U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 97–119

WATERSHED CHARACTERISTICS AND LAND MANAGEMENT IN THE NONPOINT-SOURCE EVALUATION MONITORING WATERSHEDS IN WISCONSIN

PHOTOS: OTTER CREEK EVALUATION MONITORING WATERSHED, FARM SERVICE AGENCY, 1991.

PREPARED IN COOPERATION WITH THE
WISCONSIN DEPARTMENT OF NATURAL RESOURCES

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By K.F. Rappold, J.A. Wierl, and F.U. Amerson

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Madison, Wisconsin
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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
6417 Normandy Lane
Madison, WI 53719–1133

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225–0286

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CONVERSION FACTORS

Multiply	By	To obtain
acre	0.4048	hectare
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
pound (lb)	453.6	gram
ton per year (ton/yr)	0.9072	megagram or metric ton per year
ton per acre per year (ton/acre/yr)	2.242	megagram per hectare per year
ton per stream mile per year (ton/mi/yr)	0.5638	megagram per kilometer per year

Temperature, in degrees Fahrenheit (°F) or degrees Celsius (°C) can be converted by use of the following equations:

$$°C = 5/9\ (°F - 32).$$
$$°F = 1.8\ °C + 32$$

Watershed Characteristics and Land Management in the Nonpoint-Source Evaluation Monitoring Watersheds in Wisconsin

By K.F. Rappold, J.A. Wierl, *and* F.U. Amerson

Abstract

In 1992, the Wisconsin Department of Natural Resources, in cooperation with the U.S. Geological Survey, began a land-use inventory to identify sources of contaminants and track the land-management changes for eight evaluation monitoring watersheds in Wisconsin. An important component of the land-use inventory has been developing descriptions and preliminary assessments for the eight watersheds. These descriptions establish a baseline for future data analysis. The watershed descriptions include sections on location, reference watersheds, climate, land use, soils and topography, and surface-water resources. The land-management descriptions include sections on objectives, sources of nonpoint contamination and goals of contaminant reduction, and implementation of best-management practices. This information was compiled primarily from the nonpoint-source control plans, county soil surveys, farm conservation plans, Federal and State agency data reports, and data collected through the land-use inventory.

INTRODUCTION

In 1990, the Wisconsin Department of Natural Resources (WDNR), in cooperation with the U.S. Geological Survey (USGS), initiated a comprehensive, multidisciplinary evaluation monitoring program to assess the effectiveness of the Wisconsin Nonpoint Source (NPS) Pollution Abatement Program. Eight small, rural watersheds, each within a priority watershed[1], were selected for monitoring (table 1; fig. 1). The evaluation monitoring program was designed to determine the effectiveness of using best-management practices (BMP's) in Wisconsin's priority watersheds. Biological and stream-habitat monitoring by the WDNR and water-quality monitoring by the USGS are done to quantify the improvements associated with BMP implementation. The monitoring is divided into three stages: "pre-BMP" conditions, transitional, and "post-BMP" conditions (table 2; Graczyk and others, 1993).

The original evaluation study design provided for a comprehensive analysis of biological, physical, and chemical attributes of the monitored streams; however, a need still existed for data on land-use changes and progress in the use of BMP's within the monitored watersheds. Information on the sources of nonpoint contamination and how these sources change with the implementation of BMP's is important to the interpretation of evaluation monitoring results. Thus, a land-use inventory was begun in 1992 to provide this necessary information on nonpoint contamination sources and BMP implementation. A detailed description of the land-use inventory and characteristics across the watersheds are presented in Wierl and others (1996).

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[1]The Wisconsin Nonpoint Source Pollution Abatement Program focuses on critical hydrologic units called priority watersheds. A nonpoint-source control plan is developed for a priority watershed by the WDNR, which describes the sources of nonpoint contamination and the contaminant-reduction goals.

Table 1. Features of the nonpoint-source evaluation monitoring watersheds in Wisconsin

[mi^2, square mile; mi, mile; USGS, U.S. Geological Survey; lat, latitude; long, longitude]

Feature	Evaluation monitoring watersheds							
	Brewery Creek	Garfoot Creek	Eagle Creek	Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek	Kuenster Creek
Priority watershed	Black Earth Creek	Black Earth Creek	Waumandee Creek	Waumandee Creek	East River	Sheboygan River	Lower Grant River	Lower Grant River
County	Dane	Dane	Buffalo	Buffalo	Brown	Sheboygan	Grant	Grant
Drainage area	10.5 mi^2	5.4 mi^2	[a]14.3 mi^2	5.9 mi^2	14.8 mi^2	9.5 mi^2	42.4 mi^2	9.6 mi^2
Stream length[b]	21.4 mi	10.6 mi	36.8 mi	16.2 mi	37.1 mi	13.0 mi	89.9 mi	21.2 mi
USGS sampling location	lat 43°07'09" long 89°38'25"	lat 43°06'37" long 89°40'46"	lat 44°12'34" long 91°40'42"	lat 44°12'54" long 91°39'54"	lat 44°25'21" long 87°56'24"	lat 43°47'20" long 87°55'20"	lat 42°46'49" long 90°56'32"	lat 42°47'27" long 90°57'26"
Predominant ecoregion[c]	Driftless area	Driftless area	Driftless area	Driftless area	Southeastern Wisconsin till plains	Southeastern Wisconsin till plains	Driftless area	Driftless area
Stream gradient[c]	High	High	High	High	High	Low	High	High
Fishery classification[c]	Warmwater forage	Coldwater sport	Coldwater sport	Coldwater sport	Warmwater forage	Warmwater forage	Warmwater sport	Warmwater forage
Initial stream-chemistry monitoring water year[d e]	1985	1985	1990	1990	1991	1991	1992	1993
Initial biological[b f] monitoring year	1985[g]	1985[f]	1990[c]	1990[c]	Not done	1990[c]	1991[c]	1991[c]

[a]Joos Valley Creek discharges into Eagle Creek.

[b]Stream length includes perennial and intermittent streams digitized from 1:24,000 quadrangle map.

[c]Wisconsin Department of Natural Resources, 1995a.

[d]Stream-chemistry monitoring entails sampling of base-flow periods and storms for water-quality data (Holmstrom and others, 1991–96).

[e]Water year in U.S. Geological Survey reports is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending September 30, 1995, is called water year 1995.

[f]The year that biological monitoring (fish community and physical habitat) was initiated.

[g]Field and Graczyk, 1990. Water-quality monitoring conducted from October 1984 to September 1986 and from October 1989 to current year.

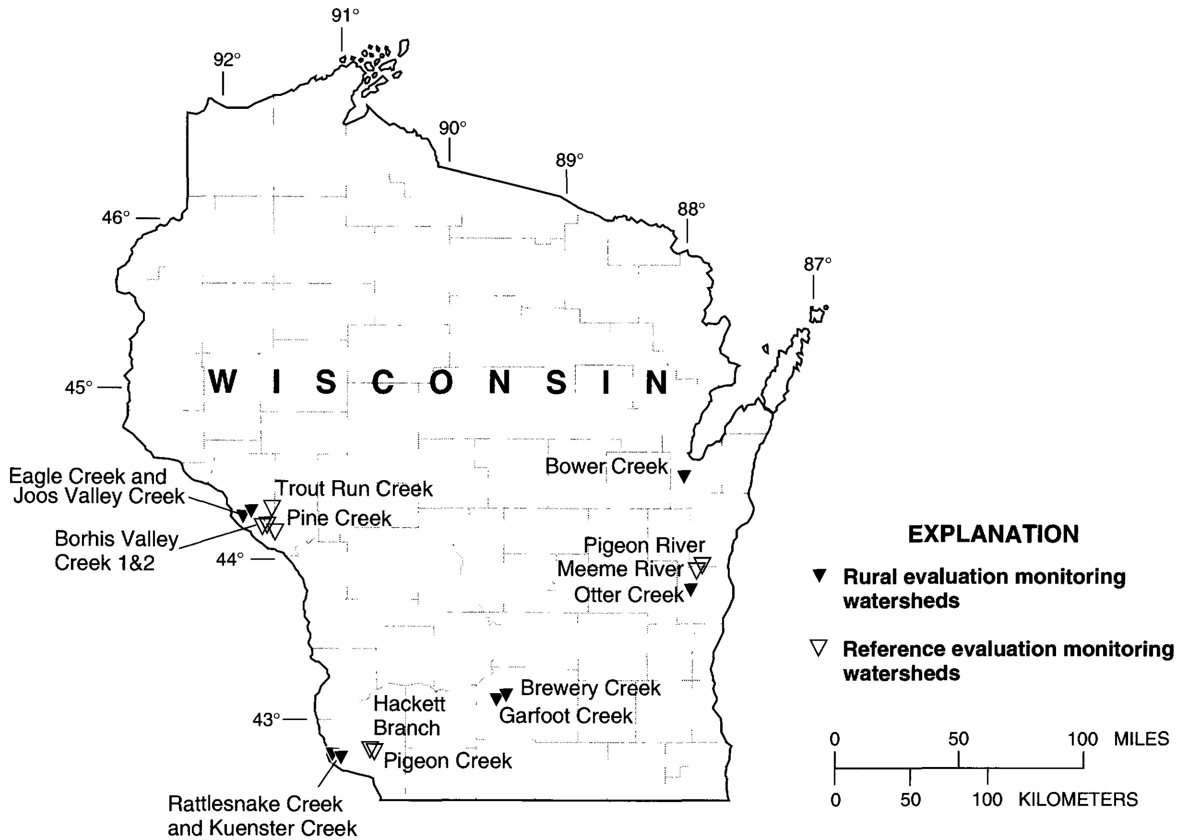


Figure 1. Locations of nonpoint-source evaluation monitoring watersheds and reference watersheds in Wisconsin.

This report describes the characteristics of the eight evaluation monitoring watersheds and the status of BMP implementation in each watershed. These descriptions are followed by a brief summary and list of land-use inventory activities planned for water year 1997.

WATERSHED CHARACTERISTICS AND LAND MANAGEMENT

The following watershed descriptions were developed for each of the evaluation monitoring watersheds to establish a baseline for future data analysis. Each watershed description includes sections on location, reference watersheds, climate, land use, soils and topography, and surface-water resources. The land-management descriptions include sections on objectives, sources of nonpoint contamination and goals of contaminant reduction, implementation of BMP's, signs-of-success sites, and single-source sites. These descriptions were compiled primarily from the nonpoint-source control plans, county soil surveys, farm conservation plans, USGS water-quality and climate data, National Oceanic and Atmospheric Administration (NOAA) climate data, WDNR biological reports, and data collected by the land-use inventory team.

Each nonpoint-source control plan contains descriptive sections on an evaluation monitoring watershed[2] (table 1). These plans document watershed characteristics (for example, land use, soils, and topography) and land management (for example, sources of nonpoint contamination and BMP eligibility criteria). In addition, the nonpoint-source control plans list the condition of surface-water resources and objectives for these resources.

[2]The boundaries for the evaluation monitoring watersheds do not always correspond with the subwatershed delineations designated by the WDNR.

Table 2. Milestone dates for project selection, watershed assessment, plan approval, signup period, end of BMP funding, pre-BMP period, transitional period, and post-BMP period for nonpoint-source evaluation monitoring watersheds in Wisconsin

[BMP, best–management practice; WDNR, Wisconsin Department of Natural Resources; LCD, Land Conservation Department]

Milestone	Evaluation monitoring watersheds							
	Brewery Creek	Garfoot Creek	Eagle Creek	Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek	Kuenster Creek
Project selected[a]	1985	1985	1985	1985	1986	1985	1986	1986
Watershed assessment[a]	1986–87	1986–87	1987–88	1987–88	1988–90	1987–88	1989–90	1989–90
Plan approved[a]	1989	1989	1990	1990	1991	1991	1991	1991
Signup period[b]	March 1989–February 1994	March 1989–February 1994	March 1990–December 2000	March 1990–December 2000	September 1991–December 1996	June 1991–May 1997	October 1991–October 1997	October 1991–October 1997
End of BMP funding[b]	February 1997	February 1997	December 2000	December 2000	December 1999	December 1999	October 1999	October 1999
Pre-BMP period[c]	Prior to October 1989	Prior to September 1989	Prior to September 1993	Prior to September 1992	Prior to November 1992	Prior to September 1993	Prior to May 1993	Prior to June 1994
Transitional period[c]	November 1989–1997	October 1989–1995	October 1993–2000	October 1992–2000	December 1992–1999	October 1993–1996	June 1993–1996	July 1994–1998
Post-BMP period[c]	After 1997	After 1995	After 2000	After 2000	After 1999	After 1996	After 1996	After 1998

[a]All years listed correspond with priority watershed plans.

[b]All years listed were obtained from the WDNR and the local LCD's.

[c]All years listed were designated by the evaluation monitoring team with information obtained from the WDNR and the local LCD's. The post-BMP and transitional periods may be changed, if all the BMP's are implemented before the date listed.

Information from other sources, collected by the land-use inventory team, augment or update descriptions contained in the plans. For example, surface-water resource conditions have been updated with the most recent information from WDNR biological monitoring reports.

For the climate description, data were extracted from annual reports produced by the USGS and NOAA (table 3). These data provide a means for comparing climatic conditions during the monitoring period with long-term averages. Land-use/land-cover, soils, and topographic information are stored in a geographic information system[3] (GIS). The GIS coverages were established with data found in the nonpoint-source control plans, county soil surveys, farm conservation plans, and inventories done by the land-use inventory team. The GIS facilitates various types of analysis and map preparation.

In the section on nonpoint contamination sources and contaminant-reduction goals (table 4; table 5), the land-use inventory team updated the barnyard loadings with data received from the local county Land Conservation Departments (LCD's). Barnyard loadings are estimated with the WDNR's BARNY model[4]. In addition, upland sediment loadings for some of the evaluation monitoring watersheds are being estimated with the WINHUSLE model[5], and most of the evaluation monitoring watersheds have been inventoried for streambank and gully erosion.

In the BMP implementation section (table 6; table 7), the information listed was obtained from the LCD's and the WDNR and was extracted in part from the nonpoint-source control plans.

[3]GIS is an interactive system that links geographical data with tabular data. The geographic data are stored in spatial data layers called coverages.

[4]BARNY is a modified version of the United States Department of Agriculture, Agriculture Research Service feedlot runoff model (Wisconsin Department of Natural Resources, 1994b). Storm-event and annual loadings are estimated for phosphorus and chemical oxygen demand (COD).

[5]The WINHUSLE model is the successor to the WIN model, which was used to estimate the original upland sediment loadings (Wisconsin Department of Natural Resources, 1994a). WINHUSLE includes an instream sediment-deposition component not available with the WIN model.

Animal-waste management practices and streambank BMP's are verified with currently available data. The upland BMP's will be verified in the future with information collected on annual land management; this information will be compared with the management practices listed in the farm conservation plans. If current data are not available, sediment reductions achieved by implementing upland BMP's will be estimated with the WINHUSLE model or with data received from the LCD's. Compilations of BMP status (table 7) summarize only the upland BMP's listed on cost-share agreements; the total upland practices implemented will be greater because of concurrent farm conservation planning. The status of BMP implementation will be updated annually and published in annual progress reports (Walker and others, 1995).

To help determine the effectiveness of BMP's, the study team has included three additional components in the evaluation monitoring program. These include reference watersheds, signs-of-success sites, and single-source sites. Seven rural watersheds were selected to function as references for the monitored watersheds (table 8). Land characteristics of these reference watersheds are similar to those in the monitored watersheds, but BMP's will not be implemented because the watersheds are not within a priority watershed[6]. The seven reference watersheds will serve as a baseline for measuring changes in streamwater quality that result from BMP implementation in the monitored watersheds.

A signs-of-success site was selected for one of the evaluation monitoring watersheds by the WDNR and the local county LCD (Wisconsin Department of Natural Resources, 1995). Signs-of-success sites are intended to provide some short-term evidence that improved land management benefits streamwater quality and stream habitat. Each signs-of-success site may include various practices, such as barnyard runoff control, manure storage, or streambank protection. Biological and water-quality monitoring is done just prior to implementation and for a short time after the practice is implemented.

[6]The Meeme River and Pigeon River Watersheds will be part of a priority watershed.

