VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 7/2/2004

Security Group: Public

Project Name: Little Sugar Creek WMP

Plan Type: Watershed Management Plan

HUC Code: 05120110 Sugar

Sponsor: Montgomery County SWCD

Contract #: 01-389

County: Montgomery

Cross Reference ID: 15743462

Comments: Boone

Additional WMP Information

Checklist: 2003 Checklist

Grant type: 319

Fiscal Year: 2002

IDEM Approval Date: 7/2/2004

EPA Approval Date:

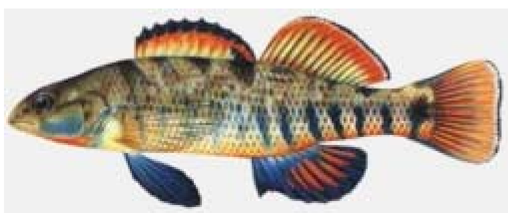
Project Manager: Amy Henninger

Watershed Management Plan

for

Little Sugar Creek

Montgomery County
Boone County



Prepared By

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Watershed Coordinator

The Little Sugar Creek Watershed: Looking Towards Future Horizons

Executive Summary

The Little Sugar Creek Watershed is located approximately 40 miles Northwest of Indianapolis. This watershed is part of the larger Sugar Creek watershed. The Little Sugar Creek 11-digit watershed contains two 14-digit subwatersheds. The watershed consists of 29,074 acres and is contained in both Boone and Montgomery Counties. Little Sugar Creek is listed on Indiana's 303(d) List of Impaired Waterbodies for Mercury, PCB's, and Fish Consumption Advisory.

The Little Sugar Creek Watershed contains mostly agricultural landuses with a small amount of residential and business. Not much development is occurring within the watershed. However, agriculture landuses, predominantly corn and soybean production, continue to dominate the land. The watershed also contains areas of livestock production, which is the second largest land use practice and has been a concern for citizens in the area.

The Little Sugar Creek Watershed: Looking Towards Future Horizons document is the result of 22 months of conducting research, gathering information, holding public meetings, education, and initiating discussions among watershed residents, local and government agencies, business owners, agricultural producers, and interested citizens to identify watershed concerns and address them. A Steering Committee was formed to lead discussion of concerns. The committee developed the following mission statement that explains the purpose of this project: *To identify problems in the Little Sugar Creek watershed and educate landowners of why good water quality is important and how they can affect it.*

This Watershed Management Plan was created as a result of the committee's efforts to reduce pollution as much as possible from nonpoint sources in the watershed. In order to accomplish this, the Committee focused its attention on four main areas in the watershed:

1. Agricultural nonpoint source pollution from cropland activities
2. Agricultural nonpoint source pollution from livestock farming
3. Lack of vegetated riparian buffers near Little Sugar Creek and its tributaries

4. Education for landowners in the watershed and community members on nonpoint source pollution problems and solutions

   The Steering Committee developed goals and objectives to address each of the four topics:

<u>Cropland Agriculture Goals</u>

1. Reduce manure application of fertilizer by educating about soil testing and optimum usage for certain soil types
2. By November 2007, see no-till on 50% of corn after soybeans and 90% of beans after corn
3. Increase awareness on how cropping practices can impact water quality and about cost-share available through other programs such as the Farm Bill.

<u>Livestock Agriculture Goals</u>

4. Promote use of alternative water and manure management systems in the Little Creek Subwatershed.
5. Fence livestock from waterways where applicable

<u>Riparian Goals</u>

6. Install buffer strips in the Little Creek subwatershed.
7. Connect buffers along waterways to create corridor in Needam-Booher subwatershed.
8. Educate the public on the importance of habitat.

<u>Educational Goals</u>

9. Start Hoosier Riverwatch program in Montgomery County and Boone County schools.
10. Get into Montgomery County and Boone County schools to provide education on watersheds, nonpoint source pollution, 319 Grant, and the importance of conservation.

Future actions as a result of this plan include more programs and activities focused on nonpoint source pollution education, increased opportunities for landowners within the watershed to get help installing conservation practices, and increase the number of participating stakeholders.

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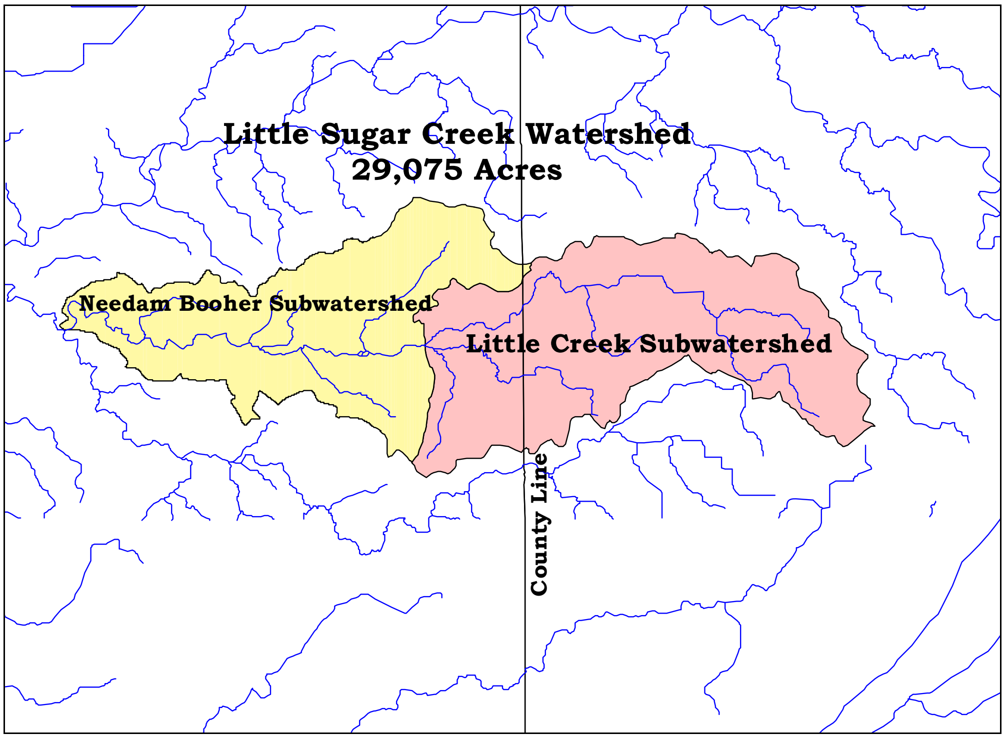
Section I: Introduction to 319 Grant

In June of 2002 the Montgomery County Soil and Water Conservation District entered into a contract with the Indiana Department of Environmental Management (IDEM) for a 319 grant. The district applied for the grant to cover the Little Sugar Creek watershed because it was an area of long standing concern. The community has witnessed Little Sugar Creek go from a wonderful fishing and swimming stream to a stream people are afraid to use recreationally. Signs are posted along the creek warning anglers not to eat the fish because of the high levels of mercury and polychlorinated biphenyls (PCB's) in the fish and there have been at least nine fish kills in the last twenty five years from manure spills. The contract with IDEM made funds available to hire a watershed coordinator who would coordinate planning efforts in the Little Sugar Creek watershed, collect baseline data, assess biotic communities, and ultimately develop a watershed management plan. The watershed management plan was to be completed within two years the start of the grant. Amy Altman, a Purdue graduate, was selected by the Montgomery County Soil and Water Conservation District Board to be the watershed coordinator. The 319 grant started on July 1, 2002.

The two 14-digit hydrologic codes for the Little Sugar Creek watershed are 05120110040030, which is the Needam Booher Ditch portion, and 05120110040020, which is the Little Creek portion. They are named after the main tributaries that flow into Little Sugar Creek. The Little Sugar Creek watershed consists of 29,075.0 acres in both the eastern portion on Montgomery County and the Western portion of Boone County (Figure 1).

Figure 1: Little Sugar Creek Subwatersheds



The two subwatersheds make up the entire Little Sugar Creek watershed, which is part of the larger Sugar Creek Watershed.

Sugar Creek is located in the Middle Wabash River Basin. Its 8-digit hydrologic code is 05120110. Counties that make up most of this area include Fountain, Montgomery, Clinton, Hamilton, Boone, Parke, Tippecanoe, and Tipton. This River basin occupies the Middle Eastern portion of the state (Figure 2).

Figure 2: Indiana 8-digit HUC watersheds

A Total Maximum Daily Load (TMDL) evaluation for Little Sugar Creek is scheduled to occur between the years 2014 and 2019. The TMDL evaluation is a process that leads to the qualification of the amount of a specific pollutant discharged into a waterbody that can be assimilated and still meet the water quality standards. Pollutants are described as sewage, chemical wastes, biological materials, and industrial, municipal, and agricultural waste. The TMDL will identify how much of the pollutant is coming from point sources and nonpoint sources. It will also specify the amount of pollutant reduction necessary form each source in order to meet the water quality standard set for that pollutant. A plan to reduce amount of pollutant coming from each source will be developed and implemented. The public will be invited to participate in the plan to develop and implement the TMDL (IDEM 2002).

Building Partnerships

Many individuals and agencies were involved in the 319 Grant project for Little Sugar Creek. These participants were gathered together to form the Little Sugar Creek Steering Committee. The steering committee met once every quarter to discuss various topics affecting the watershed and to develop the Watershed Management Plan. The group was responsible for ensuring local views and values were taken into account during the management plan development, carrying out of activities, and organizing watershed goals. Concerns were expressed through conversations at meetings and out in the field. Landowners and other concerned citizens not interested in being on the steering committee could call the Montgomery County SWCD or talk out in the field about their concerns within the watershed. Some of the major concerns identified at the first steering committee meeting inclued:

- Sedimentation
- Largest single hog farm in Indiana
- Nutrient input from manure
- Education
- E. coli
- Fish consumption advisory
- Cattle in streams
- Failed septic systems
- Septic maintenance
- Fertilizer input into stream
- Lack of buffer
- Smell of water and sediment

Evidence of sedimentation and nutrient loading in Little Sugar Creek

When asked to rank each category based on importance to the committee, the top concerns came out to be sedimentation, nutrient input from manure and other fertilizers, education, and septic maintenance. *Figure 3* is a diagram explaining the Little Sugar Creek planning process developed by the steering committee.

Figure 3: Little Sugar Creek Steering Committee Planning Process

July 2002

Project Begins

Fall 2002

Develop Steering Committee

Janurary 2003

Develop Concern List

February 2003

Introduce Project, Public Meeting

Spring 2003

Discuss Concerns List, Prioritize Concerns, Develop Mission

Summer 2003

Work on Watershed Mission, Identify Problem Areas,
Design Education Programs

Fall 2003

Compare Concern List with Data Collected and Repritorize,
Develop Goals and Objectives

Winter 2003

Compile Data and Identify Areas of Concern Based on Data

February/March 2004

Write Watershed Management Plan

May 2004

Send Draft of Watershed Management Plan to
Indiana Department of Environmental Management for Review

June 2004

Final Draft of Watershed Management turned in for Approval
Completion of Grant

Below are individuals and organizations who have actively participated in the steering committee and want to help improve the water quality in the Little Sugar Creek watershed.

The mission statement developed by the group: *"To identify problems in the watershed and educate landowners of why good water quality is important and how they can affect it."*

Indiana American Water Co.: The Water Co. has donated the testing for Nitrates and Nitritesof the water taken from Little Sugar Creek. These results will be reported in the final plan and used to determine the quality of the water. They are a stakeholder in the project. Stan Scott the Operations Superintendent is also on the steering committee. The water company has wells in the Little Sugar Creek watershed and is well aware of the water quality problems in the Creek. He also provided information on the PR Mallory superfund site.

Crawfordsville WWTP: The WWTP conducted Ammonia and E. Coli tests for the water samples taken from Little Sugar Creek. The results of these tests were a good way to track where animal and human wastes are the most concentrated. The data will be recorded and used to come up with the management plan.

Friends of Sugar Creek: This organization has been very involved in tracking the condition of Little Sugar Creek. They are a stakeholder engaged in the planning process. They have a representative, Raoul Moore owns land along the creek and is also on the steering committee. Raoul has a family farm along the creek and has a tree plot across from the large hog operation.

Pheasants Forever: This organization is very interested in cleaning up the county waterways and putting in conservation practices while providing habitat for wildlife. They have been helpful in assisting with sampling and are a stakeholder engaged in the planning process. Member, Jeff Lough, farms in the Little Sugar Creek watershed and is on the steering committee. He knows many of the landowners in the watershed and has helped in getting the word out about the grant. He also helped to make the public meetings beneficial by providing input on how to talk to the landowners.

Purdue Extension: Jim Luzar from the extension office is helpful in providing equipment to do presentations. He has good ideas for educating landowners and the general public. He has been in the area for many years and knows the landowners in the Little Sugar Creek watershed. He also can identify areas that have put in conservation practices and which areas need work.

Diane Binford: Her husband is a farmer that farms along Little Sugar Creek. She is interested in improving the quality of the creek. Their family has put in many conservation practices and would like to see other landowners do the same. She grew up in the area and knows the landowners. Having her talk to them has been a big help in gaining support for the grant. She is on the steering committee and are very interested in helping educate people on the condition of the stream and possibilities of conservation practices.

John Diehl: He is a landowner in Shannondale who does not farm, but does own land on Little Sugar Creek. He grew up in the area and has a concern with the quality of the water in the creek. Little Sugar Creek runs through his property, which is just downstream from the town of Shannondale and a large cattle operation that allows their cattle access to the creek. He provided ideas for conservation of the land and what to talk to landowners about. He gives a non-farming landowner point of view pertaining to conservation.

Montgomery County Health Department: Ron Posthower, the Environment Health Specialist, is on the steering committee and has been helpful in identifying areas that have been a problem in the past with failed septic systems. He knows the watershed fairly well and has gone to some properties and tested well water and looked at septic systems. His ideas are concerned with public health and add another perspective with which to look at the water quality. The health department is a stakeholder and is involved in the planning process.

David Stanley: He is the NRCS District Conservationist and is on the steering committee. Any information needed about the history of the watershed or landowners that live there he could provide. He is also aware of all conservation practices installed within the watershed.

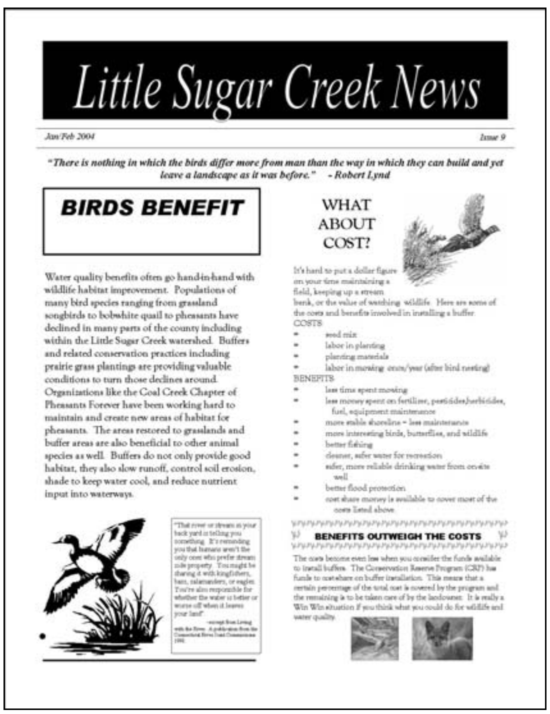
This group was developed by everyone’s willingness to get involved and their interest in the quality of the water. There is a good mix of landowners, businesses, and organizations in the watershed represented on the committee. With the different views of water quality represented in this group, many good ideas are brought to the table and utilized in the identifying problems and educating of landowners about the Little Sugar Creek watershed.

Public Involvement

The public was informed of the 319 Grant through many media sources. Radio interviews were conducted to briefly describe the project and what had been accomplished. Public meetings were also announced via radio.

Newspaper articles were written to inform the readers about the progress of the project. They were also a way to let the public know about dates the public meetings are held. The newspaper also covers other important dates in which the general public was encouraged to attend. Informational displays were set up at events such as the county fair, annual meetings, field days, and no-till meetings. Newsletters written by the watershed coordinator were also sent to landowners and operators in the watershed every other month. These newsletters addressed different water quality topics ranging from nutrient input to the importance stream temperature (Figures 4&5). Copies of all newsletters can be found in the appendix.

Figure 4: LSC Newsletter



Little Sugar Creek News

Jan/Feb 2004 — Issue 9

"There is nothing in which the birds differ more from man than the way in which they can build and yet leave a landscape as it was before." - Robert Lynd

BIRDS BENEFIT

Water quality benefits often go hand-in-hand with wildlife habitat improvement. Populations of many bird species ranging from grassland songbirds to bobwhite quail to pheasants have declined in many parts of the county including within the Little Sugar Creek watershed. Buffers and related conservation practices including prairie grass plantings are providing valuable conditions to turn those declines around. Organizations like the Coal Creek Chapter of Pheasants Forever have been working hard to maintain and create new areas of habitat for pheasants. The areas restored to grasslands and buffer areas are also beneficial to other animal species as well. Buffers do not only provide good habitat, they also slow runoff, control soil erosion, shade to keep water cool, and reduce nutrient input into waterways.

"That river or stream in your back yard is telling you something. It's reminding you that humans aren't the only ones who prefer stream side property. You might be sharing it with kingfishers, bats, salamanders, or eagles. You're also responsible for whether the water is better or worse off when it leaves your land"

-excerpt from Living with the River. A publication from the Connecticut River Joint Commissions 1998.

WHAT ABOUT COST?

It's hard to put a dollar figure on your time maintaining a field, keeping up a stream bank, or the value of watching wildlife. Here are some of the costs and benefits involved in installing a buffer.

COSTS

- seed mix
- labor in planting
- planting materials
- labor in mowing once/year (after bird nesting)

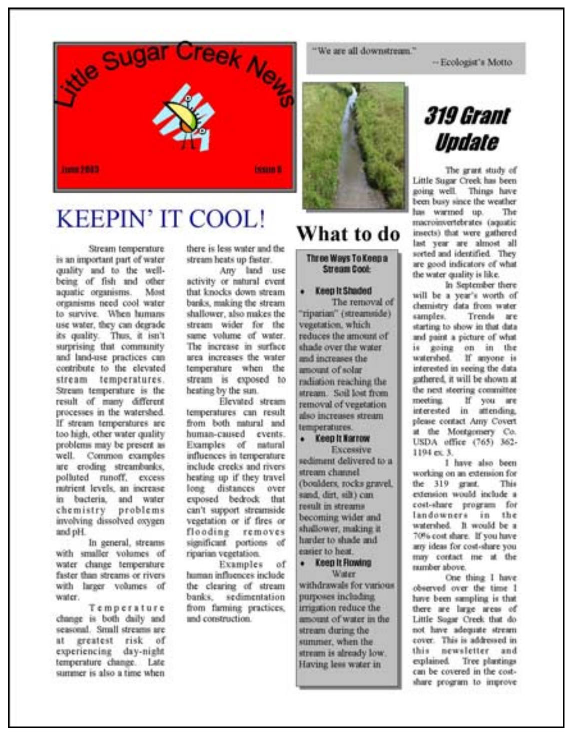
BENEFITS

- less time spent mowing
- less money spent on fertilizer, pesticides, herbicides, fuel, equipment maintenance
- more stable shoreline = less maintenance
- more interesting birds, butterflies, and wildlife
- better fishing
- cleaner, safer water for recreation
- safer, more reliable drinking water from on-site well
- better flood protection
- cost share money is available to cover most of the costs listed above

BENEFITS OUTWEIGH THE COSTS

The costs become even less when you consider the funds available to install buffers. The Conservation Reserve Program (CRP) has funds to cost-share on buffer installation. This means that a certain percentage of the total cost is covered by the program and the remaining is to be taken care of by the landowner. It is really a Win Win situation if you think what you could do for wildlife and water quality.

Figure 5: LSC Newsletter



Little Sugar Creek News

June 2003 — Issue 8

"We are all downstream." -- Ecologist's Motto

KEEPIN' IT COOL!

Stream temperature is an important part of water quality and to the well-being of fish and other aquatic organisms. Most organisms need cool water to survive. When humans use water, they can degrade its quality. Thus, it isn't surprising that community and land-use practices can contribute to the elevated stream temperatures. Stream temperature is the result of many different processes in the watershed. If stream temperatures are too high, other water quality problems may be present as well. Common examples are eroding streambanks, polluted runoff, excess nutrient levels, an increase in bacteria, and water chemistry problems involving dissolved oxygen and pH.

