12-1998

Water quality and ecological impacts of watering cattle adjacent to a small middle Tennessee stream

Jeffrey Russell Powell

To the Graduate Council:

I am submitting herewith a thesis written by Jeffrey Russell Powell entitled "Water quality and ecological impacts of watering cattle adjacent to a small middle Tennessee stream." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biosystems Engineering Technology.

Daniel C. Yoder, Major Professor

We have read this thesis and recommend its acceptance:

Ron Yoder, Larry Wilson, Robert Burns

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

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Accepted for the Council:

Associate Vice Chancellor and Dean of The Graduate School

Water Quality and Ecological Impacts of Watering Cattle Adjacent to a Small Middle Tennessee Stream

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Jeffrey Russell Powell

December 1998

To:
My wife and daughter
Amy and Sarah
and
my parents
Russell and Barbara Powell

ACKNOWLEDGMENTS

The author wishes to express his sincere gratitude and appreciation to the following:

To Dr. Roland Mote and the Department of Agricultural and Biosystems Engineering for granting me the opportunity to pursue such an enjoyable project and providing me with the resources needed to complete it.

To my major professor Dr. Daniel Yoder for his guidance and patience throughout this project. His leadership, advice, and friendship were invaluable.

To my graduate committee Dr. Ron Yoder, Dr. Larry Wilson, and Dr. Robert Burns for their time and comments while reviewing the manuscript.

To Richard Roy for his endless efforts, enthusiasm, and friendship in all aspects of this project.

To my fellow graduate students and faculty members Dr. Mike Buschermohle, John Buchanan, Cole Reagan, Page Barker, Teffany Rich, and Michael Palmer for their assistance, friendship, and sincere interest in this project.

To Dr. Arnold Saxton for sharing his time and expertise in the statistical analysis.

To the Middle Tennessee Agricultural Experiment Station, the Tennessee Department of Agriculture, the USDA-Natural Resource Conservation Service, and the U.S. Geological Survey for their financial and technical support.

To my fellow coworkers at the U.S. Geological Survey (Steve Ahlstedt, Rick Treece, Paul Hampson, Dr. Brenda Rashleigh, Andy Hickey, Dr. Joe Connell, Greg Johnson, and Jim Lewis) for their valued advice, expertise, support, and friendship over the last two years.

To Michael Woodside and Scott Gain (U.S. Geological Survey) for giving me the much appreciated incentive to complete this project.

To Dave Tomljanovich (Tennessee Valley Authority) for his friendship, confidence, and encouragement to continue my education.

To Dr. D. A. Etnier (University of Tennessee), Charlie Saylor (Tennessee Valley Authority) and Wendell Pennington (Pennington and Associates, Inc.) for their expertise, generosity, and advice while reviewing my biological data.

To Kenny Gardner, for his support and encouragement to attend graduate school.

To my father-in-law, Dr. Jim Blankenship, for his genuine enthusiasm and support of my work, and my mother-in-law, Mae Blankenship, for her love and support.

To my parents Russell and Barbara Powell for their love, support, faith, and encouragement in the pursuit of my dreams. I am eternally grateful for the foundation of sound values and ethics they have given me.

To my wonderful wife Amy for her unconditional love and support through my academic endeavors. Her encouragement, companionship, patience, and confidence are more than I'll ever deserve, and to the newest member of our family, my precious little Sarah, for showing me what life is truly about.

Most of all, I thank my Lord for surrounding me with such wonderful people and without Whom this would not have been possible.

ABSTRACT

A water quality project comparing three different cattle watering techniques was conducted on a small Middle Tennessee stream. The treatment areas were located on the same stream in sequential downstream order and were: (1) where cattle had "no access" and were given an alternative water source, (2) where cattle had access in an "improved" area, and (3) where cattle had "free access." Little quantifiable evidence exists on the cumulative effects of watering cattle in small perennial streams. This study provides farmers and other land managers with comprehensive water quality and biological data as it relates to cattle stream access and information relating the feasibility and practicality of installing and maintaining two Best Management Practice (BMP) watering techniques (an alternative water source and a limited access stream crossing).

Water quality data were collected intensively on a seasonal basis and storm data on a storm-event basis. Six intensive and three storm samples were collected between the fall of 1996 and the spring of 1998. Both mass and mass addition rates were calculated for each constituent (nitrate, ammonia, TOC, BOD, total solids, and fecal coliform bacteria) at each treatment area during each intensive sampling session. Total solids concentrations were measured during each storm event. Biological assessments (fish and aquatic macroinvertebrates) were conducted once during the study (fish in spring 1996 and macroinvertebrates in spring 1997). Differences in the macroinvertebrate community were documented between treatment areas. Fish were only sampled below the study area because of the limited sampling distance between treatment areas. Benthic and Fishery

Indices of Biotic Integrity (IBI) were used to evaluate the responses in both groups of organisms.

Results showed statistically significant differences (α=0.05) in nitrate, ammonia, and fecal coliform bacteria levels where cattle had free access to the stream. In areas where cattle were completely restricted or had limited access to the stream, significant differences were only detected for nitrate, when compared to the Control. Storm samples showed increases in total solids concentrations at all treatment areas during significant events. Benthic IBI scores indicated minimal change in the stream's biotic health as cattle access increased. Stream classifications ranged from severely impaired ("no cows") to severely/moderately impaired ("limited access" and "free access"). The Fishery IBI classified the stream as FAIR, signifying that the integrity of the stream, downstream of the cattle accessed areas, had not been severely impacted.

Research indicated that statistically significant differences in water quality can be achieved by restricting and/or limiting cattle access to streams; however, significant differences were not detected between the two different watering BMP's. Differences in the biotic integrity of the stream were probably the result of starting with a nutrient-poor, spring-fed stream. The ecological balance (benthic macroinvertebrates) within the stream was not severely impacted by increasing cattle access. In future studies, we recommend that the validity of installing similar BMP's be conducted on an individual basis because of inherent differences in stream size, geology, soils, distribution of target organisms, grazing densities, and other physiographic differences.

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CHAPTER I

INTRODUCTION

"*Rivers are the gutters down which flow the ruins of continents*," Leopold et al. (1964).

The potential impacts of watering and grazing cattle along streams have received considerable attention in recent years. Traditionally, cattle have been allowed free access to graze and water along streams because of the shade provided by streamside vegetation and the free source of water, but as cattle access and grazing intensities increase, the potential for cattle-induced stream degradation also increases. Concerns include damage to stream aesthetics, water quality degradation, declines in aquatic biodiversity, and cattle health/productivity. These concerns have prompted regulatory and other scientific agencies to seek alternative approaches to minimize cattle-induced impacts and protect stream water quality.

Cattle can have potential impacts on the physical, chemical, and biological conditions of streams. The most notable physical impact is that of soil erosion in the streambank region (Owens et al., 1996). Streambanks tend to prematurely erode under the intensive impact of cattle trampling, allowing sediment to be easily washed into the stream and deposited on the stream bottom. These depositional areas can alter the stream's natural morphology and damage sensitive habitat for fish and other aquatic organisms (Bohn, 1986).

In the terrestrial environment, soil erosion is the primary factor governing the transport of pollutants to streams (Robbins, 1979). Cattle trampling affects soil physical properties, which can cause decreased infiltration rates, and therefore increase surface runoff. Pollutant levels in streams tend to increase as eroded soils are washed into the stream during surface runoff. Pollutant transport is also accelerated by the removal of streamside vegetation and riparian zones. Streamside vegetation helps to stabilize streambanks, and riparian zones function as a filter collecting excess pollutants before they are discharged into the stream.

Other specific impacts of cattle access may include increased nutrient loading and bacterial contamination (Owens et al., 1983; Miner et al., 1992). Nutrient and bacterial impacts primarily occur when cattle defecate or urinate directly into the water, but nutrients and bacterial matter deposited on streambanks and adjacent pastureland can also reach streams during periods of surface runoff (Miner et al., 1992). As excess nutrients (nitrogen and phosphorus) enter the system, undesirable algal blooms tend to develop. Over time, these algal blooms can strip nutrients from the water, decrease dissolved oxygen levels, and degrade overall water quality.

To minimize cattle-induced water quality degradation, management techniques have been developed in recent years to restrict the degree of access cattle to streams. These techniques, or Best Management Practices (BMP's), were designed to minimize stream degradation by reducing the cumulative effects of cattle access. BMP's include streambank fencing, alternative water sources, and limited access stream crossings. Although BMP's are sometimes touted as a panacea for stream improvement, only limited work has been done to actually measure improvements in water quality and to document stream recovery. The initial assumption is that stream conditions will improve following

BMP installation. To accurately assess the cumulative impacts induced by cattle, future research must consider the interactions of biological, physical, and chemical environments as a system.

The primary focus of this study was to determine if BMP's could improve a stream's overall condition. The first specific study objective was to install two different cattle watering BMP's. The second objective was to monitor water quality and biological conditions following BMP installation. The final objective was to determine if BMP's could reduce streambank erosion and sediment yields during storm events. The results of this study provide farmers and other resource managers with a basic understanding of how water quality and biological organisms respond to BMP's in a small perennial stream.

CHAPTER 2

BACKGROUND

Cattle congregate along streams for a number of reasons. The main reasons are the availability of water and shade, and the quality and variety of vegetation. Harris and Van Horn (1992) estimated that approximately 40 percent of the cattle in the United States are watered directly from streams, lakes, and rivers. Since over 40 percent of the land mass of the U.S. is grazed by cattle, this presents an increased potential for degradation to our streams and water supplies (Robbins, 1979). Not only does water quality and aquatic biodiversity suffer, but the possibility also exists for cattle contracting a water borne illness. Therefore, better management techniques are needed to assess and correct the potential environmental impacts imposed by cattle.

Streams are complex and dynamic systems consisting of chemical, physical, and biological interactions. To understand how streams function and respond to cattle-induced perturbations, investigators must consider all of these interactions holistically. This chapter is intended to identify and provide background information on the consequences of allowing cattle access to small perennial streams. More specifically, it will discuss the varied impacts cattle can have on bacterial and nutrient levels, streambank erosion, and biological degradation. Best Management Practices (BMP's) will also be discussed as an alternative management technique to possibly reduce cattle-induced impacts.

The impact of water quality on animal health may also be a concern of farmers and other land managers, although a detailed analysis of this effect is beyond the scope of this study. A brief discussion regarding animal health as it relates to water supply quality is provided at the end of this chapter.

Cattle Impacts

Bacteriological Impacts

The most common cattle-related water quality pollutant in streams, and often the only pollutant that can be positively discerned, is an increased level of fecal bacteria (Robbins, 1979). Bacteria found in cattle wastes can be easily transferred to humans through flowing waters. The possibility of contracting a bacterial-related illness is greatly enhanced as people consume and recreate in waters that have had contact with fecal matter (Paulson et al., 1993). Although most fecal bacteria are not considered to be pathogenic, they are commonly used to indicate the possible presence of pathogens. Bacterial indicators are typically the most sensitive index of cattle-induced water quality degradation (Robbins, 1979). These organisms are used by most regulatory agencies to designate the bacteriological safety of potable water because the presence of fecal bacteria indicates contact of the water with fecal matter.

The primary source of cattle fecal matter in streams occurs from direct defecation into the water. Fecal bacteria can also reach streams from streambanks and adjacent pastureland during rainfall runoff and streambank flushing as stream discharge increases. However, Miner et al. (1992) stated that 99 percent of the time the water quality of streams adjacent to cattle grazed pastures are more influenced by direct defecation than by overland runoff. This varies considerably depending on the frequency and intensity of runoff events. Although fecal bacteria can survive outside the intestinal tract for several months, Robbins (1979) suggested that bacterial loads reaching streams is not dependent on the amount of wastes produced and deposited on pastures, but instead depends on hydrogeological and stream management factors.

When fecal matter is deposited into streams it either settles to the bottom or remains suspended in the water column (Biskie et al., 1988). Miner et al. (1992) suggested that more than 95 percent of bacterial organisms directly deposited in streams settle to the bottom and die within several weeks. The survival rate of bacteria in stream substrates is highly dependent on the chemical and physical characteristics of the water, primarily water temperature, with warmer water prolonging survival (Davenport et al., 1976). Sherer et al. (1992) suggested that bacteria can survive and even grow in stream substrates. LaBelle et al. (1980) discovered that the number of viruses in estuarine sediments had a positive correlation to the number of fecal coliforms in the sediments, but that the same correlation did not hold true in overlying waters. This was also supported by Niemi and Niemi (1991), who found that bacterial levels in ponds were considerably lower than those in running waters. They suggested that the detention time aids in settling and the eventual decay of bacteria.

It appears from most of the literature that bacterial levels can be controlled in streams by implementing sound streamside management practices (Winegar, 1977; Thelin and Gifford, 1983; Tiedemann et al., 1988). By totally restricting cattle from entering streams, direct defecation and streambank deposition will be eliminated. Allowing streamside vegetation to naturally revegetate along streambanks and adjacent areas means that the likelihood of accelerated erosion and fecal matter transport will be reduced. Another advantage of maintaining healthy streamside vegetation is minimizing water temperature increases due to direct solar radiation, which also reduces bacterial survival rates.

Nutrient Impacts

The two most common nutrients in streams are nitrogen and phosphorous. Excess nitrogen on pastureland is highly mobile and is easily transported to streams during periods of rainfall, whereas phosphorus is not as mobile. Phosphorus adheres tightly to soil particles and is therefore less likely to reach streams via surface runoff, unless soils are eroded. Excess concentrations of nutrients can produce excessive algal blooms. As these algal blooms die, dissolved oxygen can be stripped from the water, making it difficult for fish and other aquatic organisms to survive.

Very little conclusive evidence was found in the literature to suggest that watering cattle in streams is a direct cause of nutrient contamination in these streams. Doran et al. (1981) conducted studies to measure the chemical characteristics of runoff from a seasonally-grazed cow-calf operation. Results were inconclusive in relating runoff nutrient levels directly to the influence of cattle. Their conclusions suggested that nutrient levels were influenced as much by ground cover and wildlife activity as by cattle grazing. In Ohio, Owens et al. (1989) measured nutrient levels from pasture runoff in three different grazing schemes (2 years with no cattle, 3 years grazing during the summer only, and 6 years of year-round grazing). They detected low nutrient concentrations from all three schemes and their results showed no consistent seasonal variation. Levels of nitrate-nitrogen (NO_3-N) and phosphorus (P) were similar to or lower than levels in runoff from a similar ungrazed woodland watershed.

Streambank and Riparian Zone Instability

Cattle can have detrimental impacts on the stability and aesthetic quality of streambanks. As cattle trample streambanks and adjacent areas, the stresses applied to the soil beneath their hooves often exceed the strength of the soil. As a result, the soil is compacted, infiltration rates are decreased, streambanks collapse, and bare soils become highly vulnerable to erosion by wind and rain. Unstable banks also lead to accelerated channel erosion and higher instream sediment loads (Winegar, 1977), while the subsequent removal of streamside vegetation can increase sediment production from rainfall runoff (Owens et al., 1996).

Sediment from failing streambanks and damaged pastureland is both a pollutant and a carrier of pollutants. Robbins (1979) stated that the factors which govern erosion and sediment yields are the same factors that control pollutant loads in cattle impacted streams. As soil erodes, most pollutants adhere tightly to the detached aggregates, creating an easy means of transportation to the stream. Although the changes may be subtle and cumulative over many years, they can be recognized by increased stream temperatures, alteration of the channel morphology, and losses of suitable habitat for fish and other aquatic organisms (Bohn and Buckhouse, 1986).

Increased cattle stocking rates and the degree of stream accessibility are key factors, but are not the only ones contributing to bank erosion. Marlow et al. (1987) found that streambank failure was more a function of grazing season than of the degree of cattle use. They found that the greatest changes in stream channel profile occurred during the wetter months when high stream flows were accompanied by high streambank moisture levels. Because of the high moisture levels, streambanks were easily deformed by cattle trampling and were therefore more susceptible to erosion.

Cattle-induced erosion can also have significant impacts on pasture loss. For example, Bohn and Buckhouse (1986) compared streambank retreat (i.e., soil/pasture loss) in four grazing strategies (season-long, four-pasture rest rotation, two-pasture deferred rotation, and no-grazing). The amount (distance) of bank retreat was measured from reference points located a known distance from the bank. Results indicated that bank retreat was always lower in ungrazed areas than in grazed areas.

Streamside vegetation and riparian zones can minimize erosion by providing a buffer strip between the stream and the terrestrial environment, filtering detached sediment, anchoring soil particles, and decreasing the velocity of runoff water. Eliminating cattle access to streams seems to be the most logical way of avoiding the potential impacts mentioned previously. If cattle are restricted from entering stream areas, native grasses can revegetate the shoreline, creating a natural method of erosion control. As woody vegetation succeeds grasses, water temperature increases can be minimized and suitable habitat for aquatic organisms can be reestablished.

Monitoring Biological Degradation

Sediment originating from streambank failure is typically the most noted cattle-induced impact affecting biotic communities (Kauffman and Krueger, 1984; Bohn, 1986). Because most fish species are “sight feeders”, suspended sediment in the stream makes it difficult for fish to feed. Sediment also smothers spawning habitats as it is deposited on the stream bottom. As streambanks degrade, the angle of the bank also influences the success of aquatic organisms. Bank profiles affect water temperature, flow velocity, sediment input, and suitable habitat for fish and aquatic invertebrates (Bohn, 1986). The impact of streambank erosion on biological communities has been well documented, but there is still a lack of quantitative data in the literature relating the cumulative effects of cattle grazing/watering directly to biological degradation. The remainder of this section focuses on the importance of using biological indicators as one component of assessing stream health.

The indigenous fauna in a stream can be seen to function as a continuous monitor of environmental conditions. Because substances often enter and exit a system without being detected by sampling, fish and benthic macroinvertebrates provide a living indication of both the present and past condition of a system. Chemical and physical measurements merely provide an instantaneous condition of the waterbody. As a result, we often fail to consider the ability of our waters to support biotic assemblages at acceptable levels (Karr et al., 1986). Assessments using fish and aquatic insects have a long history; however, most only address one form of degradation (e.g., organic enrichment or heavy metals). Comprehensive multimetric indices have been developed in recent years to assess the overall integrity of surface waters (Kerans and Karr, 1994).

The Index of Biotic Integrity (IBI) was a method developed by Karr et al. (1986) to evaluate the biological condition of small watersheds in the Midwest by examining fish communities. The IBI has recently been modified for use with other organisms (e.g., aquatic macroinvertebrates) in various geographic and ecological regions (Barbour et al. 1997). The IBI consists of a series of metrics that attempt to quantify a diversity of environmental conditions and to produce a single biological index score representative of stream conditions. This makes information more easily and rapidly interpretable than does a list of statistical values.

The term "biotic integrity" was first described by Karr and Dudley (1981), as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a specific composition, diversity, and functional organization comparable to that of the natural habitats within a region." Waters that maintain biotic integrity have the ability to rapidly recover and rebound from most disturbances (Karr et al., 1986). Systems lack biotic integrity because their ability to recover has been stressed nearly to, or beyond, the limit where repair is possible. A system is considered to have integrity when its condition is stable, its capacity for self-repair when disturbed is preserved, and it has minimal need for outside management (Karr et al., 1986).

Biological monitoring has long been a useful tool in assessing water quality because of its sensitivity to low-level perturbations and its function as a continuous monitor (Berkman et al., 1986). Both fish and aquatic insects have been successfully used as indicators of stream health. Invertebrate communities are often used because of their sensitivity to localized disturbances based on their limited mobility, their ability to integrate the effects of short-term environmental stresses, and their ability to be quantitatively sampled (Barbour et al., 1997). A disadvantage of this method is the laboratory time required for sorting and identifying specimens. Fish are good indicators of long-term perturbations because they are long-lived and mobile, they reproduce once per year so the success of each year class is dependent upon environmental conditions, and they reflect the overall condition of the watershed (Barbour et al., 1997). Fish are commonly used, rather than invertebrates, because fish can be more easily sampled and identified.