Table 3. Climatic and surface-water conditions in nonpoint-source evaluation monitoring watersheds in Wisconsin

[in., inches; WY, water year; N/A, information not available because sampling not started or discontinued; °F, degrees Fahrenheit]

Condition	Evaluation monitoring watersheds							
	Brewery Creek	Garfoot Creek	Eagle Creek	Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek	Kuenster Creek
Annual rainfall (in.)[a]	WY[b]91 29.25 WY92 30.70 WY93 45.00 WY94 25.30 WY95 25.31	WY91 28.14 WY92 30.99 WY93 45.25 WY94 27.16 WY95 30.31	WY91 29.55 WY92 31.03 WY93 38.82 WY94 27.13 WY95 23.17	WY91 29.38 WY92 31.27 WY93 34.59 WY94 28.27 WY95 23.16	WY91 21.16 WY92 25.16 WY93 32.51 WY94 23.00 WY95 N/A	WY91 24.05 WY92 22.98 WY93 32.03 WY94 19.38 WY95 20.16	WY91 30.39 WY92 29.40 WY93 43.34 WY94 28.71 WY95 27.97	WY91 N/A WY92 27.72 WY93 43.47 WY94 28.54 WY95 27.32
Average annual rainfall (in.)[c]	31.1	32.4	29.9	29.3	25.5	23.7	32.0	31.2
Frost-free days[d]	130–200	130–200	140–200	140–200	140–180	140–180	145–180	145–180
Average air temperature[e]	46.0°F	46.0°F	46.6°F	46.6°F	45.2°F	45.6°F	45.2°F	45.2°F
Long-term average air temperature[f]	46.2°F	46.2°F	45.3°F	45.3°F	43.8°F	45.8°F	46.1°F	46.1°F
Range of average monthly air temperature	17.6–70.1°F	17.6–70.1°F	16.6–71.9°F	16.6–71.9°F	17.1–69.6°F	17.7–71.0°F	15.1–70.3°F	15.1–70.3°F
Long-term range of average monthly air temperature	16.5–71.7°F	16.5–71.7°F	13.0–72.9°F	13.0–72.9°F	14.3–69.7°F	17.5–71.1°F	15.3–72.0°F	15.3–72.0°F
Average stream temperature[g]	50.0°F	48.2°F	48.4°F	49.3°F[h]	49.3°F	9.6°F	50.7°F	51.8°F

[a]Holmstrom, B.K., and others, 1991–96, Water resources data, Wisconsin, water years 1990–95.

[b]Water year in U.S. Geological Survey reports is the 12–month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending September 30, 1995, is called water year 1995.

[c]Calculated from annual rainfall amounts for water years 1991–95.

[d]Natural Resources Conservation Service soil interpretation records.

[e]U.S. Department of Commerce, 1990–95, Climatological data, Wisconsin—Annual summary with comparative data. Average air temperature and range of average monthly air temperature were calculated for the monitoring period 1990–95 (Rattlesnake and Kuenster were calculated for the monitoring period 1991–95). The climate station most proximate to an evaluation monitoring watershed was selected.

[f]U.S. Department of Commerce, 1990–95, Climatological data, Wisconsin—Annual summary with comparative data. Long-term average air temperature and range of average monthly air temperature are based on the period 1951–90.

[g]U.S. Department of Commerce, 1990–95, Climatological data, Wisconsin—Annual summary with comparative data. Average stream temperature was calculated from averaging individual water year temperatures.

[h]Includes the water years 1990–94 only.

Table 4. Nonpoint sources of contaminants in nonpoint-source evaluation monitoring watersheds

[lb, pounds; ton/acre/yr, tons per acre per year; --, not inventoried; ton/mi/yr, tons per stream mile per year; %, percent; N/A, information not available; updated from Wierl and others, 1996]

Contaminant source	Evaluation monitoring watershed					
	Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
			Contaminant sources quantified in nonpoint-source control plans			
Barnyards (phosphorus load)[a]	559 lb	204 lb	463 lb	826 lb	80 lb	5,742 lb
Upland erosion (soil loss/sediment)[b]	12.40 ton/acre/yr --	13.46 ton/acre/yr --	6.1 ton/acre/yr .14 ton/acre/yr	-- 0.21 ton/acre/yr	4.5 ton/acre/yr .18 ton/acre/yr	-- 0.39 ton/acre/yr
Streambank erosion	Minimal	Minimal	58 ton/mi/yr	94 ton/mi/yr	4.1 ton/mi/yr	53 ton/mi/yr
Gully erosion	--	--	--	1,590 tons per year[c]	--	--
Urban	5–10% of sediment from construction sites	--	--	--	--	--
			Contaminant sources quantified through the land-use inventory			
Streambank erosion	Minimal	Minimal	30 ton/mi/yr	44 ton/mi/yr	N/A[d]	29 ton/mi/yr
Gully erosion	Minimal	Minimal	Minimal	N/A[d]	Minimal	N/A[d]

[a]Based on the modified Agricultural Research Service Barnyard Runoff Model (BARNY, 10-year, 24-hour storm event). Barnyard loadings were updated by the local LCD's.
[b]Soil loss and sediment delivery estimated with the Wisconsin Nonpoint Model (WIN). The WIN model calculates the average annual quantity of eroded soil that reaches surface waters.
[c]Gully erosion for entire priority watershed subwatershed.
[d]Watershed not inventoried in 1995; will be completed in 1996.

Table 5. Contaminant-reduction goals for nonpoint-source evaluation monitoring watersheds

[Evaluation monitoring watersheds may be divided into subwatersheds (such as upper and lower Bower for the Bower Creek evaluation monitoring watershed); %, percent]

Contaminant source	Contaminant-reduction goals for evaluation monitoring watersheds					
	Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
Total phosphorus:	50%	50%	70%	70%	50%	75%
Barnyards	75%	75%	Eagle, 70%; Joos Valley, 50%	Upper Bower, 85%; Lower Bower, 83%	50%	75%
Winter manure spreading	25–50%	25–50%	70%	70%	Not identified	75%
Total sediment:	50%	50%	50%	50%	50%	Not identified
Uplands	75%[a]	75%[a]	50%	50%	50%	30%
Streambanks	Minimal	Minimal	Eagle, 80%; Joos Valley, 60%	50%	Victory School, 50%; Wayside Park, 75%	50%

[a]The soil-erosion reduction needed to achieve the sediment reduction goal.

Table 6. Eligibility criteria for priority watershed funds and management categories for the nonpoint-source evaluation monitoring watersheds

[Evaluation monitoring watersheds may be divided into subwatersheds (such as upper and lower Bower for the Bower Creek evaluation monitoring watershed); lb, pounds; --, no criteria set; >, greater than; <, less than; ft/yr, foot per year; ft^2/yr, square foot per year; ≥, greater than or equal to]

Contaminant source	Evaluation monitoring watersheds					
	Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
Barnyards: Phosphorus-control target[a]	5 lb	5 lb	5 lb	Upper Bower, 10 lb Lower Bower, 5 lb	Little Elkhart, no barnyards Victory School, 5 lb Wayside Park, 4 lb	15 lb
Winter manure spreading: Management Category I	Plans prepared for all livestock operations	Plans prepared for all livestock operations	15 acres or more	10 acres or more	15 acres or more	15 acres or more
Management Category II[b]	--	--	--	3 to 9.9 acres	7 to 15 acres	10 to 14 acres
Upland erosion (sediment delivery and soil loss, in tons per acre per year): Management Category I	7 or more	7 or more	>0.3 and >T[c]	>0.11 and >T – 1	Little Elkhart, >0.10 and >3 Victory School, >0.21 and >3 Wayside Park, >0.20 and >3	>0.15 and >T
Management Category II	--	--	--	>0.11 and <T – 1	Little Elkhart, >0.10 and <3 Victory School, >0.21 and <3 Wayside Park, >0.20 and <3	>0.15 and <T <0.15 and >T
Streambank erosion: Management Category I	Rate of recession: 0.1 ft/yr and rate of recession times height: 0.3 ft^2/yr	Rate of recession: 0.1 ft/yr and rate of recession times height: 0.3 ft^2/yr	All project participants must restrict livestock access to perennial creeks where there is evidence of trampling, damaged streambeds, or eroded streambanks. All participants with identified eroding sites must reduce streambank erosion.	Each participant with streambank erosion accelerated by livestock access must control streambank erosion.	All project participants must restrict livestock access to perennial creeks where there is evidence of trampling, damaged streambeds, or eroded streambanks. Sites without livestock, but having eroding sites, must also be controlled.	Streambank erosion control measures and cattle access restrictions are required where there is active streambank erosion and (or) unrestricted livestock access to a stream.
Management Category II				Sites without livestock access, but having 10 or more tons of sediment must also be controlled.		
Gully erosion: Management Category I	--	--	(1) Gully depths >5 ft, (2) bare soils and active erosion, (3) gully is directly connected to a perennial stream by channelized flow.	3 or more tons	--	(1) Gully depths ≥5 ft, (2) bare soils and active erosion, (3) direct connection with streams via channelized flow during runoff events, (4) reasonable access to necessary machinery.
Management Category II	--	--	--	Less than 3 tons	--	Site <5 ft and all of the other criterium listed for Management Category I.

[a]Based on the modified Agricultural Research Service Barnyard Runoff Model (BARNY, 10-year, 24-hour storm event).
[b]Wierl and others (1995) describes the management categories.
[c]T is the maximum average annual erosion rate consistent with sustaining the soil's long-term productivity.

Table 7. Summary of eligible, contracted, and implemented rural BMP's in nonpoint-source evaluation monitoring watersheds

[ft, feet; BMP's, best-management practices. Table contains revisions to a BMP table previously published in Walker and others (1995), which are the result of changes in practices eligible, contracted, or implemented. Data are numbers of sites unless otherwise noted]

Practice	Evaluation monitoring watershed					
	Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
Animal-waste management						
Eligible manure storage	0	0	7	6	3	60[a]
Contracted manure storage	0	0	3	6	3	3
Implemented manure storage	0	0	1	4 (17 others from previous farm programs)	2	1
Eligible barnyard-runoff control systems	20	7	18 (includes 1 barnyard sold)	32	8	104
Contracted barnyard-runoff control systems	11[b]	6	8	12	8	15 (includes 1 sold)
Implemented barnyard-runoff control systems	9 (5 barns no longer have livestock)	5 (one system installed, but livestock now sold)	1	5	7	10
Streambank protection						
Eligible streambank protection[c]	22,000 ft	16,800 ft	28,100 ft	2,320 ft	7,000 ft	255,000 ft[a]
Contracted streambank protection[d]	22,000 ft	16,800 ft	8,273 ft	0	0 ft	1,730 ft
Implemented streambank protection[d]	19,100 ft	16,700 ft	323 ft	0	0 ft	1,605 ft
Contracted fencing	1,200 ft	5,475 ft	25,165 ft	625 ft	9,200 ft	0
Implemented fencing	Sites no longer with livestock	5,475 ft	3,127 ft	625 ft	9,200 ft	0
Contracted stream crossing	1	4	11	1	3	2
Implemented stream crossing	1	4	1	1	3	2
Contracted grade stabilization	2	0	8	0	3	0
Implemented grade stabilization	Sites no longer with livestock	0	5	0	3	0
Upland management						
Eligible nutrient management	2,440 acres	592 acres	990 acres	4,020 acres	1,130 acres	2,980 acres[a]
Contracted nutrient management	903 acres	156 acres	554 acres	1,080 acres	1,282 acres	274 acres[a]
Implemented nutrient management	775 acres	156 acres	0	387 acres	1,152 acres	274 acres[a]
Eligible upland BMP's[d]	5,170 acres[a]	1,520 acres[a]	2,140 acres[a]	4,480 acres	851 acres	17,400 acres[a]
Contracted upland BMP's[d]	1,143 acres	221 acres	7	99 acres	2 acres	701 acres
Implemented upland BMP's[d]	1,143 acres	221 acres	0	77 acres	1 acre	49 acres

[a]An estimate derived from the nonpoint-source control plan.

[b]Total includes a barnyard-control system to be installed by a landowner without cost-share funding.

[c]The contract for length of streambank protection reflects the total length of each practice. One eroded site can include several practices, such as riprap, shoreline and streambank stabilization, and shoreline buffers. Both banks may have been eroded, contracted, or implemented with BMP's.

[d]Includes an individual practice or series of practices, other than nutrient management, that result in a reduced pollutant source, such as contour farming, contour strip cropping, field strip cropping, grassed waterways, and reduced tillage.

Table 8. Features of the reference watersheds for the nonpoint-source evaluation monitoring watersheds

[mi^2, square mile; mi, mile; USGS, U.S. Geological Survey; lat, latitude; long, longitude]

Feature	Evaluation monitoring reference watersheds						
	Meeme River	**Pigeon River**	**Hackett Branch**	**Pigeon Creek**	**Bohris Valley Creek**	**Pine Creek**	**Trout Run Creek**
Corresponding evaluation monitoring watershed	Otter Creek	Otter Creek	Kuenster Creek	Rattlesnake Creek	Eagle Creek and Joos Valley Creek	Eagle Creek and Joos Valley Creek	Eagle Creek and Joos Valley Creek
County	Manitowoc	Manitowoc	Grant	Grant	Buffalo	Trempealeau	Trempealeau
Drainage area	16.7 mi^2	16.0 mi^2	8.3 mi^2	20.9 mi^2	Bohris-2[a], 4.8 mi^2 Borhis-1, 9.5 mi^2	10.4 mi^2	7.7 mi^2
Stream length[b]	25.1 mi	16.3 mi	43.3 mi	36.6 mi	Bohris-2, 13.0 mi Bohris-1, 22.5 mi	14.2 mi	16.4 mi
USGS sampling location	lat 43°55'20" long 87°48'45"	lat 43°53'36" long 87°51'25"	lat 42°48'47" long 90°50'17"	lat 42°47'10" long 90°48'58"	Bohris-2, lat 44°08'37" long 91°35'41"; Bohris-1, lat 44°08'44" long 91°35'50"	lat 44°06'42" long 91°31'07"	lat 44°12'49" long 91°34'07"
Predominant ecoregion[c]	Southeastern Wisconsin till plains	Southeastern Wisconsin till plains	Driftless area	Driftless area	Driftless area	Driftless area	Driftless area
Stream gradient[c]	Low	Low	High	High	High	High	High
Fishery classification[c]	Warmwater forage	Warmwater forage	Warmwater forage	Warmwater sport	Coldwater sport	Coldwater sport	Coldwater sport
Initial stream-chemistry monitoring water year[d e]	1993	1993	1993	1993	1993	1993	1993
Initial biological monitoring year[c f]	1990	1990	1991	1991	1990	1990	1990

[a]The drainage areas reflect the two sampling locations on Bohris Valley Creek. Bohris-2 discharges into Bohris-1.

[b]Stream length includes perennial and intermittent streams digitized from 1:24,000 quadrangle map.

[c]Wisconsin Department of Natural Resources, 1995a.

[d]Water year in U.S. Geological Survey reports is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending September 30, 1995, is called water year 1995.

[e]Stream-chemistry monitoring entails sampling of both base-flow periods and storms for water-quality data (Holmstrom and others, 1991–96).

[f]The year biological monitoring (fish community and physical habitat) was initiated.

A single-source site was selected in one of the evaluation monitoring watersheds by the WDNR and the local county LCD (Stuntebeck, 1995). At single-source sites, water-quality monitoring stations are upstream and downstream from a site selected for BMP implementation. Water-quality data are collected for a representative period before and after implementation. Data from the pre-BMP period are compared with data from the post-BMP period to determine the effectiveness of the BMP's implemented. Currently, all the single-source sites involve the assessment of barnyard runoff BMP's.

Brewery Creek Watershed

The following information on the Brewery Creek Watershed was taken primarily from the Black Earth Creek Priority Watershed Plan (Wisconsin Department of Natural Resources, 1989).

Watershed Characteristics

Location. The Brewery Creek Watershed is in Dane County, 10 mi northwest of Madison, in south-central Wisconsin (fig. 1). It is part of the Black Earth Creek Priority Watershed, as designated by the WDNR. Brewery Creek flows into Black Earth Creek, and Black Earth Creek discharges to Blue Mounds Creek, which eventually flows into the lower Wisconsin River. The drainage area of Brewery Creek is 10.5 mi^2, 2.8 mi^2 of which is noncontributing (Holmstrom and others, 1996). Brewery Creek's main channel is 6.1 mi long. The total length of monitored streams in the watershed is 21.4 mi. Water-quality monitoring at the USGS station on Brewery Creek at Cross Plains (fig. 3) was begun in 1989.

Reference Watersheds. Brewery Creek Watershed does not have a reference site because it is not biologically monitored.

Climate. The climate of the Brewery Creek Watershed is continental: winters are cold and snowy, and summers are warm and humid. Since 1990, the average annual air temperature recorded at Charmany University Farms in Madison, Wis. (10 mi southeast of watershed), has been 46.0°F, and the range of average monthly air temperatures has been 17.6 to 70.1°F (table 3; U.S. Department of Commerce, 1990–95). In Dane County, the growing season usually starts about April 26 and ends about October 19. The average number of frost-free days is about 176 annually (Glocker and Patzer, 1978).