In general, streams with smaller volumes of water change temperature faster than streams or rivers with larger volumes of water.

Temperature change is both daily and seasonal. Small streams are at greatest risk of experiencing day-night temperature change. Late summer is also a time when there is less water and the stream heats up faster.

Any land use activity or natural event that knocks down stream banks, making the stream shallower, also makes the stream wider for the same volume of water. The increase in surface area increases the water temperature when the stream is exposed to heating by the sun.

Elevated stream temperatures can result from both natural and human-caused events. Examples of natural influences in temperature include creeks and rivers heating up if they travel long distances over exposed bedrock that can't support streamside vegetation or if fires or flooding removes significant portions of riparian vegetation.

Examples of human influences include the clearing of stream banks, sedimentation from farming practices, and construction.

What to do

Three Ways To Keep a Stream Cool:

- **Keep It Shaded** The removal of "riparian" (streamside) vegetation, which reduces the amount of shade over the water and increases the amount of solar radiation reaching the stream. Soil lost from removal of vegetation also increases stream temperatures.
- **Keep It Narrow** Excessive sediment delivered to a stream channel (boulders, rocks gravel, sand, dirt, silt) can result in streams becoming wider and shallower, making it harder to shade and easier to heat.
- **Keep It Flowing** Water withdrawals for various purposes including irrigation reduce the amount of water in the stream during the summer, when the stream is already low. Having less water in

319 Grant Update

The grant study of Little Sugar Creek has been going well. Things have been busy since the weather has warmed up. The macroinvertebrates (aquatic insects) that were gathered last year are almost all sorted and identified. They are good indicators of what the water quality is like.

In September there will be a year's worth of chemistry data from water samples. Trends are starting to show in that data and paint a picture of what is going on in the watershed. If anyone is interested in seeing the data gathered, it will be shown at the next steering committee meeting. If you are interested in attending, please contact Amy Covert at the Montgomery Co. USDA office (765) 362-1194 ex. 3.

I have also been working on an extension for the 319 grant. This extension would include a cost-share program for landowners in the watershed. It would be a 70% cost share. If you have any ideas for cost-share you may contact me at the number above.

One thing I have observed over the time I have been sampling is that there are large areas of Little Sugar Creek that do not have adequate stream cover. This is addressed in this newsletter and explained. Tree plantings can be covered in the cost-share program to improve

The public is also engaged through the stakeholder/steering committee meetings. We met once a quarter to discuss new business, organize management plan ideas, and look at the progress of the grant. Members of the steering committee got information to the public and answered any questions anyone may have about the Little Sugar Creek watershed study. Steering committee members were also a good way to get people to come to the public meetings by word of mouth.

Through the course of the grant we found that public involvement and education was the key to getting landowners to make changes to improve the quality of the water. Most people are just not well informed on what a difference they can make by doing something as simple as installing filter strips along streams. With public outreach and education hopefully Little Sugar Creek can be made into a healthier stream.

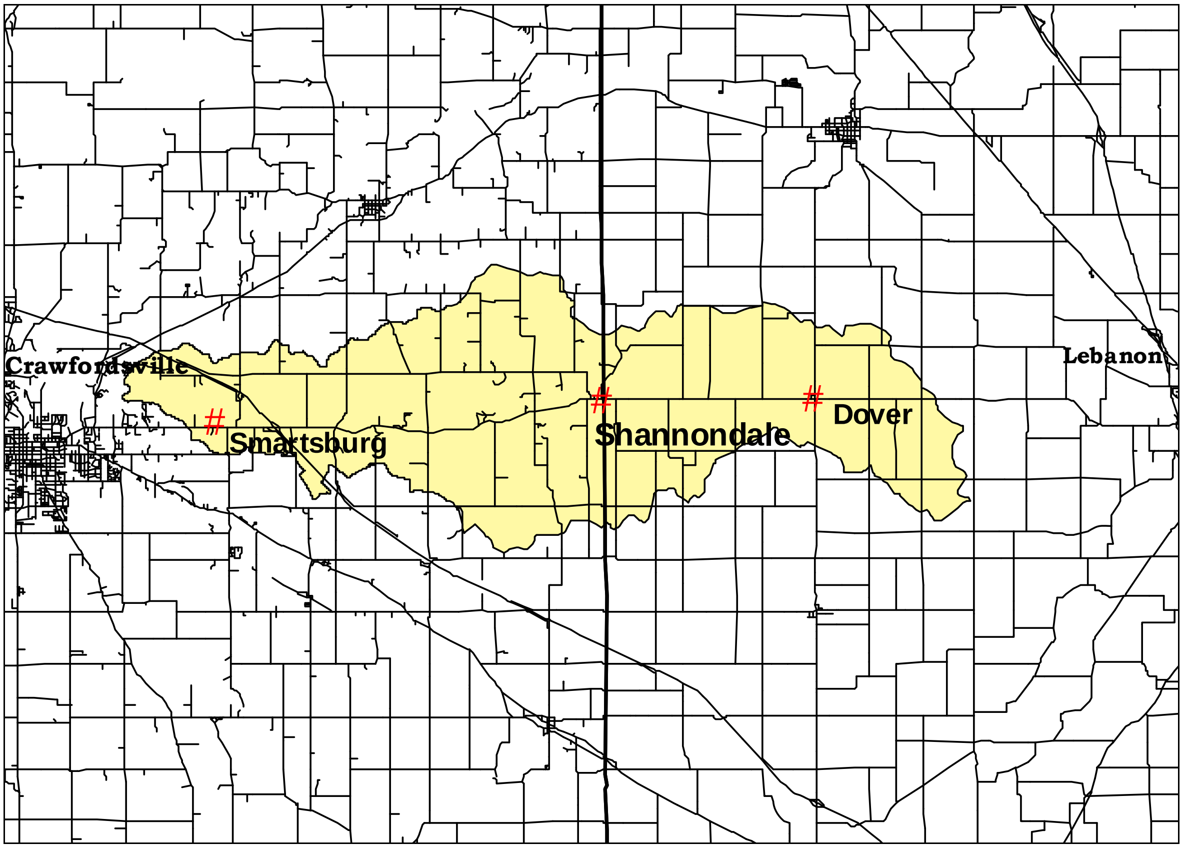
SECTION II: Description of the Watershed

This section gives a description of the Little Sugar Creek watershed and its physical features. It also describes the area's geology, climatic information, endangered species, soils, hydrologic features, topography, and wetlands within the watershed.

Watershed Description and History

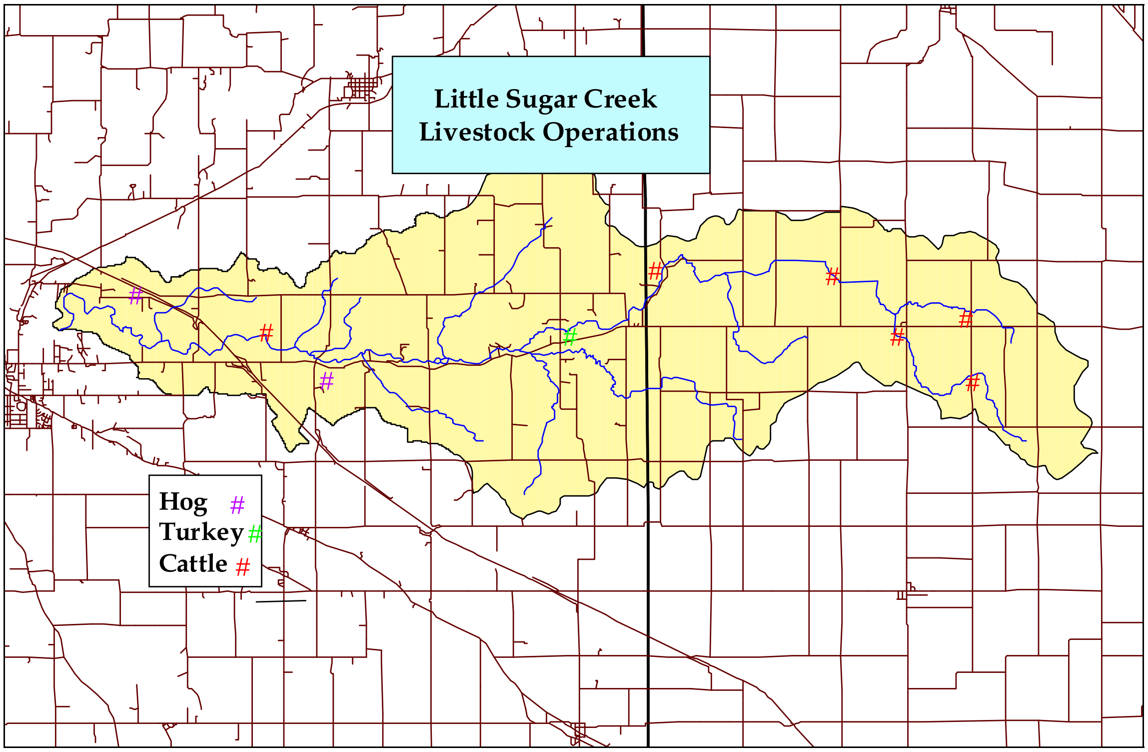
Within the Little Sugar Creek watershed there is a small amount of residential land use. Most of the residential development is in the western portion of the watershed closer to the city of Crawfordsville. The towns of Smartsburg, Shannondale and Dover sit along Little Sugar Creek as you move westward along SR 32 (Figure 6). These towns are not very large and consist of residential homes and a few small businesses. Shannondale and Dover have no more than 20 residential houses in each location. A majority of the watershed is agricultural. According to the 1999 U.S. Census of Agriculture, the percentage of woodland in both Boone and Montgomery counties has increased from 1930 to 1997. Montgomery County had an increase in woodland from 0.9% in 1930 to 4% in 1997. Boone County also had and increase from 0.4% woodland area in 1930 to 2% in 1997. According to the U.S. Census both counties have seen a decrease in pasture land and an increase in harvested cropland. Many farmers who raised livestock either sold their operations to be converted to harvested cropland by another farmer or switched to a confined system of raising livestock.

Figure 6: Towns in the LSC Watershed



Livestock production is also a large portion of the practices that occur in the watershed even though the amount of pastureland has decreased according to the 1999 U.S. Census of Agriculture. Because of technology farmers have been able to use confined feeding practices for livestock and therefore do not need as much pastureland. That pasture land then turns into cropland. There are hog, cattle, and turkey operations scattered throughout the watershed most of which are confined operations (Figure 7).

Figure 7: Livestock Operations in the LSC Watershed



Operations that allow cattle access to the creek are concentrated in the Boone County portion of the watershed. Each cattle operation along the main channel of Little Sugar Creek allows their cattle access to the creek with no exclusion. The largest area of concern involving livestock operations is the large hog operation indicated by the easternmost purple marker (Figure 6). This is the largest single site Concentrated Animal Feeding Operation (CAFO) in Indiana. A large amount of the manure produced by the hogs is applied to the fields by knifing it in and broadcasting it as fertilizer. This operation has been the cause of more manure spills into Little Sugar Creek since 1979 resulting in the loss of thousands of fish. Along with history of fish kills, the Indiana Department of Environmental Management (IDEM) has recognized Little Sugar Creek as an impaired stream in its 303d listed waters for Mercury, PCB's, and fish consumption advisories. The term "303d" comes from Section 303 (d) of the Clean Water Act. This section requires states to identify waters that do not or are not expected to meet water quality standards to be fishable and/or swimmable (IDEM 2002).

Geology & Geologic History

The Little Sugar Creek watershed is within both Boone and Montgomery Counties. This region is in the west-central portion of the United States. The last glacier to advance through the watershed was the Wisconsian Glacier 20,000 years ago. There was a re-advance of the Wisconsian glacier 1,000 years later. This re-advance formed the Crawfordsville Moraine in west-central Indiana. Sand and gravel outwash was left behind as a base for the hardwood forests, which followed (Hall, 1999).

Beneath the glacial deposits of sand and gravel, the Little Sugar Creek Watershed has four main bedrock groups: limestone, siltstone, sandstone, and shale.

> **Limestone**: Calcium carbonate in the form of calcite; limestones differ in appearance due to differences in grain size and amount of impurities; most are light to medium gray; many contain fossils
>
> **Siltstone**: Cemented or otherwise bound grains of silt; only the largest silt grains can be seen with the eye and thus identified as to composition without magnification; quartz is the most common grain
>
> **Sandstone**: Cemented grains of sand; quartz is the most common mineral grain, but other minerals can occur, as can sand-sized rock fragments; composition of the sand can be used to determine the variety of sandstone
>
> **Shale**: Composed of clay which is too small to be seen without powerful magnification; sometimes larger grains of quartz or mica may be seen; usually breaks along closely-spaced planes
>
> **(Hall, 1999)**.

Physiographic Features

The Little Sugar Creek watershed is in the Tipton Till Plain. This area which covers central Indiana and surrounding areas is a nearly flat to gently rolling glacial plain. Much of the plain is featureless being relatively flat. The Tipton Till Plain is characterized by being of low relief with some moraines and knolls that rise above ground level. The major valleys in the area were deepened by the late-glacial and post-glacial stream erosion (Hall, 1999).

Soils

Soils in the watershed were formed under an original hardwood forest. These soils have an A horizon about 12 inches thick, a recognizable E Horizon, and a B Horizon both well drained and poorly drained. These soils are classified as alfisols which are excellent for farming but may require drainage tile in the flat, poorly drained areas (Hall, 1999). The average slope in Boone County is 1-2% and the average in montgomery County is 2-6% (IWR 7980). Needless to say, Montgomery County has a higher potential for soil erosion than Boone County. The majority of the highly erodible soils are located West of Smartsburg from the Oakley-Rush association. There are seven soil associations in the Little Sugar Creek Watershed explained in the table below. Crosby, Cyclone, Fincastle, Magalasville, Miami, Ragsdale, Starks, and Whitaker are all unsitable for septic absorption fields (Table #1) (USDA SCS, 1989).

Table 1: Soils in the LSC Watershed

Soil Associations	Discription
Ockley-Rush	Nearly level to moderately sloping, well drained soils formed in silty material; Loam and gravel outwash
Fincastle-Miami	Nearly level to strongly sloping, somewhat poorly drained and well drained soils, silty, glacial drift; on uplands
Fincastle-Cyclone	Nearly level, somewhat poorly drained to poorly drained soils, silty material and glacial drift; on uplands
Starks-Mahalasville	Nearly level, somewhat poorly drained to very poorly drained silty, glaciofluvial depostis
Ragsdale-Fincastle	Deep, very poorly drained and somewhat poorly drained, fine to medium texture, nearly level silt and glacial till; upland
Miami-Crosby	Deep, well drained and somewhat poorly drained soil, medium to moderately fine texture, nearly level to moderately steep glacial till; uplands
Mahalasville-Whitaker	Deep, very poorly drained and somewhat poorly drained, moderately fine and medium texture, nearly level soils formed in glacial outwash on outwash plains

Endangered Species

Both Montgomery and Boone Counties have a variety of plant and animal species. Montgomery County has more species of endangered, threatened, and rare species. The larger abundance is due to the wider variety of habitat surrounding Sugar Creek, which runs through the county, and the presence of Shades State Park in the southwest corner. The tables below list both state and federal species within both counties that are classified as endangered, threatened, or rare. Loss of habitat is the main reason for the endangered, threatened, and rare species in Indiana. Both Montgomery and Boone Counties population has grown over the past 100 years and with growth comes a loss of habitat. Boone County has had the largest increase in population over the last 10 years with a 20.9% increase. That is about an increase of 10,000 people. Montgomery County had only had an increase of 9.3%, about 3,000 people, over the last 10 years. Below are tables showing the endangered, threatened, and rare species in both Montgomery and Boone County

Table 2 State and Federal Endangered, Threatened and Rare Species Documented from Boone County
(Indiana Department of Natural Resources, Nature Preserves, 1999)

Common Name	Type of Species	State Rank	Federal Rank
	Vascular Plant		
Grand hawthorn		SE	**
Butternut		WL	**
Heart-Leaved Plantain		SE	**
	Mussels		
Wavy-Rayed Lampshell		SSC	**
Long-Solid		SE	**
Kidneyshell		SSC	**
Purple Lilliput		SSC	
Slippershell Mussel		*	
Lilliput		*	**
	Birds		
Great Blue Heron		*	**
Upland Sandpiper		SE	**
Red-Shouldered Hawk		SSC	**
Sedge Wren		SE	**
Cerulean Warbler		SSC	**
Worn-Eating Warbler		SSC	**
Black-and White Warbler		SSC	
Black-Crowned Night Heron		SE	**
Virginia Rail		SSC	**
Hooded Warbler		SSC	**
	Mammals		
Indiana Bat		SE	LE
American Badger		SE	**

SE/LE=Endangered, SSC=Special Concern, WL=Watch List, SX=Extripated, SR=Rare, * = No Status but warrants concern, ** = Not Listed

Table 3 State and Federal Endangered, Threatened and Rare Species Documented from Montgomery County
(Indiana Department of Natural Resources, Nature Preserves, 1999)

Common Name	Type of Species	State Rank	Federal Rank
	Vascular Plant		
Longstalk Sedges		SR	**
Small Enchanter's Nightshade		SX	**
Roundleaf Dogwood		SR	**
Small Yellow Lady's Slipper		SR	**
Northern Bush-Honeysuckle		SR	**
Woodland Strawberry		SE	**
Great St. John's Wort		SE	**
Butternut		WL	**
Ostrich Fern		SR	**
Eastern White Pine		SR	**
Bog Bluegrass		WL	**
Wolf luegrass		SR	**
American Yew		SE	**
Softleaf Arrow-Wood		SR	**
	Mussels		
Wavy-Rayed Lampshell		SSC	**
Yellow Sandshell		*	**
Kidneyshell		SSC	**
Lilliput		*	**
	Fish		
Bluebreast Darter		SE	**
Bigeye Chub		*	**
	Reptiles		
Kirtland's Snake		SE	**
Eastern Massasauga		SE	**
	Birds		
Coopers Hawk		*	**
Sharp-Shinned Hawk		SSC	**
Great Blue Heron		*	**
American Bittern		SE	**
Red-Shouldered Hawk		SSC	**
Broad-Winged Hawk		SSC	**
Cerulean Warbler		SSC	**
Black-Throated Green Warbler		*	**
Worn-Eating Warbler		SSC	**
Least Bittern		SE	**
Loggerhead Shrike		SE	**
Black-and White Warbler		SSC	**
Black-Crowned Night Heron		SE	**
King Rail		SE	**
Canada Warbler		*	**
Hooded Warbler		SSC	**
	Mammals		
Northern River Otter		SE	**
Bobcat		SE	**
Indiana Bat		SE	LE
American Badger		SE	**

SE/LE=Endangered, SSC=Special Concern, WL=Watch List, SX=Extripated, SR=Rare, * = No Status but warrants concern, ** = Not Listed

Natural History

The natural history of the Little Sugar Creek watershed is not only characterized by the endangered, threatened, or rare species in the area it is also characterized by its forests and other native plant species. In presettlement times, tall grass prairies occurred in a vast area, which extended from Iowa and Missouri to central Ohio. West central Indiana was one of the many areas in the United States which had tall grass prairies. Most of the prairies have been lost to farming practices and drainage.

Forested acres have decreased significantly since the early 1900's because farmers switched from livestock operations to grain farming. Fence rows were also being taken out to make way for larger fields. Four percent of Montgomery County was forested and two percent of Boone County in 1997. The percentage of forested areas has increased since 1930 (Census of Ag 1999). Both Montgomery and Boone counties are located in the Northern survey unit. Indiana is split into four unit areas and the northern unit is the largest making up sixty percent of the state. The two major forest types for the northern unit indicated by the USDA Forest Service Inventory and Analysis of Indiana reports the Maple-Beech association being the most common and Oak-Hickory the second (Tormoehlen et. al., 2000).

Landuse

This section gives an overview of Little Sugar Creek watershed's landuse in terms of historical and recent land use changes, settlement history, important cultural resources, population changes, and other areas of interest. The section is split up into Montgomery County and Boone County because the watershed is located in both counties.

