# BIOASSESSMENT REPORT

## RAPID BIOASSESSMENT OF THE

## WOLF CREEK WATERSHED

## USING BENTHIC MACROINVERTEBRATES

**May & October 2001**

**For the**
**Soil and Water Conservation District of**
**Jay County, Indiana**


**Study Conducted By:**

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# BIOASSESSMENT SUMMARY

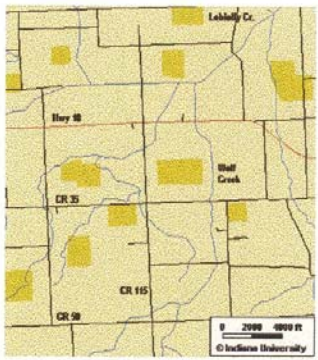
## Wolf Creek/Loblolly Creek - Jay County

### *Purpose*

**To measure the water quality of Wolf Creek and Loblolly Creek in Jay County, Indiana after implementation of "best management practices" in the watershed. A bioassessment technique was used. Bioassessment uses knowledge of the biology of stream-dwelling animals to measure stream health.**

### *Watershed Characteristics*

**The watershed is primarily agricultural. BMPS to reduce sedimentation and nutrient inputs were initiated in 1996.**



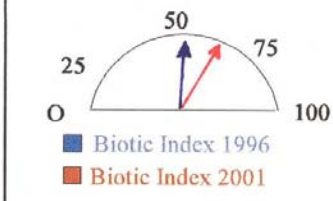

### *Results*

**Both water quality and habitat have improved since 1996, although severe channelization has damaged habitat at one site.**

### *Recommendations*

**Discourage excessive channelization, which tends to negate water quality improvements achieved by BMPs.**

Watershed Gauge
A score of 100 is our goal

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## EXECUTIVE SUMMARY

A rapid bioassessment technique was used to determine the ecological health of the Wolf Creek watershed of Jay County, Indiana. The purpose of the study was to document conditions after implementation of various land treatments coordinated by the Jay County SWCD office. The benthic communities of four sites, including a reference site, were sampled during May and October 2001 to provide information on "after treatment" conditions.

All three study sites in the Wolf Creek watershed had biotic index values less than the reference site (Stoney Creek in Delaware County, which is known to be one of the region's cleanest small streams). The study sites showed "slight" to "moderate" impacts. Impairment was due primarily to degraded habitat, although excessive sediment inputs probably also contribute somewhat.

The aquatic habitat scores had increased slightly at all study sites since a previous study in 1996. However, during the summer of 2001 the upstream site on Wolf Creek was severely channelized and its riparian vegetation completely cut along one bank. The habitat value of this site declined markedly after channelization.

One of the goals of this project was to determine whether best management practices (BMPs) being carried out in the watershed are helping improve water quality. The average biotic index and habitat scores have increased since BMPs have been implemented. This is especially true in upper Wolf Creek, where environmentally sensitive groups such as mayflies and stoneflies are no present.

Recommendations to improve the condition of the Wolf Creek watershed include bank stabilization using vegetative techniques, limiting access to the stream by livestock, restoring trees along streambanks, and continued biological monitoring to gauge the success of the program as it continues to be implemented.

## INTRODUCTION

Wolf Creek is a tributary of Loblolly Creek in the upper Wabash River Basin. The upper Wabash River is listed by the Indiana Department of Environmental Management (IDEM) as having seriously degraded water quality due to nonpoint sources of pollution such as excessive sediment and nutrient inputs from runoff [1]. To deal with this problem, the Soil and Water Conservation District office of Jay County sought and received a grant from the Indiana Department of Natural Resources to develop a soil conservation plan to help reduce nonpoint source problems.

Prior to implementing the plan, the SWCD office decided to conduct a benthic study to document "before treatment" conditions of the aquatic community of Wolf Creek. The study was completed in November 1996 [20]. One site in the watershed was "slightly impacted" while two sites were "moderately impacted," Excessive sediment deposition was probably responsible for most of the biological impairment in Wolf Creek (the number of sediment-intolerant species was very low compared to the reference stream). Loblolly Creek downstream from Wolf Creek was impaired primarily by degraded aquatic habitat.

### Local Setting

Wolf Creek is located in the "Central Corn Belt Plain" ecoregion of the Central U.S. [2]. Figure 1 shows the watershed's location in Indiana. The land in the watershed was molded by glacier activity and is relatively flat. The original forests were dominated by beech, maple, oak, and hickory trees but row crop agriculture and livestock grazing are the most common land uses today. About 95% of the watershed is devoted to agricultural uses. Only about 5% remains forested or as natural wetlands [19]. Figure 2 shows various land uses in the watershed [Indiana Geological Survey maps].

Little water quality information has been collected in this immediate watershed. IDEM classified the upper Wabash River as fully supporting its designated uses for aquatic life but not supporting its recreational uses due to *E. coli* contamination [7].