Best Management Practices (BMP's)

It has been traditionally accepted that farmers have the right to allow their cattle to "freely" water and graze along streams. However, it becomes a landowner's legal responsibility to maintain acceptable water quality levels for neighbors downstream. This issue has forced regulatory and other scientific agencies into designing alternative watering strategies. The primary goal is to provide farmers with cost-effective watering alternatives that maintain healthy/productive herds and at the same time maintain acceptable water quality standards.

One alternative is the installation of BMP's. BMP's might include fencing cattle out of the stream and providing an alternative source of water, or constructing a limited-access cattle crossing. BMP's may be a viable option to unrestricted stream access, but few studies have been conducted to determine if BMP's actually improve water quality. Limited improvement has been documented in several studies (Platts and Nelson, 1985; Owens et al., 1996). Owens et al. (1996) found that daily soil loss was reduced by 40 percent and that storm-related soil loss was reduced by 60 percent following the addition of streambank fencing. Platts and Nelson (1985) stated that riparian and instream fishery habitat can be rehabilitated by restricting cattle access to streams and allowing vegetation to naturally revegetate the streambank areas.

More scientifically based information is needed to assess the cumulative impacts of cattle on water quality. Studies should be conducted on a case by case basis to determine if BMP's can sufficiently reduce the mentioned impacts.

Livestock Health

Farmers spend millions of dollars annually on the prevention and treatment of various bovine diseases. Water supply quality is one of the basic elements in preventing disease in cattle. The importance of providing a safe and clean water supply is critical to maintaining a healthy and productive cattle herd. Water supply concerns include impaired animal performance, the spread of disease, and the safety of animal products for human consumption.

Common water-related illnesses include nitrate toxicity and bacterial infections. Nitrate toxicity is rarely caused by water alone. It is often the result of combining high nitrate feed with water having high concentrations of nitrate. Nitrate itself is not very toxic, but it becomes toxic when it is converted to nitrite in the rumen of cattle. Nitrite that enters the bloodstream reacts with the oxygen-carrying capacity of the blood (hemoglobin) to form methemoglobin, which is unable to transport oxygen. If methemoglobin levels are too high the animal will show signs of shortness of breath, frothing at the mouth, rapid heartbeat, abdominal pain, discolored blood, and a bluish-colored muzzle. In younger animals and human infants, this condition is called methaemoglobinaemia ("blue-baby" syndrome).

Bacterial infections rarely affect adult livestock. Adult livestock can consume bacterial infested water for extended periods of time, but younger animals are more vulnerable to bacterial associated infections (Hairston and Stribling, 1995). Water in ponds, streams, and watering troughs are often implicated as sources of hazardous bacteria, such as leptospira and salmonella. Maintaining a clean and safe water supply will reduce the probability of cattle contracting an infection related to these bacteria.

Although beyond the scope of this study, water quality supply for cattle should be a concern of all cattle production facilities. On rare occasions, water may be the source of health problems in cattle (Meyer, 1990). The steps required to maintain a clean water supply are not difficult to execute. Proper precautions should be taken to maintain clean watering troughs, feeding areas, and most importantly, the quality of water in streams downstream of cattle accessed areas.

Research Questions

If watering BMP's are to be justifiable alternatives to unrestricted stream access, more information needs to be provided. The present gaps in knowledge and understanding of cattle-induced impacts on steam conditions require extensive research in a variety of areas. Future research on the cumulative effects of cattle-induced perturbations must consider the interactions and responses of biological, physical, and chemical environments as a system. This study is intended to provide relative information on the installation of and potential improvements resulting from two cattle watering BMP's.

CHAPTER 3

PROCEDURES

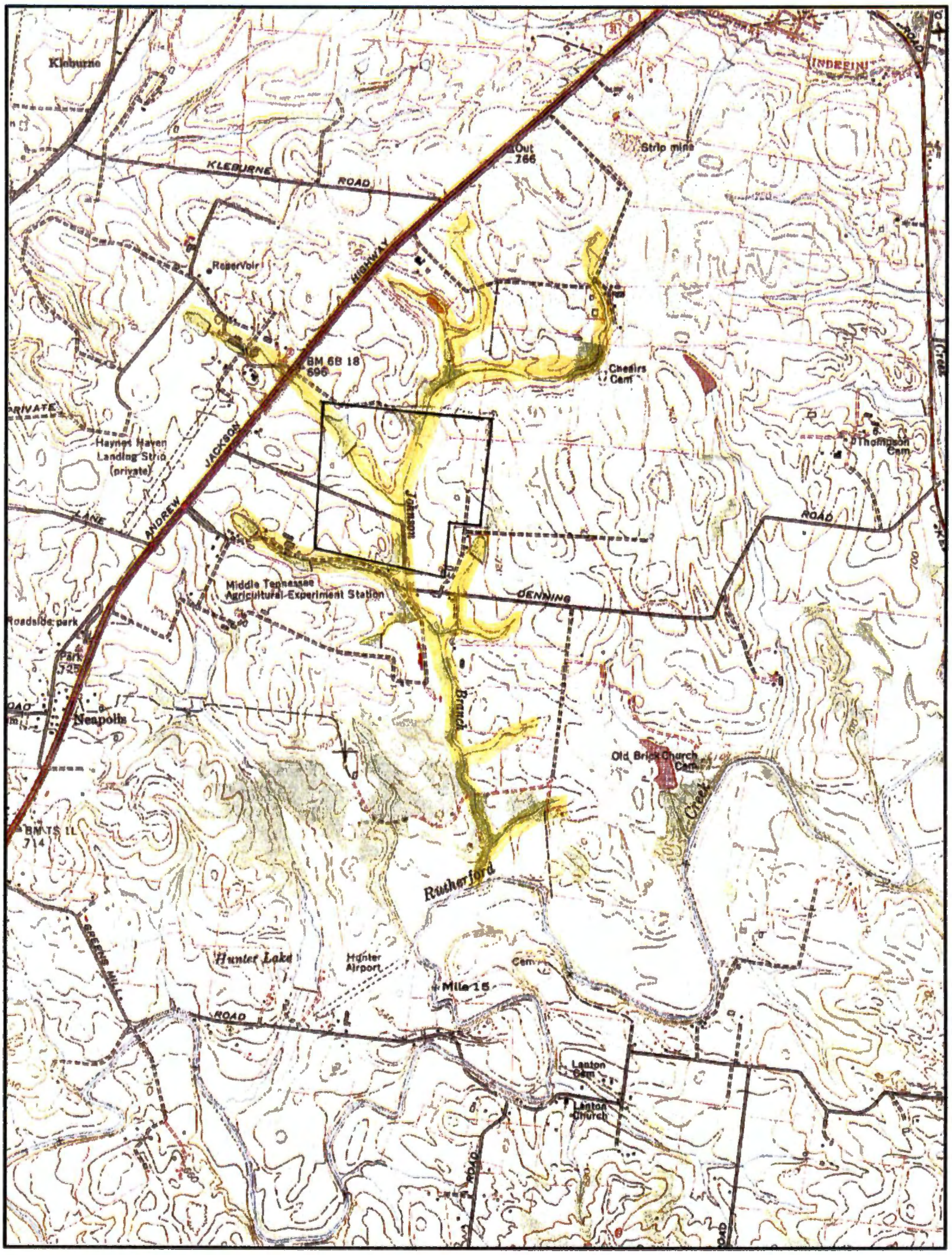
Site Description

The study was conducted on Johnson Branch, which is a small perennial stream flowing through the Middle Tennessee Agricultural Experiment Station (MTES) in Spring Hill, Tennessee (Plate 1). It is located in the outer Nashville Basin (Central Basin Physiographic Province) and is a second-order tributary to the Duck River. The contributing drainage area is slightly less than 2.5 square miles (629 hectares). The gently rolling topography ranges from 2-5 percent in Pasture 3 to 5-12 percent in Pastures 1 and 2 (USDA-SCS, 1959) (Figure 1).

The geology of the outer Central Basin is characterized by its formations of pure limestone (USDA-SCS, 1959). Heritage limestone, which has a comparatively low phosphate content, dominates the immediate study area. Below the Heritage lies a Carters formation. The underlying Carters limestone is mined and used as a general-purpose limestone, agricultural limestone, and as an additive to cement mixtures in many parts of Middle Tennessee.

Soils in this area are primarily formed from weathered limestone. Others have developed as colluvial deposits along the footslopes of hillsides or as alluvial deposits along the creek. Soil types are described in the *Soil Survey of Maury County, Tennessee* (USDA-SCS, 1959). The majority of soils are of the Braxton-Maury-Armour association.

Plate 1. Study area (partial section of the U.S.G.S. quadrangle map: Carters Creek, Tn.)



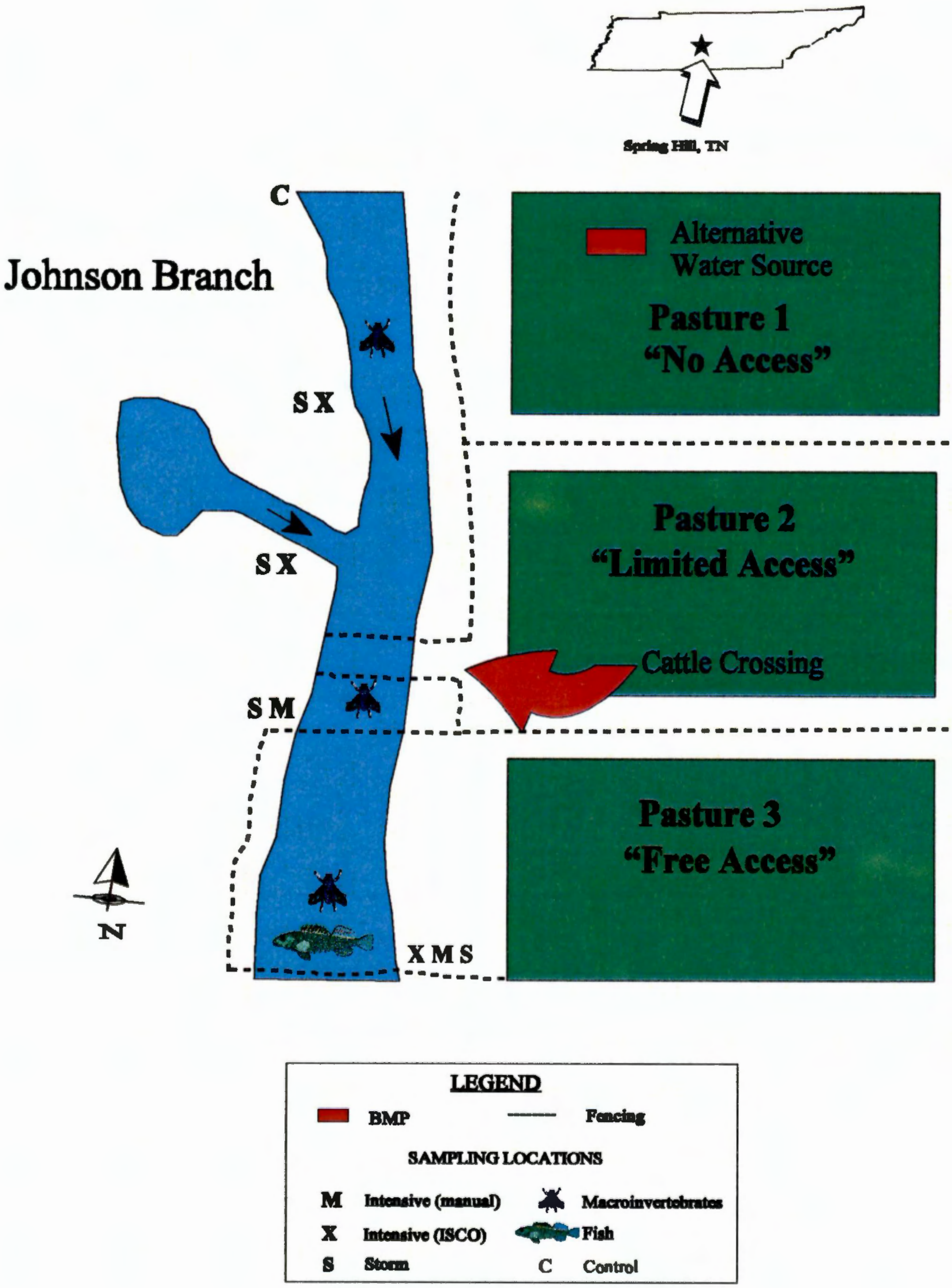


Figure 1. Schematic design of the study area illustrating BMP and sampling locations.

They are deep, well-drained, productive soils that are high in phosphorus and organic matter where they are not severely eroded. Maury soils occur on the smooth gentle slopes. Braxton soils typically occur on somewhat steeper slopes and contain fine chert fragments. The Armour soils occur at the footslopes of the Maury and Braxton formations. This group of soils was moderately to severely eroded at the time of the survey (USDA-SCS, 1959).

Land use in the broader area includes a beef cattle operation, dairy facilities, various cash crops, and an automotive production facility. Hay production, cattle grazing, and a small amount of grain farming dominate land use within the immediate study area. In the past, cattle access was limited in Pastures 1 and 2 to a short "unimproved" reach located in Pasture 2 (Figure 1). Healthy riparian zones exist in Pastures 1 and 2, dominated by sycamore (*Platanus occidentalis*), boxelder (*Acer negundo*), osage-orange (*Maclura pomifera*), and honey locust (*Gleditsia triacanthos*). The riparian zone in Pasture 3 is limited to a few large trees that have withstood cattle trampling and grazing. Because of the abuse, severe erosion and gullied streambanks present a potential hazard for cattle entering the stream from Pasture 3 (Plate 2).

Cattle have grazed these areas for approximately 25 years (Joe High, pers. commun.). Cattle stocking rates have ranged from 10 to 20 head in Pasture 1, 15 to 25 head in Pasture 2, and 10 to 20 head in Pasture 3 on an annual basis. Pastures ranged from 13 acres in Pasture 1, 33 acres in Pasture 2, to 9 acres in Pasture 3. During the study, stocking rates remained consistent with typical daily operations of the Experiment Station (refer to Appendix A for stocking rates during this study).

Plate 2. Photograph of Pasture 2 stream access area prior to BMP improvements.

Layout and Design

Study Area

The layout of the study area was designed to facilitate data collection within three different cattle watering areas located on the same stream. The three watering areas included: (1) where cattle were restricted from the stream and provided an alternative source of water (Pasture 1), (2) where cattle were watered directly from the stream via an improved limited access stream crossing (Pasture 2), and (3) where cattle had free access to the stream (Pasture 3). A sampling location upstream of Pasture 1 served as the Control (Figure 1). The Control site provided background information on the quality of water before it entered the Pasture 1. Landuse above the Control consists of closely cut grasses and hay fields.

Pasture 1, which was the most upstream site, served as the "no access" area. Cattle were completely fenced out of the stream and given an alternative source of water (detailed descriptions of each BMP are provided in the next section). The logic was that if an alternative water source was provided, it would eliminate the need for cattle to enter the stream and would therefore eliminate direct contact with the water. As mentioned previously, Pasture 1 has a healthy riparian zone on both sides of the stream. The root masses from the streambank vegetation provide excellent habitat and instream cover for a variety of aquatic organisms. The substrate is relatively clean (i.e., free of heavy silt deposits) and is dominated by rubble, gravel, and small sand deposits.

Pasture 2 served as the "limited access" area, where cattle were fenced out of most of the stream and access was limited to a short semi-restricted "improved" reach. In this treatment area, the idea was to minimize streambank erosion by limiting and stabilizing the point of access. Streambanks, in this reach, were heavily gullied due to cattle access prior to the study. Except for a small section of exposed bedrock at the upper end of Pasture 2, the stream's substrate consists mainly of gravel, sand, and silt along the stream edges. The water quality of Pasture 2 was also influenced by inflow from a tributary stream. The tributary, located upstream of the "improved" area, basically functioned as an overflow channel for a pond. It should be noted, that during the fall and winter months, this pond is the residence for many migratory ducks and geese.

Pasture 3 served as the "free access" area, where the entire stream reach was unfenced and cattle had access to the stream along the entire pasture. Streambanks were heavily eroded, due to the lack of adequate streambank vegetation and the intensive pressures of cattle trampling. The eroded banks were also creating a potential hazard for cattle entering the stream. The substrate can be characterized by predominately gravel, sand, and heavily silt deposits along the stream edges. Undercut streambanks exists along the right descending bank, where cattle traveled infrequently. Pasture 3 was seen as the worst case scenario and provided information on the cumulative effects of allowing cattle free access to the stream.

Best Management Practices (BMP's)

An alternative water source was installed in the pasture 1 ("no access") during the summer of 1996. Refer to Figure 1 for BMP locations. The system consisted of a submersible positive displacement diaphragm pump powered by batteries which were recharged by two 51-watt photovoltaic panals. Water was delivered via an underground pipe to a freeze-proof holding trough. An inline check valve, pressure switch, and float mechanism were used to assure no overflow at the trough. During night hours and cloudy days the submersible pump was powered by two 12-volt deep-cycle marine batteries (i.e., a 24-volt system) which were recharged by the photovoltaic panals during daylight hours.

A cattle half-crossing was installed in Pasture 2 ("limited access") in the spring of 1996. The travelway was constructed across the stream to provide livestock with a safe alternative route to the stream without causing further disturbances to the streambed or increased erosion to the streambanks (see Plates 2 and 3 for pre- and post-crossing photos). The travel pad was covered with gravel over a geotextile fabric. A combination of high-tensile fences and electrified streamers enclosed the travelway to ensure that cows did not migrate upstream or downstream of the designated area. Installation procedures were followed according to the specifications described in the Interim Standards for Stream Crossing, Code 576 (USDA-NRCS, 1995).

Trees were also planted along the Pasture 2 eroded streambanks to accelerate the stabilization process. The "live-stake" method was selected to minimize cost and to take advantage of the endemic tree resource on the Experiment Station. Species selected were boxelder (*Acer negundo*) and black willow (*Salix nigra*). The technique involved collecting live branches or shoots from existing trees and transplanting them directly into the streambank. Procedures were followed according to the specifications described by Thompson and Green (1994).

Plate 3. Photograph of Pasture 2 stream access area after BMP improvements.

Data Collection

Water quality and biological data were collected within each of the three treatment areas (i.e., pastures) following BMP installation. *Intensive sampling* was conducted on a seasonal basis, *storm samples* were collected on an event basis, and *biotic samples* were collected once during the study. Fish were also sampled once during the study, but individual samples were not taken within each treatment area. Refer to Figure 1 for sampling locations.

Water Quality Sampling

Intensive Sampling. Intensive sampling included a total of six sessions between the fall of 1996 and fall of 1997. Sampling procedures included one full day of data collection beginning at sunrise and terminating at sunset. The assumption was made that the stream would be used minimally by the cattle during the night hours.

A combination of four automated samplers and two continuous manually-controlled pump samplers were used for sample collection. Automatic samplers were located at the upper end of Pasture 1 (Control) to measure the quality of the incoming flow, at the lower end of Pasture 1, at the mouth of the tributary to account for potential impacts and flow addition, and at the lower end of Pasture 3. These data provided an indication of the contaminant concentrations leaving each treatment area. The automated samplers collected and composited 75-ml samples at 5-minute intervals. Three 250-ml subsamples were collected from the automated samples every four to five hours for analysis during each sampling session. This was done to ensure water samples were processed in the time-frame recommended by the method of analysis.

In addition, continuous pump samplers (samplers that were manually operated and collected samples continuously) were located just below the cattle crossing in Pasture 2 and at the lower end of Pasture 3. These samplers operated continuously to ensure complete sample collection since some data could potentially be lost between the 5-minute intervals of the automated samplers. Collected water was not composited and analyzed in the same manner as the automated samples water. Instead, each sample was collected, subsampled, and analyzed based on the activity level of the cattle (i.e., when cows were in the creek or when there were no cows in the creek). The data collected by the continuous sampler below Pasture 3 also provided replicate data which was used to determine sample variability.