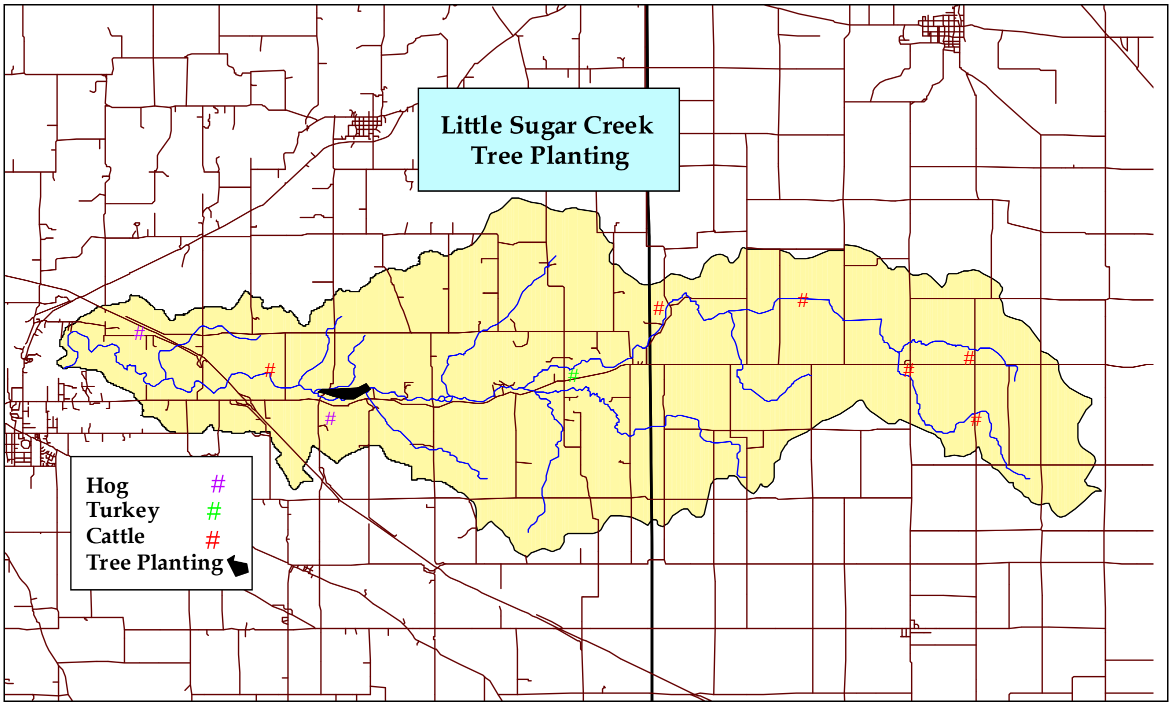
Montgomery County History

Montgomery County began its official existence on March 1, 1823. It got its name in honor of General Richard Montgomery. In 1836 Sugar Creek became an important shipping waterway for the state of Indiana. An entry into the Indiana Gazetteer paints a picture of what Montgomery County was like in 1849. "The western part of the county, and near the principal streams is somewhat hilly and broken, the north and central part undulating, and the east and south level. The timber is generally of good quality, and the soil, with scarce any exception, rich and well adapted to corn, wheat, grass, fruit and all the products common to the climate. There are several good prairies in the north part of the county, now mostly in cultivation, and occasionally barrens or oak openings, but two-thirds of the county were originally covered with heavy timber". Later on in 1881 a committee was formed to encourage new business and industry in the county.

The landscape of the county has changed dramatically since it was settled. In 1938 the Indiana Review gives an overview of what the county was like at that time with industry coming in. "Within the 501 square miles on Montgomery County is some of the best agricultural land in the state and an enormous supply of shale, used in the manufacture of paving and building brick. On several occasions Montgomery County has ranked the nation in the production of livestock. There are many war memorials in and about the Crawfordsville area. Eight miles southwest, at Offield's Creek, is a boulder marking the site of the first white settler's cabin, built in 1821. Near Waveland in the southern part of the county is one of its chief points of interest, "Shades of Death," a natural beauty spot now called Shades State Park".

After the 1950's farmers started to deforest areas to make way for larger fields and less livestock production. There is no known history of recent deforestation in the Little Sugar Creek watershed. There is a possibility of 13 acres to be taken out of forest and converted to cropland in the next five years. This 13 acres is located in the central southern portion of the watershed. Much of the deforestation in the watershed occurred between 1950-1975. More pastureland and fence rows were converted to farmland than forestland at that time. This was done to make the farm fields larger for more production. A tree plantation was installed North of SR 32 across from the largest single hog operation in Indiana in 1999. The black area in figure 8 below shows the location of the tree planting..

Figure 8: Tree Planting



Boone County History

Boone County is the other county to make up the Little Sugar Creek watershed. The Boone County portion of the watershed makes up almost half of its total area area.

Up until 1828, Miami Indians occupied the Northwest corner of the county. They were later run out in 1834. The Indians occupied 52,000 acres in the Western portions of the county. Dating back to the early 1820's, there was unbroken wilderness, no roads or mills, deep tangled brush and vines, with a good portion or the area covered with water.

Boone County began its existence on April 1, 1831. The county is names after the famous Daniel Boone. Lebanon was not always the county seat. It moved from Jamestown to Lebanon on January 21, 1823. The first settler in Lebanon was A.H. Longley. Boone County is bordered by Clinton, Hamilton, Marion, Hendricks, and Montgomery Counties. The county contains 408 square miles. The Southeastern, West, and North portions are slightly rolling. The West and interior is generally level.

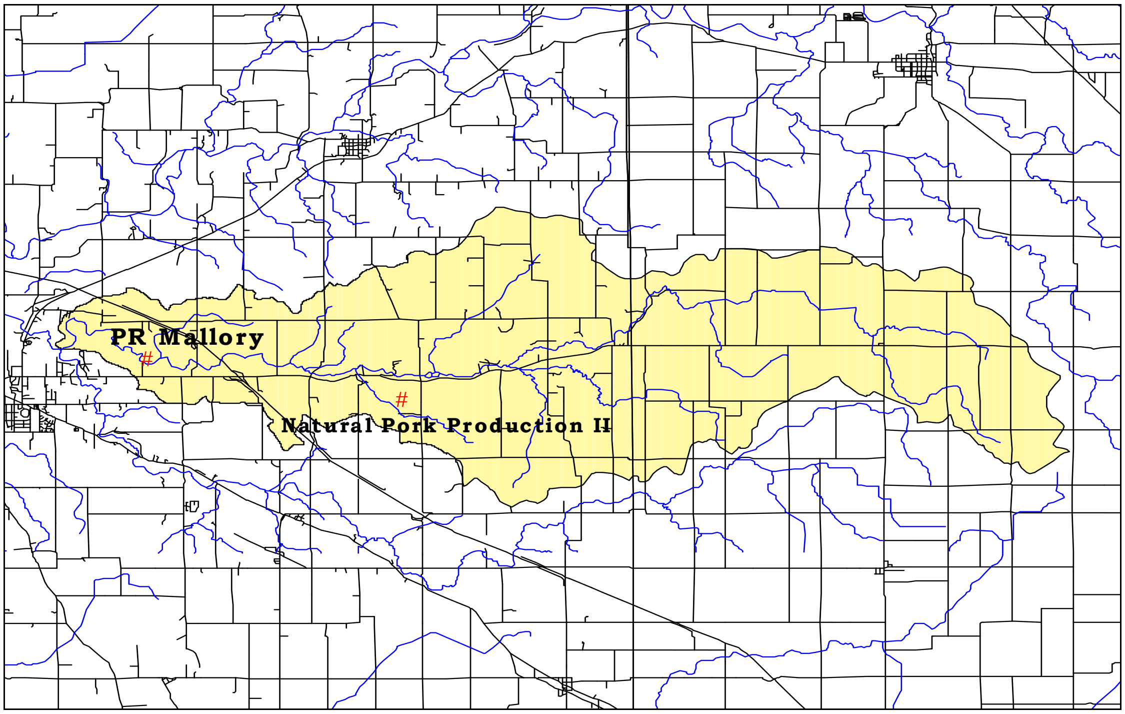
According to the Indiana Gazetteer in 1849 published by E. Chamberlain "Soil in most parts of the county is a black loam, usually several feet in depth, on a stratum of clay, and in some places of sand and gravel. It is very fertile and well adapted for the production of wheat, corn, oats, grass and all kinds of vegetables. There is no part of the state where the timber is heavier or of better quality. It is not uncommon to see one hundred oak trees four feet in diameter on one acre. There are three prairies which can be drained with a little ditching and made for tillage."
The heavy timber, level surface and porous soil of the county were not attractive to agriculturists. The pursuit of game and collection of skins, furs and honey were more important than farming. The only two real necessities for a family were two rifles, powder, lead, barrel of salt, camp kettle and a couple of dogs. Deer, turkeys, bears and wolves were abundant.

It was said in the Indiana Gazetteer that there are few counties in the state where greater alterations have taken place. Many of the swamps have disappeared to be replaced by first rate farms now found in every neighborhood.

Industry

There is also no new development of industry in the Little Sugar Creek watershed. There are a few older industry sites in the watershed, which include plastics, cement, distribution and moving companies, and agricultural product factories. The PR Mallory factory was also located in the watershed and is now a remediated superfund site at the corner of SR 32 and 400E (Figure 9). The largest confined feeding hog operation is now under the new ownership of Natural Pork Production II. The facility has been changed from a finishing facility, meaning the hogs are raised until adults, to a farrowing facility. A farrowing facility has far less adult hogs and raises baby pigs until they are 17 days old weighing 14 pounds. The new owners say that the amount of ammonia in the young pig's manure is far less than that of the adult pigs creating a natural fertilizer with less ammonia, phosphorous, and nitrogen.

Figure 9: Industry With History of Causing Water Quality Problems in LSC



Today

Conservation efforts are being made in parts of the Little Sugar Creek watershed. The largest single confined hog operation is in the watershed and has been an area of large concern with Montgomery County residents. The operation under the previous owners has caused numerous fish kills in years past. IDEM is currently taking steps to control how much manure they spread on their fields based on the amount of nutrients in the soil. This is to prevent the over-application of manure to farm fields which in the past had resulted in high nutrient levels in Little Sugar Creek. IDEM has drawn up a permit for the new owners of the Concentrated Animal Feeding Operation. This permit sets regulations on manure application along with other regulations to prevent more manure spills and nutrient loading into Little Sugar Creek. With this new permit and owners, residents hope that the amount of manure entering Little Sugar Creek from the application to fields will be considerably reduced.

Other conservation efforts in the watershed include the instillation of waterways. Many landowners have participated in installing waterways with the assistance of government programs. There has been a large increase of participants in government programs since 50%

cost-share has been available with a 40% practice incentive making it 90%. The cost-share percentage means that the landowner only has to pay 10% of the total project cost for the instillation of a conservation practice included in the USDA Conservation Reserve Program (CRP) (USDA Farm Service Agency). Some examples of conservation practices that can be eledigible for CRP money include: windbreaks, filter strips, grassed waterways, riparian forest buffers, and wetland restoration. Conservation tillage is also pushed in these counties. There is more participation in conservation tillage in the Montgomery County portion for the watershed than the Boone County portion. It is estimated that 25% of the land in the watershed is in conservation tillage (USDA 2002).

Section III: Identifying Waterbody Impairments and Benchmarks

This section gives an overview of the water quality data collected in the watershed as well as scientific information gathered in the past. It also describes why Little Sugar Creek was deemed impaired and summarizes the results of the water quality parameters studied in the watershed. The results of the habitat and visual inventory are also included in this section as well as the land inventory conducted during the project.

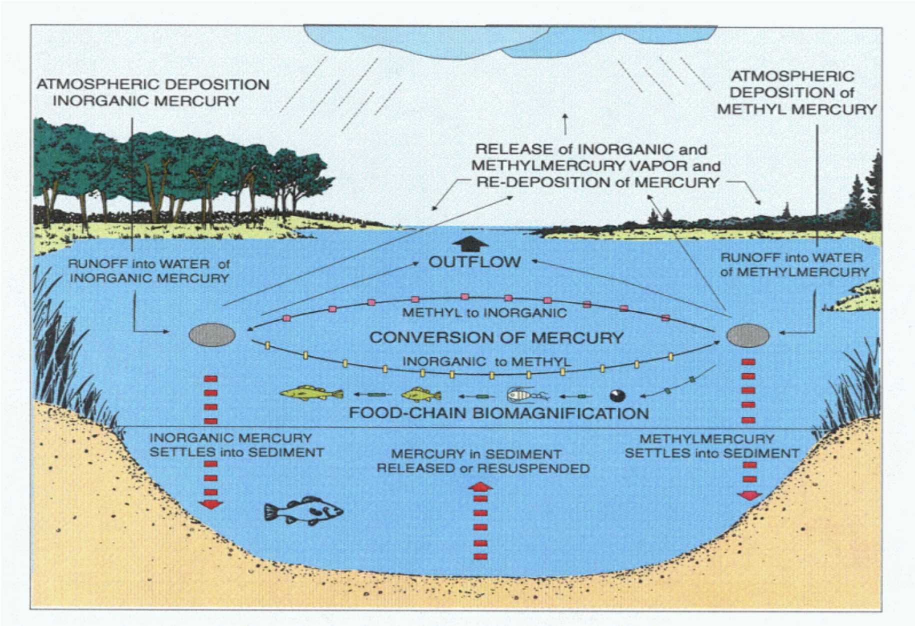
Existing Data

Little Sugar Creek has had a long history of pollution problems. The EPA has listed Little Sugar Creek on the 303d list. The creek is on the list of impaired water bodies for high levels of mercury, PCB's, and it has a Fish Consumption Advisory. There are signs at most places where the road crosses over the creek that warns anglers of the fish consumption advisory. Much of the PCB's are believed to have come from the old PR Mallory plant, which produced capacitors and transformers. The former site of the plant is on the corner of 32E and CR 400E and was the focus of a Superfund cleanup in the late 1980's. The mercury pollution in Little Sugar Creek could have come any number of sources. Mercury enters the environment from one or more of these three ways:

1. From natural sources such as volcanoes and the weathering of rocks
2. Intentional uses of mercury in light switches, thermostats and fluorescent light bulbs
3. Unintentional release by fossil fuel burning, waste combustion, and smelting metals

Once the mercury is released into the environment bacteria in the water and soil along with chemical reactions turn it into a much more toxic form called methylmercury. The largest contributor of mercury pollution in the United States is coal utilities and waste combustion (U.S. Environmental Protection Agency 1997). Precipitation (wet deposition) is the primary mechanism for transporting airborne gaseous or particulate mercury from atmosphere to surface water and land (Figure 10).

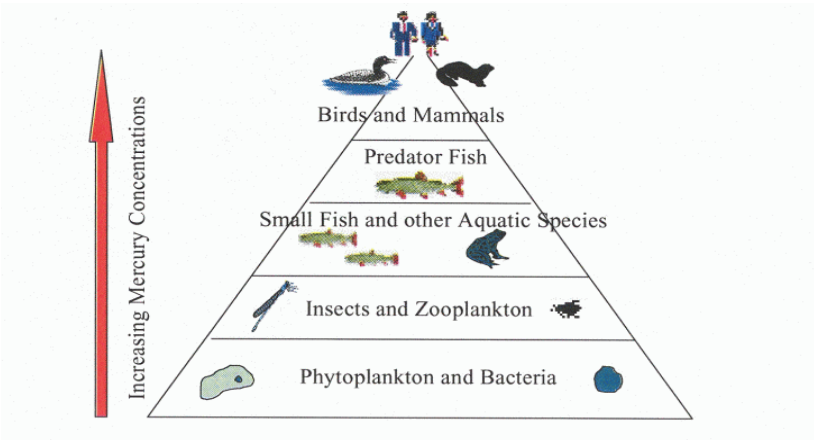
Figure 10: Mercury Cycle



(USGS, FS-216-95)

Once the precipitation has occurred streams and waterbodies become susceptible to mercury build up. When mercury gets into a body of water it stays there for a long time and accumulates in the plants and animals (Figure 11).

Figure 11: Mercury Concentration in Food Chain



(National Wildlife Federation, 2000)

The accumulation of mercury in the Little Sugar Creek fish is the reason for the fish consumption advisory. The 2004 Fish Consumption Advisory for Montgomery County recommends that no fish species from Little Sugar Creek be eaten.

EXISTING BIOLOGICAL DATA

Little Sugar Creek had a substantial amount of biological data before the grant began in July 2002. The biological (fish) aspect of Little Sugar Creek has been an area of concern for many years due to high PCB and mercury levels, also due to the farming practices and animal feeding operations (AFO's) in the watershed.

Fish samples were first taken in Little Sugar Creek and Walnut Fork of Sugar Creek by a man named Gerking in 1945. It is not known, but it is thought that he used a seining net to catch fish. He collected 11 species in Walnut Fork and did not catch any fish in Little Sugar Creek. In 1973 the two streams were sampled by the Indiana Department of Natural Resources (IDNR). There were two sites on Walnut Fork and one site on Little Sugar Creek sampled. All sites contained a diverse group of species totaling eighteen and twenty for the Walnut Fork sites and sixteen at the Little Sugar Creek site (Huffaker 1973). Between 1945 and 1973 the fish populations in Little Sugar Creek seemed to be improving. In 1976 a confined hog-feeding operation was established near Crawfordsville in the Little Sugar Creek watershed. Since its establishment in 1976 the hog operation has had a recorded nine manure spills resulting the killing of thousands of fish in Little Sugar Creek.

Keller of IDNR(1998) sampled sites along Walnut Fork and Little Sugar Creek in September 1997 using a tote barge electrofisher. This study was to determine fish distribution and abundance of game and non-game fish species, assess aquatic habitats and relate that to fish distribution and abundance, and determine recovery of a fishery following the most recent fish kills. In this study Keller collected 6,959 fish which made up 42 species and and families (Keller 1998). This study showed that both Walnut Fork and Little Sugar Creek have good rebound capabilities after devastation such as a manure spill. This is a reflection on the fishery in Sugar Creek, which is where the fish would have come from.

Keller also led a fish sampling survey one week after the most recent fish kill on April 2, 2003. The same sites were sampled on both Little Sugar Creek (LSC) and Walnut fork as in the previous study. From the sampling it was found that all darter species were eliminated where they were well represented in LSC in 1997. No Smallmouth Bass were found alive and 61 had been collected in 1997. Species that were virtually eliminated include intolerant sucker species (redhorse and hogsuckers), Intolerant minnow species, and rock bass. Seventy four rock bass were found in 1997 but only six were found in the 2003 survey. The survey concluded that about one fifth as many fish were found in LSC as in Walnut Fork for the length surveyed. Keller suspects that the kill eliminated nearly all fish in LSC downstream of the manure spill. The few that were found in the survey probably had sought refuge in one of LSC many tributaries.

Some of the most recent fish sampling was conducted in 1999, 2001, and 2002 by Dr. Jim Gammon of DePauw University. Dr. Gammon has spent much of his career studying fish ecology in agricultural stream ecosystems. The fish sampling he has done on Little Sugar Creek and Walnut Fork of Sugar Creek was by using a Safari Research 550D backpack electrofisher. The unit was set at 100 smooth pulses per second. The electrofishing team normally consisted of a person operating the electrofishing unit, one or two peripheral netters, and a person trailing with a holding net (Gammon 2002).

To evaluate fish communities the Index of Biotic Integrity (IBI) was computed from the catch results at each site (Karr 1981, Karr et al 1986, Simon & Dufour 1998). The IBI takes into account the metrics for total number of species, number of sucker species, number of sunfish species, number of sensitive species, number of darter species, percent of tolerant species, percent carnivores, percent insectivores, percent omnivores, and percent lithophilic spawners. Full table can be found in appendix 1.

The results of the fish sampling were an average IBI score for Little Sugar Creek being 42. This is a fair score compared to a good score of 48 for Walnut Fork of Sugar Creek. The scores can be found on the table below.

Table 4: IBI Scoring Table

IBI Score	Integrity Class	Attributes
58-60	Excellent	Comparable to best situation without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundance and/or size distributions; trophic structure shows some signs of stress
40-44	Fair	Signs of additional deterioration including loss of intolerant forms, fewer species, highly skewed trophic structure (e.g. increasing frequency of omnivores and other tolerant species); older age classes of top predators may be rare
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regularly occur
	No Fish	Repeated sampling reveals that no fish are present.

