North Carolina

Long Creek Watershed
Section 319
National Monitoring Program Project

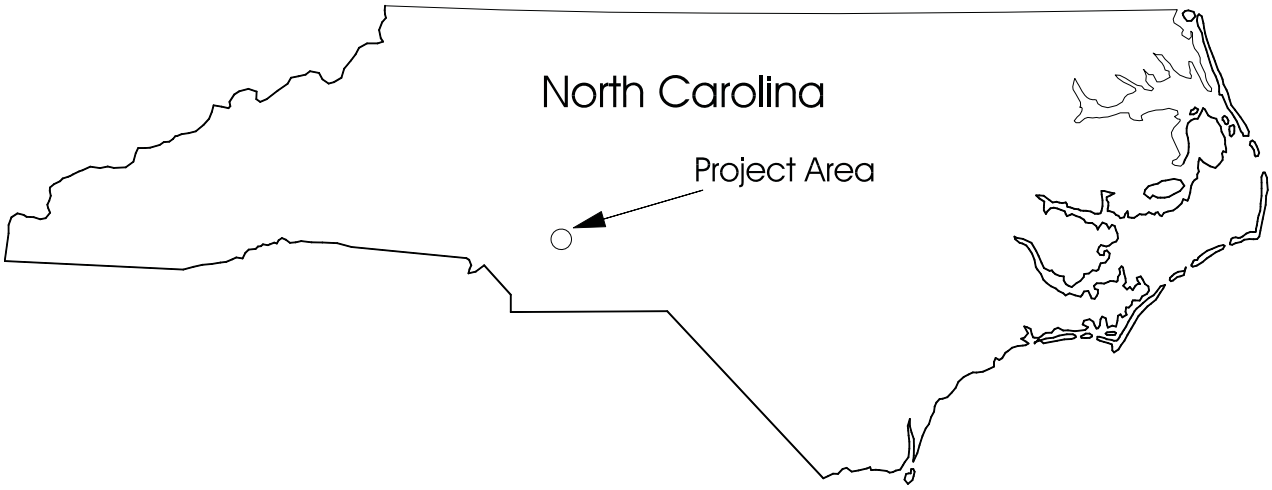

Figure 32: Long Creek (North Carolina) Watershed Project Location

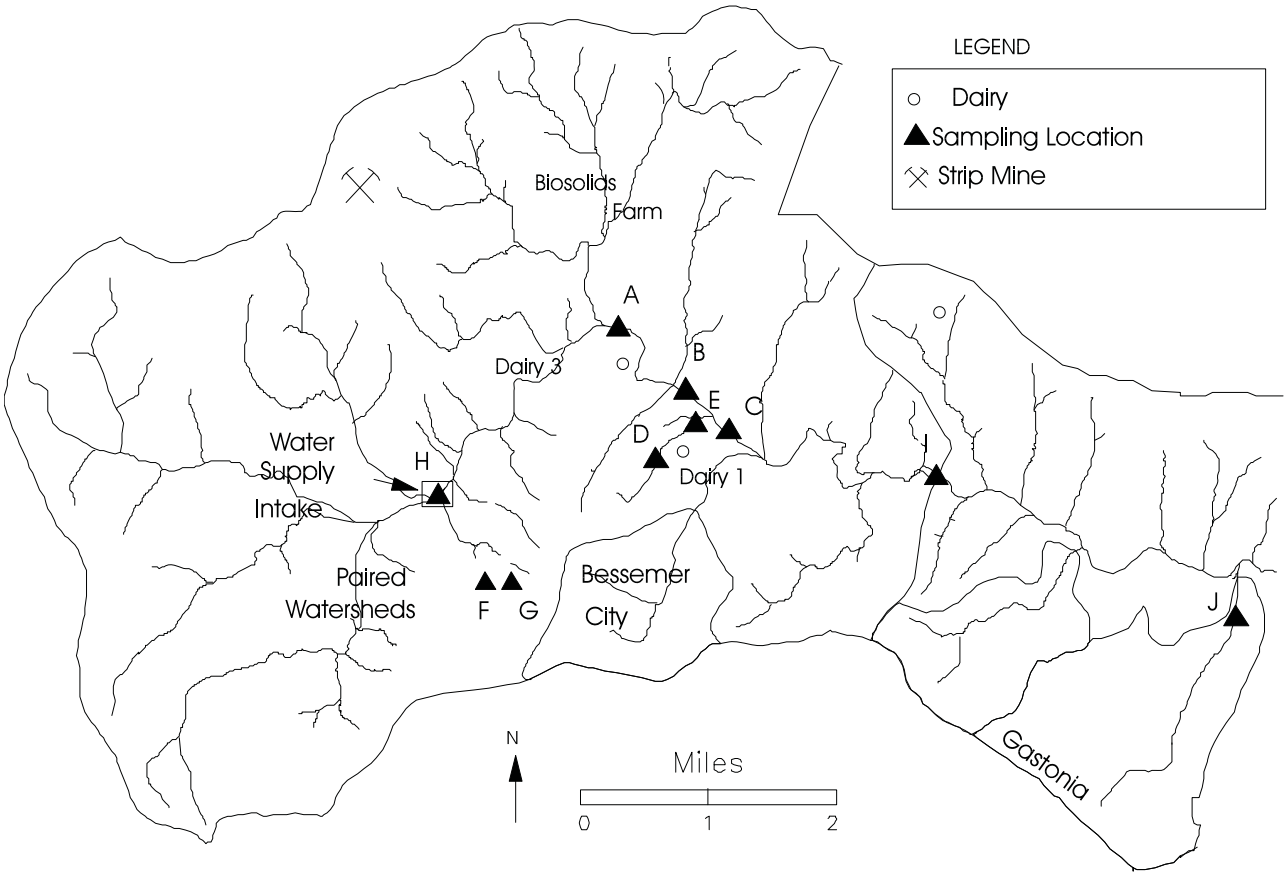

Figure 33: Water Quality Monitoring Stations for Long Creek (North Carolina) Watershed

PROJECT OVERVIEW

The Long Creek Watershed Section 319 National Monitoring Program project (28,480 acres), located in the southwestern Piedmont of North Carolina, consists of an area of mixed agricultural and urban/industrial land use (Figure 32). Long Creek is a perennial stream that serves as the primary water supply for Bessemer City, a municipality with a population of about 4,888 people (1994 estimate).

Agricultural activities related to crop and dairy production were believed to be the major nonpoint sources of pollutants to Long Creek. Sediment from eroding cropland was the major problem in the upper third of the watershed. At the start of the project, the water supply intake pool had to be dredged quarterly to maintain adequate storage volume, by the end of the project the frequency of dredging had been reduced to less than once per year. Below the intake, Long Creek is impaired primarily by bacteria and nutrients from urban areas and animal-holding facilities.

Below the intake, land treatment involved implementing a comprehensive nutrient management plan on a large dairy farm. Fencing was installed on four farms to exclude livestock from small streams. Stable stream crossings were also installed. More than 340 practices were implemented in the watershed. Land treatment and land use tracking was based on a combination of voluntary farmer record-keeping and frequent farm visits by extension personnel. Data was stored and managed in a geographic information system (GIS).

Water quality monitoring included a single-station, before-and-after-land treatment design near the Bessemer City water intake (Figure 33), upstream and downstream stations above and below an unnamed tributary on Long Creek (B and C), stations upstream and downstream of a dairy farmstead on an unnamed tributary to Long Creek (D and E), and monitoring stations on paired watersheds at a cropland runoff site (F and G). Storm-event and weekly grab samples were collected at various sites to provide the chemical and hydrologic data needed to assess the effectiveness of the land treatment program.

Post-BMP monitoring ended April 2001. The final report was completed in November, 2001.

