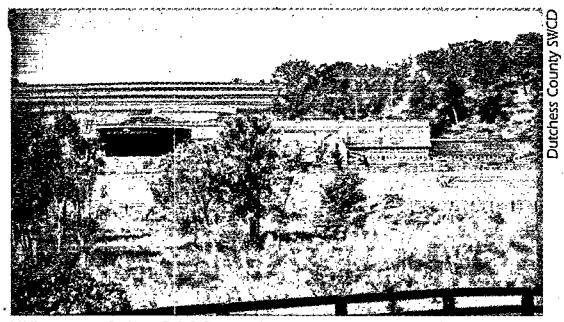
Dutchess County, New York

In 1996 the Dutchess County Soil and Water Conservation District (SWCD) took the lead in organizing partners at the local level to initiate the AEM process in the Wappingers Creek watershed. Contained entirely within Dutchess County, the Wappingers Creek watershed drains 134,900 acres into Wappingers Lake. Some 30,000 acres is agricultural land, consisting of 108 agriculture enter-



Dutchess County SWCD

Peter Coon prepares to power up the primary pumping station to the farm's new waste storage facility.



Dutchess County SWCD

Winner of the 2000 Environmental Stewardship Award, the Coon brothers' farm was one of the first in the state to participate in the AEM Program.

prises, primarily concentrated in the northern portion of the watershed. A broad diversity of agriculture is represented, ranging from traditional animal operations to vineyards and specialty cash crops.

All 108 agricultural operations in the watershed elected to participate in the AEM Program. The process involves farm inventory and assessment, planning, implementation, and evaluation. An array of nutrient management practices were implemented on more than 3,000 acres of agricultural land, covering a diversity of operations including crop farms, horse operations, and tree farms. Strip cropping techniques, in which alternating strips of different crops are planted in the same field, were used to minimize wind and water erosion.

Soil and manure were tested to assess the nutrient levels so that proper application rates could be determined. In partnership with the U.S. Department of Agriculture's Conservation Reserve Program, fences and alternative watering systems were constructed to eliminate cattle's access to surface waters. Stream crossings were constructed to prevent damage to the water body from equipment and cattle, and rotational grazing systems were tested. Integrated Pest Management practices were used, providing the dual benefits of reducing production costs and increasing environmental protection.

Of the 38 farms reaching the planning level, 50 percent have completed implementation of best management practices, resulting in a significant reduction in agriculture-related nonpoint source pollution entering Wappingers Creek. The AEM process has provided an inventory that has enhanced the Dutchess County Farmland Protection Program, helping to preserve agricultural enterprises in the headwaters of the creek.

Keeping farms viable is important for the environmental health of the watershed. As development pressure increases in Dutchess County, the AEM Program continues to play a vital role in maintaining the county's agricultural heritage.

http://h2o.enr.state.nc.us/nps/319updat.pdf

NORTH CAROLINA

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Primary Sources of Pollution:
- agriculture
- urban runoff

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- constructed wetlands

Results:
- 60 percent reduction in nitrate nitrogen
- 33 percent reduction in ammonia nitrogen
- 9.5 percent reduction in TKN, 20 percent reduction in total nitrogen
- 55 percent increase in total phosphorus

Edenton Storm Water Wetland Project:
Wetland Systems Reduce Nitrogen Concentrations

Chowan and Dare Counties, North Carolina

In northeastern North Carolina, excess rainfall is typically removed from developed areas by an existing network of field ditches and canals, often bypassing natural riparian areas before entering creeks and streams. As a result, the nutrients and sediment in storm water are often carried directly to the nutrient-sensitive river and estuarine waters.

Installing constructed wetlands

In an effort to control water flow and improve water quality, constructed wetlands were installed to intercept two ditches draining approximately 600 acres of a surrounding agricultural and urban watershed in the town of Edenton, North Carolina. The drainage area included a hospital, a shopping center, residential areas, and several hundred acres of agricultural land. In addition to the two inlet ditches, one small side ditch, several tile drains, and possible groundwater movement also contributed to the wetland.

The wetland systems are considered "constructed" wetlands because the natural relief or lack of relief is not conducive to implementing a traditional riparian system. Wetlands were created in existing drainage canals by installing water control structures and planting several native wetland species.

Educational opportunities were also provided for school groups, scout troops, and civic groups. Two field days, four educational meetings, and one training workshop for agency personnel and consultants were held.

Mixed results

The project demonstrated that wetlands with small wetland/watershed area ratios can provide significant water quality benefits for nitrogen, although phosphorus increased. Monitoring and data collection at this site were conducted from 1996 to 1999. The integration of grab and automatic sampling schemes resulted in more than 1,000 water quality samples. Concentrations of all forms of nitrogen were reduced significantly between the inlets and the wetland outlet over the evaluation period. The highest drop in concentrations was achieved for nitrate nitrogen (NO_3–N, 60 percent), with lower declines for ammonia nitrogen (NH_4-N, 33 percent) and total Kjeldahl nitrogen (TKN, 9.5 percent) levels. Total nitrogen concentrations were 20 percent lower at the wetland outlet.

Phosphorus levels increased 55 percent between the inlets and the outlet. The liberation of phosphorus bound in the wetland substrate and organic matter apparently negated any sorption or uptake occurring within the wetland. At some point in the future, phosphorus equilibrium might be reached, leading to no net increase at the outlet. Thus far, however, no decline has been observed.

Nitrate and ammonium nitrogen concentrations dropped as much through the wetland during the dormant months as during the growing season. TKN concentrations were lowered only during the winter months. The observed increase in phosphorus concentrations between wetland inlets and the outlet was significantly larger during the summer months than in the dormant periods.

Public acceptance of the project was excellent, attributed to the pleasing aesthetics of the sites. A variety of wildlife continues to flourish in the wetland.

For more information on the project, go to www.bae.ncsu.edu/research/evans_web/etd/klbass.pdf.

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Primary Sources of Pollution:
- degraded channel

Primary NPS Pollutants:
- sediment

Project Activities:
- ecosystem protection practices (stream rehabilitation)

Results:
- revegetation of 600-foot reach
- decrease in sulfate levels
- flow-reducing structures installed along 1,584 feet of streambank

Goose Creek Urban Stream Rehabilitation Project:
Ecosystem Protection Practices Installed in Low-Income Neighborhood

Durham County, North Carolina

Goose Creek is the major stream draining east-central Durham, North Carolina. The creek is a tributary of Ellerbe Creek, identified in the 1993 and 1998 Neuse River Basin Management Plans as not supportive of its intended uses. The watershed is in an old, well-established low-income neighborhood with little opportunity for landscape modification to alter runoff quantity or quality.

The channel was extremely degraded with hardened channel control structures, including concrete fiber fill lining and vertical rock wall channel banks. The hardened urban flow channels were extremely conducive to carrying large quantities of sediment at a very high velocity.

Three-phase creek restoration

Restoration of Goose Creek involved installing ecosystem protection practices, or EPPs (stream rehabilitation), to reduce sediment, reduce thermal fluctuation, and increase dissolved oxygen. Recommended EPPs were derived from typical stream restoration techniques and modified for the Goose Creek system. The project was designed to rehabilitate more than 2,100 feet of the stream, in three continuous treatment phases.

Phase I included the installation of 25 log structures in an 884-foot-long concrete-lined fiber fill channel. The concrete-lined channel provided no water quality protection or vegetation to reduce flow. The log structures provided channels to break up storm flow energy; variety of flow allows for deposit behind the logs and storage of sediment. This phase of the project included the addition of soil and planting of wetland vegetation to provide shade and some nutrient uptake in the cement-lined area. A group of volunteers planted willows and wetland plants along a 600-foot reach of the project.

Phase II of the project occurred in a public park but was constrained by vertical rock walls on both sides. Four rock cross veins were installed along a 700-foot reach to break up energy and increase dissolved oxygen in this low-gradient channel. The cross veins reduce stress on the rock walls by transferring flow toward the center of the channel.

Phase III of the project was to involve a section of the stream that runs through an industrial and commercial area. This phase was not completed within the scope of the 319 grant primarily because of the need to perform underground soil remediation at an industrial site. However, Phase III has received funding from the North Carolina Clean Water Management Trust Fund and is projected to be completed after the soil remediation is performed, possibly by the end of 2001.

Meeting the challenge

Phases I and II of the project were completed in February of 1999. The education portion of the project, which is coordinated through the Durham Soil and Water Conservation District Office, is ongoing.

The project is unique in that it has employed stream restoration techniques in an extremely constrained situation to create a sustainable creek ecosystem. The term "ecosystem protection practice" is appropriate, considering the initial channel condition. Installation of these practices through an elementary school and public park will increase education opportunities in this low-income neighborhood. The enhancements will improve public perception about the stream and potentially reduce litter and other pollutants to the system.

NORTH DAKOTA

www.health.state.nd.us/ndhd/environ/wq/

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Primary Sources of Pollution:
- agriculture (grazing and croplands)

Primary NPS Pollutants:
- nutrients (nitrogen and phosphorus)
- suspended solids
- fecal coliform bacteria

Project Activities:
- agricultural BMPs (waste management facilities, grazing practices, conservation plans, low/no-till equipment)

Results:
- agricultural practices implemented on more than 34,000 acres
- positive trends in total ammonia and nitrogen concentrations

Cottonwood Creek Watershed:
Project Is a Success in the Works

LaMoure County, North Dakota

Lake LaMoure, constructed in 1973, is a 500-acre reservoir on Cottonwood Creek in southeastern North Dakota. The reservoir's watershed encompasses some 107,000 acres, and agricultural production (crops and livestock) is the primary land use in the watershed. Swimming, boating, and fishing are the main recreational uses of the reservoir. Local residents, however, were becoming increasingly concerned about the deteriorating recreational opportunities at the lake. Of particular concern were the frequent algae blooms in mid- to late summer and a fish community dominated by rough fish such as carp and bullheads.

The LaMoure County Soil Conservation District (SCD) initiated an assessment of the Lake LaMoure watershed in 1995 to evaluate the relationship between land management and degrading water quality. Assessment activities included measuring water quality and quantity in the creek and lake and taking an inventory of current land use practices in the watershed. The SCD was able to determine that the recreational use impairments in Lake LaMoure were primarily associated with nonpoint source pollutants from agricultural lands, including nutrients (nitrogen and phosphorus) and suspended solids. Potential pollutant sources included excessively tilled croplands, overgrazed rangeland, and livestock winter feeding areas. Resuspended sediments and nutrients resulting from an excessive carp population were a possible factor contributing to the declining recreational use of the reservoir.

Improving agricultural land management practices in the watershed

As a result of the assessment, the SCD identified targeted conservation planning assistance along with voluntary implementation of best manage-

ment practices (BMPs). This approach was initiated in 1996 with the development of a watershed project implementation plan (PIP) that identified beneficial use improvement and pollutant reduction goals, specific activities for accomplishing the goals, and a process for evaluating progress. EPA granted the Cottonwood Creek Watershed PIP section 319 funding approval in January 1997 ($301,071), and the project was initiated in March 1997. Subsequent section 319 funding ($617,249) was also awarded to the project in 1999 to support expanded efforts.

The primary goal of the Cottonwood Creek watershed project is to improve the fishery and recreational use of Lake LaMoure by improving agricultural land management practices in the watershed. Land use improvement objectives include installing 12 livestock waste management facilities and implementing conservation plans on more than 50 percent of the acreage in the watershed. Target concentrations by the end of the project include a mean annual phosphorus concentration of 0.20 mg/L at the inlet and fecal coliform bacteria concentrations that remain below 200 colonies/100 mL.

Early success beyond expectations

During the first 3 years, the project focused on the promotion and installation of BMPs that reduce nutrient inputs and maintain crop residue cover on croplands after spring seeding. Particular emphasis was placed on the promotion of annual soil testing and the use of no-till or minimum tillage equipment. Through these efforts, the project has exceeded the SCD's original expectations and is already well on the way to achieving its land management goals.

As of October 2000, conservation plans were being implemented on about one-fourth of the agricultural lands in the watershed. The main practice scheduled under these conservation plans is conservation tillage, which calls for maintaining more than 30 percent crop residue cover on croplands after spring seeding. Nutrient and pesticide management practices are also being implemented concurrently on many of the conservation acres to reduce chemical inputs. The factors with the most influence on the widespread adoption of conservation tillage, nutrient management, and other BMPs are a high level of producer participation, an expanded educational effort, and targeted one-on-one planning assistance delivered by skilled project staff. Total conservation tillage acres and other BMPs applied in the watershed, to date, are as follows:

Conservation tillage	16,948.6 acres
Nutrient management	9,413.6 acres
Integrated crop management	2,717.0 acres
Crop residue use	2,246.2 acres
Cross fencing/planned grazing	220.0 acres
Hayland planting	874.9 acres
Tree planting	960.0 linear ft (Not included in acreage total)
Pesticide Management	2,454.2 acres
Total Acres Affected	34,874.5 acres

Although the SCD continues to strive toward improved management on more than 50 percent of the cropland acres, they have also recently begun to direct more assistance and attention toward livestock management to reduce water quality concerns (fecal coliform concentrations) associated with livestock manure. To date, the efforts have resulted in the installation of two livestock manure management facilities and the preliminary development of several grazing plans. In addition, project staff are working with six other producers interested in installing manure management facilities in 2001. When these systems are installed, the project will be more than halfway to its goal of installing 12 manure management facilities after just 2 years of active implementation.

Continued monitoring of water quality benefits

Project progress and BMP benefits are being evaluated through water quality monitoring at three sites on the creek. Data collected at these sites include stream stage and discharge, and pollutant concentrations. The water quality variables being monitored are nutrients (nitrogen and phosphorus), total suspended solids, and fecal coliform bacteria. Baseline data collected from 1995 to 1998 and water quality monitoring have been used to define baseline conditions and reflect water quality conditions before project implementation. Water quality data collected after 1999 will be used to document the cumulative benefits of BMPs applied in the watershed because 1999 was the first year with a significant number of BMPs.

Although the project has realized quick progress toward its land management goals, the nature of the applied practices and size of the watershed make it very difficult to accurately measure the water quality benefits associated with the practices over the short term. However, a preliminary review of water quality data collected since 1997 does indicate that water quality conditions are beginning to improve at some sampling sites in the watershed.

The most notable water quality trend has been detected at the monitoring site for the headwaters watershed. Although fluctuations in the concentrations are still within the range of natural variability, it appears that the project is having a positive effect on total ammonia and nitrogen concentrations in the upper portion of the watershed. However, examination of other water quality variables, such as fecal coliform bacteria, shows mixed results. Consequently, an accurate evaluation of the Cottonwood Creek project after just 2 years of "targeted implementation" cannot be based on measured water quality trends.

A more accurate indicator during this early stage of the project is an evaluation of the number of BMPs applied in the watershed. Based on this information, the Cottonwood Creek project is achieving land management improvements in the watershed and can truly be recognized as a "success in the works." Over the long term, as BMPs mature and additional practices are installed, the water quality benefits of these land use changes will be tracked through ongoing monitoring efforts and the data will be used to confirm and quantify the anticipated success of the Cottonwood Creek project.

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Primary Sources of Pollution:
- streambank erosion
- agriculture (grazing)
- logging

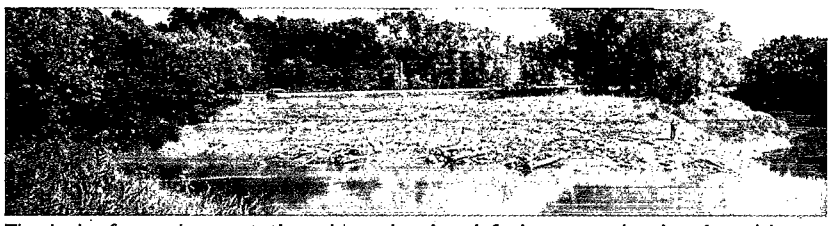
Primary NPS Pollutants:
- sediment

Project Activities:
- bioengineering practices (slope stabilization, installation of riprap, revegetation)

Results:
- establishment of riparian vegetation that withstands flooding
- reduced sedimentation

Red River Basin Riparian Project:
Turtle River Site Passes the Test

Grand Forks County, North Dakota



The lack of woody vegetation along the river left the streambank vulnerable to severe erosion.

Over the past 50 years, most riparian areas in eastern North Dakota watersheds have been mismanaged and degraded by activities like overgrazing, intensive agriculture, and indiscriminate logging. It is estimated that more than 50 percent of the original forest cover in many watersheds in eastern North Dakota has been cleared for agricultural use. In addition, unmanaged grazing has damaged a significant portion of the remaining riparian forests. Overgrazing, in combination with the 1987 to 1990 drought, left many riparian areas in a weakened condition and susceptible to insects and diseases.

Initiated in 1994, the Red River Basin Riparian Project seeks to restore degraded riparian corridors in the Red River Basin in North Dakota. An advisory committee with representatives from several state and federal agencies advises the project on behalf of the project's sponsor, the Red River Resource Conservation and Development Council (RC&D). Healthy riparian corridors offer benefits for water quality, as well as flood damage reduction and wildlife habitat.

Willows were planted along the restoration site to provide long-term stability.

The project sponsors plan to establish up to nine demonstration sites in the Red River Basin, restoring at least 100 river miles during the 5-year project term. At one demonstration site, the Turtle River site, the lack of woody vegetation had left the streambank vulnerable to severe erosion. The situation was compounded by groundwater seeps above the baseflow elevation of the river. Between 1978 and 1995, the river migrated approximately 3.5 feet per year to the east until it was only 80 feet from the county road. When the bioengineering project was initiated 1995, the site had a vertical bank about 14 feet high.

Successful bioengineering practices

To stabilize the bank and stop further migration toward the road, several bioengineering techniques were implemented. The first step was to create a

After the bioengineering work was complete, the streambank was able to withstand spring floods and an unusual 17-inch rainstorm in July 2000.

stable slope for the vegetation. The 14-foot vertical bank was reshaped to a 3:1 slope, using the waste from the top as fill at the toe. Riprap was then installed along the toe to the bankfull elevation. Bioengineering practices were installed as part of a workshop featuring the Natural Resources Conservation Services' bioengineering team from Michigan. Willow fascines and a brush mattress were installed along the 300-foot length to armor the bank and to begin the revegetation process.

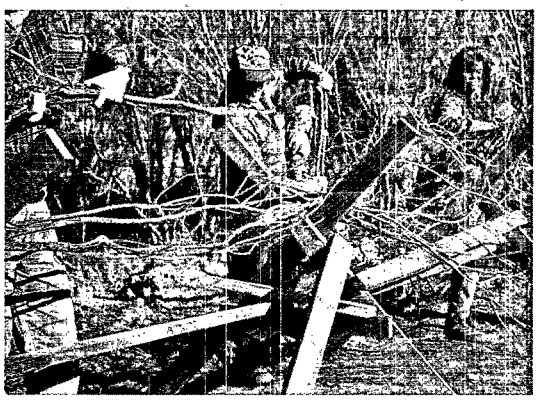
Passing the test

Serendipitously, the Turtle River project coincided with the biggest flood of the century in the Red River valley, so it has sparked a new appreciation of river systems. It has also been well positioned to offer solutions that recognize the characteristics of a naturally stable river system.

Although some maintenance was required each spring in 1996 and 1997, the project bioengineering has survived both spring floods and a 17-inch rainstorm in July 2000. The lessons learned from experience at the Turtle River site include the following:

- Soil/plant material contact is best provided by using water to place the soil over brush mattresses and fascines. Sponsors used a power washer to wash in the soil placed by the backhoe.
- The loose fill used at the toe can be susceptible to erosion, especially in the first season. The site appears to have responded well to the repair work, but adding roughness to the toe would have helped. The use of root wads will be demonstrated at the Sheyenne River site.
- Deer and beaver find willow sprouts irresistible. At the Turtle River site, time will tell whether animals were detrimental to the survival of the willows. In the future the use of repellants might be necessary.

Riparian areas are crucial to the long-term protection and enhancement of the streams, rivers, and lakes in eastern North Dakota. Well-managed riparian zones help provide optimum food and habitat for stream communities, while at the same time serve as buffer strips for controlling nonpoint source pollution. Used as a component of an integrated management system (including nutrient management and erosion control), riparian buffers can greatly benefit the quality of the state's surface water resources.



At a workshop, the Natural Resources Conservation Service demonstrated the implementation of several bioengineering techniques.

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Primary Sources of Pollution:
- agriculture

Primary NPS Pollutants:
- nutrients
- sediment

Project Activities:
- agricultural BMPs (buffers, fencing, alternate water sources, conservation tillage, nutrient management)
- education and outreach

Results:
- increases in conservation tillage
- establishment of stream buffers and constructed wetland

Stillwater River Watershed Protection Project:
High Local Interest Helps Launch Watershed Project

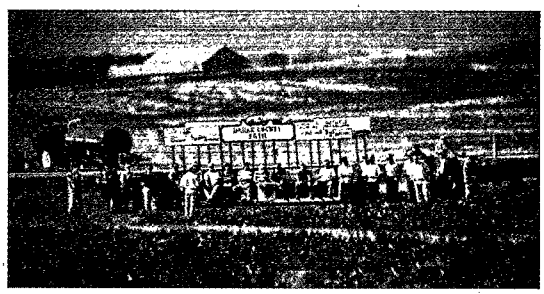
Darke and Miami Counties, Ohio

Since its inception in 1992, the Stillwater River Watershed Protection Project has been a model for other projects in the development of watershed planning and implementation for the control of agricultural nonpoint source pollution. The project was originally proposed in 1988 as a Hydrologic Unit project through the Natural Resources Conservation Service. Funding for this purpose was not granted, but local interest in a watershed project remained very high. With the assistance of 604(b) funding, the Miami Valley Regional Planning Commission completed a management plan for the project. The project was then launched with the support of a joint board of supervisors drawn from the Darke County and Miami County Soil and Water Conservation Districts.

To date, more than $2 million has been raised from external sources to help implement the watershed plan. The sources include the Ohio Environmental Protection Agency's 319 Program, as well as several funding programs through the U.S. Department of Agriculture (USDA). In addition, the joint board entered into an agreement with Ohio EPA for a Water Pollution Control Loan Fund (WPCLF) Program that so far has provided $1.3 million in loans to 57 participants.

Emphasis on agricultural practices

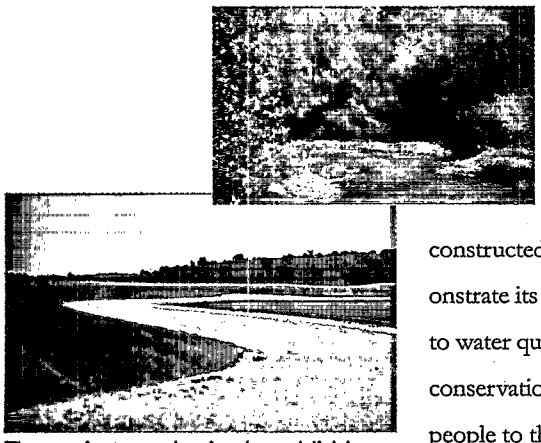
Much emphasis has been placed on the installation of best management practices (BMPs), identified in the project's management plan as key to success. Stream buffers of grass and trees were established. Where necessary, exclusion fencing was installed along with alternative water sources for cattle. Nutrient management, including soil sampling for precision farming, has been demonstrated. Additional cost-share incentives and Ohio EPA's linked deposit low-interest loan program have resulted in the purchase of equipment for conservation tillage and manure management.



Education programs, including state fair displays, emphasize the benefits of BMPs to protect water quality and increase farm productivity.

Importance of outreach

Education programs in the watershed have included two canoe trips each year to acquaint landowners, local officials, students, and others with the river and its environment. In addition to quarterly newsletters, speaking engagements, and fair displays, two sites have been established for annual field days. These sites include demonstrations of BMPs to protect water quality and increase farm productivity. Additional annual field days have emphasized conserva-

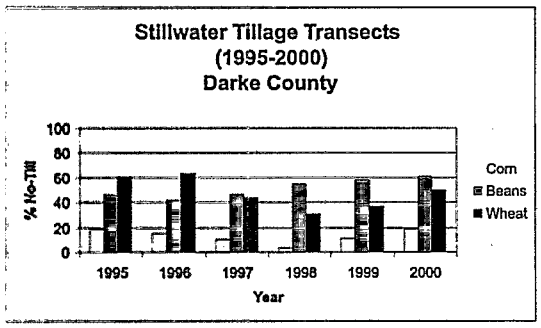


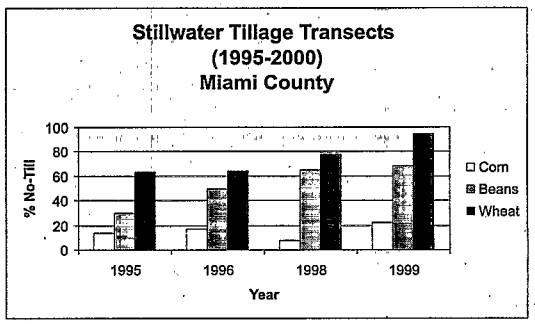
The project emphasized establishing stream buffers of grass and trees to reduce sediment and nutrients entering streams.

tion tillage, and a marked increase in its use has been documented in the watershed (see figures). A wetland was also constructed at a county park to demonstrate its function and its importance to water quality and wildlife. Annual conservation tours also have exposed people to the BMPs installed as a result of the project.

Leveraging additional funding

An additional benefit is that this project has stimulated many other sources of funding for use in the watershed. USDA committed Water Quality Incentives Project funds to three subwatersheds, one of which has a large number of livestock operations, to improve manure handling and nutrient management through effective nutrient management planning. Ohio's Department of Natural Resources has contributed grants for conservation easements (in cooperation with local park districts), a manure nutrient management technician, a wildlife technician, exclusion fencing for livestock, geographic information system (GIS) equipment and training, and a watershed coordinator. To help ensure continuation of the project, the joint board is pursuing incorporation as a 501(c)(3) nonprofit organization.





OHIO

www.epa.state.oh.us/dsw/nps/nps.html

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Primary Sources of Pollution:
- agriculture
- habitat alteration (stream channelization and removal of riparian vegetation)

Primary NPS Pollutants:
- nutrients
- sediment

Project Activities:
- filter strips
- set-aside floodplain areas
- conservation tillage practices

Results:
- established 142,213 linear feet of buffers
- conservation tillage farming methods on 1431.21 acres

Toussaint River Incentive Improvement Program:
Buffer Project Becomes a Model of Conservation Partnership

Wood, Sandusky, and Ottawa Counties, Ohio

When the Great Black Swamp was drained in the late 1800s, northwest Ohio settlers discovered very fertile soils that were capable of high-yield agricultural production. Today, with an extensive system of artificial drainage in place, the region is a leader in grain and specialty crop agriculture. Ohio's western Lake Erie watersheds devote 65 to 87 percent of their land use to farming. Because of the geologic history of this area and the current land use, Lake Erie water quality suffers from

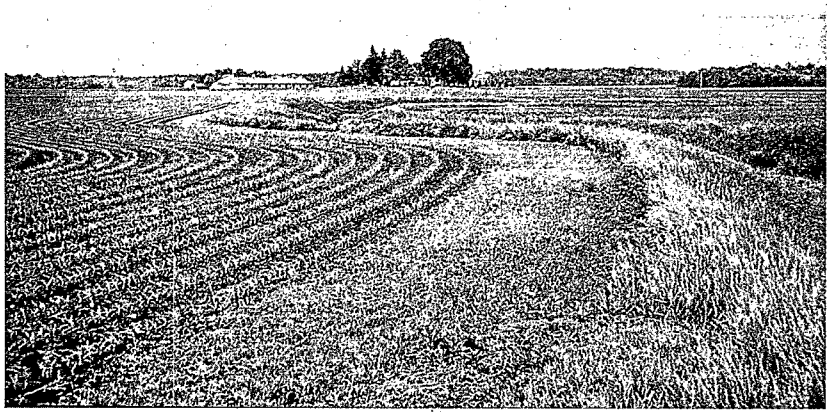
A grass filter strip, in combination with a riparian buffer, helps protect the water quality in this stream.

A 200-foot-wide floodplain is set aside along portions of the Toussaint River.

large sediment and nutrient loadings from agricultural runoff.

Nationwide initiatives and funding programs to reduce nonpoint source pollution are meeting with success in Ohio. With the introduction of the Lake Erie Conservation Reserve Enhancement Program (CREP) in 2000 and ongoing 319 and Conservation Reserve Programs, landowners have increased opportunities to receive incentives for implementing agricultural best management practices (BMPs) that improve or protect water quality. The Toussaint River Incentive Improvement Program is a watershed implementation project that has promoted buffer practices along nearly three-fourths of the river's main stem.

The Toussaint River, in northwest Ohio, flows directly into Lake Erie between Toledo and Port Clinton. A relatively small watershed, the Toussaint watershed covers about 90,000 acres and comprises portions of Wood, Sandusky, and Ottawa Counties. The main causes of water quality impairment are habitat alteration (stream channelization and removal of riparian vegetation), siltation, and nutrient enrichment due to the large agricultural land use in the watershed.



A 20-foot-wide filter strip maintained along a grass channel helps reduce sediment entering the Toussaint River.

Providing financial incentives

The Toussaint River project offered landowners along the 36-mile main stem of the river economic assistance to implement a range of BMPs. Through a $275,000 subgrant from Ohio EPA's 319 Program, financial incentives were available to establish filter strips, set aside floodplain areas, and use conservation tillage practices along the river corridor. The landowners were required to make a 5-year commitment to maintain these conservation practices. Water quality assessments of the river were made both before practices were put into place and after they were established. The goal of the program was to reduce sediment and nutrient loadings into the Toussaint River and Lake Erie.

Success in implementation

Landowners along the Toussaint River signed 57 contracts, more than 32.13 acres of filter strips were established, and 233.25 acres of floodplains were set aside and planted to grass. This means that a total of 142,213 linear feet of streamside land (nearly 27 miles of the 36-mile-long stream corridor) was converted to conservation buffer practices that will improve water quality. Along with these improvements, participating farmers switched to conservation tillage farming methods on 1,431.21 acres adjoining the new buffers.

Although the original grant objective was to install 100 acres of filter strips and to set aside 100 acres of floodplain, there was more landowner interest in the downstream reach of the river where there is a lower gradient and a broad, flat floodplain. The grant was modified to increase the maximum filter strip width to 200 feet in floodplain areas with alluvial soil types. It is believed that the

wider filter strips in these more extensively flooded areas will further control erosion, provide wildlife habitat, and benefit water quality.

The Agricultural Runoff Action Group of the Maumee Remedial Action Plan (RAP) sponsored this 319 grant. The RAP's objective is to restore the Lower Maumee River, one of 42 Great Lakes Areas of Concern. The Agricultural Runoff Action Group is a partnership of more than one dozen agencies and private organizations that have contributed some $208,000 in local and state matching funds to this project. Of particular note was the strong leadership and the cooperation between Soil and Water Conservation District staff in the three counties, as well as the donation of seed, equipment, and labor by local Pheasants Forever chapters to establish the filter strips. The Agricultural Runoff Action Group was recently awarded a second 319 grant for $300,000 to continue promoting these riparian conservation practices. The objectives of the second phase include providing incentive payments for similar buffer and tillage practices along the tributaries throughout the Toussaint River watershed.

With 22,500 miles of county ditches in Ohio and enough linear footage of drain tile in northwest Ohio to reach to the moon, there is plenty of opportunity for watershed protection groups to join the effort to establish riparian buffers, reduce soil erosion, and improve water quality. Neighboring watersheds can look to the Toussaint River project for a model of conservation partnership.

OKLAHOMA

www.okcc.state.ok.us/water_quality_web/NPSMP_final_draft.pdf

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Primary Sources of Pollution:
- acid mine drainage
- abandoned mines

Primary NPS Pollutants:
- high concentrations of metals
- acidity
- sulfate

Project Activities:
- installation of treatment wetlands systems

Results:
- improved water quality (lower concentrations of metals, acidity removal)
- increased populations of wildlife, fish, and macroinvertebrates

Acid Mine Drainage Treatment Wetlands:
A Sustainable Solution for Abandoned Mine Problems

Pittsburg and Latimer Counties, Oklahoma

Acid mine drainage (AMD) is a major nonpoint source pollution concern in many former mining regions. AMD is formed by the oxidizing action of air and water on exposed sulfidic strata and is characterized by elevated concentrations of metals (especially iron and aluminum), acidity, and sulfate. In Oklahoma, AMD impacts from abandoned coal mining activities are most prevalent in the Gaines Creek watershed of Pittsburg and Latimer Counties.

Wetlands that rely on passive treatment technologies are a viable treatment for AMD.

Traditional mine drainage treatment technologies are not viable options at abandoned mines because of their laborious and cost-intensive nature. However, passive treatment technologies that rely on natural biogeochemical and microbiological processes to ameliorate AMD, such

Dr. Keith Strevett, graduate student Denae Athay, and Dr. Robert Nairn have sampled substrate for chemical and microbiological analysis.

as treatment wetlands, often provide viable treatment alternatives if enough land area is available.

In 1998, with support of a section 319 grant provided by EPA Region 6 and the Oklahoma Conservation Commission, the University of Oklahoma initiated a treatment wetlands demonstration project to improve the quality of contaminated water at the #40 Gowen site. Of the dozen or more identified discharges in the watershed, the Gowen site was identified as having the greatest impact on the stream due to AMD. Drainage from the site affects Pitt Creek, a tributary to Gaines Creek, which drains to Lake Eufaula. Both creeks are on the state's 303(d) list for metals and pH violations related to surface mining.

Treatment technology

At the Gowen site, a Successive Alkalinity-Producing System wetland treatment process was implemented. Treatment occurs in a four-cell system of alternating vertical flow wetlands (VF) and surface flow aerobic ponds (SF). AMD is sequentially treated by charging the waters with alkalinity in the first VF, then providing near-optimum conditions for precipitating metals in the first SF. Alkalinity consumed by metal hydrolysis in the first SF is recharged to the waters in the subsequent VF, thus allowing further precipitation of metals in the final SF.

Native wetland vegetation, including cattail, sedges, rushes, willow, and water primrose, lines the constructed cell.

The size of the AMD and the flow rate into the treatment cells were calculated based on land availability, metals loading, and acidity. Because treatment of the entire discharge with the land area available was not feasible, the system was sized to demonstrate effective treatment of only a portion of the flow. Based on contaminant loadings of about 18,000 and 7,000 grams per day of acidity and iron and anticipated removal rates of 30 to 40 grams per square meter per day of acidity from published data and column studies, the system was designed with a surface area of approximately 750 square meters.

All water flows through the treatment wetlands are gravity-driven. Only a portion of the entire discharge (about 20 liters per minute) flows through the demonstration project. Each VF includes three vertical sections. The top layer (standing water) provides water head necessary to drive water through the underlying substrate. The middle layer is designed to generate alkalinity by biotic and abiotic means. It consists of a 1-meter-thick mixture of spent mushroom substrate, limestone, and hydrated fly ash. The bottom layer is a gravel underdrain that acts as a highly permeable zone to transmit water leaving the system through a network of drainage pipes. The treatment cells were planted with native wetland vegetation.

Improvements in water quality

Chemical water quality and quantity and wildlife use have been monitored every 2 weeks for 2 years. Results indicate that the treatment wetlands have successfully improved water quality to within applicable regulatory guidelines for more than 2 years. Concentrations of iron, aluminum, and manganese have decreased significantly, and pH and alkalinity concentrations have increased significantly. The

final effluent of the system has maintained a net alkaline condition (above 150 mg/L) with pH greater than 6. Concentrations of trace metals were either near the detection limit at all sampling locations (barium, cadmium, chromium, copper and lead) or retained completely by VF1 (nickel and zinc) to less than the detection limit.

Several species of amphibians, reptiles, birds, and mammals use the site. Biological assessments in the summer of 2000 indicated healthy populations of fish and macroinvertebrates in three of the four cells. Macroinvertebrate community structure indicates a trend from tolerant to less-tolerant species with flow through the wetland system.

Duplication of success

The Gowen treatment wetlands demonstration project—the first and only successful passive AMD treatment system in Oklahoma—represents a sustainable and cost-effective solution for the devastating impacts of AMD on the environment.

Perhaps the most exciting aspect of the project is the transferability of this technology to other mining-impacted watersheds. Already, the Gowen treatment wetland design is being applied to problems at the Tar Creek Superfund Site in Ottawa County, Oklahoma, and is being investigated for application in several other watersheds nationwide. The Tar Creek site is part of a former lead and zinc mining area and is ranked number one on the National Priorities List. Coupled vertical flow wetland and surface flow pond designs are applicable to these waters and represent the only treatment methodology that has been considered viable for improvement and restoration of the waters of Tar Creek.

The budget for the Gowen treatment wetlands demonstration project was $125,000. Partners in the effort included The University of Oklahoma School of Civil Engineering and Environmental Science, Oklahoma Conservation Commission's Water Quality Division, U.S. Environmental Protection Agency, Latimer County Conservation District, and landowners William Battles and Mindy Ledbetter. Local companies and volunteers provided in-kind assistance or donations.

OKLAHOMA

www.okcc.state.ok.us/water_quality_web/NPSMP_final_draft.pdf

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Primary Sources of Pollution:
- agriculture (poultry industry, pasture maintenance)

Primary NPS Pollutants:
- nutrients
- sediment

Project Activities:
- education
- agricultural BMPs
- watershed model development

Results:
- improved watershed model
- sustained partnerships

Poteau River Comprehensive Watershed Management Program:
Local Involvement Ensures Program Sustainability

LeFlore County, Oklahoma

The Upper Poteau River, including Wister Lake and its tributaries, is identified among Oklahoma's top priorities for nonpoint source control implementation in the state's section 319 Nonpoint Source Management Program. The river is cited as having impaired recreational and drinking water uses; nutrients and sediment are the major nonpoint source concerns. The land in the watershed is primarily agricultural and Forest Service land. Most of the agricultural land consists of pastureland and poultry houses.

