Arizona

Oak Creek Canyon
Section 319
National Monitoring Program Project

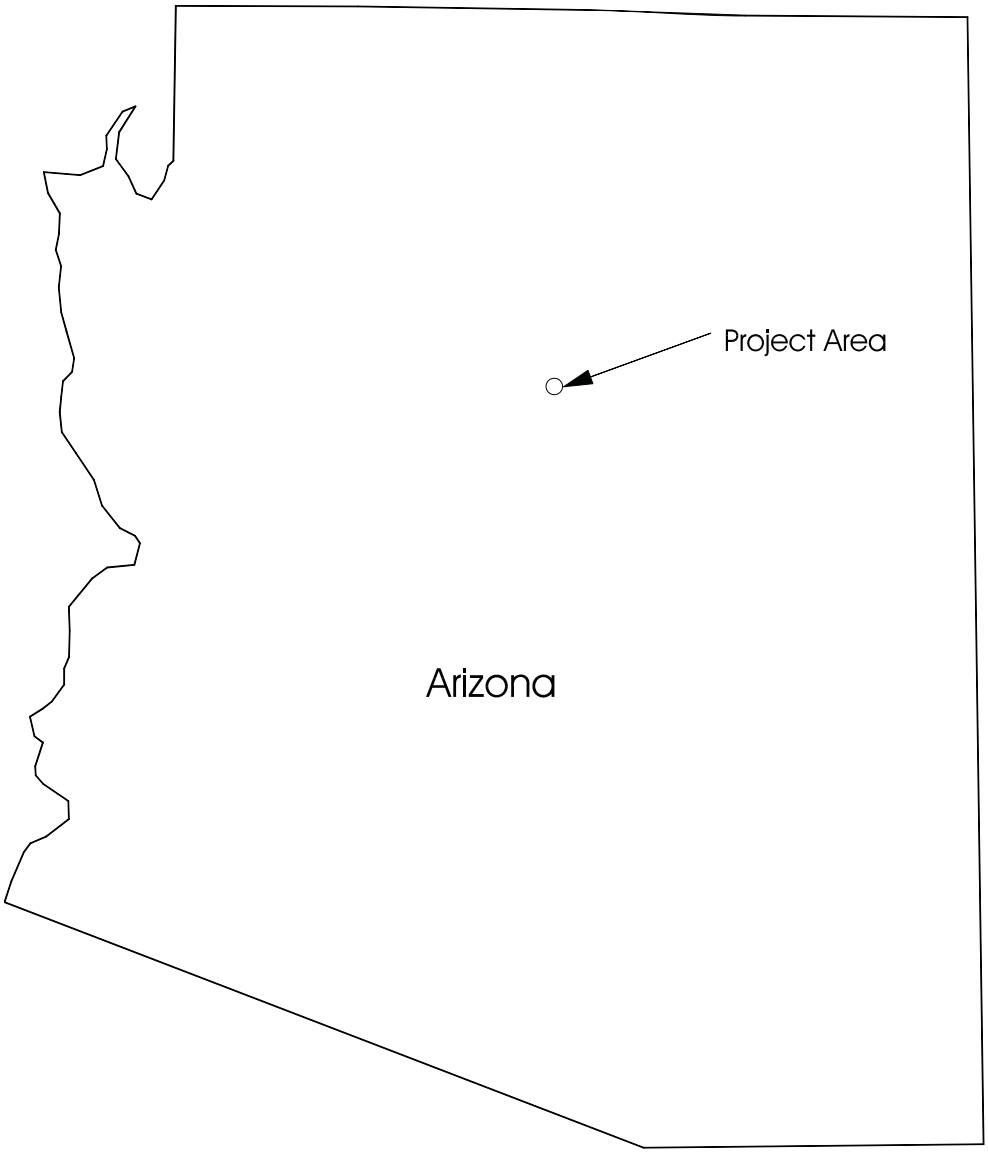

Figure 3: Oak Creek Canyon (Arizona) Project Location

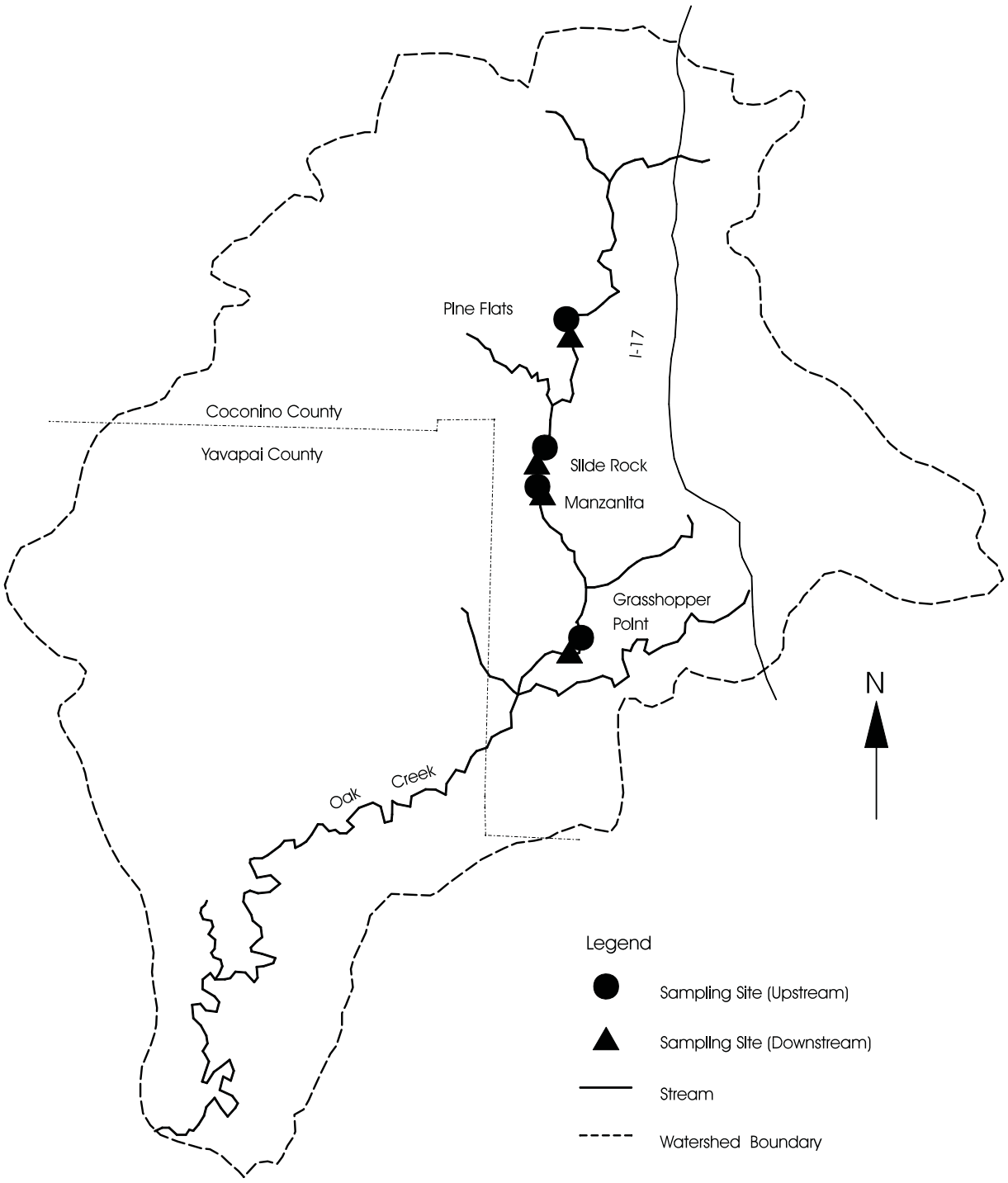

Figure 4: Water Quality Monitoring Stations for Oak Creek Canyon (Arizona)

PROJECT OVERVIEW

Oak Creek flows through the southern rim of the Colorado Plateau (Figure 3). The Oak Creek Canyon National Monitoring Project focused exclusively on that segment of water located in the canyon portion of Oak Creek, a 13-mile steep-walled area of the creek that extends from the Mogollon Rim to the city limits of Sedona. Although the Oak Creek Canyon watershed encompasses 5,833 acres, only 907 primarily recreational acres were considered to impact the water quality of Oak Creek within the Canyon.

The Oak Creek Section 319 National Monitoring Program Project focused on the implementation and documentation of integrated best management practice (BMP) systems for two locations: Slide Rock State Park and Pine Flats Campground. The eleven-acre Slide Rock State Park was used by more than 350,000 swimmers and sunbathers each season and Pine Flats Campground accommodated approximately 10,000 campers each season. Recreational use at both locations was thought to be the source of high fecal coliform and nutrient levels in Oak Creek.

The BMPs implemented at Slide Rock State Park and Pine Flats Campground included enhanced restroom facilities, better litter control through more intense monitoring by state park officials of park visitors, and the promotion of visitor compliance with park and campground regulations on use of facilities, littering, and waste disposal.