**Figure 1.**
**Wolf Creek / Loblolly Creek and Stoney Creek Watersheds**

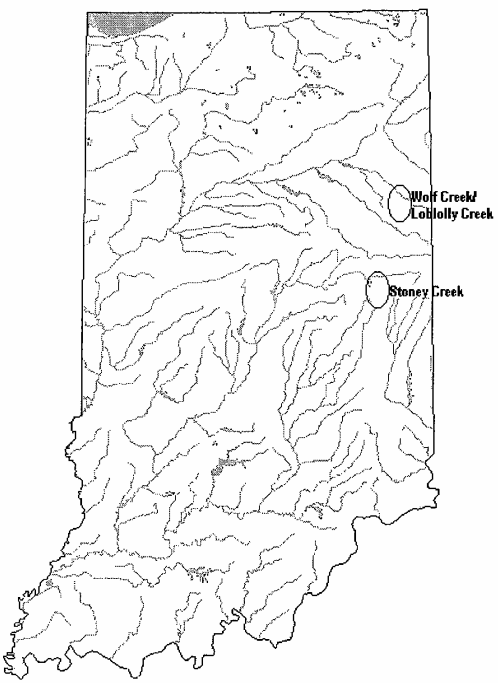
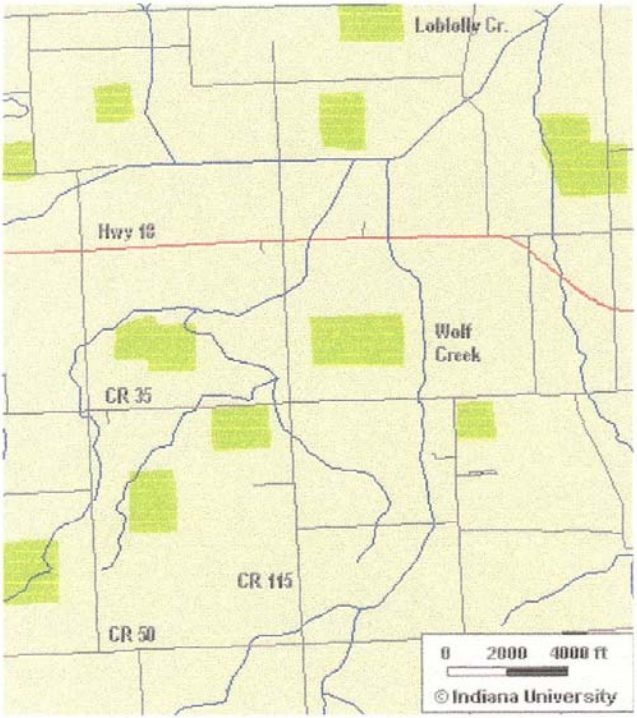
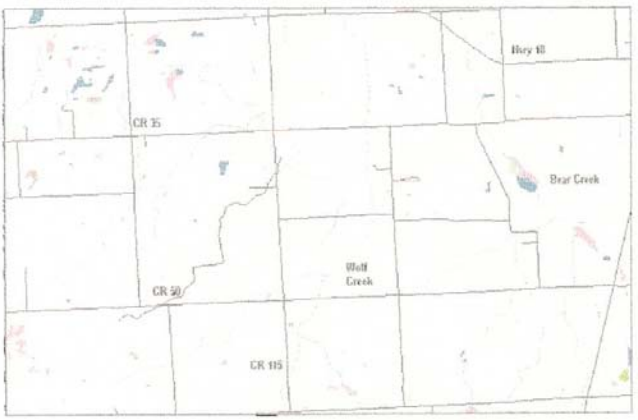


**Figure 2.**
**Land Uses in the Watershed: Green is forested, yellow is agricultural**



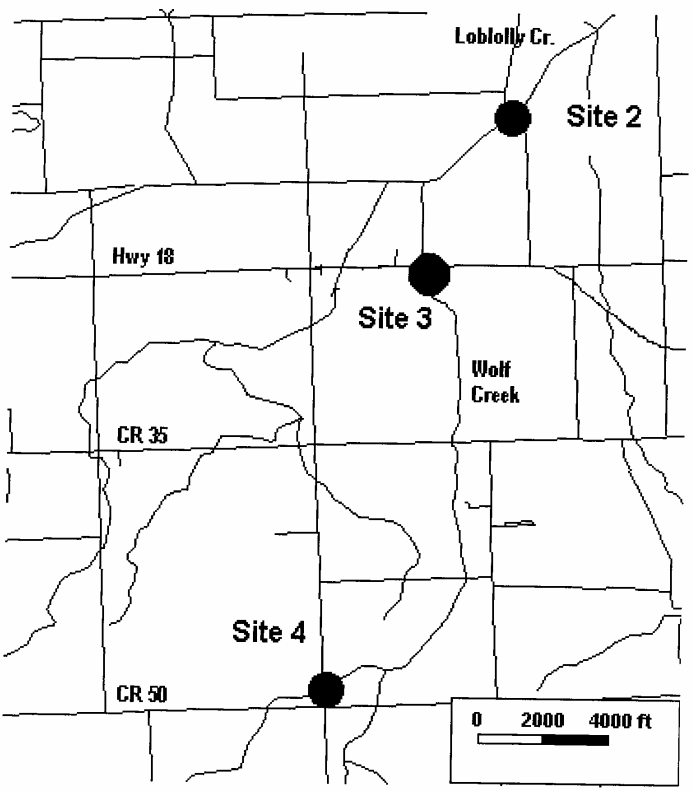

**Wetlands in the Watershed (Pink and Green)**



Four sampling sites (including a reference site) were chosen for study. These were the same sites used in the 1996 study. Watershed areas [18] and their locations are shown below:

| | | Watershed area | Lat. | Long. |
|---|---|---|---|---|
| Site 1 | Stoney Creek @ CR 300S | 60 $km^2$ (24 $mi^2$) | 0652214 | 4442586 |
| Site 2 | Loblolly Creek @ CR 129 E | 85 $km^2$ (34 $mi^2$) | 0668655 | 4491797 |
| Site 3 | Wolf Creek at Highway 18 | 15 $km^2$ (6 $mi^2$) | 0667868 | 4490426 |
| Site 4 | Wolf Creek (West Ditch) @ CR 250 W | 8 $km^2$ (3 $mi^2$) | 0667022 | 4486512 |

Figure 3
Study Sites



## METHODS

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to environmental change [3], benthic (bottom-dwelling) organisms were used to document the biological condition of each stream. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [4] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used EPA's Protocol III to conduct this study. Protocol III requires a standardized collection technique, a standardized subsampling technique, and identification of at least 100 animals from each site to the genus or species level from both "study sites" and a "reference site." CPOM (Coarse Particulate Organic Matter) samples were collected and analyzed to determine the percentage of shredder organisms. The metrics used for analysis were those suggested by EPA [4] and shown in Table 1.

Table 1. U.S. EPA Protocol III Metrics and Scoring System

| Metric | Scoring Criteria | | | |
|---|---|---|---|---|
| | 6 | 4 | 2 | 0 |
| 1. Taxa Richness | >80% | 60-80% | 40-60% | <40% |
| 2. Hilsenhoff Biotic Index ** | >85% | 70-85% | 50-70% | <50% |
| 3. Ratio of Scrapers to Filterers * | >50% | 35-50% | 20-35% | <20% |
| 4. EPT to Chironomid Abundance * | >75% | 50-75% | 25-50% | <25% |
| 5. % of Dominant Taxon | <20% | 20-30% | 30-40% | >40% |
| 6. EPT Index * | >90% | 80-90% | 70-80% | <70% |
| 7. Community Loss Index | <0.5 | 0.5-1.5 | 1.5-4.0 | >4.0 |
| 8. % Shredders in CPOM * | >50% | 35-50% | 20-35% | <20% |

* = reference site score / study site score x 100
** = study site score / reference site score x 100

The maximum score possible is 48. To make the scores comparable to habitat scores, they were nomalized according to the following formula:

Normalized Score = Actual Site Score / Reference Site Score x 100

Impairment Categories

| | |
|---|---|
| >80% of reference score | Nonimpaired |
| 55-80% of reference score | Slightly impaired |
| 20-55% of reference score | Moderately impaired |
| <20% of reference score | Severely impaired |

## Reference Site

The aquatic community of a reference site is compared to that of each study site to determine how much impact has occurred. The reference site should be in the same "ecoregion" as the study sites and be approximately the same size. It should be as pristine as possible, representing the best conditions possible for that area.

Stoney Creek in Randolph County was chosen as the reference site for this study. Its watershed area is similar to those of the study sites on Wolf and Loblolly Creeks. In addition, it is located less than 20 miles south of the study streams and therefore is representative of local conditions. Stoney Creek is know to have excellent aquatic habitat and one of the highest biotic index values for fish and macroinvertebrate communities in east-central Indiana [5, 6]. Therefore, its habitat and water quality are probably among the best available within this area.

## Habitat Analysis

Habitat analysis was conducted according to Ohio EPA methods [21]. In this technique, various characteristics of a stream and its watershed are assigned numeric values. All assigned values are added together to obtain a "Qualitative Habitat Evaluation Index." The highest value possible with this habitat assessment technique is 100. All habitat scores were normalized to the reference by the following formula:

Normalized Score = Actual Site Score / Reference Site Score x 100

## Water Chemistry

Water chemistry measurements were made at each study site on the same day that macroinvertebrate samples were collected. Dissolved oxygen was measured by the membrane electrode method. The pH measurements were made with a Cole-Parmer pH probe. Conductivity was measured with a Hanna Instruments meter. Temperature was measured with a mercury thermometer. All instruments were calibrated in the field prior to measurements.

## Macroinvertebrate Sample Collection

Benthic sampling occurred on May 2 and October 31, 2001. The April sampling period represents stream conditions in spring when crops are being

planted and the stream is most susceptible to erosion. The October sampling period represents a period of lower flow, following a season of more complete vegetative cover in the watershed.

Samples were collected by kicknet from riffle habitat where current speed was 20-30 cm/sec. Riffles were used because they were the most important benthic habitat present at all study sites. The kicknet was placed immediately downstream from the riffle while the sampler used a hand to dislodge all attached benthic organisms from rocks upstream from the net. The organisms were swept by the current into the kicknet and subsequently transferred to a white pan. Each sample was examined in the field to assure that at least 100 organisms were collected at each site. In addition, each site was sampled for organisms in CPOM (coarse particulate organic matter, usually consisting of leaf packs from fast-current areas). All samples were preserved in the field with 70% ethanol.

### Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the whole sample in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified a representative specimen was preserved as a "voucher." All voucher specimens have been deposited in the Purdue University Department of Entomology collection.

## RESULTS

### Quality Assurance

Duplicate samples were collected from Stoney Creek on October 31. Analysis of the duplicates resulted in the following IBI scores for this site:

| | |
|---|---|
| Duplicate 1 Score | 48 |
| Duplicate 2 Score | 46 |
| Mean Score | 47 |

Since the mean of the duplicates was within 10% of either value and the impairment category for both samples was "not impaired," there is good evidence that the bioassessment technique was producing reproducible results capable of making valid judgements about biotic integrity.

## Aquatic Habitat Analysis

When the Ohio EPA habitat scoring technique was used, the following aquatic habitat values were obtained for each site in the study:

| | Score | % of Reference |
|---|---|---|
| Stoney Creek - Reference (Site 1) | 77 | 100 |
| Loblolly Creek (Site 2) | 40 | 52 |
| Wolf Creek - downstream (Site 3) | 63 | 82 |
| Wolf Creek - upstream (Site 4) | 60 (39) | 78 (51) |

The maximum value obtainable by this scoring technique is 100, with higher values indicating better aquatic habitat. Sites with lower habitat values normally have lower biotic index values as well. Details of the habitat scores for each site are shown in the appendix.

The scores indicate that the lowest aquatic habitat value in this study was at site 2 on Loblolly Creek. Habitat at site 2 was hampered by a paucity of stable bottom substrate and instream cover, by a lack of any riparian buffer zone, and by severe channelization. Site 4 on upper Wolf Creek had a great loss of habitat value following a channelization project carried out during the summer of 2001. The habitat scores for the site after channelization are shown in parantheses.

**Table 2. Water Quality Measurements**

**May 2, 2001**

| | D.O. mg/l | pH SU | Cond. uS | Temp. (C) |
|---|---|---|---|---|
| Site 1 (Stoney Creek) Time = 3:25 p.m. | 13.6 | 8.1 | 410 | 20.0 |
| Site 2 (Loblolly Creek) Time = 1:15 p.m. | 10.1 | 7.6 | 550 | 22.0 |
| Site 3 (Lower Wolf Cr.) Time = 12:35 p.m. | 9.3 | 8.0 | 500 | 18.0 |
| Site 4 (Upper Wolf Cr.) Time = 1:55 p.m. | 11.8 | 7.8 | 420 | 19.0 |

**October 31, 2001**

| | D.O. mg/l | pH SU | Cond. uS | Temp. (C) |
|---|---|---|---|---|
| Site 1 (Stoney Creek) Time = 4:45 p.m. | 11.2 | 7.9 | 500 | 14.0 |
| Site 2 (Loblolly Creek) Time = 3:00 p.m. | 11.0 | 7.3 | 500 | 13.5 |
| Site 3 (Lower Wolf Cr.) Time = 2:00 p.m. | 12.2 | 8.0 | 600 | 12.5 |
| Site 4 (Upper Wolf Cr.) Time = 1:00 p.m. | 10.6 | 7.9 | 500 | 11.5 |

D.O. = Dissolved Oxygen
Cond. = Conductivity
Temp. = Temperature in Degrees Centigrade

Table 3. Data Analysis for 5/01 Samples

METRICS

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| # of Genera | 26 | 13 | 13 | 13 |
| Biotic Index | 5.9 | 7.0 | 6.0 | 6.4 |
| Scrapers/Filterers | 1.7 | 2.0 | 0.4 | 0.2 |
| EPT/Chironomids | 0.3 | 0.0 | 1.0 | 0.5 |
| % Dominant Taxon | 12 | 44 | 32 | 28 |
| EPT Index | 6 | 3 | 4 | 4 |
| Community Loss Index | 0.0 | 1.5 | 1.0 | 1.5 |
| % Shredders | 8 | 1 | 9 | 6 |

SCORING

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| # of Genera | 6 | 2 | 2 | 2 |
| Biotic Index | 6 | 2 | 6 | 4 |
| Scrapers/Filterers | 6 | 6 | 2 | 0 |
| EPT/Chironomids | 6 | 0 | 6 | 6 |
| % Dominant Taxon | 6 | 0 | 2 | 4 |
| EPT Index | 6 | 2 | 4 | 4 |
| Community Loss Index | 4 | 4 | 4 | 4 |
| % Shredders | 6 | 0 | 6 | 6 |
| TOTAL | 46 | 16 | 32 | 30 |
| % of Reference | 100 | 35 | 70 | 65 |
| Impairment Category | N | M | S | S |

N = NONE S = SLIGHT M = MODERATE Sv = SEVERE

Table 4. Data Analysis for 10/01 Samples

METRICS

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| # of Genera | 21 | 10 | 12 | 15 |
| Biotic Index | 4.4 | 4.2 | 5.8 | 5.9 |
| Scrapers/Filterers | 2.0 | 4.0 | 1.0 | 0.1 |
| EPT/Chironomids | 4.7 | 2.6 | 31 | 4.3 |
| % Dominant Taxon | 19 | 69 | 28 | 43 |
| EPT Index | 7 | 2 | 6 | 4 |
| Community Loss Index | 0.0 | 1.6 | 1.0 | 0.8 |
| % Shredders | 40 | 75 | 85 | 40 |

