Michigan

Sycamore Creek Watershed
Section 319
National Monitoring Program Project

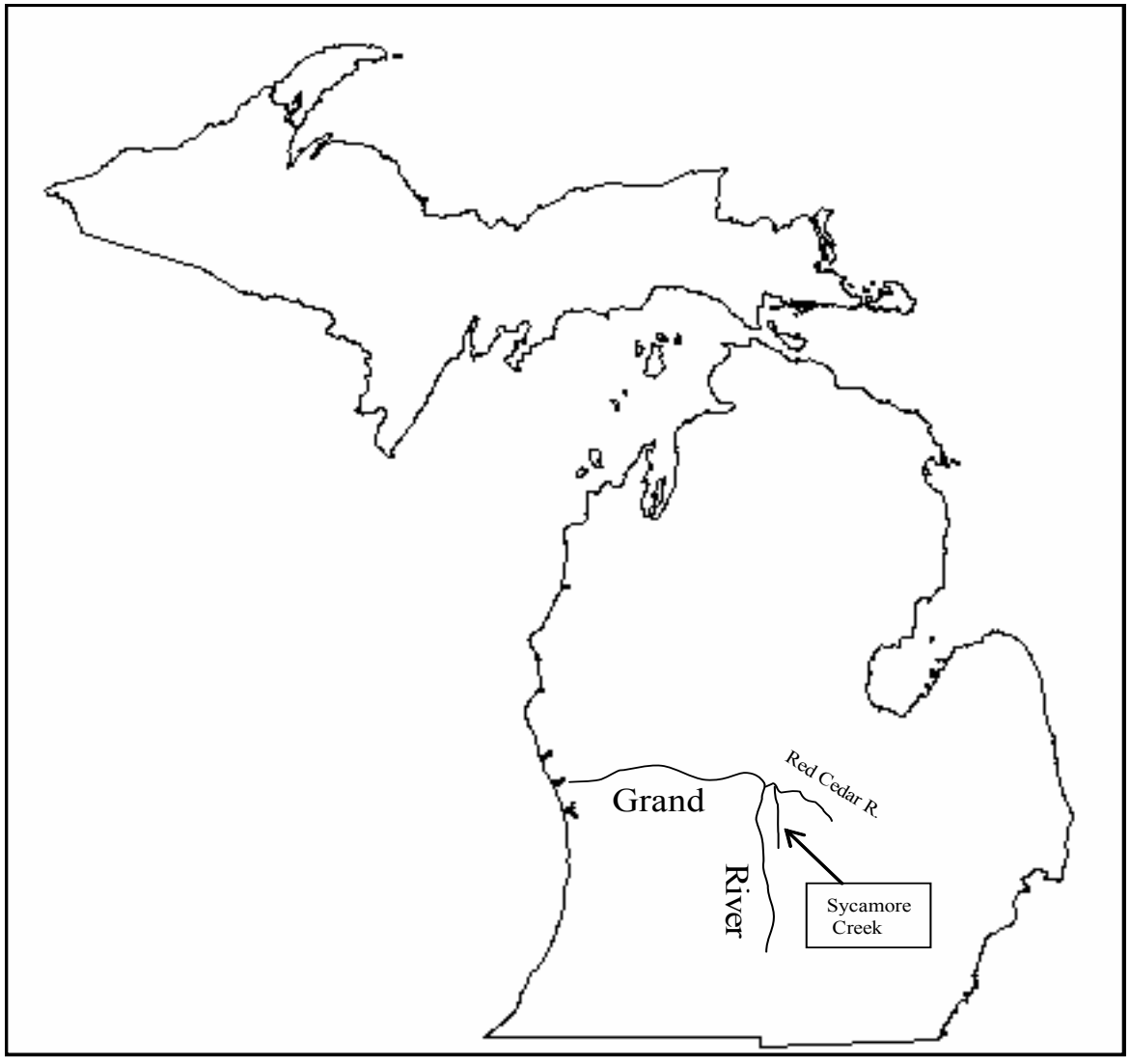

Figure 23: Sycamore Creek (Michigan) Project Location

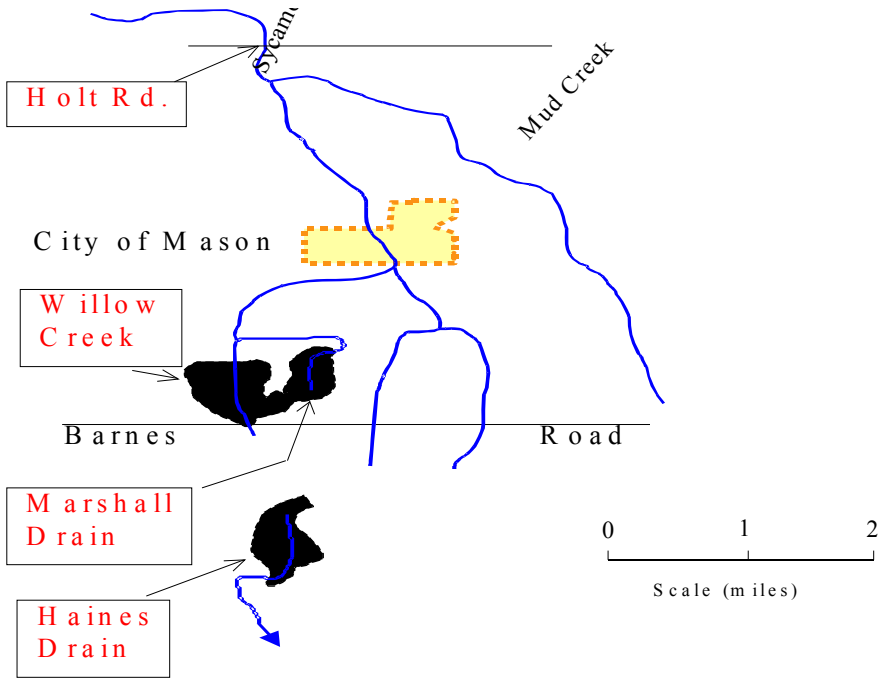

Figure 24: Paired Water Quality Monitoring Stations for the Sycamore Creek (Michigan) Watershed

PROJECT OVERVIEW

Sycamore Creek is located in southcentral Michigan (Ingham County) (Figure 23). The creek has a drainage area of 67,740 acres, which includes the towns of Holt and Mason, and part of the city of Lansing. The major commodities produced in this primarily agricultural county are corn, wheat, soybeans, and some livestock. Sycamore Creek is a tributary to the Red Cedar River, which flows into the Grand River. The Grand River discharges into Lake Michigan.

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

Water quality monitoring occured in three subwatersheds: Haines Drain, Willow Creek, and Marshall Drain (Figure 24). The Haines subwatershed, where best management practices (BMPs) were installed, served as the control and is outside the Sycamore Creek watershed. Stormflow and baseflow water quality samples from each watershed were collected from March through July of each project year. Water was sampled for turbidity, total suspended solids, chemical oxygen demand (COD), nitrogen (N), and phosphorus (P).

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

The Sycamore Creek Watershed NMP Project has terminated as of October, 1999.

PROJECT BACKGROUND

Project Area

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

Relevant Hydrologic, Geologic, and Meteorologic Factors

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

Land Use

Approximately 50% of the land in this primarily agricultural watershed is used for crops, forage, and livestock, but is experiencing a substantial increase in urban and suburban development.

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

Land Use	Acres	(%)
Agricultural	35,453	52
Forest	8,017	12