A modified nested upstream/downstream water quality monitoring design was used to evaluate the effectiveness of BMPs for improving water quality at Slide Rock State Park. Grasshopper Point, a managed water recreation area similar to Slide Rock State Park, served as the control. Water quality monitoring stations were located upstream and downstream of swimming areas at both Slide Rock (treatment) and Grasshopper Point (control). A similar monitoring design was also used for Pine Flats Campground and Manzanita Campground. Pine Flats Campground was the treatment site, while Manzanita served as the control site. Monitoring stations were upstream/downstream of campground sites. For these two studies, grab samples were taken weekly during the tourist season (May 15 through September 15) and monthly from November through April for four years. The Oak Creek National Monitoring Program Project has terminated as of June 30, 1998.

PROJECT BACKGROUND

Project Area

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

Relevant Hydrologic, Geologic, and Meteorologic Factors

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

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

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

Land Use

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

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

Water Resource Type and Size

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

The study sites for this project were located in Oak Creek Canyon. Steep canyons and rapid water flows characterize this portion of the watershed with sharp drops forming waterfalls and deep, cold pools. Oak Creek Canyon is the primary recreational area in the watershed.

Water Uses and Impairments

Designated beneficial uses of Oak Creek include full body contact (primarily in Oak Creek Canyon), cold water fishery and wildlife habitat (primarily Oak Creek Canyon), drinking water (along the entire course), agriculture (the lower third), and livestock watering (lower third).

Oak Creek was designated as a Unique Water by the Arizona State Legislature in 1991 on the basis of 1) its popularity and accessibility as a water recreation resource; 2) its aesthetic, cultural, educational, and scientific importance; and 3) its importance as an agricultural and domestic drinking water resource in the Verde Valley. Two other criteria were considered in the designation: 1) Oak Creek Canyon is susceptible to irreparable or irretrievable loss due to the ecological fragility of its location and 2) it is a surface water segment that can be managed as a unique water. Management considerations must include technical feasibility and the availability of management resources.

Indicator bacteria and excess nutrients pose the most serious and pressing current threats to Oak Creek water quality. Oak Creek water quality is impaired by high fecal coliform levels associated with the campgrounds and day-use swimming areas; bacteriological impairments coincide with peak recreational use from May through September. Residential septic systems, and natural and grazing animal populations may also contribute to water quality impairments.

Pollutant Sources

Pollutants in Oak Creek addressed in this study were believed to originate mainly from swimmers, campers, residences and animals in the watershed. Poor sanitation practices by recreational users and lack of adequate restroom facilities were initially cited as major sources of bacteria. Sediment fecal coliform analysis at one time suggested that the correlation between number of recreational users and high FC counts was a function of contaminated sediments being resuspended by recreational activity. Genotyping *Escherichia coli* isolates using Amplified Fragment Length Polymorphism (AFLP) (ADEQ Grant Agreement Number 99-0006) was performed to determine the source(s) of bacteria contamination. However, firm determination of the source(s) of the bacteria was never made.

Pre-Project Water Quality

Water Recreation and Camping Areas

Human pathogens (protozoa, bacteria, and viruses) contaminate the Canyon segment of Oak Creek. Most of the attention has focused upon Slide Rock State Park and Grasshopper Point, the two managed "swimming holes" in the area. Fecal coliform counts peak in the summer during the height of the tourist season. The seasonal deterioration of bacteriological water quality has been observed since 1973 by the AZ Department of Public Health and subsequent state and federal agency studies confirmed these results.

Fecal Coliform Levels During the Tourist Season (1993)

Date	Fecal Coliform Count (cfu/100 ml)
July	434
August	393
June	61
September	54

Water Quality Objectives

Water Recreation Project Objectives

- A 50% reduction in fecal coliform
- A 20% reduction in nutrients, particularly ammonia

Camping Project Objectives

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

Project Time Frame

1994 to 1998

PROJECT DESIGN

Nonpoint Source Control Strategy

Slide Rock and Grasshopper Point (Water Recreation Project)

Slide Rock State Park and the US Forest Service improved the access and ambience of the restroom facilities located at the Slide Rock swimming area. Public education programs promoting compliance with park regulations, including use of restroom facilities, were conducted. Based on casual observation, the rate of use has increased significantly over pre-improvement days. The USFS also replaced the old vault toilets at Grasshopper Point and constructed composting toilets. These have been well received by the public. At both swimming facilities, trash removal has improved with regular walks throughout the recreation area by staff of both the Park and the USFS. Control of visitor numbers was improved by parking restrictions on the adjacent state highway.