Using section 319 grant monies from EPA Region 6, along with state match dollars, the Oklahoma Conservation Commission (OCC), Okla-

homa State Cooperative Extension Service, Oklahoma State University Department of Biosystems and Agricultural Engineering, LeFlore County Conservation District, Natural Resources Conservation Service (NRCS), Blacklands Research Center, Poteau Valley Improvement Association, Lake Wister Advisory Association, residents of the Haw Creek Valley Watershed, Lake Wister/Poteau River Steering Committee, and U.S. Geological Survey worked in various capacities to calibrate and improve watershed models and implement best management practices (BMPs) and educational programs to restore and protect the water resources. The program incorporated all of the previous work in the Wister Lake/Poteau River watershed, such as the Clean Lakes Phase I Project and 7 years' worth of model development. One of the greatest successes of the program was the involvement of local residents and organizations in implementing the various program components and ensuring that the program will continue.

Lasting watershed-wide participation

Much of the project framework was created at a local level, making it easier to sustain several components of the project beyond the original FY 1994 section 319 funding. The steering committee was made up of representatives from the LeFlore County Conservation District, LeFlore County Cooperative Extension, NRCS, Farm Service Agency, Oklahoma Forestry Service, agricultural producers, local government and homeowners, and recreational interests. The committee met monthly throughout the project and continued to meet beyond the end of the project to discuss details of the program, plan future efforts, and make decisions regarding demonstration practices, their locations, and cost-share reimbursement percentages. Although practices were demonstrated in a subwatershed (the Haw Creek area of the Black Fork of the Poteau River), the remainder of the program was watershed-wide.

Of particular note are the activities the Conservation District has perpetuated beyond the life of the project. During the project, the Conservation District and District Conservationist secured 100 percent participation by the poultry producers in the demonstration area. They also established test plots to demonstrate the effectiveness of various BMPs at reducing nutrient and sediment runoff. They have continued to maintain these plots beyond the life of the project and have established additional plots from new sources of funding to sustain the effort. The District also established a successful education program, partnering with the Cooperative Extension Service and other groups, to inform citizens about the importance of water quality and methods of conservation. This education program has continued and expanded beyond the life of the project to include regular classes at the local college, a volunteer monitoring program, and continued newspaper articles and education programs at schools. These continued activities are geared toward expansion of the demonstrated practices outside the demonstration subwatershed.

Through their continued efforts, the Conservation District, NRCS, and other local partners have illustrated their commitment towards solving water quality problems in the watershed. In addition, the area is an Environmental Quality Incentives Program (EQIP) priority area and the District and NRCS have cooperated to target EQIP funds toward practices that benefit water quality. This commitment has led to future projects to demonstrate BMPs throughout the remainder of the Poteau River and Wister Lake watershed. An FY 2000 319(h) grant, along with state cost-share

monies, is devoted toward demonstrating BMPs throughout the watershed and achieving the river's eventual support of beneficial uses and removal from the state's 303(d) list.

Providing a platform to improve the SWAT model

Yet another result of the project was a modification to the Soil and Water Assessment Tool, or SWAT. SWAT is a basin-scale hydrologic/water quality model developed to predict the effects of alternative river basin land use management decisions on water, sediment, and chemical yields. SWAT operates on a daily time step and is capable of simulating 100 or more years. The major components of the model are hydrology, weather, erosion, soil temperature, crop growth, nutrients, pesticides, subsurface flow, and agricultural management. SWAT offers distributed-parameter and continuous time simulation with flexible watershed configuration, automatic irrigation and fertilization, interbasin water transfer, and lake water quality simulation capabilities. It is widely used in the development of Total Maximum Daily Loads (TMDLs).

Until now, in-stream nutrient dynamics were not considered in the SWAT model. This meant that although the model did a good job predicting nutrient loading coming off land surfaces, it ignored the processes that affected the nutrients once they were in the stream. To simulate the in-stream dynamics, the kinetic routines from an in-stream water quality model, QUAL2E, were modified and incorporated into SWAT. The Blacklands Research Institute in Temple, Texas, integrated QUAL2E kinetics into the SWAT model. The resulting version of SWAT is now widely used in modeling basins and in TMDL development.

OKLAHOMA

www.okcc.state.ok.us/water_quality_web/NPSMP_final_draft.pdf

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Primary Sources of Pollution:
- logging
- grazing

Primary NPS Pollutants:
- sediment

Project Activities:
- Rosgen classification
- streambank stabilization

Results:
- 75 percent decrease in erosion
- improved fish community
- improved recreational benefits
- stream meander migration slowed

The Spring Creek Project:
Streambanks Stabilized Through Stream Restoration

Cherokee County, Oklahoma

Spring Creek, a tributary to Fort Gibson Lake, spans three northeast Oklahoma counties—Delaware, Mayes, and Cherokee. Over the years, intensive logging, clearing, and grazing in the watershed have resulted in bank erosion, contributing significantly to the gravel load in the stream. Movement of this gravel (bedload) has accelerated bank erosion, causing the stream to widen and become shallow. This channel instability has resulted in excessive streambank migration, loss of fish habitat, and decreased recreational benefit.

Fluvial geomorphology

Fluvial geomorphology is the study of the form or shape of stream channels as they flow over the land. Recent work by Dave Rosgen of Wildlands Hydrology has resulted in a stream classification scheme based on eight major variables. Rosgen's

method is useful in that a stream's stable configuration can be determined and classified so that the disturbed stream can be restored to this form, using natural materials on-site. A stream restored using these techniques is stable and efficient at transporting bedload and flood flows. It is also aesthetically pleasing and provides better in-stream habitat for aquatic life.

The project

Bank restoration was implemented on two reaches of Spring Creek (Cherokee County) exhibiting highly accelerated bank erosion due to clearing for increased hay production. Rosgen's method was used to classify the current state of the segments and determine the channel configuration necessary to stabilize the bank. The reaches were reshaped accordingly, and rock vanes, cross vanes, tree root-wads, logs, and vegetation were strategically inserted to affect stream flow and preserve or supplement habitat. Habitat and fish surveys were conducted before and after implementation to assess the project's effects in these areas.

Significant improvement

In general, the project sites showed significant, positive changes from the preimplementation survey. Physically, water depth through the reaches almost doubled and total area of eroding bank decreased by about 75 percent. A visit to the project site in August 2001 showed the stream channel modifications still holding effectively. Rock vanes had successfully diverted flow to the center of the channel, deepening pools and controlling erosion on the outside of the steam bends. Stream channel stabilization was apparent from the abundance of established tree saplings and other marginal vegetation.

Some of the most notable effects of the project were exhibited in the fish community. Both project sites exhibited more species and markedly higher total numbers of fish in the postimplementation survey (1.5 and 3.5 times the preimplementation numbers for downstream and upstream sites, respectively). The total number of pool species (sunfish, chub, suckers) increased by at least 2.4 times the previous abundance in both project reaches, reflecting the deepening and enlargement of pools and changes in the overall stream channel shape. The size composition of this group indicated multiple year classes, and young of year were found for all three species. Thus, it appears that the slower flow regimes and increased habitat resulting from stabilization efforts combined to affect overall reproduction of fish in this area of Spring Creek.

Certain beneficial uses also were restored or preserved in this area of the creek. Bank instability and subsequent gravel input had shallowed many areas, limiting fishing and swimming activities previously enjoyed. The upstream site has stabilized into a long pool deep enough for swimming and fishing. Good numbers of catchable sportfish have been noted in and around the rock vanes at the site.

An additional benefit has been the near cessation of channel movement through the project reaches. In particular, channel migration that previously threatened an important road through the property has been arrested through bank stabilization efforts. Little to no movement was discernible during the August visit.

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Primary Sources of Pollution:
- diked/drained wetlands
- flooding

Primary NPS Pollutants:
- nutrients
- sediment

Project Activities:
- tide gate installation
- removal of levee and installation of new dike
- revegetation

Results:
- 30 acres of restored wetlands
- decreased flooding and sedimentation
- 80 acres of restored habitat for wildlife

Dawson Wetland Restoration Project:
Landowners and Wetlands Both Win

Douglas County, Oregon

The Smith River Estuary has been modified over the years by a number of projects that have diked and drained wetland areas in the estuary so they could be used for livestock grazing. Levees, tide gates, and dredging were all common practices from the 1900s to the 1960s.

The Dawson property near the mouth of the Smith River has been diked and used for agricultural purposes since the early 20th century. Since the floods of 1996–1997, however, the existing levee has been breached in three places, resulting in daily tidal inundation of the property.

Wetland restoration and enhancement as the answer

The Umpqua Soil and Water Conservation District (SWCD) received a 319 grant of $85,000 from the Oregon Department of Environmental Quality in August 1999 to help with the Dawson Wetland Restoration Project. The landowners originally contacted the Umpqua SWCD for assistance in repairing the dike, hoping to halt the flooding of their property. Eventually, the project evolved into one that would protect part of the property and return 30 acres to estuarine wetlands.

The landowners agreed to donate 30 acres of their 100-acre parcel to be restored as wetlands, along with construction of a new levee to protect the remaining acreage for their homestead and agricultural purposes. The Umpqua SWCD participated in fundraising for the project and directs the project inspection and planting of vegetation on the new levee. Additional partners, such as Ducks Unlimited, are providing project management and engineering assistance.

In addition to restoring the 30 acres of estuarine wetland, the project also involved enhancing the 50-acre Stowe Marsh, just upstream from the Dawson property and managed by the Oregon Department of Fish and Wildlife. The marsh contained a levee with a break in it, and the project removed a large portion of the levee so that natural floodplain function could be restored.

Project activities

The Dawson Wetland Restoration Project was divided into three phases. Phase I of the project, completed in 1999, included installation of a tide gate, as well as development of engineering plans and specifications. Phase II, completed in 2000, included removal of two sections of the Stowe Marsh levee to enhance 50 acres of estuarine wetlands, construction of the new Dawson levee, vegetation of the new levee and adjacent disturbed areas with native plants, revegetation of borrow area, and improvements to internal drainage on farmland inside the new levee.

During 2001 Phase III is removing the old failed levee on the Dawson property, allowing the

30 acres outside the new levee to be returned to estuarine wetland status. Title to the restored wetlands on the Dawson property outside the new levee will be transferred to the Oregon Department of Fish and Wildlife. Old fencing in the donated wetlands will be removed. Plantings will be fortified in the borrow area, and all interior drainage will be routed to the new tide gate. Fencing will be installed around the new levee to restore livestock grazing to the Dawson ranch.

Additional benefits

Erosion Protection. The existing levee will be left in place for one winter to protect the new structure from erosion. Plantings with native vegetation will be part of the bioengineered plan to prevent erosion, making the use of riprap unnecessary. This approach will also reduce future sedimentation into the river.

Fish and Wildlife Habitat Restoration. Various salmonid species use estuaries as incubation areas for feeding, rearing, and staging before they begin their ocean migration. The Smith River estuary is already one of the most important areas in Oregon for threatened coastal coho. The addition of 30 acres and the enhancement of 50 acres will provide 80 acres of the habitat needed for these species and others. Waterfowl are also expected to use the restored wetlands.

Restoration of Estuary Floodplain Function. One result of the extensive diking of the Smith River system is that the river's transport capacity has increased, resulting in higher river energy against the city of Reedsport's levee. This project will result in more water storage capacity in estuarine wetlands, moderating the effects of flooding and reducing the river's erosive energy.

Public-Private Collaboration. This project represents a win-win situation in which the landowners benefit by increased protection of their homesteads and the public benefits from the enhanced ecological functions provided by the restored wetlands. This collaborative approach respects the existing land use that provides the family's economic base while at the same time recognizing and protecting the important public benefits from returning a portion of the land to its former wetland status.

http://waterquality.deq.state.or.us/wq/nonpoint/NPSPlan.htm

OREGON

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Primary Sources of Pollution:
- flow modifications

Primary NPS Pollutants:
- high stream temperature

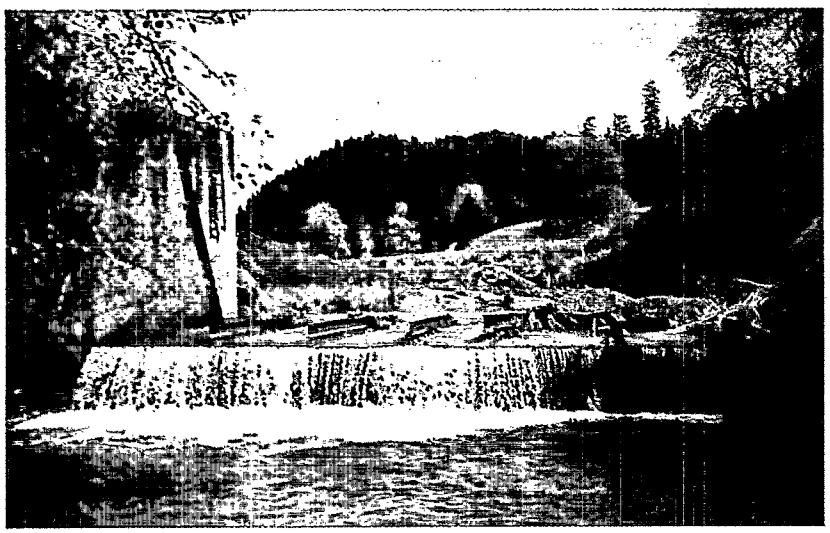
Project Activities:
- removal of diversion dam and concrete apron
- conversion from ditch to sprinkler irrigation
- revegetation of riparian area
- livestock exclusion

Results:
- additional 2.5 cfs water in stream
- reduced stream temperature
- improved aquatic life/ fish passage

South Myrtle Creek Ditch Project:
Removal of Dam Benefits Aquatic Life

Douglas County, Oregon

Historically, populations of cutthroat trout and coho salmon had journeyed through the waters of South Myrtle Creek, which flows into the South Umpqua River in Douglas County, Oregon. Since the early 20th century, however, some form of diversion structure has been blocking South Myrtle Creek. In the 1960s a concrete apron structure with metal supports for planks was installed to raise the water level to provide water for irrigation to adjacent and downstream land-



The concrete apron of the diversion structure spanned the creek with a 2-foot outfall at summer flows. This barrier prevented fish from reaching 10 miles of stream habitat.

owners. During the summer, the structure elevated water levels by 14 feet, diverting water into a 2½-mile irrigation ditch. As a result, South Myrtle Creek has been identified as having water quality problems from flow modifications and high stream temperatures.

In 1998 one of the landowners initiated a project to restore flow and improve water quality in South Myrtle Creek by removing the diversion dam and concrete apron, converting from ditch irrigation to sprinkler irrigation to conserve water, revegetating the denuded riparian area, and excluding livestock until the seedlings were well established. That landowner, along with Water Resources and the Watershed Council, recruited all of the other landowners who used water from the diversion, and they began to plan the various aspects of the project.

The project was a collaborative effort of all of the landowners, who donated services and supplies. In addition to 319 funds, funding was provided by the U.S. Fish and Wildlife Service, the Oregon Watershed Enhancement Board, the Bureau of Land Management, the Natural Resources Conservation Service's Conservation Reserve Enhancement Program, and two local foundations, the Joe Merchep Umpqua River Foundation, and the Douglas Timber Operations' Fisheries Enhancement Derby. In addition, the Oregon Water Resources Department and Douglas County Watermaster assisted with the project by examining water rights and helping to devise a plan whereby 2.5 cubic feet per second (cfs) of water is being returned to the stream.

Project highlights and successes

Using a jack hammer, acetylene torch, excavator, loader, and dump truck, the structure was successfully removed. Because ditch irrigation is the least efficient use of water because of losses from evaporation and leakage, irrigation was switched to the more efficient sprinkler type, with individual pumps drawing from the stream's surface water. Water temperature has improved, and flows have increased by 2.5 cfs during the summer. The restoration of the streambed to its historical level allows passage of salmon and trout to the 10 miles of stream above the dam for the first time in nearly a century, benefiting cutthroat trout, coho salmon, and steelhead with additional habitat. In the winter of 2000 area landowners confirmed the project's success when they identified several coho upstream of the diversion site. Other aquatic life will also benefit from the reconnection of the areas above and below the dam.

Streambank restoration along the 2½-mile project site consisted of planting the riparian area, which had not supported vegetation for a century because of annual flooding from irrigation. To protect young seedlings from livestock, the areas were fenced until the vegetation could become established. Establishing this vegetation will contribute to the efforts to reduce stream temperature to levels that better support cold-water fish.

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Primary Sources of Pollution:
- grazing
- channel modifications

Primary NPS Pollutants:
- high stream temperature

Project Activities:
- channel restoration to natural meandering
- revegetate riparian areas

Results:
- declining water temperature
- increased riparian growth

Wet Meadow Restoration in the Upper Grande Ronde Basin:
Channel Restoration Brings Cooler Waters

Upper Grande Ronde Basin, Oregon

The streams of the Grande Ronde Basin have historically provided a rich habitat for cold-water fish such as rainbow trout, salmon, summer steelhead, and bull trout. However, cold-water fish production has been declining since 1970 as a result of land use changes. Those changes have reduced riparian vegetation by 75 percent and simplified in-stream habitat through grazing practices and channel modifications. Stream temperatures have risen as riparian vegetation that once shaded the streams has been lost, and higher temperatures in the stream have resulted in reduced cold-water fish populations.

Restoring the channel to its natural pattern

In July 1997 the Oregon Department of Environment Quality used section 319 funds to divert a half-mile section of lower McCoy Creek from its channelized segment into the remnants of a historical meandering wet meadow channel. The stream was treated by stabilizing and revegetating riparian areas, restoring wet meadow conditions, and restoring old channels to allow the stream to meander naturally.

Dramatic results

Response within the newly restored channel section was quick and dramatic. Existing vegetation, particularly willows, grew quickly in the new riparian area. Beavers moved in and succeeded in building dams, which created several large, deep pools and numerous smaller pools for fish and waterfowl. Following the channel diversion in 1997, cooler temperatures were measured within the boundaries of the restored reach. Compared to the temperature of the water flowing into the restored section, maximum water temperatures measured in the middle of the reach were 3.0 °C cooler in 1997 and 4.6 °C cooler in 1998. In 1998 water temperature measured at the bottom of the reach was 0.9 °C cooler than the temperature measured at the top.

Cooling within the restored section can be attributed to the lower gradient and the deeper, meandering channel, which allows more mixing with cool subsurface water. The shading of surface waters by riparian vegetation also contributes to cooler temperatures. Further protection from solar heating is provided by the increased depth and lower width-to-depth ratio in the river. Early results of cooler water temperatures within the restored section are encouraging.

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Primary Sources of Pollution:
- streambank erosion

Primary NPS Pollutants:
- sediment

Project Activities:
- streambank stabilization (root wads, rocks, planting)

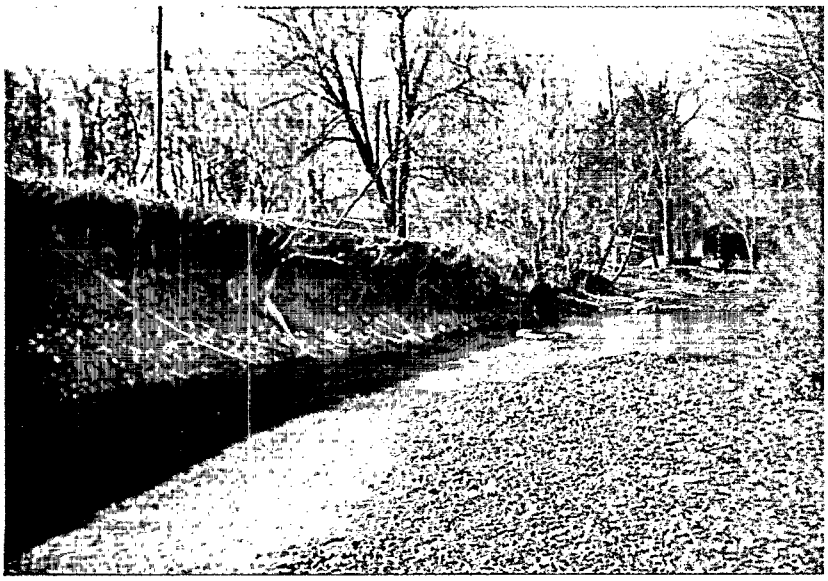
Results:
- 800 feet of streambank stabilized, deep pools, enhancement of trout populations

Narrows Bioengineering Project:
Cold-Water Fishery Restored Through Bioengineering

Adams County, Pennsylvania

Conewago Creek, just north of Arendtsville in Adams County, Pennsylvania (commonly referred to as "The Narrows") is considered one of the most scenic stream corridors in the county. The creek is listed as a "high quality cold water fishery" and a wild trout stream by the Pennsylvania Fish and Boat Commission and is actively stocked by several local private clubs.

A series of severe rain events in the summer and early fall of 1996 resulted in Adams County's receiving more than 90 inches of rain, nearly 4 feet more than the county average. As a result, two sections of Conewago Creek in The Narrows were heavily damaged, resulting in severe streambank erosion. The damage to the upper of the two sites was exacerbated by fallen trees, and the erosion on the lower section was the result of bedload deposit coming primarily from the upper site. In the past 2 years, it has been estimated that more than 8,000 tons of soil has fallen into the creek from these two sites. The eroding streambanks were filling up pools, degrading the conditions necessary for fish to thrive in the creek.



The streambank at the McDannel site was severely eroded at the beginning of the project in February 1999.

In 1998 the two sites on Conewago Creek were targeted for a streambank stabilization project totaling 800 linear feet. Because of aesthetics and cost, the standard riprap protection design was considered undesirable and bioengineering techniques were used instead.

Stabilizing eroding slope

Work began on the project in 1999 and involved the installation of native rock and root wads along the streambank. The existing site conditions included down or ready-to-fall trees, which were used as root wads to help stabilize the toe of the bank. The goal was for the root wads and rock to provide the large, heavy material necessary to stabilize the toe of the eroding slope and prevent further undercutting. The steep bank was then regraded to establish a more stable slope, using the gravel material removed from the adjacent streambank. This process "softened" this streambank, allowing the stream to "move" away from the newly stabilized banks.

The project also involved planting trees (donated by Adams County Trout Unlimited) and

grass to improve the aesthetics of the site and to further aid in stabilization. Nine varieties of trees were planted; they were chosen based on the existing tree species around the sites.

Stabilization success

The project was officially completed on March 27, 1999. Natural succession is occurring at the site as many seedlings are growing quite well. Deep pools are beginning to form, particularly at the root wad structures. The root wads are providing excellent fish habitat, and dozens of trout can now frequently be seen swimming near the root wads in the deep pools that were created. Although the project has not yet been tested by extremely high water levels, small storm events have clearly not endangered the integrity of any of the root wad structures.

www.dep.state.pa.us/dep/deputate/watermgt/WC/subjects/NonpointSourcePollution/NPS_Mgmt.htm **PENNSYLVANIA**

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Primary Sources of Pollution:
- urban runoff

Primary NPS Pollutants:
- nutrients
- metals
- suspended solids

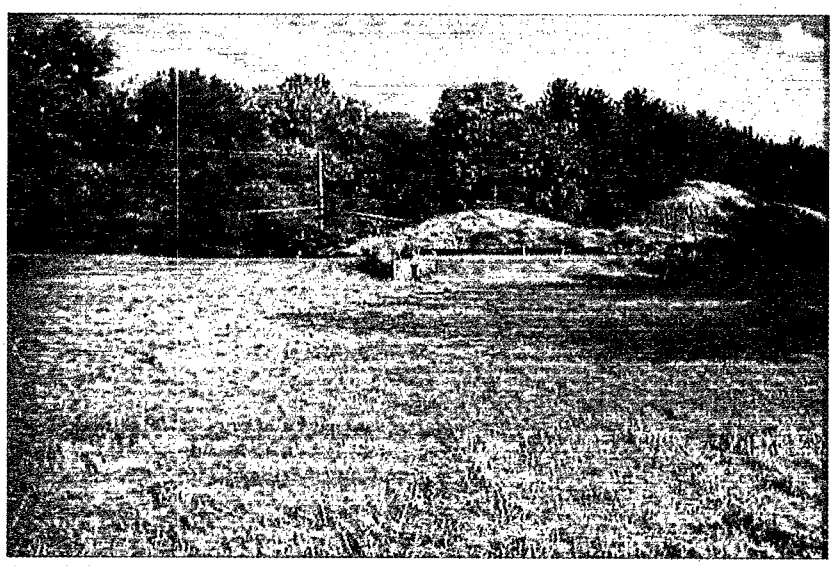
Project Activities:
- conversion of storm water detention basin to storm water wetland

Results:
- monitoring in progress

Villanova's Storm Water Wetland Retrofit:
BMP Treats Runoff and Provides Research Site

Montgomery and Delaware Counties, Pennsylvania

Along the border between Montgomery and Delaware Counties in the southeast corner of Pennsylvania lies a 41-acre urban watershed. The watershed consists of more than 16 acres of impervious surface, including Villanova University's parking lots, dormitories, office buildings, railroads, highways, and housing areas. An existing storm water detention basin on the university's property was targeted as an ideal site for a 319 retrofit project. This basin had the potential to treat the runoff that forms the headwaters of a watershed listed as medium priority on the state's degraded watershed list and to treat flows that affect a high-priority stream segment on the state's section 303(d) list.



An existing storm water detention basin was targeted for a 319 retrofit project.

Project goals

The purpose of the 319 project was to make a storm water wetland out of the existing detention basin, creating a water quality treatment facility. Water quality considerations were not part of the original design. The existing storm water detention basin was originally designed to reduce the increased peak flows coming from the university campus. Runoff entered the basin through sheet flow from a large parking lot and through two major pipes. The

A meandering channel was designed to reduce flow velocity and allow particles to settle out.

site had an existing 12-inch underdrain that quickly carried the water through the basin, directly connecting the parking lots to the headwaters of a small first-order stream. The site was designed to remain dry except during storm events, but there was always some flow through the underdrain, supporting the concept that the site was ideal for creating a storm water wetland.

One goal of the project was to prove that retrofitting could be accomplished easily on an existing structure without violating the original design concept. The retrofit of the basin therefore concentrated on retaining small storms while not violating the original storm water peak flow controls required by law.

The basin was redesigned by removing the underground pipes, moving earth to create a meandering flow path, adding a sediment forebay, and modifying the structure outlet. Wetland plantings were conducted; plants were selected for diversity and based on their ability to thrive at different inundation levels.

Low flows would now travel through the sediment forebay to give particles a chance to settle out. Flows would continue through a meandering wetland channel, maximizing contact with the plants, and finally through a deeper pool and the outlet structure. The flow path for larger storms would provide for the flow to go over a berm, preventing resuspension of the sediments collected in the structure, thus using the original design for peak flow management while avoiding damage to the low-flow components.

Multiple benefits

Because it is located on the university's property, this storm water wetland is not only aiding in the reduction of pollutants for this headwater but also serving as a permanent research and demonstration site. To date, hundreds of visitors have toured the site, and the site is being incorporated into a demonstration "theme park" of multiple BMPs (including signage) on Villanova's property.

The wetland project was completed at the end of 2000, and the current plan is to wait a year for the wetlands to mature before starting to collect water quality samples. Hydrologic and hydraulic monitoring is already under way, and flowmeters and a rain gauge also have been installed to collect data. It is projected that total suspended solids will be reduced by 70 percent, total phosphorus by 40 percent, total nitrogen by 20 percent, and lead by 75 percent.

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Coastal Nonpoint Source Controls:
Executive Order Adopts Section 6217(g) Management Measures as Official Policy

Puerto Rico

Puerto Rico is one of 29 U.S. states and territories with special programs and responsibilities for protecting and managing important coastal resources. To address more specifically the impacts of nonpoint source pollution on coastal water quality, Congress enacted the Coastal Zone Act Reauthorization Amendments of 1990. Section 6217 of the Act requires that each state with an approved coastal zone management program (including Puerto Rico) develop a Coastal Nonpoint Pollution Control Program and submit it to EPA and the National Oceanic and Atmospheric Administration (NOAA) for approval. Each program must provide for the implementation of technical management measures (section 6217(g) measures) that address major categories of nonpoint sources that impair or threaten coastal waters nationally, including agricultural runoff; urban runoff; forestry runoff; marinas and recreational boating; and channelization and channel modification, dams, and streambank and shoreline erosion.

Adopting the management measures

On February 8, 1999, Puerto Rico's governor signed an Executive Order (OE-1999-08) adopting the section 6217(g) management measures as official public policy throughout the Commonwealth of Puerto Rico. The order requires the creation of an Interagency Committee of lead Commonwealth agencies to uphold the mandate for the implementation of the section 6217(g) management measures and to ensure compliance with the measures for the major categories of nonpoint source pollution. The Committee is charged with developing and implementing a plan for the control of nonpoint sources of pollution throughout Puerto Rico, while adopting the section 6217(g) measures as "the official technical guidelines of the Plan."

The Committee is composed of representatives from various agencies in Puerto Rico, such as the Environmental Quality Board, the Department of Natural and Environmental Resources, the Regulations and Permits Administration, the Department of Agriculture, the Soil Conservation Districts, the Planning Board, the Agricultural Experiment Station and the Agricultural Extension Service, the Department of Health, the Department of Transportation and Public Works, the Highway and Transportation Authority, the Aqueduct and Sewer Authority, the Electric Power Authority, the Ports Authority, and any other government institution that the Committee identifies as essential to developing and implementing the plan.

The Executive Order calls for all Committee member agencies to adopt the 6217(g) measures and integrate them into their existing decision-making processes as soon as possible, but not later than 2 years from the effective date of the order. This requirement applies to direct agency activities and authorizations for other public and private activities. The order also lists several specific legal and administrative mechanisms that the Commonwealth agencies must use to demonstrate compliance with the measures. Finally, the order requires the Committee members to jointly develop and implement the "public policies, plans, programs, or organizational structures required" to ensure the effective implementation of the required management measures. The Committee meets every month to review and coordinate agency efforts and track plan implementation. The Committee is also responsible for preparing a plan implementation status report for the Governor by February 8, 2002.

Program approval

The Committee was deeply involved with the development of Puerto Rico's Coastal Nonpoint Pollution Control Program, which contains detailed 5-year plans and a 15-year strategy to implement the Executive Order. The Executive Order provides for adequate, enforceable policies and mechanisms to ensure implementation of the section 6217(g) management measures. As a result, on October 17, 2000, Puerto Rico received federal approval (from NOAA and EPA) for the Commonwealth's Coastal Nonpoint Pollution Control Program. The program is the first among U.S. island territories to receive full federal approval and the fourth overall after Maryland, Rhode Island, and California. Upon approval of its plan, Puerto Rico immediately began to implement the 6217(g) management measures in all public activities, including the granting of authorizations or permits for public or private actions.

RHODE ISLAND

www.state.ri.us/dem/programs/benviron/water/quality/nonpoint/index.htm

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Primary Sources of Pollution:
- urban storm water runoff

Primary NPS Pollutants:
- nutrients
- bacterial contaminants
- siltation

Project Activities:
- construction of storm water control system

Results:
- monitoring in progress

Curran Brook Sedimentation Pond:
Multiple Partners Construct Storm Water Control System

Cumberland, Rhode Island

The Pawtucket Water Supply Board (PWSB) reservoir system in Rhode Island serves the cities of Pawtucket and Central Falls and the southern portion of the town of Cumberland. The system serves some 110,000 customers. The PWSB's water resources derive from both surface water and groundwater. The four surface water reservoirs—Diamond Hill Reservoir, Arnold Mills Reservoir, Robin Hollow Pond, and Happy Hollow Pond—are the major impoundments controlled by PWSB. The water treatment plant for PWSB is located at the southern end of Happy Hollow Pond.

At the outset of the project, Rhode Island Department of Environmental Management's (RIDEM's) most recent assessment of Happy Hollow Pond determined that the reservoir was only partially supporting its designated use. The reservoir had high levels of nutrients, bacterial contaminants, siltation, and organic compounds, which were most probably conveyed by runoff from the highly urbanized surroundings.

Robin Hollow Pond, located in the lower portion of the Pawtucket Water Supply watershed, feeds directly into Happy Hollow Pond, which is an EPA-designated community water supply. Robin Hollow Pond receives runoff from the most urbanized portion of the watershed. The urbanized area is to the west of the pond in the town of Cumberland. The project focused on removing nutrients, bacterial contaminants, siltation, and inorganic compounds from runoff in the urbanized watershed, thereby decreasing the need for costly water purification treatments.

State-of-the-art storm water control system

The project consisted of designing, permitting, and building a state-of-the-art storm water control system to replace an undersized and antiquated sediment pond. The new system includes a sediment forebay, water quality pond, and artificially created wetland to treat the storm water during wet weather events. Project partners included the Northern Rhode Island Conservation District, PWSB, the U.S. Department of Agriculture's Soil Conservation Service (now the Natural Resources Conservation Service), RIDEM, and EPA Region 1.

Model project

The system was completed in October 1999. It has been featured in several field reviews, including the New England Interstate Water Pollution Control Commission's 2000 Annual Nonpoint Source Conference. PWSB has also been monitoring the system to determine its effectiveness in removing the pollutants of concern.

www.state.ri.us/dem/programs/benviron/water/quality/nonpoint/index.htm

RHODE ISLAND

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Primary Sources of Pollution:
- dredge and fill of tidal channel/salt marsh

Primary NPS Pollutants:
- sediment/fill

Project Activities:
- installation of self-regulating sluice and tide gates

Results:
- 68 percent reduction of Phragmites
- restoration of 84 acres of salt marsh habitats and 14 acres of tidal creeks and ponds

Galilee Salt Marsh Restoration:
Undersized Culverts Replaced with Self-Regulating Gates

Narragansett, Rhode Island

The coastal features of southern Rhode Island provide a breathtaking variety of special habitats. The Galilee Bird Sanctuary is a 128-acre coastal wetland complex owned and managed by the Rhode Island Department of Environmental Management (RIDEM), Division of Fish and Wildlife. The sanctuary is east of the port of Galilee and is bounded by the Galilee Escape Road to the north and Sand Hill Cove Road to the south.

Unfortunately, much of the Galilee Salt Marsh has led a fractured existence. During the 1950s unconfined dredge spoil from the Port of Galilee

was deposited over portions of the western side of the salt marsh where the Galilee Bird Sanctuary is located. This disposal filled in a tidal channel that had been present in this location and significantly altered the natural hydrology of the marsh.

During a 1954 hurricane, the extreme flooding of Sand Hill Cove Road trapped the residents of Great Island. To prevent this from occurring again, the State Division of Public Works constructed the Galilee Escape Road in 1956. Construction of the Escape Road fragmented the previously continuous salt marsh, eliminating in the process about 7 acres of valuable marsh habitat. Restriction of tidal flushing transformed the once-productive salt marsh into dense thickets of *Phragmites* and shrubs, causing reduction of natural coastal wetland habitats for migratory waterfowl, shorebirds, fish, and shellfish.

Self-regulating gates

The Galilee Salt Marsh Restoration Project was a multimillion-dollar effort with a number of contributing partners, including the Rhode Island Department of Transportation, U.S. Army Corp of Engineers, Ducks Unlimited, U.S. Fish and Wildlife Service, RIDEM Fish and Wildlife, and other agencies, under the auspices of the Coastal America Program.

Section 319 funding contributed to the restoration efforts with a $64,300 grant to replace the undersized culverts and install self-regulating sluice and tide gates. The self-regulating gates allow for minimum intervention and maintenance and were devised as an alternative to more costly and operation-intensive electric gates. The gates operate using a system of floats and balances that are precisely calibrated to close when water reaches a preset level.

Impressive results

Marsh restoration was completed and dedicated October 1997. Results have been strong. *Phragmites* was reduced by 68 percent at the completion of the 1999 growing season, and height was reduced from 11 feet to 3.5 feet. Fish and wildlife populations have responded to the restoration in dramatic fashion: finfish recolonized the tidal creeks within days following opening of the tide gates. Waterfowl (duck and geese), including the American black duck, use the restored marsh extensively for nesting and feeding and during migration. In total, approximately 84 acres of salt marsh habitats and 14 acres of tidal creeks and ponds were restored.

Complete restoration is expected to take 10 years or more. The project has been an enormous success, and the salt marsh has been designated a bird sanctuary. The project is an excellent demonstration of collaboration among various branches of government.

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Primary Sources of Pollution:
- failing septic tanks

Primary NPS Pollutants:
- fecal coliform bacteria
- nutrients

Project Activities:
- constructed wetland systems

Results:
- reductions of 99 percent in fecal coliform bacteria, 86 percent in total suspended solids, 77 percent in BOD5, 39 percent in total phosphorus, 59 percent in nitrate, 35 percent in ammonia

Constructed Wetlands for Failing Septic Tanks:
New Technologies Solve an Old Problem

Statewide

Sampling is conducted through sampling ports.

Failing septic systems can result in partially treated or untreated surface wastewater containing fecal coliform bacteria and nutrients, causing nonpoint source pollution in drainageways, streams, and lakes. Current technology resulting from a 3-year study on nine constructed wetland systems conducted by Dr. Kevin White of the University of South Alabama is being used in the design of constructed wetlands in South Carolina to treat sewage from failing septic systems.

The system consists of two shallow basins about 1 foot in depth and containing gravel, which supports emergent vegetation. The first of the two cells is lined to prevent seepage, while the second is unlined and acts as a disposal field. The water level is maintained below the gravel surface, thus preventing odors, public exposure, and vector problems. In an alternative design, a standard field drain system is used in place of the second cell.

Encouraging results

Preliminary data collected by the South Carolina Department of Health and Environmental Control (SCDHEC) between May 1999 and April 2000 on eight of these systems constructed statewide show significant reductions in nutrients and bacteria as a result of treatment. The monitoring shows an average 99 percent reduction in fecal coliform bacteria, 86 percent in total suspended solids, 77 percent in 5-day biological oxygen demand (BOD5), 39 percent in total phosphorus, 59 percent in nitrate, and 35 percent in ammonia.

Education component

The East Piedmont Resource Conservation and Development Council is managing the construction of 10 of these wetland systems to replace failing septic tank systems at homes in a watershed surrounding Lake Murray. This lake is a large recreational impoundment in central South Carolina, where poor soil conditions and steep slopes are causing some conventional systems to fail. A comprehensive technology transfer program will complement the project, educating citizens about the benefits of the management practice. The Ninety-Six District Resource Conservation and Development Council is also conducting a similar project in Greenwood County.