SCORING

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| # of Genera | 6 | 2 | 2 | 4 |
| Biotic Index | 6 | 6 | 4 | 4 |
| Scrapers/Filterers | 6 | 6 | 4 | 0 |
| EPT/Chironomids | 6 | 2 | 6 | 6 |
| % Dominant Taxon | 6 | 0 | 4 | 0 |
| EPT Index | 6 | 0 | 6 | 2 |
| Community Loss Index | 6 | 2 | 4 | 4 |
| % Shredders | 6 | 6 | 6 | 6 |
| TOTAL | 48 | 24 | 36 | 26 |
| % of Reference | 100 | 50 | 75 | 54 |
| Impairment Category | N | M | S | M |

N = NONE S = SLIGHT M = MODERATE Sv = SEVERE

## DISCUSSION

Chemical parameters measured at each site indicate that dissolved oxygen (D.O.), pH, temperature, and conductivity fell within acceptable ranges for most forms of aquatic life.

A total of 39 macroinvertebrate genera were collected at the four sites. Relatively pollution-tolerant midge larvae were dominant at all sites, including the reference. However, the benthic community at the reference site was very diverse, with twice as many macroinvertebrate genera represented there as elsewhere.

Tables 3 and 4 show how the aquatic communities at the three study sites compared to that of the reference site. Impacted sites are shown graphically in Figure 4. The stream's impairments ranged from "slight" to "moderate."

Figure 5 shows the normal relationship of biotic index scores to habitat values (a linear relationship according to [4]). The figure also shows a range of plus or minus 10% to account for a certain amount of measurement variability. When biotic index values fall outside this range, the site typically has degraded water quality. Figure 5 indicates that the study sites have biotic values very similar to their habitat values. Therefore, degraded water quality is not extremely important in these watersheds any more. The remaining impairment is probably due primarily to habitat loss.

Summary of Average Aquatic Community Index Scores (Normalized to 100)

| | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| Biotic Index | 100 | 42 | 72 | 65 (54) |
| Habitat Index | 100 | 52 | 82 | 78 (51) |

Changes in the values for site 4 between May and October are shown in parantheses, since this site experienced a drastic decline in habitat values following a channelization project in the summer of 2001.