Residential	9,336	14

Business/Industrial	2,562	4
Idle	6,381	10
Wetlands	2,324	3
Transportation	1,349	2
Open land	826	1
Gravel pits and wells	806	1
Water	359	0.5
Other	325	0.5
Total	67,738	100

Source: NRCS/CES/FSA, 1990

Water Resource Type and Size

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

Water Uses and Impairments

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

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

Sycamore Creek was chosen for monitoring because of its central location in the state, its demonstrated water quality problems, and because it was considered representative of many southern Michigan agricultural watersheds.

Pollutant Sources

Agricultural fields, streambanks, and urban areas, are the most significant sources of sediment in the watershed.

Pre-Project Water Quality

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

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

Source: NRCS/CES/FSA, 1990

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

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

Water Quality Objectives

The water quality objective was to reduce the impact of agricultural nonpoint source pollutants on surface and ground water of Sycamore Creek.

The goal of the project was to reduce sediment delivery into Sycamore Creek by 52%, a reduction projected to solve the Creek's dissolved oxygen problem according to the TMDL analysis.

Project Time Frame

1993-1999

PROJECT DESIGN

Nonpoint Source Control Strategy

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

Critical areas for targeting BMPs were agricultural fields (cropland, hayland, or pasture) within one-half mile of a stream. Priority areas for streambank stabilization were defined as those locations where bank undercutting, coupled with bare channel banks and ground water seepage, were visibly contributing to the sediment load. Priority areas were chosen by the ICDC and consultants based on observations during several field visits.