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Primary Sources of Pollution:
- agriculture

Primary NPS Pollutants:
- fecal coliform bacteria
- sediment
- nutrients

Project Activities:
- dairy farm BMPs (grazing management, fencing, alternative water sources for livestock, riparian vegetation establishment)
- nutrient management for poultry farm (dead bird composting)

Results:
- reductions in fecal coliform bacteria

Stevens Creek Watershed Project:
Demonstration Sites Show Reductions in Fecal Coliform Bacteria

Edgefield, McCormick, Greenwood, and Saluda Counties, South Carolina

The Stevens Creek watershed is in Edgefield, McCormick, Greenwood, and Saluda Counties, South Carolina. Historical water quality data indicate increasing trends in fecal coliform bacteria, turbidity, and total phosphorus and decreasing trends in dissolved oxygen. Nonpoint source pollution is degrading the quality of water for municipal water supply, contributing to deterioration of fisheries, reducing stream channel capacities, and lowering the aesthetic values of the area. About 85 to 90 percent of the water quality impacts in the Stevens Creek watershed are estimated to be caused by agriculture.

Implementing best management practices

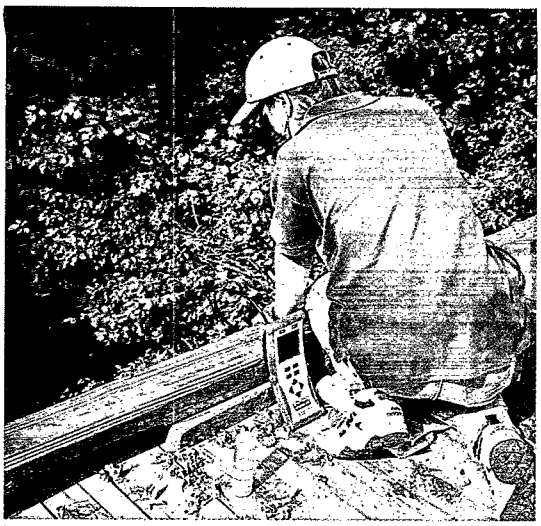
The goal of the Stevens Creek Watershed Project was to reduce sediment, nutrients, and chemical runoff from confined and unconfined livestock operations. The Edgefield Soil and Water Conservation District and Ninety-Six District Resource Conservation and Development Council, Inc., implemented the project over a 3-year period between May 1995 and July 1998. The project focused on using systems of best management practices (BMPs) and whole farm planning and management as keys to the sustainability of farming operations. Section 319 funds and the farmers on whose farms the demonstrations were located covered the costs of the demonstrations.

Project partners built a two-cell composter on the Johnson Poultry Farm to reduce nutrients from poultry waste runoff.

Two farms in the watershed were selected as demonstration sites—a dairy operation and a poultry farm, both in close proximity to flowing streams. BMPs implemented on the dairy farm included pasture grazing management, stream protection by fencing off streambanks and providing alternative water sources for livestock, and additional riparian vegetation (field borders and filter strips). Nutrient management, in the form of dead bird composting, was the target BMP for the chicken farm. A waste stacking shed was built into the ground behind the poultry houses, with minimal soil disturbance. Both farms had BMPs implemented in June 1996.

Taking stock of improvements

Three monitoring stations were established for each farm, one upstream of the project sites, one downstream, and a control (reference) site. Baseline data were collected from January 1996 through June 1996, and regular monitoring began in July 1996 and continued for 2½ years (through January 1999).



Testing revealed significant reductions in fecal coliform at Sleepy Creek downstream from Hickory Hill Dairy.

Water quality sampling results indicated significant reductions in fecal coliform bacteria at both the downstream poultry and dairy farm stations after BMP implementation. Preimplementation sampling found fecal coliform bacteria levels for all stations ranging from a low of 5 colonies per 100 mL to a high of more than 2 million colonies per 100 mL; postimplementation results for all stations ranged from 2/100 mL to 58,000/100 mL. Nutrient management (dead bird composting) on the poultry farm significantly reduced fecal coliform bacteria and total suspended solids concentrations (both spatially and temporally). On the dairy farm, pasture grazing management and animal fencing did significantly reduce fecal coliform bacteria concentrations (spatially and temporally), but they did not reduce total suspended solids concentrations at the downstream station.

www.state.sd.us/denr/watershed

SOUTH DAKOTA

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Primary Sources of Pollution:
- agriculture
- urban runoff
- drainage and land use changes

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- agricultural BMPs (animal waste management systems, no-till planting, buffers)
- construction of lake outlet control structure and debris barrier

Results:
- change of lake status from hypereutrophic to eutrophic
- shorter algal blooms
- increased state park attendance/recreational use of lake

Big Stone Lake Restoration Project:
Better Water Quality Improves Fisheries, Recreation

Big Stone Lake, South Dakota

Big Stone Lake is on the border between South Dakota and Minnesota. The lake occupies the valley of a glacial river that once drained historic Lake Aggasiz. The surface area of the lake is 12,610 acres, and the lake extends southward for 26 miles from Browns Valley, Minnesota, to Ortonville, Minnesota, and Big Stone City, South Dakota.

Big Stone Lake and its fishery are the primary feature for Big Stone Lake State Park, Hartford Beach State Park, and several resorts. The lake is also an important recreational attraction for Ortonville, Big Stone City, and surrounding communities. The fishery of the lake has the potential to contribute substantially to local and state economies. Historically, the fishery has been managed primarily for walleye, with a secondary emphasis on yellow perch, bluegill, black crappie, northern pike, largemouth bass, and channel catfish. In samples taken in 1971 through 1985, walleye abundance, as measured by average gill net catch rates, was near the low end of the "normal" range for lakes with similar physical and chemical characteristics.

Agricultural, domestic, and municipal pollution have degraded fish habitat, reduced recreational opportunities, reduced the aesthetic quality of the lake, and increased the likelihood of more direct effects on the fisheries in the form of fish kills. Drainage and land use changes in the lake's

watershed have contributed to increased sedimentation, nutrient loading, changes in tributary flows, increases in water level fluctuations, and direct destruction of aquatic habitats.

Big Stone Lake partners

In the early 1980s citizens of South Dakota and Minnesota requested assistance from both states and EPA to begin an effort to restore Big Stone Lake. The primary concerns were poor water quality, excessive algae blooms, sedimentation, rooted aquatic vegetation, and reduced recreation potential.

A series of EPA section 314 and section 319 grants, beginning in 1983, have provided funding for lake and watershed restoration projects; the most recent 319 funding was awarded in 1996 and 1999. Currently, U.S. Department of Agriculture (USDA) and Environmental Quality Incentives Program funding is also being used to implement additional conservation practices in Roberts and Marshall Counties. The key partners in the Big Stone Lake Restoration Project are watershed landowners; lake residents; local counties, conservation districts, and municipalities; Upper Minnesota River Watershed District; Citizens for Big Stone Lake; South Dakota Department of Environment and Natural Resources; Minnesota Pollution Control Agency; EPA; Natural Resources Conservation Service; and U.S. Fish and Wildlife Service.

Attendance at State Parks on Big Stone Lake

Year	Big Stone Lake State Park (MN)	Hartford Beach State Park (SD)
1986 to 1993 (avg.)	11,000 to 13,000	57,000 to 59,000
1994	15,500	55,000
1995	18,500	66,336
1996	25,000	61,994
1997	28,500	66,375
1998	33,700	72,000
1999	36,559	77,226

Restoration project

Various conservation and restoration practices have been implemented through the Big Stone Lake Restoration Project. Conservation practices in the lake's watershed include the installation of more than 50 animal waste management systems, no-till planting of crops, construction of multiple-use wetlands, grassed waterways through cropland fields, stream buffer strips, streambank stabilization, and implementation of the USDA Conservation Reserve Program. In addition, six municipal wastewater treatment facilities in the watershed have been upgraded.

Restoration practices implemented at the lake include access road erosion control, shoreline stabilization, and upgraded wastewater treatment. In addition, a new lake outlet control structure and debris barrier were constructed at the south end of the lake. The main purpose of the structure is to divert the majority of flow from the Whetstone River away from Big Stone Lake. The Whetstone River was diverted into the lake in the 1930s to augment lake levels, but the diversion resulted in excessive nutrients and sediment being deposited in the lake. The new control structure diverts these contaminants away from the lake in accordance with the original river flow pattern.

Improved water quality and recreational use

The results of the Big Stone Lake Restoration Project are beginning to be realized in improved water quality. Water sampling results have shown a gradual but steady improvement in recent years. The trophic status of the lake has changed from hypereutrophic (extremely nutrient-rich) to eutrophic (nutrient-rich). As a result, algae blooms are less extensive and shorter in duration.

The fisheries of the lake also have improved to the point that a national walleye circuit fishing

tournament is held annually at Big Stone Lake. Attendance records at Big Stone Lake State Park on the Minnesota side and Hartford Beach State Park on the South Dakota side have documented substantial increases in recreational use of the lake, which correlate with improvements in water quality (see table on previous page). Comments made by lake residents indicate appreciation of the water quality improvement that has occurred to date.

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Primary Sources of Pollution:
- cattle grazing

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- management-intensive grazing

Results:
- reduced erosion (decreases sediment/ nutrients into water)
- increased farm profit

Management-Intensive Grazing Project:
Rotational Grazing Reduces Erosion, Increases Profits

Geddes, South Dakota

Farmers, ranchers, and all landowners who manage grasslands in South Dakota face the dual challenges of running a profitable business and sustaining a quality grassland environment. Through the Management-Intensive Grazing Systems Project, initiated in July 1999 with support of 319 funding, South Dakota grassland managers, grassland and livestock organizations, and local, state, and federal agencies are working together to design, implement, and monitor six "management-intensive" grazing systems in South Dakota.

The "management-intensive" grazing method focuses on a high (intensive) level of management; the term does not mean that the grassland vegetation is grazed intensely (short). Management-intensive grazing systems often involve 15 or more pastures and short 2- or 3-day grazing periods. Information learned from the on-ranch demonstrations and from other producers using this method is shared with other grassland managers, researchers, agency specialists, and the public.

Site example

In 2000 Mark Sip of Geddes, South Dakota, began to use a 205-acre management-intensive grazing system for his pastures. The pastures were divided into 10 paddocks, ranging from 17 to 27 acres in size, with a stocking rate of 1.0 animal unit months per acre. This is a safe stocking rate under normal conditions using continuous season-long stocking.

Livestock water is supplied to the pastures by a buried pipeline using rural water as the water source. An aboveground pipeline serves as a distribution system to the 10 paddocks. All division fences consist of polywire and temporary fiberglass posts. Several of the paddocks use a narrow lane to access the water tank. The fences are moved as the cattle are rotated to fresh grass.

The entire area supports a plant community composed of a mixture of cool season and warm season native plants. Cool season plants dominate the pastures. It is projected that the warm season

native plants will benefit from the rests provided and will begin to increase. This would provide a higher-quality diet to the livestock during the hot summer months.

Benefits realized

The environmental benefits offered by management-intensive grazing include improved grassland vegetation and streambank protection, resulting in significant reductions of water runoff that carries nutrients and sediment.

Increased farm or ranch profit also results from management-intensive grazing. Sip estimates that although the initial cost of establishing a rotational grazing program in his pastures was approximately $1,560, the rotational grazing theoretically increased his revenue by $4,680. Not only are farms capable of increasing their stocking rates but they also can better stockpile grass for winter grazing, which reduces the need to feed hay and lowers total feed costs.

TENNESSEE

www.state.tn.us/agriculture/nps/index.html

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Primary Sources of Pollution:
- agriculture
- logging
- channelization

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- riparian reforestation
- wetland restoration
- cattle exclusion

Results:
- acquisition of more than 1,500 acres for long-term protection of riparian and wetland habitats

Ghost River Land Acquisition Project:
River Protected by Restoring Forested Wetlands

Grand Junction, Tennessee

The Ghost River region of the Wolf River is part of the larger Wolf River Conservation Initiative. The Wolf River is an unchannelized river in west Tennessee extending from the Mississippi-Tennessee state line in Fayette County to Memphis, where it becomes channeled in Shelby County. The Ghost River section begins at the bridge at LaGrange and continues to Bateman's bridge approximately 10 miles to the west. This section of the Wolf River features a meandering river channel, a swamp forest where the river channel is braided, and an open swamp lake. The banks and parts of the river are forested, which provides significant wildlife value. The overall water quality is considered good because the river supports many species of filter-feeding mussels.

The significance of the Ghost River region relates to its unaltered channel, which supports important forest communities in need of protection. These communities are bald cypress, water tupelo, and bottomland hardwood forests. The Wolf River has numerous recreational uses that are compatible with natural area preservation. They include hunting, fishing, canoeing, birding, and other nature appreciation activities. Education and research are encouraged and might be important parts of the management to restore bottomland hardwood forests and buffer areas.

Increasingly, land along the Wolf River is being cleared of natural bottomland hardwoods and other wetland vegetation. Much of the watershed is under agricultural production, which con-

tributes significantly to increased sedimentation in the river and loss of riparian and wetland habitats. In many places along the Wolf River, cattle access the river and associated wetlands, causing additional erosion. Primary threats to the river include forest fragmentation and erosion from logging, channelization, contamination and erosion from agricultural use, pollution caused by dumping, and urban sprawl. There are also other threats, such as noise and toxic pollution from motorboat use in the swamp lake, off-road vehicle use, and the introduction and spread of invasive exotic species. Any use of invasive exotic plant species in food plots in the adjacent Wildlife Management Area could pose a threat.

A three-phase project

The Ghost River Initiative sought to prevent these threats to the Ghost River section of the Wolf River by acquiring land and establishing conservation easements to protect and enhance water quality. The tracts identified for acquisition flood annually and have a high potential for wetland and riparian habitat restoration with associated water quality improvement.

To accomplish riparian habitat conservation and wetland habitat restoration on the Ghost River, a three-phase project was developed. First, property would be purchased. Second, with cooperating organizations, a plan would be developed for thorough restoration of the tracts, including riparian reforestation, wetland restoration, and cattle exclusion. The third phase would involve implementation of the restoration work in association with cooperating organizations. Support for this project included $250,000 in section 319 funding, plus $284,755 in match.

Results and other efforts

More than 1,500 acres have been purchased in the Ghost River section for long-term conservation of the riparian and wetland habitats. These properties are, for the most part, adjacent to one another. The Ghost River Initiative represents one of many conservation projects under way to protect the Wolf River. Other efforts continue to protect the area through acquisition, conservation easements, registry agreements, or other forms of cooperative management agreements.

Management and restoration plans for the area are under development. Subject to other funding, the Tennessee Department of Environment and Conservation, Division of Natural Heritage, will complete a biodiversity field review of the properties for use in the development of a comprehensive management and restoration plan.

The restoration of bottomland hardwood forested wetlands is important in Tennessee because of the decline in this category of wetland habitats. Efforts will continue to ensure that this unique river system is preserved in its natural state for future generations of Tennesseans to enjoy.

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Primary Sources of Pollution:
- container nurseries

Primary NPS Pollutants:
- pesticides
- nutrients

Project Activities:
- constructed wetland

Results:
- removal rates greater than 80 percent for herbicide, 90 percent for nitrogen, and 85 percent for phosphate

Using Constructed Wetlands to Clean Up Pesticides:
Container Nurseries Will Benefit from Successful Pilot-Scale Study

Baxter, Tennessee

Container nurseries account for an increasing share of total nurseries in Middle Tennessee. The nursery industry is concentrated in that part of Tennessee and ranks in the top 10 agricultural industries in the state each year. Container nurseries traditionally apply large amounts of pesticides and nutrients to the nursery crops, which are susceptible to runoff into surface waters. Collection ponds have been used with some limited success, but pesticide or nutrient residues can concentrate in the ponds because little if any treatment to remove harmful substances is used.

Although constructed wetlands have not been evaluated for use in container nurseries, Tennessee Technology University's Water Center has used such wetlands to treat the town of Baxter's wastewater, and the wetlands have been operating successfully for several years. This site was ideal for incorporation of a container nursery to demonstrate constructed wetland treatments because the nursery was in place and operational.

Project goals

The primary goal of the project was to demonstrate constructed wetlands as a cost-effective best management practice to reduce pesticide and nutrient runoff and to purify water in container nurseries. The specific objectives were to (1) determine removal rates of simazine, metolachlor, nitrogen, and phosphorus from container nursery runoff using constructed wetland cells; (2) determine the effect of vegetation (soft-stem bulrush), flow, depth, and aspect of constructed wetlands on herbicide and nutrient removal; and (3) design and install a pilot-scale, subsurface-flow gravel constructed wetland at a container nursery grower's site for removal of herbicides and nutrients and for demonstration to growers and other interested parties.

In the spring and summer of 1998 and 1999, a field study was conducted at the Baxter, Tennessee, wastewater treatment plant, where constructed wetland cells have been studied since 1992. A 450-square-meter container nursery with overhead irrigation was built on-site. Water runoff from the container nursery was pumped into 14 gravel subsurface-flow constructed wetland cells. Bulrush (*Scirpus validus*) was grown in seven of the cells, and seven cells had no plants. The wetland cells were either 30 or 45 centimeters in depth. Three loading rates of runoff water containing herbicides and nutrients were added, corresponding to hydraulic retention times of 2 to 21 days. The removal of herbicides (simazine and metolachlor) and nutrients (nitrogen and phosphorus) in each of the constructed wetland cells was calculated and correlated with bulrush vegetation, loading rates, depth of cell, and hydraulic retention time.

Promising results

Constructed wetland cells with plants removed significantly more simazine, nitrogen, and phosphorus than cells without plants. Cells with plants removed more metolachlor at 2- to 8-day retention times, but at higher water retention times there was no difference. Nitrogen removal was greater in the cells 45 cm deep (89 percent) than in the cells 30 cm deep (76 percent). Depth did not affect herbicide or phosphorus removal. Removal of simazine ranged from 57 to 96 percent, and metolachlor removal ranged from 18 to 95 percent of that applied; no significant difference in removal was seen between the first year and second year of the project. In constructed wetland cells with plants, about 60 to 65 percent of herbicides were removed at the high loading rate, which was equivalent to a 2- or 3-day hydraulic retention time. Increasing the retention time to 8 or more days improved herbicide removals to above 80 percent in the cells with plants. Nitrogen removal was greater than 90 percent in all vegetated cells. Phosphate removal was greater than 85 percent in all vegetated cells except one cell, which had the shortest retention time.

A newly constructed wetland might require some time for plants to become established, thus affecting removal efficiencies. The system at Baxter was a mature system, with wetland bulrush plants established since 1992 and plant densities greater than 300 stems per square meter. A pilot, subsurface-flow gravel constructed wetland has been installed at a nursery in Smithville, Tennessee, and is being evaluated for operation, maintenance, and removal efficiencies. A workshop and demonstration of the constructed wetland took place on October 24, 2000, at the Pirtle's Nursery site. There was a good turnout of nursery growers, and many of the growers showed a high interest in the technology.

www.tnrcc.state.tx.us/water/quality/nps/index.html

TEXAS

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Primary Sources of Pollution:
- agricultural runoff

Primary NPS Pollutants:
- atrazine

Project Activities:
- agricultural BMPs (setbacks, soil incorporation)
- information and education on pesticide application
- well-water testing

Results:
- atrazine levels below MCL in Lake Aquilla

Atrazine Problems in the Lake Aquilla and Marlin City Lake System:
Farmers Take a Proactive Stance

Hillsboro and Marlin, Texas

Increasing levels of atrazine, a herbicide, in the water supply caused concern among local citizens in the Lake Aquilla and Marlin City Lake system area of Texas. Atrazine levels exceeded the maximum contaminant level (MCL) at Lake Aquilla, and the development of a Total Maximum Daily Load (TMDL) was imminent. The presence of atrazine in the water supply was attributed to storm water runoff from agricultural areas in the rural community.

Response of the locals

Local farmers took a proactive stance in response to this water quality issue by forming the Producers' Atrazine Action Committee. The primary goal of the Committee was to reduce the presence of atrazine in water supplies by encouraging producers to use the most economically feasible management practices conducive to the reduction of atrazine-contaminated runoff. They developed a

list of recommended best management practices (BMPs) for the watershed and had meetings with pesticide dealerships to increase awareness at the chemical supply level. The Committee developed a questionaire to document adoption of BMPs over time and administered it randomly in the watershed.

The Stakeholders Group and Producers' Atrazine Action Committee sponsored a public meeting in December, featuring different speakers on water quality topics and pesticide applicator training. Farmers began to implement various BMPs from the list developed and recommended by the Committee, some of which included observing more setback area and incorporating atrazine into the soil to reduce herbicide runoff. Adoption of incorporation has been estimated at 33 percent for this year, and full adoption is expected within the next 3 years.

Role of education and outreach

Success could not have been achieved without strong, locally organized education and outreach efforts. As a result of such efforts, Lake Aquilla has had eight consecutive quarters without a violation of the atrazine MCL.

The Producers Atrazine Action Committee also targeted groundwater quality awareness, secondary to atrazine reduction, in their public outreach and education campaign. The committee promoted well-water testing through the TEX*A*Syst program and recommended that wells be tested for atrazine, bacteria, and nutrients. Many well owners were able to learn about well water disinfection processes, testing, filters, and protection of groundwater quality. As a result, 28 wells in the county have been tested for bacteria, nitrates, nitrites, sulfates, phosphates, and atrazine.

TEXAS

www.tnrcc.state.tx.us/water/quality/nps/index.html

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Primary Sources of Pollution:
- agriculture (dairy)

Primary NPS Pollutants:
- nutrients

Project Activities:
- on-farm composting of solid waste

Results:
- exporting pollutants off-site to low-risk areas
- economic gains

On-Farm Composting of Dairy Cattle Solid Waste:
Protecting Water Quality While Producing a Salable Product

Commerce, Texas (composting); Anderson/Houston SWCD, Palestine, Texas (marketing)

A section 319 grant was awarded to Texas A&M University–Commerce to initiate a cattle solid waste composting demonstration project on a 400-cow freestall dairy. The outcome of this demonstration resulted in the conversion of solid animal waste into a value-added product suitable for high-end wholesale or retail markets. This product could be marketed in bulk for use in field, landscape, or nursery applications or could be bagged for retail sales to the homeowner market. Potential buyers of the compost include landscapers, commercial nurseries, home and garden centers, greenhouses, homeowners, farmers, golf courses, cemeteries, public water works departments, road and highway contractors, schools, parks, turf growers, and developers.

Advantages of in-vessel techniques

In-vessel composting has many advantages over other composting techniques. The need to transport raw materials on public roads to a centralized composting facility is eliminated when animal waste is retained for on-farm composting. Rapid completion of the composting process, through in-vessel composting, results in product stabilization and

sanitation within 3 to 4 days during any season of the year. Raw waste material remains isolated from the environment until the process is complete, and the site manager has precise control of moisture, temperature, and aeration during the composting process, regardless of ambient weather conditions. Another advantage is that raw waste loses all offensive odors within 12 hours of start-up. The resulting composted product is of superior quality and suitable for high-end wholesale or retail markets.

Water quality and economic advantages

Water quality advantages followed as a result of 8,000 pounds of nitrogen and 3,000 pounds each of phosphorus and potassium being annually relocated and beneficially used in low-risk areas. This demonstration project also yielded a market price of $20.00 per cubic yard (bulk) for the compost. Sale of the compost provided the dairyman a total income of $43,800, which resulted in an annual net income of $20,150.

Demonstrations have also shown that this product can be substituted unilaterally for imported Canadian sphagnum peat moss in many applications, including use as an alternative plant-growing medium in greenhouses and as an organic soil amendment in the landscape.

http://ag.utah.gov/mktcons/nps4.htm

UTAH

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Primary Sources of Pollution:
- agriculture (croplands, pasture, animal feeding operations)

Primary NPS Pollutants:
- sediments
- nutrients

Project Activities:
- stream channel and bank restoration
- grazing land improvements
- animal waste management systems

Results:
- reduced concentrations of total phosphorus
- improved habitat for fish and other aquatic organisms

Little Bear River Project:
Voluntary Approaches Yield Success

Cache County, Utah

The Little Bear River watershed in Cache County, Utah, is listed as a high-priority watershed that is being adversely affected by nonpoint source pollution. The watershed covers 196,432 acres. Land use is approximately 70 percent range/forest, 19 percent irrigated cropland, 7 percent dry cropland, and 4 percent other. Land ownership is 85 percent private, 11 percent national forests, and 4 percent state lands.

In 1990 the U.S. Department of Agriculture (USDA) provided funding through the Hydrologic Unit Area Water Quality Program, giving birth to the Little Bear River Project. The Little Bear River Steering Committee was formed to provide local leadership and oversight of the watershed planning project. A technical advisory committee consisting of local, state, and federal resource agencies and representatives from Utah State University was formed to assist the Little Bear River Steering Committee with the watershed assessment. The technical advisory committee completed a watershed assessment in 1992.

The watershed assessment identified high sediment loads from eroded stream banks, as well as high nutrient and coliform loads from numerous animal feeding operations. Cropland and pastures were also found to be significant sources of nutrients in the Little Bear River watershed.

Having identified the major causes of nonpoint source pollution in the watershed, the local steering and technical advisory committees developed the following project objectives:

- Reduce erosion from streambanks and rangeland in critical areas.
- Reduce nutrient and sediment loading from cropland, pasture, animal feeding operations, and rangeland.
- Inform and educate landowners within the project boundary and the public of the need to improve and maintain water quality in the Little Bear River watershed.
- Monitor the effectiveness of best management practices (BMPs) and evaluate the benefits of water quality improvements.

Promoting voluntary approaches in the watershed

The overall project goal was to encourage landowners to implement conservation practices and BMPs voluntarily to improve the quality of water in the Little Bear River watershed. To make the voluntary approach successful, a diverse group of partners were invited to provide guidance and input into project priorities and activities. To date, more than 100 landowners have participated in the project. An important component of the project is the citizen volunteers. Local community groups have donated more than 3,000 hours to various projects.

In the early stages, watershed restoration focused on stream channel and bank restoration and on grazing land improvements. In 1994 more emphasis was placed on improving animal waste management systems. By 1998, 36 animal waste management systems had been designed, and they are currently in various stages of completion and implementation. From 1991 to 1996, $1,507,000 in section 319 funding was allocated to the watershed effort.

Measurable improvements in water quality

Currently, 6 years after the initial watershed restoration efforts, measurable improvements in water quality are being documented. There is a downward trend in total phosphorus concentrations in the watershed. As more animal waste management systems and BMPs are implemented, the downward trend is expected to continue. A Total Maximum Daily Load (TMDL) plan has been developed, and further reductions in nutrient loadings will continue once the plan is implemented. The TMDL will target and reduce point source loads of phosphorus. By measuring the reduction of total phosphorus from point sources, the reduction of nonpoint source pollution can be determined to assess the success of the 319-funded projects.

Implementing BMPs throughout the watershed is also benefiting the aquatic community. In some reaches of the watershed, meanders have been restored in the stream channel. This work, and other structural work to control bank erosion, has improved habitat for fish and other aquatic organisms. Angler use has increased in the watershed, and this success has piqued the interest of other landowners in participating in the program.

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Primary Sources of Pollution:
- agriculture

Primary NPS Pollutants:
- sediments
- nutrients

Project Activities:
- fencing
- prescribed grazing
- revegetation
- stream channel stabilization
- sprinkler irrigation systems

Results:
- reduced concentrations of total phosphorus
- enhanced aquatic community

Success in the Chalk Creek Watershed:
Reduced Phosphorus, Enhanced Habitat Result

Summit County, Utah

The Chalk Creek watershed in Summit County, Utah, encompasses 173,000 acres. Roughly 123,500 acres is rangeland, 2,000 acres is used as cropland, and 44,000 acres is forested. The watershed is 100 percent privately owned. Chalk Creek is a major tributary and source of sediment and nutrients to the Weber River, which supplies drinking water to Ogden, Utah, and other Wasatch Front communities.

Because Chalk Creek is an important water source and a recreational fishery, an intensive water quality assessment was conducted in 1990 to identify sediment and nutrient sources in the Chalk Creek watershed. The results of the watershed assessment indicated that the creek was impaired because of habitat alteration and sediment. The total phosphorus level was also above the Utah State Division of Water Quality Standards' indicator value for the beneficial use designation of a cold-water fishery. Utah officially placed the stream on its 303(d) list of impaired waters. EPA approved the Total Maximum Daily Load (TMDL) plan in 1997. Between 1991 and 1999, $1,673,000 in section 319 funding was allocated to the watershed effort.

High local support for restoring watershed

In 1991 the local soil conservation district, landowners, water users, and resource managers initiated the Chalk Creek Nonpoint Source Water Quality Project to address the water quality impairment of Chalk Creek. By 1994 a coordinated watershed resource plan had been developed and a technical advisory committee, composed of local, state, and federal agencies, private individuals, and groups, had been formed to assist the local steering committee.

The primary goal of the Chalk Creek Nonpoint Source Water Quality Project was to reduce erosion and sedimentation entering the creek. Methods identified to reduce erosion in Chalk Creek were stabilization of streambanks, restoration of riparian vegetation, and improved rangeland vegetation to reduce overland runoff.

There was a high level of landowner support in the Chalk Creek watershed. By 1997 many of the 100 major watershed landowners, working with the Natural Resources Conservation Service and other agencies, had begun designing resource management system plans and restoration projects. A typical Chalk Creek restoration project consists of fencing off the riparian zone on one or both sides of the creek, followed by implementing a rotational grazing management plan. Some projects address eroding banks by installing stream barbs or meanders in stream reaches that were historically straightened. Most restoration projects on Chalk Creek include planting willows at degraded sites. The most successful projects have natural willow regeneration on newly created floodplain deposition zones. The table summarizes the BMPs that

have been implemented in various projects in the Chalk Creek watershed.

The payoff: reduced phosphorus in watershed

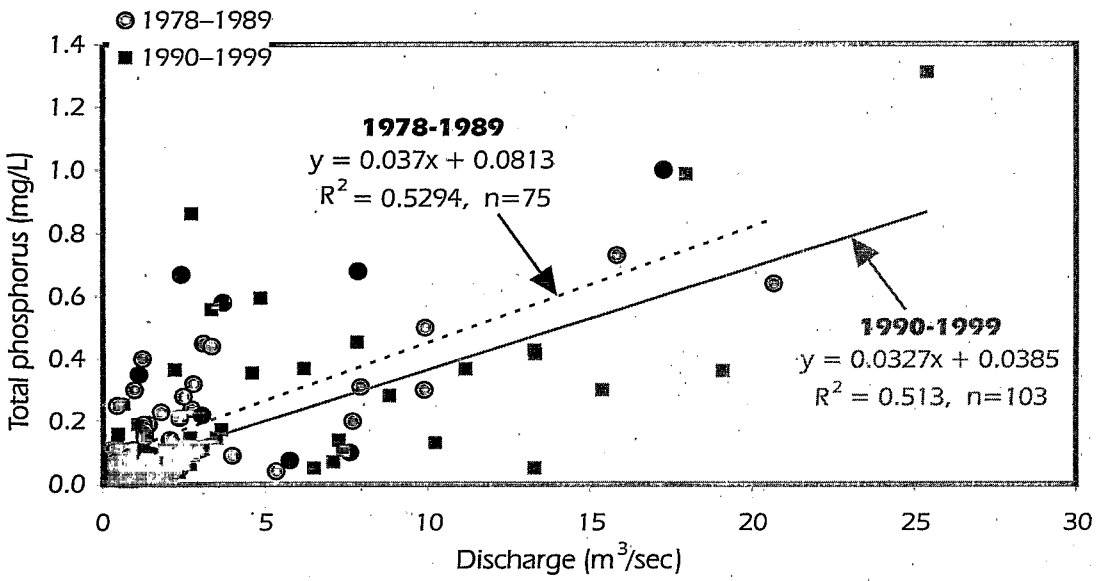
The landowners' cooperation and implementation of restoration projects have reduced the concentrations of total phosphorus in Chalk Creek. Results from water quality monitoring indicate that total phosphorus concentrations in Chalk Creek are lower for the time period of 1990 to 1999 than for the time period of 1978 to 1989 (see figure). It is expected that total phosphorus concentrations will further decrease as more restoration projects are completed and landowner resource management systems are implemented.

Implementing best management practices (BMPs) throughout the watershed has enhanced the aquatic community, with emphasis on the fishery populations. Reduced sediment from eroding banks and riparian areas has improved fish spawning and macroinvertebrate habitat. Placing willow plantings and adding in-stream log and rock features as flow-directing structures have provided fish resting habitat in addition to bank stability. As more BMPs are implemented throughout the watershed, the benefits to water quality and the aquatic community will continue to increase. A noteworthy indicator of success is the presence of a population of pure strain Bonneville cutthroat trout in the watershed.

Best Management Practices Implemented in the Chalk Creek Watershed

Best management practice	Amount completed
Brush management	1,479 acres
Riparian fencing	13,128 feet
Rangeland fencing	8,842 feet
Stock watering	3 units
Streambank protection	3,801 feet
Streambank vegetation	3,652 feet
Stream channel stabilization	8,655 feet
Prescribed grazing	15,443 acres
Sprinkler irrigation systems	1,118 acres

Total Phosphorus Concentrations in Chalk Creek (at Highway 189 in Coalville)



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Primary Sources of Pollution:
- hydroelectric development

Primary NPS Pollutants:
- sediment

Project Activities:
- reviewing/commenting on relicensing applications

Results:
- improved aquatic habitat
- increased wastewater assimilative capacity
- enhanced recreational use for swimming, fishing, and boating
- elevated dissolved oxygen levels
- reduced turbidity and suspended sediment

Flow Restoration Below Hydroelectric Facilities:
Relicensing Offers Opportunity to Increase Stream Flows

Statewide

The impacts of hydroelectric development on Vermont streams were documented in a 1988 report titled *Hydropower in Vermont: An Assessment of Environmental Problems and Opportunities*, the first comprehensive environmental study of Vermont's 62 older hydroelectric projects. Artificial regulation of natural stream flows and the lack of adequate minimum stream flows at these sites were found to have reduced to a large extent the success of the state's initiatives to restore the beneficial uses and values for which the affected waters are managed. Slightly more than three-fourths of the hydroelectric projects studied were found to be adversely affecting the streams on which they were located. The substantial advances being made to clean up Vermont's rivers were being stymied by this flow regulation problem.

The project

Since 1991 Vermont has used section 319 funding to support the Department of Environmental Conservation's (DEC) participation in the process of relicensing hydroelectric projects (under Clean Water Act section 401 authority). In doing so, DEC has developed positions on relicensing applications, influencing the preparation of conditions for future operation of the facilities to support desired multiple uses of the affected waters. Activities have also included evaluating the regulation of reservoir levels and downstream flows as related to the support of recreational uses, aquatic habitat, and aesthetics, as well as erosion of reservoir/impoundment shorelines and downstream riverbanks.

Site-specific successes

Given the technical and social complexities of relicensing, and in spite of several appeal proceedings, numerous accomplishments are a direct result of the focus provided by section 319. A few key examples illustrate these accomplishments:

- The Clyde River Project was denied certification because of a project dam that degrades habitat and impedes migration of landlocked salmon from Lake Memphremagog. DEC subsequently worked with several parties to complete dam removal and restore this reach of the river, which was accomplished in 1996.
- Projects occurring in the Passumpsic, Black, and Ottauquechee Rivers (Connecticut River Drainage) were relicensed subject to a "run-of-river conversion," requiring inclusion of special recreation and landscaping plans, bypass flows, and downstream fish passage.

- The Center Rutland Project (Otter Creek, Lake Champlain Drainage) was relicensed after issuance of a water quality certification. The project is now being operated under a new flow management plan that includes spillage to improve bypass habitat, aesthetics, and dissolved oxygen concentrations in Rutland's wastewater management zone.

Expected results

Expected benefits from this nonpoint source implementation strategy include improved aquatic habitat; increased wastewater assimilative capacity; enhanced recreational uses for swimming, fishing, and boating; elevated dissolved oxygen levels; and reduced turbidity and suspended sediment.

VERMONT

www.anr.state.vt.us/dec/waterq/wqdhome.htm

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Primary Sources of Pollution:
- agriculture (dairy)

Primary NPS Pollutants:
- sediment
- nutrients
- bacteria

Project Activities:
- livestock exclusion fencing
- alternative water supplies
- armored or bridged livestock stream crossings
- bioengineering streambank stabilization practices

Results:
- reductions in phosphorus, nitrogen, suspended solids, and indicator bacteria
- improved macroinvertebrate community

Lake Champlain Basin Watershed Project:
Significant Pollutant Reductions Achieved

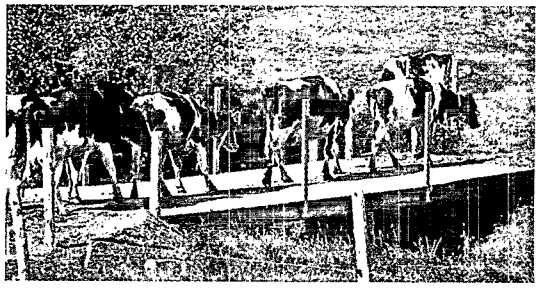
Franklin County, Vermont

Lake Champlain, the nation's sixth-largest freshwater lake, is undergoing cultural eutrophication due to excessive phosphorus loads. About 71 percent of the lake's average annual phosphorus load of 647 metric tons comes from nonpoint sources, and two-thirds of this load is estimated to come from agricultural land in the basin.

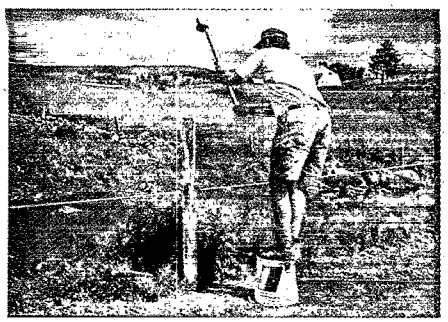
Over the past several decades, efforts to reduce agricultural nonpoint source pollution in Vermont have focused on improving animal waste management in the state's predominantly dairy agriculture. Construction of manure storage structures, barnyard runoff management, and adoption of waste utilization plans to avoid winter spreading of manure have been widely encouraged under a variety of federal and state cost-share and technical assistance programs. However, dairy cows traditionally spend half of the year away from the barn on pasture, and impacts on water quality from livestock grazing have not been addressed in previous nonpoint source reduction programs. Free access to streams and streambanks by livestock is commonplace in Vermont. Direct deposition of waste into streams, destruction of riparian vegetation, and trampling of streambanks and streambeds all represent important sources of sediment, nutrients, and bacteria to surface waters in Vermont.

Paired watershed study

The Lake Champlain Basin Watershed Project was initiated in 1994, as one of the projects composing the Section 319 Nonpoint Source National Moni-



A bridge was constructed to allow cows to cross the stream without contributing to streambank erosion.