Beginning with water year 1991, the average annual rainfall has been 31.1 in. Variations in annual rainfall for water years 1991–95 are listed in table 3. Greater than 50 percent of the rain falls from June through September, and only about 3 percent from December through February. Average runoff was 4.32 in. at the Brewery Creek water-quality monitoring station for water years 1991–95 (Holmstrom and others, 1996).

Land Use. In the Brewery Creek Watershed, the land-use inventory covers an area of 6,720 acres. Cropland accounts for 56.6 percent of the land use/land cover in the watershed (fig. 2). Woodlands, at 22.2 percent, are the second largest land use/land cover. There are 53 farms in the watershed. Average farm size is 136 acres, with an average of 98 acres in crop production. A total of 21 barnyards are in the watershed, 5 no longer have livestock and 1 is not eligible for BMP implementation. The average livestock herd for these barnyards is 104 animals; 89 percent of all animals in the watershed are dairy cows (Dane County Land Conservation Department, written commun., 1992). The south end of the watershed lies within the village of Cross Plains, a growing residential area.

Soils and Topography. Soils in the Brewery Creek Watershed were formed in glacial till, outwash, and lacustrine sediment. The Dodge-St. Charles-McHenry association is the major soil association in the watershed. These soils are moderately well drained to well drained and have formed mainly in eolian deposits of silt loam underlain by sandy loam glacial till (Glocker and Patzer, 1978).

Kidder soils, McHenry silt loam, Dodge silt loam, and Seaton silt loam cover approximately 75 percent of the watershed (table 9). These soils are primarily found on glaciated uplands and consist of deep, well-drained, gently sloping to very steep soils. The remaining soils are also predominantly silt loams and are found on drainageways, stream valleys, and uplands.

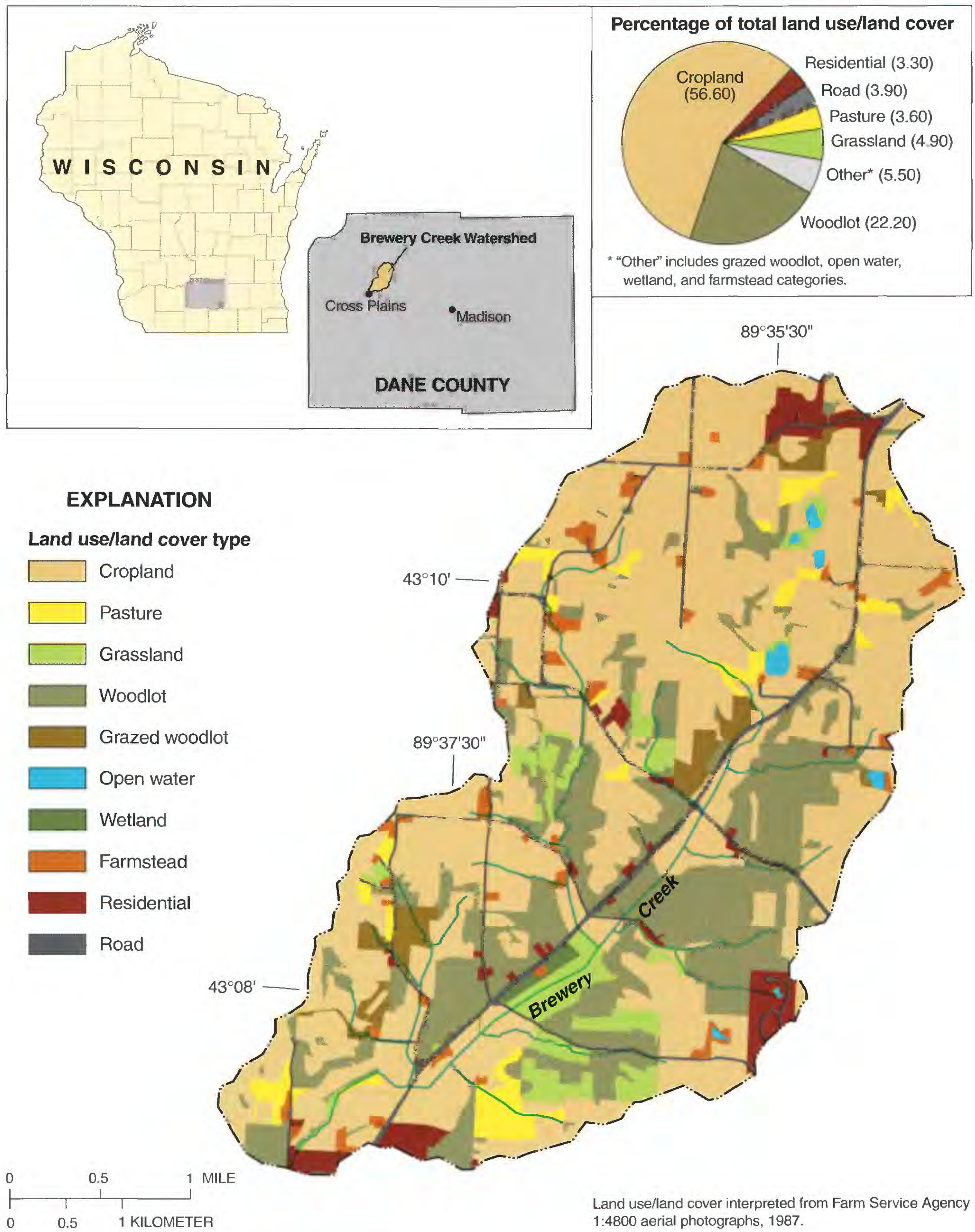


Figure 2. Land use/land cover, Brewery Creek Watershed.

Table 9. Soil series and their distribution by slope, Brewery Creek Watershed

[>, greater than]

Soil series	Percentage of watershed in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Kidder soils	37	0	0	27	49	24	0
McHenry silt loam	17	0	0	71	29	0	0
Dodge silt loam	11	0	36	64	0	0	0
Seaton silt loam	10	0	30	50	20	0	0
Other	25	18	37	14	2	3	26
All soils	100	5	16	38	25	9	7

The hydrological soil grouping assigned for the Kidder loam, McHenry silt loam, Dodge silt loam, and Seaton silt loam soils is Group B. The Group B soil has a moderate infiltration rate and runoff rate. The erosion factor designated for the Seaton silt loam soil is 0.32, an indication that this soil is slightly prone to erosion on steep or long slopes. McHenry silt loam, Dodge silt loam, and Seaton silt loam have been assigned an erosion factor of 0.37, which classifies these soils as naturally susceptible to erosion on steep or long slopes.

The land-surface elevation in Brewery Creek Watershed ranges from 900 ft to approximately 1,250 ft above sea level at the highest point in the headwaters. The land features consist of gently sloping ridgetops; narrow, steep ridgetops; and nearly level to gently sloping drainageways, stream bottoms, and flood plains. Soils in the 6- to 20-percent slope range cover 64 percent of the land surface. These generally steep slopes increase the amount of runoff and soil erosion.

Surface-Water Resources. Brewery Creek is a warmwater, high-gradient stream that has the potential to maintain a forage fish population (table 1; Wisconsin Department of Natural Resources, 1989). The creek has been ditched and straightened. Flooding and manure runoff are the most significant water-quality concerns. Low flow in the creek tends to limit aquatic life. Forage fish can tolerate the stream conditions, but have little value for wildlife or recreation.

Land Management

Objectives. The water-resource objective focuses on limiting negative water-quality effects on Black Earth Creek. This will primarily be accomplished through reducing sediment and oxygen-demanding substances in Brewery Creek.

Sources of Nonpoint Contamination and Goals of Contaminant Reduction. The nonpoint-source control plan states that sediment and oxygen-demanding substances have degraded water quality and aquatic habitat of Brewery Creek. Although Brewery Creek has a relatively low flow, it still is a significant contributor of sediment to Black Earth Creek. Sediment from Brewery Creek may impair the trout fishery of Black Earth Creek by covering the gravel bottom and pools used by trout (Field and Graczyk, 1990).

In all, 20 barnyards out of 21 each contribute 5 lb or more of phosphorus during a simulated 10-year, 24-hour storm event (Dane County Land Conservation Department, written commun., 1992). These 20 barnyards were identified for animal-waste management, based on the goals set in the Black Earth Creek Priority Watershed Plan (table 6; table 7; Wisconsin Department of Natural Resources, 1989). Runoff from these barnyards delivers a total of 559 lb of phosphorus to Brewery Creek, 459 lb of which comes from the 15 eligible[7] barnyards that still have livestock (table 4). The goal of a 50-percent reduction

[7]The NPS Program requires management actions, which are carried out through the use of BMP's, to control sources of nonpoint contamination. To achieve these management actions, eligibility criteria and management categories are established in nonpoint-source control plans. Eligibility criteria determine which contaminant sources will receive funding, according to their severity.

in oxygen-demanding substances from animal lots and manure spreading was recommended in the nonpoint-source control plan (table 5). To achieve this goal will require a 75-percent reduction in manure (phosphorus) from animal lots. Additionally, manure-spreading management plans are supposed to be prepared for all livestock operations within the watershed.

In the watershed, a total area of 5,170 acres was identified for sediment control. The nonpoint-source control plan states that eroding uplands are the largest source of sediment in the watershed. Upland acres identified during the planning process for BMP's contribute at least 7 ton/acre/yr of eroded soil. The goal of a 50-percent reduction in sediment from eroding upland fields was recommended. Streambank erosion along Brewery Creek is minimal because of improvements made before its inclusion in the priority watershed project. To reduce the effect of construction-site erosion, builders will use controls mandated by the village of Cross Plains and Dane County.

Implementation of Best-Management Practices. Since 1989, the local county LCD has contracted or implemented BMP's within the Brewery Creek Watershed (table 2). BMP implementation should be completed by the end of 1997. Barnyard-runoff control systems and upland BMP's are thought to be the most important practices to be implemented. Over the 8-year BMP implementation period, 75 percent of the eligible barnyards and 93 percent of the eligible upland acres are to be addressed (table 7; fig. 3).

Barnyard-runoff control systems installed or to be implemented are expected to control 63 percent of the phosphorus contributed from animal lots to Brewery Creek. Through 1995, 9 of the 11 contracted systems had been installed. Although the number of eligible acres for winter spreading of manure was not determined during the planning process, an estimate was obtained from the local county LCD. Upland BMP's planned or implemented are expected to control 36 percent of the upland soil erosion within the watershed. The upland BMP's include conservation cropping and tillage, contour farming, and grassed waterways.

Garfoot Creek Watershed

The following information on the Garfoot Creek Watershed was taken primarily from the Black Earth Creek Watershed Plan (Wisconsin Department of Natural Resources, 1989).

Watershed Characteristics

Location. The Garfoot Creek Watershed is in Dane County, 10 mi northwest of Madison, in south-central Wisconsin (fig. 1). The watershed is part of the Black Earth Creek Priority Watershed, as designated by the WDNR. Garfoot Creek flows into Black Earth Creek, and Black Earth Creek discharges to Blue Mounds Creek, which eventually drains to the lower Wisconsin River. The drainage area of Garfoot Creek is 5.4 mi^2. Garfoot Creek's main channel is 3.8 mi long. The total length of monitored streams in the watershed is 10.6 mi. A number of small farm ponds in the watershed have been established. A USGS water-quality monitoring station on Garfoot Creek near Cross Plains (fig. 5) was established in 1989.

Reference Watersheds. Garfoot Creek Watershed does not have a reference site because it is not biologically monitored.

Climate. The climate in the Garfoot Creek Watershed is continental and is characterized by wide extremes in temperature and precipitation. Since 1990, the average annual air temperature recorded at Charmany University Farm Madison, Wis. (approximately 10 mi southeast of the watershed), has been 46.0°F, and the range of average monthly air temperatures has been 17.6 to 70.1°F (table 3; U.S. Department of Commerce, 1990–95). In Dane County, the growing season usually starts about April 26 and ends about October 19. The average annual number of frost-free days is 176 (Glocker and Patzer, 1978).

The average annual precipitation for water years 1991–95 was 32.4 in. The annual precipitation for water years 1991–95 is listed in table 3. Nearly 50 percent of the rain falls from June through September, and only 3 percent during December through February. Average runoff was 12.87 in. (excluding water year 1994, missing data) at the Garfoot Creek water-quality monitoring station for water years 1991–95 (Holmstrom and others, 1996).

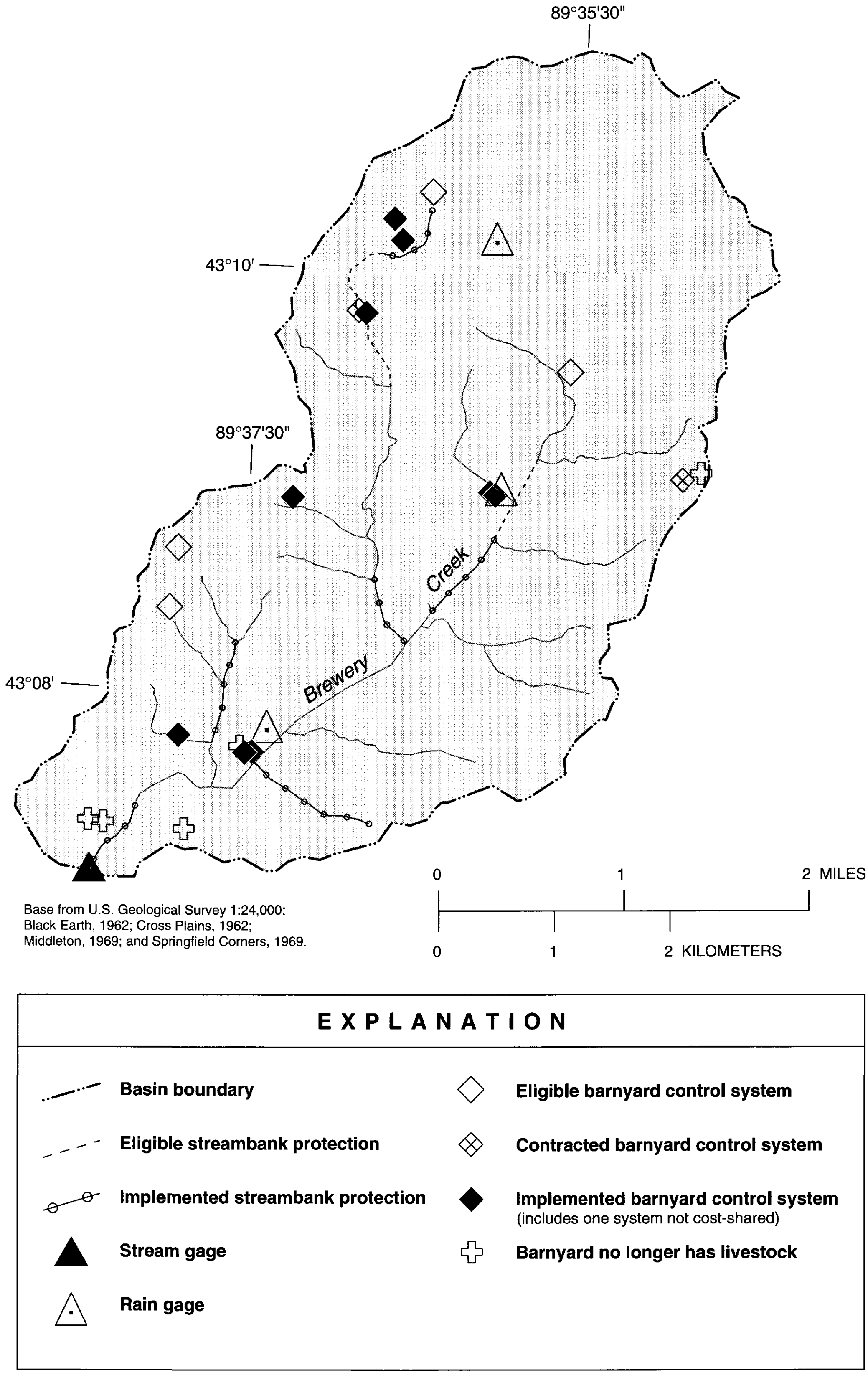


Figure 3. Eligible, contracted, and implemented best-management practices, Brewery Creek Watershed.

Land Use. In the Garfoot Creek Watershed, the land-use inventory covers an area of 3,450 acres. Predominant land use/land cover (fig. 4) is woodlots at 50.50 percent, grassland at 9.6, pasture at 8.9, and croplands at 5.8. Twenty-six farms are in the watershed. Average farm size is 146 acres, with an average of 100 acres used for cropland. A total of eight barnyards are in the watershed, one barnyard no longer has livestock and one is no longer eligible. The average livestock herd for these barnyards is 83 animals; 77 percent of all animals in the watershed are dairy cows (Dane County Land Conservation Department, written commun., 1992). The entire watershed is under exclusive agricultural zoning.