**Figure 3.**
**Degrees of Biological Impairment in the Wolf Creek Watershed**

**Yellow = Slight Impairment**
**Orange = Moderate Impairment**

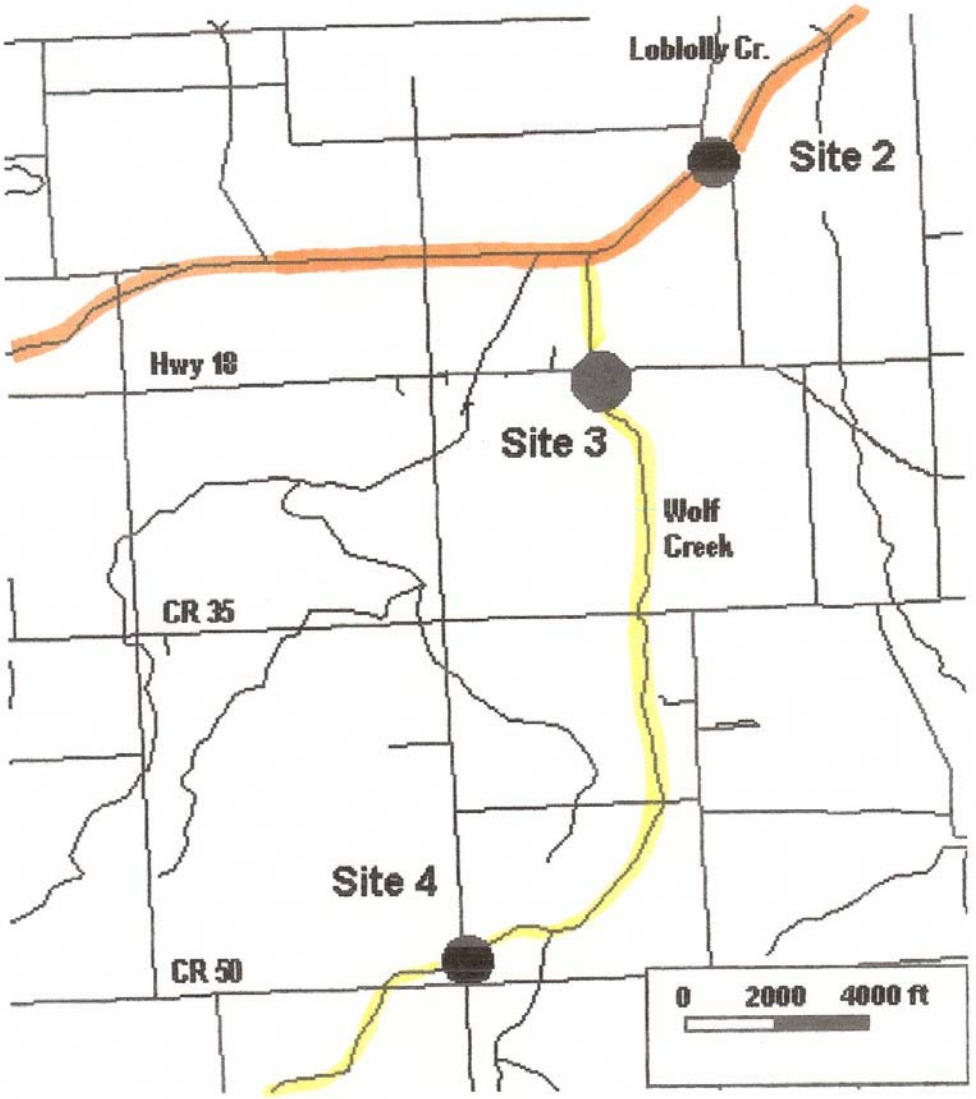


**Figure 5.**

**The normal relationship between habitat and biotic index score is shown below. Sites falling outside the normal relationship (plus or minus 10%) are probably affected by degraded water quality.**

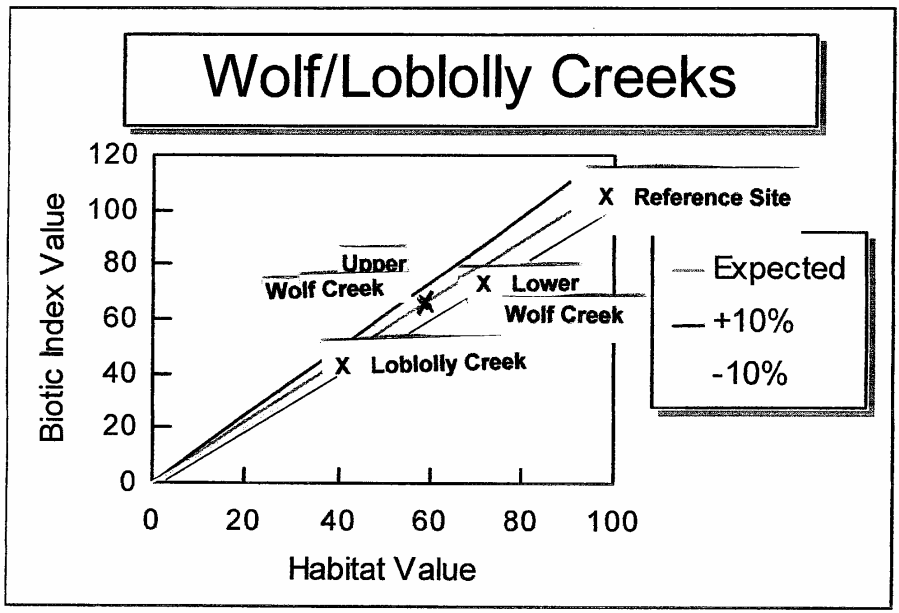


Table 4 shows sediment-tolerance values for many of the commonly collected animals in these streams. The proportion of sediment and turbidity-intolerant forms was higher at the reference site than at any of the study sites. These results indicate that sediment-related impairment still contribute to the water quality problems in the Wolf Creek watershed. This is especially true at site 2, where almost no sediment-intolerant forms of life were found in May during the season of highest potential runoff.

Still have work to do.

Table 4. Sediment-Intolerant Species Observed
(Literature references to the species as an indicator are shown in brackets)

| | |
|---|---|
| *Stenonema vicarium* | [10] [15] |
| *Stenonema femoratum* | [10][15] |
| *Nectopsyche* spp. | [10] |
| *Polycentropus* spp. | [10] |
| Plecoptera | [10] |
| *Hesperoconopa* spp. | [10] |

| | | May | Oct. |
|---|---|---|---|
| % of Sediment-Intolerant Organisms at the Reference | | 12% | 36% |
| % of Sediment-Intolerant Organisms at the Study Sites | | | |
| | Site 2 | 1% | 69% |
| | Site 3 | 9% | 30% |
| | Site 4 | 6% | 27% |

## COMPARISON TO THE 1996 RESULTS

This study was conducted to determine whether there were any significant changes in the ecological health of Wolf Creek since 1996. A comparison of the biotic index values obtained in 1996 and 2001 is shown below:

| | Average 1996 | Average 2001 | Change |
|---|---|---|---|
| Loblolly Creek (Site 2) | 40 | 42 | +2 |
| Lower Wolf Creek (Site 3) | 70 | 73 | +3 |
| Upper Wolf Creek (Site 4) | 53 | 60 | + 7 |

A comparison of the individual site aquatic habitat scores obtained in the two studies is shown below:

| | 1996 | 2001 | Change |
|---|---|---|---|
| Loblolly Creek (Site 2) | 35 | 40 | + 5 |
| Lower Wolf Creek (Site 3) | 58 | 63 | + 5 |
| Upper Wolf Creek (Site 4) | 52 | 60 (39) | + 8 (-13) |

(Values in parantheses are those after channelization)

Before the summer of 2001, all three sites had slight improvements in habitat values. Site 4 lost 13 points of its habitat score following channelization. Despite the change, however, this site still had relatively large improvements in its aquatic community. Some of the indicators in improving conditions in upper Wolf Creek include:

Environmentally sensitive animals
- Stoneflies were present for the first time
- Mayflies were present for the first time

Indicator animals
- Insects intolerant to siltation were present for the first time

Community indicators
- The community was not completely dominated by a single group.