PROJECT BACKGROUND

Project Area

About 44.5 square miles or 28,480 acres

Relevant Hydrologic, Geologic, and Meteorologic Factors

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

Land Use

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

Source: Jennings et al., 1992

Water Resource Type and Size

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

Water Uses and Impairments

Long Creek is the primary water supply for Bessemer City. Water quality impairments include high sediment, bacteria, and nutrient levels. The stream channel near the water supply intake in the headwaters area requires frequent dredging due to sediment deposition. The section of Long Creek from the Bessemer City water supply intake to near the watershed outlet sampling station (Figure 30) is listed as support-threatened by the North Carolina Nonpoint Source Management Program. Biological (macroinvertebrate) habitat is degraded in this section due to the presence of fecal coliform, excessive sediment, and nutrient loading from agricultural and urban nonpoint sources.

Pollutant Sources

Pollutants probably originate mainly from urban and residential areas and rural agricultural areas which include the following dairy farms:

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

Pre-Project Water Quality

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

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

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

Water Quality Objectives

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

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

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

Project Time Frame

January, 1993 to September, 2001

PROJECT DESIGN

Nonpoint Source Control Strategy

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

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

Dairy 1 Farmstead (sites D and E):
A larger waste storage structure was constructed. Improved pasture management, livestock exclusion from the unnamed tributary, and stream bank stabilization between sites D and E have been implemented. A fenceline feeding system that channels runoff to a waste holding pond was constructed.

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

Project Schedule

Site	Pre-BMP Monitoring	BMP Installation	Post-BMP Monitoring
D & E	8/94-2/96	2/96	3/96-3/01

Water Quality Monitoring

The water quality monitoring effort incorporated the following designs:

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

Parameters Measured

Biological

Percent canopy and aufwuchs (organisms growing on aquatic plants)

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

Bacteria: Fecal coliform (FC) and fecal streptococci (FS)

Chemical and Other

Total suspended solids (TSS)
Total solids (TS)
Dissolved oxygen (DO)
Biochemical oxygen demand (BOD) (1991-92)
pH (1993-1997) & temperature
Conductivity
Nitrate + nitrite (NO_3 + NO_2)
Total Kjeldahl nitrogen (TKN)
Total phosphorus (TP)

Physical stream indicators: width, depth and bank erosion

Covariates

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

Sampling Scheme

Water Supply Watershed (Figure 30):
Type: grab (site H)
Frequency and season: weekly from December through May and monthly for the remainder of the year for TS, TSS, FC, FS, temperature, conductivity, DO, pathogens, pH, and turbidity

Upstream/downstream of Dairy 1 Tributary on Long Creek (Figure 30):
Type: grab and storm event (sites B and C)
Frequency and season: weekly from December through May and monthly for the remainder of the year for FC and FS, temperature, pH, conductivity, turbidity, DO, TSS, TP, TKN, and NO_2+NO_3

Annual biological survey for sensitive species at station C only

Dairy 1 Farmstead Storm Event:
Type: grab (sites D and E)
Frequency and season: weekly all year for FC and FS, temperature, pH, conductivity, DO, TSS, TS, TKN, NO_2+NO_3, and TP; storm events for TSS, TS, TKN, NO_2+NO_3, TP, and pathogens

Paired Cropland Watersheds (Figure 30):
Type: storm event (sites F and G)
Frequency and season: stage-activated storm event for runoff, TS, TKN, NO_2+NO_3, and TP

Single Downstream Station at Watershed Outlet (Figure 30):
Type: grab (site I)
Frequency and season: weekly from December through May and monthly for the rest of the year for temperature, pH, conductivity, turbidity, DO, TSS, TP, TS, TKN, NO_2+NO_3, and FC and FS; annual biological for sensitive species