Soils and Topography. Soils in the watershed were formed in glacial till, outwash, and lacustrine sediment. The Dunbarton-New Glarus-Seaton association is the major soil association in the watershed. These soils are moderately well drained to well drained and have formed in loess and over dolomite. The underlying material for these soils is fractured dolomite and massive silt loam (Glocker and Patzer, 1978).

Dunbarton silt loam and New Glarus silt loam overlie approximately 40 percent of the watershed. Soils formed on steep, stony, and rocky land with slopes greater than 30 percent cover 10 percent of the watershed (table 10); these soils are well drained but easily eroded. The soils on the flood plains and stream bottoms (Orion/Otter silt loam) are somewhat poorly drained alluvial soils that cover 9 percent of the watershed. The remaining soils overlie 41 percent of the watershed and are primarily well-drained upland soils.

The hydrological soil grouping designated for the Seaton fine sandy and silt loam and New Glarus silt loam soils is Group B. The Dunbarton silt loam soil is classified as Group D. The Group B soil has a moderate infiltration rate and runoff rate, whereas the Group D soil has a low infiltration rate and high runoff rate. The erosion factor assigned to the Seaton silt loam, New Glarus silt loam, and Dunbarton silt loam soils is 0.37, which classifies these soils as naturally susceptible to erosion on steep or long slopes.

The land-surface elevation of Garfoot Creek Watershed ranges from 860 ft above sea level at the water-quality monitoring station to approximately 1,200 ft above sea level at the highest point in the headwaters. The land features include gently sloping ridgetops; narrow, steep ridgetops; and nearly level to gently sloping drainageways, stream bottoms, and flood plains. Soils in the 6- to 20-percent slope range cover 55 percent of the watershed. The generally steep land increases the amount of runoff and soil erosion.

Surface-Water Resources. Garfoot Creek is classified as a coldwater sport fishery (table 1; Wisconsin Department of Natural Resources, 1989). Some natural trout reproduction takes place in the creek, but artificial propagation is required to maintain the fishery (Field and Graczyk, 1990). According to the nonpoint-source control plan, the greatest threats to streams in the watershed are sedimentation and the presence of oxygen-demanding substances. Another concern is maintaining the base flow of springs that sustain Garfoot Creek. In water years 1991–95, dissolved-oxygen concentration was less than the 6 mg/L State standard on 44 days (6 percent) of the 717 days monitored (Corsi and others, 1995; Holmstrom and others, 1995–96)).

Land Management

Objectives. The water-resources objectives are to maintain the Class II trout fishery in the lower 2 mi of Garfoot Creek and to maintain and improve conditions in the upper 1.8 mi to support a Class I trout fishery. These objectives are to be achieved through maintaining the base flow of springs important to the creek and decreasing sediment and oxygen-demanding substances entering the creek.

Sources of Nonpoint Contamination and Goals of Contaminant Reduction. The nonpoint-source control plan states that sediment from eroding uplands and manure from animal lots and winter manure spreading are the most significant nonpoint-contamination sources. These contaminants impair not only the surface-water resources in Garfoot Creek Watershed but also contribute to the degradation of the Black Earth Creek fishery and stream ecosystem.

In all, six barnyards out of seven each contribute 5 lb of phosphorus or more during a simulated 10-year, 24-hour storm event (Dane County Land Conservation Department, written commun., 1992). These six barnyards were identified for animal-waste management (table 6; table 7; Wisconsin Department of Natural Resources, 1989).

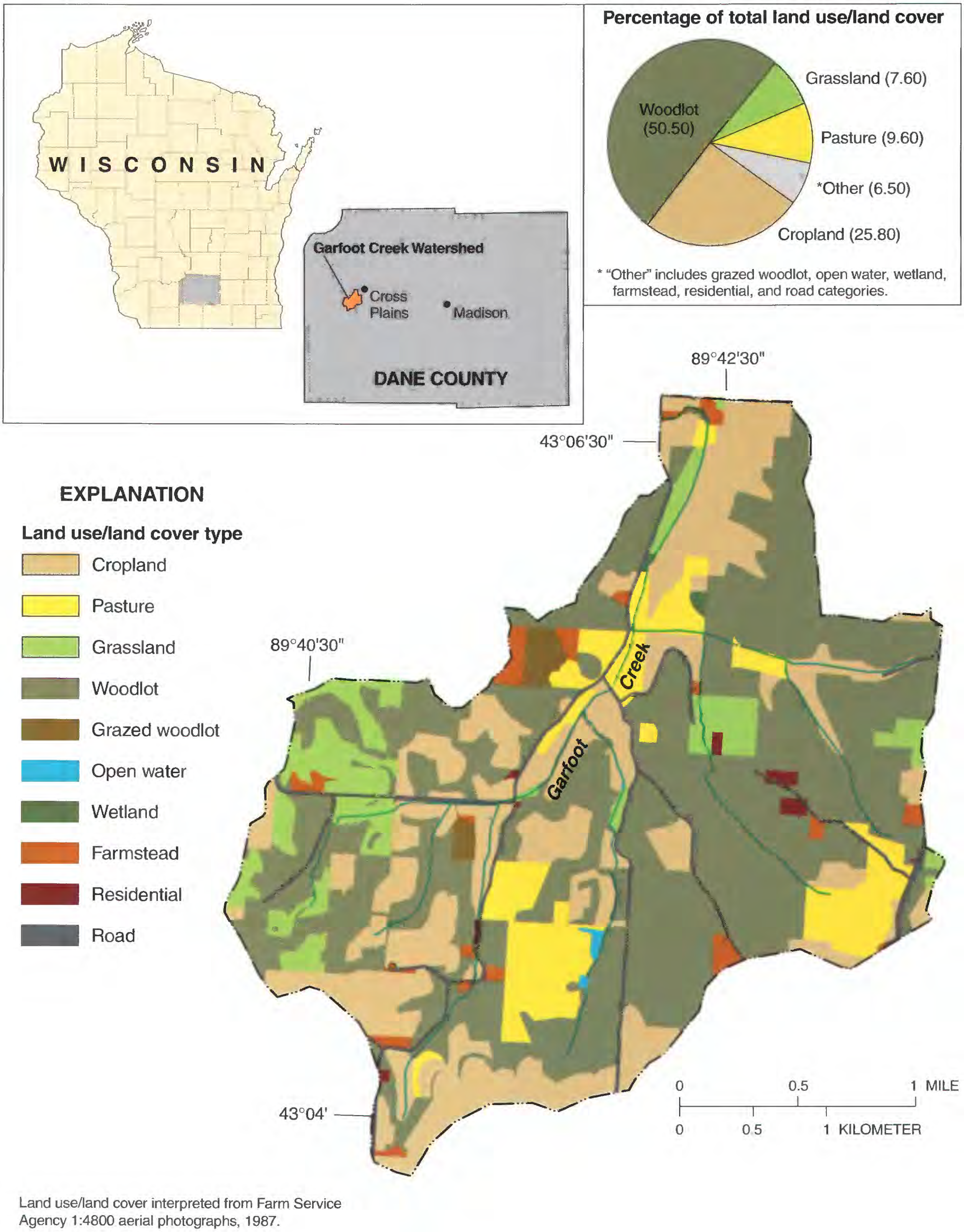


Figure 4. Land use/land cover, Garfoot Creek Watershed.

Table 10. Soil series and their distribution by slope, Garfoot Creek Watershed

[>, greater than]

Soil series	Percentage of watershed in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Dunbarton silt loam/New Glarus silt loam	40	0	17	34	31	18	0
Steep, stony, and rocky land	10	0	0	0	0	0	100
Orion/Otter silt loam	9	100	0	0	0	0	0
Seaton fine sandy and silt loam	8	0	3	47	50	0	0
Other	33	10	9	34	30	14	3
All soils	100	12	10	29	26	12	11

Runoff from the seven barnyards delivers a total of 204 lb total phosphorus to Garfoot Creek; 193 lb of which is from the six eligible barnyards that still have livestock (table 4). The nonpoint-source control plan recommends a 50-percent reduction in oxygen-demanding substances (table 5; Wisconsin Department of Natural Resources, 1989). To achieve this goal will require a 75-percent reduction in manure (phosphorus) from animal lots. In addition, manure-spreading management plans are supposed to be prepared for all livestock operations within the watershed.

In Garfoot Creek Watershed, a total area of 1,515 acres was identified for sediment control. The nonpoint-source control plan states that eroding uplands contribute greater than 90 percent of the sediment reaching Garfoot Creek. Upland acres identified for BMP's contribute at least 7 ton/acre/yr of sediment. Sediment from uplands is to be reduced by 50 percent. Streambank erosion along Garfoot Creek is minimal because of improvements made before its inclusion in the priority watershed project.

Implementation of Best-Management Practices. The local county LCD has contracted or implemented BMP's within the Garfoot Creek Watershed since 1989 (table 2). BMP implementation was completed in 1995. It is the first evaluation monitoring watershed in the post-BMP monitoring period. Barnyard-runoff control systems, upland BMP's, and streambank fencing were thought to be the most important practices implemented. During the 6-year BMP implementation period, 100 percent of the eligible barnyards and upland acres were addressed (table 7; fig. 5).

Barnyard-runoff control systems implemented are expected to control 91 percent of the phosphorus contributed from animal lots to Garfoot Creek. In addition, nutrient-management plans have also been developed to control the winter spreading of manure. Although the number of eligible acres was not determined during the planning process, an estimate was obtained from the local county LCD. Upland BMP's implemented are expected to control 65 percent of the upland soil erosion within the watershed. The upland BMP's include conservation cropping, contour strips, and grassed waterways.

Eagle Creek and Joos Valley Creek Watersheds

Most of the following information on the Eagle Creek and Joos Valley Creek Watersheds was taken primarily from the Waumandee Creek Priority Watershed Plan (Wisconsin Department of Natural Resources, 1990).

Watershed Characteristics

Location. The Eagle Creek and Joos Valley Creek Watersheds are in Buffalo County, 10 mi east of the Mississippi River, in western Wisconsin (fig. 1). These watersheds are within the Waumandee Creek Priority Watershed, as designated by the WDNR. Joos Valley Creek is a tributary to Eagle Creek, which discharges into Waumandee Creek, which eventually flows to the Mississippi River. The total length of monitored streams in the two watersheds is 36.8 mi; this total includes perennial and intermittent streams.

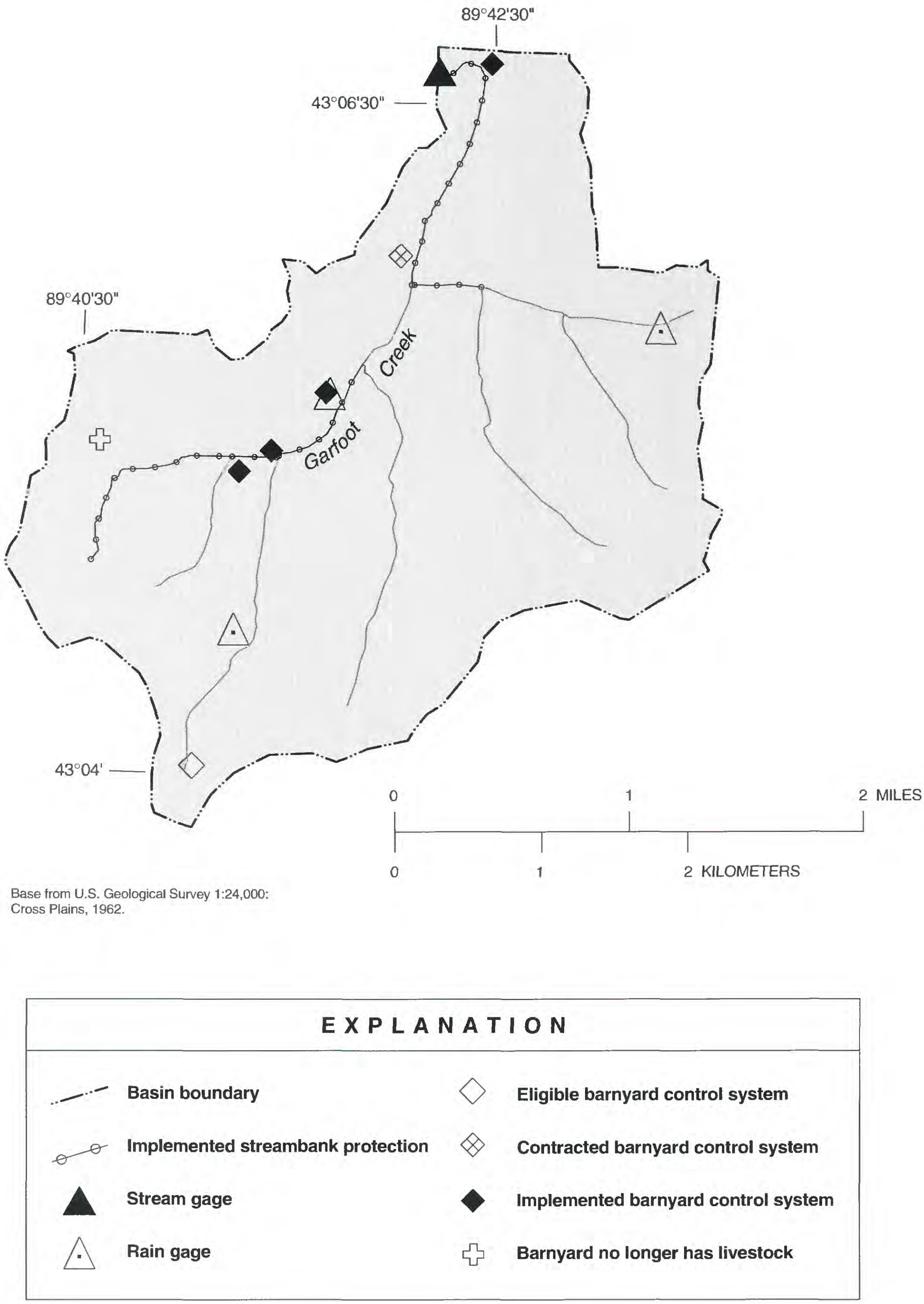


Figure 5. Eligible, contracted, and implemented best-management practices, Garfoot Creek Watershed.

Monitored streams in the Joos Valley Creek Watershed (drainage area, 5.9 mi^2) consist of 4.6 mi of perennial streams and 11.6 mi of intermittent streams. Additional stream mileage in Eagle Creek Watershed (drainage area, 14.3 mi^2) consists of 8.0 mi of perennial streams and 12.6 mi of intermittent streams. Water-quality monitoring at the USGS stream-monitoring station on Joos Valley Creek near Fountain City (fig. 7) began in October 1990. Water-quality monitoring at the USGS stream-monitoring station on Eagle Creek at County Highway G near Fountain City (fig. 7) began in July 1990.

Reference Watersheds. There are four reference watersheds for the Eagle Creek and Joos Valley Creek Watersheds, all of which are in the Little Trempealeau Watershed (table 8; fig. 1). The Pine Creek and Trout Run Creek Watersheds are joined together near their headwaters. The sampling locations are Pine Creek at Whistler Pass Road, 3 mi south of Dodge; and Trout Run Creek at County Trunk J, 5 mi southwest of Arcadia. Sampling locations for the other two reference watersheds are on Borhis Valley Creek at Brandhorst Road, 3 mi west of Dodge (Borhis-2), and at County Trunk P, 3 mi west of Dodge (Borhis-1).

Climate. The climate in the Eagle Creek and Joos Valley Creek Watersheds is humid continental, characterized by moderately long, cold winters and short, humid summers. Since 1990, the average annual air temperature recorded in Alma, Wis. (15 mi northwest of watershed), has been 46.6°F, but the range of average monthly air temperatures range has been 16.6 to 71.9°F (table 3; U.S. Department of Commerce, 1990–95). In Buffalo County, the growing season usually starts about May 11 and ends about September 29; the average number of frost-free days is 141 (Thomas and others, 1962).

The average annual rainfall for water years 1991–95 is 29.3 in. for the Joos Valley Creek Watershed and 29.9 in. for the Eagle Creek Watershed; rainfall for each water year since monitoring began is listed in table 3. About 50 percent of the rain falls from June through September. The least amount of rain, about 2 percent of the annual total, falls from December through February. The average runoff during water years 1991–95 was 10.34 in. at the Joos Valley Creek water-quality monitoring station and 9.85 in. at the Eagle Creek water-quality monitoring station (Holmstrom and others, 1996).

Land Use. The land-use inventory in these watersheds covers an area of approximately 9,192 acres. In the two watersheds combined, 42.6 percent of the land is cropland, 41.1 percent is woodlots, and 9.3 percent is pasture (fig. 6). There are 34 farms in the Joos Valley Creek and Eagle Creek Watersheds. The average size of each farm is 355 acres, with an average of 158 acres in crop production. A total of 27 barnyards are in the Joos Valley Creek and Eagle Creek Watersheds, 18 of which are eligible for BMP implementation. On average, each farm has 91 cows, 98 percent being dairy cows (Buffalo County Land Conservation Department, written commun., 1992). The low percentage of cultivated land is a result of the steep ridges, deep narrow valleys, and overall rough terrain.