Exclusion fencing, requiring only normal fence maintenance, is a simple way to keep livestock from degrading streambanks.

toring Program (http://h2osparc.wq.ncsu.edu/319index.html), to evaluate the effectiveness of grazing management, livestock exclusion, and streambank protection as tools for controlling nonpoint source pollution in small agricultural watersheds. The project used a paired watershed design, using two treatment watersheds and a control watershed, to track changes over a 7-year period. Contributing partners included the U.S. Department of Agriculture's Natural Resources Conservation Service, U.S. Fish and Wildlife Service, Franklin County Natural Resource Conservation District, and participating watershed agricultural landowners.

Healthy vegetation along streambanks protects water quality by preventing erosion and filtering nutrients.

In 1997, following a 3-year monitoring/calibration period, a number of land treatments were applied throughout the Samsonville Brook and Godin Brook watersheds. The treatments included livestock exclusion fencing, alternative water supplies, armored or bridged livestock stream crossings, and bioengineering streambank stabilization practices (with brushrolls, tree revetments, and willow plantings).

Maintenance was not a major problem for the treatments; only normal fence maintenance was required. Water supply was an obvious concern following livestock exclusion from stream reaches, but the project was fortunate in that alternative supplies could be exploited relatively simply at all sites. In a limited way, the project demonstrated some success in using pasture pumps to provide water for beef cattle, but water for dairy cows is a serious operational issue to be considered in future applications.

The bioengineering installations appeared to work well, as demonstrated by rapid and strong growth of planted willows and native riparian zone vegetation throughout the treatment period. Brushrolls survived high flows very well and appeared to perform their function of trapping sediment, supporting new vegetation growth, and protecting streambanks.

Confirmed pollutant reduction

Three years of post-treatment monitoring was completed in November 2000. The final results confirm significant reductions in phosphorus, nitrogen, suspended solids, and indicator bacteria in response to treatment (see table). Biomonitoring data also suggested improvements in the macroinvertebrate community, particularly due to riparian zone protection. Although no significant improvements in fish assemblages were observed, physical habitat improvements were noted in the treated sections of both Samsonville Brook and Godin Brook. Overall, the project was successful in demonstrating that practical, low-technology, low-cost practices can yield significant improvements in water quality.

Average Documented Pollutant Reductions Over Three Post-treatment Years in Samsonville Brook

Total phosphorus	-15%
Total Kjeldahl nitrogen	-12%
Total suspended solids	-34%
Total phosphorus export	-49%
Total Kjeldahl nitrogen export	-38%
Total suspended solids export	-28%
E. coli	-29%
Fecal coliform bacteria	-38%
Fecal streptococcus	-40%
Conductance	-11%
Temperature	-6%

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Primary Sources of Pollution:
- acid mine drainage
- overfarming

Primary NPS Pollutants:
- heavy metal concentrations
- low pH
- sediment

Project Activities:
- storm water diversion from mine site
- dredging spoil materials
- sealing shafts
- covering mine spoil
- revegetation

Results:
- decrease in heavy metals (copper, zinc, and iron)
- decrease in sulfate levels
- improvements in fish community (taxa and individual numbers)

Cabin Branch Mine Orphaned Land Project:
Flora and Fauna Benefit from Mine Reclamation

Prince William County, Virginia

Virginia's Nonpoint Source Pollution (NPS) Management Program has long recognized the need to improve surface and ground water quality by reducing nonpoint source pollution associated with abandoned and orphaned mineral mines. Virginia's Department of Conservation and Recreation's Division of Soil and Water, which administers the NPS Management Program, recently had the unique opportunity to partner with the Virginia Department of Mining, Minerals and Energy's Orphaned Lands Program to support several innovative reclamation projects to achieve improved surface and ground water quality.

From 1890 to the early 1920s, Cabin Branch Mine operated at a site along Quantico Creek, a tributary of the Potomac River, in Prince William County, Virginia. Large by Virginia standards, the mine had 200 to 300 people working aboveground and up to 2,400 feet belowground at any given time, excavating pyrite for use in the production of sulfuric acid.

In 1933 the Civilian Conservation Corps obtained the abandoned mine and its surrounding land, and it is now part of Prince William Forest Park. The park's 18,633 acres cover a major portion of the Quantico Creek watershed and contain one of the few remaining piedmont forest ecosystems in the National Park System. The area had been heavily farmed for tobacco since colonial times, leaving the soil degraded and subject to intense erosion. Since the area was acquired by the National Park Service, the native forest has been allowed to reclaim the overfarmed and exhausted landscape. However, the area incorporating the mine site was not able to revegetate naturally because highly acidic mine tailings were inhibiting growth.

Water quality in Quantico Creek just downstream was severely compromised because of the acid mine drainage and heavy metal contamination. During rain and storm events, surface water mobilized and carried oxidized sulphur compounds and acidic material into the creek. The resulting impacts on the water quality of the creek were low pH, high conductivity, and significant sediment loading.

Multiple funding sources

After years of coordination between the National Park Service, Geologic Resources Division and Water Resources Division; Virginia Department of Mines, Minerals and Energy; and the natural resources staff at Prince William Forest Park, the Cabin Branch Mine site was reclaimed in 1995. In addition to section 319 funding, support was provided through a grant from the National Park Service's Water Resources Division, and the balance was covered by Virginia's Orphaned Land Program administered by the Virginia Department of Mines, Minerals and Energy's Division of Mineral Mining.

The primary goal of the Cabin Branch Mine Orphaned Land Project was to improve the water quality of the downstream reach of Quantico Creek contaminated by acid drainage and heavy metals. Additional goals included making the site safer for park visitors and restoring native vegetation. Reclamation plans included diverting storm water away from the mine site to limit acidification of off-site storm waters, sealing all shafts so surface water would not enter mine workings or groundwater, covering mine spoil materials with a good soil medium, and revegetating all disturbed areas with tolerant grasses and legume species. All of these actions were designed to reduce acid mine drainage discharges, thereby reducing heavy metal concentrations in the surface waters.

Benefits to water quality and aquatic life

Water chemistry monitoring of Quantico Creek was conducted before and after reclamation of the Cabin Branch Mine site to quantify the success of the reclamation project. Initial water sampling taken after reclamation activities were completed showed a marked decrease in the presence of heavy metal contamination in Quantico Creek. A 2-year monitoring program conducted by George Mason University (see table) recently confirmed that levels of copper, zinc, and iron in the stream have been appreciably reduced since project completion; sulfate levels and conductance have also improved. In addition, remotely sensed images taken by the US Army Corps of Engineers before and after reclamation visually illustrate the elimination of acid materials from the creek itself. The George Mason study also included fish and invertebrate sampling of the stream. The fish community in the downstream reach has increased in both number of taxa and number of individuals since the project was completed. Results of invertebrate monitoring are inconclusive because of large population fluctuations during the monitoring period.

The park's resource management staff also teamed up with U.S. Geological Survey staff to initiate a monitoring and research study to investigate the effects of storm water retention ponds, created during the reclamation project to minimize acid mine drainage from the site, on breeding amphibians. Although low pH levels and heavy metal concentrations in the surface water retention ponds have been shown to negatively affect amphibian reproduction, results of this study confirm that the ponds are doing what they were designed to do—trap contaminants from surface mine drainage and keep it from reaching Quantico Creek.

The public outreach activities integral to the project continue to be a success. Community involvement was high, and at the end of the project 150 volunteers gathered at the reclamation site to plant 5,000 native trees and shrubs. This effort will help further stabilize the streambank and assist in restoring native forest to previously bare ground.

Water Quality Data Before and After Reclamation, Cabin Branch Mine

Element	Pre-Reclamation Concentration	Post-Reclamation Concentration
Copper	0.06 mg/L	0.0010–0.012 mg/L
Iron	0.49 mg/L	0.18–1.20 mg/L
Sulfate	590.0 mg/L	10.0–30.0 mg/L
Zinc	0.32 mg/L	0.05–0.12 mg/L

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Primary Sources of Pollution:
- acid mine drainage

Primary NPS Pollutants:
- heavy metal concentrations (copper)

Project Activities:
- diversion of water from mine site
- sealing of all mine shafts
- regrading mine spoil materials
- constructed wetlands

Results:
- reduced copper levels
- improved invertebrate community
- reestablishment of native brook trout

Toncrae Mine Orphaned Land Project:
Mine Site Reclamation Increases Species Diversity

Floyd County, Virginia

The Toncrae Mine in southern Floyd County operated as a copper mine intermittently from the late 1700s to 1947. The abandoned mine had severely degraded East Prong Creek with acid mine drainage and heavy metal contamination. Barren mine tailings, underground seeps, open mine shafts, and old ore processing areas contributed to the deposition of large concentrations of heavy metals into the creek, a tributary of the Little River. At one bog site, copper was measured at levels thousands of times greater than the limits set by EPA. In addition, upland areas surrounding the mine were barren of vegetation because of contaminated and inhospitable soil conditions. Reclamation of the Toncrae Mine site was considered a high priority because of the excessive pollutant levels, the numerous open mine shafts, and perhaps most important, the high potential for successful recovery of the site.

Innovative solutions

Beginning in 1993, Phase I of the reclamation included diverting unpolluted waters away from the mine site to limit effluent discharge, sealing all mine shafts, regrading mine spoil materials, constructing wetlands to treat mine seepage, and revegetating all disturbed areas with tolerant grasses and legume species. Sixteen shafts were capped and sealed, and mine markers were installed.

An innovative wetland system was also designed to naturally filter out the heavy metals before they reached the surface waters of East Prong Creek. Contaminated discharge from 16 shafts and 6 spoils dumps is routed through 6 cells of constructed wetland, 5 of which filter the drainage through bark and straw mulch, and then limestone, before discharging into the next cell. Within the cells anaerobic sulfate-reducing bacteria remove toxic heavy metals, while cattails, reeds, and other wetland plant species also contribute to metal uptake, providing a future source of nutrients for the bacteria. The treated water is finally discharged into East Prong Creek.

Phase II of the Toncrae Mine Orphaned Land Project was initiated in 1997 in response to continued chemical monitoring of the constructed wetlands. Monitoring results indicated that two of the wetland cells were not functioning as well as desired in the winter months. The goal of Phase II was to reconfigure the wetland design to increase detention time and improve performance. This phase of the project also included continued chemical monitoring to quantify success.

The reconfiguration of the constructed wetlands was required because the drainage was being oxygenated too rapidly in the winter months because of higher-than-expected flows, combined with cooler temperatures. Because of the rapid

oxygenation, the system was unable to maintain the anaerobic conditions that the sulfate-reducing bacteria required to adequately break down the metals in solution. The first step of Phase II involved increasing the size of the two problem cells. The effect was to create one large wetland cell from the previous two, thereby increasing detention time and the overall time the drainage remains in an anaerobic state. Next, another much larger wetland cell was constructed below the existing cells to further increase detention time. Finally, an anoxic drain was installed to reduce oxygen levels entering the system and assist the wetlands in functioning in an anaerobic state.

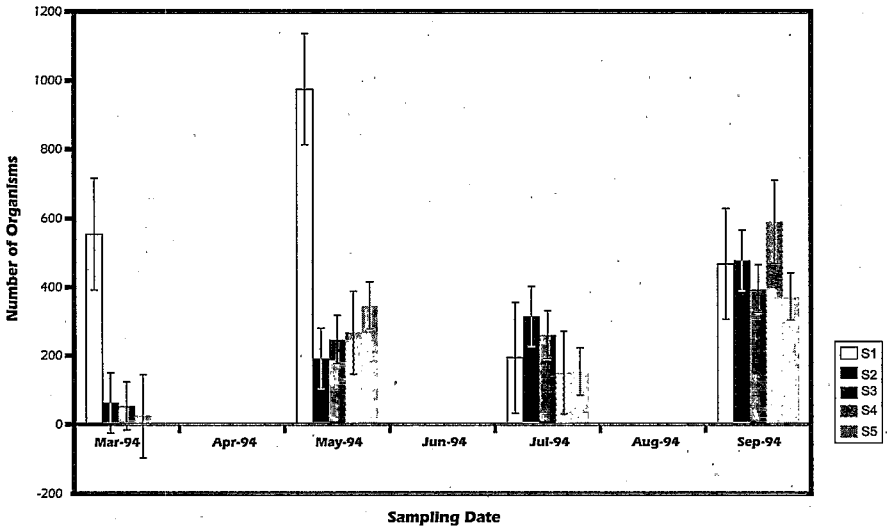
Successful results

Invertebrate sampling conducted before reclamation showed the invertebrate population of East Prong Creek to be severely affected below the Toncrae Mine site. Both the number of species and the total number of organisms were significantly lower than those recorded at a reference site located upstream from the mine and its toxic effluent (see figure). After project completion, copper levels were appreciably reduced: copper concentrations ranged from 9 to 32 micrograms per liter (mg/L) before the project and between 0.1 and 14 mg/L after the project. The invertebrate community showed signs of a rapid recovery. Within months of project completion, both the number of invertebrate taxa and the number of individuals were approaching reference site conditions.

Monitoring for Phase II continued through 1998. Chemical monitoring of the wetlands indicated that since reconfiguration, the wetlands are successfully removing metals, even in the cool temperatures of fall and winter.

The success of this project led the Virginia Wildlife Federation to award its 1995 Mineral Conservationist of the Year Award to the Virginia Department of Mines, Minerals, and Energy's Division of Mineral Mining. The award was granted for the successful rehabilitation of the Toncrae Mine site and East Prong Creek. The nomination for the award notes that "the creek now has a healthy animal life with growing diversity, and the revegetated land surface is now a camping and picnic ground."

The long-range goal of the Toncrae Mine Orphaned Land Project was a return of the native brook trout to the contaminated stream section below the mine site. According to residents, no fish had been seen in the contaminated section of East Prong stream in years. Biologists with the Virginia Department of Game and Inland Fisheries confirmed that although brook trout did inhabit the stream above the Toncrae Mine site, they did not occur downstream of the site. However, recent surveys conducted by the Department's fisheries biologists verify that since reclamation was completed, brook trout have successfully moved into East Prong Creek below the abandoned mine site.



Total number of organisms collected at five sites in East Prong Creek before (March 1994 and May 1994) and after (July 1994 and September 1994) reclamation activities were complete. Site 1 (S1) is a reference site upstream of the Toncrae mine site; S2 to S5 are downstream of the mine. Before the wetlands became operational, the sites downstream of the mine showed an appreciable decrease in number of organisms compared to the upstream site. After the wetlands became operational, however, the invertebrate communities appeared to have recovered quite well, becoming very similar to those of the upstream reference site.

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Primary Sources of Pollution:
- failing septic systems

Primary NPS Pollutants:
- nutrients
- pathogens

Project Activities:
- alternative treatment systems installed

Results:
- effectively controlled discharge of residential wastewater

Virgin Islands Partnership:
Alternative Treatment Systems Prevent Contamination of Coastal Waters

U.S. Virgin Islands

Preservation of coastal water quality is critical in the U.S. Virgin Islands, where tourism is the main industry. Public sewer systems do not extend throughout the islands, and there is a large dependency on conventional septic tank/seepage pit systems. Unfortunately, the hilly terrain of the islands, the shallow soils, and in many instances the dense residential development are factors that contribute to the failure of conventional systems and subsequent discharge of improperly treated waste.

The Virgin Islands Department of Planning and Natural Resources (DPNR), through a study conducted by Kimball-Chase, documented that a major source of contamination of beaches and other coastal areas in the U.S. Virgin Islands is failing septic systems. These widely used units are failing because they lack the 2 to 3 feet of pervious soil through which effluent should pass to be properly treated.

An innovative solution

To remedy this problem, DPNR and the University of the Virgin Islands (UVI) entered into a partnership. DPNR asked the public for proposals for the design and installation of affordable alternative systems that would treat residential wastewater using nonmechanical means and would require minimal maintenance. Two of the designs submitted were selected, and the systems were installed at two residences where conventional systems had failed to meet treatment needs. The new systems used a series of closed cells filled with gravel and soil in which plants with high water uptake rates were planted. In addition, the systems blended in with the topography of the sites and were installed in such a way that they enhanced the appearance of the properties.

DPNR observed the installation of the systems, and UVI closely monitored their performance for a 6-month period following their installation. Plants thrived in the systems, and it was interesting to note that at one site exotic flowers fared better than anywhere else on the island. No discharge of effluent from the systems, odor, or any other unpleasant effects were recognized at either site. Effluent quality was found to improve as it passed through the systems. Most significantly, because no discharge was ever noted, the surrounding environment was never threatened.

The pilot alternative systems for treatment of residential wastewater have a high potential for reducing the pollution threat to the fragile coastal ecosystems of the Virgin Islands. Thus far, they have proven to be affordable to install, effective, and easy to maintain. The systems are being closely monitored to assess their performance over an extended period.

Because of the high public interest in these systems, DPNR has developed a handbook available to the public to guide in their design, con-

struction, and use. DPNR is also proposing regulations that would permit use of these systems in areas where sensitive environmental factors preclude the installation of conventional septic tank systems. The innovative systems have the potential to maintain high environmental quality for present and future generations in the U.S. Virgin Islands.

www.ecy.wa.gov/programs/wq/nonpoint/index.html

WASHINGTON

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Primary Sources of Pollution:
- horse farms

Primary NPS Pollutants:
- sediment
- nutrients

Project Activities:
- farm plan management (pasture management, manure management, mud management, wildlife enhancement, stream corridor management)

Results:
- 84 percent decrease in TSS from grass filter strips
- 35 to 85 percent pollutant reductions from paddocks

Best Management Practices on Model Horse Farms:
Farm Plan Management Reduces Nutrients and Sediment

King County, Washington

"Implementation and Evaluation of Livestock Water Quality Best Management Practices (BMPs) on Model Horse Farms" was a joint project between the King County Water and Land Resources Division (formerly Surface Water Management) and the King County Conservation District. King County has nearly 9,000 farms, housing between 30,000 and 40,000 horses. Some 600 of those farms are near Class 1 and 2 streams, and even more have drainage systems that flow to nearby streams, lakes, or wetlands. The primary goal of the project, which received $85,000 in 319 grant funding for the years 1995 to 1998, was to promote education and technical assistance to horse and farm owners with the Model Farm Project.

Model farms were selected in 11 watersheds throughout the county, and farm plans were implemented on 12 different sites. Farms were selected based in part on their ability to function as an education site and the owner's experience and interest in providing a role model for other horse and farm owners. Also, geographic location, potential for improvement, and the owner's willingness to implement and maintain the elements of the farm plan were important factors.

Education and technical assistance on model farms

For the 12 farms selected, costs for materials and labor associated with implementation were funded through a cost share, and the farm plan expenses were covered by funds from the farm owner and the 319 grant. Cost-shared farm plan elements included materials for composting facilities, fencing, pasture and hay land planting, and paddock areas.

Education concentrated on encouraging implementation of four BMPs—pasture management, manure management, mud management, and wildlife enhancement, including stream corridor management. Between 1995 and 1998, a series of education and outreach activities took place, including 10 tours, 13 education sessions, 12 outreach events, farm-related events, and presentations. They reached more than 5,000 horse and small farm owners in King County.

Real results

Support, encouragement, and a sustainable connection with the farmers were critical and resulted in full implementation of the farm plan BMPs on each of the 12 farms. The education activities not only promoted proper management practices but also encouraged a sense of stewardship for aquatic resources in the respective basins. But the clear results stem from the post-BMP implementation assessment.

The two BMPs chosen for assessment purposes were use of wood waste as a winter paddock footing material and use of grass filter strips for the treatment of surface runoff from winter paddocks. There was a reduction in pollutant concentrations after BMP implementation for all nutrients monitored except nitrite/nitrate/nitrogen. Despite this increase, consideration of the dissolved oxygen concentration after BMP implementation indicates that toxic nitrite levels would be unlikely because nitrite is rapidly broken down to nontoxic nitrate when a high dissolved oxygen content is present. Reductions in all other measured pollutants ranged from 35 to 85 percent.

WASHINGTON www.ecy.wa.gov/programs/wq/nonpoint/index.html

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Primary Sources of Pollution:
- dairy farms

Primary NPS Pollutants:
- fecal coliform bacteria

Project Activities:
- dairy farmer outreach/ education
- BMPs to control manure
- fencing

Results:
- fecal coliform loads down 21 percent

A Moo-ving Approach to Dairy Waste Management:
Fecal Coliform Pollution Reduced in Whatcom County

Whatcom County, Washington

The goal of the "Watershed-Based Approach to Dairy Waste Management" is to lower dairy-related levels of fecal coliform bacteria and other manure-associated contaminants in a watershed without alienating the dairy industry. The project, which is coordinated by the Washington State Department of Ecology, has received $90,000 in 319 funding for the past 3 years to improve water quality. The project has focused on Whatcom County in the northwest corner of Washington State, which borders British Columbia. To fully grasp the nature of the problem, consider that every adult milk cow produces the equivalent waste of 22 humans. There are some 69,000 cows (or the equivalent of 1.5 million people) in Whatcom County. This figure does not even account for the stock (about 30,000 cows) used to replace older, non-milk-producing cows.

Monitoring to target priorities

The Department of Ecology partnered with the Northwest Indian College to monitor fecal coliform levels bimonthly. In addition to the inspections of the state's dairy farms that are required by law, the consistent monitoring data collected by the college for this and other 319-funded projects have helped determine which subbasin tributaries have the highest levels of fecal coliform loading. Subsequently, reinspections are being conducted in those areas to determine

whether the pollution is related to nearby dairies. Then the detected problems can be corrected. The fecal data collected by the Northwest Indian College are posted on the college's web site and cover all of the subbasin tributaries of the Nooksack River, as well as sites in the Drayton Harbor/Portage Bay areas. The web site is at www.nwic.edu.

Farm plans and agreements

Once the basins with the highest loading have been identified, the Department of Ecology inspects the area farmers' milking facilities, as well as all of the off-site replacement stock operations. Most of the problems have been found at the off-site locations because farmers typically do not invest as much time, attention, or money in those locations as they do in their primary milking facilities. Outreach and education are vital, and farmers are referred to the Whatcom County Conservation District for farm planning and technical assistance. These referrals, together with education and outreach, have encouraged farmers all over the county to implement best management practices (BMPs) such as long-term waste storage facilities, manure solids separators, rainwater gutters and downspouts, agronomic manure field applicator schedules, and fencing to keep livestock out of streams.

Although the Department of Ecology's goal is to increase compliance rather than to impose penalties, about $200,000 in fines have been imposed on roughly 4 percent of the dairy farmers in the county. Notices of Correction, an informal non-penalty means of enforcement for potential discharge problems, are used amply. The Department of Ecology issued about 75 notices as preventive solutions between July 1998 and June 2000.

As an additional measure, the Department of Ecology has recently signed an agreement with the Governor's office. This new agreement calls for a reduction of 15 percent per year in the fecal coliform loads as compared with the loads reported by the Department of Ecology's 1996 to 1998 Total Maximum Daily Load (TMDL) fecal coliform monitoring study.

Real results

Although much work remains to be completed in terms of controlling nonpoint sources of contamination on dairy farms in Whatcom County, the current dairy inspection program has brought unprecedented change in the way dairy farmers operate their farms. The Department of Ecology's new approach to working with dairy farmers, particularly with respect to implementing BMPs, is still enforcement-oriented but also has struck a good balance with education and outreach. Fair but firm enforcement, both formal and informal, has helped break down the image of the enforcing agency as an enemy.

Upgrades to control pollution to date have been completed through partnerships established between the Department of Ecology, the Whatcom Conservation District, and the Whatcom County office of the Natural Resources Conservation Service. By working together, the partners have achieved impressive results. As of the last quarter of 1999, fecal coliform loads in the Bertrand/Fishtrap Creek subbasin were down 21 percent, and they are expected to drop further during the fall.

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Primary Sources of Pollution:
- furrow irrigation in agricultural fields

Primary NPS Pollutants:
- sediment

Project Activities:
- conversion to sprinklers and drip irrigation
- other sediment reduction practices (PAM application)

Results:
- 30 percent reduction in sediment load in the Moxee Drain
- decrease in total suspended solids (86 percent in subbasin 10 and 56 percent in subbasin 5)

Sediment Reduction in Yakima River Basin:
People Become Stewards of Their Own Watershed

Yakima River Basin, Washington

Sulphur Creek is a tributary of the Yakima River and receives runoff from about 41,500 acres of agricultural land.

After the installation of BMPs, subbasins reported decreases in TSS of as much as 86 percent.

Since 1994 the Yakima Conservation District and Department of Ecology, along with many other groups, have been working to reduce sediment in the Yakima River Basin in eastern Washington State, including the Moxee Drain, Granger Drain, and Sulphur Creek Drain. The primary problem has been furrow irrigation, most notably on hops farms. This method of irrigation is notorious for causing sediment flow and also for introducing poisonous pesticides like DDT into the water. In 1994 furrowed irrigation was delivering 100 tons of sediment and pesticides per acre per year into the water. There are about 19,000 acres of irrigated land in the watershed.

In late 1993 the North Yakima Conservation District received 319 funding, and in 1996–1997, the South Yakima Conservation District also received 319 funding to work on the problem from the south. In the past several years, the Department of Ecology has begun to work on Total Maximum Daily Loads (TMDLs) on the Yakima River watershed in its entirety. By 1997 a 30 percent reduction in sediment load had been achieved in the Moxee Drain alone, and drip irrigation had been implemented on more than 2,000 acres of farmland.

Sulphur Creek progress

Sulphur Creek is a tributary of the Yakima River and one of the three major irrigation return flows in the Yakima Valley. It receives runoff from about 41,500 acres of irrigated agricultural land in the Sulphur Creek Basin. In 1997 the South Yakima Conservation District received 319 funding to implement best management practices (BMPs) in two subbasins of the watershed. Thirty farmers applied for technical and financial assistance in implementing these practices, and 16 of the proposals (covering 679 acres) were accepted.

The primary method used to reduce sediment loads due to furrow irrigation is implementing more efficient drip irrigation methods, such as sprinklers. Site-specific BMPs were designed with the individual landowners. In one case, the demonstration included application of polyacrylamide (PAM) through a central pivot irrigation system. PAM is a coagulating agent that when used in irrigation causes better soil saturation and less runoff in the fields. The combination of these two management practices was new in this area.

Monitoring was conducted to measure the effects of installing the BMPs. Samples were

collected at about 15 sites in the two subbasins from June 1997 through October 1999. One subbasin registered a decrease in total suspended solids of 86 percent, and the other subbasin showed a decrease of 56 percent.

The big picture

One of the primary goals of these combined 319-funded projects was to provide education and outreach to local groups and individual farmers to inspire people to become involved in their watershed. When people become stewards of their watershed, they begin to take responsibility for restoring and protecting it. In the past few years, stewardship of this watershed has become a vital interest of local irrigation districts and individual farmers.

In fact, education and outreach using demonstrated BMPs funded by 319 grants have been so successful that the irrigation districts have joined together on their own, forming a joint interest group called Roza-Sunnyside Board of Joint Control (RSBOJC). *Taking responsibility for water quality* themselves, they have applied for State Revolving Fund loan money. As an indirect result of 319 outreach and education, the RSBOJC succeeded in obtaining $10 million in loans to improve water quality in the watershed. Because of the RSBOJC's outstanding efforts, in 1998 Washington's Governor presented the Board an award for Environmental Excellence.

This phenomenal stewardship shows in the recovery effort. The Department of Ecology recently initiated its TMDL program to reduce pollutant loads in waters across Washington. For example, one of the Yakima TMDL goals was to reduce turbidity to below 25 ntu (turbidity units) by the end of 2002. Thanks to earlier 319 projects and to RSBOJC's current efforts, that goal has already been reached this year in most drains. Additionally, the Department of Ecology reports that as a result of RSBOJC's stewardship efforts, there has been no need to write an enforcement order in more than a year.

http://www.dep.state.wv.us/wr/

WEST VIRGINIA

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Primary Sources of Pollution:
- timbering
- streambank erosion
- agriculture
- roads

Primary NPS Pollutants:
- fecal coliform bacteria
- sediment

Project Activities:
- critical area planting
- streambank fencing
- feedlot relocation
- nutrient management plans

Results:
- 340 acres under nutrient management plans
- 85 percent agricultural landowner participation rate

The North Fork Project:
Farmers' Cooperation Leads to Proposed Delisting of Degraded River

Pendleton and Grant Counties, West Virginia

The North Fork Project illustrates a successful multiagency partnership approach to solving a water quality problem on a scenic high-quality trout stream in the rural Potomac Headwaters area. As a result of the implementation of numerous best management practices (BMPs) funded under several federal and state programs, the West Virginia Department of Agriculture is now proposing that the North Fork River be removed (delisted) from the list of impaired water bodies in West Virginia.

The North Fork of the South Branch Potomac River watershed is in Pendleton and Grant Counties in West Virginia; a portion of the watershed is in Highland County, Virginia. The area within the watershed is predominantly forested, with agriculture as the second dominant land use. Beef and

poultry enterprises are the main agricultural activities. Because of the rugged nature of the terrain, many of the concentrated livestock feeding areas and poultry operations were located on the narrow valley bottoms and floodplains adjacent to the streams. High levels of bacteria and sediment loading were adversely affecting both the North Fork and South Branch watersheds. A U.S. Geological Survey surface water study found that the numbers of feedlots and poultry houses per square mile had a positive correlation with concentrations of fecal coliform bacteria in surface streams. Based on the South Branch Potomac watershed Total Maximum Daily Load (TMDL) allocations, the North Fork required a 35 percent reduction in fecal coliform bacteria loading from agricultural land to meet West Virginia's water quality standards.

The Potomac Headwaters area historically has produced beef cattle, forages, timber, and some corn and apples; since the early 1990s, however, the area has seen a significant increase in the poultry industry. In 1993 this area became a component of the U.S. Department of Agriculture's (USDA) Water Quality Initiative, a cooperative effort of federal, state, and local agencies to address water quality issues. In January 1997 a Public Law 534 Land Treatment Watershed cost-share program was initiated in the upper Potomac River Basin to address the structural and technical needs of the area farmers in order to improve water quality and protect the associated natural resources of the area.

In March 2000 the North Fork Watershed Association launched a section 319 project to address bacteria and sediment problems associated with agricultural activities, past timbering operations, streambank erosion, and road maintenance activities. Partners in developing the plan included the Potomac Valley Soil Conservation District, West Virginia Soil Conservation Agency, West Virginia University Extension Service, West Virginia Division of Environmental Protection (DEP), West Virginia Division of Forestry, West Virginia Division of Highways, USDA Natural Resources Conservation Service, and Trout Unlimited. The West Virginia Agriculture Water Quality Loan Program, funded through the DEP Clean Water Act State Revolving Fund, also provided complementary low-interest loans (2 percent) to landowners to help finance BMP installation.

Implementing multiple BMPs

To date, 12 agricultural 319 projects, one forestry 319 project, and 19 PL-534 projects/contracts have been implemented in the North Fork watershed to control nonpoint source pollution. A range of BMPs have been established to control runoff from feedlots and to eliminate or reduce cattle's access to the streams. These BMPs include installing streambank fencing, relocating feedlots away from streams, constructing roofs over concentrated feeding areas, controlling roof runoff, establishing filter strips, establishing riparian buffers, developing alternative livestock watering facilities, drilling livestock water wells, and stabilizing critical eroding areas.

Rotational grazing systems with intra-pasture fencing systems and alternative watering facilities have been established to improve the conditions of pastures, reduce runoff, and control bacterial, sediment, and nutrient pollution. To control or eliminate runoff from the poultry operations, poultry litter storage sheds, waste composting facilities, and mortality composters have been constructed and buffer/filter strips have been established. In addition, nutrient management plans have been developed and implemented for more than 340 acres of cropland and pastureland receiving animal manure.

In cooperation with West Virginia Division of Forestry, educational workshops are being held

to educate landowners and people in the forestry industry on conservation practices. West Virginia foresters are developing forestry plans to promote logging conservation and BMPs. One severely eroded, steep hillside site has been planted with trees and fenced for livestock exclusion as part of a reforestation project.

Another component of the North Fork Project has included working with the West Virginia Division of Highways (DOH) to implement a variety of conservation practices, including a seeding demonstration using poultry litter as a fertilizer, a sediment erosion control workshop for DOH employees, and the selection of a site on DOH property for the construction of a poultry mortality composting facility.

A West Virginia University research project associated with the North Fork project has selected a site to test whether acid mine drainage (AMD) sludge, high in iron oxides, can be applied in buffer strips to absorb soluble phosphorus before it enters waterways. If results are favorable, AMD waste from the nearby coal mining region can be used to reduce phosphorus pollution from excessive manure in the poultry-producing region of the state.

Receptive agricultural community

The agricultural community within the watershed has been extremely receptive: 85 percent of the farmers have participated in BMP implementation. Based on recent water quality monitoring results and the extent of BMPs installed, it is being proposed that the North Fork River be delisted from the 303(d) list of impaired waters in West Virginia.

Ongoing and future projects and activities

Future projects will emphasize wetland and riparian corridor restoration. Working in cooperation with Trout Unlimited, stream channel restoration projects using natural stream channel design technology are being planned to address stream erosion and sedimentation problems. One site for a stream restoration project has been selected near the Seneca Rocks scenic area, and design plans are being developed. An educational display about the watershed is planned for the Seneca Rocks Visitors Center in the Monongahela National Forest. Educational programs for landowners on stream channel protection and maintenance are planned, and water quality monitoring by the West Virginia Department of Agriculture is continuing.

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Primary Sources of Pollution:
- agriculture (cropland, dairy farms)

Primary NPS Pollutants:
- phosphorus
- sediment
- fecal coliform bacteria

Project Activities:
- BMPs to control barnyard runoff and manure
- nutrient management and reduced tillage on cropland
- shoreline and streambank stabilization

Results:
- more than 8,100 feet of streambank fencing
- reductions in suspended solids (81 percent), total phosphorus (88 percent), ammonia nitrogen (97 percent), biological oxygen demand (80 percent), and fecal coliform bacteria (84 percent)

Otter Creek Project:
319 National Monitoring Program Goals Met

Otter Creek Watershed, Wisconsin

The largely agricultural, 7,040-acre Otter Creek watershed drains to Lake Michigan via the Sheboygan River. Biological monitoring in the watershed has shown that the fish community lacks fishable numbers of warm-water sport fish, largely because of inadequate fish habitat and polluted water. Dissolved oxygen concentrations occasionally drop below Wisconsin's state standard of 5.0 milligrams per liter. In addition, bacteria levels exceed the state's recreational standard of 400 fecal coliforms per 100 milliliters in many samples.

Achieving program goals

Modeling and field inventories have identified critical areas needing treatment to achieve the project goals of the National Monitoring Program (http://h2osparc.wq.ncsu.edu/319index.html)—improving the fishery, restoring the endangered striped shiner in Otter Creek, improving recreational uses by reducing bacteria levels, reducing pollutant loadings to the Sheboygan River and Lake Michigan, and restoring riparian vegetation.

Improved management of barnyard runoff and manure, nutrient management and reduced tillage on cropland, and shoreline and streambank stabilization are all being implemented to control sources of phosphorus, sediment, bacteria, and streambank erosion in the watershed. Best management practices (BMPs) installed on dairy farms include rainwater diversions, concrete loafing areas, filter screens to trap large solids in runoff, and grassed filter strips for treating runoff.

Paired watershed and upstream/downstream monitoring studies covering eight monitoring sites are used to evaluate the benefits of the BMPs. Monitoring sites are located above and below a dairy with barnyard and streambank stabilization BMPs. Habitat, fish, and macroinvertebrates are being sampled each year during the summer. Water chemistry is tracked through analysis of 30 weekly samples collected each year from April to October at the paired watershed and upstream/downstream sites. Runoff events are also sampled at the upstream/downstream sites and at the single downstream station site at the outlet of Otter Creek.

Key successes

To reduce upland soil erosion, more than 8,100 feet of streambank fencing was installed and a significant change in cropping practices was made. In the treatment watershed, 2 years of post-BMP monitoring data indicate that the system of BMPs was responsible for reductions in suspended solids (81 percent), total phosphorus (88 percent), ammonia nitrogen (97 percent), biological oxygen demand (80 percent), and fecal coliform bacteria (84 percent).

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Primary Sources of Pollution:
- agriculture (crop farming, heavily pastured areas, manure runoff)

Primary NPS Pollutants:
- sediment
- nutrients
- bacteria

Project Activities:
- agricultural BMPs (barnyard runoff management, shoreline fencing, contour farming, reduced tillage, conservation crop sequence, strip crop, and critical area stabilization)

Results:
- improved stream habitat, bank stability, in-stream cover, and fish communities, including natural reproduction of trout

Success in Spring Creek Watershed:
Natural Reproduction of Trout Confirms Water Quality Improvement

Union Township (Rock County), Wisconsin

A medium-gradient (16 feet/mile) trout stream, Spring Creek drains about 6 square miles (3,500 acres) of Rock County farmland in the southeastern Wisconsin Till Plains Eco-region. Spring Creek is one of only three managed cold-water fisheries in Rock County. Although the creek had been capable of supporting stocked trout during the fishing seasons, it had been unable to provide habitat or water quality suitable for trout survival throughout the year. Because the waters of Spring Creek did not support natural trout reproduction, annual stocking of legal-size fish was required to provide a sport fishery.

The major land use in the Spring Creek watershed is cropland (83 percent), but land uses also include grass and wood (6 percent), wetlands (5 percent), development (3 percent), and some pasture (3 percent). Excessive amounts of sediment, nutrients, and bacteria degrade the creek's water quality, causing unbalanced fish communities with depressed populations and limited diversity. The upland sediment delivery in the watershed is 3,241 tons per year, or 92 percent of the entire watershed load, and cropland is the major sediment source in the watershed. Manure runoff from five animal lots created additional problems by contributing more than 500 pounds of phosphorus annually to the watershed. The headwaters of the stream had also lost much of their original habitat to channelization.

In 1991 Wisconsin's Department of Natural Resources selected Spring Creek as a "priority watershed management area" to restore stream habitat so that trout could reproduce naturally in its waters. Spring Creek was selected as one of five evaluation watersheds for a 7-year study to examine the responses of stream physical habitat, fish, and macroinvertebrates to watershed-scale best management practices (BMPs).