Five sites were sampled on Little Sugar Creek and four sites were sampled on Walnut Fork of Sugar Creek. The reason both of these streams were sampled was because they are so close in proximity, have virtually the same landuse, and watersheds of almost exactly the same size. Walnut Fork has a watershed of 30,570 Acres and Little Sugar Creek has a watershed of 29,075 Acres (Figure 12). Walnut Fork does not have the history of fish kills and is a good comparison to Little Sugar Creek water quality.

Figure 12: Acres in the Little Sugar Creek and Walnut Fork Watersheds

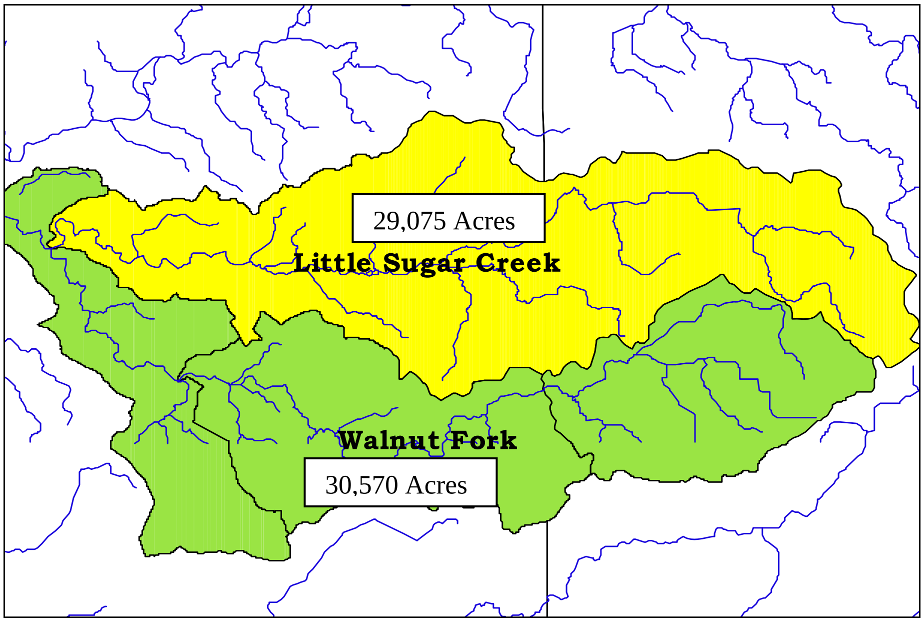
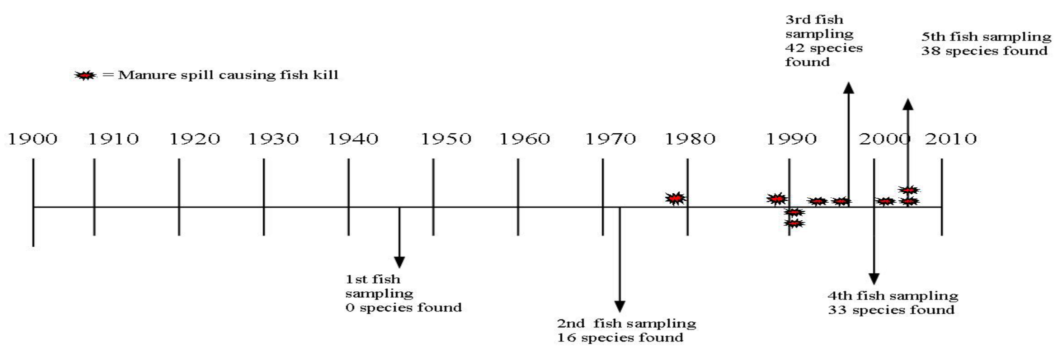


Figure 13 shows a timeline of manure spills from the large hog operation in the watershed along with fish sampling events. The fish populations have been going up since the first sampling event in 1945 when zero species were found. A bulk of the manure was spilled between 1990 and 2002 when it seem fish populations were starting to redevelop. Fish populations did decline between 1998 and 2002 due to the most recent fish kills and the little time there was to build the populations back up.

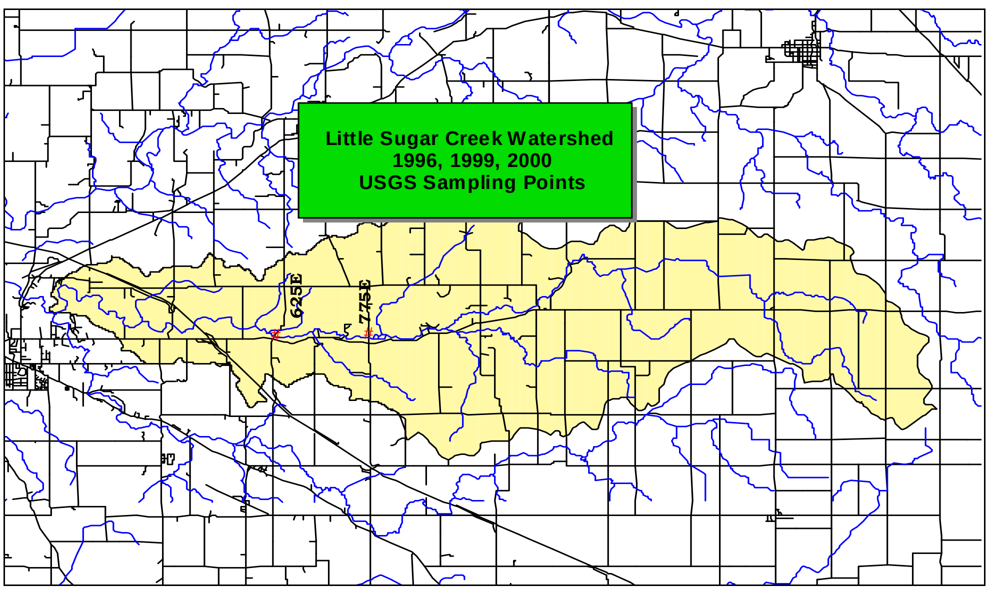
Figure 13: Fish Sampling Dates vs. Fish Kills



EXISTING WATER QUALITY DATA

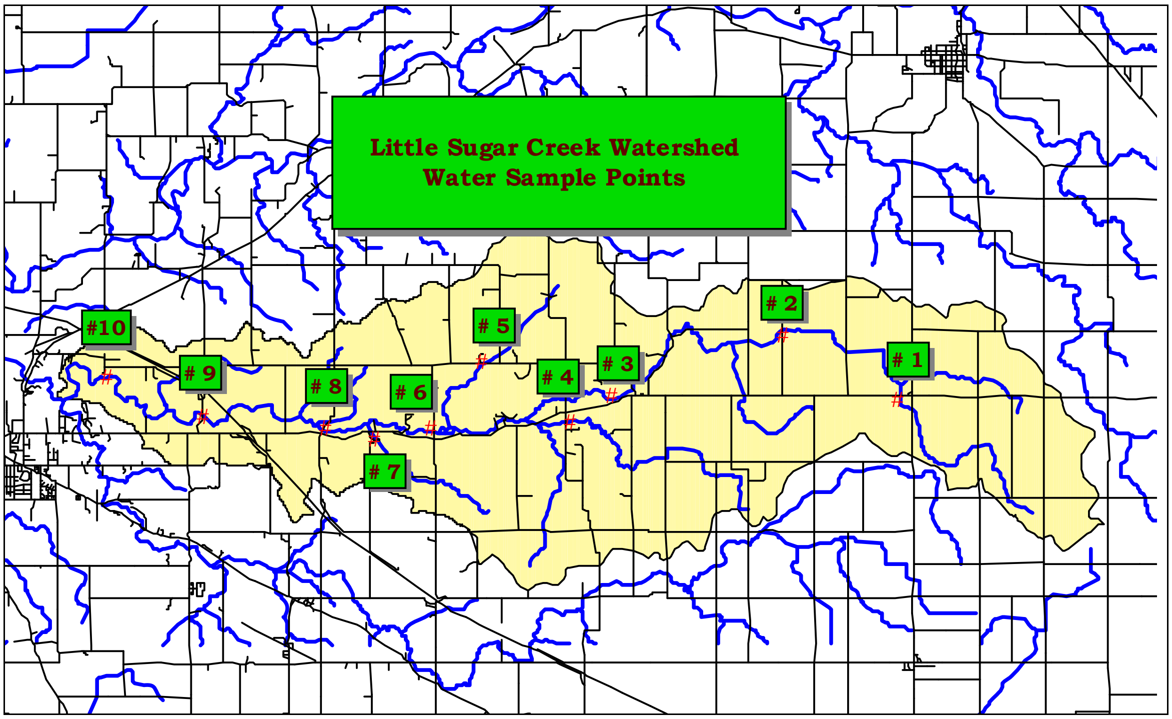
Water chemistry data collected before the grant was gathered by the US Geological Survey (USGS). Three sample sets were taken on two locations of Little Sugar Creek (Figure 14). One test site on cross road 625E and the other at cross road 775E. The first testing was in the fall of 1996, and second in September of 1999, and the third in May of 2000. Parameters they tested for included Temperature, pH, Conductivity, Dissolved Oxygen, E. Coli, Ammonia, and Nitrates+Nitrites. It was found that the nitrogen levels in Little Sugar Creek were on average above normal as well as ammonia levels being 10.38mg/l and 0.14 mg/l consecutively (Appendix 2).

Figure 14: USGS Sample Points



The 319 Little Sugar Creek watershed study had a very intensive water sampling requirement to it. The watershed coordinator chose 10 sites within the watershed to give a good representation of the water quality in the main channel as well as in its tributaries (Figure 15). Of the ten sites sampled four were tributaries and the other six along the main channel.

Figure 15: LSC 319 Water Sample Sites



Water sample were taken twice a month for 22 months. If weather conditions were at all hazardous sampling did not take place for safety concerns. The watershed coordinator conducted all water sampling with the help of one other person. Three individuals were trained to go into the field and help with the water monitoring. Each sampling event started by the watershed coordinator labeling and dating bottles, filling out chain of custody forms, calibrating handheld equipment, and notifying landowners whose property we would go on that we would be out that day. The parameters we sampled for with instant read handheld devices were: Temperature (^oC), Dissolved Oxygen (mg/l), pH, Conductivity (µs), and Total Dissolved Solids (mg/l). Total Kjeldahl Nitrogen *organic nitrogen* (mg/l), Total Phosphorus (mg/l), Ammonia nitrogen (mg/l), E.coli (#/100ml), Nitrate (mg/l), and nitrite (mg/l) samples were sent off to laboratories for testing (table 5).

Table 5: Water Qualtiy Parameters

WATER PARAMETER TESTED	WHAT IT MEASURES	NATURAL REANINGS	CAUTIONARY READINGS	POSSIBLE SOURCES/INFULENCES	REMIDES
WATER TEMPERATURE	Average amount of heat in the water	0^0-34^0C (32^0-95ºF)	-Above 32^0C (90^0F) -Above 24^0C for smallmouth bass	-Thermal discharges (industrial, waste water treatment) -Increased turbidity -solar heat heated runoff from asphalt/concrete	-Discharge permits -increased riparian shade
DISSOLVED OXYGEN	Amount of oxygen dissolved in the water	-Typically the concentration of DO in surface water is less than 10 mg/L -Subject to daily/seasonal fluctuations	-Minimum of 4 mg/L for aquatic invertebrates. -3-5 mg/L causes stress on fish (abnormal feeding and reduced reproduction - 0 mg/L = anoxic	-Atmosphere via aeration (wind, running water, riffles)	-Control quality of algae by limiting nutrients (N,P) -Reduce water temperature
pH	Acid/base of the water	Generally 6.5-9.0	-below 6.5 -above 9.0	-acid rain -industrial pollution -chemical spills	-pollution controls -pH moderation by addition of acid or basic compounds
NITRATE	Principal form of nitrogen found in natural waters, most oxidized stable form	less than 0.3 mg/L	Consistant readings above 3 mg/L	-human sewage -industry output -fertilizer -animal wastes	-vegetated riparian zones -limit usage of fertilizers -properly maintained septic systems
NITRITE	Form of nitrogen rapidly oxidized to nitrite, used as nutrient for plants	Less than 0.001 mg/L	-one time maximum of 0.06 mg/L -average of 0.02 mg/L	-human sewage -industry output -fertilizer -animal wastes	-vegetated riparian zones -limit usage of fertilizers -properly maintained septic systems
AMMONIA	Most reduced inorganic form of nitrogen, essential plant nutrient	0.1 mg/L	The criteria set for ammonia to protect aquatic life are dependant on the temp. and pH of the water. The matrix is too extensive to present here. (Explanation below with chemistry data).	-sewage treatment plants -agriculture -urban developments -recreation -fertilizer -animal wastes	-vegetated riparian zones -limit usage of fertilizers -properly maintained septic systems
TOTAL PHOSPHOROUS	Measure of organic and inorganic forms, essential and often most limiting nutrient	0.0-0.2 mg/L	Consistent readings above 0.2 mg/L	-sewage treatment plants -urban development -fertilizer -animal wastes	-vegetated riparian zones -limit use of fertilizers -properly maintained septic systems

WATER PARAMETER TESTED	WHAT IT MEASURES	NATURAL REANINGS	CAUTIONARY READINGS	POSSIBLE SOURCES/INFULENCES	REMIDES
TOTAL DISSOLVED SOLIDS	Amount of dissolved material in water, amount of filterable residue	0-1000 mg/L	Consistent reading of 1000 mg/L or more	-industrial effluent -sewage treatment -soil runoff -road salts	-sediment controls -riparian buffers
CONDUCTIVITY	Measurement of the ability of water to conduct an electric current, dissolved metals and other dissolved materials	50-1500 µs	Due to its natural variability, there is no criterion recommended for this variable.	-road de-icing salts -municipal and industrial effluents	-sediment controls -riparian buffers -industrial permits
KJELDAHL NITROGEN	Measure of both the ammonia and organic forms of nitrogen	0.3-7 mg/L	Consistent reading above7 mg/L	Sewage treatment plant effluents, agriculture, paper plants, recreation, animal manure	-vegetated riparian zones -limit usage of fertilizers -properly maintained septic systems
E. COLI	Bacteria found in intestine tracts of warm blooded animals. *Escherichia Coli*	0.2- +	235 cfu (colony forming units)	Human, animal, wildlife, and pet watste	Septic system function properly, upgrades sewage treatment plants, prevent manure from entering tiles, ditches, streams.

The water chemistry data collected throughout the grant is included in the appendix 4. The readings of concern are highlighted.

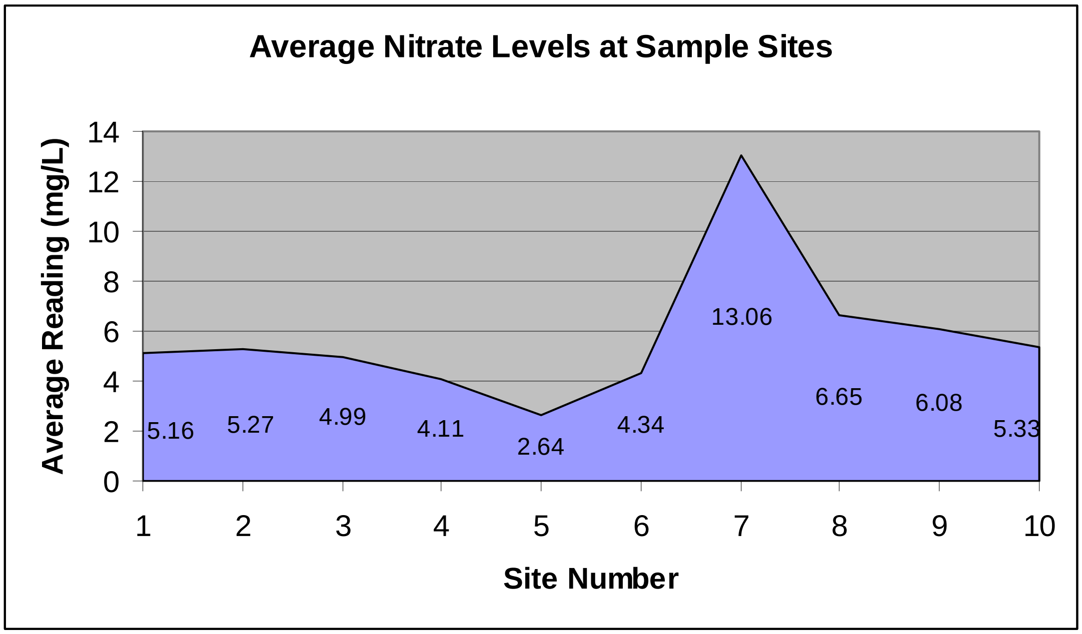
Section IV: Identifying Problems

Review of Data Collected

Water chemistry:

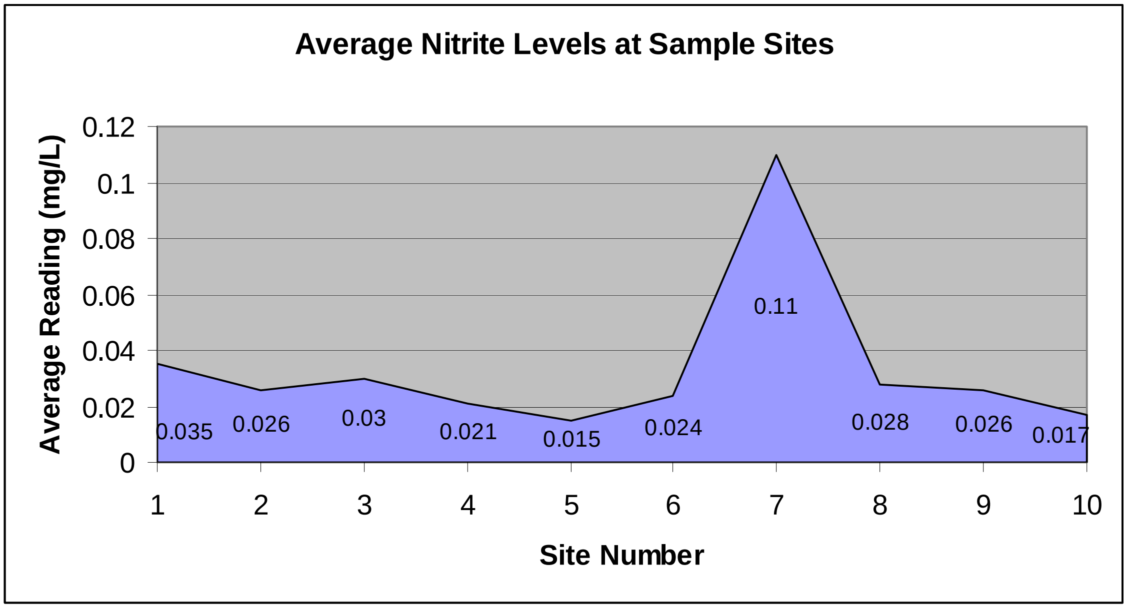
Sampling Little Sugar Creek's water has proven to be beneficial in ruling out certain areas of the watershed as being the cause of high nutrient levels. The charts of water chemistry results in the appendix show a trend of high nitrogen levels coming from a single tributary to Little Sugar Creek. The high nitrogen levels are thought to come from the large hog operation. The tributary sampled originates east of the hog barns in a farm field where manure is applied for fertilizer. The average nitrate and nitrite levels for Site #7, the tributary running east of hog barns, is 13.06 mg/L and 0.21 mg/L consecutively. Conductivity readings were also highest at this site having an average of 938.25 µm. Desirable Nitrate levels need to be under 3 mg/L and Nitrite levels need to be under 0.02 mg/L. A majority of the nitrate/nitrite samples taken at this location were well above desirable levels (Figure 16).