Cropland BMPs included conservation tillage, conservation cropping sequence, crop residue use, pest management, nutrient management, waste utilization, critical area planting, and erosion control structures. Hayland BMPs consisted of conservation cropping sequence, conservation tillage, pest management, nutrient management, pasture/hayland management, and pasture/hayland planting. BMPs utilized on pastureland were conservation cropping sequence, conservation tillage, pasture/hayland management, pasture/hayland planting, fencing, waste utilization, filter strips, and critical area planting. The following practices were eligible for ACP funding:

- No till
- Permanent vegetative cover establishment
- Diversions
- Cropland protective cover
- Permanent vegetative cover on critical areas
- Sediment retention erosion or water control structure
- Sod waterways
- Integrated crop management
- Critical area planting
- Pest management
- Nutrient management

Streambank stabilization BMPs were also implemented. Measures were selected based on their effectiveness in reducing ground water seepage and slope instability. The techniques chosen for implementation on Willow Creek included brush mattresses, live fascines, fiber rolls, biolunkers, riprap, underdrain, slope reduction, vegetative plantings, tree/branch revetments, current deflectors, and rock cascades.

The Ingham County Drain Commission (ICDC) received an implementation grant under Section 319 of the Clean Water Act for the installation of streambank stabilization in Willow Creek (Figure 22). Innovative and environmentally sensitive techniques for streambank stabilization were selected to minimize the sediment load in Willow Creek.

Project Schedule

Site	Pre-BMP Monitoring	BMP Installation	Post-BMP Monitoring
Haines Drain	1990-95	1996	1997
Willow Creek	1990-95 1996		1997
Marshall Drain	1990-92	1993-94	1995-97

Water Quality Monitoring

A paired watershed design was used to document water quality changes in Sycamore Creek. Two subwatersheds within the project, Willow Creek and Marshall Drain, were compared to a control subwatershed, Haines Drain, that lies outside the boundaries of the project (Figure 22). BMPs were installed in the Haines Drain prior to the commencement of water quality monitoring in 1990.

Variables Measured

Biological

None

Chemical and Other

Total suspended solids (TSS)
Turbidity
Total phosphorus (TP)
Total Kjeldahl nitrogen (TKN)
Nitrate + nitrite (NO_3 + NO_2)
Chemical oxygen demand (COD)
Orthophosphate (OP)
Ammonia (NH_3)

Covariates

Rainfall
Flow
Erosion-intensity index

Sampling Scheme

A ~20-week sampling period was defined from snowmelt (approximately March) through the development of crop canopy (approximately July).

Samples were collected every one to two hours during storm events over the sampling period. For each location and storm, six to twelve samples were selected for analysis. Automatic stormwater samplers equipped with liquid level actuators were used.

Weekly grab samples were also taken for trend determination. Sampling began in March when the ground thaws and continued for the next 20 weeks.

A continuous record of river stage was obtained with Isco model 2870 flow meters. The river stage converted to a continuous flow record using a stage discharge relationship which was periodically updated by field staff of the Land and Water Management Division of the Michigan Department of Environmental Quality.

One recording rain gauge is installed in each agricultural subwatershed (Figure 22).

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

Design	Sites	Primary Parameters	Covariates	Frequency of WQ Sampling	Duration
Three-way W paired	illow Creek[T]	TSS Turbidity	Rainfall flow Erosion-intensity	Weekly for 20 samples starting	6 yrs pre-BMP 1 yr BMP
Ha	ines Drain[C]	TP TKN	index	after snow melt	1 yr post-BMP
M	arshall Drain [T]	NO 3 + NO2 OP NH3		Storm sampling until canopy closure)	3 yrs pre-BMP 2 yr post-BMP

[T] Treatment watersheds
[C] Control watershed

Land Treatment Monitoring

Land use and tillage practices were recorded annually by NRCS staff. A 10-acre grid was superimposed on a USGS topographic map for each subwatershed as a template for storing land use data in a spreadsheet. Practice installation and the effect on water quality was tracked using the database ADSWQ (Automatic Data System for Water Quality). The EPIC model (Erosion Productivity Index Calculator) was used to estimate changes in edge-of-field delivery of sediment, nutrients, and bottom of root zone delivery of nutrients resulting from BMP implementation.

Variables Measured

Land use was tracked on a 10-acre cell basis. Categories were crops and tillage practice, woods, residential, and mining (sand and gravel).