The water-intake, for both the automated and continuous samplers, was designed to sample an even volume of water across the stream. The intake was constructed out of 4-foot*$^3/_4$-inch (O.D.) polyvinyl chloride (PVC) pipe. A series of holes were drilled in the pipe to allow water inflow.

In order to calculate mass rates (i.e., loading rates) for each constituent, stream velocity was measured during each sampling session with an electromagnetic flow meter and stream discharge was computed by the velocity-area method. The flow rates were multiplied by the concentration to calculate the masses of contaminants leaving each area, and comparison of these allowed for calculation of the mass additions from each reach.

Storm Sampling. A total of three storms were sampled during the study. Analyses were limited to total solids because of the driving distance and required processing time for other parameters (many of the desired water quality parameters allow a maximum delay of approximately six hours from the time of collection, and samples could not be retrieved that quickly).

An automated sampling network was designed for storm sample collection. The nucleus of the network was a single float switch located in the stream within Pasture 2. It became activated when the water level reached a significant stage, which was determined by prior visual observation of high water marks. Samplers triggered by this switch were located at the lower end of Pasture 1, at the lower end of Pasture 2, at the lower end of Pasture 3, and at the mouth of the tributary. A series of 100 ml samples were collected at three-minute intervals and composited until the water level receded. Water samples were retrieved from the samplers as soon as possible following the storm event and transported to Knoxville for analysis. Loading rates were not calculated because no stream discharge data were available.

Biotic Sampling

Macroinvertebrates. Macroinvertebrates were sampled once (March 1997) during the study. A spring sample time was selected to maximize the availability of pollution-intolerant organisms and to maximize the efficiency of the selected sampling equipment. Ideally, sampling should occur at a time of the year that the majority of insects are at or near maturity. Identification otherwise becomes difficult to impossible for early instar forms (i.e., very small juveniles).

Samples were taken within each treatment area (see Figure 1 for biotic sampling locations) using a modified version of the Rapid Bioassessment III Protocol (RBP) (TDEC, 1996). The method consisted of three quantitative samples and one qualitative sample per stream reach. A Surber sampler was used for quantitative sample collection. The technique involved placing the sampler in the streambed and disturbing the substrate to a depth of approximately 9 cm. Drifting organisms were captured in a downstream collection net (mesh 908 um). This process was replicated three times in each treatment area. All habitats inaccessible to the Surber were qualitatively sampled by a timed random search and used to supplement the data set. This involved hand-picking rocks and woody debris and sampling the undercut streambanks with a D-net. Samples were preserved in a solution of 10 percent formalin and transported back to the Agricultural Engineering Lab for sorting and identification using several taxonomic keys (Brigham et al., 1982; Stewart and Stark, 1993; Merritt and Cummins, 1996; Wiggins, 1996). A reference collection was made and identifications were verified by Dr. D.A. Etnier (Univ.of Tennessee, Dept. of Zoology), Wendell Pennington (Pennington and Associates, Inc.), and Steven Ahlstedt (U.S. Geological Survey). Refer to Appendix A for sample site information.

To facilitate the analysis, a reference stream was selected. Upon the advice of Jimmy Smith (Biologist, Tennessee Department of Environment and Conservation), Clear Fork was selected as a reference stream (Smith, pers. commun.). Note, however, that Clear Fork was not sampled as a component of this project. Data were collected and generously provided by the Tennessee Department of Environment and Conservation.

Refer to Appendix A and Appendix B for reference stream benthic data and site location).

Fish. Fish were sampled once (July 1996) during the study. A summer sample time was selected because stream flows were moderately low and fish migration movements were somewhat limited during this time. Sampling began downstream of Pasture 3 and continued upstream until an adequate sample was acquired. RBP's were followed according to Barbour et al. (1997). All available habitats (i.e., runs, riffles, and pools) were sampled to ensure a representative sample. Direct comparisons between treatments were not made because of the limited sampling distance between treatment areas. Instead, results were used as a baseline indication of the watershed's overall health.

In addition, a reference stream was also selected and sampled in the summer of 1997. Upon the advice of C. F. Saylor (pers. commun.), the upper portion of Leipers Creek was selected as the best possible reference site. Sampling procedures were the same as for Johnson Branch. Refer to Appendix A for reference site information.

Equipment included a backpack electrofishing unit, a 15-foot seine (1/4 inch mesh) and four assistants. Refer to Plate 4 for an illustration of fish sampling. Nearly all specimens were captured and released unharmed following identification and counting. Selected species were preserved in 10 percent formalin and transported back to Knoxville for confirmation using taxonomic keys described in *The Fishes of Tennessee* (Etnier and Starnes, 1993). Final identifications were verified by Dr. D.A. Etnier (Univ. Of Tennessee) and C.F. Saylor (Tennessee Valley Authority).

Plate 4. Photograph of fish sampling activity in Johnson Branch.

Data Analysis

Water Quality

Intensive Samples. All intensive water quality samples were processed or stabilized *in situ* within two hours after collection. Samples were analyzed for fecal coliform bacteria, biological oxygen demand (BOD), nitrogen (ammonia, nitrite, nitrate, and TKN), orthophosphate, total organic carbon (TOC), and total solid concentrations at the University of Tennessee Agricultural and Biosystems Engineering Department's Water Quality Lab located in Knoxville.

As noted previously, three 250-ml subsamples were collected every four to five hours from each automated sampler during each sampling session. The composite sample containers were well mixed before the subsamples were taken. The unused volume of water was discarded and the empty containers were thoroughly rinsed and placed back in the sampler. Three 250-ml subsamples were also collected from each continuous sampler in the same manner, but the time of subsampling was based on the activity level of the cows (i.e., when cows were in the creek or when cows were not in the creek). Storm event subsamples were collected as soon as possible following an event and subsampled in the same manner as mentioned above. Refer to Table 1 for water quality analysis methods.

Mass rates (i.e., loading rates) were calculated for each water quality constituent at each sampling location. Mass rates were calculated by multiplying the measured

Table 1. Water quality analysis methods.

Constituent	Method
Biological Oxygen Demand (BOD)	Method 5210 B, 5-Day BOD Test (USEPA, 1983a)
Total Organic Carbon (TOC)	Method 5310 C (USEPA, 1983b)
Ammonia	HACH Method #8038 (USEPA, 1983c)
Total Kjeldahl Nitrogen (TKN)	Lachat Method #10-107-06-2-D (USEPA, 1983d)
Fecal Coliform Bacteria (FC)	Method 9222 D (USEPA, 1983e)
Nitrite, Nitrate, and Orthophosphate	Method 300.0 (USEPA, 1983g)
Total Solids	Method 2540 B (USEPA, 1983f)

concentration (concentrations were measured in mg/L for all constituents except for fecal coliform bacteria which was measured in cfu/mL) by flow rate (cfs), and time (time = duration of sample in hours). Refer to Appendix B for concentrations, flow rates, and dates of each sampling session. The contribution from each treatment area was determined by the amount of mass added. Each constituent's mass addition rate was determined by subtracting the mass rate of the upstream treatment from the next treatment downstream (e.g., for calculating the mass addition rate for Pasture 3, the mass at Pasture 2 was subtracted from the mass at Pasture 3). An overall average mass addition rate was generated from the six daily mean masses. Mass rates from the tributary inflow were always subtracted from Pasture 2 values to account for potential outside influences.

SAS was used to statistically analyze the data set (SAS Institute, 1996). Mean addition rates for each constituent were confirmed to be normally distributed. The mean mass rate addition values for the six sampling sessions were tested for significant differences in seasonal variation and differences between sampling locations. A pairwise comparison was also done to compare the actual mass collected at each reach. Mass values at Pastures 2 and 3 represent values minus the tributary inflow. Significance levels for mass addition rates and seasonal variation were always tested at $\alpha=0.05$. Refer to Appendix D for SAS programs used in this analysis.

Storm Samples. As mentioned previously, storm samples were analyzed only for total solid concentrations. Refer to Table 1 for the method of analysis. Mass rates were not calculated because flow rate data were not available. Average concentrations for each treatment area were compared to the next treatment upstream and compared to the non-storm event concentration averages to illustrate the "flushing" of pastureland and streambanks that takes place during storm related discharge.

Biology

Macroinvertebrates. A benthic Index of Biotic Integrity (BIBI) methodology was used for data analysis (TDEC, 1996; Barbour et al., 1997). The BIBI is a regionally standardized method of assessing a waterbody, where a series of scoring metrics are applied to a target stream or segment of a stream to determine the stream's biotic classification. BIBI index values and corresponding stream classifications are listed in

Table 2 . The metrics are designed to assess four general elements and processes within the benthic community (taxa richness, composition, tolerance/intolerance, and trophic structure). These elements were then divided into seven quantifiable metrics which are listed below (detailed explanations and methods of calculation are provided in Appendix C).

- Comparative Taxa Richness (Taxa Richness)
- North Carolina Biotic Index (NCBI)
- Five Dominant Taxa in Common
- Indicator Assemblage Index (IAI)
- Community Loss Index (CLI)
- Functional Feeding Group Percent Similarity (FFGPS)
- Percent Ephemeroptera/Plecoptera/Trichoptera Index (% EPT)

Scoring criteria for each metric were based on conditions in an appropriate reference stream. The reference site selection was based on stream size, geographic similarity, and one that exhibited the "least impacted" conditions. It should be noted that the selection process was not an attempt to characterize "pristine" conditions, as such streams do not naturally exist (Ohio EPA, 1987). These data were then used to "calibrate" each metric used in evaluating the three treatment areas along Johnson Branch.

Table 2. BIBI index values and corresponding stream classifications.

BIBI Index	>83%	54-79%	21-50%	<17%
Stream Classification	Nonimpaired	Slightly Impaired	Moderately Impaired	Severely Impaired

In addition to the BIBI, independent components were also evaluated. EPT (Ephemeroptera + Plecoptera + Trichoptera), chironomids, and isopod/amphipod population percentages were calculated and compared within each treatment area. EPT is a common measure of the groups of insects most intolerant to poor water quality. Stream health generally increases as the percentage and diversity of EPT organisms increases. On the other hand, chironomids and annelids have long been used as indicators of organic pollution (Schindler, 1987). Numbers of chironomids/annelids tend to increase as organic matter is added to the system (TDEC, 1996). Isopods and amphipods are organisms that occur in a wide variety of unpolluted streams, seeps, springs, and subterranean waters. Because they are light sensitive, they generally occupy areas that contain adequate instream cover, such as root wads and grass-mats. They also have the ability to tolerate colder water temperatures often avoided by other benthic organisms (Pennak, 1953).

Fish. A fishery IBI methodology, as described by Barbour et al. (1997), was used for fish data analysis. The fishery IBI combines 12 fishery related metrics that are based on the community's taxonomic and trophic composition and the abundance and condition of the fish. Each metric was scored against criteria that were derived from an appropriate reference stream. The 12 individual metrics used by the IBI are listed below. A description for each metric is provided in Appendix C.

- Total Number of Native Species
- Number of Darter Species
- Number of Sunfish Species, Less *Micropterus*
- Number of Sucker Species
- Number of Intolerant Species
- Percent of Individuals as Tolerant Species
- Percent of Individuals as Omnivores
- Percent of Individuals as Specialized Insectivores
- Percent of Individuals as Piscivores
- Catch Rate (average number of fish per 27.9 m^2)
- Percent of Individuals as Hybrids
- Percent of Individuals with Disease, Tumors, Fin Damage, and other Anomalies

The reference site selection process was conducted in basically the same manner as the benthic IBI site selection, but more emphasis was placed upon the contributing drainage area. The data collected were then used to calibrate each metric. Scores of 5, 3, or 1 were assigned to each metric according to whether its value is similar (5), somewhat similar (3), or not similar at all (1) to the values based on the reference site (Ohio EPA, 1987). The scores for the 12 metrics were added together to produce a single stream index (Table 3 lists index values and their corresponding stream classification). Descriptions of individual metrics and their rationale are discussed in Appendix C.

Table 3. Fish IBI index values and corresponding stream classifications.

IBI Range	0	12-22	28-34	40-44	48-52	58-60
Stream Classification	No Fish	Very Poor	Poor	Fair	Good	Excellent

CHAPTER 4

RESULTS

The goal of this project was to determine if cattle watering BMP's could improve the biotic health and quality of downstream water by reducing cattle-induced impacts. Three types of cattle watering techniques were investigated: (1) cattle were fenced out of the stream and provided an alternative source of water (Pasture 1), (2) stream access was limited to a short "improved" reach (Pasture 2), and (3) cattle had "free" access to the stream (Pasture 3).

Water quality was monitored intensively on a seasonal basis and total solids concentrations on a storm event basis. Samples from the intensive sampling sessions were analyzed for nitrogen (nitrate, nitrite, ammonia, and TKN), orthophosphate, biological oxygen demand (BOD), total organic carbon (TOC), fecal coliform bacteria, and total solids. Concentrations of TKN, nitrite, and orthophosphate are not reported because they were never found above the detection level.

Biological (macroinvertebrates) data were collected once during the study and BIBI responses were compared between each of the three treatments. Fish IBI results were used as an indication of the overall condition or health of the watershed.

This chapter provides results from the water quality, storm, and biotic sampling. Water quality results are discussed in terms of the amount of mass that was measured and the amount of mass that was added by each treatment area. Storm sampling results provide concentrations of total solids and allow generalized comparisons between storm and non-storm events. Biotic results provide an overall condition of the entire watershed (fish) and a community response comparison between each treatment area (macroinvertebrates).

Water Quality Results

Water quality results are reported as average daily mass values (Tables 4 and 5) and as average daily mass addition values (Table 6). Mass values represent the actual mass that was measured at a particular point in the stream (e.g., the mass reported at Pasture 1 represents the mass measured at the lower end of Pasture 1, and the mass reported at Pasture 2 represents the mass measured below the cattle crossing minus the mass contributed by the tributary) (Table 4). A pairwise comparison was conducted for all treatment areas, including the Control, to determine if there were statistical differences in the mean daily mass values (Table 5). Mass addition values represent the mass that was contributed by a particular area (i.e., the mass reported at Pasture 1 was the average daily mass produced by that entire pasture, not the mass that was measured in the stream). Refer to Appendix C for mass addition calculations. Comparisons were made to determine if the mass added by each pasture was statistically different than the next pasture upstream (Table 6). Storm samples are reported as concentrations (mg/L) of total solids (Table 7). Generalized comparisons were made between storm and non-storm events.

Table 4. Average daily mass values of water quality constituents for the six sample sessions expressed in lbs/day (fecal coliform values expressed as 10^8 cfu/day). Mass values for Pastures 2 and 3 represent the mass collected minus contributions from the tributary.

Constituent	Control	Pasture 1 "No Access"	Pasture 2 "Limited Access"	Pasture 3 "Free Access"
Nitrate	17.3	19.9	19.3	22.3
Ammonia	0.29	0.32	0.10	0.59
Total Solids	3459	3393	3276	3514
TOC	382	389	404	398
BOD	15.1	15.6	14.0	16.3
Fecal Coliform	380	447	525	804

Table 5. Pairwise comparison of average daily mass values (n=6) measured below each treatment area (shaded areas represent *p*-values that were statistically significant at α=0.05).

Constituent	C -P1*	C-P2*	C-P3*	P1-P2	P1-P3	P2-P3
Nitrate	.0016	.0111	.0001	.3980	.0038	.0006
Ammonia	.7923	.0847	.0111	.0508	.0195	.0002
Total Solids	.6530	.2246	.7130	.4338	.4169	.1202
TOC	.4964	.0618	.1644	.2109	.4598	.5945
BOD	.5595	.1927	.1517	.0672	.3788	.0106
Fecal Coliform	.3704	.0625	.0001	.3001	.0001	.0012

* C=Control, P1=Pasture 1, P2=Pasture 2, P3=Pasture 3.

Table 6. Average daily mass addition values and significance levels (p-values) of water quality constituents for the six sample sessions expressed in lbs/day (fecal coliform values expressed as 10^8 cfu/day). Shaded areas represent pastures that produced statistically significant (at α=0.05) mass additions that were higher than the pasture upstream.

Constituent	Pasture 1 "No Access"		Pasture 2 "Limited Access"		Pasture 3 "Free Access"	
	mass addition	p-value	mass addition	p-value	mass addition	p-value
Nitrate	2.60	0.0016	-0.61	0.0002	3.00	0.0001
Ammonia	0.03	0.8768	-0.22	0.0298	0.49	0.0001
Total Solids	-66.0	0.6534	-117.1	0.7353	239.0	0.0257
TOC	7.0	0.4964	14.48	0.5540	-7.00	0.0825
BOD	0.50	0.5595	-1.58	0.0204	2.20	0.0001
Fecal Coliform	67.0	0.3704	77.5	0.8839	280.0	0.0123

Table 7. Average total solids concentrations for non-storm (n=6) and storm (n=3) events at each treatment area expressed in mg/L.

Event	Pasture 1	Tributary	Pasture 2	Pasture 3
Non-storm	358	394	347	411
Storm	373	393	447	441

Pasture 1

The results showed slight increases in mass values within Pasture 1 for all constituents except total solids, when compared to the Control (Table 4). However, the differences in mass measured (Table 5) and mass added (Table 6) were only statistically significant (α=0.05) for nitrate. The significant addition of nitrate and the apparent loss of total solids could not be explained (Table 4). There were statistical differences in seasonal variability, but the differences followed no logical pattern. These results support the hypothesis that streambank fencing and a healthy riparian zone can reduce or at least maintain water quality.

There was a slight increase in total solid concentrations during storm events (Table 7). This may be explained by natural erosion or it may have been influenced by a construction project located upstream.

Pasture 2

Limiting cattle access to an "improved" access area did not appear to have a severe negative impact on any of the measured constituents when compared to Pasture 1 (Table 6). There were significant decreases in nitrate, ammonia, total solids, and BOD within this treatment area, which could not be explained (Table 6). There were no changes in stream gradient, there were no pools between the tributary and Pasture 2, and the tributary basically functioned as an overflow channel for a pond, so it was difficult to account for these losses. The pairwise analysis did detect statistically significant differences in nitrate, when compared to the Control (Table 5). It should be noted that fecal coliform levels within Pasture 2 were also very close to being statistically significant (p=0.06), when compared to the Control (Table 5). The increase in fecal coliform levels could be the result of increasing cattle access. It should also be noted that fecal coliform values were extremely high in the stream before it entered the study area (i.e., at the Control) (Table 4). An explanation for this is beyond the scope of this study. There were statistical differences in seasonal variability, but the differences followed no logical pattern.

The Pasture 2 total solids concentrations measured during storm events were considerably higher than those of non-storm events (Table 7). This was possibly due to existing streambank failure prior to the study. There was only a six month recovery period between the time the crossing was installed and the first intensive sampling session, therefore the streambanks were not fully stabilized. Also, the power supplied to the electric-fence around the travel-way of the crossing failed several times during the study. During these times, cattle had increased access to the stream by walking around the borders of the crossing. Some of the streambank vegetation planted prior to the study was trampled and dislodged by the cattle.

Pasture 3

The cumulative impacts of allowing cattle "free" access to the stream were observed in Pasture 3. There were significant additions of all measured constituents except for TOC when compared to Pasture 2 (Table 6). However, when compared to Pasture 1 and the Control, only nitrate, ammonia, and fecal coliform levels were statistically different (Table 5). The apparent insignificance of total solids was probably the result of high sample variability measured in the initial concentrations. Another explanation is the time at which the samples were taken. All intensive samples were collected when the stream's flow was relatively low. Therefore, there was no transport mechanism (e.g., surface runoff) available to move the deposited sediment in the stream or along the streambanks. The statistical difference in BOD levels is probably the result of the increased amount of cattle manure directly deposited in the stream. There were statistical differences in seasonal variability, but the differences followed no logical pattern.

Total solids concentrations measured during storm events were slightly higher than those of non-storm events (Table 7). Lower than expected sediment concentrations may have been the result of less localized impacts; i.e., the impacts from streambank trampling were not as severe when spread along the entire pasture length. In Pasture 2, before the study, the cattle repeatedly trampled the same areas moving up and down the streambank, thus causing increased degradation to the same location.