## RECOMMENDATIONS

1. **Work toward continued protection of the vegetative buffer zone along the stream corridors. Tree plantings along streams should be encouraged to provide shade, especially on Loblolly Creek.**

2. **Discourage channelization of the streams. Minimizing channelization allows the streams to retain a natural channel that enhances aquatic habitat.**

3. **Discourage direct access to the streams by livestock. Large numbers of livestock can trample stream banks, decreasing the ability of streamside vegetation to filter out pollutants and hastening erosion.**

4. **Monitor the watershed every three to five years to determine whether conditions continue to improve.**

5. **Continue to encourage volunteer monitoring in the watershed. Such programs provide invaluable educational opportunities and give participants a sense of ownership in the water quality improvements observed over the years.**

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## Appendix A.
## Rapid Bioassessment Results - Wolf Creek Watershed
## May 2001

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Chironomidae (Midges) | | | | |
| Cricotopus trifascia | 4 | | 3 | |
| C. sylvestris | 4 | 3 | | |
| C. tremulus | | | | 4 |
| C. bicinctus | | 3 | | |
| Orthocladius obumbratus | 12 | 44 | 15 | 28 |
| O. annectens | | 6 | | |
| Euorthocladius spp. | | | | 4 |
| Parametriocnemus lundbecki | 4 | 12 | | |
| Eukiefferiella potthasti | | 3 | 1 | 8 |
| E. discoloripes | | 6 | | 2 |
| E. pseudomontana | | | 1 | |
| Parakiefferiella spp. | | 3 | | |
| Psectrocladius psilopterus | 4 | | | |
| Polypedilum convictum | 10 | | 4 | |
| Dicrotendipes nervous | 4 | | | |
| Chironomus riparius | 2 | | | |
| Cryptochironomus spp. | 2 | | | |
| Stenochironomus spp. | | 3 | | |
| Thienemannimyia gr. | 2 | | | |
| Ablabesmyia sp. | | 9 | 3 | 2 |
| Sympothastia sp. | 2 | | 2 | 4 |
| Simuliidae (Blackflies) | 9 | 1 | 32 | 19 |
| Ceratopogonidae (Biting Midges) | 1 | | | |
| Tipulidae (Craneflies) | | | | |
| Hesperoconopa spp. | 3 | | | |
| Ephemeroptera (Mayflies) | | | | |
| Stenonema femoratum | | | 6 | |
| S. vicarum | 4 | | | |
| Stenacron interpunctatum | | | | 1 |
| Baetis brunneicolor | 1 | | | |
| B. flavistriga | | | 5 | |
| Caenis latipennis | | 2 | | |
| Trichoptera (Caddisflies) | | | | |
| Cheumatopsyche spp. | 2 | 2 | 8 | 17 |
| Hydropsyche betteni | 1 | | | |
| Polycentropus sp. | | | | 1 |
| Nectopsyche spp. | 4 | | | |

Rapid Bioassessment Results - Wolf Creek Watershed
May 2001

| | Site # 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Plecoptera (Stoneflies) | | | | |
| Isoperla decepta | 2 | 1 | 9 | 6 |
| Perlesta placida | 1 | | | |
| Alloperla spp. | 2 | | | |
| Odonata (Dragonflies) | | | | |
| Ischnura spp. | | 1 | | |
| Coleoptera (Beetles) | | | | |
| Stenelmis crenata | 8 | | 3 | 2 |
| Stenelmis larvae | 6 | | 5 | |
| Dubiraphia larvae | 1 | 1 | | |
| Macronychus glabratus | 1 | | | |
| Agabus spp. | | | | 2 |
| Dystiscus sp. | | | | |
| Decapoda (Crayfish) | | | | |
| Orconectes sp. | | | 3 | |
| Pelecypoda (Clams) | | | | |
| Pisidium spp. | 3 | | | |
| Turbellaria (Flatworms) | | | | |
| Oligochaeta (Worms) | | | | |
| Tubificidae | 1 | | | |
| Total | 100 | 100 | 100 | 100 |