Watershed-scale response

Between 1994 and 1999, Wisconsin implemented a number of watershed-scale BMPs to help reduce nonpoint source pollution in the Spring Creek watershed. By 1999 implemented BMPs included barnyard runoff and roof runoff management practices (diverting runoff away from animal waste); 1,600 feet of shoreline fencing; 289 acres of contour farming; reduced tillage (297 acres long rotation, 1,486 acres short rotation); 513 acres using conservation crop sequence; 24 acres of strip crop; critical area stabilization of 2 acres; and wetland preservation easements on 1.6 acres.

Confirming success

Wisconsin assessed stream habitat, fish and macroinvertebrates, and streambank erosion throughout Spring Creek at various times from 1993 through 1999, using two reference streams to

effectively determine the effects of BMPs applied in the watershed. Sampling results indicated that upland and riparian BMP installations have significantly improved overall stream habitat quality, bank stability, in-stream cover for fish, and catch of all fishes. These improvements were more apparent at stream segments with streambank fencing than at segments without such fencing.

Trout populations in Spring Creek improved after BMP installation. The first-ever catch of young-of-the-year trout in 1999 indicated that Spring Creek has gained the ability to partially sustain its trout population through natural reproduction. Fish abundance also increased after BMP implementation, including a significant increase in the number of cool- and cold-water fishes.

WYOMING

http://deq.state.wy.us/wqd/watershed/00712-DOC.pdf

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Primary Sources of Pollution:
- urban storm water runoff
- runoff from snow storage area

Primary NPS Pollutants:
- heavy metals
- oils
- suspended solids

Project Activities:
- installation of storm water filtration system

Results:
- successful removal of storm water particulates

Jackson Hole Rodeo Grounds Snow Storage Site:
Filtration System Reduces Urban Storm Water Runoff

Jackson, Wyoming

Flat Creek is in the Upper Snake River watershed. Upstream of the town of Jackson, within the National Elk Refuge, the creek is a Class 1 trout stream. Historically, Flat Creek has provided diverse recreational opportunities and aesthetic value to the residents and visitors of Jackson as it meanders through the community. For many years, however, it has become increasingly apparent that once the creek enters the town, fish habitat quality is significantly diminished.

In response to these concerns, the Wyoming Department of Environmental Quality and Jorgensen Engineering completed a water quality assessment of Flat Creek in 1982. The study revealed a number of factors affecting water quality, including increased impervious surface area, increased traffic volume, and land uses resulting in concentrations of heavy metals, oils, and suspended solids. The study also found that urban storm water was adversely affecting Flat Creek.

In 1994 the Teton County Conservation District (TCCD), in cooperation with the Town of Jackson, conducted a thorough investigation of nonpoint source pollutants affecting Flat Creek. This comprehensive program, which included establishing permanent monitoring stations in key areas, identified the snow storage area at the rodeo grounds as a significant source of nonpoint source pollutants.

The TCDD, Town of Jackson, and Nelson Engineering prepared a grant proposal for installation of a commercially available storm water filtration system and submitted the proposal to the Wyoming Nonpoint Source Task Force. The project was approved for funding in the amount of $32,735 in the fall of 1997.

In the course of determining the necessary sizing of the filtration unit, snowmelt runoff samples were collected and analyzed. This analysis revealed that the sediment load in the runoff

would exceed the capacity of existing commercial units and require excessive maintenance. Given these findings, the Town Engineer and Nelson Engineering designed a surrogate filtration system. The new design lowered the project cost to $14,824, resulting in a savings of 50 percent over the cost of the commercial unit. Because of the experimental nature of the new design, an amendment to the grant proposal was sought and approved. The project was completed in the fall of 1998 and evaluated for effectiveness in the spring of 1999.

Project details

The Jackson Hole Rodeo Grounds cover 6.2 acres, with a 1-percent southwesterly slope. Snow removed from the streets of Jackson is stored on the western half of the lot. To improve drainage to the southwest corner of the site, where the filtration system is installed, the snow storage area was graded. In the immediate area surrounding the filtration system, a shallow detention basin was cut to provide a settling area for particulates prior to entering the filtration system.

The primary filter installed by the Town of Jackson is composed of 2-inch-diameter washed rock and a nonwoven geotextile fabric. Particles from runoff, 0.0059 inch or greater, are trapped and held in the top surface of the fabric in the gravels. The filtered runoff is collected in a 6-foot-diameter perforated manhole and then conveyed to a catch basin sediment trap that provides additional sediment removal and storage in a sump-type facility. Runoff then passes to the storm water collection system. The perforated manhole has 4 feet of effective depth with 1.5-inch perforations on 8-inch centers; the immediate filtering surface is 484 square feet (22 feet by 22 feet).

A winning combination

During the winter of 1998–1999, roughly 120,000 cubic yards of snow from the streets of Jackson was stockpiled at the rodeo grounds. The results of storm water runoff sampling collected during the spring runoff period were inconclusive, so Nelson Engineering was contracted to evaluate the system's effectiveness. The investigation found that the three-phase rodeo ground filtration system was effective in removing gross pollutants 0.0059 inch and larger. There was no evidence of sediment in the bypass, so the geotextile fabric was not replaced for the 2000 runoff season.

The design combination of sediment basin, geofabric, washed rock filtration, and sump for bypass flows was successful in removing particulates and can be used in areas of limited space. This application can be used with favorable results in urban areas where sediments are a storm water concern. The only modification to the system being considered is the use of filter fabric with a smaller sieve size.

http://deq.state.wy.us/wqd/watershed/00712-DOC.pdf

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Primary Sources of Pollution:
- erosion from heavy grazing

Primary NPS Pollutants:
- sediment

Project Activities:
- revised grazing management practices (short-duration grazing rotation)
- livestock management (off-site watering, electric fencing, vegetation management)
- prescribed burning

Results:
- increase in plant cover trends on streambanks (documented from 5 percent in 1989 to more than 90 percent in 1995 in the Sulphur Springs Allotment)
- easier cattle management
- increased beef production

Muddy Creek Coordinated Resource Management Project:
Cattle Ranches and Trout Streams Can Coexist

Carbon County, Wyoming

In 1989 vegetation cover on the banks of Muddy Creek was only about 5 percent.

The Muddy Creek Coordinated Resource Management (CRM) project is one of the original national "Seeking Common Ground" demonstration projects. It encompasses nearly 300,000 acres of mixed federal, state, and private lands in Carbon County, Wyoming. Using the philosophy of ecosystem management on a watershed basis, the local conservation district initiated the CRM process to get all affected interests in the watershed working on consensus management of the natural resources in the project area. To date, more than 25 members representing private landowners; federal, state, and local agencies; environmental and conservation organizations; industry; and the public at large have worked on the project.

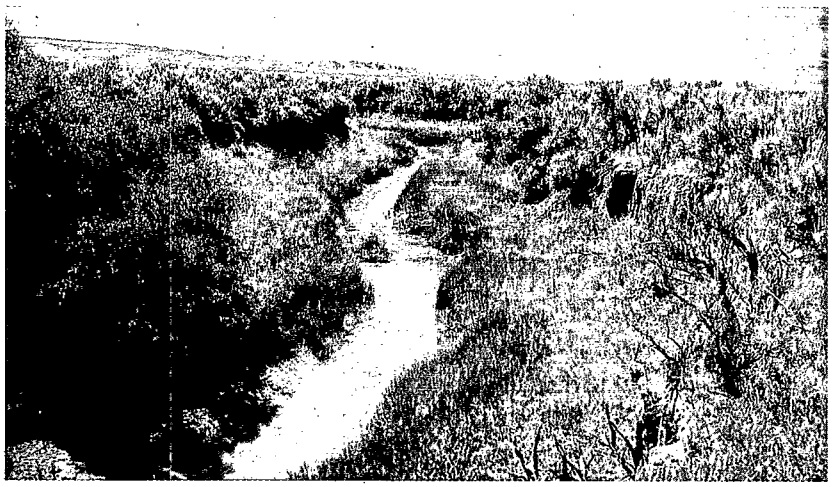
Many conservation and land management tools have been implemented to restore, enhance, and maintain the abundant natural resources in the area while maintaining the economic stability and cultural heritage of the people on the land. The ecosystem management philosophy dictates that before any action is taken or management practice implemented, all impacts and users of the area must be addressed. It is because of this philosophy and spirit of cooperation that the wildlife, livestock, and all the associated natural resources in the watershed have shown improvement since the project began. A comment from Millicent Sanger, whose family has been in the area since the 1930s, sums up the progress made: "I have never seen the water as clear and clean as it is now."

The CRM project contains several grazing allotments established when the Bureau of Land Management first began to permit grazing on federal lands. The following are some examples of the cooperation among people and the coordination of management practices implemented on grazing allotments that have contributed to the success of the Muddy Creek CRM project.

Doty Mountain Allotment

"Getting to know the land, building relationships through communication, earning the trust so that people can identify their common ground and

work together to achieve success" is what the CRM process means to Ray Weber of the Doty Mountain Allotment. Weber believes that "it takes commitment to not just work hard but to deal with the many diverse people and their interests" to make successful improvements on the land. In this case, just a simple change from spring to fall grazing was the solution. "What this CRM group and many others have found out is that our 'common ground' is much greater than our differences," Weber says, "so let's set our differences aside for the moment and work together to be successful."



By installing pasture fencing and using managed grazing rotations, ranchers were able to increase vegetative cover by 85 percent from 1989 conditions.

Grizzly and Daly Allotments

Other types of changes in grazing practices have been implemented throughout the project area. For example, the Wyoming Game and Fish Department (WGFD) purchased the base property of the Grizzly and Daly Allotments and designated it as part of a wildlife and livestock demonstration project. Historical use of these allotments allowed for season-long grazing by cattle and sheep. Once the WGFD took ownership of the Grizzly Allotment, it implemented a short-duration grazing season. Each of the eight pastures was grazed for 7 to 21 days rather than the usual 60 to 90 days. This type of management promotes recovery of healthy riparian areas by giving plants plenty of time to grow.

But simply moving to a short-duration grazing rotation wasn't good enough for Jim Chant of the Desert Cattle Company. As the lessee of the Grizzly and Daly Allotments, Chant has shown a strong commitment to improving the resources and proving that wildlife and cattle can coexist beneficially. He and two full-time cowboys implement the WGFD's short-duration grazing season by herding the cattle out of the riparian areas and onto the uplands each afternoon. Not only does this approach improve utilization within each pasture, but it also reduces time spent in the lush riparian zones. In addition, improvements to facilitate livestock management such as spring developments, off-site watering, electric fencing (much of it solar-powered), high-tension fencing, and vegetation management are ongoing. A primary goal of the CRM group is to reintroduce the Colorado River cutthroat trout into Muddy Creek, whose headwaters are in the Grizzly Allotment. Once these upper portions of the watershed are in proper condition, trout will thrive. Chant says he wants to be the first rancher to run cattle next to a Colorado cutthroat trout stream, "to show it can be done."

Prescribed burning has proved extremely beneficial for livestock, wildlife, and vegetation communities in the Muddy Creek drainage. Burning upland areas allows sagebrush seedlings to sprout, thereby creating a more diverse age class of sagebrush. Also, the livestock are enticed away from the riparian areas to graze on the more desirable grasses produced by the burning. Fire removes the sagebrush competition so that aspen can expand its area in both riparian and

upland sites. After burning, regrowth occurs quickly, and within a few years a larger, healthier community emerges.

Sulphur Springs Allotment

The Sulphur Springs Allotment is managed by Millicent and Kathryn Sanger, a mother and daughter whose family has used this area since the 1930s. It was one of the first allotments for which management plans were developed in conjunction with the Bureau of Land Management during the 1960s. The various pastures in the allotment are used to control grazing time and use. This approach allows the Sangers to congregate the cattle in smaller areas, resulting in improved conception rates, easier management of the cattle, and overall increased beef production. Plant cover on the streambanks increased from only 5 percent in 1989 to more than 90 percent in 1995. Most of this change occurred after pasture fencing and managed grazing rotation were implemented. The Sangers appreciate how the land looks when they leave in the fall, knowing there is plenty of forage left for the elk and mule deer indigenous to the area.

Working together to be successful

Using various conservation and land management tools, a coalition of government agencies, private organizations, and individuals are making a difference in Carbon County. Their cooperative effort has resulted in benefits for waters, wildlife, and cattle ranches alike.

All states recognize that strong information and education programs are critical to achieving their nonpoint source program goals. This special feature section highlights nine especially innovative state information and education programs. It focuses on programs that provide technical assistance tailored to the locality (e.g., Rhode Island's onsite wastewater training center, Florida's Yards & Neighborhood program, California's voluntary rangeland management program, and Connecticut's NEMO program) and programs that incorporate an education component geared toward kids (e.g., Wyoming's stream monitoring program, Illinois's Salt Creek Wilderness, and North Dakota's Eco-Camp). It also includes the more "traditional" information and education programs (e.g., Wisconsin's Water Action Volunteers and Colorado's media campaign). These programs all have in common a wide network of partners and funding sources, as well as a creatively packaged approach.

Ranch Water Quality Planning: Voluntary Rangeland Management Eases Impacts on California Watersheds

There are more than 40 million acres of rangeland in California, half of which is in private ownership and provides 90 percent of the forage base. Most of this acreage is located at strategic mid-level elevations, between California's upper elevations and urban and agricultural uses in valley and coastal areas. More than 9,000 miles of waterways drain the area. California's major water supply reservoirs are located on rangeland, and eight of the state's major drainage basins are dominated by commonly grazed vegetation.

Streams that once could depend on riparian vegetation to keep them cool and clean have become degraded. Their riparian vegetation has been stripped, their trampled banks are collapsing, and their temperatures are rising. The water quality problems include nutrients and pathogens, erosion, and sedimentation. Some of the more serious impacts have threatened the state's drinking water supply with bacterial contamination and caused significant declines in the state's cold-water salmon and steelhead trout fishery.

With partial funding through 319 grants, the University of California Cooperative Extension, in cooperation with the California Cattlemen's Association and others, has developed and is presenting a voluntary Ranch Water Quality Planning Short Course. In the course, ranchers receive information to assist them in making an assessment of nonpoint source pollution on their land and to help them determine the extent to which their operation might be causing the problem. The program is voluntary, and individual ranchers, at their own discretion, may or may not use outside technical assistance.

Various materials are provided to help the ranchers: aerial photographs and maps of their lands; monitoring strategies, including photo-point monitoring and residual ground covering monitoring; and informative, easy-to-understand, one-page information sheets on a variety of pertinent topics that provide the basic kinds of information needed to understand the ecological relationships among rain, soil, plants, grazing animals, and water quality.

If a rancher decides that few or no changes need to be made in the ranch operation, a short Letter of Intent declaring the finding is to be written to become a part of the personal ranch record. If problems are identified that the rancher determines result from the operation, the rancher is encouraged to complete a Rangeland Water Quality Management Plan. The plan is done at the discretion of the rancher. If done, the plan indicates the structural and operational changes the rancher intends to implement to eliminate polluted runoff from the land. The plan becomes a part of the personal ranch record, and local Natural Resources Conservation Service representatives are available to offer technical and financial assistance if the rancher chooses to use their services.

In the first year of program operation, about 100 ranchers, who own or manage some 400,000 acres of ranchland, enrolled for Ranch Water Quality Planning Short Courses. Since September 1997 plans have been completed for approximately 475,000 acres along the coast and in the San Joaquin Valley and foothills. The State Water Resources Control Board and the Regional Water Quality Control Boards are committed to this approach and continue to support the program with section 319 funds and staff participation. Cooperative Extension routinely schedules additional courses throughout California.

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Colorado Water Protection Project: League of Women Voters Guides Extensive Urban NPS Campaign

"Crystal clear" and "sparkling blue" are common media references to Colorado's waters. Citizens throughout the state have been hearing another water message, though, through a special outreach crusade. The message shares how an average homeowner can actively protect and avoid polluting Colorado's waters.

The League of Women Voters' Colorado Education Fund is reaching the state with this message through the Colorado Water Protection Project, supported in part through 319 funding. The project seeks to raise citizens' awareness of the need for more preventative approaches for emerging water issues. Because most of Colorado's population is urban, three information areas were identified for emphasis: home fertilizer and pesticide use, pet waste, and do-it-yourself auto maintenance.

The media campaign kicked off with a 30-second television message that aired statewide for a 10-day period in spring 1999. About 90 percent of potential Colorado viewers were reached with the television products. The campaign was broadened with the concurrent release of information through newspaper articles, eye-catching local bus advertisements, and pollution prevention pamphlets that were dis-

tributed statewide.Project partners include a diverse representation of private and government entities. Nearly 40 representatives serve on the project's technical committee, and 16 organizations have contributed funds and services.

Surveys conducted before implementing the project found that less than 50 percent of the respondents knew that storm water runs into local rivers, streams, and lakes untreated by municipal treatment facilities. A majority did not realize household-generated polluted runoff was a significant contributor to water pollution. More than 25 percent did not think household-generated polluted runoff was a local community concern or had an impact on their quality of life. Twenty percent did not think a person could make a difference by preventing pollution in his or her household.

Lack of information and inconvenience were noted as barriers to changing behavior. Television and newspapers were found to be best means to convey needed information. Health concerns, drinking water protection, and environmental quality for future generations were the main motivation factors for changing behavior.

Post-project survey results showed that respondents have been affected by the project's efforts. Two project goals were met—greater awareness of what household-generated polluted runoff is and increased understanding that individuals can make a difference. Less success was realized in meeting the goal of increasing people's understanding of how polluted runoff enters local rivers, lakes, and streams.

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Nonpoint Education for Municipal Officials (NEMO): Successful Connecticut Project Used as Model Nationwide

NEMO is an educational program for land use decision makers that addresses the relationship between land use and natural resource protection, with a focus on water resources. The NEMO project was created in 1991 by the University of Connecticut Cooperative Extension Service (Uconn/CES), in partnership with the Department of Natural Resources Management and Engineering and the Connecticut Sea Grant Program. NEMO receives funding from a number of federal and state agencies; major funding is provided by the USDA/Cooperative Research, Education, and Extension Service Water Quality Program, the University of Connecticut, the Connecticut Department of Environmental Protection, the National Oceanic and Atmospheric Administration, and the Environmental Protection Agency.

NEMO helps communities to better protect their natural resources while charting the future course of their towns. The project uses advanced technologies—geographic information systems (GIS), remote sensing, and the Internet—to create effective education programs. NEMO presentations, publications, and Web-based services form an integrated package of information centered around the theme of natural resource-based planning. The presentations help explain the links between land use, water quality, and community character. The project also offers follow-up presentations and materials to help communities move forward on the two major aspects of natural resource-based planning, namely, planning for areas to be preserved and planning for developed or developing areas.

A Connecticut success story

The Connecticut Department of Environmental Protection (CT DEP) estimates that about one-third of the state's rivers and streams and three-quarters of the state's portion of Long Island Sound are impaired, primarily because of nonpoint source pollution from urban and suburban areas and construction sites. Nonpoint source pollution is generated by land use, and most land use decisions in Connecticut are made at the local level by municipal officials and private landowners. Federal and state nonpoint source laws and programs established over the past 30 years have created a growing need for local officials to be more knowledgeable about the causes, effects, and management of polluted runoff. With 169 municipalities in Connecticut, the large number of local officials and the continual turnover of volunteer commissioners present a challenge to those who want to educate land use decision-makers.

In 1997 CT DEP awarded section 319 grant funds to NEMO to expand its program to provide technical assistance for local officials. During the first year, NEMO delivered its basic presentation through a series of 10 regional workshops. More than 120 of the state's 169 municipalities were represented at the workshops, and many participants contacted NEMO to schedule follow-up meetings on specific issues or concerns. Each municipality also received a map set (watersheds and land cover) to help educate local officials and facilitate nonpoint source management at the local level. In 1998 and 1999 NEMO conducted regional workshops to teach local officials how to manage nonpoint source pollution by addressing imperviousness through their land use planning and regulatory authorities. Over the past 2 years, although still conducting regional workshops that focus on new land use commissioners, the project has moved to a more intensive approach, selecting on a competitive basis five communities per year to enter the "Municipal Program." In this educational model, each community is charged with listing specific goals, creating a NEMO committee made up of representatives from all the land use boards and commissions and other interested parties, and designating a chief NEMO contact to facilitate the progress.

Proven results

After 8 years of the NEMO Project, there is concrete evidence that Connecticut municipalities are giving greater consideration to water quality in their land use planning and regulatory programs than in years past. Two such examples are highlighted below.

As a result of NEMO's Eightmile River Watershed Project, the towns of Lyme, East Haddam, and Salem signed the "Eightmile River Watershed Conservation Compact," which commits the towns to work together to protect natural resources from new development. Since the signing, the three towns, local land trusts, and The Nature Conservancy have protected more than 1,800 acres of open space in the watershed. In addition, UConn/CES foresters have worked with landowners to develop forest stewardship plans on almost 500 acres and provided information that is being used to manage another 2,500 acres of forestland. The project was also instrumental in helping to build a fish ladder to restore access to upstream habitat for alewives and blueback herring for the first time since the early 1700s.

As one of NEMO's original pilot projects, the suburban coastal municipality of Old Saybrook has a long-term relationship with the project that has resulted in a progression of positive impacts that contin-

ues to broaden in scope. The Zoning Commission reduced the number of required parking spaces in several site plans to reduce the amount of impervious surface where it could be demonstrated that fewer cars were likely. Associated landscaping regulations were revised to require the breaking up of "seas of asphalt" through the use of landscaped islands and buffers. The Conservation Commission revised the town's Conservation Plan to include a recommendation on controlling nonpoint source pollution and recently completed a natural resources inventory for the town. The Board of Selectmen prepared a Policy Statement that includes alternative design and construction standards and vegetative storm water management practices that were incorporated directly from NEMO Project design principles and are in keeping with Phase II storm water permit requirements.

Future of NEMO

Based on the success of the first several years of this partnership, CT DEP anticipates continuing its section 319 funding support for NEMO and now considers NEMO an integral part of the state's Nonpoint Source Management Program. In 2001 NEMO is continuing its Municipal Program, as well as impervious surface research.

The UConn NEMO Project is the coordinating center for the National NEMO Network, a growing network of projects around the country adapted from the Connecticut project. As a result of NEMO's success in Connecticut, 34 other states have established or are planning to establish technical assistance programs based on the NEMO model. For more information about the NEMO Project, visit http://nemo.ucon.edu.

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Florida Yards & Neighborhoods Program: More Than 1.2 Million People Reached

Putting the right plant in the right spot, as demonstrated in this award-winning yard, reduces the need for water and toxic pest control measures.

The Florida Yards & Neighborhoods (FY&N) Program was developed to address the serious problems of pollution and disappearing habitats by enlisting homeowners in the battle to save the natural environment. The program provides educational and outreach activities directed at the community to help residents reduce pollution and enhance their environment by improving home and landscape management. The program is being implemented statewide, using the University of Florida County Extension Service and other local, regional, state, federal, and nongovernmental agencies as partners.

FY&N encourages "Florida Friendly" yards and landscapes by promoting basic landscaping principles to homeowners: water efficiently; mulch; recycle; select the least toxic pest control measures; put the right plant in the right spot; fertilize only when necessary; provide food, water, and shelter for wild-

life; protect surface water bodies; and minimize storm water runoff. Other stakeholders targeted by this program include the landscape, turf, and nursery industry; property developers and builders; water resource managers; and youth.

Water efficiency was achieved in this award-winning lawn by replacing a traditional grass lawn with native plants and mulch.

An FY&N project in a neighborhood near the Indian River Lagoon was the basis for initiating the statewide FY&N Program. Residents in neighborhoods near the lagoon were provided educational information through pamphlets, presentations, workshops, and on-site workdays on how household activities might affect the water quality of the lagoon. Each household received information on methods for reducing nonpoint source pollutants such as fertilizers, pesticides, solid waste, freshwater flow, and on-site water retention. The program focused on alternative pesticide/fertilizer use and frequency of application, and on landscape maintenance and design. Demonstration landscapes were placed at highly visible locations throughout the six-county area to promote the program's concepts.

The project resulted in the training of 128 volunteer Florida Yard Advisors through the Master Gardener program; the advisors provide technical assistance to area property owners. More than 10,000 residents were reached directly at 830 workshops. It is estimated that more than 1.2 million people were informed about the program through radio and television broadcasts, newspaper articles, and exhibits. Thirteen demonstration landscapes were installed throughout the region as examples of FY&N practices. More than 600 homeowners participated in the program, and 404 completed pre/post surveys that helped measure the project's effectiveness. For adopting a sufficient number of recommended practices, 330 properties were certified as Florida Yards. Efficient watering and irrigation practices were adopted by 45 percent of the program participants, and 32 percent adopted Florida Friendly landscape management practices.

The FY&N program is active in 21 different counties, and expansion plans have been developed to include all the other counties in Florida. To find out more about the FY&N program, visit the FY&N web site at http://hort.ufl.edu/fyn.

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The Salt Creek Wilderness: Illinois Zoo Offers Interactive Environmental Learning Experience

The western section of Brookfield Zoo is called Salt Creek Wilderness. It includes a quarter-mile hiking trail, the 4-acre Indian Lake, and a new 1-acre demonstration wetland called Dragonfly

Marsh. This 10-acre wooded area focuses on native Illinois plants and animals and provides naturalistic experiences for many of the zoo's 2 million annual visitors.

Staff from Brookfield Zoo, Illinois EPA, U.S. EPA Region 5, and the Northeastern Illinois Planning Commission created the unique educational interpretive experience. The first goal was to develop a "big idea" that would serve as the underlying theme for all of the experiences in the Salt Creek Wilderness. The big idea is "Healthy urban watersheds must be managed to provide clean water resources essential for diverse plant and animal habitat."

Key concepts were developed to support the big idea, including the role people must play in managing natural systems, the definition and importance of biodiversity, the impacts of nonpoint source pollution, and appreciation and conservation of natural areas. Next came the development of statements and interactive mechanisms for conveying these ideas, especially concepts like nonpoint source pollution and watersheds. These concepts were translated into graphic signs and interactive devices. The zoo plans to do a summational evaluation to quantify the effectiveness of the messages and the usage of each element.

Dragonfly Marsh consists of two deep pools, an emergent aquatic area, sedge meadow, wet prairie, and prairie. In addition, more than 12,000 individual plants, including flowers, grasses, sedges, and bulrushes, have been planted in the marsh. To create the wetland, two soil scientists from the Natural Resources Conservation Service surveyed the area to determine the soil suitability and design the wetland. The area was excavated and graded. Water is pumped from Indian Lake into the pools and then allowed to flow and percolate through the soils back to the lake.

An 85-foot boardwalk, constructed of wood from tropical ipe trees, overlooks the wetland. Lining the boardwalk's railing are about 250 color illustrations that identify the plants, mammals, fishes, invertebrates, reptiles, and amphibians that can be found in northeastern Illinois's woodlands, prairies, and wetlands. At the end of the boardwalk is the Biodiversity Gallery, a 30-foot by 30-foot covered shelter. A collage of signs communicates the importance of biodiversity and explains why people should work to protect it. In the gallery, children can also learn about biodiversity by reading the giant storybook *The Adventures of Duncan the Dragonfly*. The children's story details the life cycle of a dragonfly and introduces a number of the animals that share the dragonfly's habitat.

Several strategies are necessary to manage the wetland and allow new growth to develop fully. Surrounding the wetland, 850 feet of 7½-foot-high fencing prevents deer from trampling and eating the plants. In addition, a grid of black nylon rope with white flags is stretched across the entire site to discourage geese from landing and destroying the vegetation.

This project began in July 1996 and culminated with a celebration on August 14 and 15, 1999, highlighting the Indian Lake and Dragonfly Marsh interactive exhibits. Salt Creek Wilderness is a tremendous educational tool that encourages zoo guests to explore and understand the complex relationships among water, plants, and wildlife. It also gives people knowledge of nonpoint source pollution and how to reduce it in their local environments.

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North Dakota Eco-Ed Camps: Thousands of Students Have Fun While Learning

Can you imagine taking 100 sixth-grade students camping overnight and having no problems finding adult volunteers to come along? Students are expected to play in the mud, chew on wildflower roots, canoe in the creek, locate and identify things like deer and bird droppings, and get utterly dirty and wet. And they love it!

Nine years ago, the Barnes County Soil Conservation District (SCD) in North Dakota began a program using an EPA section 319 grant as the basis for improving the format of the county's conservation tour. Five topics of study were identified, and every Eco-Ed Camp must address them—prairie/grasslands, soils, wetlands, woodlands, and water quality. All of the subjects are covered in relation to water and its importance. A session on water safety is also required before the students may canoe.

In addition to the required material, the camps feature scavenger hunts, canoeing, Native American presentations, live birds like eagles and falcons, live bugs (cockroaches, spiders, and others), characters like Teddy Roosevelt and Sam Ting, artifacts, mountain men, campfires and guitar sing-a-longs, nature walks, flint fires, water relays, recycling demonstrations, and more.

The schedule has been revised to accommodate 1-day tours; however, most students, teachers, and chaperones prefer the 2-day format if facilities are available. The longer format provides students with a diversified, hands-on learning experience. Students are immediately able to relate the five topics to the environment as they function in it. Teachers use the material and experiences as a basis for their earth science classes when they return to their classrooms.

In 1997 the Barnes County SCD received additional section 319 funding to develop Eco-Ed Camps in coordination with any SCD in North Dakota. This effort is referred to as the Statewide Eco-Ed Program. It was projected that 20 to 25 camps would be developed within the first 5 years of the grant. In the first season (fall 1997), 11 new counties joined the program (conducting eight 1-day tours and three 2-day camps). A total of 1,418 students, about 200 parents and chaperones, and 65 classroom teachers participated. In the 9 years Barnes County has conducted the Eco-Ed Camps, more than 2,000 Barnes County students have attended the camps. Those first alumni are now 20 years old and living in all parts of the country. It is gratifying to know that these young adults have the education to understand ecology and the importance of water quality.

To date some 12,000 students have attended an Eco-Ed tour or camp in North Dakota. As one former student put it, "I had so much fun at camp that I was surprised that I actually learned something!"

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University of Rhode Island Onsite Wastewater Training Center: Pioneering Agency Teaches, Demonstrates Innovative Systems

Approximately one-third of Rhode Island's population is served by some 150,000 on-site wastewater treatment systems, which discharge about 7 billion gallons of wastewater annually. Failed and substandard systems are considered to be one of the greatest contributors of pathogens to Rhode Island's waters. For many years, on-site systems have been considered temporary infrastructure to be abandoned as soon as centralized sewer systems became available. Neither government nor individual owners gave operation and maintenance of these systems much thought. Over the past few years, thinking has changed as the reality has set in that suburban economies cannot support ubiquitous central sewers.

In light of this realization, Rhode Island has become active in promoting improved on-site wastewater treatment technology and development of management infrastructure for these systems. One of the pioneering agencies of the decentralized wastewater management paradigm is the University of Rhode Island's (URI) Onsite Wastewater Training Center.

In 1994 and 1995 URI received 319 funding to help establish the training center. The 319 grant seed money helped fund the aboveground installation of several innovative technologies, as well as development of several training modules. The 319 funds were used in combination with Rhode Island Cooperative Extension funds, other outside grants, substantial private-sector donations, and class training fees.

In addition to providing a wide variety of training activities, the training center has spearheaded, under the auspices of several federal and state-funded demonstration projects, the installation of several dozen innovative demonstration systems throughout the state to remediate failed septic systems. Training center personnel work with municipalities to assist them in developing on-site wastewater management programs, assessing risks, and drafting zoning ordinances based on treatment standards and performance-based wastewater protection zones. Demonstration systems and training systems at the center are used to educate audiences that range from homeowners to septic system design and installation professionals.

The training center supports regulatory programs in Rhode Island by monitoring alternative and innovative system treatment performance, developing numerous licensing program courses for wastewater practitioners, assessing standards and regulations, and developing guidance documents. In short, URI's Onsite Wastewater Training Center has become a major focal point for helping to promote change and for demonstrating innovation in the field of on-site wastewater treatment.

For more information about individual demonstration projects, see www.edc.uri.edu/cewq/owtc.html.

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Water Action Volunteers: WAV and Its Partners Make a Difference in Wisconsin

Wisconsin's Water Action Volunteers (WAV) program has continued to grow and flourish since it was last highlighted in *Section 319 Success Stories: Volume II*. This statewide program, funded by a combination of 319 and University of Wisconsin Extension money, provides educational opportunities, materials, and assistance to individuals and groups interested in caring for streams and rivers. Three major WAV activities are storm drain stenciling, river cleanup, and river and stream monitoring.

Storm drain stenciling

Painting a message next to storm drain inlets has become the water quality hallmark for about 100 Wisconsin communities. In the past 5 years, more than 3,400 volunteers, armed with spray paint and a lot of enthusiasm, have stenciled nearly 9,000 storm drains with the message "Dump No Waste—Drains to River [or Lake or Stream]." The volunteers announce their event with educational door hangers that describe storm water pollution and ways to curb its effects. The stencils and door hangers are also available in Spanish. The success of this effort is the result of the many county, University of Wisconsin-Extension, and Department of Natural Resources local offices that have worked closely with the WAV program to distribute or loan supplies to local volunteers.

WAV conducted an evaluation of the effectiveness of storm drain stenciling. The results show that the stenciled messages do leave an impression on people who have seen them, successfully influencing their awareness of basic storm water facts such as storm drain destinations. The degree of influence of a stenciled message on a person's behavior is less apparent. The brief message might be too general; it does not contain specific information to connect specific actions to storm water concerns. The strength of this message is that it can be a catalyst, or an additive to reinforce existing storm water educational programs. Stenciling storm drains might best be used as a positive message for those already using environmentally friendly practices.

River cleanups

Each year, WAV coordinates a statewide river cleanup program. In the past 5 years, more than 11,000 volunteers have collected 2,550 bags of trash plus another 80 tons of garbage from nearly 500 miles of shoreline. The cooperative efforts between WAV and several environmental and outdoor groups and county land conservation departments made the great success of this effort possible.

River and stream monitoring

WAV has also launched a program to allow citizens to monitor the health of their local rivers and streams. The program supports data sharing for educational purposes; provides a network for volunteer groups, individuals, and schools to interact; provides support to civic, conservation, and environmental groups; and helps increase linkages between volunteer monitoring efforts and public resource protection programs. The program was designed so that sampling parameters would be common among sampling groups, easy to

measure, and would well represent stream health over time. The monitoring protocols require equipment that is easily obtained and affordable, and the parameters are those safe to monitor.

Five parameters that are currently part of the program are temperature, turbidity, dissolved oxygen, habitat, and biotic community health (assessed using a macroinvertebrate biotic index). A sixth parameter, flow, will be added in the coming months.

At least 10 groups are using WAV protocols, and several groups are considering beginning monitoring programs. The current groups are monitoring between 1 and 25 sites and in most cases have 1 to 20 volunteers. The groups are generally citizen-based, but some schools use WAV protocols to sample during the spring and fall months. Local monitoring groups are working with DNR biologists, interest groups (such as Trout Unlimited), watershed associations, county and municipal offices, and local schools. Most groups hold training sessions during the spring for new monitors, and some offer troubleshooting/support meetings during the sampling season.

Many of the monitoring groups interact with Watershed Education Resource Centers. There are 13 such centers across the state. The centers are designed to make watershed-focused resources available to civic organizations, clubs, schools, and individuals at little or no cost. Monitoring and stenciling equipment, as well as instructional guides, videos, and keys, are available to be borrowed.

The newest addition to the WAV monitoring program is a Web-based database. The database will provide an opportunity for volunteers to view and subsequently analyze data from their stream or other streams in the state that are being monitored by WAV volunteers. Two volunteer groups are testing the database, and it should be ready for use in spring 2002.

In the meantime, look for information about stenciling and monitoring (including access to the database, downloadable fact and data sheets for monitoring, and reporting forms for stenciling or cleanup projects) to appear soon at the WAV web site at http://clean-water.uwex.edu.

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Publications and Educational Materials

- Water Action Volunteers. Make WAVes for Action: Introductory Activity Packet. Hands-on stream and river action projects for Wisconsin. 1998, updated spring 2001.
- Community Water Education and Action Opportunities for Youth and Adult. Brochure. 1998. Now available online at www.dnr.state.wi.us/org/caer/ce/bureau/education/reslst.htm
- Storm Drain Stenciling. Impacts on Urban Water Quality (Winter 1999).
- Volunteer Monitoring Fact Sheet Series (6). 1998, updated 2001.
- The WAV web site: http://clean-water.uwex.edu/wav/.
- Monitoring data sheets.
- Wacky, Wonderful, Water Critters. Booklet.
- Key to Macroinvertebrate Life in the River.
- Key to Life in the Pond.
- Biotic Index poster.

Stream Monitoring Network with Wyoming Schools: Trained Teams Initiate, Expand School Monitoring Programs

Beginning in March 1993, the Wyoming Department of Environmental Quality used a 319 grant to fund Teton Science School to conduct a 3-year statewide education and monitoring program with secondary school teachers and Conservation District personnel teams. The program used the *Monitoring Wyoming's Water Quality* curriculum developed by Teton Science School to train the teams on water quality

monitoring and also distributed an extensive water quality monitoring kit to each of the teams. By December 1995, 22 teacher/Conservation District teams had been trained and had established annual testing sites throughout Wyoming.

In the summers of 1993, 1994, and 1995, the Teton Science School conducted training workshops in monitoring protocol, reporting guidelines, and use of the water quality monitoring kits. The three week-long workshops trained 47 teachers and 23 Conservation District personnel. By spring 1996, 56 rivers or streams were being monitored annually on 109 sites. The school estimates that 1,175 students are involved in the monitoring programs.

The real success of the program is demonstrated where teams participating in the monitoring workshop have enhanced or expanded the monitoring programs in their communities. Teams working on the Tongue River in Sheridan and on the Upper North Platte River in Saratoga, for example, have expanded their monitoring efforts to include long-term intensive watershed assessment projects. Students and teachers from Lander High School have adopted a site on Squaw Creek and are now involved in a long-term habitat improvement project. The monitoring training has allowed Pinedale Middle School to establish several long-term monitoring projects, which they have integrated into their science curriculum. Teachers from the Jackson School District are working with the local Conservation District to create a monitoring program for elementary school students, and their efforts have already reached more than 75 elementary school children.