Soils and Topography. The New Glarus-Palsgrove-Seaton association is the major soil association in the watershed. The soils in this soil association are well drained and have formed in loess ranging in thickness from 15 to 48 in. The soils are underlain by dolomitic limestone or by materials weathered from limestone. Palsgrove silt loam and New Glarus silt loam cover approximately 34 percent of the watershed (table 11; Thomas and others, 1962). The soils found on the upland ridges on slopes greater than 30 percent are well drained and eroded and cover 7 percent of the watershed. The remaining soils cover 24 percent of the watershed and include somewhat poorly drained alluvial soils on level lands adjacent to Joos Valley and Eagle Creeks.

The hydrological soil grouping designated for the Seaton soil loam, Palsgrove silt loam, and New Glarus silt loam soils is Group B. When wet but not saturated, soils in this group have a moderate infiltration rate and runoff rate. The erosion factor assigned to these soils is 0.37, an indication that these soils are naturally susceptible to erosion on steep or long slopes.

The land-surface elevation of the monitored watersheds ranges from 800 ft above sea level at the monitoring station on Joos Valley Creek Watershed, 770 ft above sea level at the station on Eagle Creek, to approximately 1,320 ft above sea level at the uppermost boundary of both watersheds. Topography consists of rolling and narrow, steep ridges and some gently sloping, rounded ridgetops.

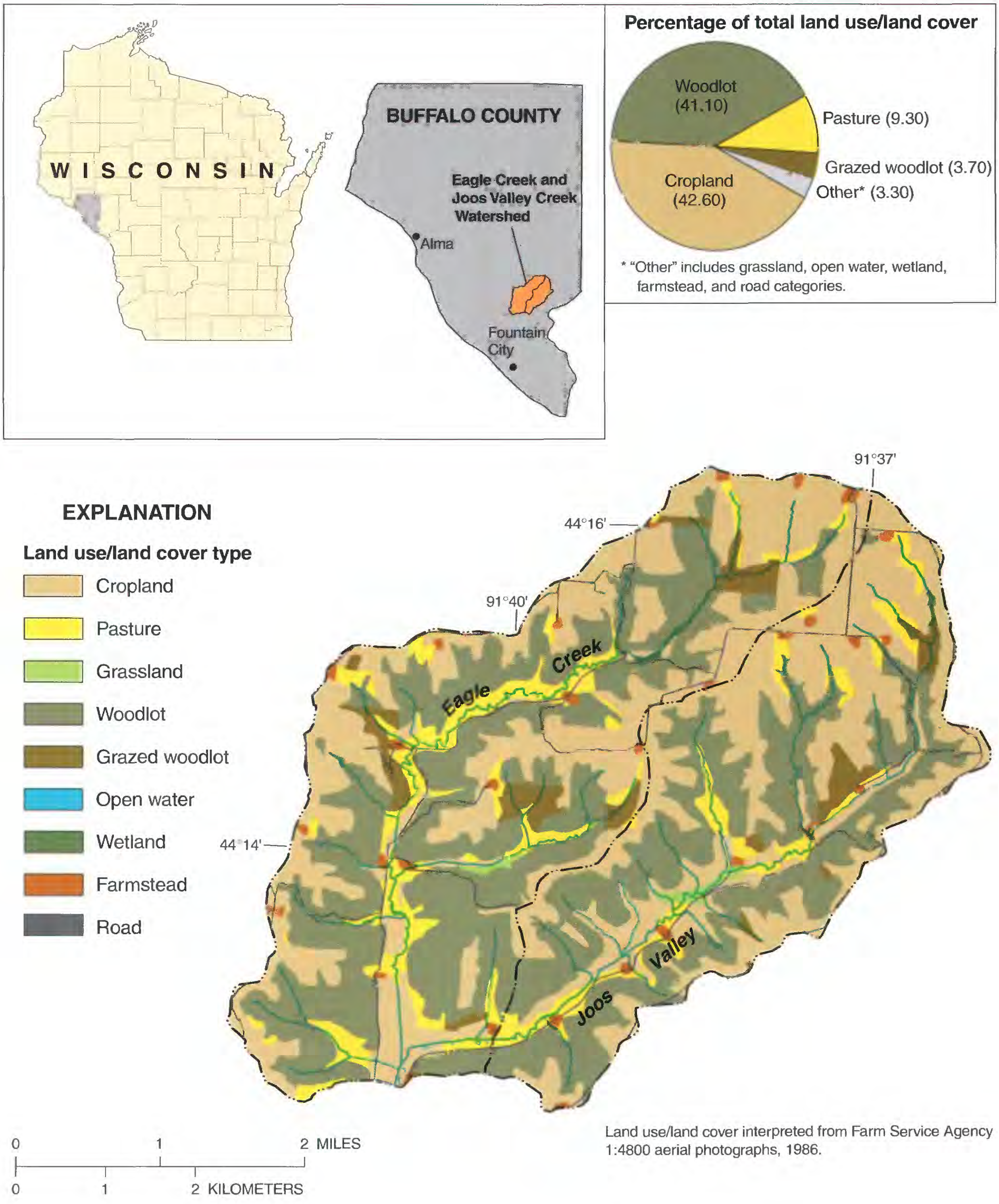


Figure 6. Land use/land cover, Eagle Creek and Joos Valley Creek Watersheds.

Table 11. Soil series and their distribution by slope, Eagle Creek and Joos Valley Creek Watersheds

[>, greater than]

Soil series	Percentage of watersheds in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Seaton silt loam	35	0	39	31	19	5	6
Palsgrove silt loam/New Glarus silt loam	34	0	16	32	44	5	3
Steep, stony, and rocky land	7	0	0	0	0	0	All 40 percent or greater slopes
Rowley silt loam	5	0	100	0	0	0	0
Other	19	0	50	10	12	15	13
All soils	100	0	34	24	24	6	12

Steep slopes of 40 percent and 20 to 30 percent constitute 7 percent and 6 percent of the watersheds, respectively. Land is nearly flat along the narrow stream terraces. Few natural land features in the watersheds intercept, collect, and store runoff. Most runoff is shed directly to streams.

Surface-Water Resources. Eagle Creek is classified as a coldwater sport fishery (table 1; Wisconsin Department of Natural Resources, 1990). It supports a Class III trout fishery and has the potential to be a Class II fishery. Joos Valley Creek is a high-gradient, coldwater sport fishery. The creeks are fed by a constant supply of coldwater springs. The quality of Joos Valley is affected by high organic loadings, which include ammonia and bacteria, and low dissolved-oxygen concentrations (Graczyk and others, 1993). Both streams are heavily pastured, which has caused habitat destruction, increased sedimentation, and increased water temperatures (Wisconsin Department of Natural Resources, 1995a). During 1991 and 1992, dissolved-oxygen concentration was below the State standard for 23 days (6 percent) of 396 days monitored (Holmstrom and others, 1992–94).

Land Management

Objectives. A primary objective stated in the nonpoint-source control plan for Eagle Creek is to change its classification as a Class III fishery to a Class II fishery by improving the physical and biotic conditions. A primary objective for Joos Valley Creek is to improve the creek's physical and biotic conditions to support a Class III coldwater trout fishery.

Source of Nonpoint Contamination and Goals of Contaminant Reduction. Degraded barnyards and manure spreading on steep slopes contribute to increased phosphorus loading. In all, 18 barnyards out of 27 have been identified as discharging 15 lb of phosphorus or greater during a simulated 10-year, 24-hour storm event (table 6; table 7; Buffalo County Land Conservation Department, written commun., 1992). Runoff from these barnyards delivers 258 lb of phosphorus to Eagle Creek and 205 lb of phosphorus to Joos Valley Creek (table 4). The contaminant-reduction goals are reductions of organic load by 50 percent in Joos Valley Creek Watershed and 70 percent in Eagle Creek Watershed (table 5).

Farm operators spreading manure on critical areas exceeding 15 acres are eligible for manure-storage facilities. The contaminant-reduction goal is to control 70 percent of livestock waste on critical lands by limiting manure spreading to 15 acres or less, as stated in the nonpoint-source control plan.

According to the nonpoint-source control plan, 55 percent of the croplands containing erodible soils contribute 55 percent of sediment delivery to the surface water; the corresponding upland sediment-reduction goal is 50 percent. A total of 131 fields meet upland-management criteria for sediment delivery and are targeted for BMP implementation. Total area of these fields in the Joos Valley Creek Watershed is 434 acres, and total area in the Eagle Creek Watershed is 562 acres (Buffalo County Land Conservation Department, written commun., 1992).

Heavy pasturing of the area has caused degradation of streambanks, decreasing the habitat for trout (Wisconsin Department of Natural Resources, 1994a). Streambank erosion on perennial streams in the Joos Valley Creek Watershed is 1.94 mi, approximately 21 percent of both banks being eroded; in Eagle Creek Watershed, erosion has affected approximately 3.39 mi of both banks being eroded. The length of eligible eroded sites is 28,100 ft within both watersheds (Buffalo County Land Conservation Department, written commun., 1992). The sediment-reduction goal for Eagle Creek is 80 percent, and the goal for Joos Valley Creek is to reduce streambank erosion by 60 percent, according to the nonpoint-source control plan.

Implementation of Best-Management Practices. Since 1990, the local county LCD has contracted or implemented BMP's within the Eagle Creek and Joos Valley Creek Watersheds (table 2). BMP implementation should be completed by the end of the year 2000. Barnyard-runoff control systems and streambank practices (for example, fencing and riprap) are thought to be the most significant practices to be implemented. Over the 10-year BMP implementation period, 56 percent of the eligible barnyards and 73 percent of the eligible streambank sites are to be addressed (table 7; fig. 7).

Barnyard-runoff control systems planned or implemented are expected to control 36 percent of the phosphorus delivered from barnyards to Eagle Creek and 52 percent of the phosphorus delivered to Joos Valley Creek. By 1995, only one of the nine contracted systems had been installed in the watersheds. Nutrient-management plans also were developed to control the winter spreading of manure. Streambank BMP's implemented or to be implemented are expected to control 90 percent of the sediment entering Eagle Creek and 69 percent of the sediment entering Joos Valley Creek. Sediment reductions associated with the implementation of upland BMP's will probably be estimated with the WINHUSLE model.

In late summer of 1992, a signs-of-success site was established about 500 ft upstream from the Joos Valley Creek water-quality monitoring station. Before and after implementing BMP's, biological monitoring was done on a reach of eroded and trampled streambank. Several BMP's were implemented to improve the eroded site. For example, fencing was installed to restrict livestock from the banks, and riprap and lunker structures were used to stabilize the bank (Wisconsin Department of Natural Resources, 1995a).

Bower Creek Watershed

Most of the following information on the Bower Creek Watershed was taken primarily from the East River Priority Watershed Plan (Wisconsin Department of Natural Resources, 1993a).

Watershed Characteristics

Location. The Bower Creek Watershed is in Brown County, 10 mi south of Green Bay, in east-central Wisconsin (fig. 1). It is within the East River Priority Watershed, as designated by the WDNR. Bower Creek discharges to the Fox River, which eventually flows into Green Bay. The drainage area of Bower Creek is 14.8 mi^2. In the original priority watershed delineation, Bower Creek was separated into Upper Bower and Lower Bower Subwatersheds; drainage areas computed by the USGS for these subwatersheds are 4.6 mi^2 (100 percent of Upper Bower) and 10.2 mi^2 (27 percent of Lower Bower), respectively. The monitored stream length is 37.1 mi, including perennial and intermittent streams. Water-quality monitoring at the USGS station on Bower Creek at Highway MM near De Pere (fig. 9) began with the 1991 water year.

Climate. The climate in the Bower Creek Watershed is continental: winters are cold, and summers are warm and humid. Since 1990, the average annual air temperature recorded in Green Bay, Wis. (10 mi north of watershed), has been 45.2°F, and the range of average monthly air temperatures has been 17.1 to 69.6°F (table 3; U.S. Department of Commerce, 1990–95). Green Bay's close proximity to Lake Michigan insulates this area from the extreme temperature changes that other parts of the State experience. The growing season usually starts about May 6 and ends about October 14; the average number of frost-free days is 161 (Link and others, 1974).

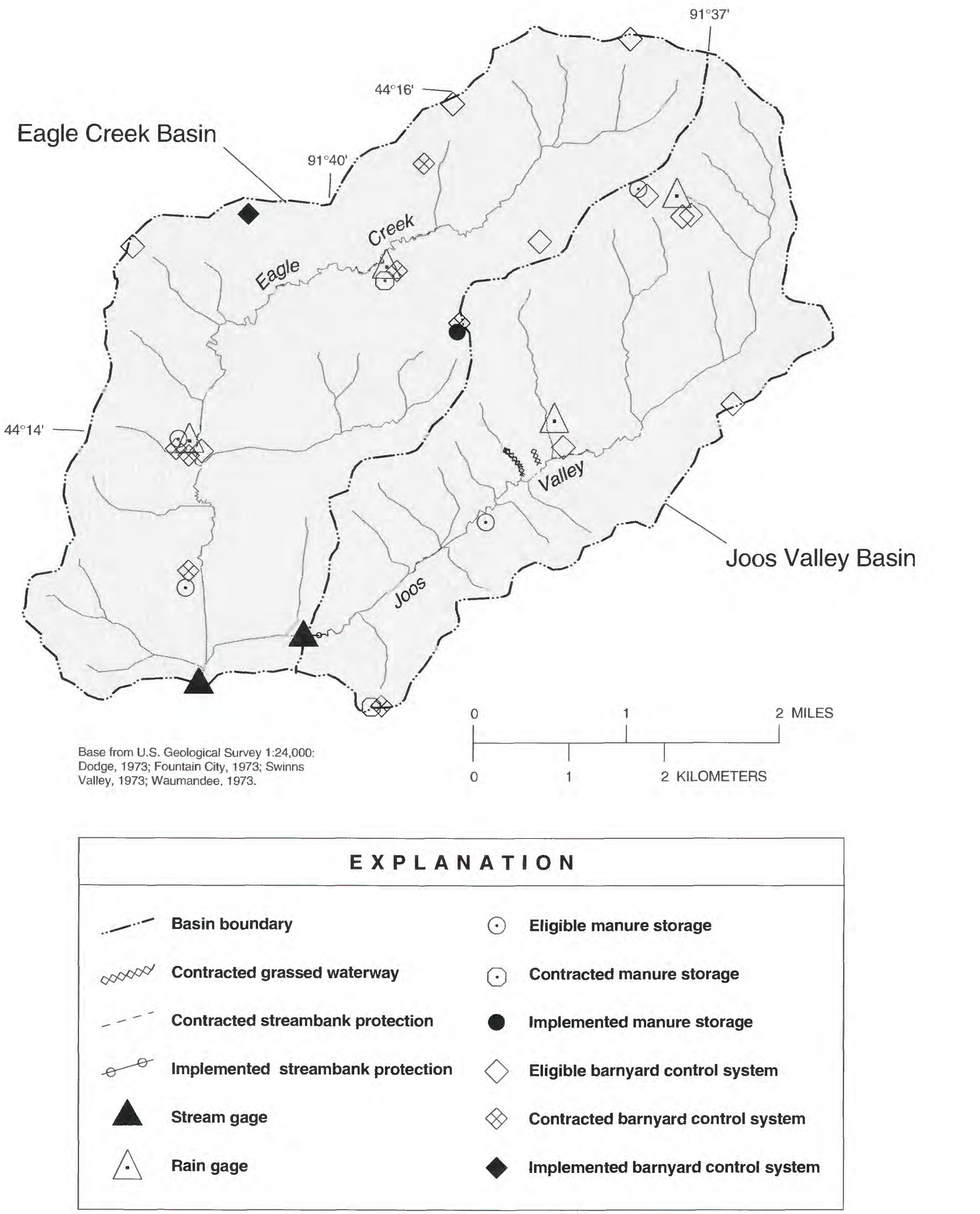


Figure 7. Eligible, contracted, and implemented best-management practices, Eagle Creek and Joos Valley Creek Watersheds.

During water years 1991–95, the average annual rainfall was 25.5 in. Rainfall for each water year since 1991 is listed in table 3. Greater than 50 percent of the rain falls from June through September. The driest months are in December, January, and February, accounting for about 4 percent of annual rainfall. The average annual runoff from 1991–95 is 8.32 in. at the Bower Creek water-quality monitoring station (Holmstrom and others, 1996).