Figure 16: Average Nitrate Levels in Little Sugar Creek 2001-2004



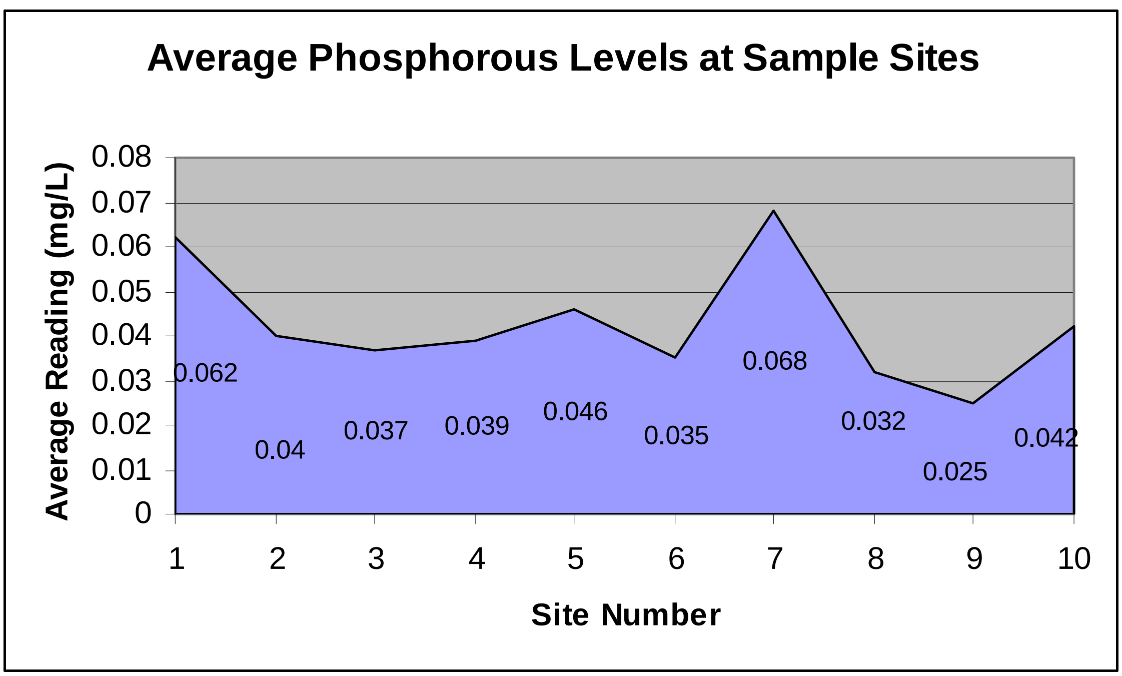
All sites except for number five had an average nitrate reading above desirable levels. Site number seven is a major contributor of nitrate nitrogen. The graph shows that there is some recovery downstream but does not recover to the upstream levels. The same trend is also seen in the nitrite levels (Figure 17). However, the recovery in nitrite levels is greater and the most downstream site has an average value of 0.017 mg/L which resembles the healthiest tributary reading of 0.015 mg/L at site number five. Nitrite levels usually recover quickly than nitrate levels since the conversion from nitrite nitrogen to nitrate nitrogen occurs very fast. Nitrite nitrogen is not in the water long before it is converted to nitrate nitrogen.

Figure 17: Average Nitrite Levels in Little Sugar Creek 2001-2004



Phosphorous levels were of concern in the Little Sugar Creek watershed because of manure application to fields and allowing livestock access to streams. Phosphorous levels should not be above 0.2 mg/L on a consistent basis. Although the averages of phosphorous at each site are below 0.2 mg/L, site number seven had the most readings above 0.2 mg/L (figure 17).

Figure 17: Average Phosphorous Levels in Little Sugar Creek 2001-2004



Not only are there increased nutrient levels at site number seven. There are also increased nutrient levels at site number one. It is believed that the reason site number one has elevated levels is because the sampling site is just below a farm with cattle, horses, and sheep that have access to the creek.

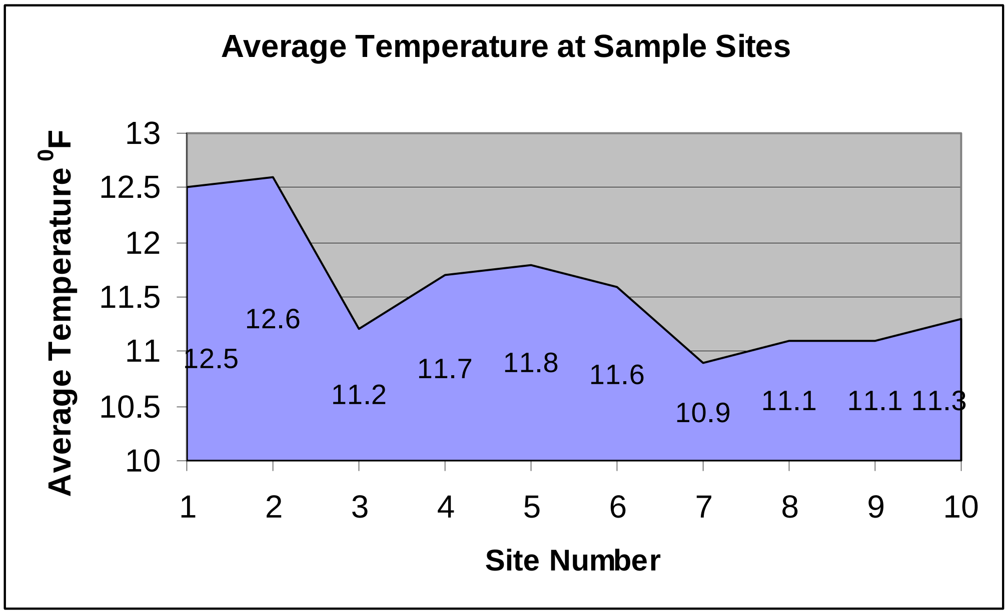
The water chemistry data correlates with the concerns listed in the Building Partnerships section developed by the steering committee. High levels of nitrogen and phosphorous confirm the concerns of sedimentation, the large hog farm, nutrient input, livestock in creek, and lack of buffer. A concern the Steering Committee had that the water chemistry was able to prove not a problem is the E. coli levels. The only time E. coli was over the recommended 235 cfu (Colony Forming Units) was in the fall of 2002. The samples taken in the fall of 2002 were in dryer periods than in the fall of 2003. This may have accounted for the lower readings in 2003. Some fall data was not able to be collected in 2003 because of a few factors. The October 30th sampling did not occur because there was a mix up and not bottles were available. The November 26th sample was also not collected due to low flow at a majority of the sites.

Average E. coli levels are highest at site number one with an average of 100 cfu. Even with this site having the highest average, it is well below the 235 cfu recommended level to be below. Site number one, as stated previously, is just below a farm that allows livestock access to the creek and would naturally have higher E. coli levels than other sample sites farther downstream from other livestock operations.

One concern the group had that was not able to be determined was the issue of poorly maintained or failing septic systems. The Montgomery County Health Department did not have any information as to the condition of septic systems in the Little Sugar Creek watershed. Inventories and observations from 2002-2004 have not uncovered any septic problems.

A problem that was not a group concern in the beginning in thermal pollution. Little Sugar Creek has areas of wooded conditions for stream side buffers. Little Sugar Creek in the Montgomery County portion of the watershed has good canopy cover from forested buffers. The Boone County portion of the watershed has much less canopy cover and therefore has higher water temperatures (Figure 19).

Figure 19: Average Temperature Levels in Little Sugar Creek 2001-2004

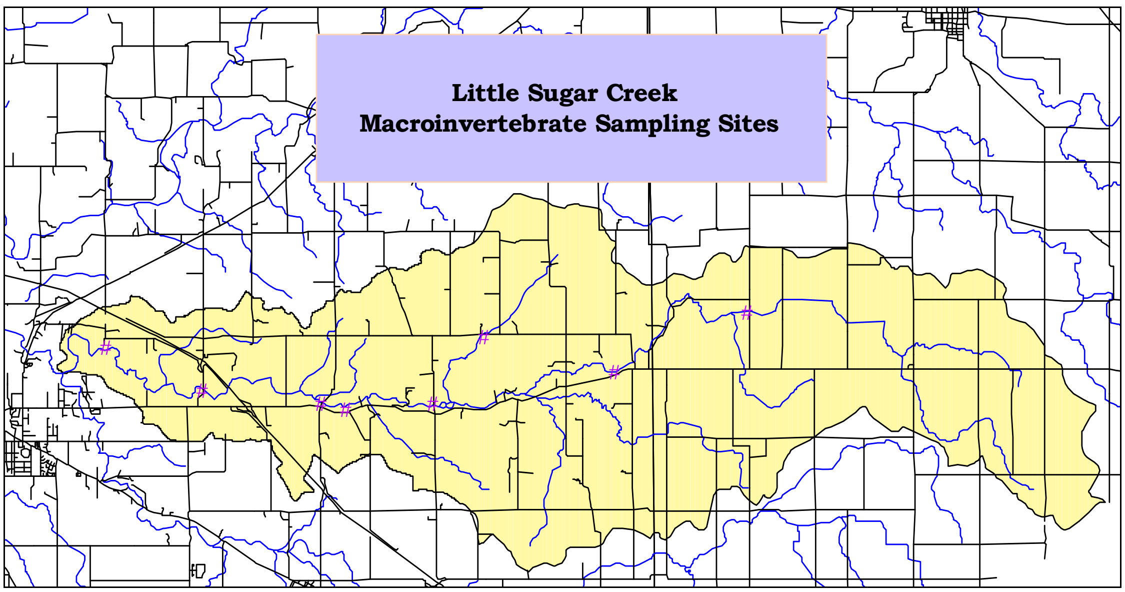


Small mouth bass, a popular game fish, are stressed at temperatures above 24 °F. In the summer months sample sites one, two, and three have temperatures unsuitable for small mouth bass. The lack of canopy cover in the form of bushes and trees creates an environment where the sun heats the water and raises temperatures so that they are not ideal for fish and aquatic insects. With the raising of temperatures there is also a decrease in dissolved oxygen and causes stress on organisms living in the waters.

Macroinvertebrate Sampling:

Ten sites were chosen along Little Sugar Creek and the main tributaries for collection of aquatic macroinvertebrates (insects that live in the water). Macroinvertebrates are a good way to determine the health of a water body. Sampling was conducted during the months of September and October of 2002. Only eight of the ten sites planned for analysis were sampled due to habitat and time of year. The last sampling was on the 30th of October and after that date the there was low to no flow at the last site to sample. The sites tested are identified on the map below (Figure20).

Figure 20: Aquatic Macroinvertebrate Sampling Sites



The aquatic macroinvertebrate sampling was done using a 500-micron Surber sampler. Three riffle areas were chosen at each sample site to be tested. Each riffle area was tested in three locations to get a representation of the entire width of the riffle. The surber sampler was placed with the net facing downstream and the surfaces in the area were gently rubbed by hand to dislodge organisms. The substrate within the sampler was also disturbed to get the macroinvertebrate that burrow. Each sample covered one square foot area. The macroinvertebrates were then picked out of the net and put in a 70% ethanol solution. In the laboratory the watershed coordinator transferred a sample to a girdded pan and organisms were picked from randomly selected grid cells until the cell that contained the 100th individual (if possible) was completely picked (EPA Volunteer Stream Monitoring: A Methods Manual). The macroinvertebrates tallied and identified to the family level. Once all insects were identified, the watershed coordinator used the Hilsengoff Biotic Index (HBI). The index is designed to summarize the organic pollution tolerance of aquatic macroinvertebrates. Each family is assigned a value of 0-10. The most sensitive having the lowest values (Hilsenhoff 1988). The HBI was figured using the equation:

$$\mathbf{HBI} = \sum_{(I=1-n)} [Ti*Ni] / X$$

Where:

Ti = Tolerance Value of Species I from (1 to n)
Ni = Number of Individuals of Species I from (1 to n)
X = Total Number of Organisms

Results of Macro sampling

Numbers in appendix

Chart of results

Habitat Analysis

Procedures for habitat assessments were derived from the EPA's Rapid Bioassessment Protocols (RBP's) (Plafkin et al. 1989), as modified by Barbour and Stribling 1991). The completed habitat assessment forms for the Little Sugar Creek sites can be found in appendix 5. Habitat assessments showed that the sites on Little Sugar Creek did not have optimal conditions. The habitat scores can range from a value of 200-0 (Table 6)

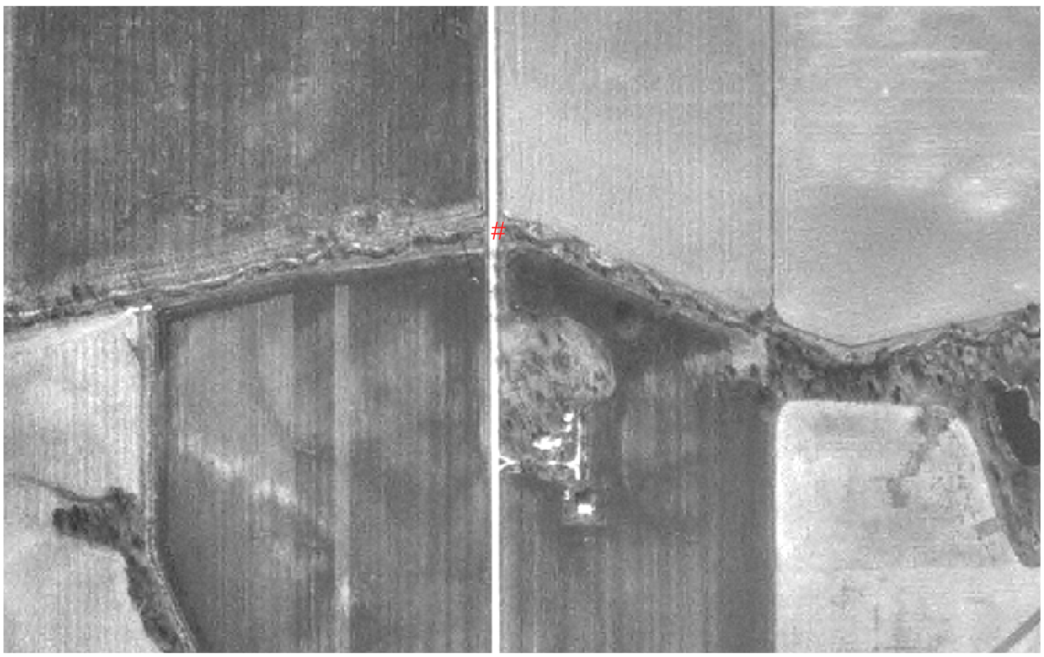
.

Table 6: Habitat Scores

Habitat Scores	Value
Optimal	160-200
Sub-optimal	110-159
Marginal	60-109
Poor	<60

Many of the sites had sub-optimal habitat values due to the better substrate material and riparian zones. The sites that had the lowest scores are the ones that have low amounts of riparian cover and/or poor substrate structure. Sites 2, 6, and 10 had the lowest scores being 56, 99, and 97 consecutively. Figures 21-23.

Figure 21: Site #2



Site#2 is wide with little riparian cover. The banks were stripped of vegetation in the spring of 2003. Since then there has been large amounts of sedimentation and a slight warming of the waters. Not only does the riparian zone protect the water from becoming heated it also helps to stabilize the banks so there will be reduced sedimentation.

Figure 22: Site #6

Site #6 has a few more trees than #2. It has a low number because substrate is mainly fine soil and sand. This site also does not have any good shallow areas and instead consists of very large deep pools. The south side of the creek is grassed and mowed to the edge so that there is not adequate cover for shading.

Figure 23: Site#10

Site #10 did not get a marginal score due to poor riparian habitat. There is actually adequate riparian habitat and buffer on both sides of the creek at this site. The low habitat value was due to the in stream substrate quality. The substrate in the western most portions of the watershed is bedrock and it is very wide in areas. At the sample site the stream bed is very wide and the water does not reach across at all times of the year leaving parts of the substrate exposed. The substrate is also bedrock which is flat and smooth. This does not provide for good in stream habitat for fish and aquatic macroinvertebrates.

Problem Statements

The watershed coordinator evaluated the benchmark data and existing water quality information and determined the magnitude of the water quality concerns developed by the steering committee. The problem statements summarize the concerns of the steering committee and landowners within the watershed.

Dr. Gammon's fish studies confirmed the problem of less than desirable fish communities. The aquatic macroinvertebrate sampling supported the water testing results. The sample sites with the highest level of nitrogen also had poor macroinvertebrate communities. The sites with the lowest habitat scores also had poor macroinvertebrate communities. In conservation with the Natural Resource Conservation Service (NRCS) District Conservationists in both Montgomery and Boone counties they confirmed that more tillage is done in the Boone County portion of the watershed than in the Montgomery County portion.

Loss of riparian corridors was confirmed using aerial photographs and visual observations. It was approximated that 50% of the waterways are not adequately buffered. The majority of the buffer problems are in the Boone County portion of the watershed. Fields are tilled very close to waterways and cattle are also pastured in the waterways within the watershed. Visual observations made by the watershed coordinator found that areas with poor canopy cover were often noted with the presence of algae. It was also noted that Little Sugar Creek and its tributaries are considered legal drains. Boone County's legal drains within the watershed had less riparian zone than the remaining portion of the watershed. The lack of adequate buffer zones along waterways within the Little Sugar Creek watershed was connected to certain water quality parameters. Habitat scores were down, temperatures in summer months were elevated, less desirable fish and macroinvertebrate communities, and higher nutrient levels were found in these areas. Based on the findings, the Steering Committee developed the following problem statements:

1. Over-application of manure to fields results in runoff and nutrient input into waterbodies.
2. Conventional tillage methods leave soil exposed and results in runoff sedimentation and nutrient loading of waterbodies in the watershed.
3. The lack of vegetated buffer impacts the health of waterbodies. The lack of buffer is seen by increased erosion, algae blooms, decreased stream habitat, decreased aesthetic qualities, and sedimentation.
4. Livestock without controlled access to waterbodies cause sedimentation from breakdown of stream banks. Increased nutrients enter the water causing algae blooms and increased numbers of pathogens are present.
5. Lack of education to landowners and general public on how land practices effect the quality of the water.

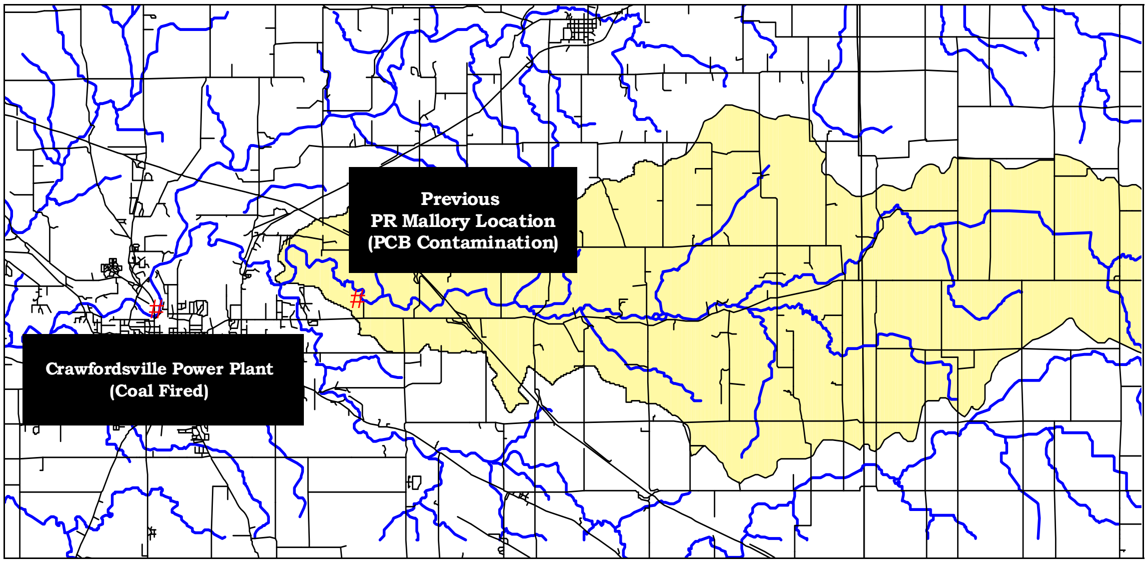
Section 5: Identifying Sources of Stressors & Threats

<u>PCB's and Mercury</u>

The sources of PCB's in Little Sugar Creek are thought to have come from an old manufacturing company called PR Mallory. PR Mallory made transformers and was a user of PCB's on a regular basis. The plant closed down and was designated a superfund site (Figure #). The Environmental Protection Agency remediated the area and it was taken off the EPA's list of superfund sites. Even though the old PR Mallory site is no longer designated a superfund site because of PCB's the evidence of them is still in the sediment and organisms living in Little Sugar Creek.