The success of the 3-year education and monitoring program is evident in the commitment of participants, the data submitted, and the positive feedback from all those involved in the project. Teton Science School has recently received numerous requests from educators throughout the state to conduct more workshops on water quality issues. To meet the demand and continue the success of the program, Teton Science School applied for and received a 319 grant for 2001 to conduct two week-long workshops for Wyoming teachers on nonpoint source pollution.

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States are implementing a wide variety of innovative programs to help them achieve their nonpoint source program goals. This special feature section highlights six especially innovative state programs. Some programs feature regulatory components (e.g., Hawaii's erosion and sediment control project, Massachusetts' storm water utility program, and Idaho's dairy pollution initiative), whereas others highlight the nonregulatory, voluntary adoption of nonpoint source best management practices (e.g., New York's Agricultural Environmental Management Program, California's BIOS Program, and South Carolina's Forestry Best Management Practice Compliance Program). These programs all have in common a wide network of partners and funding sources, some beyond 319 entirely (e.g., Idaho's dairy pollution initiative). This section also highlights a compilation of statewide Clean Marinas Programs that are fast becoming a popular way of promoting environmentally responsible marina and boating practices across the nation.

California's BIOS Program: Growers Adopt Whole-System Management Approach to Reduce Pesticide Use

The Biologically Integrated Orchard Systems (BIOS) project is a community-based pollution prevention program that uses biological methods to replace chemical farming practices. It was started in 1993 to help California almond growers and other farmers reduce their reliance on synthetic pesticides. Already reported as a success in *Section 319 Success Stories: Volume II* (1997), the program continues to expand and attract new funding sources in addition to 319 funding.

The program was designed to address the problems caused by the pesticide diazinon, which is applied as a dormant spray during the winter as a routine almond production practice. During heavy rainstorms, the pesticide flows into surface irrigation systems, creeks, and streams and eventually into the major rivers of the San Joaquin Valley, the Delta, and San Francisco Bay. Diazinon is an organophosphate that the National Academy of Science has recommended be present only at concentrations below 9 nanograms per liter. It was being found at more than 1,000 ng/L in some runoff pulses.

How the program works

In 1995 the Central Valley Regional Board and the State Board joined the University of California, the Natural Resources Conservation Service, EPA, and numerous private foundations (which were already supporting the BIOS program) to expand the program in Merced and Stanislaus Counties, where diazinon was causing water quality problems.

BIOS participation begins with a customized management plan for each farmer who enrolls a new block of acreage (typically 20 to 30 acres) under BIOS management. Participating growers adopt a

whole-system management approach that considers all aspects of production: tillage practices; nutrient, water, and pest management; and soil and water issues in the larger landscape. For example, BIOS uses cover crops, compost, and other natural fertilizers to decrease soil-borne pest problems and promote soil health. It uses biological controls (cover crops, natural areas, and hedgerows) to provide habitat for predators and beneficial insects and to reduce or even eliminate plant diseases and pests. Finally, it relies on monitoring and observation to determine if and when the least harmful chemical should be applied.

The plan is developed with the help of a BIOS Management Team that includes a local farm advisor, university researchers, local experienced participant farmers, and a Pesticide Control Advisor with extensive experience in helping almond farmers reduce their reliance on diazinon and other farm chemicals. Follow-up support continues with technical support, consultation with members of the management team, local educational events like field days and workshops, and technical publications. A comprehensive monitoring program is also integral to each BIOS project.

Encouraging results

According to the Community of Alliance with Family Farmers Foundation (CAFF), 98 percent of the growers who joined the expansion program completely eliminated the use of diazinon. The pollution prevention methods BIOS teaches have influenced not only the 90 growers officially enrolled in the program but also many more growers who have introduced at least some of the BIOS practices in their orchards. A long-time Pesticide Control Advisor in Merced County estimates that at least 60 percent of the county's almond growers are cutting back on pesticides and using some form of biological management that they weren't using before the BIOS program began.

Looking toward the future

As with all innovative programs, the time comes when subsidized start-up funds are no longer available and programs must continue on their own. Direct BIOS management is provided for 3 years; then a transition period begins. From the outset of the BIOS program, the concept was to develop the capability of local organizations to lead BIOS activities and to create a structure that sustains the BIOS presence even after CAFF no longer plays the coordinating role.

In Merced and Stanislaus Counties, the BIOS program is successfully making that transition with the help of two local Resource Conservation Districts (RCDs). The current work with the East Merced RCD and the East Stanislaus RCD is designed not only to transfer BIOS outreach and activities to local control but also to create and document a model for other BIOS projects.

East Merced RCD has already hired a coordinator to take over the BIOS project in that area. Coordinating a BIOS project takes an array of skills—event planning and production, project planning, and group facilitation—and a background in agriculture, including knowledge of agronomy and pest management. Also necessary are skills in database management, newsletter publication, and media outreach. To facilitate the transition, a Transition Coordinator from the BIOS program is mentoring the new East Merced RCD coordinator. As part of the mentor training, the RCD coordinator will meet the network of growers, researchers, extensionists, government representatives (including State and Regional Board representatives), and industry leaders with whom CAFF has established relationships through the BIOS program.

In addition, a Transition Advisory Team (TAT) has been established to guide the RCD program much as the current management teams now do for BIOS projects. Through the TAT, the RCD program will remain connected to the communities of growers, educators, agency personnel, and agricultural consultants that team members represent. Over the coming year, new possibilities for program activities and funding sources will be identified and prioritized and BIOS activities will continue to evolve. Growers are

being consulted regarding the activities most important to them—the activities they most want to see continued and the new subject areas into which they would like to see BIOS activities expand.

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Maui County Erosion and Sediment Control Training Project: Workshops Explain Ordinance, Teach BMP Installation

Hawaii's Maui County includes the islands of Maui, Molokai, and Lanai and thus many different watersheds that are diverse in geophysical features, soil types, rainfall, and coastal water uses. The State Department of Health lists the waters of West Maui, Kahului Harbor, and the South Molokai shoreline as water quality-limited segments because they often exceed nutrient and turbidity standards. Construction and grading projects were identified as the primary source of water quality problems.

Maui County's grading ordinance, last revised in 1975, did not specifically require the installation of best management practices (BMPs) to control erosion and sedimentation and did not require the posting of performance bonds for large projects. In addition, much grading work was unregulated because of exemptions in the grading ordinance for certain types of grading activities. Thus, construction and grading activities resulted in soil erosion, causing sediment and other pollutants to enter receiving water bodies. The Maui County grading ordinance needed to be revised.

Revising Maui County's grading ordinance

With support of 319 funding, a revised grading ordinance was developed to require erosion and sediment control BMPs for all construction projects, including minor work that does not require a permit. The County Council adopted this revised grading ordinance on August 10, 1998.

The revised ordinance met federal guidance under the Coastal Zone Act Reauthorization Amendments of 1990. The provisions of the grading ordinance before and after the revision are summarized in the table. The major changes are the following:

- All projects, even those that do not require grading permits, must use BMPs to control erosion, sedimentation, and dust to the maximum extent practicable.
- Projects that aren't in the Special Management Area (SMA) and that have excavation or fill quantities of 100 cubic yards or more or exceed 4 feet in height require grading permits.
- Projects in the SMA have stricter requirements. Grading permits are required when excavation or fill quantities are 50 cubic yards or more or when excavation or fill exceeds 2 feet in height. In addition, grading or mining a coastal dune is prohibited, as is importing soil for fill material in the shoreline setback area. Filling with sand is acceptable.
- An erosion control plan showing BMPs to control erosion, sedimentation, and dust to the maximum extent practicable must be submitted with the grading permit application.
- Grubbing and grading permit fees are revised in the annual budget.

	Existing Ordinance	Revised Ordinance
Purpose	To protect public health, safety, and welfare	To protect/preserve the natural environment and protect water quality, and public health, safety, and welfare
Exclusions	-Single-family residences < 4 acres -Regulated mining or quarrying -Agriculture, ranching, recreation, forestry, conservation in conformance with local Soil and Water Conservation Districts	-Subsurface excavations for buildings and structures -Excavation, fill, stockpiling < 100 cubic yards and < 4 feet in height -Grubbing < 1 acre which does not affect drainage -Underground utility trenching
Grading Permits	Required if grading > 5 feet in height	-Required if grading > 100 cubic yards or > 4 feet in height -In Special Management Area: permit required if grading > 50 cubic yards or > 2 feet in height
Best Management Practices	No minimum standards or controls required	Required for all grading, grubbing, and stockpiling to maximum extent practicable (including limited exclusion activities)
Shoreline Provisions	No shoreline grading provisions	-Use of soil as fill is prohibited in shoreline area -No grading or mining of coastal dune
Permit Application	-Tax Map Key (TMK) or street address -Start and end dates for grading -Responsible party -Plot plan	Also required: -Grading plan -Photographs -BMPs to prevent erosion and sedimentation to the maximum extent practicable
Drainage and erosion control plans	Required for projects > 1 acre or grading > 15 feet height Use of HESL erosion formula	Required if grading > 1 acre or > 15 feet height. Engineers soils report required if grading > 15 feet. Emphasis on BMPs to prevent or reduce pollutant discharge. Hydraulic calculations per county drainage facility design standards.
Permit Fees	$1 per 100 cubic yards (0 to 1000 cubic yards) $20 plus $2 for each additional 1,000 cubic yards (1,001 to 10,000 cubic yards)	Pending proposed revisions to permit fee schedule (fees to be increased)
Penalties	No penalty for grading without a permit	Penalties for grading without a permit (doubling of permit fees or an additional $200, whichever is greater) and requirements to correct/restore on-site and off-site damages. Performance bond may be required.
Bonding	Bonding required at the discretion of the director	Required for cut, fill, or stockpiling > 500 cubic yards or excavations of fill > 15 feet height, and for increments which are part of larger development
Bond Amount	$1 per 100 cubic yards (0 to 1000 cubic yards) $10,000 plus $.50 for each cubic yard over 10,000 (10,001 to 100,000 cubic yards) $55,000 plus $.20 for each cubic yard over 100,000 cubic yards	Bond amount determined by director based on costs for completion of grading, drainage improvements, and erosion control measures

- New provisions require corrections for unpermitted earthwork and impose penalties when earthwork is started before a permit is issued.
- A performance bond is required for all earthwork involving more than 500 cubic yards.

Raising awareness of the new ordinance

Another goal of the project is to train engineers, contractors, inspectors, and the public in planning and installing effective BMPs. Workshops were held on Maui, Molokai, and Lanai to explain the new grading ordinance, teach the procedures for deriving an effective erosion control plan, show the latest BMP technology, and discuss the proper methods for installing BMPs. More than 100 people attended the workshops and found them to be very informative and useful. The success of this project has inspired other counties in the state (Honolulu, Kauai) to revise or consider revising their erosion control standards to match Maui's efforts.

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Idaho's Dairy Pollution Prevention Initiative: Unique Program Eliminates Direct Dairy Discharges

The Idaho Dairy Pollution Prevention Initiative is an unusual public-private partnership formed to resolve major environmental problems not adequately addressed by the federal and state environmental agencies that traditionally regulate such problems. The partnership is an alliance among two federal and two state agencies, an industry group, and a state university.

In 1995 it was determined that 280 Idaho dairies (about one-fourth of the total number) were discharging untreated animal and dairy process waste to roadside ditches, streams, and ground water. Dairy waste discharges are typically high in levels of *Escherichia coli, Salmonella*, and *Cryptosporidium*. When ingested, these microorganisms can cause illness and death. Some water bodies that had been receiving dairy waste discharges were also used for human contact sports and as drinking water sources. No known outbreaks of disease can be attributed directly to discharges from Idaho dairies; however, fish kills have been recorded on several occasions.

Before the Dairy Initiative, dairy waste control efforts by EPA and the Idaho Department of Environmental Quality (IDEQ) were somewhat misdirected and only marginally effective. EPA regulations generally restrict coverage to only those dairies with more than 200 cows. Most (approximately 70 percent) of the 280 dairies discovered discharging fell beneath this 200-cow cutoff. Unless a complaint was filed, it was quite possible for discharges from the smaller dairies to go undetected by EPA and IDEQ.

Dairy MOU partners

The Idaho Dairy Pollution Prevention Memorandum of Understanding (Dairy MOU) was signed in October 1995. It assigned the Idaho State Department of Agriculture (ISDA) the lead role of interacting directly with the dairy industry to address the concerns of IDEQ and EPA. A set of guidelines and criteria were jointly conceived.

Under the Dairy MOU, EPA and IDEQ agreed to train ISDA inspectors and support the ISDA in circumstances of major environmental or public health risk and the Idaho Dairy Association (IDA) agreed to contact and inform the industry, promote the program, and educate IDA members about the values of environmental stewardship along with production capacity. To establish this innovative program's credibility and to build public confidence, all parties decided to review the program annually in a public forum and make the results available to interested parties.

Though not signatory parties to the Dairy MOU, the Natural Resources Conservation Service and the University of Idaho Extension Service are considered partners in that they played key roles in developing and implementing the Idaho Dairy Initiative.

Dairy MOU components

All Idaho dairies are required to obtain a license to sell milk for human consumption. The ISDA had administered a comprehensive inspection program focusing on milk sanitation for all dairies but had not

addressed the waste problem. The Dairy MOU capitalized on the frequent presence of ISDA inspectors and provided for their expanded role to ensure that all dairies could contain and properly handle their waste. Each dairy and its waste storage and handling system would now be inspected for compliance at least annually. (Inspections averaged 2.5 times per year in 2000.) In early 1996 state legislation and rules were developed, providing ISDA with authority to require full containment of dairy waste. Under the new ISDA rules, dairies found to be in noncompliance cannot sell milk until they agree to implement a plan for corrective action.

The new ISDA rules also require all dairies to construct large-capacity waste containment ponds that are less prone to leakage than older ponds. These restrictions are more protective of surface and ground water than the former IDEQ and EPA requirements. In addition, the new ISDA rules have been modified to require that dairy waste be land applied only in accordance with an approved nutrient management plan. These plans are required on all dairies by July 2001 and will ensure that the waste will be balanced against the crop uptake and not be lost to groundwater or surface waters.

Measures of success

Although the earlier EPA penalties were significant, their deterrence ability was diminished by recognition that fewer than 5 percent of the dairies would be inspected in any one year. Since the program's inception, ISDA has conducted more than 14,000 inspections of dairy farms, resulting in an increase in inspections from an average of 40 per year to 2,800 per year. The dairies now understand that they will be inspected frequently, and this level of certainty has caused dairies with marginal facilities to be much more proactive in installing and managing proper waste handling facilities.

Improvement in compliance has resulted in the virtual elimination of direct discharges to the environment. In 1996, 25 percent of the dairies had some type of discharge violation. This percentage has dropped to less than 0.5 percent of the dairies. In addition, violations not related to discharges have dropped by 76 percent (ISDA 2000 Annual Report).

The number of dairy waste handling facilities put into place since 1996 also represents a strong measure of program success. The new program has directly resulted in more than $10 million worth of construction for more than 500 dairy waste containment ponds and handling facilities. This significant increase in environmental protection would not have been possible without the innovative partnerships formed as a result of the Dairy Initiative.

A model for other states

Because of the success of the Idaho Dairy Initiative, several states and industry groups are considering adopting similar approaches. States considering the Initiative as a model include Oregon, Georgia, Ohio, Minnesota, and Florida.

In August 1998 Vice President Al Gore's "Hammer Award" for reinventing government was presented to each of the signatory parties of the Idaho Dairy MOU, to the University of Idaho Extension Service, and to nine individuals who were key contributors to the successful negotiation of the MOU. In

early 1999 EPA awarded Silver Medals to the EPA employees who had contributed significantly to the development and implementation of the MOU. Most recently, the Dairy Initiative has been named as a semifinalist in the Innovations in American Government Award, sponsored by the Institute for Government Innovation at Harvard University's John F. Kennedy School of Government.

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Creating a Storm Water Utility in Chicopee, Massachusetts: Project Praised as Outstanding Planning Project

The importance of storm water management in Massachusetts will undoubtedly increase in the coming years as Phase II of the National Pollutant Discharge Elimination System (NPDES) storm water management program goes into effect, requiring communities to take action to reduce pollution coming from storm water. The number of Massachusetts communities covered by NPDES storm water permits will dramatically increase from 2 to 191 when Phase II becomes effective.

In 1997 the Massachusetts Pioneer Valley Planning Commission and the City of Chicopee, Massachusetts, received 319 funding to investigate the feasibility of creating a storm water utility. Like electric and water utilities, storm water utilities collect fees from residents to pay for a "product." The product offered by storm water utilities is storm water management to control or eliminate water pollution, erosion, and flooding.

Researching the legal framework

One of the first steps was to research existing utilities around the country to identify key issues. To effectively present the information developed to the public, it was neatly packaged into a "how-to" kit. The kit includes the research on storm water utilities across the country, summarized in an easy-to-read format for both a professional audience (briefing papers) and the public (graphical summaries). The first 500 copies of the how-to kit were in high demand. The Massachusetts Department of Environmental Protection is now producing 1,000 additional copies in anticipation of the interest in storm water management techniques that will accompany Phase II of the NPDES storm water permit program.

A critical part of the project also included reviewing Massachusetts' laws to determine the legality of creating storm water utilities. All Massachusetts laws and regulations pertaining to storm water management were reviewed and summarized in the how-to kit. A model storm water management ordinance was also developed and included in the kit.

Although it was determined that municipalities may create storm water utilities, the legal framework is weak and would be strengthened by state enabling legislation. Draft state enabling legislation, developed as part of the project, is being sponsored for the 2001 Massachusetts legislative session. When enacted, it will strengthen communities' authority to put storm water management utilities in place.

Chicopee pilot program

The project also involved implementing a pilot storm water utility or fee-based management program in Chicopee, Massachusetts. Chicopee is an old industrial city of 56,000 people. It occupies 24 square miles in western Massachusetts at the confluence of the Connecticut and Chicopee Rivers. Urban runoff and combined sewer overflows are the most significant pollution problems on the lower Connecticut River in Massachusetts. Chicopee straddles the two segments of the lower Connecticut River that do not support their use classifications.

Although the City of Chicopee did not establish a storm water utility per se, the city opted to incorporate storm water management into the existing Wastewater Department to save on administrative costs and take advantage of the expertise of the Wastewater Department's staff. Chicopee also passed an ordinance to collect fees from residents specifically for the purpose of managing storm water. The city conducted extensive research before instituting the storm water ordinance. Residents said that they would be willing to pay a new fee for storm water management if they were sure that the money would be used to address the problems directly affecting them, such as sewer back-ups during wet weather. The ordinance was therefore designed to address such concerns.

Instituting a specific storm water fee rather than increasing sewer fees to cover the costs of storm water management had two advantages. First, it meant that Chicopee could assess fees based on the amount of storm water generated by each property tied into the sewer system. Second, the city expects that over time, large storm water generators will begin to invest in best management practices and remediation measures to treat their storm water in order to reduce their storm water management fee, thus reducing the amount of storm water pollution being generated.

Chicopee's storm water management fee has been in place since December 1998. In the first year, the city raised some $400,000 for storm water management; by the third year, revenues had increased to $550,000. To date, the money has been used for activities such as stepping up cleaning of catch basins, purchasing a catch basin cleaning truck, grouting joints in the sewer system to stop leakage and inflow, stenciling storm drains, and cleaning sewer lines. Chicopee has also used the funds to leverage additional state loan funding for a $5 million sewer separation project.

A model of success

In fall 2000 the Pioneer Valley Planning Commission and the City of Chicopee were jointly awarded the Massachusetts Chapter of the American Planning Association's Outstanding Planning Project Award. The how-to kit and Chicopee's storm water management pilot have been widely presented as successful models, and interest in replicating these concepts in other municipalities has been high. The City of Holyoke, another old industrial community in western Massachusetts, is now actively working to develop a similar storm water management program.

The most obvious short-term results of this project are the production of a successful model to create storm water utilities (or, at a minimum, a fee-based storm water management program) and

Chicopee's successful piloting of this type of program in Massachusetts. The fully researched, piloted example of how a municipal storm water management program can be developed and funded within the context of Massachusetts' laws, climate, and geography is a valuable tool that the Massachusetts Department of Environmental Protection can now present as an option for Phase II communities.

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New York's Agricultural Environmental Management Program: Incentive-based Program Helps Farmers Meet Tough Standards

The Agricultural Environmental Management (AEM) Program has put New York State in the forefront of a national effort to help farmers identify and address agricultural nonpoint source pollution. New York's AEM Program is a statewide voluntary, incentive-based program that helps all farmers operate environmentally sound and economically viable businesses. The AEM Program provides cost-sharing and educational and technical assistance for developing and implementing agricultural plans. The plans enable farmers of operations of all sizes to remain good stewards of the land, maintain the economic viability of the farm operation, and comply with federal, state, and local regulations relating to water quality and other environmental concerns.

The AEM partnership of state, federal, and local agencies, conservation representatives, private sector businesses, and farmers has been recognized and bolstered by AEM legislation proposed by New York's governor and passed by the state's Senate and Assembly in June 2000. On August 24, 2000, the governor signed the AEM Bill into law, codifying the program to help New York's agricultural community in its stewardship of the state's soil and water resources.

The partnership operates at both the state and local levels. The New York State Department of Agriculture and Markets and the New York State Soil and Water Conservation Committee provide leadership at the state level, while Soil and Water Conservation Districts (SWCDs) provide local leadership. The flexibility of the AEM Program allows the partners to address both statewide and specific local water quality needs. The local delivery of AEM, along with state funding support, has resulted in participation approaching 8000 farms statewide.

AEM funding

The AEM Program is funded by a mix of section 319 money and grants from the state's 1996 Clean Water/Clean Air Bond Act and the State Environmental Protection Fund. The ability of farmers to access funding through SWCDs has been a driving factor in farmers' acceptance of and participation in the AEM Program. The governor, with the assistance of the state's Soil and Water Conservation Committee, awarded about $6.3 million in 2000 from the state's Environmental Protection Fund and Clean

Water/Clean Air Bond Act for planning and implementing best management practices (BMPs) to prevent or reduce nonpoint source pollution to water bodies. Through fiscal year 1998, a total of $1,863,660 in section 319 money had been used to develop and promote the program in New York's agricultural community. In 2000 the total allocation from state funding sources stood at $20.4 million, with annual funding showing a consistent trend upward.

New York's response to tougher standards

AEM offers farmers a way to comply with stricter regulatory requirements, advance the state's water quality objectives, and meet business objectives on the farm at the same time. The concepts, partnerships, and materials that constitute AEM grew from many sources, including watershed projects and the national Farm*A*Syst program.

The AEM program begins with the farmer's expressing an interest in the program. After that, there are five tiers to be completed. Under Tier I, a short questionnaire surveys the farmer's current activities and future plans and begins to identify potential environmental concerns. Tier II involves completing worksheets that document current environmental stewardship while identifying and prioritizing environmental concerns. Tier III involves the development of a conservation plan that is directly tailored toward the goals for the individual farm. This plan is mutually developed by the AEM Coordinator, the farmer, and several members of the cooperating agency staff. Under Tier IV, agricultural agencies and consultants provide the farmer with technical, educational, and financial assistance to implement BMPs on the farm, using Natural Resources Conservation Service (NRCS) standards and guidance from professional engineers. The last tier includes ongoing evaluations to ensure that AEM helps protect both the environment and the viability of farm businesses.

AEM provides a mechanism for all sizes and types of farms to meet the requirements of various state and federal environmental laws and regulations within the unique limitations of each farm's resource base. For example, the AEM Program is helping farmers meet New York State Department of Environmental Conservation (DEC) permit requirements for concentrated animal feeding operations (CAFOs). As a response to federal requirements, the state has developed a general permit for certain large livestock farms. As a result, more than 600 CAFOs have filed Notices of Intent to comply with the DEC permit requirements.

To meet an increasing workload, the AEM Steering Committee adopted a certification process in conjunction with NRCS to get qualified AEM planners into the field. Certification assures environmental regulators, producers, and the public of quality work in AEM. The program has now trained 104 persons from the public and private sectors in the development of comprehensive nutrient management plans (CNMPs). To date, seven planners have been certified, resulting in the completion of CNMPs for 33 farms.

Looking ahead

Agriculture is a multibillion-dollar business in New York State, and the AEM Program works to keep all of the state's farms environmentally sound and economically viable. Every farm is valuable for what it contributes to the economy, the environment, and the beauty of New York State, and AEM is strength-

ening this legacy for the future. We all depend on clean drinking water and wholesome food for our existence. With sufficient support and assistance, through Agricultural Environmental Management, New York State's farm families will provide both of these.

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South Carolina Forestry BMP Compliance Program: Proactive Strategy Raises BMP Compliance Rate

In South Carolina, as well as in most other states with large tracts of forested land where timber is harvested, nonpoint source runoff due to the lack of proper practices can be a threat to water quality. To address this situation, the South Carolina Forestry Commission (SCFC) adopted a set of silvicultural best management practices (BMPs) and published *South Carolina's Best Management Practices for Forestry* in 1994. To ensure compliance with the BMPs, the Commission focuses on a proactive strategy for preventing nonpoint source pollution, using a multipronged approach.

One component of the program provides voluntary courtesy BMP exams to forest landowners, foresters, and forestry operators. Specially trained Forestry BMP Specialists, located in each of the SCFC's three regions, conduct these exams. About 500 harvesting operations were evaluated during fiscal year 2000. Ongoing forestry operations are located through regular flights over high-priority watersheds, through voluntary notification, and through response to complaints. Courtesy BMP exams are then offered to the landowner, forester, and logging contractor. Based on the exam results, site-specific recommendations regarding BMP implementation are provided. Recommendations may include streamside management zones, forest road construction, stream crossing design and location, harvesting systems, and site preparation techniques. Where damage has already occurred, recommendations for mitigating the damage are offered.

After the harvesting operation is completed, a final on-site inspection is conducted to determine whether the appropriate BMPs were implemented. BMP compliance is significantly higher—98 percent according to a 1999 statistical survey—on sites where a courtesy BMP exam has been conducted. A monthly summary report of completed courtesy BMP exams is provided to the state water quality agency and to timber buyers. The report identifies loggers who failed to implement the appropriate water quality BMPs. Failure to implement BMPs might negatively influence a forest industry company's decision to purchase forest products and services from the logger. The threat of being on "the list" has proven to be a real incentive to loggers to implement appropriate BMPs. In addition, the South Carolina Department of Health and Environmental Control, the state's water quality agency, may initiate enforcement action based on the referral.

Another component of the program is education. Forestry BMP Specialists conduct BMP training throughout the state. Educational programs are tailored to the unique operating conditions in each physiographic region. More than 1,800 loggers, landowners, foresters, and forestry operators have attended the Timber Operating Professional (TOP) Logger course since its inception in 1995. The program is

produced in cooperation with the South Carolina Forestry Association. In addition, short courses on site preparation, forest road construction, and other topics are offered annually. BMP educational presentations are given throughout the year to forest landowner associations, forestry clubs, civic groups, environmental groups, and other interested parties.

This innovative program has proven to be very effective in increasing the BMP compliance rate statewide. Surveys conducted over the past 10 years show that a statistically valid increase in forestry-related BMP compliance on harvesting sites has occurred. In fact, the compliance rate rose from 84.5 percent in 1989 to 91.5 percent in 1999. Compliance with site preparation BMPs was 86.4 percent in 1996 and rose to 98 percent in the second evaluation, completed in the spring of 1999.

BMP compliance monitoring continues. During FY 2000, the SCFC initiated an additional monitoring cycle of harvesting and site preparation BMP compliance, consisting of (1) initial site location and harvest monitoring and (2) the initial site preparation compliance evaluation.

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Statewide Clean Marina Programs: BMPs, Recognition, and Outreach Help Protect Coastal Resources

Many states across the nation are designing voluntary programs to address a broad range of issues related to the environmental impacts of marina operations. These "Clean Marina Programs" provide information, guidance, and technical assistance to marinas, local governments, and recreational boaters on how to minimize their impacts on water quality and coastal resources. To reduce adverse impacts, states are promoting voluntary adoption of best management practices (BMPs) cited in the states' clean marina guidebooks. They also are establishing some type of recognition or awards program for participation in the program and adoption of these practices and are providing outreach activities to further promote environmentally responsible marina and boating practices. A few examples of such programs follow.

Maryland's Clean Marina Initiative

The Maryland Department of Natural Resources developed the state's Clean Marina Initiative, and EPA, the National Oceanic and Atmospheric Administration, and the state of Maryland provided financial support. The Initiative distributes a comprehensive pollution prevention guidebook for marinas with advice on topics like marina design and maintenance, storm water management, vessel maintenance and repair, sewage handling, waste containment and disposal, and more. The guidebook is written for managers of full-service marinas with boatyards, but it is equally applicable to marinas with limited services, independent boatyards, and marine contractors.

Marinas, boatyards, and yacht clubs that adopt a significant proportion of the BMPs suggested in the guidebook will be recognized as "Maryland Clean Marinas." They will receive a certificate acknowledging their environmentally responsible actions, authorization to use the Maryland Clean Marina logo on their letterhead and in their advertising, a flag to fly from their property, and promotion by the Clean Marina Initiative in publications, on the World Wide Web, and at public events.

For more information on Maryland's Clean Marina Initiative, see www.dnr.state.md.us/boating/cleanmarina.

Virginia's Clean Marina Program

On January 12, 2001, Virginia's Clean Marina Program was launched as an implementation element of the Virginia Coastal Nonpoint Pollution Control Program, supporting compliance with section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990. Virginia has established a Marina Technical Advisory Program to work with marinas to achieve voluntary designation as a "Virginia Clean Marina" by following a series of steps. The first step involves a pledge by a marina operator to work toward becoming a Virginia Clean Marina. Second, the marina operator conducts a self-assessment using an evaluation checklist that contain criteria taken directly from Virginia's *Clean Marina Guidebook* of marina BMPs. After the checklist is complete, the operator requests a formal site visit from the Marina Technical and Environmental Advisory Committee to confirm the adequate assessment scores. Once scores are confirmed, the Committee recommends a Clean Marina designation. Designated facilities report annually to retain their designation, and they are encouraged to consider additional projects that prevent pollution.

For more information on Virginia's Clean Marina Program, see www.deq.state.va.us/vacleanmarina.

North Carolina's Clean Marina Program

The National Marine Environmental Education Foundation, a nonprofit organization that works to clean up waterways for better recreational boating, developed North Carolina's Clean Marina Program. The program was initiated in July 2000 as a joint project between the North Carolina Marine Trades Services and the North Carolina Division of Coastal Management. As in the Maryland and Virginia programs, marina owners are asked to voluntarily complete an evaluation form to determine their use of specific BMPs. If a marina meets the criteria, it is eligible to fly the Clean Marina flag and use the logo in its advertisements. Through the promotion, boaters are able to identify marinas that care about the cleanliness of area waterways.

For more information on North Carolina's Clean Marina Program, see www.ncmta.com/Regulatory/CleanMarineIndex.htm.

Other state marina programs

Many other states are also developing their own Clean Marina Programs. Other programs include the Clean Texas Marina Program (see www.cleanmarinas.org); Florida's Clean Marina Program (see www.dep.state.fl.us/law/bosp/grants/clean_marina); and the Tennessee Valley Authority's Clean Marina Initiative (see www.tva.gov/environment/water/boating.htm).

States are increasingly dedicating substantial funding above and beyond the federal funding under section 319 and the required 40 percent state match to support and sustain expanded nonpoint source management programs. States are using many different mechanisms to fund their nonpoint source activities, including bond initiatives, low-interest loan programs, grants, and land acquisition programs. States are also increasing private sector involvement in program implementation so that they can progressively decrease their current reliance on government funds to support implementation of nonpoint source best management practices. This section highlights a variety of such programs that states are administering, beyond the 319 match, to address the effects of nonpoint source pollution.

States With Significant Funding Beyond 319 Match

California's Water Bond Program

In March 2000 California voters approved Proposition 13, the Costa-Machado Water Act of 2000 (2000 Water Bond), authorizing the state to sell $1.97 billion in general obligation bonds to support safe drinking water, flood protection, and water reliability projects throughout the state. The budget authorizes $468 million specifically for watershed protection, dedicating $90 million of this amount to implementing watershed management plans (to reduce flooding, control erosion, improve water quality, improve aquatic and terrestrial species habitats, restore native vegetation and riparian zones, and restore beneficial uses of water) and $95 million of this to river parkway acquisition and riparian habitat restoration. The budget authorizes $30.5 million specifically to the State Revolving Fund Loan Subaccount for the purposes of providing loans pursuant to the Clean Water Act. In addition, the budget specifically authorizes $100 million for nonpoint source pollution control activities and $90 million for coastal nonpoint control activities over the next several years.

For the money specifically authorized for nonpoint source activities, grants of up to $5 million (per project) may be awarded to local public agencies or nonprofit organizations formed by landowners to prepare and implement local nonpoint source plans. Projects must use best management practices (BMPs) or management measures and must demonstrate a capability to sustain water quality benefits for a period of 20 years. Categories of nonpoint source pollution addressed by projects may include, but are not limited to, silviculture, agriculture, urban runoff, mining, hydromodification, grazing, on-site disposal systems, boatyards and marinas, and animal feeding operations. Projects to address nonpoint source pollution may include, but are not limited to, wildfire management, installation of vegetative systems to filter or retard pollutant loading, incentive programs or large-scale demonstration programs to reduce commercial reliance

on polluting substances or to increase acceptance of alternative methods and materials, and engineered features to minimize impacts of nonpoint source pollution. Projects must have defined water quality or beneficial use goals.

For more information on California's Water Bond Program, see www.swrcb.ca.gov/prop13/index.html.

California's Loan Programs

The California State Board administers two funds that provide loans to help private parties control nonpoint sources of pollution: the State Revolving Fund (SRF) Loan Program and the more recent Agricultural Drain Management Program (ADMP) created by Proposition 204 in 1996. Most of the SRF dollars (up to $100 million) come from the federal government. The state matches the federal contribution on an 80 percent federal/20 percent state basis. In addition to the SRF, $27.5 million was made available to the ADMP with the passage of Proposition 204 in 1996. Of this amount, $5 million has been obligated for dairy waste management. Dollars from previous SRF loans that have been repaid are also available to make new loans.

Merced County is an example of the local beneficiaries of California's loan programs. The county has borrowed $10 million from the SRF Loan Program and $5 million from the ADMP to make loans to Merced County dairies through a county-administered mini-loan program. The loans may be used to reduce drainage runoff, which is high in nitrates and salinity and currently threatens the quality of the county's groundwater and surface waters. Most of the money is expected to be used to install structural improvements for animal waste source control. The county will also use a portion of the funds to provide a public education and outreach program to educate dairymen, as well as to establish criteria for evaluating problem dairies and to develop solutions to control animal waste. The dairy industry is growing in Merced County, and the county's goal is to ensure that dairies under its jurisdiction are properly operated so that they comply with county, state, and federal laws.

Florida Forever Program

The 2-year effort to enact a successor to the Preservation 2000 Program, which had acquired 1 million acres and was successful in saving many of Florida's beaches, rivers, bays, forests, coral reefs, and estuaries, culminated in the passage of the Florida Forever bill on April 30, 1999. While devoting major resources toward land acquisition, Florida Forever also recognizes and refocuses on Florida's water resource needs. The bill devotes 24 percent of funds to urban efforts, recognizing both the need for greater environmental protection and the need for more recreation space in urban areas. A significant feature is the creation of Florida's first-ever land acquisition advisory committee. This committee will

clearly focus on measurable goals and invest taxpayer funds wisely to develop measurable statewide objectives for Florida Forever.

Florida Forever created a 10-year, $3 billion program. The state will receive about $300 million each year through a bond program. The funds will be apportioned among the Department of Environmental Protection (with 35 percent of the funds for acquisition programs, 1.5 percent for recreation and parks, and 1.5 percent for greenways and trails); the Water Management Districts (35 percent); the Department of Community Affairs, Florida Communities Trust (24 percent); the new Florida Fish and Wildlife Conservation Commission (1.5 percent); and the Department of Agriculture and Consumer Services, Division of Forestry (1.5 percent).

For more information on the Florida Forever program, see www.dca.state.fl.us/ffct/florida_forever_program.htm.

Georgia's Greenspace Program

Georgia's governor signed the Greenspace Program into law on April 16, 2000. The program is a voluntary, noncompetitive, county-based program. It provides for awards of formula grants to eligible counties if they develop and implement plans to permanently protect at least 20 percent of the county's geographic area as natural, undeveloped greenspace that furthers one or more of the nine stated goals of the program. Five of the goals address water-quality protection, including flood protection; wetland protection; reduction of erosion; protection of riparian buffers; and water quality protection for rivers, streams, and lakes.

For fiscal year 2001, $30 million has been appropriated for the program. Counties are not required to provide matching funds, but they must commit to providing adequate stewardship of the lands once acquired.

For more information on Georgia's Greenspace Program, see www.ganet.org/dnr/greenspace/index.html.

Iowa's Water Quality Initiative

Iowa's new Water Quality Initiative (2000) provides $11.2 million per year for a number of water quality improvement projects throughout the state. Highlights of the Initiative include financial incentives to install conservation buffers, conduct water quality monitoring, and support local watershed protection projects.

The Initiative provides $1.5 million to accelerate the implementation of the Conservation Reserve Program (CRP) through soil and water conservation district field offices. Through the CRP program, farmers receive payments from the U.S. Department of Agriculture (USDA) to establish riparian buffers,

grassed waterways, contour buffer strips, field borders, and other buffers on private farmlands. The buffer initiative will provide funding for additional field office staff to prepare materials, contact prospective participants, and process applications. Local government and private, nonprofit organizations are being challenged to provide matching funds to further leverage the initiative. Funds are also being used to provide $100/acre sign-up bonus payments for eligible practices of contour buffer strips, shallow water areas for wildlife, and cross-wind trap strips. The first-year goal is to enroll an additional 100,000 acres in the continuous-sign-up Conservation Reserve Program.

The Initiative also provides $1.9 million to conduct an ongoing assessment of Iowa's rivers and streams, lakes, groundwater, beaches, wetlands, and precipitation. In addition, the program focuses on public education on water quality issues and encourages participation in volunteer water quality monitoring. Two years ago, only $120,000 from federal sources was being spent on water monitoring in Iowa.