Biological Results

Macroinvertebrates

Index scores generated by the BIBI analysis tended to remain relatively consistent within all 3 study reaches (i.e., scores indicated very little change in the stream's biotic integrity) (Table 8). BIBI scores ranged from 16 (severely impaired) in Pasture 1 to 18

Table 8. Benthic Index of Biotic Integrity (BIBI) analysis for each treatment area on Johnson Branch.

Metric Description	Scoring Criteria 6	4	2	0	Score (Observed Value) Pasture 1 "No Cows"	Pasture 2 "Limited Access"	Pasture 3 "Free Access"
1. Taxa Richness	>80%	60-79%	40-59%	<40%	4 (63)	2 (50)	2 (59)
2. NCBI	>85%	70-85%	50-69%	<50%	2 (69)	4 (71)	4 (83)
3. FFGPS	>85%	75-85%	65-74%	<65%	2 (65.3)	0 (60.9)	0 (56)
4. IAI	0.8-1	0.65-0.79	0.5-.64	<0.5	2 (2)	6 (.9)	6 (.9)
5. DIC	4-5	3	2	0-1	2 (2)	2 (2)	2 (2)
6. Percent EPT Index	>80%	80-90%	70-79%	<70%	0 (50)	0 (46)	0 (46)
7. CLI	<0.5	0.51-1.5	1.51-4.0	>4.0	4 (1.1)	4 (1.4)	4 (1.2)
BIBI Score					**16**	**18**	**18**
Stream Classification					**Severely Impaired**	**Sev/Mod Impaired**	**Sev/Mod Impaired**

BIBI Range	>83%	54-79%	21-50%	<17%
Stream Classification	Nonimpaired	Slightly Impaired	Moderately Impaired	Severely Impaired

(severely/moderately impaired) in Pastures 2 and 3. This indicated that the increased cattle accessibility did not appear to have a severe negative impact on the benthic community.

There were very few changes in metric scores between pastures (Table 8). The greatest change was that of metric 4 (Indicator Assemblage Index). This suggests that the ratio of chironomid and annelid's to EPT organisms increased between Pasture 1 and Pastures 2 and 3. As cattle access was increased, benthic populations tended to switch from a predominately isopod/amphipod dominated community to an EPT dominated community (EPT indicates the most intolerant groups of insects - Ephemeroptera + Plecoptera + Trichoptera). Refer to Table 9 for benthic community comparisons by pasture. The percentage of EPT organisms were considerably higher in Pasture 3 (59%) than in Pasture 1 (38%). This indicated that the increased cattle access did not have a severe negative impact on the benthic community. As the percentage of EPT organisms increased the percentage of isopods and amphipods decreased. This may have been the result of more instream cover and/or low nutrient levels at Pasture 1 (Table 9). This seems logical since vegetative growth was encouraged in Pasture 1 because of the denied cattle access, thus maintaining cooler water temperatures. Also, the percentages of chironomids slightly increased as cattle access was increased. In general, increasing chironomid numbers tend to represent increases in organic matter, thus illustrating that cattle did have a small impact on the stream's nutrient levels, yet the impact was not severe enough to impact the entire benthic community.

The most likely explanation is that Johnson Branch is a small spring-fed stream, and spring-fed streams are typically colder and lower in nutrients than are larger streams. In addition, upstream of this reach the stream flows primarily through closely-cut grassy areas and hay fields. The BIBI results and the dominance of isopods and amphipods in Pasture 1 may be the product of a nutrient-poor, spring-fed system. The additional organic matter from increasing the cattle access may have actually increased the stream's biotic productivity within this reach. Note, however, that contaminant contributions within these reaches could contribute to excessive contaminant levels further downstream.

Table 9. Benthic community structure expressed as a percentage of the total sampled population.

Taxa	Pasture 1	Pasture 2	Pasture 3
% EPT	38	45	59
% Isopods and Amphipods	53	23	9
% Chironomids	3	4	8
% other taxa	6	28	24

Fish

As mentioned previously, fish were not sampled within each treatment area because of the limited sampling distance. The IBI was used as an indication of overall stream condition and to support the results of the BIBI. The results of the IBI indicated that Johnson Branch was classified as "Fair" (Table 10), while Leiper's Creek (reference site) was classified as "Good" (Appendix C).

There were several metrics that decreased the overall IBI score (e.g., number of sunfish species, number of sucker species, percent specialized insectivores, and catch rate). Refer to Table 10 for individual metric scores. The number of sunfish is highly dependent on physical habitat conditions. Sunfish are typically pool dwelling species. The lack of long deep pools may have contributed to the lower than expected number of sunfish species. The absence of sucker species was unexplainable. Habitat conditions were adequate to support at least two sucker species. Percent specialized insectivores is essentially a measure of percent darter species. There were five darter species collected (only four were collected from the reference stream); however, the numbers of darters collected were not high enough to make a significant difference in the score. The sampling effort produced a catch rate of approximately 19 fish per 27.9 m^2 (300 ft^2) of sampling area. This was considerably lower than what was expected for even the next increase in score. If nutrients were truly being added to the system by increasing cattle access, the catch rate of fish should have been higher. However, this was also true for the macroinvertebrates, where the density of insects actually decreased as cattle access was increased. The low catch rate of fish could not be explained; but, an argument can be made that invertebrate numbers were low because of the method used for quantitative sampling. The device used (Surber sampler) does a very good job of sampling the area where it is placed, but because of the non-homogenous nature of streams, it is very difficult to replicate samples in a given reach.

Table 10. Fishery Index of Biotic Integrity (IBI) analysis for Johnson Branch.

Metric Description	Scoring Criteria 1	Scoring Criteria 3	Scoring Criteria 5	Observed	Score
Total number of native fish species	<9	9-16	>16	17	5
Number of darter species	<2	2-3	>3	5	5
Number of sunfish species, less *Micropterus*	<2	2-3	>3	3	3
Number of sucker species	0	1	>1	0	1
Number of intolerant species	<2	2	>2	2	3
Percent of individuals as tolerant species	>37%	19%-37%	<19%	29	3
Percent of individuals as omnivores	>46%	24%-46%	<24%	44	3
Percent of individuals as specialized insectivores	<22%	22%-44%	>44%	20.3	1
Percent of individuals as piscivores	<1.5%	1.5%-2.9%	>2.9%	5	5
Catch rate (average number of fish per 27.9 m^2 sampling unit)	<28.5	28.5-56.9	>56.9	19.1	1
Percent of individuals as hybrids	>1%	TR-1%	0%	0	5
Percent of individuals with disease, tumors, fin damage, and other anomalies	>5%	2%-5%	<2%	0.01	5
IBI Score					**40**
Stream Classification					**Fair**

IBI Range	0	12-22	28-34	40-44	48-52	58-60
Stream Classification	No Fish	Very Poor	Poor	Fair	Good	Excellent

CHAPTER 5

SUMMARY AND CONCLUSIONS

The goal of this project was to determine if watering BMP's could improve the biotic health and quality of water downstream by reducing the cumulative effects of cattle. Research indicated that the water quality of Johnson Branch benefitted from adding BMP's. In general, BMP's were successful at minimizing cattle-induced impacts. However, significant differences were not always detected between the two BMP treatments.

The mass addition rates for Pastures 1 ("no access") and 2 ("limited access") produced mixed results. Nitrate added within Pasture 1 was the only constituent that produced a significant mass addition rate (Table 6). Pasture 2 produced significant differences (Table 6), but the differences were actually losses in mass. The reason for this could not be explained since there were no major changes in stream gradient or offsite influences. High fecal coliform levels were measured in all pastures, and progressively increased as cattle access increased (Table 4). Statistically significant differences were only detected within Pasture 3, but were very close to being statistically significant in Pasture 2 (Table 5). This could have been the result of increasing cattle access or a combination of the additional inflow from the tributary. The inflow from the tributary also presented unexplainable results. Every effort was made to account for the additional inflow from the tributary, but there almost always appeared to be an unusually high mass load contributed to the study area. Pasture 2 did produce statistically significant differences in nitrate when compared to the Control (Table 5). This could be the result of increasing cattle access at the crossing. As expected, Pasture 3 ("free access") consistently produced significant mass additions for all reported constituents except TOC (Table 6). However, total solids levels were not statistically significant when compared to the Control, Pasture 1, and Pasture 2, (Table 5). This was probably the result of high sample variability within the initial concentrations measured.

Storm event results did in fact produce higher concentrations of total solids than the non-storm events (Table 7). This supports the initial hypothesis that increased stream discharge and surface runoff produces a "flushing effect" on the streambanks and adjacent pastureland. However, the increase in total solids concentrations were higher than expected for Pasture 1. This was probably the result of a small construction project that traversed the stream upstream of Pasture 1. The increase within Pasture 2 was probably the result of existing streambank failure prior to the study. As mentioned earlier, there was only a six month streambank recovery period between the time the stream crossing was completed and the time of the first intensive sampling session. The Pasture 2 concentrations could also have been elevated by periods when the fencing at the crossing was not functioning properly and cattle had increased access around the borders of the designated area. Storm concentrations basically remained the same at the tributary. This reiterates the fact that it was difficult to explain the mass additions encountered during the intensive sampling sessions. For Pasture 3, storm total solids concentrations were only slightly higher than the concentrations of non-storm events. This was not expected since cattle had free access along the entire pasture. One possible explanation is that the impacts from trampling were not as localized as in Pasture 2, spreading the impacts over a longer length of stream, and therefore minimizing soil compaction at any single location.

The expected incremental changes in BIBI values as cattle access was increased did not generate the results anticipated. The responses of the biotic community (aquatic invertebrates) showed no significant negative impacts as cattle access increased (Table 8). The likely explanation is that Johnson Branch is a small spring-fed stream and is thus lower in nutrients than most larger streams. This is supported by the dominance of isopods and amphipods in Pasture 1 (Table 9). The added organic matter from increased cattle accessibility actually increased the stream's biotic productivity. It should be noted that it is often difficult to measure immediate success in biotic communities, because of inherent differences within the stream and the recolonization time required of most aquatic invertebrate communities. Therefore, it is difficult to base biotic responses on a single sample, especially one that took place so soon (6 months) after an improvement.

BMP's were installed and performed without any major difficulties, but it should be noted that BMP's are not maintenance-free. They do require periodic repairs and inspections. Problems encountered were relatively simple, such as water pumps and water delivery lines freezing during the winter months (Pasture 1). These problems were easily fixed by moving the pump to deeper areas of the stream and by increasing the insulation around the delivery line. Also, the problems encountered at the crossing (Pasture 2) could have been avoided with more frequent periodic checks and inspections. In general, both types of BMP's performed well and achieved the initial goal (i.e., reducing cattle-induced impacts to the stream).

This research illustrates the impacts and biotic responses of watering moderate numbers of cattle in a small perennial stream in the Outer Nashville Basin. The same results may not be found in other geographic areas because of geological and stocking rate variability (Appendix A). As mentioned earlier, it is very difficult to account for all the outside influences when attempting to quantify nonpoint source pollution. It is also very difficult to quantify benthic invertebrate data because of the non-homogeneity of stream habitats. However, BMP's should offer significant improvements over doing nothing at all (i.e., allowing cattle free access to streams), but at this time differences in types of BMP's cannot be identified. Future evaluations should be conducted on an individual basis and for a longer time frame because of the recovery time required for streambanks to stabilize and biotic communities to recover.

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APPENDICES

APPENDIX A.

STUDY AREA MANAGEMENT

Time Line of Project Related Activities.

	1996				1997				1998			
Activity	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Win	Spr	Sum	Fall
Installation of half-crossing and alternative water source	✓											
Installation of "live-stakes"	✓											
▸BioSurveys:												
Fish	✓											
Benthos					✓							
▸Surface Water												
Intensive Sampling			✓		✓	✓✓	✓	✓				
Storm Sampling					✓			✓	✓			
Data analysis/report preparation									✓	✓	✓	✓

Pasture Size, Stream Length, and Cattle Stocking Rates During the Study

Date	Location		
	Pasture 1 (No Access)	Pasture 2 (Limited Access)	Pasture 3 (Free Access)
Pasture size (acres)	13	33	9
Stream frontage/pasture (ft)	565	1180	885
Stream access length (ft)	0	12	885
10/24/96			
number of head:	16	23	18
avg. wt. (lbs):	975	1075	825
stocking rate (head/acre):	1.2	0.7	2
2/13/97			
number of head:	17	23 cows/10 newborns	16
avg. wt. (lbs):	975	1075/newborns	975
stocking rate (head/acre):	1.3	0.7	1.8
4/12/97			
number of head:	8	13 cows/13 calves	20 cows/8 calves
avg. wt. (lbs):	1000	1175/500	1280/450
stocking rate (head/acre):	0.6	0.8	3.1
6/27/97			
number of head:	7	14	8
avg. wt. (lbs):	1000	1200	925
stocking rate (head/acre):	0.5	0.4	0.9
8/15/97			
number of head:	9	24 cows/24 calves	22
avg. wt. (lbs):	1000	1185/580	1200
stocking rate (head/acre):	0.7	0.8	2.4
9/26/97			
number of head:	9	25	16
avg. wt. (lbs):	1000	1185	1200
stocking rate (head/acre):	0.7	0.8	1.8

Site Descriptions and Locale Information

Creek: Johnson Branch (study area)
Physiographic Area: Outer Nashville Basin
Date Sampled: May 16, 1996
Drainage Area (sq. mi.): 2.4
County: Maury
Latitude: 35-42-57 Longitude: 86-57-17
Reference Location: Bridge at Denning Road
Quad: Carter's Creek, Tenn. (64-NW)
Location: Middle Tennessee Agricultural Experiment Station (MTES). Approximately one mile SW of Saturn Parkway between Spring Hill and Columbia, Tn.
Access: MTES
Collection Gear: Fish-backpack shocker and seine, Invertebrates-surber and D-net
Crew: Jeff Powell, Mike Palmer, Page Barker, Joe Milner (UT, Dept. of Ag. and Biosy. Eng.)

Creek: Leiper's Creek (reference stream-fish)
Physiographic Area: Outer Nashville Basin
Date Sampled: August 1, 1996
Drainage Area (sq. mi.): 3.6
County: Williamson
Latitude: 35-48-26 Longitude: 87-04-14
Reference Location: Bridge at junction of Sulfer Springs Road and Leiper's Creek Road
Quad: Theta, Tenn. (56-SE)
Location: Approximately eight miles NW of Spring Hill, Tn. Began sampling approximately ½ mile downstream of bridge and continued above bridge.
Access: William Reed farm.
Collection Gear: Backpack shocker and seine
Crew: Jeff Powell, John Buchanan, Page Barker, Teffany Rich (UT, Dept. of Ag. and Biosy. Eng.), Jenny Adkins (USDA-NRCS)

Creek: Clear Fork (reference stream-invertebrates)
Physiographic Area: Outer Nashville Basin
Date Sampled: May 12, 1997
County: Cannon
Central Log No.: B9706034-038
Field Office No.: 831-835
Field No.: 71H06
Collection Gear: Invertebrates-kick-net
Crew: Jimmy Smith (Tennessee Department of Environment and Conservation)

APPENDIX B.

RAW DATA

Appendix B. - Nomenclature

BOD	Biological Oxygen Demand
BMP	Best Management Practice
BIBI	Benthic Index of Biotic Integrity
cfu	Coliform Forming Unit
cfs	Cubic feet per second
event	cattle activity (e.g., NC=cows were not in stream; C=cows were in stream)
FC	Fecal Coliform
IBI	Index of Biotic Integrity
lbs	pounds
M	manual pump sampler (e.g., 2M=manual pump sampler at Pasture 2)
mg/L	milligram per liter
ml	milliliter
NO_2	Nitrite
NO_3	Nitrate
NPS	Non-point source pollution
Q	Flow rate
Qual	Qualitative sample
TOC	Total Organic Carbon
TS	Total Solids
T	Time (hours)
TKN	Total Kjeldahl nitrogen

Nitrate concentrations in mg/L (10/24/96)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2M event	pasture 3	pasture 3M	3M event
700	700.00	1.08	1.3	1.25	1.25	nc			
759	798.33	1.08	1.3	1.25	1.25	nc			
800	800.00	1.08	1.3	1.25	1.19	c		1.4	nc
829	848.33	1.08	1.3	1.25	1.19	c		1.4	nc
830	850.00	1.08	1.3	1.25	1.25	nc		1.4	nc
904	906.67	1.08	1.3	1.25	1.25	nc		1.4	nc
905	908.33	1.08	1.3	1.25	1.25	nc		1.41	c
919	931.67	1.08	1.3	1.25	1.25	nc		1.41	c
920	933.33	1.08	1.3	1.25	1.19	c		1.41	c
925	941.67	1.08	1.3	1.25	1.19	c		1.41	c
926	943.33	1.08	1.3	1.25	1.19	c		1.4	nc
950	983.33	1.08	1.3	1.25	1.19	c		1.4	nc
951	985.00	1.08	1.3	1.25	1.25	nc		1.4	nc
958	996.67	1.08	1.3	1.25	1.25	nc		1.4	nc
959	998.33	1.08	1.3	1.25	1.23	c		1.4	nc
1014	1023.33	1.08	1.3	1.25	1.23	c		1.4	nc
1015	1025.00	1.08	1.3	1.25	1.23	c		1.41	c
1016	1026.67	1.08	1.3	1.25	1.23	c		1.41	c
1017	1028.33	1.08	1.3	1.25	1.3	nc		1.41	c
1035	1058.33	1.08	1.3	1.25	1.3	nc		1.41	c
1036	1060.00	1.08	1.3	1.25	1.3	nc		1.4	nc
1049	1081.67	1.08	1.3	1.25	1.3	nc		1.4	nc
1050	1083.33	1.08	1.3	1.25	1.3	nc		1.35	c
1100	1100.00	1.08	1.3	1.25	1.3	nc		1.35	c
1101	1101.67	1.04	1.38	1.39	1.3	nc	1.51	1.35	c
1114	1123.33	1.04	1.38	1.39	1.3	nc	1.51	1.35	c
1115	1125.00	1.04	1.38	1.39	1.3	c	1.51	1.35	c
1124	1140.00	1.04	1.38	1.39	1.3	c	1.51	1.35	c
1125	1141.67	1.04	1.38	1.39	1.3	c	1.51	1.35	c
1126	1143.33	1.04	1.38	1.39	1.3	c	1.51	1.4	nc
1129	1148.33	1.04	1.38	1.39	1.3	c	1.51	1.4	nc
1130	1150.00	1.04	1.38	1.39	1.3	c	1.51	1.35	c
1143	1171.67	1.04	1.38	1.39	1.3	c	1.51	1.35	c
1144	1173.33	1.04	1.38	1.39	1.3	nc	1.51	1.35	c
1200	1200.00	1.04	1.38	1.39	1.3	nc	1.51	1.35	c
1201	1201.67	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1219	1231.67	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1220	1233.33	1.04	1.38	1.39	1.3	c	1.51	1.4	nc
1254	1290.00	1.04	1.38	1.39	1.3	c	1.51	1.4	nc
1255	1291.67	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1256	1293.33	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1311	1318.33	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1344	1373.33	1.04	1.38	1.39	1.3	nc	1.51	1.4	nc
1345	1375.00	1.04	1.38	1.39	1.33	c	1.51	1.4	nc
1404	1406.67	1.04	1.38	1.39	1.33	c	1.51	1.4	nc
1405	1408.33	1.04	1.38	1.39	1.33	c	1.51	1.36	c
1450	1483.33	1.04	1.38	1.39	1.33	c	1.51	1.36	c
1451	1485.00	1.04	1.38	1.39	1.33	c	1.51	1.4	nc
1500	1500.00	1.04	1.38	1.39	1.33	c	1.51	1.4	nc
1501	1501.67	1.11	1.35	1.25	1.23	nc	1.47	1.4	nc
1504	1506.67	1.11	1.35	1.25	1.23	nc	1.47	1.4	nc
1505	1508.33	1.11	1.35	1.25	1.23	nc	1.47	1.76	c
1525	1541.67	1.11	1.35	1.25	1.23	nc	1.47	1.76	c
1526	1543.33	1.11	1.35	1.25	1.23	nc	1.47	1.68	nc
1531	1551.67	1.11	1.35	1.25	1.23	nc	1.47	1.68	nc
1532	1553.33	1.11	1.35	1.25	1.24	c	1.47	1.68	nc
1549	1581.67	1.11	1.35	1.25	1.24	c	1.47	1.68	nc
1550	1583.33	1.11	1.35	1.25	1.24	c	1.47	1.76	c
1615	1625.00	1.11	1.35	1.25	1.24	c	1.47	1.76	c
1616	1626.67	1.11	1.35	1.25	1.24	c	1.47	1.68	nc
1618	1630.00	1.11	1.35	1.25	1.24	c	1.47	1.68	nc
1619	1631.67	1.11	1.35	1.25	1.57	nc	1.47	1.68	nc
1830	1850.00	1.11	1.35	1.25	1.57	nc	1.47	1.68	nc
1900	1900.00	1.11	1.35	1.25			1.47		