Land Use. The land-use inventory of the Bower Creek Watershed covers a total of approximately 9,226 acres. The predominant land-cover types in the watershed are cropland at 83.1 percent and woodlots at 6 percent (fig. 8). Within the watershed, 115 farms are being inventoried. The average farm size is 120 acres, with an average of 83 acres in cropland. There are 41 barnyards in the watershed, 9 which are not eligible for BMP implementation. Average herd size is 118 animals: 70 percent are dairy cows, 27 percent are young dairy cattle, 2 percent are sheep, and 1 percent are steers (Brown County Land Conservation Department, written commun., 1992). New residential development has increased noticeably in the watershed over the past few years. This development in the watershed is related to Bower Creek's proximity to the city of Green Bay.

Soils and Topography. Glaciation within the Bower Creek Watershed affected the soil characteristics and topography. Most soils in the area contain high amounts of clay, which inhibits infiltration and increases the amount of surface runoff. The Kewaunee-Manawa association is the major soil association in the watershed. Soils in this association are well drained to somewhat poorly drained. Sandy or silt loams make up the top 8 in. of the surface layer, and a reddish-brown silty clay loam and silty clay make up 19 in. of the subsoil layer. The soils are underlain by limestone or by clayey glacial till (Link and others, 1974).

The Kewaunee silt loams cover approximately 73 percent of the watershed (table 12). The Kewaunee-Manawa Complex covers approximately 9 percent of the watershed. The remaining 10 percent is covered by soils developed in glacial till plains or lacustrine plains; these soils generally are poorly drained unless a tile system is used.

The hydrological soil grouping designated for the Kewaunee silt loam, the Kewaunee-Manawa Complex, and the Manawa silty clay loam is Group C. When wet but not saturated, soil in this group has a low to moderate infiltration rate and a high to moderate runoff rate. The erosion factor assigned to these soils is 0.37 for the Kewaunee and 0.28 for the Manawa soils. These ratings indicate that the Kewaunee soil is more susceptible to natural erosion on steep or long slopes than Manawa soils are.

The land-surface elevation of the monitored watershed ranges from 790 ft above sea level at the monitoring station to approximately 960 ft above sea level at the upper edge of the watershed. This glaciated watershed has gently sloping hills or nearly level land; approximately 76 percent of the land has a slope of 6 percent or less. Most drainage patterns in this watershed are influenced by the bedrock formations; for example, Bower Creek and Baird Creek are the only streams that flow west in Brown County.

Surface-Water Resources. The main stem of Bower Creek is classified as a warmwater forage fishery (table 1; Wisconsin Department of Natural Resources, 1993a). According to the nonpoint-source control plan, sedimentation to this stream reduces habitat, spawning areas, and fish-reproduction activity. Biological activity is further reduced when the streambed dries up during low flows. There are about 80 acres of wetlands dispersed around Bower Creek's streambank and 8.9 acres of ponded surface water within the watershed.

Land Management

Objectives. The nonpoint-source control plan states that primary objectives are to restore wetlands and maintain existing wetlands for preservation of wildlife habitat. In addition, an objective is to improve the aquatic habitat for the resident fish population (table 5).

Source of Nonpoint Contamination and Goals of Contaminant Reduction. Barnyards eligible for a barnyard-runoff control system are discharging greater than 10 lb of phosphorus during a simulated 10-year, 24-hour storm event in the Upper Bower Subwatershed and greater than 5 lb in the Lower Bower Subwatershed (table 6; table 7; Brown County Land Conservation Department, written commun., 1992). In all, 32 barnyards out of 41 have been identified for animal-waste management in the nonpoint-source control plan. The total amount of phosphorus delivered to the stream from these barnyards is 826 lb (table 4).

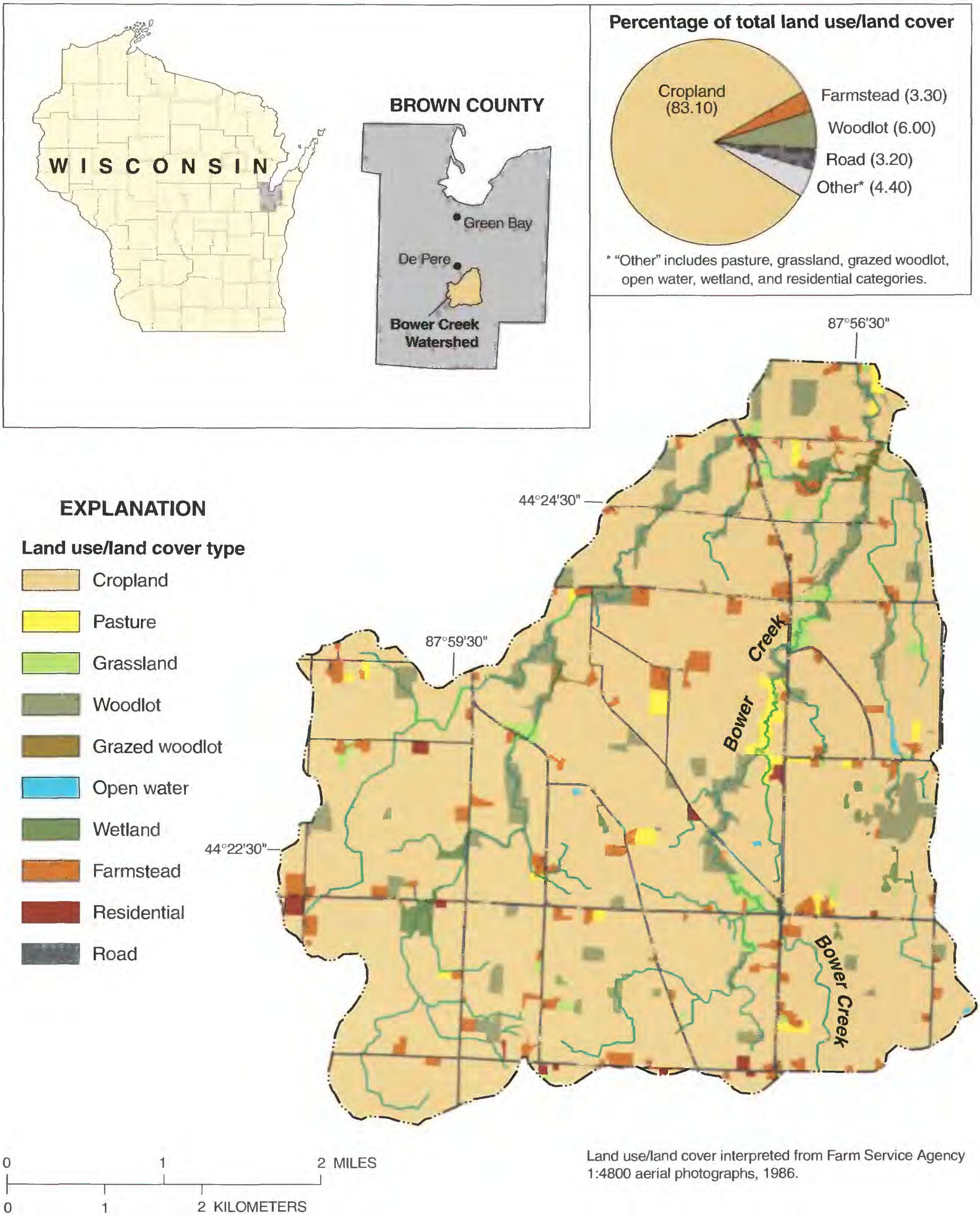


Figure 8. Land use/land cover, Bower Creek Watershed.

Table 12. Soil series and their distribution by slope, Bower Creek Watershed

[>, greater than]

Soil series	Percentage of watershed in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Kewaunee silt loam	73	0	86	12	1	1	0
Kewaunee-Manawa Complex	9	0	100	0	0	0	0
Manawa silty clay loam	8	All 1 to 3 percent slope	0	0	0	0	0
Poygan silty clay loam	5	100	0	0	0	0	0
Other	5	0	98	0	2	0	0
All soils	100	13	76	9	1	1	0

Winter manure-spreading management categories for critical areas in Bower Creek Watershed are Category I, 10 acres or more; Category II, 3 to 9.9 acres; and Category III, 0 to 2.9 acres. Critical acres in Category I include areas where manure is spread in or near sensitive wetland or where it can contaminate ground water. The contaminant-reduction goal, according to the nonpoint-source control plan, is to reduce phosphorus inputs by 70 percent (table 5; Wisconsin Department of Natural Resources, 1993a).

With regard to sediment delivery and soil loss, a total of approximately 2,139 acres of cropland meet the eligibility criteria for Category I, in which sediment delivery is greater than 0.11 ton/acre/yr and soil loss is greater than 1 ton/acre/yr more than the tolerable soil-loss level. A total of approximately 4,373 acres of cropland meet the eligibility Category II, in which sediment delivery is greater than 0.11 ton/acre/yr and soil loss is less than 1 ton/acre/yr more than the tolerable soil-loss level.

Streambank erosion contributes 10 percent of the sedimentation to surface waters in the East River Priority Watershed. The inventory has identified 2,320 ft of erosion on both banks due to slumping or trampling by cattle. The nonpoint-source control plan states that 50 percent of the eroded streambanks are a result of cattle access; the contaminant-reduction goal is 50 percent.

Implementation of Best-Management Practices. Since 1991, the local county LCD has contracted or implemented BMP's within the Bower Creek Watershed (table 2). All BMP's should be completed by the end of 1999. Barnyard-runoff control systems, manure-storage facilities, and upland BMP's are thought to be the most important practices to be implemented. During the 8-year BMP implementation period, 39 percent of the eligible barnyards are to be addressed, and 100 percent of the eligible manure-storage facilities are to be implemented (table 7; fig. 9).

Barnyard-runoff control systems planned or implemented are expected to control 36 percent of the phosphorus contributed from barnyards to Bower Creek. By 1996, 5 of the 12 contracted systems had been installed. Additional reductions in the amount of manure entering Bower Creek are to be achieved through planned and implemented nutrient-management plans and manure-storage facilities. Sediment reductions associated with the implementation of upland BMP's will probably be estimated with the WINHUSLE model. The upland practices listed on the farm conservation plans include conservation cropping, minimum tillage, and critical-area stabilization.

Otter Creek Watershed

Most of the following information on the Otter Creek Watershed was taken primarily from the Sheboygan River Priority Watershed Plan (Wisconsin Department of Natural Resources, 1993b).

Watershed Characteristics

Location. The Otter Creek Watershed is in Sheboygan County, 15 mi west of Lake Michigan, in east-central Wisconsin (fig. 1). It is within the Sheboygan River Priority Watershed, as designated by the WDNR. Otter Creek discharges into the Sheboygan River, which flows into Lake Michigan.

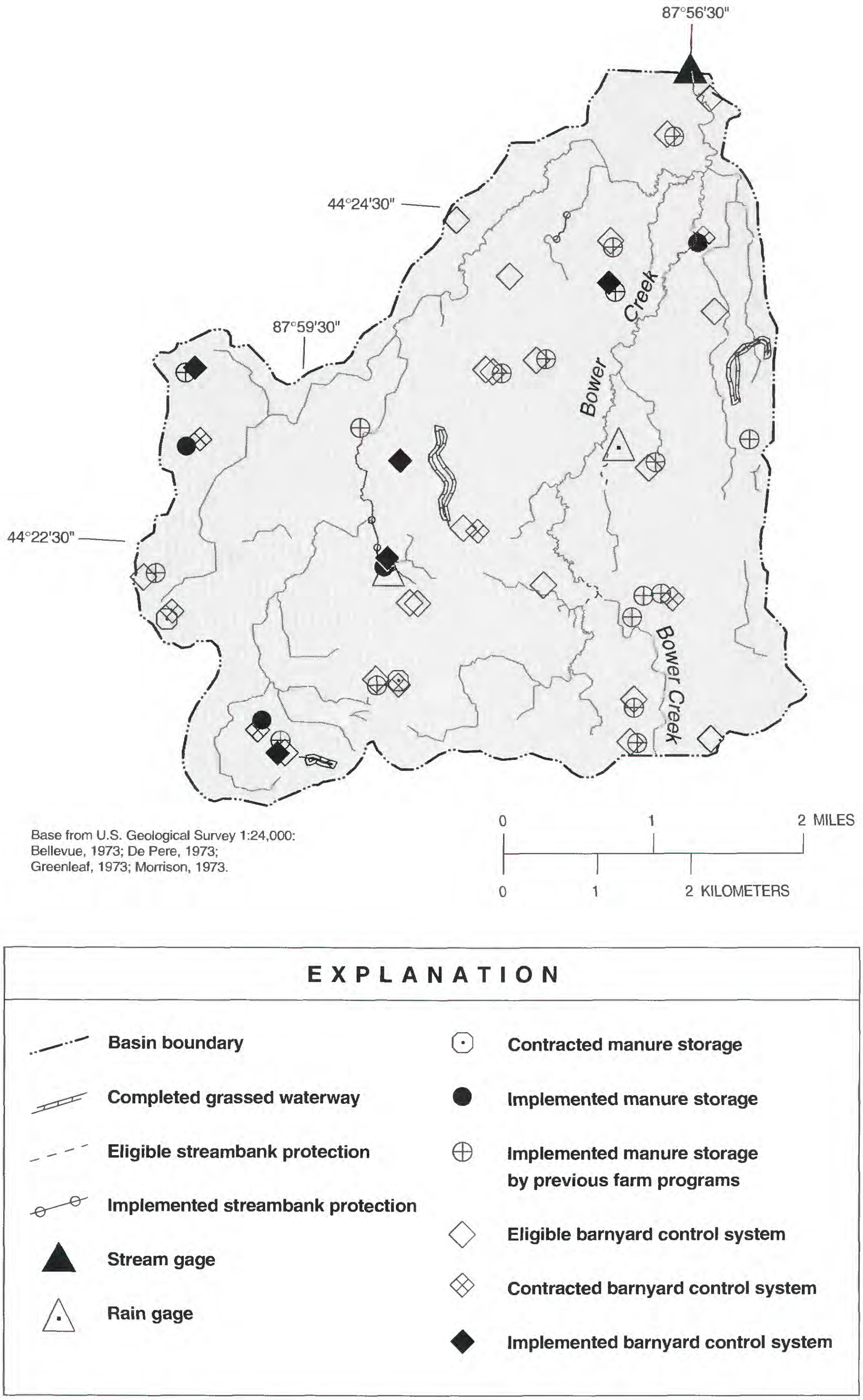


Figure 9. Eligible, contracted, and implemented best-management practices, Bower Creek Watershed.

Drainage area of the Otter Creek Watershed is 9.5 mi^2. The monitored stream length of perennial and intermittent streams is approximately 13.0 mi. The original priority watershed delineation separates the Otter Creek Watershed into three subwatersheds: Wayside Park, Victory School, and Little Elkhart. Water-quality monitoring at the USGS station on Otter Creek at Willow Road near Plymouth (fig. 11) began with the 1991 water year.

Reference Watersheds. Two adjacent reference watersheds have been established for the Otter Creek Watershed, both within the Pigeon River Watershed (table 8). The sampling locations are Pigeon River at County Line Road, 5 mi northwest of Howards Grove, and Meeme River at County Highway XX, 3.5 mi west of Cleveland.

Climate. The climate in the Otter Creek Watershed is continental: winters are long, cold, and snowy, and summers are warm and occasionally humid. Since 1990, the average annual air temperature recorded in Plymouth, Wis. (approximately 7 mi southwest of the watershed), has been 45.6°F, but the range of average monthly air temperatures has been 17.7 to 71.0°F (table 3; U.S. Department of Commerce, 1990–95). The nearness of the watershed to Lake Michigan keeps the winters warmer and the summers cooler than for inland areas within the State. The growing season usually starts about May 9 and ends about October 11; the average number of frost-free days is 155 (Engel and others, 1978).

Since water year 1991, the average annual rainfall has been 23.7 in. Rainfall for each water year since 1991 is listed in table 3. Approximately 50 percent of the rain falls from June through September. The driest months are December, January, and February, which account for only 4 percent of annual rainfall. The average annual runoff from 1991–95 is 9.30 in. at the Otter Creek water-quality monitoring station (Holmstrom and others, 1996).

Land Use. The evaluation monitoring watershed designated for Otter Creek is 263 acres larger than the original priority watershed. The land-use inventory covers an area of 6,106 acres. Drainage areas of the three smaller watersheds are 1,985 acres for Victory School, 3,661 acres for Wayside Park, and 461 acres for Little Elkhart. Land use/land cover in the watershed is 62.2 percent cropland, 14.5 percent woodlots, 10.3 percent grassland, and 5.7 percent wetlands (fig. 10). In all, 64 farms are being monitored in the Otter Creek Watershed. Average farm size is 140 acres, with an average of 129 acres in crop production. There are eight barnyards in the watershed. An average herd size is 45 animals, all of which are dairy cows (Sheboygan County Land Conservation Department, written commun., 1992). Little Elkhart Lake has a small residential community served by a wastewater-treatment facility.