Mercury contamination of Little Sugar Creek is harder to pinpoint than the PCB's. Mercury is transported through wed deposition (precipitation) and can travel many distances until being deposited into waterbodies. The main sources of mercury are from coal-fired power plants, municipal incinerators, and industrial boilers (U.S. Environmental Protection Agency, 1997). Just downstream of where Walnut Fork empties into Sugar Creek there is the Power Company for Crawfordsville (Figure 24). This power company uses coal to power the plant and could be a local source for the mercury contamination in Little Sugar Creek.

Figure 24: Location of PCB contamination and possible mercury contamination

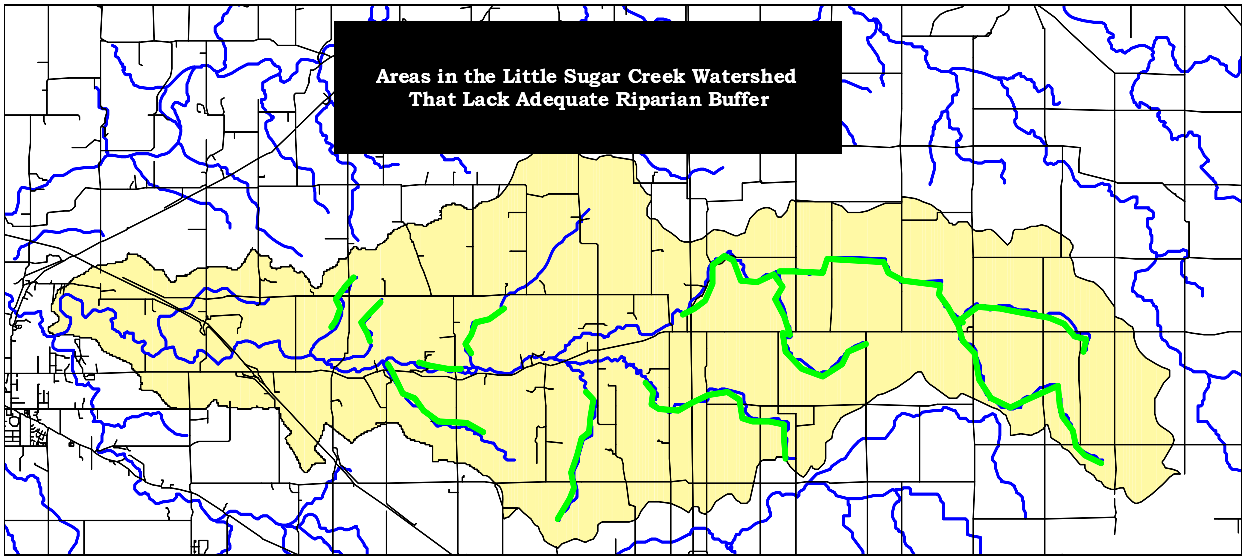


<u>Vegetated Riparian Buffer Width</u>

In the Little Sugar Creek Watershed There is a problem with lack of riparian buffer. Approximately half of the waterways within the watershed do not have adequate buffer (Figure 25). The majority of the problem lies in the Boone county portion of the watershed. In this area Little Sugar Creek is considered a legal drain. The county rule is that one side of a legal drain be kept free of trees for maintenance purposes. The county will clean out the legal drain when needed and does not want trees in the way. Since Boone county requires one side of the legal drain to be kept clear landowners tend to keep both sides clear. Another problem that there is no requirement as to which side of the legal drain is better kept untouched. Many areas along the legal drain in Boone county the trees and shrubs in buffers have been removed on the South side. The South side is where landowners should keep untouched so that more shade will be provided to the waters within the Little Sugar Creek watershed.

It is estimated that The Little Sugar Creek watershed could use forty nine acres of filterstrip (grass strip) or riparian buffer (grass and trees). The average width of a buffer strip is sixty feet from the edge of the channel.

Figure 25: Areas in Need of Buffer Zones



Nonpoint Source Pollution

Nonpoint source pollution within the Little Sugar Creek watershed has many sources. Nonpoint sources of pollution in the watershed include:

- Low adoption of conservation tillage
- Fertilizer application
- Livestock farming practices
- Lack of vegetated buffer

Low conservation tillage

A major source of nonpoint source pollution is the lack of conservation tillage. It is estimated that the tillage percent for *corn* in the watershed is: 27% no till
2% mulch till
71% conventional till

The tillage percent for beans is just about the opposite. Beans are very easy to grow with no till farming techniques and many farmers have adopted this practice. It is estimated that the tillage percent for *beans* in the watershed is: 78% no till
2% mulch till
20 % conventional till

Having so many farmers practice no till beans helps to control erosion problems, but the largest producer in the watershed grows corn after corn as a regular practice. The land the producer farms accounts for seven percent of the entire watershed. The corn after corn rotation requires tillage and could be a large source of sediment runoff. The other area in the watershed that has the least amount of conservational tillage is in the Boone county portion. Generally the land in Boone county is flat and not highly erodable, but there are areas that are. The figure below shows general areas of highly erodable land.

Figure 26.

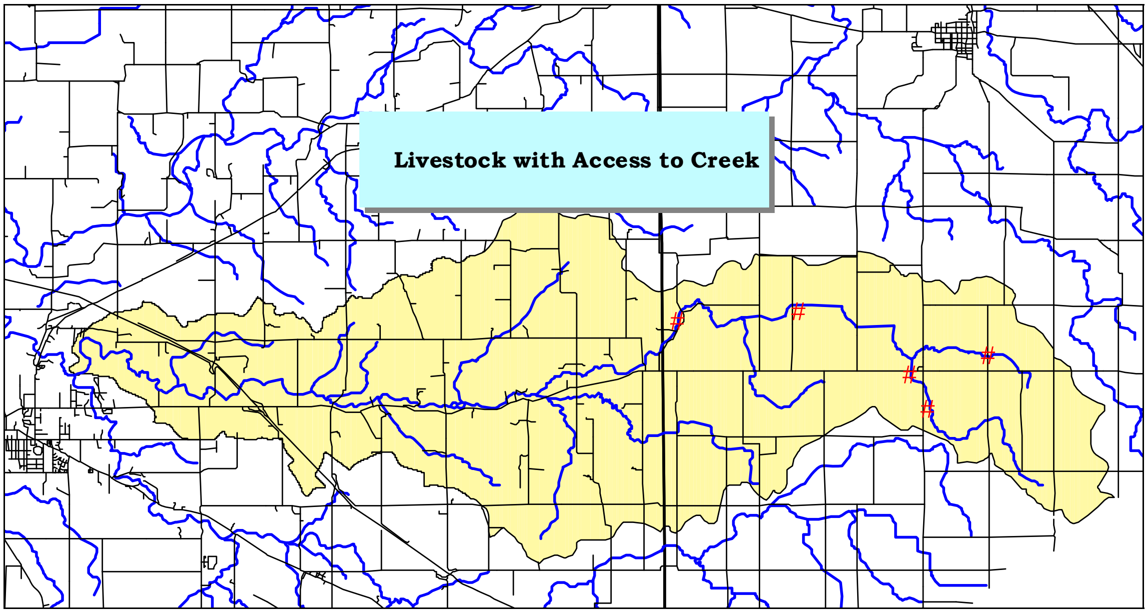
Fertilizer application

Fertilizers and manure are a useful way to get nutrients to crops. It is when they are applied incorrectly that they cause a problem. There are ten livestock operations in the Little Sugar Creek and a few of them use the manure as fertilizer for the crops. Farms that do not have covered or contained facilities to store the manure run the risk of runoff before application to fields. This runoff adds to the nutrient inputs to the watershed. The other way fertilizer application may cause nutrient inputs is over-application. When over applied, manure does not get absorbed and runs off the land before it can be utilized by plants. Another problem with fertilizer application is that there are old farms with broken or leaking tiles which have not been identified. When manure is applied to these fields the manure can leak out the old tiles when not known.

Livestock farming practice

As stated previously, there are ten livestock operations in the watershed. Some of them are confined and others are not. The operations that allow the livestock access to the creek are the direct source of nutrients and pathogens to the Little Sugar Creek watershed. They also cause streambank erosion from the livestock going up and down the bank to gain access to water. Below is a map showing areas where livestock have access to the waterway (Figure 27)

Figure 27: Areas Where Livestock Have Access to Creek



Lack of vegetated buffer

As stated previously, the area of the watershed lacks vegetated buffer is concentrated in Boone county (Figure 25). Little Sugar Creek is considered a legal drain in Boone county and therefore has to be kept free on one side for maintenance purposes. The lack of adequate buffer causes soil erosion, nutrient loss from runoff, warming water temperatures, etc.

Table 7: Water Quality Chart

Water Quality Concern	Stressor	Source
Nonpoint Source Pollution	Bank erosion	Livestock
	Waterborn pathogens	
	Nutrient loading	
	Sedimentation	Conventional tillage
	Nutrient Loading	
	High nitrogen levels	Manure/Fertilizer application
	Ammonia levels	
	Algae Blooms	
Riparian Habitat	Streambank erosion	Not enough bank cover
	Elevated temperatures	
	Channelization	
	Inadequate habitat	
	Sedimentation	
	Nutrient loading	Buffer not wide enough
	Flooding	
	Habitat fragmentation	
Mercury & PCB's	High levels in fish	Industry

SECTION V: Identifying Critical Areas

Target Areas

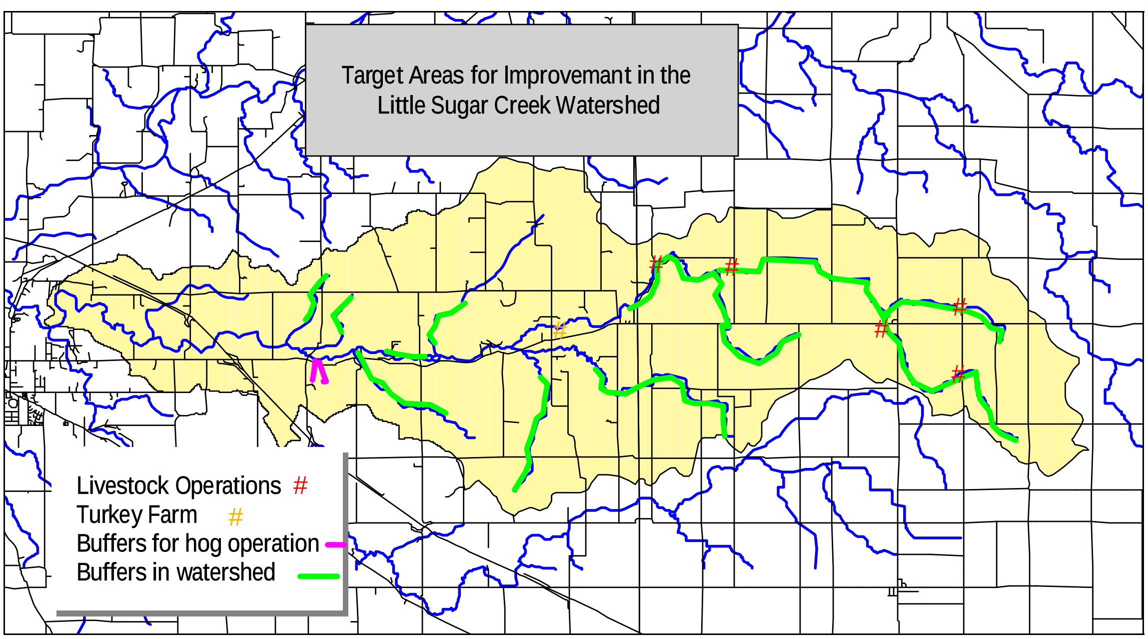
Target areas in the Little Sugar Creek watershed are areas that have proven a source of nutrient input, sediment loss, and/or poor habitat. They are selected based on the sources/stressors causing the greatest damage and can be addressed in the next three to five years. Target areas chosen for the Little Sugar Creek watershed are:

- Boone County livestock operations
- Turkey farm
- Buffers of warm season grasses for large hog operation
- Buffer strips and waterways on a watershed scale

* The reason PCB's and mercury problems are not being targeted is because the ways to lower the levels are not known. The manufacturing plant PR Mallory that was responsible for PCB contamination is no longer in existence and the site has been remediated with no known sources of further contamination. Mercury on the other hand is still being produced from various sources and unless coal is no longer used for power plants no change can be made.

Below is a map identifying the target areas within the watershed (Figure 28).

Figure 28: Map of Target Areas in the Watershed



Prioritization of Target Areas

The target areas are prioritized by landowner participation and impact on water quality. The target areas are in the order of:

1. **Turkey farm**
   - The turkey farm is located within a few hundred feet of Little Sugar Creek. Manure is stored on the ground uncovered in two separate locations. The owner wants to get the manure covered to improve water quality and it is beneficial to the farm. Turkey manure is high in nitrogen and the location and method of storage currently used is at risk of leaching into Little Sugar Creek.
2. **Boone County livestock operations**
   - The majority of livestock operations with access to the creek are located in Boone County. Livestock in streams are a direct source of nutrient pollution which causes algae blooms. They also cause streambank erosion and habitat loss and results in elevated stream temperatures.
3. **Buffers along tributaries on large hog farm**
   - Buffers of warm season grasses are needed around tributaries located around the barns of the large hog operation. The owners of the buildings would like to see water quality in Little Sugar Creek improve. The tributaries originating around the barns have high levels of nitrogen output year-round. Warm season grasses are great at taking up nitrogen and would hopefully improve the water quality while providing habitat. The facility is currently under construction and planting would have to wait until things are finished.
4. **Buffers and waterways over entire watershed**
   - Habitat in general in the form of buffers is needed throughout the watershed especially in the Boone County portion. Boone County is lacking in buffer area where Montgomery County is in more need of waterways.

The reasoning behind prioritizing the target areas in this way is because of timeframe to finish certain projects and landowner willingness to put in a conservation practice. One of the major water quality problems in the Little Sugar Creek watershed is high nitrogen levels. By addressing the manure storage and livestock problems it can help reduce the nitrogen levels. High nitrogen does not just come from livestock in streams it also comes from the land application of manure and other fertilizers. The large hog farm applies more manure to fields than any other farm and having buffers of warm season grasses on critical areas could reduce the nitrogen levels. Habitat creation through buffers and waterways is prioritized last since the major problem in the Little Sugar Creek watershed is high nitrogen levels. Once measures are in place to solve the water chemistry problems then buffers, plantings, and waterways will be encouraged more.

SECTION VI: Setting Goals & Indicators

Goal development

Based on the problem statements in Section 6, the steering committee looked at data collected, considered sources, and advised solutions. From that information goals were developed to improve water quality problems and habitat quality in the Little Sugar Creek watershed.

Cropland Agriculture Goals

1. Reduce manure application of fertilizer by educating about soil testing and optimum usage for certain soil types
2. November 2006, see no-till on 50% of corn after soybeans and 90% of beans after corn
3. Increase awareness on how cropping practices can impact water quality and about cost-share available through other programs such as the Farm Bill.

Livestock Agriculture Goals

4. Promote use of alternative water and manure management systems in the Little Creek subwatershed.
5. Fence livestock from waterways where applicable.

Riparian Goals

6. Install buffer strips in the Little Creek subwatershed
7. Connect buffers along waterways to create corridor in Needam-Booher subwatershed.
8. Educate the public on the importance of habitat.

Education Goals

9. Get into Montgomery County and Boone County schools to educate on watersheds, nonpoint source pollution, 319 Grant, and the importance of conservation.
10. Start Hoosier Riverwatch program in Montgomery County and Boone County schools.

Cropland Agriculture

Goal #1: Reduce manure application of fertilizer by educating about soil testing and optimum usage for certain soil types.

Objective	Action	Person Responsible	Date	Objective Indicators
Educate landowners on how to test their soils for proper nutrient requirements.	-Develop program with NRCS soil specialist -Invite landowners to program and see demonstrations	LSC Watershed Coordinator, NRCS District Conservationist, and Soil specialist	November 2004-November 2006	-Number of attendants at meetings -Number of requests for resources
Obtain soil tests the SWCD can give to landowners	-Find sponsor to donate soil tests -Have tests available at soil programs and at the SWCD office	LSC Watershed Coordinator and donating organization	November 2004-November 2006	Number of samples given out.
Recognize people who have made a change in fertilizer application practices in the Little Sugar Creek Watershed	-Develop criteria for recognition of landowners/operators who change fertilizer application rates to reduce runoff -Publish success stories in newsletter -Handout certificate to people who reduce application rates.	LSC Watershed Coordinator	January 2005-November 2006	-Number of people who show reduced application rates. -Number of certificates handed out.

Goal #2: By November 2006, see no-till on 50% of corn after soybeans and 90% of beans after corn

Objective	Action	Person Responsible	Date	Objective Indicators
Keep information about number of acres in conservation tillage within the watershed	-Have record of tillage transect data -Map LSC watershed for conservation tillage	LSC Watershed Coordinator and SWCD Resource Specialist	Begin November 2004	-Tillage Transect data -Numbers of farms that are converted to conservation tillage
Create a cost-share program that promotes conservation tillage	-Develop criteria for cost-share program -Advertise the cost-share program -Provide information about criteria -Implement cost-share program	LSC Watershed Coordinator	November 2004-November 2006	Number of projects funded through program
Encourage farmers to attend no-till meetings if considering conservation tillage	-Advertise dates of no-till and information to be covered in the meetings	LSC Watershed Coordinator & NRCS District Conservationist	On-going, once every year	Number in attendance at meetings

Goal #3: Increase awareness on how cropping practices can impact water quality and about cost-share available through other programs such as the Farm Bill.

Objective	Action	Person Responsible	Date	Objective Indicators
Educate adults and high school students about cropping/water quality relations.	-Develop program -Advertise in schools, paper, newsletter, and co-op offices -Cary out program	LSC Watershed Coordinator and SWCD Education Conservationist	November 2004-November 2006	-Number in appendance in adult and high school programs

Livestock Agriculture

Goal #4: Promote use of alternative water and manure management systems in the Little Creek Subwatershed.

Objective	Action	Person Responsible	Date	Objective Indicators
Research advances and costs of alternative watering and manure mgt. systems.	-Gather information on newest advances in the systems -Compile informational handout to distribute to landowners and publish in LSC newsletter	LSC Watershed Coordinator	November2004-April 2005	-Mail information to landowners in the LSC watershed
Show landowners how alternative watering systems and manure mgt. systems work.	-Set date for farm tour -Notify landowners in the Little Creek subwatershed of the tour -Hold tour of a farm with alternative watering systems and manure management	LSC Watershed Coordinator and NRCS District Conservationist	November 2004-March 2005	-Number of individuals who attend tour

Goal #5: Fence livestock from waterways where applicable.

Objective	Action	Person Responsible	Date	Objective Indicators
Encourage livestock exclusion with cost-share program	-Develop cost-share program -Promote program -Meet with landowners -Implement program	LSC Watershed Coordinator	November2004-November 2006	-Number of projects funded -Number of animals kept out of creek
Educate landowners on livestock exclusion and stream crossings.	-Develop adult program -Advertise program -Hoast program	LSC Watershed Coordinator	November 2004-November 2006	-Number of individuals who attend programs

Riparian Zones

Goal #6: Install buffer strips in the Little Creek subwatershed.

Objective	Action	Person Responsible	Date	Objective Indicators
Increase stream buffers 40% by 2006 in the Little Creek subwatershed	-Advertise CRP programs -Inform landowners by meeting one on one -Provide information through various media sources	LSC Watershed Coordinator and NRCS District Conservationist	Ongoing	-Acres put in conservation buffer strips -Pounds of soil loss reduced

Goal #7: Connect buffers along waterways to create corridor in Needam-Booher subwatershed.

Objective	Action	Person Responsible	Date	Objective Indicators
Increase connectivity of buffers so that 80% of the Needam-Booher watershed is connected	-Advertise CRP programs -Inform landowners by meeting one on one -Provide information through various media sources	LSC Watershed Coordinator and NRCS District Conservationist	Ongoing	-Acres put in conservation buffers -Length of connected riparian zones

Goal #8: Educate the public on the importance of habitat.