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

Design	Sites or Activities	Primary Parameters	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Single downstream	Water supply watershed	TS TSS FC FS Pathogens	Discharge (weekly)	Weekly (Dec.-May) Monthly	Annually	2 yrs pre-BMP 6 yrs BMP
Upstream/ downstream	Long Creek	TP $NO_3 + NO_2$ TKN TSS FS & FC	Discharge (weekly)	Weekly	Annually (downstream)	2 yrs pre-BMP 4 yrs BMP 2 yrs post-BMP
Upstream/ downstream	Dairy 1 Farmstead	TP $NO_3 + NO_2$ TS TSS FC FS Pathogens	Discharge (continuous) Rainfall Water table	Weekly and storm event		2 yrs pre-BMP 4 yrs post-BMP
Paired	Paired cropland watersheds	TP $NO_3 + NO_2$ TS TKN	Discharge (continuous) Rainfall Water table	Storm event		2 yrs pre-BMP 6 yrs post-BMP
Single downstream	Watershed outlet	TP $NO_3 + NO_2$ TKN TSS FC FS	Discharge (continuous)	Weekly (Dec.-May) Monthly (June-Nov.)	Annually	2 yrs pre-BMP 6 yrs BMP

Modifications Since Project Start

Dairy 2 went out of business and was purchased by the city of Gastonia for conversion to a biosolids application area.

In May – June, 1994, four monitoring wells were installed at the paired watersheds to gain a better understanding of ground water movement. Ten wells were installed between Sites D and E in July, 1996, and have been sampled monthly for nutrients, bacteria, and metals. Approximately 16 wells above Site B were also installed on a Biosolids Application site.

Also, storm-event sampling (Site J) on a small stream draining an urban subwatershed was added. Assessment monitoring for the pathogens *cryptosporidium* and *giardia* was initiated at several locations in the overall Long Creek watershed. The monitoring began in April, 1996 and included collecting grab samples at 12 locations within the watershed. Samples from three current sites, as well as additional sites, were collected and analyzed for indicator organisms such as E. coli, clostridium perfringens, and coliphages and the pathogens *giardia* and *cryptosporidium*.

Sampling at sites A, B,C, and J ceased on March 31, 2001 and sampling at sites D, E, H, and I stopped in July, 2001.

Progress To Date

Farm plans for more than 20 farms within the watershed were developed. Twenty-five Water Quality Incentive Project (WQIP) applications were submitted by landowners in the Long Creek watershed. Eight plans were prepared representing more than $50,000 of BMP installations to control nonpoint source pollution on these sites.

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

A watering system and a stream crossing were installed at a beef farm and fencing was planned on a dairy farm to exclude cows from tributary streams.

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

A solid waste storage structure was completed in July, 1993. A watering system was installed in the pastures of the watershed. Fencing for cattle exclusion between monitoring sites D and E was completed and the streamside buffers were planted in pine and hardwood trees. Grass was planted on severely eroding streambanks.

Beginning in June, 1998, the Dec through May sampling scheme at sites A, B, C, H, & I was extended to the whole year thereby replacing the June through November scheme.

DATA MANAGEMENT AND ANALYSIS

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

NPSMS Data Summary

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B **YEAR:** 1994

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3600	1700	810
Fecal Streptoccoci 9230C	U	CFU/100ML	3700	1400	270
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	.53	.49	.45
Nitrogen, Kjeldahl, Total (MG/L as N)	S		.30	.22	.15
Phosphorus, Total (MG/L as P)	S		.30	.18	.10
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	8	5.0	4.0

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C **YEAR:** 1994

Chemical Parameters

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

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D **YEAR:** 1994

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	81000	31000	7700
Fecal Streptoccoci 9230C	U	CFU/100ML	28000	10000	2600
Flow, Stream, Daily mean, (CFS)	S	CFS	0.08	0.05	0.04
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	2.7	2.085	1.405
Nitrogen, Kjeldahl, Total (MG/L as N)	S		3.2	1.3	.615
Phosphorus, Total (MG/L as P)	S		.745	.45	.285
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	145	102	90
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	44.5	12.5	2