Pine Flats and Manzanita (Campgrounds Project)

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

Project Schedule

Site Name	Pre-BMP Monitoring	BMP Installation	Post-BMP Monitoring	BMP(s) Installed
Pine Flats Campground	May 1994 – Jan 1996	January 1996	Feb 1996 – March 1997	Educational Outreach
Slide Rock State Park	May 1994 – Jan 1996	Oct – Jan 1995-6	Feb 1996 – March 1997	Restroom improvements, trail improvement, post and cable installation on roadside to reduce parking, improve foot bridge, development of and posting of an operations and management strategy
Manzanita Campground	May 1994 – Jan 1996	Control Site	Feb 1996 – March 1997	Control Site for Pine Flats Campground
Grasshopper Point	May 1994 – Jan 1996	Control Site	Feb 1996 – March 1997	Control Site for Slide Rock State Park

Water Quality Monitoring

The water recreation project, which was a modified nested upstream/downstream monitoring design (Figure 4), was designed to document the change in water quality as a result of the application of BMPs. The swimming sites at Slide Rock State Park (treatment site) and Grasshopper Point (the control site) were compared. Water quality monitoring stations were located above and below each swimming area.

The camping area project also used an upstream/downstream monitoring design. Water quality monitoring stations were installed above and below both the camping area at Pine Flats (treatment site) and the site at Manzanita (control site).

The two-year BMP implementation phase entailed sampling protocols identical to those instituted in the calibration and project sampling phase. The objective of this monitoring phase was to demonstrate the extent to which land treatment reduced nonpoint source pollution.

Variables Measured

Biological (Critical Parameters)

Fecal coliform (FC) (water column and stream sediments)

Chemical and Others (Critical Parameters)

Ammonia (NH_3)
Nitrate (NO_3)
Phosphate (PO_4^-)

Covariates (Noncritical Parameters)

Water temperature
Stream flow
Number of users of the sites
Weekly precipitation
Alkalinity
Calcium (Ca^{2+})
Chloride (Cl^-)
Conductivity
Dissolved oxygen (DO)
Magnesium (Mg^{2+})
pH
Potassium (K^+)
Sodium (Na^+)

Sampling Scheme

Grab samples were collected weekly from May 15 through September 15 and monthly from November through April. Samples were taken in the deepest part of the stream at each sampling site.

The monitoring scheme for the projects is presented as follows.

Monitoring Scheme for the Oak Creek Section 319 National Monitoring Program Project

Design	Activity/Sites*	Critical Monitoring Parameters	Noncritical Covariates	Frequency	Time	Duration
Upstream/ downstream	**Water Recreation** Slide Rock (T) Grasshopper Point (C) **Camping** Pine Flats (T) Manzanita (C)	FC NH_3/NH_4^+ NO_3^- PO_4^{3-} BOD	Alkalinity Ca^{2+} Cl^- Conductivity DO Mg^{2+} pH K^+ Rainfall Na^+ Streamflow Visitor count Water temperature	9/15-5/15 monthly 5/15-9/15 weekly	10 am – 5 pm Saturdays	2 years pre-BMP 2 years BMP

* T = the treatment site; C = the control site

Modifications Since Project Start

The Slide Rock State Park parking lot study has been discontinued.

Progress To Date

The Oak Creek Task Force implemented the following BMPs:

Slide Rock State Park

- Enhanced access and ambience of restroom facilities
- Social strategies promoting compliance with Park regulations, including use of restroom facilities
- Preparation of kiosk warning swimmers of potential dangers of elevated bacteria counts
- Reduction in number of Park visitors by parking restrictions on State Hwy 89A

Pine Flats Campground

- Improved garbage collection
- Visitor education program

DATA MANAGEMENT AND ANALYSIS

Data Management and Storage

The project team submitted all raw data for storage in STORET and reported the project results in USEPA's Nonpoint Source Management System (NPSMS) software.

NPSMS Data Summary

Submitted to EPAS.

Final Results

The BMPs implemented at Slide Rock and Pine Flats resulted in limited improvement to the water quality of Oak Creek. It is important to locate the source of pollution so that appropriate measures can be taken to control the problem. However, identifying fecal coliform sources proved difficult. Slide Rock visitors are, undoubtedly, a source of pollution (i.e., discarding dirty diapers in the water and defecating in the water or on land nearby). However, visitor behavior cannot account for the cyclical nature of elevated bacteria in this area. High bacteria levels approaching the current water quality standard of 800 cfu/100 ml historically and during this project are typically detected during the July 15 to September 15 "monsoon season". If visitors were the sole source of elevated fecal pollution, then high levels should have occurred between Memorial Day and July 4, when visitor counts are as high as during the monsoon season. This has not occurred; therefore, there must be one or more other sources of fecal coliform.