Soils and Topography. Otter Creek Watershed has level to nearly level land, a result of glacial scouring of the landscape. The Kewaunee-Waymor-Manawa association and the Hochheim-Theresa association are the major soil associations in the watershed. The Kewaunee silt loam and the Kewaunee silty clay loam cover approximately 30 percent and 29 percent of the watershed, respectively (table 13). These soils are well drained to somewhat poorly drained. The surface layer is a silt loam, and the subsoils are a silty clay loam and clay. Bedrock is Niagara Dolomite (Engel, 1978).

The hydrological soil grouping designated for the Kewaunee silt loam and the Kewaunee silty clay loam is Group C. When wet but not saturated, soil in this group has a low to moderate infiltration rate and a high to moderate runoff rate. The erosion factor assigned to these soils is 0.37, an indication that these soils are naturally susceptible to erosion on steep or long slopes.

The land-surface elevation of the watersheds ranges from 760 ft above sea level at the monitoring station to approximately 960 ft above sea level at the upper edge of the watershed. In the watershed, gently sloping hills and shallow depressions decrease the runoff rate during spring and after periods of heavy rainfall. Only 2 percent of the area has slopes of greater than 12 percent.

Surface-Water Resources. Otter Creek is classified as a warmwater forage fishery able to support a variety of fish species, including intolerable species, and as a nursery for sport fish (table 1; Wisconsin Department of Natural Resources, 1993b). It is possible that the increased numbers of macrophytes noted in recent years has been caused by nutrients associated with manure (Wisconsin Department of Natural Resources, 1995a). The mean dissolved-oxygen concentration decreased during water years 1991–95; in addition, on 151 days (18 percent) of the 863 days monitored, dissolved-oxygen concentrations were below the State standard of 5 mg/L during water years 1991–95 (Corsi and others, 1995; Holmstrom and others, 1995–96).

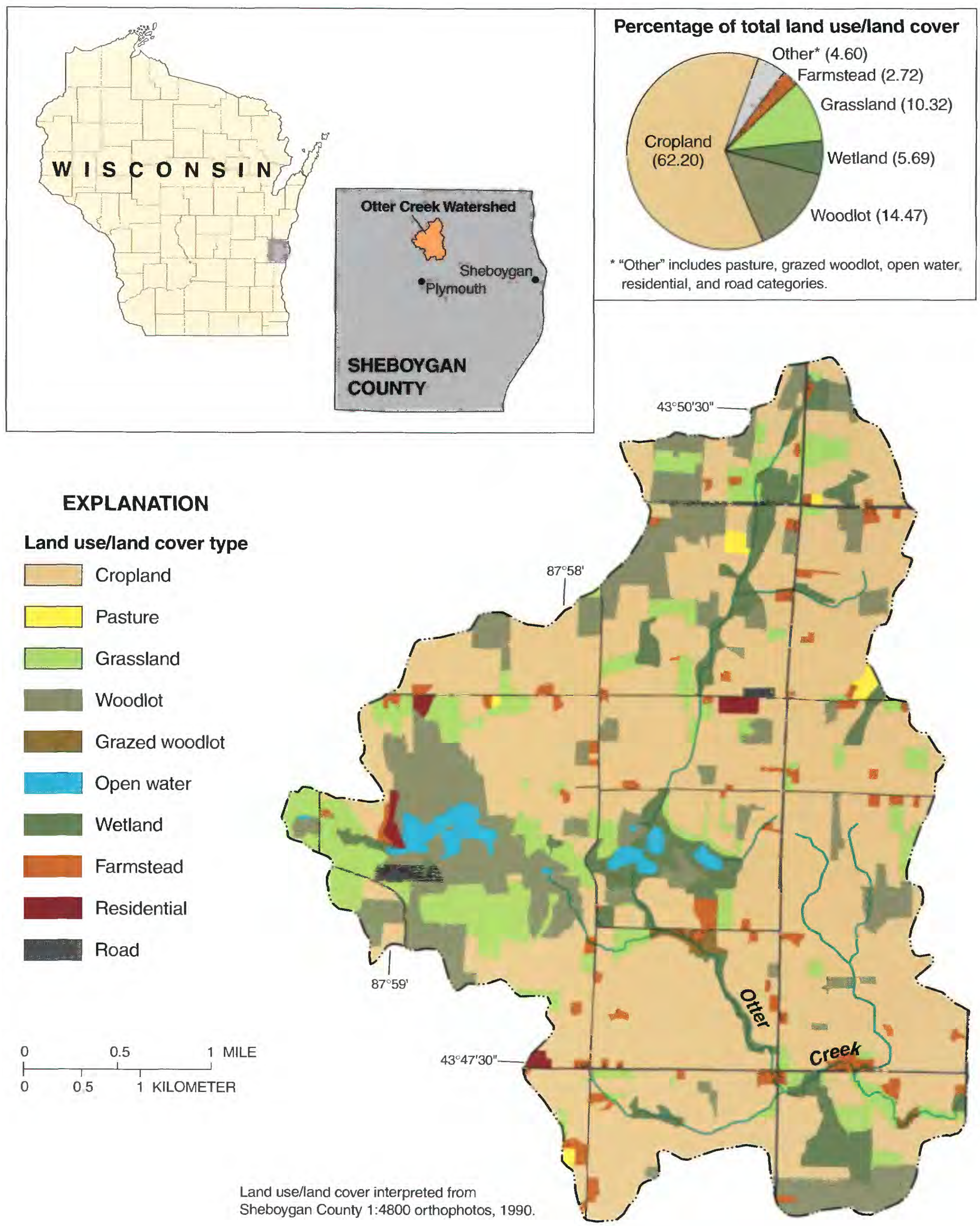


Figure 10. Land use/land cover, Otter Creek Watershed.

Table 13. Soil series and their distribution by slope, Otter Creek Watershed

[>, greater than]

Soil series	Percentage of watershed in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Kewaunee silt loam	30	0	100	0	0	0	0
Kewaunee silty clay loam	29	0	46	52	2	0	0
Hochheim silt loam	23	0	48	50	2	0	0
Waymor silt loam	5	0	69	31	0	0	0
Other	13	18	55	16	11	0	0
All soils	100	2	66	30	2	0	0

Three lakes are within the Otter Creek watershed: Little Elkhart Lake (surface area, 47 acres) in the Little Elkhart Watershed, and Big Gerber and Little Gerber Lakes (surface areas, 15.2 and 6.8 acres, respectively) in the Victory School Watershed.

Land Management

Objectives. The nonpoint-source control plan states that the primary objectives are to maintain the classifications of forage fishery and human recreational use. According to the nonpoint-source control plan, the primary water-resource objectives for Big and Little Gerber Lakes are to maintain the lakes' trophic status and to protect surrounding wetlands and recreational values; the primary water-resource objectives for Little Elkhart Lake are to improve the lake's trophic status and to enhance species richness and abundance of sport and forage fish.

Sources of Nonpoint Contamination and Goals of Contaminant Reduction. The nonpoint-source control plan states that animal-waste runoff is a significant source of contamination in the Otter Creek Watershed. Eight barnyards have been identified for animal-waste management (table 6; table 7; Wisconsin Department of Natural Resources, 1993b). These barnyards are discharging greater than 5 lb of phosphorus during a simulated 10-year, 24-hour storm event in the Victory School Subwatershed and greater than 4 lb in the Wayside Park Subwatershed (Sheboygan County Land Conservation Department, written commun., 1992). Runoff from these barnyards delivers 80 lb of phosphorus to Otter Creek (table 4). In the Little Elkhart Subwatershed, no barnyards were identified as being a significant source of contamination. The reduction goal for phosphorus is 50 percent (table 5), according to the nonpoint-source control plan.

Manure-management categories for critical areas in the Otter Creek Watershed are Category I, 15 acres or more; Category II, 7 to 15 acres; and Category III, 0 to 7 acres. The contaminant-reduction goal, as stated in the nonpoint-source control plan, is to reduce phosphorus inputs by 50 percent.

The Wayside Park Subwatershed has one of the highest sediment-delivery rates in the original priority watershed inventory. Upland-erosion management categories are the following (amounts are tons per acre per year): Category I is soil loss greater than 3 and sediment delivery greater than 0.10 in the Lake Elkhart Subwatershed, greater than 0.21 in the Victory School Subwatershed, and greater than 0.20 in the Wayside Park Subwatershed; Category II is soil loss less than 3 and the same sediment-delivery rates as for Category I. A total of 801 acres of cropland are in Management Category I, and 987 acres are in Management Category II.

The stream degradation has been caused by pasturing along streambanks, which has reduced riparian vegetation and increased bank erosion and sedimentation to the stream channel (Wisconsin Department of Natural Resources, 1995a). The total length of original inventoried streambank, including perennial and intermittent streams, is 66,700 ft. The total length of eroded sites is 7,000 ft, which includes both banks. According to the nonpoint-source control plan, the sediment-reduction goal for upland and streambank erosion is 75 percent.

Implementation of Best-Management Practices. The local county LCD has contracted or implemented BMP's within the Otter Creek Watershed since 1991 (table 2). All BMP's were to be implemented by the end of 1996. Barnyard-runoff control systems and upland BMP's are thought to be the most important practices to be implemented. Over the 5-year BMP implementation period, 100 percent of the eligible barnyards and 80 percent of the eligible upland acres are to be addressed (table 7; fig. 11).

Barnyard-runoff control systems planned or implemented are expected to control 89 percent of the phosphorus contributed from barnyards to Otter Creek. Through 1995, seven of the eight contracted systems had been implemented. In addition, reductions in the amount of manure entering Otter Creek are to be achieved through planned or implemented nutrient-management plans and manure-storage facilities. Sediment reductions associated with the implementation of upland BMP's will probably be estimated with the WINHUSLE model. The upland practices listed on the farm conservation plans include conservation cropping, minimum tillage, critical-area stabilization, and grassed waterways.

In 1994, a single-source site was established approximately 1 mi upstream from the evaluation monitoring station (Stuntebeck, 1995). Two water-quality samplers were installed above and below the barnyard for the purpose of quantifying the conditions before and after BMP's were implemented. These samplers were used to monitor the loading changes from the implementation of a barnyard-runoff control system. The barnyard-runoff control system was installed in fall 1994, but not fully operational until mid-1995.

Rattlesnake Creek and Kuenster Creek Watersheds

The following information on the Rattlesnake Creek and Kuenster Creek Watersheds was taken primarily from the Lower Grant River Priority Watershed Plan (Wisconsin Department of Natural Resources, 1991).

Watershed Characteristics

Location. The Rattlesnake Creek and Kuenster Creek Watersheds are in Grant County, 15 mi southwest of Lancaster (fig. 1). They are part of the Lower Grant River Priority Watershed, as designated by the WDNR. Kuenster Creek is a tributary to Rattlesnake Creek, which flows into the Grant River, which, in turn, flows to the Mississippi River. The drainage area of Rattlesnake Creek is 42.4 mi^2. The Kuenster Creek Watershed has a drainage area of 9.6 mi^2. About 111 mi of perennial and intermittent streams are found in the two watersheds. The USGS water-quality monitoring stations on Kuenster Creek at Muskellunge Road near North Andover and Rattlesnake Creek near North Andover (fig. 13) were established in 1991.

Reference Watersheds. The Pigeon Creek Watershed, in the Middle Grant Watershed, is the reference watershed for Rattlesnake Creek and Kuenster Creek (table 8). The sampling location at State Highway 81 is 2 mi west of Hurricane, Wis. Hackett Branch, also in the Middle Grant Watershed, is the reference watershed for Kuenster Creek. The sampling location at County Highway N is 7 mi southwest of Lancaster, Wis.

Climate. The climate of the Rattlesnake Creek and Kuenster Creek Watersheds is continental and is characterized by wide extremes in seasonal temperatures. Since 1991, the average annual air temperature recorded at Lancaster, Wis. (15 mi northeast of the watershed), has been 45.2°F, but the range of average monthly air temperatures has been 15.1 to 70.3°F (table 3; U.S. Department of Commerce, 1990–95). In Grant County, growing seasons average about 155 days (Robinson and Klingelhoets, 1961); however, the growing season in the Rattlesnake Creek and Kuenster Creek Watersheds may be longer because of their proximity to the Mississippi River.

Since water year 1991, the average annual precipitation has been 32 in. for the Rattlesnake Creek Watershed. Since 1992, the average rainfall for Kuenster Creek Watershed is 31.76 in. Variations in annual rainfall for water years 1991–95 are listed in table 3. About 50 percent of the rain falls from June through September, and only about 4 percent falls during December and January. Average runoff was 9.76 in. at the Kuenster Creek water-quality monitoring station for water years 1992–95 and 8.98 in. at the Rattlesnake Creek water-quality monitoring station for water years 1991–95 (Holmstrom and others, 1996).

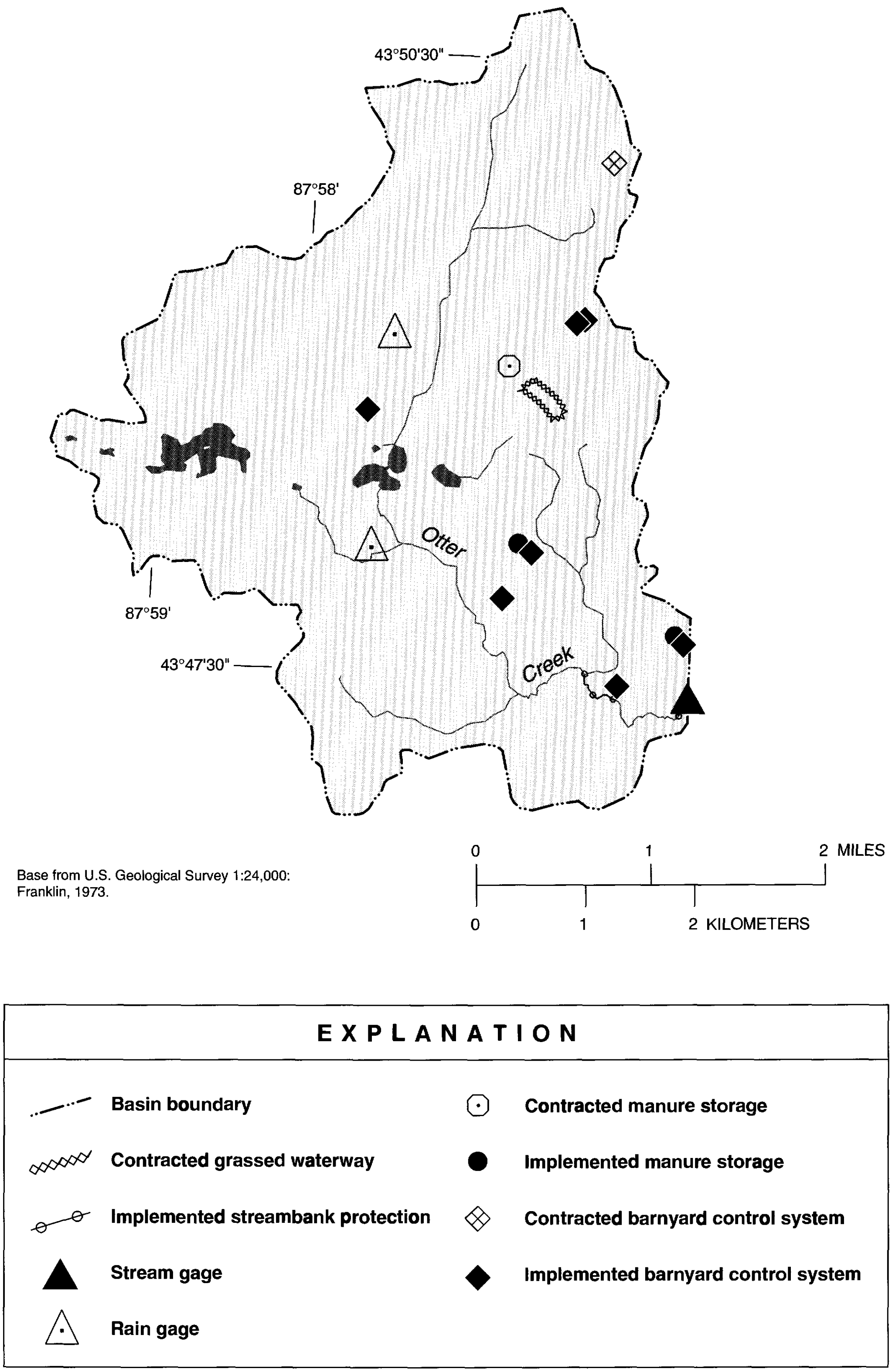


Figure 11. Eligible, contracted, and implemented best-management practices, Otter Creek Watershed.