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E **YEAR:** 1994

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE VALUES -75-	-50-	-25-
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	485000	60000	21000
Fecal Streptoccoci 9230C	U	CFU/100ML	215000	42500	8150
Flow, Stream, Daily mean (CFS)	S	CFS	0.15	0.10	0.08
Nitrate + Nitrite (353.1 EPA, 1983)	U	MG/L	3.275	1.925	1.28
Nitrogen, Kjeldahl, Total (MG/L as N)	S		12.00	2.80	1.65
Phosphorus, Total (MG/L as P)	S		2.865	.815	.59
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	309	139	114
Total Suspended Solids	U	MG/L	71.5	13	3

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H **YEAR:** 1994

Chemical Parameters

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

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B **YEAR:** 1995 (2)

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform,	S	CFU/100ML	9	9	9	6
Nitrogen, Kjeldahl, Total (MG/L as N)	S		3	8	6	16
Phosphorus, Total (MG/L as P)	S		22	6	4	1
Total Suspended Solids	U	MG/L	8	3	14	8

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C **YEAR:** 1995 (2)

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	7	5	13	8
Nitrogen, Kjeldahl, Total (MG/L as N)	S		3	6	16	8
Phosphorus, Total (MG/L as P)	S		24	5	3	1
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	4	15	6	8

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D **YEAR:** 1995 (2)

Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	7	3	13	8
Fecal Streptoccoci 9230C	U	CFU/100ML	11	20	24	5
Flow, Stream, Daily mean, CFS	S	CFS	91	91	92	91
Nitrogen, Kjeldahl, Total (MG/L as N)	S		19	23	9	1
Phosphorus, Total (MG/L as P)	S		29	16	5	2
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	21	14	11	6
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	9	33	7	3

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E **YEAR:** 1995 (2)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	19	10	8	15
Fecal Streptoccoci 9230C	U	CFU/100ML	11	17	17	7
Flow, Stream, Daily mean (CFS)	S	CFS	91	91	92	91
Nitrogen, Kjeldahl, Total (MG/L as N)	S		31	6	14	1
Phosphorus, Total (MG/L as P)	S		29	8	13	2
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	25	12	10	5
Total Suspended Solids	U	MG/L	13	21	12	6

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H **YEAR:** 1995 (2)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3	12	8	5
Fecal Streptoccoci 9230C	U	CFU/100ML	7	7	9	5
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	16	6	3	7
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	8	8	11	5

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B **YEAR:** 1996 (3)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform,	S	CFU/100ML	9	7	9	6
Nitrogen, Kjeldahl, Total (MG/L as N)	S		6	7	9	7
Phosphorus, Total (MG/L as P)	S		27	3	0	1
Total Suspended Solids	U	MG/L	8	5	5	13

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C **YEAR:** 1996 (3)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	14	3	7	7
Nitrogen, Kjeldahl, Total (MG/L as N)	S		7	1	11	12
Phosphorus, Total (MG/L as P)	S		27	3	0	1
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	7	10	4	10

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D **YEAR:** 1996 (3)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	4	27	12	8
Fecal Streptoccoci 9230C	U	CFU/100ML	10	23	11	7
Flow, Stream, Daily mean, CFS	S	CFS	85	26	57	196
Nitrogen, Kjeldahl, Total (MG/L as N)	S		26	17	7	2
Phosphorus, Total (MG/L as P)	S		43	7	0	2
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	29	6	11	6
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	15	29	4	4

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E **YEAR:** 1996 (3)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	6	8	9	29
Fecal Streptoccoci 9230C	U	CFU/100ML	4	7	9	32
Flow, Stream, daily mean (CFS)	S	CFS	55	73	113	125
Nitrogen, Kjeldahl, Total (MG/L as N)	S		21	6	15	10
Phosphorus, Total (MG/L as P)	S		23	3	16	10
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	13	13	15	11
Total Suspended Solids	U	MG/L	9	19	11	13

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H **YEAR:** 1996 (3)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	6	10	2	13
Fecal Streptoccoci 9230C	U	CFU/100ML	5	9	4	13
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	13	3	6	9
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	9	6	7	9

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B **YEAR:** 1997 (4)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform,	S	CFU/100ML	12	12	6	3
Nitrogen, Kjeldahl, Total (MG/L as N)	S		4	4	11	14
Phosphorus, Total (MG/L as P)	S		32	0	0	1
Total Suspended Solids	U	MG/L	10	2	9	11