Objective	Action	Person Responsible	Date	Objective Indicators
Educate high school and middle school students in Montgomery and Boone Counties on habitat.	-Develop habitat program for middle and high school students -Advertise program in schools -Teach program	LSC Watershed Coordinator and SWCD Education Conservationist	Ongoing	-Number of students taught
Educate adults about importance of habitat	-Develop adult program -Advertise program -Hoast program	LSC Watershed Coordinator	November 2004-November 2006	-Number of individuals who attend programs

Education

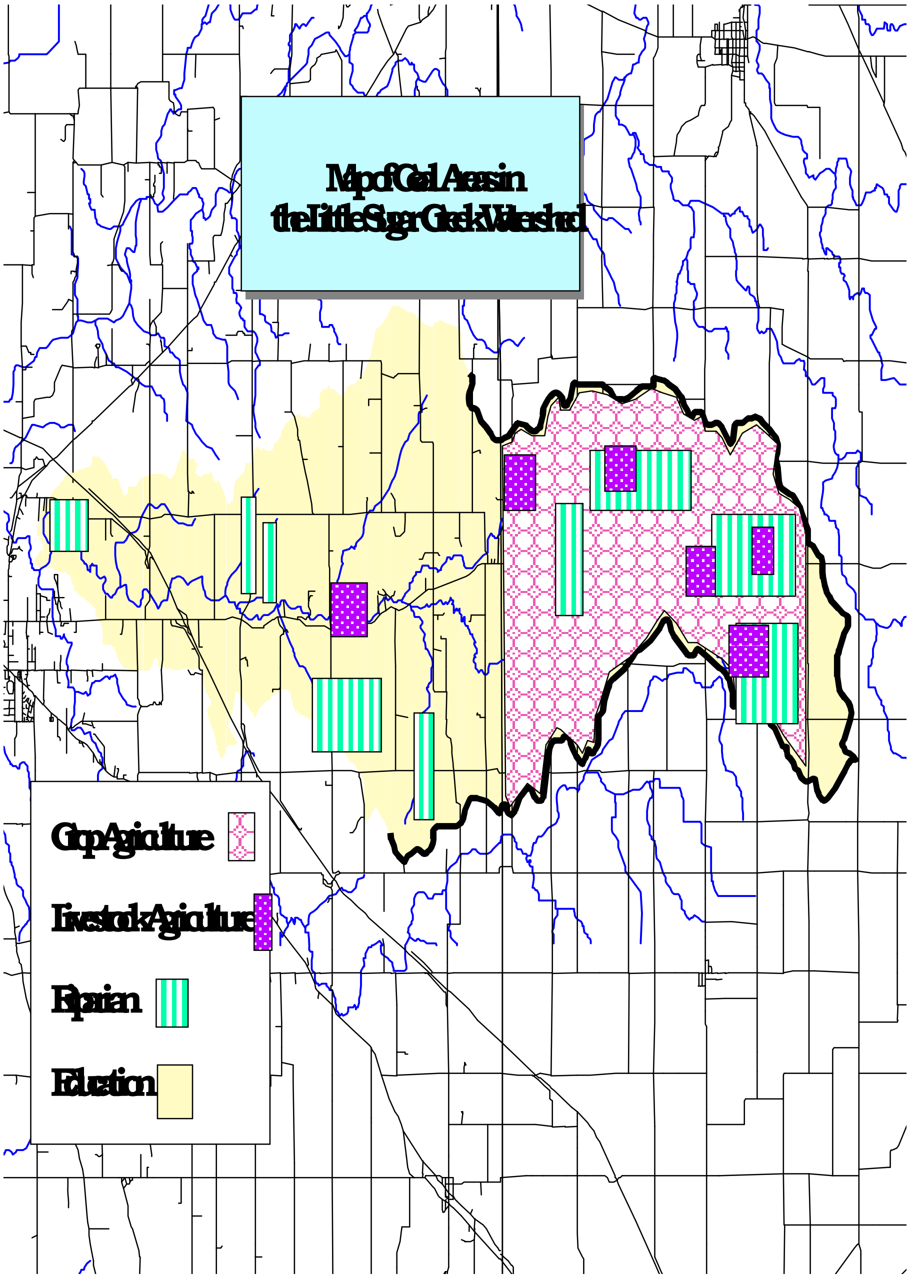
Goal #9: Get into Montgomery County and Boone County schools to educate on watersheds, nonpoint source pollution, 319 Grant, and the importance of conservation.

Objective	Action	Person Responsible	Date	Objective Indicators
Increase number of kids taught from 342 to 1,000.	-Develop programs -Advertise program in schools -Teach program	LSC Watershed Coordinator and SWCD Education Conservationist	Ongoing	-Number of students taught

Goal #10: Start Hoosier Riverwatch program in Montgomery County and Boone County schools.

Objective	Action	Person Responsible	Date	Objective Indicators
Increase number of teachers trained to teach Hoosier Riverwatch materials from 0 to 5	-Put on workshops for teacher cretification -Advertise workshops in schools -Teach workshop	LSC Watershed Coordinator and SWCD Education Conservationist	November 2004-November2006	-Number of teachers certified
Start sampling schedule for classes using Hoosier Riverwatch	-Choose sample sites -Choose dates for sampling -Record information	LSC Watershed Coordinator	November 2004-ongoing	-Number of sampling events -Data entered into HRW database

Map of LSC Goal Areas



Goals for the Little Sugar Creek Watershed Management Plan are attainable and aim for a positive impact on the landowners as well as the environment. By education on calculating proper fertilizer application rates landowners will possibly save money in the long run by not having to apply such high levels of fertilizer depending on soil testing results. Costs to the landowner can be reduced by keeping cattle out of the waterways. By not having cattle stand in water many health problems can be prevented and reduce care costs.

The largest impacts in the watershed will be the ones on environmental quality. Lack of riparian zones and nutrient loading are a few of the serious problems effecting the Little Sugar Creek environment today. Proper buffers along waterways alone will solve many nutrient leading problems as well as much needed habitat. By adding buffers along waterways in the watershed nitrogen and phosphorous levels will be decreased. With the nutrients and sediments being trapped there will be less algae blooms, fish kills and sedimentation.

Social impacts of the educational goals are positive. Education of both children and adults will show how landuse practices effect the environment and give solutions for lessening that impact. A majority of the population does not know what a watershed is let alone how things work within one. Education on non-point source pollution, watersheds, and conservation practices will make a large impact on how people look at the environment. Great things can come from education. One reason for the environmental problems in the United States today is that people do not have the knowledge on how what they effects the environment.

If nothing is done in the Little Sugar Creek watershed to help improve the water quality problems the situation will get worse as population expands and more habitat is cleared. All water is connected in one way or another. Ground water and surface water do mix and if steps are not taken to improve surface water quality all other water is also affected in one way or another. A quote stated by conservationist John Muir states it very clearly, "When one tugs a single thing in nature he finds it attached to the rest of the world." What landowners can do to *improve* the quality of Little Sugar Creek will have an impact on Sugar Creek which will impact the Wabash which will impact the Ohio and so on. The same also goes for the opposite.

Appendices

Appendix # . Water Chemistry Data

Dissolved Oxygen	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	18.18	9.83	13.47	6.18	8.64	9.28	9.26	8.05	9.39	10.43
10/8/2002	19.5	12.55	8.89	5.86	8.8	9.12	9.44	9.33	9.89	11.8
10/24/2002	18.6	14.38	9.6	5.57	9.22	10.33	10.25	10.6	11.51	11.92
11/4/2002	12.24	12.73	9.7	6.34	8.73	9.64	8.78	9.66	10.43	10.23
11/19/2002	12.93	12.14	10.79	10.2	10.13	11.08	10.5	11	10.46	11.59
12/4/2002	17.24	18.53	14.16	14.63	14.55	*	14.72	16.43	16.47	13.32
12/20/2002										
2003										
1/10/2003	12.37	13.5	12.6	12.76	11.73	11.51	13.66	12.32	11.9	11.36
1/30/2003	15.12	13.72	11.4		12.85		13.65	13	12.26	11.67
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	16.2		13.34		15.07	13.84	15.06	14.77	15.06	14.05
3/17/2003	11.68	10.58	11.57	12.51	11.44	12.77	12.22	11.27	11.83	10.86
3/26/2003			12.22			11.4		10.9	7.55	11.31
3/31/2003	15.94	17.04	15.2	13.56	15.61	14.86	14.7	15.14	13.47	12.44
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	13.58	12.53	9.66	11.17	9.79	9.71	11.71	11.21	11.51	10.64
5/7/2003	8.63	8.82	8.39	8.26	8.2	8.23	8.56	7.97	8.53	7.86
5/27/2003	16.09	16.89	9.97	10.01	11.64	10.86	10.25	10.63	10.97	11.46
6/9/2003	15.51	16.4	8.74	8.85	11.23	10.1	10.14	10.38	10.22	10.56
6/25/2003	10.68	11.31	6.68	7.23	8.53	7.45	9.22	7.62	9.48	8.58
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	9.21	10.49	8.54	6.79	7.96	9.26	7.92	8.49	8.63	9.05
8/5/2003	14.28	16.86	6.63	7.11	9.46	7.74	8.87	7.77	9.06	10.54
8/25/2003	*	*	*	*	*	*	*	*	*	*
9/11/2003	19.35	17.2	9.7	9.99	11.85	12.67	9.37	11	10.89	16.4
9/30/2003	13.96	12.73	11.56	11.04	9.98	12.44	10.74	11.77	11.83	11.95
10/15/2003	10.82	11.39	10.64	9.82	10.23	10.6	9.18	10.27	10.36	10.4
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	14.52	16.25	12.69	12.73	15.67	14.61	13.61	16.69	15.34	14.97
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	13.46	12.44	11.81	12.2	11.48	12.03	11.6	12.46	12.33	11.55
12/16/2003	10.83	10.8	10.68	10.66	9.65	9.92	9.34	10.56	10.66	8.99
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	12.27	12.26	12.93	*	12.36	12.43	13.58	12.46	12.36	10.85
2/12/2004	16.69	13.72	12.54	*	11.8	13.86	15.2	14.26	12.48	11.48
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	12.66	12.56	12.42	12.68	12.08	12.37	13.11	12.64	12.65	11.27
3/18/2004	12.97	13.58	12.32	12.56	12.46	12.32	12.07	12.24	12.39	11.91
4/7/2004	17.67	16.92	13.96	13.28	13.82	13.17	15.54	12.85	13.09	12.7
4/20/2004	10.97	10.62	9.34	10.27	10.61	10.06	10.18	9.48	9.35	9.38
5/5/2004	not working	*	*	*	*	*	*	*	*	*
5/24/2004	not working	*	*	*	*	*	*	*	*	*

TKN	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	0.77	0.6	0.99	0.62	0.4	0.69	0.28	0.79	0.83	0.67
10/8/2002	1.4	0.64	0.76	0.72	0.5	0.63	0.54	<0.1	0.79	0.78
10/24/2002	0.63	1.3	0.74	0.78	0.7	0.53	0.64	0.39	0.58	0.63
11/4/2002	0.83	0.73	0.96	1.35	0.64	1.35	1	1.09	0.95	0.82
11/19/2002	0.72	0.56	0.51	0.48	1.02	0.62	0.19	0.46	0.57	0.68
12/4/2002	1.32	0.56	0.62	0.58	0.76		0.71	0.76	0.56	0.58
12/20/2002	1.22	0.82	1.01	0.81	0.7	1.03	0.38	0.88	0.82	0.93
2003										
1/10/2003	0.84	0.7	0.36	0.54	0.37	0.72	0.25	0.66	0.68	0.81
1/30/2003	0.67	0.17	0.69		0.33		1.1	0.25	0.47	0.41
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	0.75		0.43		0.37	0.4	0.13	0.35	0.41	0.27
3/17/2003	0.67	0.52	0.42	0.38	0.38	0.5	0.1	0.5	0.43	0.53
3/26/2003			1.26			0.89		2.62	48.6	2.48
3/31/2003	0.82	0.63	0.51	0.62	0.45	0.56	0.37	0.51	0.63	0.58
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	0.57	0.53	0.59	0.56	0.51	0.54	1.14	0.65	0.65	0.6
5/7/2003	1.57	1.96	2.65	0.11	2.21	1.16	1.21	1.09	0.29	0.95
5/27/2003	0.77	0.97	0.94	0.93	0.57	0.8	0.38	0.6	0.83	0.8
6/9/2003	0.63	1.2	0.76	0.6	0.62	0.65	0.59	0.63	0.71	0.88
6/25/2003	0.79	0.6	0.64	0.18	0.84	0.53	0.61	0.7	0.56	0.6
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	1.13	0.75	0.73	0.6	0.51	0.62	0.77	0.67	0.71	0.88
8/5/2003	0.62	2.1	1.34	0.6	0.74	0.48	0.56	0.85	0.56	0.56
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	0.77	0.67	0.62	0.54	0.36	0.53	0.25	0.56	0.52	0.7
9/30/2003	0.81	0.52	0.54	0.52	0.5	0.57	0.35	0.54	0.61	0.77
10/15/2003	0.91	0.62	0.67	0.59	0.69	0.8	0.28	0.94	0.91	0.92
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	0.65	0.52	0.52	0.58	0.47	0.58	0.48	0.59	0.61	0.66
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	0.88	0.59	0.59	0.57	0.52	0.44	0	0.55	0.54	0.68
12/16/2003	0.89	0.74	0.77	0.98	1.46	0.65	0.44	0.76	0.69	0.43
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	0.6	0.39	0.4	*	0.43	0.36	0.45	0.51	0.42	0.43
2/12/2004	1.42	0.7	0.55	*	0.48	0.55	0.54	0.46	0.37	0.44
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	1.24	1.33	1.33	0.6	0.7	0.59	0.44	0.52	0.48	0.5
3/18/2004	1.21	1.09	1.12	1.32	1.16	1.14	0.78	1.09	1.16	1.09
4/7/2004	0.53	0.59	0.55	0.51	0.45	0.61	0.4	0.5	0.52	0.6
4/20/2004	1.05	0.78	0.88	1.09	0.68	0.93	1.03	0.87	0.86	0.71
5/5/2004										
5/24/2004										

Total P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	0	0.13	0.28	0	0	0.11	0.1	0	0.11	0
10/8/2002	0	0	0	0	0	0	0	0	0	0
10/24/2002	0	0	0	0	0	0.22	0	0	0	0
11/4/2002	0.15	0	0.1	0.16	0.84	0	0.22		0.14	0.1
11/19/2002	0.13	0.33	0.17	0.12	0.14	0	0.69	0	0.12	0.18
12/4/2002	0	0	0	0	0		0	0	0	0
12/20/2002	0.39	0.22	0.21	0	0	0.14	0.22	0.16	0.14	0.12
2003										
1/10/2003	0.11	0	0	0	0	0	0.12	0	0	0.11
1/30/2003	0	0	0		0		0	0	0	0
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	0		0		0	0	0	0	0	0
3/17/2003	0.13	0.12	0.12	0	0	0.1	0.12	0.12	0.16	0.1
3/26/2003			0			0		0.31	6.61	0.22
3/31/2003	0	0	0	0	0	0	0	0	0	0
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	0	0	0	0	0	0	0	0	0	0
5/7/2003	0.31	0.17	0.19	0.51	0.2	0.21	0.22	0.21	0.27	0.19
5/27/2003	0	0	0	0	0	0	0	0	0	0
6/9/2003	0	0	0	0	0	0	0	0	0	0
6/25/2003	0	0	0	0	0	0	0	0	0	0
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	0.22	0.23	0.11	0.12	0	0	0	0	0	0
8/5/2003	0	0	0	0	0	0	0	0	0	0
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	0	0	0	0	0	0	0	0	0	0
9/30/2003	0	0	0	0	0	0	0	0	0	0
10/15/2003	0.16	0	0	0	0	0	0	0	0	0
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	0	0	0	0	0	0	0	0	0	0
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	0	0	0	0	0	0	0	0	0	0
12/16/2003	0	0	0	0	0	0	0	0	0	0
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	0	0	0	*	0	0	0	0	0	0
2/12/2004	0.18	0	0	*	0.24	0.27	0.25	0.2	0.37	0.23
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	0	0	0	0	0	0	0	0	0	0
3/18/2004	0	0	0	0	0	0	0	0	0	0
4/7/2004	0	0	0	0	0	0	0	0	0	0
4/20/2004	0.14	0	0	0.15	0	0	0.16	0	0	0.1
5/5/2004										
5/24/2004										

Nitrate	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	3.47	3.36	3.41	0.54	0.03	3.24	17.25	8.42	6.1	4.14
10/8/2002	3.52	2.89	2.75	0.43	0.02	1.54	16.14	10.68	8.47	5.3
10/24/2002	2.8	2.09	2.02	0.54	0.02	1.06	14.6	9.32	7.48	6.18
11/4/2002	4.34	3.6	3.29	0.12	0.02	1.6	13.58	7.55	6.04	4.88
11/19/2002	4.96	4.94	4.54	3.9	2.3	4.1	12.92	5.74	5.36	5.02
12/4/2002	4.65	4.26	3.87	3.07	0.92		12.39	6.64	5.78	5.54
12/20/2002										
2003										
1/10/2003	7.5	7.63	7.54	7.17	5.58	7.43	31.29	8.03	7.84	7.96
1/30/2003	4.72	4.71	5.62		1.37		10.48	5.72	5.98	5.56
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003			4.56		1.55	3.85	10.6	6.08	5.46	5.62
3/17/2003	5.72	6.36	6.33	6.02	4.98	6.14	4.47	6.72	6.5	6.83
3/26/2003			5.1			4.71		5.48	4.7	5.02
3/31/2003	5.43	5.36	5.26	4.93	3.02	4.78	10.94	5.86	5.5	5.26
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	3.99	4.98	3.53	2.5	1.71	2.77	10.46	4.71	4.23	3.48
5/7/2003	9.04	9.32	10.14	10.74	9.88	8.04	10.74	10.18	10.42	9.44
5/27/2003	6.18	5.88	5.38	5.56	3.02	4.94	12.01	6.32	5.82	4.56
6/9/2003	6.46	6.3	5.89	5.54	3.59	4.88	11.82	6.44	5.78	4.85
6/25/2003	6.82	10.56	5.76	5.84	3.59	5.44	11.71	7.1	6.16	5.13
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	3.91	4.73	4.9	4.73	3.49	4.89	13.5	6.08	6.04	5.6
8/5/2003	3.48	3.28	3.33	1.68	0.71	3.06	11.28	7.28	7.28	4.28
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	2.74	2.97	2.75	1.74	0.17	2.28	10.53	5.81	4.99	3.12
9/30/2003	5.29	5.75	5.31	4.83	3.38	5.01	11	5.63	5.41	5.26
10/15/2003	6.37	6.59	6.64	5.82	4.88	6.24	20.7	6.34	6.04	5.83
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	4.39	3.96	3.93	3.2	2.23	3.39	9.02	5.09	4.78	3.91
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	5.38	5.54	5.55	4.88	2.92	5.13	12.87	6.1	5.98	
12/16/2003	5.69	5.74	5.49	5.2	3.28	5.17	14.75	6.38	6.1	6.26
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	4.97	5.68	5.54	*	1.85	4.85	13.08	*	*	6.38
2/12/2004	5.29	4.88	5.82	*	1.83	3.97	10.94	6.66	6.11	4.89
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	7.13	7.08	6.91	6.25	4.45	5.24	17.24	7.13	7.02	6.81
3/18/2004	5.06	5.1	4.88	4.38	2.34	4.34	16.06	5.83	5.41	4.86
4/7/2004	5.21	5.51	5.27	5.3	3.01	4.75	12.18	5.91	5.52	5.19
4/20/2004	4.75	4.42	4.01	3.22	1.73	2.87	8.71	5.04	4.77	3.76
5/5/2004	5.48	4.72	4.37	2.76	4	4.49	11.69	5.81	5.4	4.36
5/24/2004										