Land Use. In the Rattlesnake Creek and Kuenster Creek Watersheds, the land-use inventory covers an average of 27,100 acres. Land use is primarily agricultural in the two watersheds. Croplands comprise 81.3 percent of the land use/land cover (fig. 12), and 15.3 percent of the watershed is used for grazing livestock. A total of 170 farms are in the two watersheds. An average farm size is 310 acres, with an average of 240 acres in cropland. A total of 182 barnyards are in the two watersheds, of which 104 are eligible. The average livestock herd for an eligible barnyard consists of 94 beef cattle, 81 dairy cows, and 164 swine[8] (Grant County Land Conservation Department, written commun., 1992).

Soils and Topography. The watershed lies within the unglaciated part of Wisconsin. Soils are derived mainly from loess. The Tama-Downs-Muscatine association is the major soil association in the watershed. These soils are deep, silty, and well drained. Silt depth can exceed 48 in., but is much less in many areas because of soil erosion over the years. The underlying bedrock for these soils is Dolomite (Robinson and Klingelhoets, 1961).

Tama silt loam, Fayette silt loam, and Downs silt loam overlie approximately 98 percent of the watershed (table 14). These soils can be found on rolling ridges and valley slopes. They have formed under forest and prairie vegetation in a thick blanket of silt. The soils that cover the remaining 2 percent of the watershed are primarily nearly level, silty, alluvial soils and silty, well-drained soils on upland ridges.

The hydrological soil grouping designated for the Tama silt loam, Downs silt loam, and Fayette silt loam soils is Group B. The Group B soil has a moderate infiltration rate and runoff rate. The erosion factor ranges from 0.28 to 0.43 for the Tama silt loam, Downs silt loam, and Fayette silt loam. The soils with a 0.28 erodibility factor would be the least prone to erosion, and the soils with a 0.43 erodibility factor the most prone.

The land-surface altitude of the monitored watershed ranges from 800 ft above sea level at the water-quality monitoring station on Rattlesnake Creek, 820 ft above sea level at the water-quality monitoring station on Kuenster Creek, to approximately 1,100 ft above sea level at the highest point in the headwaters. More than 80 percent of the watershed's slopes exceed 6 percent. In these steep areas, large amounts of water run off the surface.

Surface-Water Resources. Streams in the Rattlesnake Creek and Kuenster Creek Watersheds are primarily classified as warmwater and high gradient (table 1; Wisconsin Department of Natural Resources, 1991). Rattlesnake Creek is large enough to support a smallmouth bass sport fishery, but the other streams, including Kuenster Creek, can support only a forage fishery.

According to the nonpoint-source control plan, low dissolved-oxygen concentration associated with contaminated runoff is the most significant water-quality problem. In water years 1991–95, dissolved-oxygen concentration was less than the 5 mg/L State standard on 59 days (7 percent) of the 820 days monitored for Rattlesnake Creek and 79 days (14 percent) of 578 days monitored for Kuenster Creek (Corsi and others, 1995; Holmstrom and others, 1995–96). In addition, streambank erosion from livestock trampling produces sediment that may damage aquatic and wildlife habitat. The effects of livestock on the biotic community, however, tend to be less severe than low dissolved-oxygen concentrations (Wisconsin Department of Natural Resources, 1995a).

Land Management

Objectives. The nonpoint-source control plan states that water-resource objectives for Rattlesnake Creek and Kuenster Creek are to improve the current smallmouth bass fishery and also to improve riparian habitat to support waterfowl and other wildlife.

Sources of Nonpoint Contamination and Goals of Contaminant Reduction. The Rattlesnake Creek and Kuenster Creek Watersheds have the highest percentage of croplands and barnyards in the Lower Grant River Priority Watershed. Correspondingly, more than 50 percent of the upland erosion and nearly 50 percent of the barnyard phosphorus load occur in these watersheds.

In all, 104 out of 182 barnyards each contribute 15 lb or more of phosphorus during a simulated 10-year, 24-hour storm event and were identified for animal-waste management in the nonpoint-source control plan (table 6; table 7; Grant County Land Conservation Department, written commun., 1992).

[8]Some farms may have all three types of livestock; others have only one or two of the types.

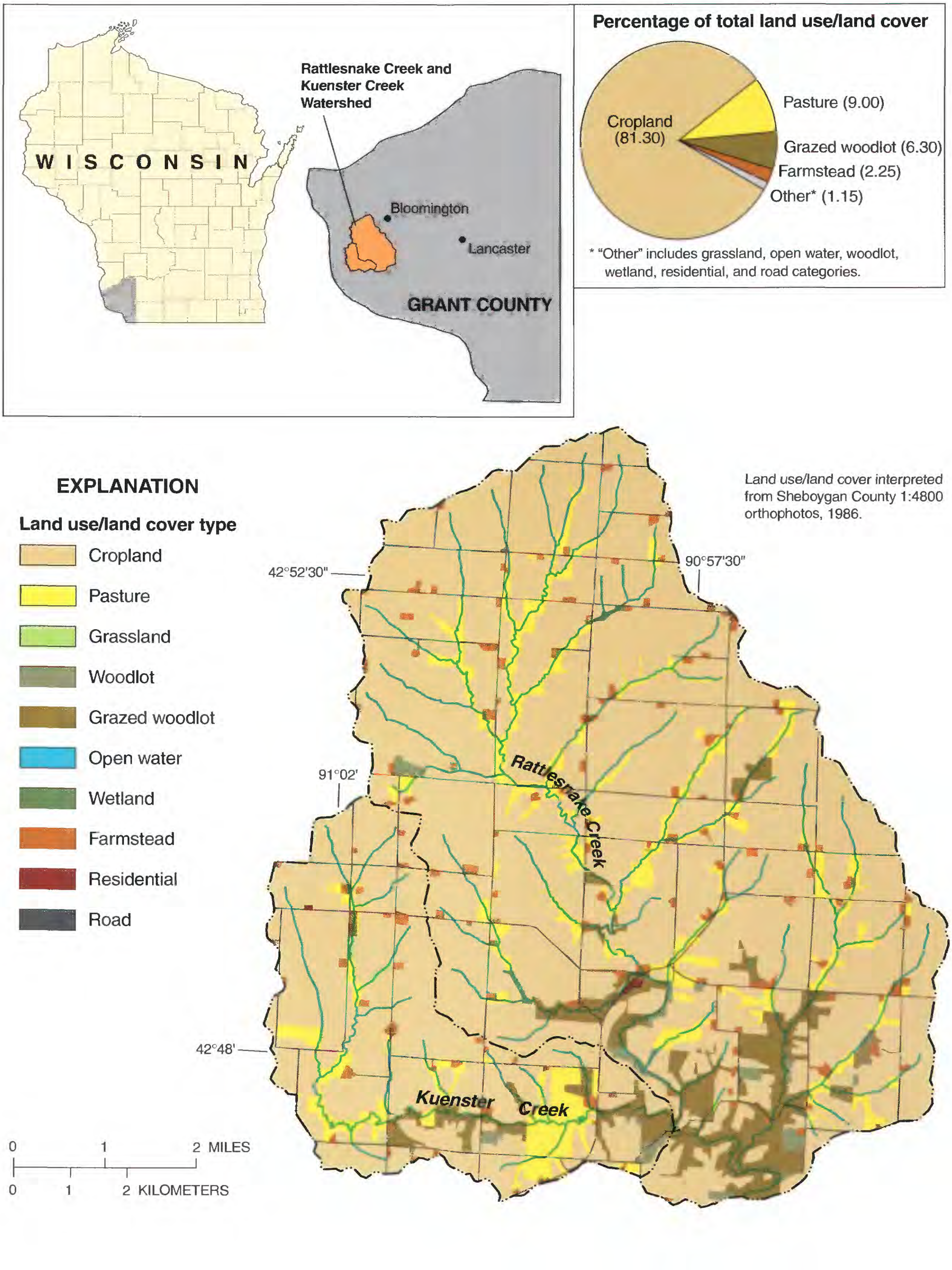


Figure 12. Land use/land cover, Rattlesnake Creek and Kuenster Creek Watersheds.

Table 14. Soil series and their distribution by slope, Rattlesnake Creek and Kuenster Creek Watersheds

[>, greater than]

Soil series	Percentage of watersheds in series	Percentage of series within indicated range of slope					
		0–2	2–6	6–12	12–20	20–30	>30
Tama silt loam	72	0	24	72	4	0	0
Fayette silt loam	16	0	2	78	20	0	0
Downs silt loam	10	0	12	76	12	0	0
Other	2	1	0	9	33	0	57
All soils	100	0	18	73	8	0	1

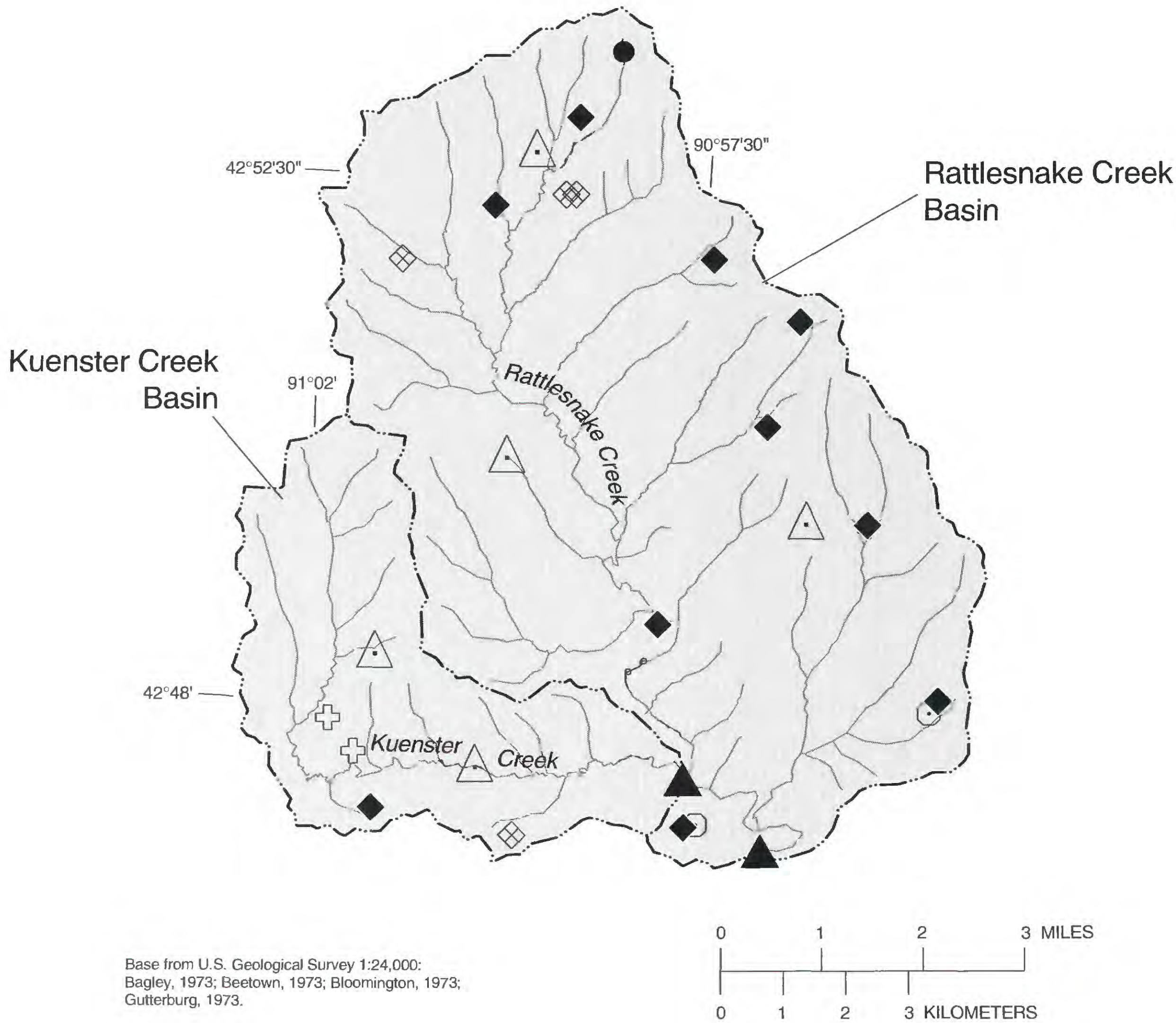
Runoff from these barnyards delivers a total of 4,700 lb of phosphorus to Rattlesnake Creek and 1,000 lb of phosphorus to Kuenster Creek (table 4). To achieve a 50-percent reduction in phosphorus loading (table 5; Wisconsin Department of Natural Resources, 1991), the winter spreading of manure also must be controlled. The manure-spreading management categories for critical areas are 15 acres or more, Category I; 10–14 acres, Category II; and less than 10 acres, Category III.

In the nonpoint-source control plan, a total area of approximately 17,500 upland acres were identified for sediment control in the two watersheds. These uplands were above tolerable soil-loss criterion and usually deliver more than 0.15 ton/acre/yr of sediment to streams in the watershed. There are 9,760 acres in Management Category I and 7,750 acres in Management Category II. A 30-percent reduction in sediment from eroding upland fields was recommended in the nonpoint-source control plan.

Cattle access to streams causes streambank erosion, which has a detrimental effect on riparian habitat and the smallmouth bass fishery. Streambank erosion occurs on about 70 percent of the perennial stream miles; this translates into 24.1 combined miles of eroding streambank on Kuenster and Rattlesnake Creeks. A 50-percent reduction in riparian habitat destruction from livestock access and a 50-percent reduction in sediment from streambank sources were proposed in the nonpoint-source control plan.

Implementation of Best-Management Practices. Since 1991, the local county LCD has contracted or implemented BMP's within the Rattlesnake Creek and Kuenster Creek Watersheds (table 2). Implementation of BMP should be completed by the end of 1996 in Rattlesnake Creek and 1998 in Kuenster Creek. Barnyard-runoff control systems, streambank practices (for example, riprap and stream crossings), and upland BMP's are thought to be the most important practices to be implemented. During the 5-year implementation period for Rattlesnake Creek, 11 percent of the eligible barnyards and 15 percent of the eligible streambank sites are to be addressed. Over the 7-year implementation period for Kuenster Creek, 10 percent of the eligible barnyards and 20 percent of the eligible streambank sites are to be addressed (table 7; fig. 13).

Barnyard-runoff control systems planned or implemented are expected to control 16 percent of the phosphorus delivered from barnyards to Rattlesnake Creek and 19 percent of the phosphorus delivered to Kuenster Creek. By 1996, 10 of the 14 contracted systems had been installed in both watersheds. Additional reductions in the amount of manure entering Rattlesnake Creek are to be achieved through planned or implemented nutrient-management plans and manure-storage facilities. Streambank BMP's implemented or to be implemented are expected to control 15 percent of the sediment entering Rattlesnake Creek and 20 percent of the sediment entering Kuenster Creek. Sediment reductions resulting from the implementation of upland BMP's will be estimated with data from the local county LCD. The upland practices listed on the farm conservation plans include conservation cropping, contour farming, minimum tillage, grassed waterways, and buffer strips.



EXPLANATION

(line symbol)	Basin boundary	(symbol)	Contracted manure storage
(line symbol)	Eligible streambank protection	(symbol)	Implemented manure storage
(line symbol)	Implemented streambank protection	(symbol)	Contracted barnyard control system
(symbol)	Stream gage	(symbol)	Implemented barnyard control system
(symbol)	Rain gage	(symbol)	Barnyard no longer has livestock

(Eligible practice not shown in this figure; see table 7)

Figure 13. Contracted and implemented best-management practices, Rattlesnake Creek and Kuenster Creek Watersheds.

SUMMARY AND PLANNED FUTURE INVENTORY ACTIVITIES

This report is a summary of the data collected as part of a land-use inventory to identify sources of contaminants and track land-management practices in eight evaluation monitoring watersheds in Wisconsin. Watershed characteristics were identified and quantified for each of the watersheds. A preliminary assessment of BMP implementation was also done for each watershed. The land-use inventory team will document any future changes in watershed characteristics, such as land use, and also track the implementation of BMP's.

The following land-use inventory activities are planned for water year 1997:

1. Update the GIS database that contains all essential land-use data.
2. Publish a fact sheet that details the progress of each local county LCD in implementing BMP's and the expected contaminant reduction obtained with these BMP's.
3. For some of the evaluation monitoring watersheds, estimate upland sediment loadings with the WINHUSLE model.
4. Verify that upland BMP's are being implemented within the monitored watersheds. This will be done by comparing information in the farm conservation plans with the annual land-cover data.
5. Complete an inventory of land-cover types.
6. Complete an analysis that identifies annual land-cover types for critical upland sites.

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