Modifications Since Project Start

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

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

An additional station was added in 1995 at the United States Geological Survey (USGS) gauging station at Holt Road. Sampling was conducted year round using a flow stratified strategy. The monitoring data from this station was used to determine the annual load of pollutants near the mouth of the stream and to compare these loads with various models for estimating pollutant loads in the watershed. Automatic sampling equipment was used to collect samples and the USGS flow data was used to determine loads. The parameters tested for were the same as the other three stations.

For purposes of data analysis, the experimental design was changed from a paired watershed to a before/after design. This was due to the fact that the control watershed was subject to land use changes. Accordingly, the control watershed was analyzed as a treatment watershed.

DATA MANAGEMENT AND ANALYSIS

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

NPSMS Data Summary

Summaries of quartile data from 1990 through 1993 are presented in the table below. These summaries include all data including storm event data for 1990-1993, base flow grab samples for 1990-1992, and weekly sampling in 1993. Differences can be seen among the watersheds, for example, stable flow and NO2+NO3 levels in Willow Creek compared to the other stations and the higher flows in Haines Drain compared to the other stations.

Monitoring Station Parameters Report

CHEMICAL PARAMETERS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

STATION NAME: Willow Creek (Treatment; 1087 acres) **YEAR:** 1993

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

Final Results

Data analysis was performed to detect changes or trends in water quality in the treatment watersheds and the control watershed. Because the control watershed (Haines Drain) had changing land use, and therefore was not a control watershed, analysis for change was performed on all three watersheds using streamflow as an explanatory variable.

A statistically significant reduction in sediment and total phosphorus load occurred in Willow Creek storm runoff over the eight years of monitoring. These reductions were 60% and 57% for total suspended solids and total phosphorus respectively. This water quality improvement was correlated with the percent of land in no-till.

No reductions were found in Haines Drain or Marshall Drain even though they had a greater increase in no-till land than did Willow Creek. This suggests that land management factors affecting the riparian zone may have an equal or greater effect on suspended sediment loads in these Grand River tributaries than no-till. The stream bank stabilization program implemented in Willow Creek may be responsible for the reduction in sediment and total phosphorus observed there. The adoption of no-till farming alone may not, therefore, accomplish major reductions in suspended solids loads, but when coupled with streambank erosion control, can result in significant reduction in sediment loads.

Weekly grab samples from Willow Creek indicated a downward trend in nitrate and nitrite concentration declining from an average of 2.3 mg/l in 1990 to 1.73 mg/l in 1997. This was a statistically significant difference and accounted for seasonal variation and streamflow. This trend may reflect adoption of soil testing and reduced nitrogen application as a result of the USDA water quality program.

Haines Drain exhibited an increase in nitrate and nitrite from an average of 2.8 mg/l in 1990 to 4.07 mg/l in 1997 after adjustment for seasonal variation and streamflow. The cause of this increase is unknown, but could be changes in fertilizer use or changes in cropping patterns.

One of the subwatersheds (Haines Drain) produced significantly more surface runoff and suspended solids load than did either of the other two subwatersheds., despite having similar soils and land use and lower average field slope. Because loading models frequently use these factors to estimate relative watershed loadings, this finding suggests that application of models to target nonpoint source control measures may need to be supplemented with stream monitoring data to verify results.

INFORMATION, EDUCATION, AND PUBLICITY

The Ingham County Cooperative Extension Service (CES) is responsible for all information and education (I&E) activities within the watershed. These I&E activities have been developed and were implemented as part of the Sycamore Creek HUA project. Activities included public awareness campaigns, conservation tours, media events such as news releases and radio shows, display setups, workshops, short courses, farmer-targeted newsletters, homeowner-targeted newsletters, on-farm

demonstrations, meetings, and presentations. Ingham County CES assists producers with nutrient management plans and integrated pest management.

1994 activities included:

- Ten on-farm demonstrations
- One watershed tour
- One watershed winter meeting
- Monthly newsletters for area farmers
- One homeowners' newsletter
- Twenty-five farm plans for nutrient and pesticide management

TOTAL PROJECT BUDGET

The estimated budget for the Sycamore Creek Watershed Section 319 National Monitoring Program project for the life of the project is:

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

Source: John Suppnick (Personal Communication), 1993

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

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

OTHER PERTINENT INFORMATION

Agencies involved in this project are as follows:

- USDA – Natural Resources Conservation Service (NRCS)
- Farm Service Agency (FSA)
- Michigan State University Extension – Ingham County
- Ingham County Health Department (Environmental Division)
- Ingham Conservation District

- Landowners within the Sycamore Creek watershed
- Michigan Department of Environmental Quality

PROJECT CONTACTS

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