The Initiative provides $2.7 million to develop and encourage integrated approaches to address multiobjective water quality protection, flood control, erosion control, recreation, wildlife habitat, and other resource protection issues. Funding is provided for watershed solutions to water quality and water management problems that affect local communities, the state, and the country. The first year goal is to financially support more than 20 local watershed protection projects that are providing improved flood protection and erosion control and are beginning to address the water quality problems of the state's impaired waters. Assistance will be provided to local communities and Soil and Water Conservation Districts for the development of water quality projects and funding applications. The Watershed Task Force will complete its study of Iowa watershed protection efforts and will report (with recommendations) on the status of watershed protection needs, program capacity, and local initiatives.

The Initiative provides financial incentives for many other programs, including $600,000 for septic system renovations (to match $2.4 million from the State Revolving Fund); $2 million in financial incentives to install soil conservation practices on private farmlands (with 5 percent directed to lands in the watersheds of high-priority, publicly owned lakes in the state); $372,000 to develop new or improved water quality standards and assessment techniques; $1.5 million to restore or construct wetlands to intercept tile runoff from agricultural lands; $153,000 to develop an efficient Total Maximum Daily Load program; $200,000 to educate local floodplain managers; $250,000 to review and issue National Pollutant Discharge Elimination System permits; $850,000 for demonstrations of integrated farm and livestock management; $70,000 to support the Department of Natural Resources' volunteer programs; and $195,000 to provide geographic information system data to local watershed groups.

Maine's Funding Programs

In 2000 the Maine Department of Agriculture used a $2.5 million state general fund appropriation to establish the Nutrient Management Grant Program, a cost share program to help producers construct manure-handling facilities to comply with the state's Nutrient Management Law.

Maine also established the Watershed Improvement Financial Assistance Partnership in 2000. It provides financial assistance to help state Soil and Water Conservation Districts conduct nonpoint source pollution control projects to restore or protect lakes, streams, or coastal waters that are polluted or considered threatened. The funding is from the Environmental Protection Agency ($240,000), administered by the Maine Department of Environmental Protection (MDEP), and the State of Maine general fund ($160,000), administered by the Maine Department of Agriculture, Food, and Rural Resources. EPA-New England and the Maine Association of Conservation Districts are cooperating partners. Maine's 16 Districts joined together to form four watershed regions for this program. Annually each region is eligible to receive a grant of $100,000.

MDEP and Agriculture established the Nutrient Management Loan program in 1999. Loans are available through the Financial Authority of Maine. These loans have an effective interest rate of 4 percent the first year and 3 percent each year thereafter for up to 20 years. They may be used for building storage and handling facilities for manure and milk room wastes, including equipment that is used solely for handling waste. In 1999 MDEP also issued $500,000 grants of state bond funds for watershed projects under the Priority Watershed Protection Grants Program.

In 1998 the Maine Department of Transportation established the Surface Water Quality Protection Program to help reduce polluted runoff from highways. The program uses federal Transportation Equity Act funds (about $200,000 per year). The projects funded usually involve reconstruction of highway drainage systems to reduce sediment discharges to waters.

The state legislature initiated the Maine Overboard Discharge Program in 1989 to help fund replacement systems that would eliminate licensed overboard discharges in certain areas. Licensed overboard discharges are treated discharges, to surface bodies of water, of domestic pollutants not conveyed to a municipal or quasi-municipal wastewater treatment facility. High priority is given to shellfish areas that could be opened for harvesting if the licensed overboard discharges were eliminated. The state share of funding for projects in this grant program comes from bond issues approved by the voters. Since 1989, $4.5 million has been used.

The Small Community Grant Program is a water pollution control program administered by MDEP. Funding levels range from $500,000 to $1 million per year, and a state bond is used to fund the program. The goals are to improve water quality, protect public health, and reopen shellfishing areas that are affected by wastewater discharges. The program may provide financial and technical assistance in solving wastewater disposal problems in unsewered areas. For qualifying systems, grants for 25 to 100 percent of the replacement costs for a year-round residence, 25 to 50 percent for a business, and 25 to 50 percent for a seasonal or second home are available.

Clean Michigan Initiative

In 1998 Michigan voters overwhelmingly approved the Clean Michigan Initiative (CMI), authorizing $675 million in state bonds to finance environmental and natural resources protection programs.

A large portion of the CMI ($50 million) has been earmarked for Nonpoint Source Pollution Control grants. These grant funds can be used to implement the physical improvements, such as structural and vegetative BMPs, recommended in approved watershed management plans. The Nonpoint Source Pollution Control grants are budgeted at $7 million per year through 2006. An additional $90 million has been allocated to the Clean Water Fund to implement a comprehensive water quality monitoring program in the state. That fund will also be used to protect high-quality waters, eliminate illicit connections to storm drains, address failing on-site septic systems, plug abandoned wells, implement storm water management activities, implement recommendations found in Remedial Action Plans and Lakewide Management Plans, and implement agricultural BMPs in targeted watersheds.

For example, $5 million of the Clean Water Fund will be used to provide funding as state match for the federal Conservation Reserve Enhancement Program (CREP), which will implement practices on agricultural lands to improve water quality and wildlife habitat. The state of Michigan applied to the U.S. Department of Agriculture for a CREP grant of $126 million, with a total state match of $25.75 million. The practices to be implemented include 60,000 acres of riparian buffer strips, filter strips, field windbreaks, and wetland restoration, as well as 20,000 acres of wetland restoration, shallow water areas for wildlife, permanent native grasses, and permanent introduced grasses and legumes.

The CMI grants are available to local units of government and nonprofit organizations. Watershed management plans are approved by the Michigan Department of Environmental Quality and are often developed by local agencies with federal Clean Water Act support.

For more information on the Clean Michigan Initiative, see www.deq.state.mi.us/exec/cmi/cmiimp.html.

Minnesota's Clean Water Partnership Program

Minnesota's Clean Water Partnership was created in 1987 to address pollution associated with run off from agricultural and urban areas. The program provides local governments with resources to protect and improve lakes, streams, and groundwater. Financial assistance available through the program falls into two categories: grants and low-interest loans. Grants are available for up to 50 percent of project costs; loans may be used for only the project implementation phase and may cover the entire cost of implementation or supplement a grant. The implementation phase involves putting in place BMPs such as sedimentation ponds, manure management, conservation tillage, terraces, new ordinances, wetland restoration, fertilizer management, education, or other methods designed to reduce nonpoint source pollution.

During the 1999 application cycle for financial assistance, the Minnesota Pollution Control Agency awarded $2,370,107 in grants and $5,778,524 in loans. Through 11 application cycles, more than $30 million of state, federal, and local funds have been allocated to protect and improve lakes, streams, groundwater, wellhead areas, and wetlands.

For more information on Minnesota's Clean Water Partnership Program, see www.pca.state.mn.us/water/cwpartner.html.

Reinvest in Minnesota (RIM) Program

The Reinvest in Minnesota (RIM) Program, created in 1986, has two primary components: RIM and RIM Reserve. The RIM Program focuses on improving fish and wildlife habitat on public lands, and the RIM Reserve Program focuses on acquiring easements on private land.

The RIM Reserve Program protects water quality, reduces soil erosion, and enhances fish and wildlife habitat by retiring marginal lands from agricultural production and restoring previously drained wetlands. The owners of these lands are paid a percentage of the assessed value of their land to voluntarily enroll it in a conservation easement. A variety of land types are eligible, including drained wetlands, riparian agricultural lands, erodible cropland, pastured hillsides, and sensitive groundwater areas. Since the program began in 1986, landowners have enrolled about 2,400 easements, covering 83,000 acres.

The RIM Reserve Program has helped to leverage significant outside dollars for conservation in Minnesota. Under the Conservation Reserve Enhancement Program (CREP), the federal government will provide Minnesota landowners with up to $163 million to retire land in the Minnesota River valley. This money must be matched by $70 million in state funding. By combining a federal Conservation Reserve Program contract with a RIM Reserve easement, this funding will retire approximately 100,000 acres and more than double the amount of acreage currently enrolled in RIM Reserve.

The RIM Reserve/Wetland Reserve Program (WRP) partnership is another state/federal/local partnership that provides Minnesota with an opportunity to leverage federal dollars to increase conservation easement enrollment. Under the partnership, drained wetlands are enrolled and restored by combining WRP's 30-year easement option with a perpetual RIM Reserve easement. About 6,208 acres of RIM Reserve/WRP easements have been enrolled since the program began in 1997, costing about $5 million in federal dollars and $2.8 million in state dollars.

For more information on Minnesota's RIM Reserve Program, see www.bwsr.state.mn.us/programs/major/rim.html.

New Hampshire's Water Supply Land Conservation Grant Program

In spring 2000 the New Hampshire legislature created the Water Supply Land Conservation Grant Program. Under the program, the New Hampshire Department of Environmental Services (DES) provides grants to municipal or nonprofit water suppliers for the purchase of land or conservation easements critical to the quality of their water. These water supply lands must be within the source water protection areas for existing or planned public drinking water sources. DES has $1.5 million available for grants during the first year of the program.

The state grants must be matched by 75 percent from local sources. These match sources can include donated land or easements that also lie within the source water protection area, public funds, transaction expenses, or private funds. A low-interest loan fund is also available from DES to help communities finance some or all of the match.

For more information on New Hampshire's Water Supply Land Conservation Grant Program, see www.des.state.nh.us/dwspp/ws_landgrant.htm.

New Jersey's Funding Programs

Over the past several years, the New Jersey legislature has appropriated $5.3 million to the state's Department of Environmental Protection (DEP) and Department of Agriculture for technical and financial assistance grants to farmers who develop and implement conservation plans that incorporate agricultural BMPs to control nonpoint source pollution. Direct state cost-share funding assistance is pooled with federal Environmental Quality Incentives Program cost-share funds and made available to farmers based on potential environmental benefit.

In June 1999 New Jersey's governor signed the Garden State Preservation Trust Act, which will enable the state to preserve 1 million acres of open space over the next 10 years (by 2010). In 1998 New Jersey residents voted to amend the New Jersey constitution to provide a stable source of funding to acquire and preserve open space, farmland, and historic sites around the state. The amendment dedicates $98 million annually for 10 years to preservation efforts and authorizes the issuance of up to $1 billion in revenue bonds. For more information on the Garden State Preservation Trust Act, see www.state.nj.us/dep/greenacres/preservation.htm.

New Jersey's DEP has received $5 million each fiscal year from State Corporate Business Tax receipts to implement watershed management and nonpoint source pollution control. Funds for nonpoint source and watershed activities have been increased to include $600,000 for each of the 20 Watershed Management Areas for a 4-year watershed planning process. For more information on New Jersey's Corporate Business Tax, see www.state.nj.us/dep/watershedmgt/financial.htm.

New Jersey's DEP awarded $1.8 million in grant funds on April 17, 2001, for the development of regional storm water management planning in four counties. Storm water plans to improve streams and water quality will be developed for five priority watersheds: the Upper Maurice River in Gloucester County; the Smithville Drainage in Atlantic County; part of the Rancocas watershed in Burlington County; and Masons Creek and Little Creek, both tributaries to the Cooper River. Additional grants totaling $740,000 are being awarded for storm water planning in the Shrewsbury and Cohansey watersheds. These funds are from the 1989 Stormwater and Combined Sewer Overflow Bond Act.

New York's Clean Water/Clean Air Bond Act

New York's 1996 Clean Water/Clean Air Bond Act devoted $1.75 billion to protect and restore the state's environment. Of that amount, $790 million in funding is devoted to clean water projects to help carry out existing management plans for major water resources. Funds are available for municipal wastewater treatment improvement, pollution prevention, agricultural and nonagricultural nonpoint source abatement and control, and aquatic habitat restoration. Significant support is available to acquire open space that protects water resources, acquire public parklands, and protect farmland. Funding is also available to help small businesses protect the environment, help small municipalities address flood control, and improve the safety of dams throughout New York.

The Bond Act also specifically devotes $355 million for safe drinking water projects. These funds include $265 million for a revolving loan fund and $90 million for state assistance payments to economically distressed water systems upgrading their drinking water facilities.

For more information on New York's Clean Water Bond Act, see www.dec.state.ny.us/website/bondact/index.html.

North Carolina's Clean Water Management Trust Fund

In 1996 North Carolina's General Assembly established the Clean Water Management Trust Fund (CWMTF) to help finance projects that specifically address water pollution problems and focus on upgrading surface waters, eliminating pollution, and protecting and conserving unpolluted surface waters, including urban drinking water supplies. Moneys from the CWMTF may be used to acquire land or easements for riparian buffers and watersheds; to restore wetlands, buffers, and watershed lands; to repair failing wastewater treatment systems; and to improve storm water controls and management practices.

At the end of each fiscal year, 6.5 percent of the unreserved credit balance in North Carolina's General Fund (or a minimum of $30 million) will go into the CWMTF. In 2000 the Board of Trustees approved 59 grants for a total of $49.8 million. The Board has approved 234 grants for a total of $211 million since 1997. CWMTF grants have leveraged at least $60 million in other private and public funds.

The CWMTF's $40 million investment in the Conservation Reserve Enhancement Program will leverage $221 million in U.S. Department of Agriculture funds and $10 million in other funds over the next 6 years. The 2000 session of the General Assembly committed to appropriate $40 million to CWMTF in FY 2001–2002, $70 million in FY 2002–2003, and $100 million in FY 2003–2004 and subsequent years.

The CWMTF has helped to protect 1,560 miles of riparian buffers and preserve 134,673 acres of land. The CWMTF has assisted 60 local governments with wastewater improvements, funded 45 restoration projects, and funded 16 storm water projects.

For more information on North Carolina's Clean Water Management Trust Fund, see www.cwmtf.net.

Clean Ohio Fund

On November 7, 2000, Ohio voters passed Issue 1, a $400 million statewide ballot initiative that will help support brownfields restoration, farmland preservation, stream and watershed restoration and protection, open space conservation, and outdoor recreation.

In January 2001 Ohio's governor released the Clean Ohio Fund Implementation White Paper, detailing his vision regarding the administration of the fund. The administration proposes to set aside $25 million for a pilot program to purchase agricultural easements on valuable agricultural land. A total of $50 million will be available over the program's initial 4 years to protect high-quality streams and restore impaired water resources through protection of habitat along Ohio streams. Eligible projects will include the purchase of easements or fee simple interest in land to protect and restore streams and forested riparian corridors. Funding will also support projects that protect or restore natural stream channel functions, floodplains, and riparian corridors (for example, removal of dams that are no longer needed, provisions for fish passage, protection and restoration of natural flow regimes, or restoration of floodplains and associated wetlands).

In addition, the Clean Ohio Fund will set aside $175 million for brownfields restoration, $100 million for greenspaces, and $25 million each for developing recreational trails and cleaning up threats to public health.

For more information on the Clean Ohio Fund, see www.dnr.state.oh.us/cleanohiofund.

Oregon's Watershed Restoration Grants

Oregon's Watershed Enhancement Board administers Watershed Restoration Grants for numerous activities, including watershed restoration and enhancement, watershed assessment and monitoring, watershed education and outreach, land and water acquisition, and watershed council support. Grants are used to fund on-the-ground watershed management projects such as planting along

streambanks to slow erosion, developing off-stream livestock watering facilities or fencing stream areas to restore riparian function, controlling upland vegetation to encourage the growth of native grasses, reseeding old logging roads, restoring or enhancing natural wetlands, improving fish habitat, removing or replacing ineffective culverts, and purchasing conservation easements or leasing water rights.

The funds for these grants come from a voter-approved ballot measure that designates 7.5 percent of lottery proceeds for watershed restoration and protection. In January 2001 alone, the Watershed Enhancement Board awarded nearly $10 million in watershed improvement grants to watershed action groups around the state.

For more information on Oregon's Watershed Restoration Grants, see www.oweb.state.or.us.

Pennsylvania's Growing Greener Program

In December 1999 the governor signed Pennsylvania's Growing Greener program into law, providing nearly $650 million over 5 years to address the state's most pressing environmental challenges. Funds provided by Growing Greener will be split among four state agencies on an annual basis: Department of Conservation and Natural Resources, Department of Environmental Protection, Department of Agriculture, and Pennsylvania Infrastructure Investment Authority. These agencies will direct Growing Greener funding to protect open space, clean up abandoned mines, restore watersheds, and provide new and upgraded water and sewer systems, among other projects.

The first year of Pennsylvania's Growing Greener grant program has been very successful. Growing Greener grants have led to 55 watershed assessment and protection plans and 85 restoration/demonstration projects being implemented. Projects facilitating 58 environmental education projects and the organization of 21 watershed groups have also been set in motion.

With the help of Growing Greener funds, 3,603 acres of wetlands and 117 miles of riparian buffers are being restored. In addition, 279 miles of streams affected by acid mine drainage are being cleaned up, nearly 800 acres of abandoned mine lands are being reclaimed, and 43 miles of stream improvement structures are being built. Growing Greener has also enabled Pennsylvania to eliminate its backlog of mine reclamation and oil and gas well plugging projects. As a result, an additional 612 acres of abandoned mine lands are being reclaimed and more than 134 abandoned oil and gas wells are being plugged.

Grant recipients took the initiative to seek out other sources of funding to build on their Growing Greener grants. Nearly $45 million in matching funds supplemented the Commonwealth's investment. Match money was received in the form of cash, volunteer time, or donations of equipment or materials.

For more information on Pennsylvania's Growing Greener program, see www.dep.state.pa.us/growgreen.

Vermont's Funding Programs

Agricultural BMP cost-share program

In 1996 the Vermont legislature created a program that provides financial assistance to Vermont farmers in support of voluntary implementation of BMPs on farms. This program has provided a unique opportunity to combine state funds with federal USDA funds on many projects, thereby reducing the farmer's share of project costs to as little as 15 percent. Since the program's inception, the legislature has gradually increased annual funding levels from $250,000 to the current $1.2 million. In total, $3.9 million has now been earmarked for this program, with $2.7 million committed to build 737 BMP projects on 388 farms. This year's fiscal year 2001 allocation of $1.2 million is currently being committed to farm projects. The most common BMPs funded through the program to date have been systems to store manure, manage barnyard runoff, and treat milkhouse effluent. Using a phosphorus crediting procedure for each BMP, the state estimates that the practices funded thus far will reduce annual phosphorus loading to watercourses by about 31,900 pounds. The loading estimates provide one means for the state to track progress toward phosphorus reduction goals in key water bodies such as Lake Champlain.

The Vermont Department of Agriculture, Food and Markets administers the program in close coordination with USDA cost-share programs. BMP systems eligible for state cost-share dollars must meet design standards and specifications established by the USDA's Natural Resources Conservation Service. A system must be operated and maintained for its design life (typically at least 10 years) according to a plan that includes strict provisions for nutrient management and system upkeep.

Contact information: Phil Benedict (phil@agr.state.vt.us) or Jeff Cook (cookie@agr.state.vt.us) at the Vermont Department of Agriculture, Food and Markets, 802-828-2431.

Vermont Better Backroads Program

The Vermont Department of Environmental Conservation initiated a small grants program for correcting erosion and drainage problems along the state's backroads in 1997 using a small amount (about $20,000) of section 319 funding. Approximately 81 percent of Vermont's road miles are maintained by municipalities, and most of these roads are gravel roads. The goal of Vermont's Better Backroads Program is to promote the use of erosion control and maintenance techniques that save money while protecting and enhancing Vermont's lakes and streams. The program has been so successful that the Vermont General Assembly voted to more than triple its size in 1999 by adding $48,000 in state appropriations. Grants are awarded to towns and local organizations for erosion control measures not already required by town, state, or federal regulations. The 20 projects funded this year range from the installation of rock-lined ditches and diversion berms to culvert repairs and streambank stabilization. A portion of the funds is made available for road inventories, problem prioritizing, and capital budget planning to incorporate erosion control into ongoing town road maintenance.

Contact information: Susan Warren, Vermont Agency of Natural Resources, 802-241-3794, susan.warren@anrmail.anr.state.vt.us.

Vermont Watershed Fund

The Vermont Watershed Fund was established with funds from the sale of a special conservation license plate, authorized by the state legislature in 1996. The plates first became available in April 1997, and more than 9,000 were sold by fall 1999. Revenues for projects supported by the fund are raised by an additional $20 per year motor vehicle registration fee for each plate. The proceeds from plate sales are divided between the Vermont Watershed Management Fund and the Nongame Wildlife Fund.

The Watershed Fund, administered by Vermont's Agency of Natural Resources, supports watershed projects that protect, restore, or enhance Vermont's watershed resources. The funds are granted to community-based watershed organizations through the Vermont Watershed Grants Program. A wide range of projects are eligible for funding, including monitoring, outreach, land acquisition, recreational enhancement, and pollution prevention. A wide range of projects were funded in 1998 and 1999, including mine remediation, lake watershed surveys, river stabilization, and integrated crop management in a small watershed. Funds available for the watershed grants program have grown steadily from $16,000 in 1998 to $45,000 in 2000. Although modest in size, the program already has produced many successful results. It fills a critical gap in statewide funding sources for watershed-based projects.

Contact information: Susan Warren, Vermont Agency of Natural Resources, 802-241-3794, susan.warren@anrmail.anr.state.vt.us.

Virginia's Water Quality Improvement Act

The purpose of the Virginia Water Quality Improvement Act of 1997 is to restore and improve the quality of state waters and protect them from impairment and destruction for the benefit of current and future citizens of the Commonwealth of Virginia. Because this responsibility is shared among state and local governments and individuals, the Water Quality Improvement Fund (WQIF) was created.

The purpose of the fund is to provide water quality improvement grants to local governments, Soil and Water Conservation Districts, and individuals for point and nonpoint source pollution prevention, reduction, and control programs. A primary objective of the WQIF is to fund grants that will reduce the flow of excess nitrogen and phosphorus into the Chesapeake Bay through the implementation of Tributary Strategies prepared in accordance with the multistate/EPA/DC Chesapeake Bay Program and with state law.

Fund appropriations for fiscal year 1998 included $15 million (with $10 million for point sources and $5 million for nonpoint sources), and appropriations for 1999–2000 included more than $50 million (including $27 million for nonpoint sources). Most of the grants from the fund will be provided as matching funds, usually on a 50/50 cost-share basis.

For more information on Virginia's Water Quality Improvement Act, see www.dcr.state.va.us/sw/wqia.htm.

Washington's Water Quality Funding Programs

Washington Department of Ecology's Water Quality Program administers three major funding programs (managed as one) that provide low-interest loans and grants for projects that protect and improve water quality. The three programs that share guidelines, application, and funding cycles are (1) the Centennial Clean Water Fund, which provides low-interest loans and grants for wastewater treatment facilities and fund-related activities to reduce nonpoint sources of water pollution; (2) the State Revolving Fund (SRF), which provides low-interest loans for wastewater treatment facilities and related activities, or to reduce nonpoint sources of water pollution; and (3) the section 319 grants program.

During fiscal year 2001, 82 projects will receive funding in the form of grants and loans totaling $93.7 million. Projects will address water quality improvement and protection initiatives, including wastewater collection, treatment, reuse, and reclamation; salmon habitat and riparian corridor improvements; sediment control; agricultural BMPs; watershed action plans; wellhead protection; storm water treatment; environmental education; and water quality monitoring.

Each year Washington reserves 20 percent of its lendable funds (through the SRF and Centennial Clean Water Fund programs) for nonpoint source and estuary projects. In state fiscal year 2001, that 20 percent (more than $12 million) was fully committed to these types of projects.

For more information on Washington's water quality funding programs, see www.ecy.wa.gov/programs/wq/funding.

Wisconsin's Grant Programs for Runoff Management

Wisconsin's Nonpoint Source Water Pollution Abatement Program provides grants averaging $20 million per year in both urban and rural watersheds selected for priority watershed projects. In 1997 and 1998 the Wisconsin legislature created two new grant programs to address the effects of polluted runoff. The Targeted Runoff Management (TRM) Grant Program provides up to $150,000 to rural and urban governmental units to control polluted runoff from urban and rural sites. The Urban Nonpoint Source and Stormwater Grant Program focuses on financial assistance for projects in urban areas, providing up to 70 percent of technical assistance.

For more information on Wisconsin's grant programs for polluted runoff management, see www.dnr.state.wi.us/org/water/wm/nps/npsprogram.html.

State Conservation Reserve Enhancement Programs

State Conservation Reserve Enhancement Programs (CREP) address important local conservation concerns by combining USDA's Conservation Reserve Program (CRP) with state technical and funding assistance. CRP is administered by the USDA's Farm Service Agency, which protects fragile farmland by assisting owners and operators in conserving and improving soil, water, and wildlife resources. This is done by converting highly erodible and other environmentally sensitive acreage normally devoted to the production of agricultural commodities to a long-term approved cover. Participants enroll in contracts for 10 to 15 years and, in some cases, easements, in exchange for annual rental payments and cost-share assistance for installing certain conservation practices.

At least 14 states have approved CREP agreements in place, and at least an additional 8 states have CREP proposals under review. Many states are contributing significant amounts of funding to CREP. For example, Oregon provides $50 million (along with $200 million from USDA); North Carolina, $54 million (with $221 million from USDA); and Pennsylvania, $77 million (with $137 million from USDA).

States are also enrolling large tracts of land in the CREP. For example, Illinois's $250 million CREP may have up to 232,000 acres continuously enrolled in the CRP through 2002. Goals of the program include reducing total sediment loading to the Illinois River by 20 percent; reducing phosphorus and nitrogen loading to the Illinois River by 10 percent; increasing populations of waterfowl, shorebirds, and state and federally listed species by 15 percent within the project area; and increasing native fish and mussel stocks by 10 percent in the lower reaches of the Illinois River.

For more information on State Conservation Reserve Enhancement Programs, see www.fsa.usda.gov/dafp/cepd/crep/crepstates.htm.

Clean Water State Revolving Fund Programs

Under the Clean Water State Revolving Fund (CWSRF) program, EPA provides grants or "seed money" to all 50 states and Puerto Rico to capitalize state loan funds. The states, in turn, make loans to communities, individuals, and others for high-priority water quality activities. As money is paid back into the revolving fund, new loans are made to other recipients that need help in maintaining the quality of their water. Currently, the program has more than $27 billion in assets.

The CWSRF program allows states the flexibility to provide funding for projects that will address their highest-priority needs. Although the CWSRF has traditionally been used to build or improve wastewater treatment plants, eligible nonpoint source projects include virtually any activity that a state has identified in its nonpoint source management plan. Loans can be used for control of agricultural runoff, conservation tillage and other projects to address soil erosion, development of streambank buffer zones, and wetland protection and restoration. Twenty-eight states have funded more than $1 billion of such nonpoint source and estuary projects through 2000.

For more information on the CWSRF program, see www.epa.gov/owm/cwsrf.htm.

In 1987 Congress added sections 319 and 518 to the Clean Water Act to enable states, territories, and tribes to address the problems caused by nonpoint source pollution. Section 319 established baseline requirements for state and territorial nonpoint source management programs and authorized national funding to support implementation of approved management programs. Section 518 authorized EPA to treat federally recognized Indian tribes in the same manner as states and to grant up to one-third of 1 percent of national 319 grant funds to tribes.

In FY 2000 and FY 2001, Congress authorized EPA to award grants to Indian tribes under section 319 in an amount that exceeds the statutory cap, recognizing that Indian tribes need and deserve increased financial support to implement their nonpoint source programs. As a result, in FY 2000 and FY 2001, $2.5 million and $6 million (respectively) were made available to tribes—the first time that total national 319 grants to tribes had exceeded $1 million. EPA's long-term goal is for the cap on tribal nonpoint source grants to be permanently eliminated.

EPA annually awards section 319 grants to tribes that submit approved nonpoint source assessments and management plans. Each grant awarded under section 319 requires a 40 percent nonfederal match. If a tribe demonstrates a special financial need, however, EPA may (and frequently does) approve a 10 percent nonfederal match. As of September 2001 more than 70 tribes (representing more than 70 percent of Indian Country) have EPA-approved nonpoint source assessments and management programs. Despite very limited resources, a number of tribes have been able to implement some good-quality projects designed to achieve water quality improvements on tribal lands. Several examples of these projects are highlighted in this special feature section.

Restoring Watersheds by Decommissioning Forest Roads: Karuk Tribe and Forest Service Form Successful Partnership

For years the tribal lands of the Karuk Tribe of California, located in Northern California near the Oregon state line, have been honeycombed with roads for mining (gold, gravel, and quartz) and timber harvesting. Today, however, the watersheds are in imminent danger of environmental crisis because of sedimentation resulting from those past activities, threatening the habitat of coho and chinook salmon and steelhead trout. A 72 percent decline in timber harvesting between 1989 and 1997 has also devastated the region's economy. Many tribal members who once worked for logging or mining operations are now unemployed.

Today, 95 percent of tribal ancestral lands are located in the Klamath and Six Rivers National Forests. In 1994 a government-to-government protocol agreement emerged from this overlap to help pro-

tect and restore the region. The Steinacher Road, once serving as the region's main corridor, was soon identified as the largest contributor of sediment to Steinacher and Wooley Creeks, which eventually lead to the Lower Salmon River. It is estimated that since the road's construction in 1971, more than 10,600 cubic yards of sediment has entered stream channels from cutbanks and the road surface; annual delivery is more than three times background levels.

Securing funding

In 1998 the Karuk Tribe entered into a memorandum of understanding (MOU) with the Klamath National Forest calling for the sharing of resources, funding, and staff to help with decommissioning Steinacher Road. The Karuk Tribe secured 319 funding to help provide "storm-proofing" and prescription planning until significant restoration funds could be secured for the remainder of the decommissioning. Over the next 2 years, the Karuk Tribe and the Northern California Indian Development Council secured more than $1 million of funding from seven different funding sources to help with the project. In January 2000 an MOU was signed between the Karuk Tribe and the Six Rivers National Forest to continue completion of the Steinacher Road project as funding becomes available. Organizers of the project estimate that it will cost $1.9 million and take one project team 3 years to complete.

Building tribal capability

With assistance from the Northern California Indian Development Council, the Karuk Tribe initiated a Comprehensive Watershed Restoration Training and Implementation Program for tribal members and staff. The goal is to prepare the members of a Tribal Restoration Division for careers as watershed restoration specialists while supplying an on-the-job apprenticeship completing critical restoration work on projects available throughout the tribe's ancestral territory.

Since the Tribal Restoration Division was established, at least 16 tribe members have undergone training in heavy equipment application, prescription planning and surveying, and supervision of project sites. The new watershed restoration specialists have also removed about 94,800 cubic yards of sediment to stable locations and reestablished the natural drainage for five major streams that cross the abandoned Steinacher Road.

Improved water quality and fisheries are seen as a significant component of rebuilding the economy of the region. Watershed restoration represents an opportunity for long-term, stable employment based on non-resource-extraction ecosystem management and a stable, fully functioning ecosystem. Building the tribe's capability to play an appropriate role in ecosystem management is the only means by which ecosystem restoration, cultural survival, and community prosperity will be achieved.

Looking ahead

Over the long term, more than 2,000 miles of road throughout the Karuk's ancestral territory will need decommissioning or significant upgrading and remediation of mining impacts. These projects will take 12 project teams 25 to 30 years to complete. At a minimum, continuing this program requires $3 million

per year above the current forest watershed budget for planning, inspection, administration, and logistical support. If funding can be secured, the partnership created between the Karuk Tribe and the Forest Service will continue to serve as a model for a systematic approach to long-term salmon recovery efforts on the Klamath River.

Winchester Lake Watershed Project: Local Partners Join in Implementing TMDL Plan

Winchester Lake is located within the exterior boundaries of the Nez Perce Reservation, about 30 miles southeast of Lewiston, Idaho. Originally, the lake served as a mill pond from 1910 to 1963. The 100-acre body of water is now the central focus of a 218-acre State Park that surrounds the lake.

In the late 1980s, local residents and visitors increasingly complained about the lake's nuisance algae blooms and poor water clarity. In 1990, through EPA's Clean Lakes Program, high levels of nutrients and low levels of dissolved oxygen were identified as adversely affecting water quality in the lake. In 1996 Idaho's 303(d) list of impaired waters identified Winchester Lake as not meeting state water quality standards, requiring the development of a Total Maximum Daily Load (TMDL).

A local Watershed Advisory Group (WAG) was formed in 1998 to develop recommendations for improvements that they wanted to see installed in the area. The WAG members are local residents from all sectors, including stakeholders from the agriculture and grazing communities, forestry, the Nez Perce Tribe, the Road District, city government, and recreation. A Memorandum of Understanding (MOU) was developed between the state of Idaho, Nez Perce Tribe, and EPA with the intent to work collectively on the development of the TMDL. In February 1999 the TMDL was completed and approved, representing the success of the collaborative approach of the many agencies and the WAG.

Following the completion of the TMDL, the Nez Perce Tribe received 319 funding to help implement water quality projects in the watershed, as an integral piece of the TMDL's phased implementation plan. Funds were used to restore two forest road segments noted as high sediment producers in the TMDL. Gates for seasonal closure were also installed to restrict travel during the wet season.

Using 319 funds, the tribe collaborated with private landowners along the stream corridor to enhance riparian shading and stabilize streambanks. In spring 2000, volunteers and personnel from Nez Perce Tribe Water Resources, the Natural Resources Conservation Service, and the Soil Conservation Commission planted 150 trees and shrubs. A larger planting effort for 2,500 shrubs was planned for the remainder of the corridor.

These ongoing improvements are possible because of the collaborative efforts among the many Nez Perce tribal departments, state and federal agencies, private landowners, and members of the watershed group. Restoration efforts in this watershed will continue with additional 319 funding for agricultural practices, livestock best management practices, riparian plantings, culvert replacements for fish passage and maintenance, and road rehabilitation.

Water Quality Best Management Practices Plan: Choctaw Tribe Addresses Soil Erosion

The Mississippi Choctaw trust lands consist of eight individual communities in eight counties of east-central Mississippi and encompass more than 24,000 acres. Land ownership in these eight communities is like a checkerboard, adjoined and fragmented by non-Indian lands. The tribe is currently acquiring additional land parcels as they become available to consolidate the Choctaw ownership pattern to facilitate access and management capabilities and the delivery of services to its members. The Choctaw population is more than 8,100. Siltation resulting from various silviculture, construction, and resource extraction activities has been identified as the primary nonpoint source pollutant affecting water quality on the Choctaw lands. Soil losses to erosion in some upland (hilly) areas might be as high as 40 to 50 tons per acre per year. In some places the land is devoid of adequate tree, brush, or grass cover; in others, skid trails, fire lanes, and roads have created gullies that cause annual soil losses in excess of 100 tons per acre per year.

To address these problems, the Choctaw Tribe has developed a Water Quality Best Management Practices Plan for tribal lands. A Natural Resource Conservation Committee will oversee the implementation of best management practices (BMPs) to address erosion and siltation problems. Various BMPs will be used, including the use of both vegetative and structural measures during construction in residential areas to control erosion and sedimentation.

The plan also calls for the development and passing of tribal ordinances adopting erosion and sediment controls for disturbed areas and enforcement of selected BMPs. There are plans to hold meetings with stakeholders to discuss and implement the plan.

Monitoring activities will be conducted to identify discharge points, drainage patterns, direction of flow, water quality at surface water bodies affected by discharges, locations of significant materials exposed to storm water, and structural measures to control erosion and siltation. The data will also indicate the effect that recent changes in construction management activities have on water quality in the watershed.

Contact Information: Bernadette Hudnell, Mississippi Band of Choctaw Indians, P.O. Box 6013, Choctaw Branch, Philadelphia, MS 39350, 601-656-5251

Restoring Little Porcupine Creek: Alternative Water Sources and Grazing Rotation Help to Restore Stream

Several years ago Little Porcupine Creek was listed as the most impaired water body on the Fort Peck Indian Reservation in northeastern Montana. The area was broken into two pastures, and the stream was being used as the only source of water. It was heavily used by cattle, which congregated along this source of water and shade.

In 1998 the Assiniboine and Sioux Tribes of the Fort Peck Reservation received 319 funding to embark on a 13,000-acre restoration effort in the watershed. The tribes also collaborated with the Natural Resources Conservation Service (NRCS) to obtain technical assistance, as well as financial support through the Environmental Quality Incentives Program (EQIP).

Part of the project focused on helping vegetation to recover through increased fencing to promote better rotation of cattle grazing. Where only 2 pastures had previously been, extensive fencing broke the area into 17 pastures, allowing the tribal ranch manager to use a deferred rotation grazing system to move cattle through each pasture twice a year.

NRCS engineers helped to design new pipeline routes to provide alternative sources of drinking water for the cattle to decrease the cattle's visits (and ensuing damage) to the stream. Indian contractors then installed more than 14 miles of water pipeline, allowing access to watering tanks in each pasture.

The project was recently completed, and monitoring will provide information on its effects within a year. Studies of the vegetative growth in the project area will be conducted, as well as continued macroinvertebrate monitoring and studies of the physical characteristics of the stream itself.

Contact information: Debi Madison, Environmental Director, Fort Peck Tribes, 406-768-5155 (ext. 399)

Streambank Restoration at Bradley and Standingdeer Campgrounds: An Innovative Solution Solves a Common Problem

The Cherokee Indian Reservation in the southern Appalachian Mountains of western North Carolina comprises some 56,000 acres. The topography of much of the reservation land consists of very steep slopes and narrow valleys. In this area, soils are thin and generally highly erodible. Siltation is the primary cause of impairment of tribal waters. Major sources of siltation have resulted from past logging practices, gravel mining, road construction, housing construction, landfill, and other development activities. The rock/gravel mined area of Soco Creek has been designated a priority area for streambank restoration and reduction of nonpoint source pollution.

Sites on Soco Creek and the Oconaluftee River have undergone streambank restoration by stabilization techniques. Two sites where streambank restorations have been completed are Bradley Campground

and Standingdeer Campground. At these sites, erosion from overland flow had resulted from land disturbance due to the high level of foot traffic by campers. A large part of the problem was campers creating footpaths and removing riparian vegetation on streambanks, leaving the banks vulnerable to erosion during storm events.

The objective of the project was to reduce erosion from overland flow and from streambank failure as the streams undercut their banks at both Bradley and Standingdeer Campgrounds. Components of the project were designed to restrict campers' access down erodible streambanks and redirect their access down nonerodible steps.

An innovative solution

To reduce erosion, native riparian trees and shrubs were planted, along with grass seeding, and coconut erosion control fabric was installed to hold the soil in place until the vegetation was established. In addition to the benefits of holding soil in place, the vegetation will eventually grow into a barrier that restricts campers' movement down the streambanks. Using a method developed by Dave Rosgen of Wildland Hydrology (Pagosa Springs, Colorado), access to the stream was provided by making a modification to rock vanes. Without compromising the hydraulic design of the rock vanes, they were extended approximately 3 feet above their normal design elevation to the top of the streambank, which is the level of the rest of the campground. The purpose of extending the vanes was to make solid rock (boulder) stair steps that serve as access points for campers to enter the stream corridor.