Ammonia concentrations in mg/L (10/24/96)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2M event	pasture 3	pasture 3M	3M event
700	700.00	0.01	0.01	0	0.02	nc			
759	798.33	0.01	0.01	0	0.02	nc			
800	800.00	0.01	0.01	0	0.07	c		0.1	nc
829	848.33	0.01	0.01	0	0.07	c		0.1	nc
830	850.00	0.01	0.01	0	0.02	nc		0.1	nc
904	906.67	0.01	0.01	0	0.02	nc		0.1	nc
905	908.33	0.01	0.01	0	0.02	nc		0.09	c
919	931.67	0.01	0.01	0	0.02	nc		0.09	c
920	933.33	0.01	0.01	0	0.07	c		0.09	c
925	941.67	0.01	0.01	0	0.07	c		0.09	c
926	943.33	0.01	0.01	0	0.07	c		0.1	nc
950	983.33	0.01	0.01	0	0.07	c		0.1	nc
951	985.00	0.01	0.01	0	0.02	nc		0.1	nc
958	996.67	0.01	0.01	0	0.02	nc		0.1	nc
959	998.33	0.01	0.01	0	0.06	c		0.1	nc
1014	1023.33	0.01	0.01	0	0.06	c		0.1	nc
1015	1025.00	0.01	0.01	0	0.06	c		0.09	c
1016	1026.67	0.01	0.01	0	0.06	c		0.09	c
1017	1028.33	0.01	0.01	0	0.02	nc		0.09	c
1035	1058.33	0.01	0.01	0	0.02	nc		0.09	c
1036	1060.00	0.01	0.01	0	0.02	nc		0.1	nc
1049	1081.67	0.01	0.01	0	0.02	nc		0.1	nc
1050	1083.33	0.01	0.01	0	0.02	nc		0.06	c
1100	1100.00	0.01	0.01	0	0.02	nc		0.06	c
1101	1101.67	0.02	0.02	0.01	0.02	nc	0.09	0.06	c
1114	1123.33	0.02	0.02	0.01	0.02	nc	0.09	0.06	c
1115	1125.00	0.02	0.02	0.01	0.08	c	0.09	0.06	c
1124	1140.00	0.02	0.02	0.01	0.08	c	0.09	0.06	c
1125	1141.67	0.02	0.02	0.01	0.08	c	0.09	0.06	c
1126	1143.33	0.02	0.02	0.01	0.08	c	0.09	0.1	nc
1129	1148.33	0.02	0.02	0.01	0.08	c	0.09	0.1	nc
1130	1150.00	0.02	0.02	0.01	0.08	c	0.09	0.06	c
1143	1171.67	0.02	0.02	0.01	0.08	c	0.09	0.06	c
1144	1173.33	0.02	0.02	0.01	0.02	nc	0.09	0.06	c
1200	1200.00	0.02	0.02	0.01	0.02	nc	0.09	0.06	c
1201	1201.67	0.02	0.02	0.01	0.02	nc	0.09	0.1	nc
1219	1231.67	0.02	0.02	0.01	0.02	nc	0.09	0.1	nc
1220	1233.33	0.02	0.02	0.01	0.08	c	0.09	0.1	nc
1254	1290.00	0.02	0.02	0.01	0.08	c	0.09	0.1	nc
1255	1291.67	0.02	0.02	0.01	0.02	nc	0.09	0.1	nc
1256	1293.33	0.02	0.02	0.01	0.02	nc	0.09	0.13	nc
1311	1318.33	0.02	0.02	0.01	0.02	nc	0.09	0.13	nc
1344	1373.33	0.02	0.02	0.01	0.02	nc	0.09	0.13	nc
1345	1375.00	0.02	0.02	0.01	0.1	c	0.09	0.13	nc
1404	1406.67	0.02	0.02	0.01	0.1	c	0.09	0.13	nc
1405	1408.33	0.02	0.02	0.01	0.1	c	0.09	0.19	c
1450	1483.33	0.02	0.02	0.01	0.1	c	0.09	0.19	c
1451	1485.00	0.02	0.02	0.01	0.1	c	0.09	0.13	nc
1500	1500.00	0.02	0.02	0.01	0.1	c	0.09	0.13	nc
1501	1501.67	0.19	0.04	0.04	0.05	nc	0.13	0.13	nc
1504	1506.67	0.19	0.04	0.04	0.05	nc	0.13	0.13	nc
1505	1508.33	0.19	0.04	0.04	0.05	nc	0.13	0.19	c
1525	1541.67	0.19	0.04	0.04	0.05	nc	0.13	0.19	c
1526	1543.33	0.19	0.04	0.04	0.05	nc	0.13	0.09	nc
1531	1551.67	0.19	0.04	0.04	0.05	nc	0.13	0.09	nc
1532	1553.33	0.19	0.04	0.04	0.1	c	0.13	0.09	nc
1549	1581.67	0.19	0.04	0.04	0.1	c	0.13	0.09	nc
1550	1583.33	0.19	0.04	0.04	0.1	c	0.13	0.19	c
1615	1625.00	0.19	0.04	0.04	0.1	c	0.13	0.19	c
1616	1626.67	0.19	0.04	0.04	0.1	c	0.13	0.09	nc
1618	1630.00	0.19	0.04	0.04	0.1	c	0.13	0.09	nc
1619	1631.67	0.19	0.04	0.04	0.06	nc	0.13	0.09	nc
1830	1850.00	0.19	0.04	0.04	0.06	nc	0.13	0.09	nc
1900	1900.00	0.19	0.04	0.04			0.13		

Total Solids concentration in mg/L (10/24/96)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2M event	pasture 3	pasture 3M	3M event
700	700.00				356	nc			
759	798.33	401	326	251	356	nc			
800	800.00	401	326	251	382	c		423	nc
829	848.33	401	326	251	382	c		423	nc
830	850.00	401	326	251	356	nc		423	nc
904	906.67	401	326	251	356	nc		423	nc
905	908.33	401	326	251	356	nc		381	c
919	931.67	401	326	251	356	nc		381	c
920	933.33	401	326	251	382	c		381	c
925	941.67	401	326	251	382	c		381	c
926	943.33	401	326	251	382	c		423	nc
950	983.33	401	326	251	382	c		423	nc
951	985.00	401	326	251	356	nc		423	nc
958	996.67	401	326	251	356	nc		423	nc
959	998.33	401	326	251	394	c		423	nc
1014	1023.33	401	326	251	394	c		423	nc
1015	1025.00	401	326	251	394	c		381	c
1016	1026.67	401	326	251	394	c		381	c
1017	1028.33	401	326	251	356	nc		381	c
1035	1058.33	401	326	251	356	nc		381	c
1036	1060.00	401	326	251	356	nc		423	nc
1049	1081.67	401	326	251	356	nc		423	nc
1050	1083.33	401	326	251	356	nc		352	c
1100	1100.00	401	326	251	356	nc		352	c
1101	1101.67	378	398	423	356	nc	321	352	c
1114	1123.33	378	398	423	356	nc	321	352	c
1115	1125.00	378	398	423	399	c	321	352	c
1124	1140.00	378	398	423	399	c	321	352	c
1125	1141.67	378	398	423	399	c	321	352	c
1126	1143.33	378	398	423	399	c	321	423	nc
1129	1148.33	378	398	423	399	c	321	423	nc
1130	1150.00	378	398	423	399	c	321	352	c/3
1143	1171.67	378	398	423	399	c	321	352	c
1144	1173.33	378	398	423	391	nc	321	352	c
1200	1200.00	378	398	423	391	nc	321	352	c
1201	1201.67	378	398	423	391	nc	321	423	nc
1219	1231.67	378	398	423	391	nc	321	423	nc
1220	1233.33	378	398	423	399	c	321	423	nc
1254	1290.00	378	398	423	399	c	321	423	nc
1255	1291.67	378	398	423	391	nc	321	423	nc
1256	1293.33	378	398	423	391	nc	321	423	nc
1311	1318.33	378	398	423	391	nc	321	423	nc
1344	1373.33	378	398	423	391	nc	321	423	nc
1345	1375.00	378	398	423	361	c	321	423	nc
1404	1406.67	378	398	423	361	c	321	423	nc
1405	1408.33	378	398	423	361	c	321	364	c
1450	1483.33	378	398	423	361	c	321	364	c
1451	1485.00	378	398	423	361	c	321	316	nc
1500	1500.00	378	398	423	361	c	321	316	nc
1501	1501.67	317	326	378	298	nc	412	316	nc
1504	1506.67	317	326	378	298	nc	412	316	nc
1505	1508.33	317	326	378	298	nc	412	371	c
1525	1541.67	317	326	378	298	nc	412	371	c
1526	1543.33	317	326	378	298	nc	412	322	nc
1531	1551.67	317	326	378	298	nc	412	322	nc
1532	1553.33	317	326	378	392	c	412	322	nc
1549	1581.67	317	326	378	392	c	412	322	nc
1550	1583.33	317	326	378	392	c	412	371	c
1615	1625.00	317	326	378	392	c	412	371	c
1616	1626.67	317	326	378	392	c	412	322	nc
1618	1630.00	317	326	378	392	c	412	322	nc
1619	1631.67	317	326	378	341	nc	412	322	nc
1830	1850.00	317	326	378	341	nc	412	322	nc
1900	1900.00	317	326	378			412		

Total Organic Carbon (TOC) concentrations in mg/L (10/24/96)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2M event	pasture 3	pasture 3M	3M event
700	700.00	52.37	56.65	50.04	62.34	nc			
759	798.33	52.37	56.65	50.04	62.34	nc			
800	800.00	52.37	56.65	50.04	56.9	c		54.62	nc
829	848.33	52.37	56.65	50.04	56.9	c		54.62	nc
830	850.00	52.37	56.65	50.04	62.34	nc		54.62	nc
904	906.67	52.37	56.65	50.04	62.34	nc		54.62	nc
905	908.33	52.37	56.65	50.04	62.34	nc		54.42	c
919	931.67	52.37	56.65	50.04	62.34	nc		54.42	c
920	933.33	52.37	56.65	50.04	56.9	c		54.42	c
925	941.67	52.37	56.65	50.04	56.9	c		54.42	c
926	943.33	52.37	56.65	50.04	56.9	c		54.62	nc
950	983.33	52.37	56.65	50.04	56.9	c		54.62	nc
951	985.00	52.37	56.65	50.04	62.34	nc		54.62	nc
958	996.67	52.37	56.65	50.04	62.34	nc		54.62	nc
959	998.33	52.37	56.65	50.04	60.72	c		54.62	nc
1014	1023.33	52.37	56.65	50.04	60.72	c		54.62	nc
1015	1025.00	52.37	56.65	50.04	60.72	c		54.42	c
1016	1026.67	52.37	56.65	50.04	60.72	c		54.42	c
1017	1028.33	52.37	56.65	50.04	55.86	nc		54.42	c
1035	1058.33	52.37	56.65	50.04	55.86	nc		54.42	c
1036	1060.00	52.37	56.65	50.04	55.86	nc		54.62	nc
1049	1081.67	52.37	56.65	50.04	55.86	nc		54.62	nc
1050	1083.33	52.37	56.65	50.04	55.86	nc		55.25	c
1100	1100.00	52.37	56.65	50.04	55.86	nc		55.25	c
1101	1101.67	58.41	57.97	53.04	55.86	nc	57.35	55.25	c
1114	1123.33	58.41	57.97	53.04	55.86	nc	57.35	55.25	c
1115	1125.00	58.41	57.97	53.04	57.08	c	57.35	55.25	c
1124	1140.00	58.41	57.97	53.04	57.08	c	57.35	55.25	c
1125	1141.67	58.41	57.97	53.04	57.08	c	57.35	55.25	c
1126	1143.33	58.41	57.97	53.04	57.08	c	57.35	54.62	nc
1129	1148.33	58.41	57.97	53.04	57.08	c	57.35	54.62	nc
1130	1150.00	58.41	57.97	53.04	57.08	c	57.35	55.25	c
1143	1171.67	58.41	57.97	53.04	57.08	c	57.35	55.25	c
1144	1173.33	58.41	57.97	53.04	55.86	nc	57.35	55.25	c
1200	1200.00	58.41	57.97	53.04	55.86	nc	57.35	55.25	c
1201	1201.67	58.41	57.97	53.04	55.86	nc	57.35	54.62	nc
1219	1231.67	58.41	57.97	53.04	55.86	nc	57.35	54.62	nc
1220	1233.33	58.41	57.97	53.04	57.08	c	57.35	54.62	nc
1254	1290.00	58.41	57.97	53.04	57.08	c	57.35	54.62	nc
1255	1291.67	58.41	57.97	53.04	55.86	nc	57.35	54.62	nc
1256	1293.33	58.41	57.97	53.04	55.86	nc	57.35	55.64	nc
1311	1318.33	58.41	57.97	53.04	55.86	nc	57.35	54.62	nc
1344	1373.33	58.41	57.97	53.04	55.86	nc	57.35	54.62	nc
1345	1375.00	58.41	57.97	53.04	57.01	c	57.35	54.62	nc
1404	1406.67	58.41	57.97	53.04	57.01	c	57.35	54.62	nc
1405	1408.33	58.41	57.97	53.04	57.01	c	57.35	58.73	c
1450	1483.33	58.41	57.97	53.04	57.01	c	57.35	58.73	c
1451	1485.00	58.41	57.97	53.04	57.01	c	57.35	55.64	nc
1500	1500.00	58.41	57.97	53.04	57.01	c	57.35	55.64	nc
1501	1501.67	55.8	54.9	50.22	57.41	nc	61.72	55.64	nc
1504	1506.67	55.8	54.9	50.22	57.41	nc	61.72	55.64	nc
1505	1508.33	55.8	54.9	50.22	57.41	nc	61.72	51.06	c
1525	1541.67	55.8	54.9	50.22	57.41	nc	61.72	51.06	c
1526	1543.33	55.8	54.9	50.22	57.41	nc	61.72	48.57	nc
1531	1551.67	55.8	54.9	50.22	57.41	nc	61.72	48.57	nc
1532	1553.33	55.8	54.9	50.22	55.85	c	61.72	48.57	nc
1549	1581.67	55.8	54.9	50.22	55.85	c	61.72	48.57	nc
1550	1583.33	55.8	54.9	50.22	55.85	c	61.72	51.06	c
1615	1625.00	55.8	54.9	50.22	55.85	c	61.72	51.06	c
1616	1626.67	55.8	54.9	50.22	55.85	c	61.72	48.57	nc
1618	1630.00	55.8	54.9	50.22	55.85	c	61.72	48.57	nc
1619	1631.67	55.8	54.9	50.22	55.53	nc	61.72	48.57	nc
1830	1850.00	55.8	54.9	50.22	55.53	nc	61.72	48.57	nc
1900	1900.00	55.8	54.9	50.22			61.72		

BOD concentrations in mg/L (10/24/96)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2M event	pasture 3	pasture 3M	3M event
700	700.00	1.22	1.52	2.12	1.02	nc			
759	798.33	1.22	1.52	2.12	1.02	nc			
800	800.00	1.22	1.52	2.12	1.62	c		2.12	nc
829	848.33	1.22	1.52	2.12	1.62	c		2.12	nc
830	850.00	1.22	1.52	2.12	1.02	nc		2.12	nc
904	906.67	1.22	1.52	2.12	1.02	nc		2.12	nc
905	908.33	1.22	1.52	2.12	1.02	nc		1.82	c
919	931.67	1.22	1.52	2.12	1.02	nc		1.82	c
920	933.33	1.22	1.52	2.12	1.62	c		1.82	c
925	941.67	1.22	1.52	2.12	1.62	c		1.82	c
926	943.33	1.22	1.52	2.12	1.62	c		2.12	nc
950	983.33	1.22	1.52	2.12	1.62	c		2.12	nc
951	985.00	1.22	1.52	2.12	1.02	nc		2.12	nc
958	996.67	1.22	1.52	2.12	1.02	nc		2.12	nc
959	998.33	1.22	1.52	2.12	3.12	c		2.12	nc
1014	1023.33	1.22	1.52	2.12	3.12	c		2.12	nc
1015	1025.00	1.22	1.52	2.12	3.12	c		1.82	c
1016	1026.67	1.22	1.52	2.12	3.12	c		1.82	c
1017	1028.33	1.22	1.52	2.12	0.62	nc		1.82	c
1035	1058.33	1.22	1.52	2.12	0.62	nc		1.82	c
1036	1060.00	1.22	1.52	2.12	0.62	nc		2.12	nc
1049	1081.67	1.22	1.52	2.12	0.62	nc		2.12	nc
1050	1083.33	1.22	1.52	2.12	0.62	nc		1.42	c
1100	1100.00	1.22	1.52	2.12	0.62	nc		1.42	c
1101	1101.67	0.72	0.72	1.32	0.62	nc	1.22	1.42	c
1114	1123.33	0.72	0.72	1.32	0.62	nc	1.22	1.42	c
1115	1125.00	0.72	0.72	1.32	1.32	c	1.22	1.42	c
1124	1140.00	0.72	0.72	1.32	1.32	c	1.22	1.42	c
1125	1141.67	0.72	0.72	1.32	1.32	c	1.22	1.42	c
1126	1143.33	0.72	0.72	1.32	1.32	c	1.22	2.12	nc
1129	1148.33	0.72	0.72	1.32	1.32	c	1.22	2.12	nc
1130	1150.00	0.72	0.72	1.32	1.32	c	1.22	1.42	c
1143	1171.67	0.72	0.72	1.32	1.32	c	1.22	1.42	c
1144	1173.33	0.72	0.72	1.32	0.62	nc	1.22	1.42	c
1200	1200.00	0.72	0.72	1.32	0.62	nc	1.22	1.42	c
1201	1201.67	0.72	0.72	1.32	0.62	nc	1.22	2.12	nc
1219	1231.67	0.72	0.72	1.32	0.62	nc	1.22	2.12	nc
1220	1233.33	0.72	0.72	1.32	1.32	c	1.22	2.12	nc
1254	1290.00	0.72	0.72	1.32	1.32	c	1.22	2.12	nc
1255	1291.67	0.72	0.72	1.32	0.62	nc	1.22	2.12	nc
1256	1293.33	0.72	0.72	1.32	0.62	nc	1.22	1.12	nc
1311	1318.33	0.72	0.72	1.32	0.62	nc	1.22	1.12	nc
1344	1373.33	0.72	0.72	1.32	0.62	nc	1.22	1.12	nc
1345	1375.00	0.72	0.72	1.32	3.12	c	1.22	1.12	nc
1404	1406.67	0.72	0.72	1.32	3.12	c	1.22	1.12	nc
1405	1408.33	0.72	0.72	1.32	3.12	c	1.22	5.52	c
1450	1483.33	0.72	0.72	1.32	3.12	c	1.22	5.52	c
1451	1485.00	0.72	0.72	1.32	3.12	c	1.22	1.12	nc
1500	1500.00	0.72	0.72	1.32	3.12	c	1.22	1.12	nc
1501	1501.67	0.42	1.12	1.62	0.82	nc	1.72	1.12	nc
1504	1506.67	0.42	1.12	1.62	0.82	nc	1.72	1.12	nc
1505	1508.33	0.42	1.12	1.62	0.82	nc	1.72	1.02	c
1525	1541.67	0.42	1.12	1.62	0.82	nc	1.72	1.02	c
1526	1543.33	0.42	1.12	1.62	0.82	nc	1.72	1.12	nc
1531	1551.67	0.42	1.12	1.62	0.82	nc	1.72	1.12	nc
1532	1553.33	0.42	1.12	1.62	1.12	c	1.72	1.12	nc
1549	1581.67	0.42	1.12	1.62	1.12	c	1.72	1.12	nc
1550	1583.33	0.42	1.12	1.62	1.12	c	1.72	1.02	c
1615	1625.00	0.42	1.12	1.62	1.12	c	1.72	1.02	c
1616	1626.67	0.42	1.12	1.62	1.12	c	1.72	1.02	nc
1618	1630.00	0.42	1.12	1.62	1.12	c	1.72	1.02	nc
1619	1631.67	0.42	1.12	1.62	1.02	nc	1.72	1.02	nc
1830	1850.00	0.42	1.12	1.62	1.02	nc	1.72	1.02	nc
1900	1900.00	0.42	1.12	1.62			1.72		