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C **YEAR:** 1997 (4)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	10	7	10	6
Nitrogen, Kjeldahl, Total (MG/L as N)	S		3	4	14	12
Phosphorus, Total (MG/L as P)	S		32	0	0	1
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	7	11	6	9

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D **YEAR:** 1997 (4)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3	33	13	1
Fecal Streptoccoci 9230C	U	CFU/100ML	9	20	13	7
Flow, Stream, Daily Mean (CFS)	S	CFS	123	44	109	89
Nitrogen, Kjeldahl, Total (MG/L as N)	S		33	13	3	1
Phosphorus, Total (MG/L as P)	S		44	3	2	1
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	24	11	12	3
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	21	22	6	1

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E **YEAR:** 1997 (4)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	14	24	7	5
Fecal Streptoccoci 9230C	U	CFU/100ML	12	24	3	10
Flow, Stream, Daily Mean (CFS)	S	CFS	252	33	27	54
Nitrogen, Kjeldahl, Total (MG/L as N)	S		44	3	3	0
Phosphorus, Total (MG/L as P)	S		42	3	3	2
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	21	9	8	2
Total Suspended Solids	U	MG/L	33	12	4	1

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H **YEAR:** 1997 (4)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	3	14	5	12
Fecal Streptoccoci 9230C	U	CFU/100ML	3	7	13	10
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	9	4	2	3
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	7	10	6	11

STATION TYPE: Downstream Station **PRIMARY CODE:** Site E **YEAR:** 1998 (5)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	20	22	3	5
Fecal Streptoccoci 9230C	U	CFU/100ML	19	19	5	6
Flow, Stream, Daily mean (CFS)	S	CFS	192	62	44	66
Nitrogen, Kjeldahl, Total (MG/L as N)	S		44	3	5	0
Phosphorus, Total (MG/L as P)	S		44	2	1	5
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	28	14	5	5
Total Suspended Solids	U	MG/L	33	13	3	3

STATION TYPE: Upstream Station **PRIMARY CODE:** Site H **YEAR:** 1998 (5)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	15	11	2	8
Fecal Streptoccoci 9230C	U	CFU/100ML	8	14	6	6
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	29	8	5	8
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	9	16	8	7

STATION TYPE: Upstream Station **PRIMARY CODE:** Site B **YEAR:** 1998 (5)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform,	S	CFU/100ML	25	4	0	6
Nitrogen, Kjeldahl, Total (MG/L as N)	S		5	13	7	11
Phosphorus, Total (MG/L as P)	S		29	2	3	2
Total Suspended Solids	U	MG/L	14	5	7	9

STATION TYPE: Downstream Station **PRIMARY CODE:** Site C **YEAR:** 1998 (5)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	22	4	1	8
Nitrogen, Kjeldahl, Total (MG/L as N)	S		9	5	14	8
Phosphorus, Total (MG/L as P)	S		28	2	4	2
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	7	13	7	8

STATION TYPE: Upstream Station **PRIMARY CODE:** Site D **YEAR:** 1998 (5)
Chemical Parameters

Parameter Name	Parm Type	Reporting Units	QUARTILE COUNTS 1	2	3	4
Fecal Coliform, Membr Filter, M-FC Broth, 44.5 C	S	CFU/100ML	11	31	5	3
Fecal Streptoccoci 9230C	U	CFU/100ML	13	25	7	4
Flow, Stream, Daily mean, CFS	S	CFS	123	42	95	105
Nitrogen, Kjeldahl, Total (MG/L as N)	S		40	7	2	3
Phosphorus, Total (MG/L as P)	S		43	3	1	5
Total Solids (Residue) 2540B (17th SMEWWW)	U	MG/L	27	8	11	6
Total Suspended Solids (2540C 17th SMEWWW)	U	MG/L	25	17	6	4