## Rapid Bioassessment Results - Wolf Creek Watershed
## October, 2001

| | Site # 1 | 2 | 3 | 4 | 1-dupl |
|---|---|---|---|---|---|
| Chironomidae (Midges) | | | | | |
| Brillia flavifrons | 2 | | | | |
| Cricotopus tremulus | | 2 | | | |
| Orthocladius obumbratus | 4 | 10 | | 6 | 1 |
| Euorthocladius spp. | 1 | | | | |
| Zalutschia spp. | | 11 | | | |
| Cardiocladius spp. | | 1 | | | |
| Stictochironomus spp. | | | 1 | | |
| Microtendipes caelum | | | 1 | | |
| Paratanytarsus sp. | 2 | 1 | 1 | 3 | 2 |
| Ablabesmyia sp. | 1 | 2 | | 2 | 1 |
| Simuliidae (Blackflies) | | | | 8 | |
| Tipulidae (Craneflies) | | | | | |
| Tipula spp. | 1 | | | 4 | 1 |
| Antocha spp. | 1 | | | | |
| Hesperoconopa spp. | 2 | | | 3 | 3 |
| Ephemeroptera (Mayflies) | | | | | |
| Stenonema femoratum | | 2 | 31 | 2 | |
| S. vicarum | 6 | | | | 6 |
| Stenacron interpunctatum | 2 | | 1 | | 1 |
| Isonychia spp. | 1 | | | | 2 |
| Paraleptophlebia spp. | | | | | 1 |
| Caenis hilaris | 1 | | 4 | | 2 |
| Trichoptera (Caddisflies) | | | | | |
| Cheumatopsyche spp. | 13 | | 28 | 43 | 8 |
| Hydropsyche betteni | | | | | 2 |
| Ceratopsyche bifida | 5 | | 1 | 2 | 8 |
| Polycentropus sp. | | | | | 1 |
| Ptilostomis sp. | | | | 1 | |
| Cyrnellus fraternus | | | | | 2 |
| Plecoptera (Stoneflies) | | | | | |
| Allocapnia vivipara | 19 | 69 | 28 | 18 | 10 |

Rapid Bioassessment Results - Wolf Creek Watershed
October,2001

| | Site # 1 | 2 | 3 | 4 | 1-dupl |
|---|---|---|---|---|---|
| Coleoptera (Beetles) | | | | | |
| Stenelmis crenata | 4 | | | | 7 |
| S. humerus | 3 | | | | 4 |
| Stenelmis larvae | 10 | | 1 | | 24 |
| Dubiraphia vittata | 1 | | | | |
| Dubiraphia larvae | 1 | | | | 1 |
| Berosus spp. | | 1 | | 2 | |
| Dystiscus sp. | | 1 | | | |
| Psephenus herricki | 14 | | | | 6 |
| Decapoda (Crayfish) | | | | | |
| Orconectes sp. | | | 1 | | |
| Amphipoda (Sideswimmers) | | | | | |
| Hyalella azteca | | | | | 1 |
| Isopoda (Aquatic sowbugs) | | | | | |
| Lirceus spp. | | | | 3 | |
| Pelecypoda (Clams) | | | | | |
| Sphaerium spp. | 2 | | 2 | | 2 |
| Gastropoda (Snails) | | | | | |
| Helisoma spp. | | | | 1 | |
| Elimia livescens | 3 | | | | 3 |
| Physella gyrina | 1 | | | | 1 |
| Ferrissia spp. | | | | | |
| Hirudinea (Leeches) | | | | 2 | |
| Total | 100 | 100 | 100 | 100 | 100 |

## Appendix B. Habitat Scoring Results

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 4 after channelization |
|---|---|---|---|---|---|
| SUBSTRATE | 10 | 5 | 12 | 10 | 10 |
| COVER | 10 | 2 | 10 | 9 | 1 |
| CHANNEL | 12 | 7 | 8 | 9 | 4 |
| RIPARIAN | 12 | 7 | 8 | 10 | 7 |
| POOL/RIFFLE | 14 | 3 | 10 | 9 | 4 |
| GRADIENT | 10 | 6 | 8 | 8 | 8 |
| DRAINAGE AREA | 9 | 10 | 7 | 5 | 5 |
| TOTAL | 77 | 40 | 63 | 60 | 39 |

## Appendix C. COMMONWEALTH BIOMONITORING
## Macroinvertebrate Identification Literature


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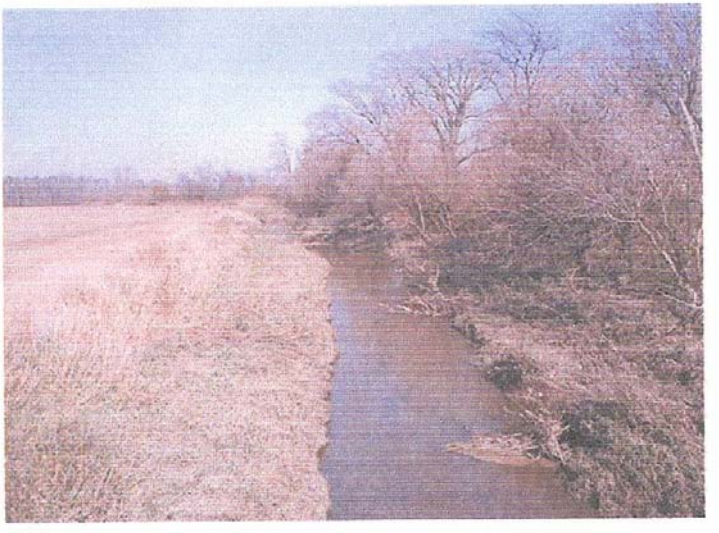
# Study Sites on October 31, 2001

Site 1
Upper Wolf Creek

Recent Channel Modifications

Site 2
Lower Wolf Creek



Site 3
Loblolly Creek

Site 4 - Reference Site
Stoney Creek

Upstream Wolf Creek - May 2001

Upstream Wolf Creek - October 2001