Fecal Coliform concentrations in cfu/100mL (10/24/96)

timo(cst)	Ab. timo	control	pasture 1	tributary	pasturo 2M	2M ovont	pasture 3	pasturo 3M	3M ovont
700	700.00	1000	500	2500	2500	nc			
759	798.33	1000	500	2500	2500	nc			
800	800.00	1000	500	2500	7000	c		1500	nc
829	848.33	1000	500	2500	7000	c		1500	nc
830	850.00	1000	500	2500	2500	nc		1500	nc
904	906.67	1000	500	2500	2500	nc		1500	nc
905	908.33	1000	500	2500	2500	nc		1700	c
919	931.67	1000	500	2500	2500	nc		1700	c
920	933.33	1000	500	2500	7000	c		1700	c
925	941.67	1000	500	2500	7000	c		1700	c
926	943.33	1000	500	2500	7000	c		1500	nc
950	983.33	1000	500	2500	7000	c		1500	nc
951	985.00	1000	500	2500	2500	nc		1500	nc
958	996.67	1000	500	2500	2500	nc		1500	nc
959	998.33	1000	500	2500	4200	c		1500	nc
100014	100023.33	1000	500	2500	4200	c		1500	nc
100015	100025.00	1000	500	2500	4200	c		1700	c
100016	100026.67	1000	500	2500	4200	c		1700	c
100017	100028.33	1000	500	2500	800	nc		1700	c
100035	100058.33	1000	500	2500	800	nc		1700	c
100036	100060.00	1000	500	2500	800	nc		1500	nc
100049	100081.67	1000	500	2500	800	nc		1500	nc
100050	100083.33	1000	500	2500	800	nc		1600	c
110000	110000.00	1000	500	2500	800	nc		1600	c
1101	1101.67	700	600	2200	800	nc	1800	1600	c
1114	1123.33	700	600	2200	800	nc	1800	1600	c
1115	1125.00	700	600	2200	8300	c	1800	1600	c
1124	1140.00	700	600	2200	8300	c	1800	1600	c
1125	1141.67	700	600	2200	8300	c	1800	1600	c
1126	1143.33	700	600	2200	8300	c	1800	1500	nc
1129	1148.33	700	600	2200	8300	c	1800	1500	nc
1130	1150.00	700	600	2200	8300	c	1800	1600	c
1143	1171.67	700	600	2200	8300	c	1800	1600	c
1144	1173.33	700	600	2200	800	nc	1800	1600	c
1200	1200.00	700	600	2200	800	nc	1800	1600	c
1201	1201.67	700	600	2200	800	nc	1800	1500	nc
1219	1231.67	700	600	2200	800	nc	1800	1500	nc
1220	1233.33	700	600	2200	8300	c	1800	1500	nc
1254	1290.00	700	600	2200	8300	c	1800	1500	nc
1255	1291.67	700	600	2200	800	nc	1800	1500	nc
1256	1293.33	700	600	2200	800	nc	1800	2100	nc
1311	1318.33	700	600	2200	800	nc	1800	2100	nc
1344	1373.33	700	600	2200	800	nc	1800	2100	nc
1345	1375.00	700	600	2200	6700	c	1800	2100	nc
1404	1406.67	700	600	2200	6700	c	1800	2100	nc
1405	1408.33	700	600	2200	6700	c	1800	1700	c
1450	1483.33	700	600	2200	6700	c	1800	1700	c
1451	1485.00	700	600	2200	6700	c	1800	2100	nc
1500	1500.00	700	600	2200	6700	c	1800	2100	nc
1501	1501.67	1100	700	1600	2200	nc	2800	2100	nc
1504	1506.67	1100	700	1600	2200	nc	2800	2100	nc
1505	1508.33	1100	700	1600	2200	nc	2800	2600	c
1525	1541.67	1100	700	1600	2200	nc	2800	2600	c
1526	1543.33	1100	700	1600	2200	nc	2800	1800	nc
1531	1551.67	1100	700	1600	2200	nc	2800	1800	nc
1532	1553.33	1100	700	1600	5900	c	2800	1800	nc
1549	1581.67	1100	700	1600	5900	c	2800	1800	nc
1550	1583.33	1100	700	1600	5900	c	2800	2600	c
1615	1625.00	1100	700	1600	5900	c	2800	2600	c
1616	1626.67	1100	700	1600	5900	c	2800	1800	nc
1618	1630.00	1100	700	1600	5900	c	2800	1800	nc
1619	1631.67	1100	700	1600	1500	nc	2800	1800	nc
1830	1850.00	1100	700	1600	1500	nc	2800	1800	nc
1900	1900.00	1100	700	1600			2800		

Nitrate concentrations in mg/L (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m (event)	pasture 3	pasture 3M	3m (event)
800	800.00	2.35	2.57	2.3			2.6		
805	808.33	2.35	2.57	2.3			2.6	2.51	NC
830	850.00	2.35	2.57	2.3	2.48	NC	2.6	2.51	NC
1000	1000.00	2.35	2.57	2.3	2.48	NC	2.6	2.51	NC
1001	1001.67	2.35	2.57	2.3	2.54	C	2.6	2.51	NC
1010	1016.67	2.35	2.57	2.3	2.54	C	2.6	2.51	NC
1030	1050.00	2.35	2.57	2.3	2.54	C	2.6	2.51	NC
1031	1051.67	2.35	2.57	2.3	2.42	NC	2.6	2.51	NC
1100	1100.00	2.35	2.57	2.3	2.42	NC	2.6	2.51	NC
1101	1101.67	2.35	2.57	2.3	2.3	NC	2.6	2.51	NC
1145	1175.00	2.35	2.57	2.3	2.3	NC	2.6	2.51	NC
1146	1176.67	2.35	2.57	2.3	2.3	NC	2.6	2.56	NC
1159	1198.33	2.35	2.57	2.3	2.3	NC	2.6	2.56	NC
1200	1200.00	2.38	2.33	2.21	2.3	NC	2.26	2.56	NC
1210	1216.67	2.38	2.33	2.21	2.3	NC	2.26	2.56	NC
1219	1231.67	2.38	2.33	2.21	2.3	NC	2.26	2.56	NC
1220	1233.33	2.38	2.33	2.21	2.3	NC	2.26	2.45	C
1235	1258.33	2.38	2.33	2.21	2.3	NC	2.26	2.45	C
1236	1260.00	2.38	2.33	2.21	2.3	NC	2.26	2.56	NC
1325	1341.67	2.38	2.33	2.21	2.3	NC	2.26	2.56	NC
1326	1343.33	2.38	2.33	2.21	2.46	C	2.26	2.56	NC
1335	1358.33	2.38	2.33	2.21	2.46	C	2.26	2.56	NC
1336	1360.00	2.38	2.33	2.21	2.26	NC	2.26	2.56	NC
1520	1533.33	2.38	2.33	2.21	2.26	NC	2.26	2.56	NC
1521	1535.00	2.38	2.33	2.21	2.26	NC	2.26	2.22	NC
1535	1558.33	2.38	2.33	2.21	2.26	NC	2.26	2.22	NC
1800	1800.00	2.38	2.33	2.21	2.26	NC	2.26	2.22	NC
1815	1825.00				2.26	NC		2.22	NC
1820	1833.33							2.22	NC

Ammonia concentrations in mg/L (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
800	800.00	0.02	0.03	0.07			0.11		
805	808.33	0.02	0.03	0.07			0.11	ND<0.02	NC
830	850.00	0.02	0.03	0.07	ND<0.02	NC	0.11	ND<0.02	NC
1000	1000.00	0.02	0.03	0.07	ND<0.02	NC	0.11	ND<0.02	NC
1001	1001.67	0.02	0.03	0.07	ND<0.02	C	0.11	ND<0.02	NC
1010	1016.67	0.02	0.03	0.07	ND<0.02	C	0.11	ND<0.02	NC
1030	1050.00	0.02	0.03	0.07	ND<0.02	C	0.11	ND<0.02	NC
1031	1051.67	0.02	0.03	0.07	0.07	NC	0.11	ND<0.02	NC
1100	1100.00	0.02	0.03	0.07	0.07	NC	0.11	ND<0.02	NC
1101	1101.67	0.02	0.03	0.07	0.05	NC	0.11	ND<0.02	NC
1145	1175.00	0.02	0.03	0.07	0.05	NC	0.11	ND<0.02	NC
1146	1176.67	0.02	0.03	0.07	0.05	NC	0.11	0.08	NC
1159	1198.33	0.02	0.03	0.07	0.05	NC	0.11	0.08	NC
1200	1200.00	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.08	NC
1210	1216.67	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.08	NC
1219	1231.67	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.08	NC
1220	1233.33	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.07	C
1235	1258.33	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.07	C
1236	1260.00	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.08	NC
1325	1341.67	ND<0.02	ND<0.02	0.08	0.05	NC	0.13	0.08	NC
1326	1343.33	ND<0.02	ND<0.02	0.08	0.13	C	0.13	0.08	NC
1335	1358.33	ND<0.02	ND<0.02	0.08	0.13	C	0.13	0.08	NC
1336	1360.00	ND<0.02	ND<0.02	0.08	ND<0.02	NC	0.13	0.08	NC
1520	1533.33	ND<0.02	ND<0.02	0.08	ND<0.02	NC	0.13	0.08	NC
1521	1535.00	ND<0.02	ND<0.02	0.08	ND<0.02	NC	0.13	ND<0.02	NC
1535	1558.33	ND<0.02	ND<0.02	0.08	ND<0.02	NC	0.13	ND<0.02	NC
1800	1800.00	ND<0.02	ND<0.02	0.08	ND<0.02	NC	0.13	ND<0.02	NC
1815	1825.00				ND<0.02	NC		ND<0.02	NC
1820	1833.33							ND<0.02	NC

Total Solids concentrations in mg/L (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
800	800.00	337	358	316			411		
805	808.33	337	358	316			411	401	NC
830	850.00	337	358	316	328	NC	411	401	NC
1000	1000.00	337	358	316	328	NC	411	401	NC
1001	1001.67	337	358	316	361	C	411	401	NC
1010	1016.67	337	358	316	361	C	411	401	NC
1030	1050.00	337	358	316	361	C	411	401	NC
1031	1051.67	337	358	316	399	NC	411	401	NC
1100	1100.00	337	358	316	399	NC	411	401	NC
1101	1101.67	337	358	316	387	NC	411	401	NC
1145	1175.00	337	358	316	387	NC	411	401	NC
1146	1176.67	337	358	316	387	NC	411	341	NC
1159	1198.33	337	358	316	387	NC	411	341	NC
1200	1200.00	325	364	382	387	NC	341	341	NC
1210	1216.67	325	364	382	387	NC	341	341	NC
1219	1231.67	325	364	382	387	NC	341	341	NC
1220	1233.33	325	364	382	387	NC	341	376	C
1235	1258.33	325	364	382	387	NC	341	376	C
1236	1260.00	325	364	382	387	NC	341	341	NC
1325	1341.67	325	364	382	387	NC	341	341	NC
1326	1343.33	325	364	382	325	C	341	341	NC
1335	1358.33	325	364	382	325	C	341	341	NC
1336	1360.00	325	364	382	415	NC	341	341	NC
1520	1533.33	325	364	382	415	NC	341	341	NC
1521	1535.00	325	364	382	415	NC	341	462	NC
1535	1558.33	325	364	382	415	NC	341	462	NC
1800	1800.00	325	364	382	415	NC	341	462	NC
1815	1825.00				415	NC		462	NC
1820	1833.33							462	NC

TOC concentrations in mg/L (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
800	800.00	34.05	33.59	39.39			36.84		
805	808.33	34.05	33.59	39.39			36.84	35.93	NC
830	850.00	34.05	33.59	39.39	34.44	NC	36.84	35.93	NC
1000	1000.00	34.05	33.59	39.39	34.44	NC	36.84	35.93	NC
1001	1001.67	34.05	33.59	39.39	37.08	C	36.84	35.93	NC
1010	1016.67	34.05	33.59	39.39	37.08	C	36.84	35.93	NC
1030	1050.00	34.05	33.59	39.39	37.08	C	36.84	35.93	NC
1031	1051.67	34.05	33.59	39.39	35.9	NC	36.84	35.93	NC
1100	1100.00	34.05	33.59	39.39	35.9	NC	36.84	35.93	NC
1101	1101.67	34.05	33.59	39.39	36.77	NC	36.84	35.93	NC
1145	1175.00	34.05	33.59	39.39	36.77	NC	36.84	35.93	NC
1146	1176.67	34.05	33.59	39.39	36.77	NC	36.84	35.5	NC
1159	1198.33	34.05	33.59	39.39	36.77	NC	36.84	35.5	NC
1200	1200.00	31.13	33.94	38.79	36.77	NC	37.06	35.5	NC
1210	1216.67	31.13	33.94	38.79	36.77	NC	37.06	35.5	NC
1219	1231.67	31.13	33.94	38.79	36.77	NC	37.06	35.5	NC
1220	1233.33	31.13	33.94	38.79	36.77	NC	37.06	35.73	C
1235	1258.33	31.13	33.94	38.79	36.77	NC	37.06	35.73	C
1236	1260.00	31.13	33.94	38.79	36.77	NC	37.06	35.5	NC
1325	1341.67	31.13	33.94	38.79	36.77	NC	37.06	35.5	NC
1326	1343.33	31.13	33.94	38.79	36.56	C	37.06	35.5	NC
1335	1358.33	31.13	33.94	38.79	36.56	C	37.06	35.5	NC
1336	1360.00	31.13	33.94	38.79	35.65	NC	37.06	35.5	NC
1520	1533.33	31.13	33.94	38.79	35.65	NC	37.06	35.5	NC
1521	1535.00	31.13	33.94	38.79	35.65	NC	37.06	34.82	NC
1535	1558.33	31.13	33.94	38.79	35.65	NC	37.06	34.82	NC
1800	1800.00	31.13	33.94	38.79	35.65	NC	37.06	34.82	NC
1815	1825.00				35.65	NC		34.82	NC
1820	1833.33							34.82	NC

BOD concentrations in mg/L (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
800	800.00	1.47	1.47	1.57			1.67		
805	808.33	1.47	1.47	1.57			1.67	1.77	NC
830	850.00	1.47	1.47	1.57	1.67	NC	1.67	1.77	NC
1000	1000.00	1.47	1.47	1.57	1.67	NC	1.67	1.77	NC
1001	1001.67	1.47	1.47	1.57	1.47	C	1.67	1.77	NC
1010	1016.67	1.47	1.47	1.57	1.47	C	1.67	1.77	NC
1030	1050.00	1.47	1.47	1.57	1.47	C	1.67	1.77	NC
1031	1051.67	1.47	1.47	1.57	1.37	NC	1.67	1.77	NC
1100	1100.00	1.47	1.47	1.57	1.37	NC	1.67	1.77	NC
1101	1101.67	1.47	1.47	1.57	1.87	NC	1.67	1.77	NC
1145	1175.00	1.47	1.47	1.57	1.87	NC	1.67	1.77	NC
1146	1176.67	1.47	1.47	1.57	1.87	NC	1.67	1.97	NC
1159	1198.33	1.47	1.47	1.57	1.87	NC	1.67	1.97	NC
1200	1200.00	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1210	1216.67	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1219	1231.67	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1220	1233.33	1.67	1.67	1.87	1.87	NC	1.77	1.67	C
1235	1258.33	1.67	1.67	1.87	1.87	NC	1.77	1.67	C
1236	1260.00	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1325	1341.67	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1326	1343.33	1.67	1.67	1.87	1.17	C	1.77	1.97	NC
1335	1358.33	1.67	1.67	1.87	1.17	C	1.77	1.97	NC
1336	1360.00	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1520	1533.33	1.67	1.67	1.87	1.87	NC	1.77	1.97	NC
1521	1535.00	1.67	1.67	1.87	1.87	NC	1.77	2.07	NC
1535	1558.33	1.67	1.67	1.87	1.87	NC	1.77	2.07	NC
1800	1800.00	1.67	1.67	1.87	1.87	NC	1.77	2.07	NC
1815	1825.00				1.87	NC		2.07	NC
1820	1833.33							2.07	NC

Fecal Coliform concentrations in cfu/100mL (2/13/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
800	800.00	200	600	1000			700		
805	808.33	200	600	1000			700	700	NC
830	850.00	200	600	1000	200	NC	700	700	NC
1000	1000.00	200	600	1000	200	NC	700	700	NC
1001	1001.67	200	600	1000	1200	C	700	700	NC
1010	1016.67	200	600	1000	1200	C	700	700	NC
1030	1050.00	200	600	1000	1200	C	700	700	NC
1031	1051.67	200	600	1000	100	NC	700	700	NC
1100	1100.00	200	600	1000	100	NC	700	700	NC
1101	1101.67	200	600	1000	0	NC	700	700	NC
1145	1175.00	200	600	1000	0	NC	700	700	NC
1146	1176.67	200	600	1000	0	NC	700	1100	NC
1159	1198.33	200	600	1000	0	NC	700	1100	NC
1200	1200.00	400	300	1800	0	NC	1300	1100	NC
1210	1216.67	400	300	1800	0	NC	1300	1100	NC
1219	1231.67	400	300	1800	0	NC	1300	1100	NC
1220	1233.33	400	300	1800	0	NC	1300	2200	C
1235	1258.33	400	300	1800	0	NC	1300	2200	C
1236	1260.00	400	300	1800	0	NC	1300	1100	NC
1325	1341.67	400	300	1800	0	NC	1300	1100	NC
1326	1343.33	400	300	1800	700	C	1300	1100	NC
1335	1358.33	400	300	1800	700	C	1300	1100	NC
1336	1360.00	400	300	1800	500	NC	1300	1100	NC
1520	1533.33	400	300	1800	500	NC	1300	1100	NC
1521	1535.00	400	300	1800	500	NC	1300	600	NC
1535	1558.33	400	300	1800	500	NC	1300	600	NC
1800	1800.00	400	300	1800	500	NC	1300	600	NC
1815	1825.00				500	NC		600	NC
1820	1833.33							600	NC