E. Coli	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Site 9**	**Site 10**
2002										
9/24/2002	210	110	90	320	60	40	20	120	380	190
10/8/2002	90	60	10	40	0	30	30	120	90	60
10/24/2002	70	70	15	60	20	30	60	100	100	40
11/4/2002	1500	200	110	0	10	10	40	580	70	1200
11/19/2002	50	40	130	440	20	60	420	60	50	20
12/4/2002	30	70	20	0	40		270	140	20	60
12/20/2002	50	40	10	0	50	60	140	110	30	40
2003										
1/10/2003	40	60	30	10	40	70	120	90	10	40
1/30/2003	20	40	60		30		90	70	20	10
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	20		100		50	40	20	0	50	80
3/17/2003	40	70	120	30	60	40	50	70	40	90
3/26/2003						50		200		
3/31/2003	70	0	10	40	0	10	0	0	0	10
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	60	20	20	30	10	0	60	10	0	10
5/7/2003	60	70	20							
5/27/2003	20	30	90	50	60	40	20	10	40	60
6/9/2003	20	20	80	60	70	40	10	20	50	70
6/25/2003	50	70	70	30	50	80	70	10	60	70
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	100	40	70	0	60	80	40	30	50	40
8/5/2003	20	30	0	60	40	10	70	50	80	20
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	60	40	60	70	40	60	40	20	40	20
9/30/2003	80	20	50	70	50	80	90	10	60	40
10/15/2003	20	30	50	70	40	10	80	20	40	0
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	30	30	40	50	20	20	40	30	40	50
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	40	30	50	30	20	10	20	10	40	40
12/16/2003	20	20	30	10	20	20	10	40	30	30
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	20	40	40	*	30	20	10	no bag	no bag	no bag
2/12/2004	50	20	20	*	30	10	40	20	60	10
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	40	20	10	40	30	20	50	30	40	20
3/18/2004	70	50	40	20	0	30	20	40	40	10
4/7/2004	60	40	30	40	20	30	40	60	40	20
4/20/2004										
5/5/2004										
5/24/2004										

Nitrite	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	0.06	0.021	0.035	0.008	0.004	0.014	0.065	0.019	0.011	0.009
10/8/2002	0.068	0.013	0.061	0.01	0.004	0.009	0.065	0.017	0.013	0.009
10/24/2002	0.064	0.011	0.02	0.007			0.069	0.015	0.011	0.011
11/4/2002	0.048	0.019	0.018			0.007	0.076	0.017	0.011	0.009
11/19/2002	0.017	0.019	0.016	0.018	0.012	0.014	0.089	0.015	0.011	0.011
12/4/2002	0.018	0.004	0.011	0.01	0.007		0.07	0.009	0.009	0.007
12/20/2002										
2003										
1/10/2003	0.011	0.009	0.009	0.01	0.007	0.009	0.054	0.011	0.01	0.011
1/30/2003	0.011	0.015	0.019		0.011		0.045	0.01	0.008	0.008
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003			0.019		0.011	0.013	0.051	0.015	0.012	0.011
3/17/2003	0.015	0.011	0.011	0.01	0.009	0.012	0.034	0.015	0.016	0.014
3/26/2003			0.016			0.037		0.069	0.145	0.075
3/31/2003	0.014	0.017	0.015	0.02	0.013	0.033	0.048	0.037	0.031	0.034
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	0.068	0.053	0.059	0.053	0.042	0.067	0.127	0.073	0.051	0.034
5/7/2003	0.053	0.055	0.056	0.082	0.058	0.02	0.062	0.062	0.056	0.042
5/27/2003	0.029	0.037	0.04	0.034	0.012	0.029	0.112	0.021	0.015	0.009
6/9/2003	0.039	0.067	0.069	0.049	0.025	0.054	0.165	0.046	0.039	0.026
6/25/2003	0.056	0.043	0.085	0.036	0.026	0.091	0.136	0.034	0.031	0.024
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	0.037	0.027	0.024	0.02	0.017	0.014	0.93	0.017	0.013	0.004
8/5/2003	0.159	0.053	0.112	0.01	0.009	0.053	0.155	0.096	0.072	0.018
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	0.02	0.018	0.024	0.008		0.01	0.09	0.006	0.01	0.008
9/30/2003	0.015	0.012	0.008	0.007	0.011	0.01	0.08	0.012	0.01	0.01
10/15/2003	0.014	0.016	0.018	0.016	0.014	0.018	0.096	0.02	0.02	0.022
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	0.042	0.02	0.016	0.012	0.012	0.012	0.07	0.012	0.021	0.01
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	0.016	0.012	0.012	0.01	0.01	0.01	0.08	0.014	0.01	
12/16/2003	0.016	0.011	0.009	0.007	0.008	0.009	0.087	0.012	0.01	0.007
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	0.009	0.006	0.005	*	0.005	0.006	0.047	-	-	0.006
2/12/2004	0.022	0.004	0.016	*	0.014	0.012	0.07	0.012	0.012	0.008
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	0.01	0.012	0.012	0.01	0.008	0.01	0.055	0.014	0.014	0.004
3/18/2004	0.012	0.022	0.012	0.01	0.01	0.01	0.055	0.012	0.012	0.01
4/7/2004	0.018	0.022	0.022	0.02	0.009	0.02	0.08	0.02	0.02	0.018
4/20/2004	0.046	0.096	0.078	0.05	0.026	0.052	0.11	0.082	0.074	0.046
5/5/2004	0.054	0.056	0.038	0.022	0.034	0.04	0.145	0.042	0.038	0.026
5/24/2004										

Ammonia	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	0.14	0.13	0.15	0.17	0.15	0.15	0.17	0.2	0.12	0.11
10/8/2002	0.16	0.12	0.14	0.16	0.1	0.09	0.11	0.1	0.14	0.15
10/24/2002	0.24	0.11	0.11	0.13	0.1	0.08	0.11	0.09	0.16	0.13
11/4/2002	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.11	0.18
11/19/2002	0.17	0.14	0.11	0.07	0.09	0.08	0.1	0.05	0.09	0.09
12/4/2002	0.31	0.12	0.1	0.094	0.093		0.21	0.093	0.085	0.078
12/20/2002	0.068	0.069	0.038	0.034	0.058	0.06	0.036	0.059	0.035	0.039
2003										
1/10/2003	0.24	0.12	0.14	0.09	0.09	0.2	0.24	0.09	0.12	0.08
1/30/2003	0.22	0.14	0.14		0.1		0.28	0.12	0.14	0.1
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	0.7		0.4		0.6	0.8	0.5	0.6	0.6	0.7
3/17/2003	2.4	0.45	0.42	2.1	0.9	0.24	0.61	5.3	10.4	3.4
3/26/2003			0.28			0.37		8.2	200	7.1
3/31/2003	0.12	0.11	0.1	0.094	0.091	0.085	0.086	0.084	0.081	0.08
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	0.51	0.58	0.52	0.35	0.38	0.68	0.8	0.45	0.39	0.36
5/7/2003	1.1	1.2	1.3	1.7	1.3	0.64	1.2	1.3	1.1	1.2
5/27/2003	0.19	0.13	0.19	0.18	0.16	0.23	0.38	0.12	0.21	0.12
6/9/2003	0.14	0.15	0.19	0.19	0.14	0.25	0.4	0.12	0.26	0.12
6/25/2003	0.21	0.2	0.14	0.18	0.16	0.28	0.4	0.16	0.24	0.14
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	0.12	0.13	0.12	0.12	0.13	0.15	0.61	0.12	0.13	0.16
8/5/2003	0.12	0.14	0.12	0.12	0.13	0.14	0.32	0.14	0.13	0.12
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	0.17	0.15	0.15	0.14	0.12	0.12	0.22	0.17	0.14	0.13
9/30/2003	0.13	0.15	0.14	0.14	0.1	0.14	0.28	0.16	0.13	0.1
10/15/2003	0.16	0.14	0.17	0.09	0.1	0.2	0.24	0.13	0.18	0.1
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	0.19	0.059	0.062	0.063	0.067	0.069	0.073	0.077	0.083	0.12
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	0.21	0.07	0.08	0.07	0.07	0.06	0.08	0.08	0.09	0.14
12/16/2003	0.1	0.06	0.04	0.06	0.05	0.08	0.09	0.06	0.12	0.17
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	0.18	0.11	0.14	*	0.14	0.06	0.14	0.12	0.08	0.21
2/12/2004	0.24	0.12	0.21	*	0.09	0.09	0.12	0.09	0.14	0.21
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	0.21	0.14	0.24	0.24	0.08	0.12	0.11	0.12	0.15	0.34
3/18/2004	0.36	0.24	0.36	0.4	0.12	0.1	0.16	0.17	0.14	0.42
4/7/2004	0.41	0.31	0.44	0.44	0.14	0.21	0.16	0.18	0.21	0.6
4/20/2004										
5/5/2004										
5/24/2004										

Conductivity	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	848	679	656	594	771	605		618	562	516
10/8/2002	835	747	760		761			818	779	781
10/24/2002	846	765	730	738	798	747	983	836	806	818
11/4/2002	870	806	788	817	813	785	1000	840	824	815
11/19/2002	806	805	804	764	764	805	981	817	816	796
12/4/2002	918	865	860	831	818		1027	874	871	858
12/20/2002	702	690	689	695	714	683	1116	687	691	694
2003										
1/10/2003	690	678	649	667	708	647	1062	636	640	647
1/30/2003	862	821	797		796		954	846	851	839
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	912		842		788	812	972	826	841	417
3/17/2003	618	645	653	623	646	642	941	651	654	653
3/26/2003			715			696		727	1209	743
3/31/2003	683	677	707	654	693	694		708	698	705
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	798	727	709	657	755	701	935	727	709	710
5/7/2003	642	644	589	551	575	545	835	547	545	533
5/27/2003	735	685	670	653	740	698	916	689	698	715
6/9/2003	725	692	711	702	740	700	923	715	726	747
6/25/2003	773	728	706	699	769	700	909	735	725	731
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	613	643	656	629	715	668	905	691	689	679
8/5/2003	759	635	681	679	739	694	899	751	750	763
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	739	677	694	668	752	698	895	748	729	747
9/30/2003	727	726	713	661	697	683	912	685	680	669
10/15/2003	714	698	681	662	672	668	963	656	650	644
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	779	736	735	733	738	732	902	744	761	761
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	780	780	776	725	738	769	938	791	793	798
12/16/2003	796	784	777	730	739	785	945	793	794	779
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	787	778	790	*	764	799	920	824	821	822
2/12/2004	784	784	790	*	735	791	882	800	818	815
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	685	687	692	649	687	677	921	680	677	682
3/18/2004	755	741	737	683	749	731	930	744	743	761
4/7/2004	696	669	673	635	705	665	844	677	684	692
4/20/2004	meter	not	working	---	---	---	---	---	---	752
5/5/2004	681	648	657	644	685	662	861	689	683	717
5/24/2004	690	655	670	651	670	664	878	658	647	660

TDS	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	422	343	332	307	377	304	450	310	276	268
10/8/2002	417	375	373					403		
10/24/2002	426	382	367	371	401	376	492	418	405	409
11/4/2002	434	403	393	407	406	394	499	421	415	409
11/19/2002	403	403	404	384	383	403	492	411	410	399
12/4/2002	460	432	431	413	410		514	437	435	430
12/20/2002	350	344	344	348	357	342	555	345	344	347
2003										
1/10/2003	347	337	324	333	355	323	531	318	320	324
1/30/2003	432	414	402		400		481	424	425	423
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	451		420		392	408	486	413	422	843
3/17/2003	308	324	324	314	320	323	472	322	327	327
3/26/2003			359			343		366	605	370
3/31/2003	341	339	354	328	345	347		352	349	348
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	400	359	355	350	380	353	468	361	356	359
5/7/2003	321	319	295	274	288	271	418	272	274	266
5/27/2003	367	341	336	362	371	348	460	345	351	358
6/9/2003	364	346	357	350	371	345	462	355	366	371
6/25/2003	387	364	355	349	385	348	456	365	362	365
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	307	322	328	309	358	332	454	344	346	338
8/5/2003	379	318	338	341	363	348	446	377	375	388
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	370	338	347	335	373	350	449	374	361	375
9/30/2003	363	362	355	366	348	343	453	344	341	333
10/15/2003	357	348	341	329	336	333	480	329	324	322
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	390	367	369	365	369	362	452	371	381	375
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	390	390	388	362	369	384	468	395	396	399
12/16/2003	398	391	390	364	370	391	471	397	398	388
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	393	390	391	*	382	399	459	409	412	410
2/12/2004	392	392	399	*	394	396	439	398	409	407
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	342	343	344	327	343	340	460	340	337	341
3/18/2004	378	370	368	343	374	367	464	372	371	381
4/7/2004	346	334	334	318	349	333	421	339	342	347
4/20/2004	meter	not	working	---	---	---	---	---	---	376
5/5/2004	341	324	330	320	344	329	432	341	343	355
5/24/2004	345	326	336	323	336	330	440	329	325	327

Temperature	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	21.2	19.6	20.1	17.6	17.9	17.7	16	19	17.3	17.4
10/8/2002	15.68	14.56	14.56	11.2	15.12	14.56	14.56	14.56	15.12	15.12
10/24/2002	10.64	10.08	9.52	7.84	9.52	8.96	9.52	8.4	8.96	8.96
11/4/2002	5.6	5.6	5.6	5.04	6.16	4.48	5.6	5.6	5.6	5.6
11/19/2002	10.08	8.96	6.72	6.72	9.52	6.72	7.84	6.72	6.72	6.72
12/4/2002	1.12	0	0	0	3.36		0	0	0	0
12/20/2002	5.6	5.04	4.48	5.6	6.72	5.04	5.6	5.04	5.04	5.04
2003										
1/10/2003	3.92	3.36	3.36	3.36	5.04	3.92	3.36	3.92	3.92	3.92
1/30/2003	3.36	1.12	1.12		4.48		3.36	1.12	1.12	1.12
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	1.68		1.12		4.48	2.24	3.92	1.68	1.68	1.12
3/17/2003	10.64	11.76	11.2	11.2	11.2	11.2	11.2	14.56	11.2	11.2
3/26/2003										
3/31/2003	12	11.5	10	10	12.5	10	11	9.5	11	11
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	10.8	12.4	11.5	10.5	10	10.5	9.4	11.2	11.3	11.8
5/7/2003	14.56	15.68	16.24	15.12	15.12	15.68	15.68	15.68	16.24	16.24
5/27/2003	18.48	17.92	16.24	15.12	14.56	15.68	14	16.24	16.24	16.24
6/9/2003	20.16	20.72	16.8	16.8	16.24	17.92	15.12	18.48	16.8	17.92
6/25/2003	24.64	26.32	24.64	16.24	20.16	22.4	16.8	22.96	22.96	22.96
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	24.08	26.32	24.08	22.4	21.28	24.08	17.92	22.96	23.52	23.52
8/5/2003	22.4	24.08	22.96	20.72	19.6	16.8	16.24	21.28	20.72	20.72
8/25/2003	*	*	*	*	*	*	*			
9/11/2003	24.64	24.64	22.96	21.28	20.16	22.96	17.92	21.84	21.84	22.4
9/30/2003	14.56	15.68	14.56	14	16.24	15.68	13.44	14.56	15.12	15.12
10/15/2003	16.8	16.8	16.24	15.12	16.8	15.68	16.24	15.12	15.12	15.12
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	12.32	11.2	9.52	9.52	11.2	9.52	11.2	9.52	9.52	12.32
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	7.28	7.28	6.16	6.72	9.52	6.16	8.96	5.6	5.6	5.6
12/16/2003	8.96	5.6	5.6	5.6	9.52	6.72	9.52	5.6	6.16	5.6
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	4.48	3.92	3.36	*	4.48	3.36	6.72	3.36	2.8	2.8
2/12/2004	4.48	4.48	1.12	*	6.72	3.36	6.72	3.36	3.36	4.48
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	8.4	8.4	5.6	5.6	8.4	6.72	8.4	6.72	6.72	7.84
3/18/2004	5.6	5.04	5.04	5.04	6.72	5.04	7.84	5.04	5.6	5.04
4/7/2004	15.12	15.68	14.56	14.56	12.88	12.88	14.56	12.88	13.44	12.88
4/20/2004	14	14.56	15.68	15.68	12.88	15.68	13.44	16.24	16.24	15.68
5/5/2004	26.88	21.28	17.92	17.92	18.48	17.36	17.36	17.36	18.48	19.6
5/24/2004	21.28	23.52	21.84	20.16	18.48	21.28	19.04	20.16	21.28	21.28

pH	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
2002										
9/24/2002	8.5	8.5	8.3	8	8.1	8.4	8.3	8.3	8.5	8.5
10/8/2002	8.6	8.5	8.3	8	8.1	8.3	8.3	8.3	8.5	8.7
10/24/2002	8.6	8.5	8.3	7.9	8.1	8.3	8.3	8.3	8.5	8.5
11/4/2002	8.3	8.4	8.2	8	8.1	8.3	8.1	8.1	8.4	8.3
11/19/2002	8.3	8.3	8.3	8.2	8.1	8.3	8.2	8.4	8.4	8.5
12/4/2002	8.4	8.5	8.3	8.3	8.3		8.3	8.5	8.5	8.5
12/20/2002	7.7	8	8.1	8.1	8	8.3	8.2	8.2	8.3	8.3
2003										
1/10/2003	7.7	7.9	8	8.2	7.9	8.2	8.3	8.2	8.3	8.1
1/30/2003	8.3	8.3	8.2		8.2		8.4	8.4	8.3	8.3
2/4/2003	*	*	*	*	*	*	*	*	*	*
2/18/2003	8.3		8.2		8.3	8.4	8.5	8.5	8.5	8.5
3/17/2003	7.9	8.2	8.2	8.5	8	8.3	8.3	8.3	8.4	8.3
3/26/2003			8.4			8.5		8.5	8.3	8.5
3/31/2003	8.7	8.8	8.6	8.7	8.5	8.7	8.5	8.7	8.7	8.7
4/2/2003	*	*	*	*	*	*	*	*	*	*
4/24/2003	8.5	8.5	8.3	8.2	8.2	8.3	8.4	8.5	8.5	8.5
5/7/2003	7.7	7.9	7.9	7.9	7.7	7.9	7.9	8	8.1	8.2
5/27/2003	8.3	8.7	8.3	8.3	8.3	8.5	8.3	8.4	8.5	8.3
6/9/2003	8.4	8.5	8.2	8.3	8.2	8.3	8.2	8.3	8.4	8.3
6/25/2003	8.2	8.3	8.1	8.2	8	8.1	8.1	8.2	8.3	8.2
7/3/2003	*	*	*	*	*	*	*	*	*	*
7/17/2003	7.8	8.1	8	8.1	7.9	8.2	8	8.2	8.3	8.4
8/5/2003	8.2	8.5	8	8	8	8.1	8	8.1	8.2	8.2
8/25/2003	*	*	*	*	*	*	*	*	*	*
9/11/2003	8.4	8.4	8	8.2	8	8.2	8	8.2	8.4	8.4
9/30/2003	8.1	8	8	8.2	7.9	8.1	8.1	8.2	8.3	8.4
10/15/2003	7.7	8	8	8	7.8	8.1	8	8.1	8.1	8.2
10/30/2003	*	*	*	*	*	*	*	*	*	*
11/10/2003	8.3	8.5	8.2	8.4	8.4	8.4	8.3	8.1	8.4	8.2
11/26/2003	*	*	*	*	*	*	*	*	*	*
12/3/2003	8.1	8.2	8.2	8.3	8	8.3	8.2	8.4	8.4	8.3
12/16/2003	8	8.2	8.2	8.2	8	8.2	8.1	8.2	8.4	8.2
2004										
1/7/2004	*	*	*	*	*	*	*	*	*	*
1/20/2004	8.1	8.2	8.3	*	8	8.2	8.2	8.2	8.3	8.1
2/12/2004	8.2	8.3	8.2	*	8	8.4	8.3	8.4	8.4	8.2
2/26/2004	*	*	*	*	*	*	*	*	*	*
3/3/2004	7.8	8	8	8.2	7.9	8.2	8.2	8.3	8.4	8.2
3/18/2004	8.2	8.3	8.3	8.4	8.1	8.4	8.2	8.4	8.5	8.4
4/7/2004	8.4	8.5	8.3	8.4	8.2	8.4	8.4	8.4	8.5	8.4
4/20/2004	8.2	8.2	8.2	8.2	8	8.2	8.2	8.2	8.3	8
5/5/2004	8.6	8.4	8.4	8.5	8.4	8.6	8.3	8.5	8.5	8.2
5/24/2004	8	8.4	8.2	8.2	7.9	8.3	8.1	8.2	8.3	8.4