In this project, revegetation and rock vane construction were successfully employed for streambank restoration. Revegetation solved the erosion problem from overland storm flow, while construction of rock vanes addressed undercutting of the streambanks. The constructed vanes slow floodwater velocities near the banks and deflect high-velocity water toward the channel center to replicate conditions in healthy natural channels.

Contact Information: Dannie Childers, Environmental Planner, Tribal Environmental Office, P.O. Box 455, Cherokee, NC 28719, 828-497-3814

Appendix

Success Story Index and Sources

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Alabama	**Tuscumbia-Fort Payne Aquifer Protection Program: Multiagency, Cooperative Approach Protects Aquifer**	8	Information for this success story was gleaned from "A Multi-Agency Cooperative Approach to Aquifer Protection: Program Completion," by Enid Probst, Ph.D., Alabama Department of Environmental Management. Submitted by Norm Blakey, Alabama Department of Environmental Management.
Alaska	**Restoration Work on the Kenai: Section 319 Funds Are Key to Youth Restoration Corps's Success**	10	Submitted by Kent Patrick-Riley, Alaska Department of Environmental Conservation.
Alaska	**Road and Stream Crossing Project in Tongass National Forest: New Data Help Identify Needed Fish Habitat Restoration**	11	Information for this success story was gleaned from *Tongass Road Condition Survey Report* (Technical Report No. 00-7) by Linda Shea Flanders and Jim Cariello, Alaska Department of Fish and Game, Habitat and Restoration Division, June 2000. Submitted by Kent Patrick-Riley, Alaska Department of Environmental Conservation.
American Samoa	**Nu'uuli Pala Lagoon Restoration Project: Efforts Spread to Other Island Villages**	12	Submitted by Carl Goldstein, EPA Region 9.
Arizona	**Restoration in Nutrioso Creek: Successful Results Beginning to Show**	13	Information for this success story was gleaned from Nutrioso Creek Turbidity TMDL, Arizona Department of Environmental Quality (July 2000), and James Crosswhite, EC Bar Ranch web site at www.ecbarranch.com. Submitted by Ephraim Leon-Guerrero, EPA Region 9.
Arizona	**Sediment Reduction at Hackberry Ranch: Reduction of 4 Tons Per Acre Realized**	16	Submitted by Kris Randall, Arizona Department of Environmental Quality.
Arkansas	**Buffalo National River Watershed Partnerships: Partners Improve Swine Waste Management**	17	Submitted by Sandi Formica, Arkansas Department of Environmental Quality. Project summary authors also include John Giese, Tim Kresse, Tony Morris, Matt Van Eps, and McRee Anderson of ADEQ and Dr. Tommy Daniel of the University of Arkansas.

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California	**Grassland Bypass Project: Economic Incentives Program Helps to Improve Water Quality**	21	Information for this success story was gleaned from Grassland Bypass "Project Description and Update." Submitted by Katherine Domeny, California Environmental Protection Agency, and Joe McGahan, Drainage Coordinator for the Grassland Area Farmers.
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Delaware	**Partners Upgrade Septic Systems in Coverdale Crossroads: Quality of Life Improved for Residents**	33	Information for this success story was gleaned from Delaware's *Nonpoint Source Program Annual Report* (January 1, 1999, to December 31, 1999).
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Georgia	**North Griffin Storm Water Detention Pond Project: Constructed Wetland System Protects Water, Wins Award**	41	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.
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Hawaii	**Integration of Aquaculture with Taro Production: Nonpoint Source Pollutants Reduced in Demonstration Project**	44	Submitted by Denis Lau, P.E., Chief, Clean Water Branch, State of Hawaii, Department of Health.
Idaho	**Conservation in Hatwai Creek: Partners Work Together on Four Successful Projects**	45	Submitted by Gary Dailey, Idaho Department of Environmental Quality.
Idaho	**Restoring the Paradise Creek Watershed: Phased Approach Implemented to Address Pollution and Flooding**	47	Submitted by Gary Dailey, Idaho Department of Environmental Quality.
Idaho	**Streambank Stabilization in the Thomas Fork Watershed: Photo Monitoring Sells Landowners on Bank Stabilization**	49	Submitted by Craig Thomas, Bear Lake Regional Commission.

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Illinois	**Lake Pittsfield Project: Ninety Percent Reduction in Sediment Loading Achieved**	50	Submitted by Barb Lieberoff, Illinois Environmental Protection Agency.
Illinois	**Restoration of the Flint Creek Watershed: Restoration Partnership Completes Multiple Projects**	52	Submitted by Barb Lieberoff, Illinois Environmental Protection Agency.
Indiana	**Blue River Riparian Reforestation: The Nature Conservancy Gets Landowners Involved**	53	Submitted by Jill Reinhar, Indiana Department of Environmental Management, jreinhar@dem.state.in.us.
Indiana	**Little Pine Creek and Indian Watersheds: Constructed Wetland System Averts Agricultural Nonpoint Source Pollution**	55	Submitted by Jill Reinhar, Indiana Department of Environmental Management, jreinhar@dem.state.in.us.
Iowa	**Bigalk Creek Watershed Project: Rainbow Trout Population Rebounds**	56	Submitted by Kevin Baskins, Iowa Department of Natural Resources.
Iowa	**The Lake Fisher Water Quality Project: Chipped Tires Help Protect Public Water Supply**	57	Information for this success story was gleaned from Iowa's nonpoint source brochures at www.state.ia.us/dnr/organiza/epd/wtrq/npsource/nptbro.htm. Submitted by Kevin Baskins, Iowa Department of Natural Resources.
Iowa	**Pine Creek Water Quality Project: Life Expectancy of Pine Lakes Extended**	59	Information for this success story was gleaned from Iowa's nonpoint source brochures at www.state.ia.us/dnr/organiza/epd/wtrq/npsource/nptbro.htm. Submitted by Kevin Baskins, Iowa Department of Natural Resources.
Kansas	**Braeburn Golf Course Project: Nitrates Reduced by More Than 80 Percent**	60	Information for this success story was gleaned from the Wichita State University web site on the Braeburn Golf Course Project at http://webs.wichita.edu/biology/319Web/Braeburn_Golf_Course_Project.htm. Submitted by Lisa Duncan, Kansas Department of Health and Environment, and Nate Davis, Wichita State University.
Kansas	**On-site Sewage Disposal on Difficult Sites: Special Conditions Demand Alternative Response**	62	Submitted by Lisa Duncan, Kansas Department of Health and Environment.
Kentucky	**Elkhorn Creek BMP Demonstration Project: Farmers See Water Supply Alternatives in Action**	63	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.

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Louisiana	**Bayou Plaquemine Brule: Louisiana Applies Satellite Imagery to Watershed Planning and Management**	64	Submitted by Jan Boydstun, Louisiana Department of Environmental Quality.
Louisiana	**Flat River and Red Chute Bayou Watersheds: BMPs Reduce Soil Loss**	66	Information for this success story was gleaned from *Louisiana's Nonpoint Source Management Program's Annual Report* (2000). Submitted by Jan Boydstun, Louisiana Department of Environmental Quality.
Maine	**Highland Lake Watershed Project: Hotspots Model Links Land Use and Water Quality**	67	Submitted by Norm Marcotte, Maine Department of Environmental Protection.
Maine	**Silver Spring Brook Watershed Demonstration Project: Landowners' Cooperation Plus Town's Commitment Equals Success**	69	Submitted by Norm Marcotte, Maine Department of Environmental Protection.
Maryland	**Evaluating the Effectiveness of Maryland's Forestry BMPs: Paired Watershed Study Tests BMP Performance**	71	N/A
Massachusetts	**Broad Marsh River Storm Water Remediation Project: Infiltration Structures Reduce Pollutants, Save Shellfish Beds**	72	Submitted by Elizabeth McCann, Massachusetts Department of Environmental Protection.
Massachusetts	**Lake Tashmoo Storm Water Remediation Project: First Flush Leaching Basins More Effective Than Expected**	74	Submitted by Elizabeth McCann, Massachusetts Department of Environmental Protection.
Michigan	**Innovative Farmers of Michigan: Blending Farm Profitability and Water Quality Protection**	76	Submitted by Karol Smith, Michigan Department of Environmental Quality.
Michigan	**Little Rabbit River Watershed Project: One-to-One Approach Wins Landowners' Support**	78	Information for this success story was gleaned from the Allegan Conservation District report *The Gateway to Natural Resources Management: Little Rabbit Watershed Project.* Submitted by Karol Smith, Michigan Department of Environmental Quality.
Minnesota	**North St. Paul Urban Ecology Center: Wetland Improvements Needed to Control Storm Water**	80	Submitted by Sarah Lehmann, EPA Region 5.

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State	Success Story	Page	Source
Minnesota	**Prior Lake/Spring Lake Improvement Project: Long-Term Implementation Strategy Off to a Good Start**	81	Submitted by Sarah Lehmann, EPA Region 5.
Mississippi	**Muddy Creek Watershed Demonstration Project: BMPs Retain 3,500 Tons of Soil per Year**	83	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.
Mississippi	**Roebuck Lake Demonstration Project: Slotted-Board Risers Installed to Save Topsoil and Improve Water Quality**	84	N/A
Missouri	**Mississippi Delta Irrigation Water Management Project: Irrigation Efficiency Improved**	85	Submitted by Becky Shannon and Tod Hudson, Missouri Department of Natural Resources.
Missouri	**Upper Niangua Grazing Demonstration Project: Counties Unite to Start Demonstration Farms**	87	Submitted by Becky Shannon and Colleen Meredith, Missouri Department of Natural Resources.
Montana	**Careless Creek Watershed Project: Sediment Delivery Reduced by 25 Percent**	90	Submitted by Jim Bauermeister, Montana Department of Environmental Quality.
Montana	**Restoration in Muddy Creek: Will a Name Change Be Needed?**	92	Submitted by Jim Bauermeister, Montana Department of Environmental Quality.
Nebraska	**Walnut Creek Lake Project: Partnership Drives Watershed Protection**	94	Submitted by Elbert Traylor, Nebraska Department of Environmental Quality.
Nebraska	**Wellhead Protection in Guide Rock: Village Closes Abandoned Wells to Protect Water Supply**	95	Submitted by Elbert Traylor and Tom Malmstrom, Nebraska Department of Environmental Quality.
Nevada	**Martin Slough Water Quality Enhancement Project: Water Quality Improves in the Upper Carson River Basin**	97	Submitted by: Mary Kay Riedl, Nevada Division of Environmental Protection.
Nevada	**Middle Carson River Restoration Project: Bioengineering Used to Restore Unstable Banks**	98	Submitted by Mary Kay Riedl, Nevada Division of Environmental Protection.
New Hampshire	**Chocorua Lake Project: BMPs Reduce Phosphorus by 82 Percent**	100	Submitted by Eric Williams, New Hampshire Department of Environmental Services.

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New Hampshire	**Lake Opechee Watershed Project: City-State Partnership Takes on Multiple Pollutants**	101	Submitted by Eric Williams, New Hampshire Department of Environmental Services.
New Jersey	**Restoration of Strawbridge Lake: Volunteers Assist in Stabilizing Shoreline and Constructing Wetlands**	103	Information for this success story was gleaned from New Jersey Department of Environmental Protection's *Watershed Focus* (Summer 2000). Submitted by Liz Semple, New Jersey Department of Environmental Protection.
New Jersey	**The Stony Brook-Millstone Watershed Restoration Project: Streamwatch Volunteers Monitor Success of Restoration Efforts**	104	Information for this success story was gleaned from New Jersey Department of Environmental Protection's *Watershed Focus* (Summer 2000). Submitted by Liz Semple and Mike Haberland, New Jersey Department of Environmental Protection.
New Mexico	**Lower Bitter Creek Restoration Project: Sediment Loads Reduced by Implementing BMPs**	105	Submitted by Peter Monahan, New Mexico Environment Department.
New Mexico	**Valle Grande Grass Bank Water Quality Improvement Project: Success Breeds More Success**	107	Information for this success story was gleaned from FY 2000 Work Plan, *Valle Grande Grass Bank Water Quality Improvement Projects: A Composite of Projects Within the Valle Grande Grass Bank Program.* Submitted by Peter Monahan, New Mexico Environment Department.
New York	**Keuka Lake Watershed: Grape Growers Implement Soil Conservation Practices**	109	Information for this success story was gleaned from *Agricultural Environmental Management Report* (2000) and the Keuka Lake Association web site at www.keukalakeassoc.org/. Submitted by Lester Travis, Yates County Soil and Water Conservation District, and Barbara Silvestri, New York State Soil and Water Conservation Committee.
New York	**Wappingers Creek Watershed: AEM Plays a Vital Role**	110	Information for this success story was gleaned from the draft *Agricultural Environmental Management Report* (2001). Submitted by Barbara Silvestri, New York State Soil and Water Conservation Committee.
North Carolina	**Edenton Storm Water Wetland Project: Wetland Systems Reduce Nitrogen Concentrations**	111	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm. For more information on the project, go to www.bae.ncsu.edu/research/evans_web/etd/kibass.pdf. Submitted by Alan Clark, North Carolina Division of Water Quality.
North Carolina	**Goose Creek Urban Stream Rehabilitation Project: Ecosystem Protection Practices Installed in Low-Income Neighborhood**	113	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm. Submitted by Alan Clark, North Carolina Division of Water Quality.
North Dakota	**Cottonwood Creek Watershed: Project Is a Success in the Works**	114	Submitted by Greg Sandness, North Dakota Department of Health.

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North Dakota	**Red River Basin Riparian Project: Turtle River Site Passes the Test**	117	Information for this success story was gleaned from *Quality Water Newsletter* (Spring 1997), www.health.state.nd.us/ndhd/pubs/wq/qw/v8n2/v8n2.htm. Submitted by Linda Kingery, Riparian Project Manager, and Greg Sandness, North Dakota Nonpoint Source Pollution Management Coordinator.
Ohio	**Stillwater River Watershed Protection Project: High Local Interest Helps Launch Watershed Project**	119	Submitted by Alicia Brown, EPA Region 5.
Ohio	**Toussaint River Incentive Improvement Program: Buffer Project Becomes a Model of Conservation Partnership**	120	Submitted by Alicia Brown, EPA Region 5.
Oklahoma	**Acid Mine Drainage Treatment Wetlands: A Sustainable Solution for Abandoned Mine Problems**	122	Information for this success story was gleaned from *Use of Staged Wetlands for Mitigation of Acid Mine Drainage,* Oklahoma's FY 1995 319(h) Task Report No. 800 (OCC Task No. 71), C9-996100-03-0. Submitted by Scott Stoodley, Oklahoma Conservation Commission.
Oklahoma	**Poteau River Comprehensive Watershed Management Program: Local Involvement Ensures Program Sustainability**	124	Submitted by Shanon Phillips, Oklahoma Conservation Commission, and Nikole Witt, EPA Region 6.
Oklahoma	**The Spring Creek Project: Streambanks Stabilized Through Stream Restoration**	126	Submitted by Greg Kloxin, Oklahoma Conservation Commission.
Oregon	**Dawson Wetland Restoration Project: Landowners and Wetlands Both Win**	128	Information for this success story was gleaned from the Oregon Department of Environmental Quality's *Watershed Improvement Project Bulletin: Dawson Wetland Restoration Project, Douglas County, Oregon.* Submitted by Ivan Camacho, Oregon Department of Environmental Quality.
Oregon	**South Myrtle Creek Ditch Project: Removal of Dam Benefits Aquatic Life**	129	Information for this success story was gleaned from the Oregon Department of Environmental Quality's *Watershed Improvement Project Bulletin: South Myrtle Creek Ditch Project, Douglas County, Oregon.* Project Completion Report by Bob Kinyon, Umpqua Basin Watershed Council, February 2001. Submitted by Ivan Camacho, Oregon Department of Environmental Quality.
Oregon	**Wet Meadow Restoration in the Upper Grande Ronde Basin: Channel Restoration Brings Cooler Waters**	131	Information for this success story was gleaned from *Grande Ronde Section 319 National Monitoring Program Project, Temperature Monitoring Summary Report, 1993-1998* by Larry Whitney, Oregon Department of Environmental Quality.

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State	Success Story	Page	Source
Pennsylvania	**Narrows Bioengineering Project: Cold-Water Fishery Restored Through Bioengineering**	132	Information for this success story was gleaned from *The Narrows Bioengineering Section 319 Grant Project Proposal* and *The Narrows Bioengineering Section 319 Grant Project Final Report.* Submitted by Russell Wagner, Pennsylvania Department of Environmental Protection.
Pennsylvania	**Villanova's Storm Water Wetland Retrofit: BMP Treats Runoff and Provides Research Site**	133	Information for this success story was gleaned from *Conversion of an Urban Stormwater Detention Basin to a Wetland Best Management Practice,* Final Report (December 2000), and the project web page at www87.homepage.villanova.edu/robert.traver (select "319 Stormwater Wetland Retrofit"). Submitted by Russell Wagner, Pennsylvania Department of Environmental Protection.
Puerto Rico	**Coastal Nonpoint Source Controls: Executive Order Adopts Section 6217(g) Management Measures as Official Policy**	135	Submitted by Katie Lynch, EPA Region 2.
Rhode Island	**Curran Brook Sedimentation Pond: Multiple Partners Construct Storm Water Control System**	136	Submitted by Jim Riordan, Rhode Island Department of Environmental Management.
Rhode Island	**Galilee Salt Marsh Restoration: Undersized Culverts Replaced with Self-Regulating Gates**	137	Submitted by Jim Riordan, Rhode Island Department of Environmental Management.
South Carolina	**Constructed Wetlands for Failing Septic Tanks: New Technologies Solve an Old Problem**	139	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.
South Carolina	**Stevens Creek Watershed Project: Demonstration Sites Show Reductions in Fecal Coliform Bacteria**	140	Information for this success story was gleaned (in part) from *The Stevens Creek Watershed Project* (Technical Report No. 010-99), December 1999. Submitted by Doug Fabel, South Carolina Department of Health and Environmental Control.
South Dakota	**Big Stone Lake Restoration Project: Better Water Quality Improves Fisheries, Recreation**	141	Submitted by Duane Murphy, South Dakota Department of Environment and Natural Resources.
South Dakota	**Management-Intensive Grazing Project: Rotational Grazing Reduces Erosion, Increases Profits**	143	Information for this success story was gleaned from the South Dakota Association of Conservation Districts' web site at www.sd.nacdnet.org/grazing/index.html.
Tennessee	**Ghost River Land Acquisition Project: River Protected by Restoring Forested Wetlands**	144	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.

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Tennessee	**Using Constructed Wetlands to Clean Up Pesticides: Container Nurseries Will Benefit from Successful Pilot-Scale Study**	146	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.
Texas	**Atrazine Problems in the Lake Aquilla and Marlin City Lake System: Farmers Take a Proactive Stance**	147	N/A
Texas	**On-Farm Composting of Dairy Cattle Solid Waste: Protecting Water Quality While Producing a Salable Product**	148	N/A
Utah	**Little Bear River Project: Voluntary Approaches Yield Success**	149	Submitted by Jack Wilbur, Utah Department of Agriculture and Food.
Utah	**Success in the Chalk Creek Watershed: Reduced Phosphorus, Enhanced Habitat Result**	151	Submitted by Jack Wilbur, Utah Department of Agriculture and Food.
Vermont	**Flow Restoration Below Hydroelectric Facilities: Relicensing Offers Opportunity to Increase Stream Flows**	153	Submitted by Rick Hopkins, Vermont Agency of Natural Resources.
Vermont	**Lake Champlain Basin Watershed Project: Significant Pollutant Reductions Achieved**	154	Submitted by Rick Hopkins, Vermont Agency of Natural Resources.
Virginia	**Cabin Branch Mine Orphaned Land Project: Flora and Fauna Benefit from Mine Reclamation**	156	Submitted by Rick Hill, Virginia Department of Conservation and Recreation.
Virginia	**Toncrae Mine Orphaned Land Project: Mine Site Reclamation Increases Species Diversity**	158	Submitted by Rick Hill, Virginia Department of Conservation and Recreation.
Virgin Islands	**Virgin Islands Partnership: Alternative Treatment Systems Prevent Contamination of Coastal Waters**	160	Submitted by Donna Somboonlakana, EPA Region 2.
Washington	**Best Management Practices on Model Horse Farms: Farm Plan Management Reduces Nutrients and Sediment**	161	Information for this success story was gleaned from *Year 2000 Report on Activities to Implement Washington State's Water Quality Plan to Control Nonpoint Source Pollution*, March 2001. Submitted by Gabrielle Kirouac, Washington State Department of Ecology.

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Washington	**A Moo-ving Approach to Dairy Waste Management: Fecal Coliform Pollution Reduced in Whatcom County**	162	Information for this success story was gleaned from *Year 2000 Report on Activities to Implement Washington State's Water Quality Plan to Control Nonpoint Source Pollution*, March 2001. Submitted by Gabrielle Kirouac, Washington State Department of Ecology.
Washington	**Sediment Reduction in Yakima River Basin: People Become Stewards of Their Own Watershed**	164	Information for this success story was gleaned from *Year 2000 Report on Activities to Implement Washington State's Water Quality Plan to Control Nonpoint Source Pollution*, March 2001. Submitted by Gabrielle Kirouac, Washington State Department of Ecology.
West Virginia	**The North Fork Project: Farmers' Cooperation Leads to Proposed Delisting of Degraded River**	165	Submitted by Leo Essenthier, EPA Region 3.
Wisconsin	**Otter Creek Project: 319 National Monitoring Program Goals Met**	168	Information for this success story was gleaned from *Section 319 Nonpoint Source National Monitoring Program Successes and Recommendations* by L.A. Lombardo, G.L. Grabos, J. Spooner, D.E. Line, D.L. Osmond, and G.D. Jennings, NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh. Submitted by Tom Davenport, EPA Region 5.
Wisconsin	**Success in Spring Creek Watershed: Natural Reproduction of Trout Confirms Water Quality Improvement**	169	Information for this success story was gleaned from *Responses of Stream Habitat, Macroinvertebrate, and Fish to Watershed BMPs: Lessons From Wisconsin*, by Lizhu Wang, John Lyons, Paul Kanehl, David Marshall, and Michael Sorge, Wisconsin Department of Natural Resources, Watershed Management 2000 Conference, Vancouver, British Columbia, Canada. Also see the EPA Region 5 web site at www.epa.gov/r5water/wshednps/sc_watershed.htm. Submitted by Russ Rassmussen, Chief, Runoff Management Section, Wisconsin Department of Natural Resources.
Wyoming	**Jackson Hole Rodeo Grounds Snow Storage Site: Filtration System Reduces Urban Storm Water Runoff**	170	Submitted by Brian Lovett and Steve Bubnick, Wyoming Department of Environmental Quality.
Wyoming	**Muddy Creek Coordinated Resource Management Project: Cattle Ranches and Trout Streams Can Coexist**	172	Submitted by Steve Bubnick, Wyoming Department of Environmental Quality.

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INFORMATION AND EDUCATION PROGRAMS			
California	**Ranch Water Quality Planning: Voluntary Rangeland Management Eases Impacts on California Watershed**	175	Information for this success story was gleaned from "Opportunity, Responsibility, Accountability," California Environmental Protection Agency, State Water Resources Control Board.
Colorado	**Colorado Water Protection Project: League of Women Voters Guides Extensive Urban NPS Campaign**	176	Information for this success story was gleaned from *Colorado Extensive Urban Nonpoint Source Pollution Campaign*, by Randy Ristau, Colorado Department of Public Health and Environment, EPA Region 8 *Natural News* (EPA 908-F-00-009), Fall 2000. Submitted by Laurie Fisher, Colorado Department of Public Health and Environment
Connecticut	**Nonpoint Education for Municipal Officials (NEMO): Successful Connecticut Project Used as a Model Nationwide**	177	Information for this success story was gleaned (in part) from Connecticut Department of Environmental Protection web site at http://dep.state.ct.us/wtr. Submitted by Mel Cote, EPA Region 1, and Laurie Giannotti, University of Connecticut Cooperative Extension System.
Florida	**Florida Yards & Neighborhoods Program: More than 1.2 Million People Reached**	179	N/A
Illinois	**The Salt Creek Wilderness: Illinois Zoo Offers Interactive Environmental Learning Experience**	180	Submitted by Barb Lieberoff, Illinois Environmental Protection Agency.
North Dakota	**North Dakota Eco-Ed Camps: Thousands of Students Have Fun While Learning**	182	Information for this success story was gleaned from North Dakota Department of Health, *Quality Water Newsletter*, Vol 8, No. 4 (Fall 1997).
Rhode Island	**University of Rhode Island Onsite Wastewater Training Center: Pioneering Agency Teaches, Demonstrates Innovative Systems**	183	Submitted by Jim Riordan, Rhode Island Department of Environmental Management.
Wisconsin	**Water Action Volunteers: WAV and Its Partners Make a Difference in Wisconsin**	184	Submitted by Carol Holden, NPS Education Coordinator, Wisconsin Department of Natural Resources.
Wyoming	**Stream Monitoring Network with Wyoming Schools: Trained Teams Initiate, Expand School Monitoring Programs**	185	Submitted by Steve Bubnick, Wyoming Department of Environmental Quality.

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INNOVATIVE STATE PROGRAMS			
California	**California's BIOS Program: Growers Adopt Whole-System Management Approach to Reduce Pesticide Use**	187	Information for this success story was gleaned from *Opportunity, Responsibility, Accountability,* California Environmental Protection Agency, State Water Resources Control Board.
Hawaii	**Maui County Erosion and Sediment Control Training Project: Workshops Explain Ordinance, Teach BMP Installation**	189	Submitted by Denis Lau, P.E., Chief, Clean Water Branch, State of Hawaii, Department of Health.
Idaho	**Idaho's Dairy Pollution Prevention Initiative: Unique Program Eliminates Direct Dairy Discharges**	191	Information for this success story was gleaned from The Idaho Dairy Pollution Prevention Initiative, Innovations in American Government 2001 Semifinalist Application, April 2001. Submitted by Gary Voerman and Warren McFall, EPA Region 10.
Massachusetts	**Creating a Storm Water Utility in Chicopee, Massachusetts: Project Praised as Outstanding Planning Project**	193	Submitted by Elizabeth McCann, Massachusetts Department of Environmental Protection.
New York	**New York's Agricultural Environmental Management Program: Incentive-based Program Helps Farmers Meet Tough Standards**	195	Information for this success story was gleaned from *Agricultural Environmental Management Report* (2000 and 2001). Submitted by Gerard Chartier, New York State Department of Environmental Conservation, and Barbara Silvestri, New York State Soil and Water Conservation Committee.
South Carolina	**South Carolina Forestry BMP Compliance Program: Proactive Strategy Raises BMP Compliance Rate**	197	Submitted by Doug Fabel, South Carolina Department of Health and Environmental Control.
National	**Statewide Clean Marina Programs: BMPs, Recognition, and Outreach Help Protect Coastal Resources**	198	N/A
STATE FUNDING PROGRAMS			
California	**California's Water Bond Program**	201	Information for this story was gleaned from www.swrcb.ca.gov/prop13/
California	**California's Loan Programs**	202	Information for this success story was gleaned from *Opportunity, Responsibility, Accountability,* California Environmental Protection Agency, State Water Resources Control Board.
Florida	**Florida Forever Program**	202	Information for this story was gleaned from www.dca.state.fl.us/ffct/florida_forever_program.html
Georgia	**Georgia's Greenspace Program**	203	Information for this story was gleaned from www.ganet.org/dnr/greenspace/index.html

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Iowa	**Iowa's Water Quality Initiative**	203	Information for this success story was gleaned from *The Iowa Water Quality Initiative: Better Water for a Better Iowa*, Department of Natural Resources and the Department of Agriculture and Land Stewardship (August 2000).
Maine	**Maine's Funding Programs**	205	Submitted by Norm Marcotte, Maine Department of Environmental Protection.
Michigan	**Clean Michigan Initiative**	206	Information for this story was gleaned from www.state.mi.us/exec/cmi/cmiimp/html.
Minnesota	**Minnesota's Clean Water Partnership Program**	206	Information for this story was gleaned from www.pca.state.mn.us/water/cwpartner.html.
Minnesota	**Reinvest in Minnesota (RIM) Program**	207	Information for this success story was gleaned from *The RIM Program Annual Report* (January 2000).
New Hampshire	**New Hampshire's Water Supply Land Conservation Grant Program**	208	Submitted by Carol Holden, NPS Education Coordinator, Wisconsin Department of Natural Resources.
New Jersey	**New Jersey's Funding Programs**	208	Submitted by Steve Bubnick, Wyoming Department of Environmental Quality.
New York	**New York's Clean Water/ Clean Air Bond Act**	209	Information for this story was gleaned from www.dec.state.ny.us/website/bondact/index.html.
North Carolina	**North Carolina's Clean Water Management Trust Fund**	209	Information for this story was gleaned from www.cwmtf.net.
Ohio	**Clean Ohio Fund**	210	Information for this story was gleaned from www.dnr.state.oh.us/cleanohiofund.
Oregon	**Oregon's Watershed Restoration Grants**	210	Information for this story was gleaned from www.oweb.state.or.us.
Pennsylvania	**Pennsylvania's Growing Greener Program**	211	Submitted by Russ Wagner, Pennsylvania Department of Environmental Protection.
Vermont	**Vermont's Funding Programs**	212	Submitted by Eric Perkins, EPA Region 1.
Virginia	**Virginia's Water Quality Improvement Act**	213	Information for this story was gleaned from www.dcr.state.va.us/sw/wqia.htm.
Washington	**Washington's Water Quality Funding Programs**	214	Information for this story was gleaned from www.ecy.wa.gov/programs/wq/funding.
Wisconsin	**Wisconsin's Grant Programs for Runoff Management**	214	Information for this story was gleaned from www.dnr.state.wi.us/org/water/wm/nps/npsprogram.html.
National	**State Conservation Reserve Enhancement Programs**	215	Information for this story was gleaned from www.fsa.usda.gov/dafp/cepd/crep/crepstates.htm
National	**Clean Water State Revolving Fund Programs**	215	Information for this story was gleaned from www.epa.gov/owm/cwsrf.htm.

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TRIBAL SECTION 319 PROJECTS			
California Tribal	**Restoring Watersheds by Decommissioning Forest Roads: Karuk Tribe and Forest Service Form Successful Partnership**	217	Information for this success story was gleaned (in part) from *A Watershed Restoration Partnership*, Karuk Tribe of California/Six Rivers and Klamath National Forest. Submitted by Jenee Gavette, EPA Region 9.
Idaho Tribal	**Winchester Lake Watershed Project: Local Partners Join in Implementing TMDL Plan**	219	Submitted by Gary Dailey, Idaho Department of Environmental Quality.
Mississippi Tribal	**Water Quality Best Management Practices Plan: Choctaw Tribe Addresses Soil Erosion**	220	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.
Montana Tribal	**Restoring Little Porcupine Creek: Alternative Water Sources and Grazing Rotation Help to Restore Stream**	221	Submitted by Barbara Burkland, EPA Region 8.
North Carolina Tribal	**Streambank Restoration at Bradley and Standingdeer Campgrounds: An Innovative Solution Solves a Common Problem**	221	Information for this success story was gleaned from the EPA Region 4 Nonpoint Source Program web site at www.epa.gov/region4/water/nps/projects/index.htm.

Glossary

Acid mine drainage—Mine leachate, or drainage, that contains free acidic sulfates (usually, ferrous acid). Sulfide minerals generally break down in the presence of oxygen and water.

Animal feeding operations (AFOs)—Facilities where animals have been, are, or will be stabled or confined for a total of 45 or more days in any 12-month period and crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Aquifer—A groundwater supply that is able to release water in quantities sufficient to supply reasonable amounts to wells.

Best management practice (BMP)—A practice or combination of practices that are determined to control point and nonpoint pollutants at levels compatible with environmental quality goals.

Channelization and channel modification—Engineering activities or techniques undertaken to change stream and river channels for certain reasons, including flood control, navigation, and drainage improvement. These activities include straightening, widening, deepening, relocating, and clearing or snagging operations that generally result in more uniform channel cross sections.

Concentrated animal feeding operations (CAFOs)—Facilities that (1) confine more than 1,000 animal units or (2) confine 301 to 1,000 animal units and discharge pollutants into waters of the United States.

Constructed wetland—An engineered system designed to simulate natural wetlands to exploit the water purification functional value for human use and benefits. Constructed wetlands consist of former upland environments that have been modified to create poorly drained soils and wetland flora and fauna for the primary purpose of removing contaminants or pollutants from wastewater runoff.

Dissolved oxygen—The concentration of free molecular oxygen in the water column. Although oxygen makes up about 90 percent of water, its concentration in water is higher near the surface and declines to almost zero at the lowest depths. An absence of dissolved oxygen causes fish kills and the condition known as hypoxia, or dead water.

Effluent—Solid, liquid, or gaseous wastes that enter the environment as a by-product of human activities.

Erosion—Wearing away of the land surface by running water, glaciers, wind, and waves.

Estuary—The part of the river that is affected by tides; the region near a river's mouth in which the fresh water in the river mixes with the salt water of the sea.

Eutrophication—The alteration of lake ecology through excessive nutrient input, characterized by excessive growth of aquatic plants and algae and low levels of dissolved oxygen.

Fecal coliform bacteria—Bacteria normally found in the intestinal tracts of warm-blooded animals. These bacteria are normally harmless to humans but are used as indicators of the presence of sewage that might contain other bacteria and viruses.

Feedlots—See Animal feeding operations and Concentrated animal feeding operations.

Glossary (cont.)

Floodplains—Land areas adjacent to rivers and streams that are subject to recurring flooding.

Groundwater—Underground water supplies stored in aquifers; the source of groundwater is rain, which soaks into the ground and flows down until it is collected at a point where the ground is not permeable.

Habitat—The place where a biological species naturally lives or grows.

Heavy metals—Elements with a large atomic number, including copper, cadmium, lead, selenium, arsenic, mercury, and chromium. These elements accumulate in the tissues of organisms that come into contact with them (especially in aquatic settings) and are passed through the food chain. Heavy metals can be harmful or fatal in high concentrations.

Hydrocarbons—Organic compounds containing hydrogen and carbon atoms that are found in petroleum products. These compounds have adverse affects on human and animal health and might be linked to some forms of cancer.

Impaired waters—Lakes, streams, or rivers where pollutant concentrations exceed those set by the water quality standards for the waterways' designated uses.

Integrated pest management (IPM)—A pest population management system that uses cultural practices to anticipate and prevent pests from reaching damaging levels. IPM uses all suitable tactics, including natural enemies, pest-resistant plants, cultural management, and pesticides, leading to economically sound and environmentally safe agriculture.

Invasive species—A species that does not naturally inhabit an area and whose introduction is likely to cause economic or environmental harm or adversely affect human health.

Karst—A type of topography characterized by closed depressions, sinkholes, underground caverns, and solution channels.

Leachate—Liquid that has percolated through a soil and contains substances in solution or suspension.

Leaching basins—A method of capturing and treating urban runoff from roadways. These basins are designed to catch runoff water and remove pollutants such as hydrocarbons, heavy metals, and fecal coliform bacteria.

Load—The quantity of material that enters a water body over a given time interval.

No-till farming—Farming practices that reduce the need for tilling and the number of times soil is tilled each year. By reducing the frequency of tilling, soil is left undisturbed, resulting in less sediment runoff into nearby waterways.

Nonpoint source pollution—Water pollution that comes from many diffuse sources rather than from a specific point, such as an outfall pipe; often the unintended result of human activities.

Nutrients—Elements, or compounds, essential as raw materials for organism growth and development, such as carbon, nitrogen, and phosphorus.

On-site sewage treatment systems—Means of treating human or animal wastes for properties that are not connected to a central sewage treatment system. On-site systems, or septic systems, break down wastewater and disperse it into the ground to be recycled.

Glossary (cont.)

Organic enrichment—Amounts of organic material that exceed a waterway's capacity to maintain high levels of dissolved oxygen. Decaying organic material, such as aquatic plants or organic material in nonpoint runoff wastewater, depletes oxygen levels in a waterway and sometimes results in impairment or death in aquatic life.

Pathogens—Disease-causing agents, including viruses, microorganisms, and bacteria.

Point source pollution—Water pollution that comes from a specific, definable source.

Pollutant—Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (Section 502(6) of the Clean Water Act as amended by the Water Quality Act of 1987, Public Law 100-4).

Retrofitting—The creation or modification of an urban runoff management system in a previously developed area. Such systems include wet ponds, infiltration systems, wetland plantings, streambank stabilization, and other best management practices for improving water quality and creating aquatic habitat.

Riparian areas—Vegetated ecosystems along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body.

Runoff—The part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters.

Section 303(d)—The section of the Clean Water Act that requires states to identify impaired waters and prepare the Total Maximum Daily Load required to ensure protection of the impaired waters.

Sediment—Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice.

Sedimentation—The process or act of depositing sediment.

Sewage lagoon—A reservoir or pond built to contain water and animal wastes until they can be decomposed by aerobic or anaerobic action.

Storm water—Water generated by rainfall.

Surface water—All water whose surface is exposed to the atmosphere.

Suspended sediment—The very fine soil particles that remain in suspension in water for a considerable period of time.

Tailings—Rock residue from the mining process.

Glossary (cont.)

Total Maximum Daily Load (TMDL) Program—This program, established by Section 303(d) of the Clean Water Act, provides for the protection of waters in areas where pollution control is not stringent enough to achieve water quality standards. The program authorizes states to assess water quality and to allocate the total maximum allowable daily load(s) of pollutant discharges to those waters, regardless of the pollutant's source. Future TMDLs are expected to emphasize wet-weather storm water discharges and nonpoint source pollution problems.

Turbidity—A cloudy condition in water due to suspended sediment or organic matter.

Water quality—A term that reflects the condition of water that has been affected by natural processes and human activities; good water quality may mean that the water meets its designated uses; that is, it is fishable and swimmable.

Watershed—A drainage area or basin in which all land and water areas drain of flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wetlands—Areas that are inundated or saturated by surface water or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, and bogs.