Nitrate concentrations in mg/L (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	1.55	1.42	1.72			1.55		
720	733.33	1.55	1.42	1.72	1.3	NC	1.55		
730	750.00	1.55	1.42	1.72	1.3	NC	1.55	1.09	C
745	775.00	1.55	1.42	1.72	1.3	NC	1.55	1.09	C
746	776.67	1.55	1.42	1.72	1.3	NC	1.55	1.94	NC
850	883.33	1.55	1.42	1.72	1.3	NC	1.55	1.94	NC
851	885.00	·1.55	1.42	1.72	1.3	NC	1.55	1.89	C
905	908.33	1.55	1.42	1.72	1.3	NC	1.55	1.89	C
906	910.00	1.55	1.42	1.72	1.3	NC	1.55	1.65	C
1015	1025.00	1.55	1.42	1.72	1.3	NC	1.55	1.65	C
1016	1026.67	1.55	1.42	1.72	2.49	C	1.55	1.65	C
1030	1050.00	1.55	1.42	1.72	2.49	C	1.55	1.65	C
1031	1051.67	1.55	1.42	1.72	2.49	C	1.55	1.47	C
1050	1083.33	1.55	1.42	1.72	2.49	C	1.55	1.47	C
1051	1085.00	1.55	1.42	1.72	1.84	NC	1.55	1.47	C
1102	1103.33	1.55	1.42	1.72	1.84	NC	1.55	1.47	C
1103	1105.00	1.55	1.42	1.72	2.16	C	1.55	1.47	C
1112	1120.00	1.55	1.42	1.72	2.16	C	1.55	1.47	C
1113	1121.67	1.55	1.42	1.72	1.84	NC	1.55	1.47	C
1220	1233.33	1.55	1.42	1.72	1.84	NC	1.55	1.47	C
1221	1235.00	1.55	1.42	1.72	1.46	C	1.55	1.47	C
1225	1241.67	1.55	1.42	1.72	1.46	C	1.55	1.47	C
1226	1243.33	1.55	1.42	1.72	1.46	C	1.55	1.2	C
1235	1258.33	1.55	1.42	1.72	1.46	C	1.55	1.2	C
1236	1260.00	1.55	1.42	1.72	1.48	NC	1.55	1.2	C
1300	1300.00	1.55	1.42	1.72	1.48	NC	1.55	1.2	C
1301	1301.67	1.54	1.76	2.81	1.48	NC	2.07	1.2	C
1304	1306.67	1.54	1.76	2.81	1.48	NC	2.07	1.2	C
1305	1308.33	1.54	1.76	2.81	1.46	C	2.07	1.2	C
1330	1350.00	1.54	1.76	2.81	1.46	C	2.07	1.2	C
1331	1351.67	1.54	1.76	2.81	1.48	NC	2.07	1.2	C
1335	1358.33	1.54	1.76	2.81	1.48	NC	2.07	1.2	C
1336	1360.00	1.54	1.76	2.81	1.48	NC	2.07	1.86	NC
1355	1391.67	1.54	1.76	2.81	1.48	NC	2.07	1.86	NC
1356	1393.33	1.54	1.76	2.81	1.48	NC	2.07	1.18	C
1359	1398.33	1.54	1.76	2.81	1.48	NC	2.07	1.18	C
1400	1400.00	1.54	1.76	2.81	1.46	C	2.07	1.18	C
1406	1410.00	1.54	1.76	2.81	1.46	C	2.07	1.18	C
1407	1411.67	1.54	1.76	2.81	1.39	NC	2.07	1.18	C
1459	1498.33	1.54	1.76	2.81	1.39	NC	2.07	1.18	C
1500	1500.00	1.54	1.76	2.81	1.46	C	2.07	1.18	C
1545	1575.00	1.54	1.76	2.81	1.46	C	2.07	1.18	C
1546	1576.67	1.54	1.76	2.81	1.39	NC	2.07	1.18	C
1554	1590.00	1.54	1.76	2.81	1.39	NC	2.07	1.18	C
1555	1591.67	1.54	1.76	2.81	1.17	C	2.07	1.18	C
1605	1608.33	1.54	1.76	2.81	1.17	C	2.07	1.18	C
1606	1610.00	1.54	1.76	2.81	1.17	C	2.07	1.54	NC
1615	1625.00	1.54	1.76	2.81	1.17	C	2.07	1.54	NC
1616	1626.67	1.54	1.76	2.81	1.39	NC	2.07	1.54	NC
1620	1633.33	1.54	1.76	2.81	1.39	NC	2.07	1.54	NC
1621	1635.00	1.54	1.76	2.81	1.39	NC	2.07	1.46	C
1830	1850.00	1.54	1.76	2.81	1.39	NC	2.07	1.46	C

Ammonia concentrations in mg/L (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	0.04	0.03	0.13			0.08		
720	733.33	0.04	0.03	0.13	0.02	NC	0.08		
730	750.00	0.04	0.03	0.13	0.02	NC	0.08	0.05	C
745	775.00	0.04	0.03	0.13	0.02	NC	0.08	0.05	C
746	776.67	0.04	0.03	0.13	0.02	NC	0.08	0.09	NC
850	883.33	0.04	0.03	0.13	0.02	NC	0.08	0.09	NC
851	885.00	0.04	0.03	0.13	0.02	NC	0.08	0.04	C
905	908.33	0.04	0.03	0.13	0.02	NC	0.08	0.04	C
906	910.00	0.04	0.03	0.13	0.02	NC	0.08	0.02	C
1015	1025.00	0.04	0.03	0.13	0.02	NC	0.08	0.02	C
1016	1026.67	0.04	0.03	0.13	0.08	C	0.08	0.02	C
1030	1050.00	0.04	0.03	0.13	0.08	C	0.08	0.02	C
1031	1051.67	0.04	0.03	0.13	0.08	C	0.08	ND<.02	C
1050	1083.33	0.04	0.03	0.13	0.08	C	0.08	ND<.02	C
1051	1085.00	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1102	1103.33	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1103	1105.00	0.04	0.03	0.13	0.07	C	0.08	ND<.02	C
1112	1120.00	0.04	0.03	0.13	0.07	C	0.08	ND<.02	C
1113	1121.67	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1220	1233.33	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1221	1235.00	0.04	0.03	0.13	ND<.02	C	0.08	ND<.02	C
1225	1241.67	0.04	0.03	0.13	ND<.02	C	0.08	ND<.02	C
1226	1243.33	0.04	0.03	0.13	ND<.02	C	0.08	ND<.02	C
1235	1258.33	0.04	0.03	0.13	ND<.02	C	0.08	ND<.02	C
1236	1260.00	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1300	1300.00	0.04	0.03	0.13	ND<.02	NC	0.08	ND<.02	C
1301	1301.67	0.04	0.03	0.06	ND<.02	NC	0.1	ND<.02	C
1304	1306.67	0.04	0.03	0.06	ND<.02	NC	0.1	ND<.02	C
1305	1308.33	0.04	0.03	0.06	ND<.02	C	0.1	ND<.02	C
1330	1350.00	0.04	0.03	0.06	ND<.02	C	0.1	ND<.02	C
1331	1351.67	0.04	0.03	0.06	ND<.02	NC	0.1	ND<.02	C
1335	1358.33	0.04	0.03	0.06	ND<.02	NC	0.1	ND<.02	C
1336	1360.00	0.04	0.03	0.06	ND<.02	NC	0.1	0.01	NC
1355	1391.67	0.04	0.03	0.06	ND<.02	NC	0.1	0.01	NC
1356	1393.33	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1359	1398.33	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1400	1400.00	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1406	1410.00	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1407	1411.67	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1459	1498.33	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1500	1500.00	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1545	1575.00	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1546	1576.67	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1554	1590.00	0.04	0.03	0.06	ND<.02	NC	0.1	0.03	C
1555	1591.67	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1605	1608.33	0.04	0.03	0.06	ND<.02	C	0.1	0.03	C
1606	1610.00	0.04	0.03	0.06	ND<.02	C	0.1	0.07	NC
1615	1625.00	0.04	0.03	0.06	ND<.02	C	0.1	0.07	NC
1616	1626.67	0.04	0.03	0.06	ND<.02	NC	0.1	0.07	NC
1620	1633.33	0.04	0.03	0.06	ND<.02	NC	0.1	0.07	NC
1621	1635.00	0.04	0.03	0.06	ND<.02	NC	0.1	0.11	C
1830	1850.00	0.04	0.03	0.06	ND<.02	NC	0.1	0.11	C

Total Solids concentrations in mg/L (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	348	404	396			544		
720	733.33	348	404	396	340	NC	544		
730	750.00	348	404	396	340	NC	544	336	C
745	775.00	348	404	396	340	NC	544	336	C
746	776.67	348	404	396	340	NC	544	340	NC
850	883.33	348	404	396	340	NC	544	340	NC
851	885.00	348	404	396	340	NC	544	400	C
905	908.33	348	404	396	340	NC	544	400	C
906	910.00	348	404	396	340	NC	544	364	C
1015	1025.00	348	404	396	340	NC	544	364	C
1016	1026.67	348	404	396	524	C	544	364	C
1030	1050.00	348	404	396	524	C	544	364	C
1031	1051.67	348	404	396	524	C	544	344	C
1050	1083.33	348	404	396	524	C	544	344	C
1051	1085.00	348	404	396	360	NC	544	344	C
1102	1103.33	348	404	396	360	NC	544	344	C
1103	1105.00	348	404	396	312	C	544	344	C
1112	1120.00	348	404	396	312	C	544	344	C
1113	1121.67	348	404	396	360	NC	544	344	C
1220	1233.33	348	404	396	360	NC	544	344	C
1221	1235.00	348	404	396	364	C	544	344	C
1225	1241.67	348	404	396	364	C	544	344	C
1226	1243.33	348	404	396	364	C	544	360	C
1235	1258.33	348	404	396	364	C	544	360	C
1236	1260.00	348	404	396	316	NC	544	360	C
1300	1300.00	348	404	396	316	NC	544	360	C
1301	1301.67	340	284	364	316	NC	308	360	C
1304	1306.67	340	284	364	316	NC	308	360	C
1305	1308.33	340	284	364	364	C	308	360	C
1330	1350.00	340	284	364	364	C	308	360	C
1331	1351.67	340	284	364	316	NC	308	360	C
1335	1358.33	340	284	364	316	NC	308	360	C
1336	1360.00	340	284	364	316	NC	308	408	NC
1355	1391.67	340	284	364	316	NC	308	408	NC
1356	1393.33	340	284	364	316	NC	308	348	C
1359	1398.33	340	284	364	316	NC	308	348	C
1400	1400.00	340	284	364	364	C	308	348	C
1406	1410.00	340	284	364	364	C	308	348	C
1407	1411.67	340	284	364	328	NC	308	348	C
1459	1498.33	340	284	364	328	NC	308	348	C
1500	1500.00	340	284	364	364	C	308	348	C
1545	1575.00	340	284	364	364	C	308	348	C
1546	1576.67	340	284	364	328	NC	308	348	C
1554	1590.00	340	284	364	328	NC	308	348	C
1555	1591.67	340	284	364	404	C	308	348	C
1605	1608.33	340	284	364	404	C	308	348	C
1606	1610.00	340	284	364	404	C	308	404	NC
1615	1625.00	340	284	364	404	C	308	404	NC
1616	1626.67	340	284	364	328	NC	308	404	NC
1620	1633.33	340	284	364	328	NC	308	404	NC
1621	1635.00	340	284	364	328	NC	308	396	C
1830	1850.00	340	284	364	328	NC	308	396	C

TOC concentrations in mg/L (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	37.16	36.51	39.62			37.66		
720	733.33	37.16	36.51	39.62	35.48	NC	37.66		
730	750.00	37.16	36.51	39.62	35.48	NC	37.66	36.41	C
745	775.00	37.16	36.51	39.62	35.48	NC	37.66	36.41	C
746	776.67	37.16	36.51	39.62	35.48	NC	37.66	36.96	NC
850	883.33	37.16	36.51	39.62	35.48	NC	37.66	36.96	NC
851	885.00	37.16	36.51	39.62	35.48	NC	37.66	38.17	C
905	908.33	37.16	36.51	39.62	35.48	NC	37.66	38.17	C
906	910.00	37.16	36.51	39.62	35.48	NC	37.66	37.95	C
1015	1025.00	37.16	36.51	39.62	35.48	NC	37.66	37.95	C
1016	1026.67	37.16	36.51	39.62	39.84	C	37.66	37.95	C
1030	1050.00	37.16	36.51	39.62	39.84	C	37.66	37.95	C
1031	1051.67	37.16	36.51	39.62	39.84	C	37.66	39.09	C
1050	1083.33	37.16	36.51	39.62	39.84	C	37.66	39.09	C
1051	1085.00	37.16	36.51	39.62	38.91	NC	37.66	39.09	C
1102	1103.33	37.16	36.51	39.62	38.91	NC	37.66	39.09	C
1103	1105.00	37.16	36.51	39.62	37.64	C	37.66	39.09	C
1112	1120.00	37.16	36.51	39.62	37.64	C	37.66	39.09	C
1113	1121.67	37.16	36.51	39.62	38.91	NC	37.66	39.09	C
1220	1233.33	37.16	36.51	39.62	38.91	NC	37.66	39.09	C
1221	1235.00	37.16	36.51	39.62	32.98	C	37.66	39.09	C
1225	1241.67	37.16	36.51	39.62	32.98	C	37.66	39.09	C
1226	1243.33	37.16	36.51	39.62	32.98	C	37.66	38.99	C
1235	1258.33	37.16	36.51	39.62	32.98	C	37.66	38.99	C
1236	1260.00	37.16	36.51	39.62	36.54	NC	37.66	38.99	C
1300	1300.00	37.16	36.51	39.62	36.54	NC	37.66	38.99	C
1301	1301.67	36.96	35.16	37.15	36.54	NC	35.45	38.99	C
1304	1306.67	36.96	35.16	37.15	36.54	NC	35.45	38.99	C
1305	1308.33	36.96	35.16	37.15	32.98	C	35.45	38.99	C
1330	1350.00	36.96	35.16	37.15	32.98	C	35.45	38.99	C
1331	1351.67	36.96	35.16	37.15	36.54	NC	35.45	38.99	C
1335	1358.33	36.96	35.16	37.15	36.54	NC	35.45	38.99	C
1336	1360.00	36.96	35.16	37.15	36.54	NC	35.45	37.26	NC
1355	1391.67	36.96	35.16	37.15	36.54	NC	35.45	37.26	NC
1356	1393.33	36.96	35.16	37.15	36.54	NC	35.45	34.81	C
1359	1398.33	36.96	35.16	37.15	36.54	NC	35.45	34.81	C
1400	1400.00	36.96	35.16	37.15	32.98	C	35.45	34.81	C
1406	1410.00	36.96	35.16	37.15	32.98	C	35.45	34.81	C
1407	1411.67	36.96	35.16	37.15	36.84	NC	35.45	34.81	C
1459	1498.33	36.96	35.16	37.15	36.84	NC	35.45	34.81	C
1500	1500.00	36.96	35.16	37.15	32.98	C	35.45	34.81	C
1545	1575.00	36.96	35.16	37.15	32.98	C	35.45	34.81	C
1546	1576.67	36.96	35.16	37.15	36.84	NC	35.45	34.81	C
1554	1590.00	36.96	35.16	37.15	36.84	NC	35.45	34.81	C
1555	1591.67	36.96	35.16	37.15	37.88	C	35.45	34.81	C
1605	1608.33	36.96	35.16	37.15	37.88	C	35.45	34.81	C
1606	1610.00	36.96	35.16	37.15	37.88	C	35.45	37.55	NC
1615	1625.00	36.96	35.16	37.15	37.88	C	35.45	37.55	NC
1616	1626.67	36.96	35.16	37.15	36.84	NC	35.45	37.55	NC
1620	1633.33	36.96	35.16	37.15	36.84	NC	35.45	37.55	NC
1621	1635.00	36.96	35.16	37.15	36.84	NC	35.45	38.92	C
1830	1650.00	36.96	35.16	37.15	36.84	NC	35.45	38.92	C

BOD concentrations in mg/L (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	1.94	1.34	1.54			1.44		
720	733.33	1.94	1.34	1.54	1.84	NC	1.44		
730	750.00	1.94	1.34	1.54	1.84	NC	1.44	2.04	C
745	775.00	1.94	1.34	1.54	1.84	NC	1.44	2.04	C
746	776.67	1.94	1.34	1.54	1.84	NC	1.44	1.54	NC
850	883.33	1.94	1.34	1.54	1.84	NC	1.44	1.54	NC
851	885.00	1.94	1.34	1.54	1.84	NC	1.44	1.94	C
905	908.33	1.94	1.34	1.54	1.84	NC	1.44	1.94	C
906	910.00	1.94	1.34	1.54	1.84	NC	1.44	2.14	C
1015	1025.00	1.94	1.34	1.54	1.84	NC	1.44	2.14	C
1016	1026.67	1.94	1.34	1.54	1.54	C	1.44	2.14	C
1030	1050.00	1.94	1.34	1.54	1.54	C	1.44	2.14	C
1031	1051.67	1.94	1.34	1.54	1.54	C	1.44	1.94	C
1050	1083.33	1.94	1.34	1.54	1.54	C	1.44	1.94	C
1051	1085.00	1.94	1.34	1.54	1.94	NC	1.44	1.94	C
1102	1103.33	1.94	1.34	1.54	1.94	NC	1.44	1.94	C
1103	1105.00	1.94	1.34	1.54	1.84	C	1.44	1.94	C
1112	1120.00	1.94	1.34	1.54	1.84	C	1.44	1.94	C
1113	1121.67	1.94	1.34	1.54	1.94	NC	1.44	1.94	C
1220	1233.33	1.94	1.34	1.54	1.94	NC	1.44	1.94	C
1221	1235.00	1.94	1.34	1.54	1.94	C	1.44	1.94	C
1225	1241.67	1.94	1.34	1.54	1.94	C	1.44	1.94	C
1226	1243.33	1.94	1.34	1.54	1.94	C	1.44	2.04	C
1235	1258.33	1.94	1.34	1.54	1.94	C	1.44	2.04	C
1236	1260.00	1.94	1.34	1.54	1.74	NC	1.44	2.04	C
1330	1350.00	1.94	1.34	1.54	1.74	NC	1.44	2.04	C
1301	1301.67	1.64	1.34	1.24	1.74	NC	1.14	2.04	C
1304	1306.67	1.64	1.34	1.24	1.74	NC	1.14	2.04	C
1305	1308.33	1.64	1.34	1.24	1.94	C	1.14	2.04	C
1330	1350.00	1.64	1.34	1.24	1.94	C	1.14	2.04	C
1331	1351.67	1.64	1.34	1.24	1.74	NC	1.14	2.04	C
1335	1358.33	1.64	1.34	1.24	1.74	NC	1.14	2.04	C
1336	1360.00	1.64	1.34	1.24	1.74	NC	1.14	1.84	NC
1355	1391.67	1.64	1.34	1.24	1.74	NC	1.14	1.84	NC
1356	1393.33	1.64	1.34	1.24	1.74	NC	1.14	1.94	C
1359	1398.33	1.64	1.34	1.24	1.74	NC	1.14	1.94	C
1400	1400.00	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1406	1410.00	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1407	1411.67	1.64	1.34	1.24	1.64	NC	1.14	1.94	C
1459	1498.33	1.64	1.34	1.24	1.64	NC	1.14	1.94	C
1500	1500.00	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1545	1575.00	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1546	1576.67	1.64	1.34	1.24	1.64	NC	1.14	1.94	C
1554	1590.00	1.64	1.34	1.24	1.64	NC	1.14	1.94	C
1555	1591.67	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1605	1608.33	1.64	1.34	1.24	1.94	C	1.14	1.94	C
1606	1610.00	1.64	1.34	1.24	1.94	C	1.14	1.34	NC
1615	1625.00	1.64	1.34	1.24	1.94	C	1.14	1.34	NC
1616	1626.67	1.64	1.34	1.24	1.64	NC	1.14	1.34	NC
1620	1633.33	1.64	1.34	1.24	1.64	NC	1.14	1.34	NC
1621	1635.00	1.64	1.34	1.24	1.64	NC	1.14	1.54	C
1830	1850.00	1.64	1.34	1.24	1.64	NC	1.14	1.54	C