Final Results

At the start of the project in 1993, headwater tributaries were contributing significant amounts of sediment to Long Creek. In addition to sediment, tributary streams further downstream were supplying elevated levels of nutrients and bacteria to Long Creek such that Long Creek was considered degraded and of poor water quality for aquatic life support by the time it emptied into the South Fork of the Catawba River. At the start of the project, a coordinated program to monitor water quality throughout key areas of the watershed was initiated. Shortly thereafter a concerted effort, which included information and education activities and enhanced cost share availability, to implement BMPs in the watershed was begun and continued for several years. The implementation of BMPs and land use changes resulted in considerable and statistically significant decreases in total phosphorus and bacteria levels in Long Creek during the 8 years of the project.

More than 350 BMPs to treat runoff from 10,000 acres of pasture and cropland were implemented in the watershed. Animal waste management systems were installed to properly handle and apply 7,732,000 gallons of animal waste from four dairy operations.

The implementation of primarily erosion control practices and the conversion of some land from row crop to tree production in the headwaters or water supply watershed of Long Creek resulted in a decrease in the frequency of dredging around the water supply intake for Bessemer City. Prior to 1996, the stream channel required dredging of deposited sediment three to four times per year, but after, the need for dredging decreased to less than once per year.

The implementation of BMPs and changes in land use in the watershed resulted in 75 and 70% decreases in median annual total phosphorus and fecal coliform levels at three downstream monitoring sites on Long Creek.

The closure of the surface mining operation and subsequent draining of several large tailings ponds coincided with decreases in suspended sediment and fecal coliform levels at three monitoring sites on Long Creek.

The installation of livestock exclusion fencing and riparian buffer establishment in the pasture of a large dairy operation resulted in 43, 75, 74, 85% reductions in weekly nitrate+nitrite, total Kjeldahl nitrogen, total phosphorus, and suspended sediment loads from the stream draining the pasture. Fecal coliform and streptococci levels decrease 90 and 80%, respectively following livestock exclusion. Statistical analyses suggested that all the reductions were significant except for nitrate+nitrite.

Monthly sampling of 10 monitoring wells in a dairy pasture documented elevated levels of nitrogen and phosphorus species in ground water beneath heavily use areas of the pasture. Wells along a transect in the riparian buffer show that the buffer was effective at nitrogen removal from ground water, but was not effective at phosphorus removal.

Annual sampling has documented that the abundance and diversity of the macroinvertebrate community at several sites in Long Creek has been increasing indicating an improving trend in water quality.

Monitoring of a small wetland, constructed along an urban stream, documented decreases in the concentrations of petroleum-related polycyclic aromatic hydrocarbons (PAHs) as water from the stream passed through the wetland. However, the wetland had little effect on combustion-related PAHs.

Sampling of cropland soil, stream banks, and stream beds indicated that cropland had considerably higher total phosphorus levels than stream bank or bed material. Storm sampling of two tributaries and Long Creek itself showed that, on average, the phosphorus burden in suspended sediment was an order of magnitude greater than for bedload sediment.

At least 1.5 years of background or pre-treatment water quality monitoring is required to document the effectiveness of nonpoint source controls; however, the start of a project and the initiation of monitoring often prompts landowners to implement improved management practices. Therefore, a concerted effort to explain the timeline of the study must be spent prior to the start of monitoring.

INFORMATION, EDUCATION, AND PUBLICITY

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

An education plan developed for Gaston County included activities in the Long Creek watershed. Also, a Stream Watch group had been formed to 1) educate other watershed residents and 2) conduct quality monitoring by volunteers. Project overviews were presented at state, local, regional, and international water-related conferences.

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

The information and education effort was expanded to an urban watershed that is drained by Kaglor Branch. Streambank stabilization practices and a stormwater wetland were installed in an urban park near the outlet of the Kaglor watershed. A boardwalk to facilitate viewing of various features of the wetland is in place and educational displays along the boardwalk were planned.

TOTAL PROJECT BUDGET

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

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

Source: Jennings et al., 1992

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

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

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

OTHER PERTINENT INFORMATION

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

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