Although efforts continue to identify the exact bacterial sources, it appears there are virtually no water quality violations in Oak Creek until the sediment plumes have been reinstated after the spring thaw and high water levels. Once the sediments are contaminated, agitation of the sediments by either

high flows or recreational users nearly always results in closure of the recreation areas. This loading of the sediments generally occurs at the end of June and beginning of July, resulting in closures early in July.

Genotyping of *E. coli* populations in Oak Creek by Northern Arizona University using amplified fragment length polymorphism (AFLP) helped to differentiate between human and animal sources of pollution.and revealed additional contributions to the fecal loading of Oak Creek. These included the tracking of a fecal plume from residences along the creek and sediment interstitial loading. Most importantly, by employing a watershed approach to water quality monitoring, the project determined that natural animal populations are responsible for a larger proportion of the fecal pollution in Oak Creek than humans are. Therefore, BMPs designed to address the historical misconception that recreational users are solely responsible for polluting Oak Creek cannot be expected to improve water quality. An important unidentified sediment reservoir of fecal pollution still remains in the upper reaches of Oak Creek Canyon. The success of the project in developing a high throughput method for bacterial genotyping and the development of an *E. coli* strain collection for the Oak Creek Watershed will facilitate future investigation of the pollution problems of Oak Creek.

INFORMATION, EDUCATION, AND PUBLICITY

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

The Oak Creek Advisory Committee, which was formed in 1992, involved federal, state, and local government agencies and private organizations such as Keep Sedona Beautiful and the Northern Audubon Society as well as several homeowner organizations. The committee met monthly to keep participants informed of current project activities and results, gain insights into areas of concern, and learn about the BMPs that are being implemented as part of the 319 National Monitoring Program.

Progress Toward Meeting Goals

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

- The U.S. Forest Service prepared a Public Education Plan for Slide Rock State Park and hired a public education specialist to continue and expand the public education effort.
- The Arizona State Parks staff has developed bi-lingual brochures and a three stage alert signage system, posted daily at the park, for the visitors.
- The USFS volunteer organization, Friends of the Forest, in conjunction with Slide Rock State Park, have developed and implemented an educational program aimed at school children and their parents that visit the recreational area. Programs were held for all of the elementary schools within a one-hour drive of Sedona and with a school from Tucson, AZ. In addition, road signs are being installed throughout the canyon alerting visitors to use toilets and take care of the creek. Messages were developed by the school children who participated in the education program. Finally, a promotional Public Announcement slide was produced by the Friends of the Forest. This "Help Keep Oak Creek Unique" slide will be shown before every movie in every movie theater in Northern Arizona during the intensive recreational use period.

TOTAL PROJECT BUDGET

The estimated budget for the Oak Creek Canyon Section 319 National Monitoring Program project for the life of the project was:

Funding Source ($)			
Federal	**State**	**Local**	**Total**
330,000	87,000	288,000	705,000

The Arizona Department of Environmental Quality decided not to fund the Oak Creek Canyon National Monitoring Program project after the funding from Region IX of the U.S. Environmental Protection Agency was discontinued (Spring, 1998).

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The Oak Creek Section 319 National Monitoring Program project complemented several other programs (federal, state, and local) located in the Verde Valley:

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

OTHER PERTINENT INFORMATION

None.

PROJECT CONTACTS

Administration

Susan Craig
Arizona Department of Environmental Quality
Nonpoint Source Unit
1110 W. Washington St.
Phoenix, AZ 850007
(602) 207-4509; Fax: (602) 207-4467
Internet: susan.craig@azdeq.gov

Land Treatment

Department of Biological Sciences
Northern Arizona University
Flagstaff, AZ 86011-5640

Water Quality Monitoring

Dr. Richard D. Foust
Department of Chemistry and Environmental Science
Northern Arizona University
Flagstaff, AZ 86011-5698
(520) 523-7077; Fax: (520) 523-2626
Internet: richard.foust@nau.edu

Statistical Analysis

Dr. Brent Burch
Mathematics
Northern Arizona University
Flagstaff, AZ 86011-5717
(520) 523-6875; Fax: (520) 523-5847
Internet: brent.burch@nau.edu