Fecal Coliform concentrations in cfu/100mL (4/12/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	1000	2100	4000			5000		
720	733.33	1000	2100	4000	5000	NC	5000		
730	750.00	1000	2100	4000	5000	NC	5000	7000	C
745	775.00	1000	2100	4000	5000	NC	5000	7000	C
746	776.67	1000	2100	4000	5000	NC	5000	8000	NC
850	883.33	1000	2100	4000	5000	NC	5000	8000	NC
851	885.00	1000	2100	4000	5000	NC	5000	4000	C
905	908.33	1000	2100	4000	5000	NC	5000	4000	C
906	910.00	1000	2100	4000	5000	NC	5000	2200	C
1015	1025.00	1000	2100	4000	5000	NC	5000	2200	C
1016	1026.67	1000	2100	4000	6000	C	5000	2200	C
1030	1050.00	1000	2100	4000	6000	C	5000	2200	C
1031	1051.67	1000	2100	4000	6000	C	5000	1000	C
1050	1083.33	1000	2100	4000	6000	C	5000	1000	C
1051	1085.00	1000	2100	4000	4000	NC	5000	1000	C
1102	1103.33	1000	2100	4000	4000	NC	5000	1000	C
1103	1105.00	1000	2100	4000	4000	C	5000	1000	C
1112	1120.00	1000	2100	4000	4000	C	5000	1000	C
1113	1121.67	1000	2100	4000	4000	NC	5000	1000	C
1220	1233.33	1000	2100	4000	4000	NC	5000	1000	C
1221	1235.00	1000	2100	4000	10000	C	5000	1000	C
1225	1241.67	1000	2100	4000	10000	C	5000	1000	C
1226	1243.33	1000	2100	4000	10000	C	5000	4000	C
1235	1258.33	1000	2100	4000	10000	C	5000	4000	C
1236	1260.00	1000	2100	4000	6000	NC	5000	4000	C
1300	1300.00	1000	2100	4000	6000	NC	5000	4000	C
1301	1301.67	5000	6000	9000	6000	NC	9000	4000	C
1304	1306.67	5000	6000	9000	6000	NC	9000	4000	C
1305	1308.33	5000	6000	9000	10000	C	9000	4000	C
1330	1350.00	5000	6000	9000	10000	C	9000	4000	C
1331	1351.67	5000	6000	9000	6000	NC	9000	4000	C
1335	1358.33	5000	6000	9000	6000	NC	9000	4000	C
1336	1360.00	5000	6000	9000	6000	NC	9000	5000	NC
1355	1391.67	5000	6000	9000	6000	NC	9000	5000	NC
1356	1393.33	5000	6000	9000	6000	NC	9000	9000	C
1359	1398.33	5000	6000	9000	6000	NC	9000	9000	C
1400	1400.00	5000	6000	9000	10000	C	9000	9000	C
1406	1410.00	5000	6000	9000	10000	C	9000	9000	C
1407	1411.67	5000	6000	9000	7000	NC	9000	9000	C
1459	1498.33	5000	6000	9000	7000	NC	9000	9000	C
1500	1500.00	5000	6000	9000	10000	C	9000	9000	C
1545	1575.00	5000	6000	9000	10000	C	9000	9000	C
1546	1576.67	5000	6000	9000	7000	NC	9000	9000	C
1554	1590.00	5000	6000	9000	7000	NC	9000	9000	C
1555	1591.67	5000	6000	9000	10000	C	9000	9000	C
1605	1608.33	5000	6000	9000	10000	C	9000	9000	C
1606	1610.00	5000	6000	9000	10000	C	9000	7000	NC
1615	1625.00	5000	6000	9000	10000	C	9000	7000	NC
1616	1626.67	5000	6000	9000	7000	NC	9000	7000	NC
1620	1633.33	5000	6000	9000	7000	NC	9000	7000	NC
1621	1635.00	5000	6000	9000	7000	NC	9000	7000	C
1830	1850.00	5000	6000	9000	7000	NC	9000	7000	C

Nitrate concentrations in mg/L (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	2.13	2.34	0.89	1.41	NC	1.88	1.72	NC
815	825.00	2.13	2.34	0.89	1.41	NC	1.88	1.72	NC
816	826.67	2.13	2.34	0.89	1.41	NC	1.88	1.8	C
1200	1200.00	2.13	2.34	0.89	1.41	NC	1.88	1.8	C
1201	1201.67	2.13	2.34	0.89	1.41	NC	1.88	2.01	C
1215	1225.00	2.13	2.34	0.89	1.41	NC	1.88	2.01	C
1216	1226.67	2.13	2.34	0.89	1.45	NC	1.88	2.01	C
1230	1250.00	2.13	2.34	0.89	1.45	NC	1.88	2.01	C
1231	1251.67	1.49	2.03	0.89	1.45	NC	1.75	2.01	C
1315	1325.00	1.49	2.03	0.89	1.45	NC	1.75	2.01	C
1316	1326.67	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1345	1375.00	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1346	1376.67	1.49	2.03	0.89	1.34	C	1.75	1.82	NC
1415	1425.00	1.49	2.03	0.89	1.34	C	1.75	1.82	NC
1416	1426.67	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1424	1440.00	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1425	1441.67	1.49	2.03	0.89	1.6	C	1.75	1.82	NC
1435	1458.33	1.49	2.03	0.89	1.6	C	1.75	1.82	NC
1436	1460.00	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1438	1463.33	1.49	2.03	0.89	1.45	NC	1.75	1.82	NC
1439	1465.00	1.49	2.03	0.89	1.45	NC	1.75	1.72	C
1510	1516.67	1.49	2.03	0.89	1.45	NC	1.75	1.72	C
1511	1518.33	1.49	2.03	0.89	1.45	NC	1.75	1.79	NC
1855	1891.67	1.49	2.03	0.89	1.45	NC	1.75	1.79	NC
1900	1900.00	1.49	2.03	0.89	1.45	NC	1.75		
1930	1950.00	1.49	2.03	0.89	1.45	NC	1.75		

Ammonia concentrations in mg/L (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	0.07	0.06	0.05	0.01	NC	0.05	0.08	NC
815	825.00	0.07	0.06	0.05	0.01	NC	0.05	0.08	NC
816	826.67	0.07	0.06	0.05	0.01	NC	0.05	0.13	C
1200	1200.00	0.07	0.06	0.05	0.01	NC	0.05	0.13	C
1201	1201.67	0.07	0.06	0.05	0.01	NC	0.05	ND<0.02	C
1215	1225.00	0.07	0.06	0.05	0.01	NC	0.05	ND<0.02	C
1216	1226.67	0.07	0.06	0.05	0.02	NC	0.05	ND<0.02	C
1230	1250.00	0.07	0.06	0.05	0.02	NC	0.05	ND<0.02	C
1231	1251.67	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	C
1315	1325.00	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	C
1316	1326.67	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1345	1375.00	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1346	1376.67	0.02	ND<0.02	0.06	ND<0.02	C	0.05	ND<0.02	NC
1415	1425.00	0.02	ND<0.02	0.06	ND<0.02	C	0.05	ND<0.02	NC
1416	1426.67	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1424	1440.00	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1425	1441.67	0.02	ND<0.02	0.06	0.01	C	0.05	ND<0.02	NC
1435	1458.33	0.02	ND<0.02	0.06	0.01	C	0.05	ND<0.02	NC
1436	1460.00	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1438	1463.33	0.02	ND<0.02	0.06	0.02	NC	0.05	ND<0.02	NC
1439	1465.00	0.02	ND<0.02	0.06	0.02	NC	0.05	0.08	C
1510	1516.67	0.02	ND<0.02	0.06	0.02	NC	0.05	0.08	C
1511	1518.33	0.02	ND<0.02	0.06	0.02	NC	0.05	0.12	NC
1855	1891.67	0.02	ND<0.02	0.06	0.02	NC	0.05	0.12	NC
1900	1900.00	0.02	ND<0.02	0.06	0.02	NC	0.05		
1930	1950.00	0.02	ND<0.02	0.06	0.02	NC	0.05		

Total Solids concentrations in mg/L (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	420	372	608	356	NC	568	364	NC
815	825.00	420	372	608	356	NC	568	364	NC
816	826.67	420	372	608	356	NC	568	372	C
1200	1200.00	420	372	608	356	NC	568	372	C
1201	1201.67	420	372	608	356	NC	568	360	C
1215	1225.00	420	372	608	356	NC	568	360	C
1216	1226.67	420	372	608	288	NC	568	360	C
1230	1250.00	420	372	608	288	NC	568	360	C
1231	1251.67	408	332	464	288	NC	432	360	C
1315	1325.00	408	332	464	288	NC	432	360	C
1316	1326.67	408	332	464	288	NC	432	376	NC
1345	1375.00	408	332	464	288	NC	432	376	NC
1346	1376.67	408	332	464	360	C	432	376	NC
1415	1425.00	408	332	464	360	C	432	376	NC
1416	1426.67	408	332	464	288	NC	432	376	NC
1424	1440.00	408	332	464	288	NC	432	376	NC
1425	1441.67	408	332	464	388	C	432	376	NC
1435	1458.33	408	332	464	388	C	432	376	NC
1436	1460.00	408	332	464	288	NC	432	376	NC
1438	1463.33	408	332	464	288	NC	432	376	NC
1439	1465.00	408	332	464	288	NC	432	400	C
1510	1516.67	408	332	464	288	NC	432	400	C
1511	1518.33	408	332	464	288	NC	432	368	NC
1855	1891.67	408	332	464	288	NC	432	368	NC
1900	1900.00	408	332	464	288	NC	432		
1930	1950.00	408	332	464	288	NC	432		

TOC concentrations in mg/L (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	38.18	38.36	38.68	39.88	NC	39.99	38.2	NC
815	825.00	38.18	38.36	38.68	39.88	NC	39.99	38.2	NC
816	826.67	38.18	38.36	38.68	39.88	NC	39.99	38.73	C
1200	1200.00	38.18	38.36	38.68	39.88	NC	39.99	38.73	C
1201	1201.67	38.18	38.36	38.68	39.88	NC	39.99	38.16	C
1215	1225.00	38.18	38.36	38.68	39.88	NC	39.99	38.16	C
1216	1226.67	38.18	38.36	38.68	40.94	NC	39.99	38.16	C
1230	1250.00	38.18	38.36	38.68	40.94	NC	39.99	38.16	C
1231	1251.67	38.61	37.04	38.28	40.94	NC	38.96	38.16	C
1315	1325.00	38.61	37.04	38.28	40.94	NC	38.96	38.16	C
1316	1326.67	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1345	1375.00	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1346	1376.67	38.61	37.04	38.28	40.06	C	38.96	39.41	NC
1415	1425.00	38.61	37.04	38.28	40.06	C	38.96	39.41	NC
1416	1426.67	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1424	1440.00	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1425	1441.67	38.61	37.04	38.28	39.58	C	38.96	39.41	NC
1435	1458.33	38.61	37.04	38.28	39.58	C	38.96	39.41	NC
1436	1460.00	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1438	1463.33	38.61	37.04	38.28	40.94	NC	38.96	39.41	NC
1439	1465.00	38.61	37.04	38.28	40.94	NC	38.96	37.78	C
1510	1516.67	38.61	37.04	38.28	40.94	NC	38.96	37.78	C
1511	1518.33	38.61	37.04	38.28	40.94	NC	38.96	38.34	NC
1855	1891.67	38.61	37.04	38.28	40.94	NC	38.96	38.34	NC
1900	1900.00	38.61	37.04	38.28	40.94	NC	38.96		
1930	1950.00	38.61	37.04	38.28	40.94	NC	38.96		

BOD concentrations in mg/L (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	1.44	2.64	1.34	0.54	NC	1.24	1.24	NC
815	825.00	1.44	2.64	1.34	0.54	NC	1.24	1.24	NC
816	826.67	1.44	2.64	1.34	0.54	NC	1.24	2.44	C
1200	1200.00	1.44	2.64	1.34	0.54	NC	1.24	2.44	C
1201	1201.67	1.44	2.64	1.34	0.54	NC	1.24	2.04	C
1215	1225.00	1.44	2.64	1.34	0.54	NC	1.24	2.04	C
1216	1226.67	1.44	2.64	1.34	1.74	NC	1.24	2.04	C
1230	1250.00	1.44	2.64	1.34	1.74	NC	1.24	2.04	C
1231	1251.67	1.24	1.64	1.84	1.74	NC	1.74	2.04	C
1315	1325.00	1.24	1.64	1.84	1.74	NC	1.74	2.04	C
1316	1326.67	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1345	1375.00	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1346	1376.67	1.24	1.64	1.84	1.14	C	1.74	0.84	NC
1415	1425.00	1.24	1.64	1.84	1.14	C	1.74	0.84	NC
1416	1426.67	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1424	1440.00	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1425	1441.67	1.24	1.64	1.84	0.94	C	1.74	0.84	NC
1435	1458.33	1.24	1.64	1.84	0.94	C	1.74	0.84	NC
1436	1460.00	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1438	1463.33	1.24	1.64	1.84	1.74	NC	1.74	0.84	NC
1439	1465.00	1.24	1.64	1.84	1.74	NC	1.74	1.34	C
1510	1516.67	1.24	1.64	1.84	1.74	NC	1.74	1.34	C
1511	1518.33	1.24	1.64	1.84	1.74	NC	1.74	1.34	NC
1855	1891.67	1.24	1.64	1.84	1.74	NC	1.74	1.34	NC
1900	1900.00	1.24	1.64	1.84	1.74	NC	1.74		
1930	1950.00	1.24	1.64	1.84	1.74	NC	1.74		

Fecal Coliform concentrations in cfu/100mL (6/27/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	300	200	200	0	NC	300	1100	NC
815	825.00	300	200	200	0	NC	300	1100	NC
816	826.67	300	200	200	0	NC	300	0	C
1200	1200.00	300	200	200	0	NC	300	0	C
1201	1201.67	300	200	200	0	NC	300	200	C
1215	1225.00	300	200	200	0	NC	300	200	C
1216	1226.67	300	200	200	1200	NC	300	200	C
1230	1250.00	300	200	200	1200	NC	300	200	C
1231	1251.67	0	200	3200	1200	NC	500	200	C
1315	1325.00	0	200	3200	1200	NC	500	200	C
1316	1326.67	0	200	3200	1200	NC	500	2100	NC
1345	1375.00	0	200	3200	1200	NC	500	2100	NC
1346	1376.67	0	200	3200	200	C	500	2100	NC
1415	1425.00	0	200	3200	200	C	500	2100	NC
1416	1426.67	0	200	3200	1200	NC	500	2100	NC
1424	1440.00	0	200	3200	1200	NC	500	2100	NC
1425	1441.67	0	200	3200	1600	C	500	2100	NC
1435	1458.33	0	200	3200	1600	C	500	2100	NC
1436	1460.00	0	200	3200	1200	NC	500	2100	NC
1438	1463.33	0	200	3200	1200	NC	500	2100	NC
1439	1465.00	0	200	3200	1200	NC	500	900	C
1510	1516.67	0	200	3200	1200	NC	500	900	C
1511	1518.33	0	200	3200	1200	NC	500	4300	NC
1855	1891.67	0	200	3200	1200	NC	500	4300	NC
1900	1900.00	0	200	3200	1200	NC	500		
1930	1950.00	0	200	3200	1200	NC	500		

Nitrate concentrations in mg/L (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	1.08	1.37	1.53	0.84	NC	2.1	1.33	NC
744	773.33	1.08	1.37	1.53	0.84	NC	2.1	1.33	NC
745	775.00	1.08	1.37	1.53	0.84	NC	2.1	1.55	C
802	803.33	1.08	1.37	1.53	0.84	NC	2.1	1.55	C
803	805.00	1.08	1.37	1.53	0.82	C	2.1	1.55	C
825	841.67	1.08	1.37	1.53	0.82	C	2.1	1.55	C
826	843.33	1.08	1.37	1.53	0.93	NC	2.1	1.55	C
1155	1191.67	1.08	1.37	1.53	0.93	NC	2.1	1.55	C
1156	1193.33	1.08	1.37	1.53	3.47	C	2.1	1.55	C
1200	1200.00	1.08	1.37	1.53	3.47	C	2.1	1.55	C
1201	1201.67	1.04	1.22	0.51	3.47	C	2.53	2.87	C
1340	1366.67	1.04	1.22	0.51	3.47	C	2.53	2.87	C
1341	1368.33	1.04	1.22	0.51	1.1	NC	2.53	2.87	C
1502	1503.33	1.04	1.22	0.51	1.1	NC	2.53	2.87	C
1503	1505.00	1.04	1.22	0.51	1.77	C	2.53	2.87	C
1616	1626.67	1.04	1.22	0.51	1.77	C	2.53	2.87	C
1617	1628.33	1.04	1.22	0.51	1.77	C	2.53	2.4	NC
1655	1691.67	1.04	1.22	0.51	1.77	C	2.53	2.4	NC
1656	1693.33	1.04	1.22	0.51	1.12	NC	2.53	2.4	NC
1800	1800.00	1.04	1.22	0.51	1.12	NC	2.53	2.4	NC
1900	1900.00				1.12	NC		2.4	NC

Ammonia concentrations in mg/L (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	ND<0.02	0.01	0.03	0.01	NC	0.09	ND<0.02	NC
744	773.33	ND<0.02	0.01	0.03	0.01	NC	0.09	ND<0.02	NC
745	775.00	ND<0.02	0.01	0.03	0.01	NC	0.09	0.15	C
802	803.33	ND<0.02	0.01	0.03	0.01	NC	0.09	0.15	C
803	805.00	ND<0.02	0.01	0.03	0.08	C	0.09	0.15	C
825	841.67	ND<0.02	0.01	0.03	0.08	C	0.09	0.15	C
826	843.33	ND<0.02	0.01	0.03	0.08	NC	0.09	0.15	C
1155	1191.67	ND<0.02	0.01	0.03	0.08	NC	0.09	0.15	C
1156	1193.33	ND<0.02	0.01	0.03	0.11	C	0.09	0.15	C
1200	1200.00	ND<0.02	0.01	0.03	0.11	C	0.09	0.15	C
1201	1201.67	0.04	0.07	0.1	0.11	C	ND<0.02	ND<0.02	C
1340	1366.67	0.04	0.07	0.1	0.11	C	ND<0.02	ND<0.02	C
1341	1368.33	0.04	0.07	0.1	ND<0.02	NC	ND<0.02	ND<0.02	C
1502	1503.33	0.04	0.07	0.1	ND<0.02	NC	ND<0.02	ND<0.02	C
1503	1505.00	0.04	0.07	0.1	ND<0.02	C	ND<0.02	ND<0.02	C
1616	1626.67	0.04	0.07	0.1	ND<0.02	C	ND<0.02	ND<0.02	C
1617	1628.33	0.04	0.07	0.1	ND<0.02	C	ND<0.02	ND<0.02	NC
1655	1691.67	0.04	0.07	0.1	ND<0.02	C	ND<0.02	ND<0.02	NC
1656	1693.33	0.04	0.07	0.1	0.08	NC	ND<0.02	ND<0.02	NC
1800	1800.00	0.04	0.07	0.1	0.08	NC	ND<0.02	ND<0.02	NC
1900	1900.00				0.08	NC		ND<0.02	NC

Total Solids concentrations in mg/L (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	372	364	536	308	NC	436	376	NC
744	773.33	372	364	536	308	NC	436	376	NC
745	775.00	372	364	536	308	NC	436	436	C
802	803.33	372	364	536	308	NC	436	436	C
803	805.00	372	364	536	388	C	436	436	C
825	841.67	372	364	536	388	C	436	436	C
826	843.33	372	364	536	380	NC	436	436	C
1155	1191.67	372	364	536	380	NC	436	436	C
1156	1193.33	372	364	536	476	C	436	436	C
1200	1200.00	372	364	536	476	C	436	436	C
1201	1201.67	436	432	408	476	C	404	404	C
1340	1366.67	436	432	408	476	C	404	404	C
1341	1368.33	436	432	408	372	NC	404	404	C
1502	1503.33	436	432	408	372	NC	404	404	C
1503	1505.00	436	432	408	396	C	404	404	C
1616	1626.67	436	432	408	396	C	404	404	C
1617	1628.33	436	432	408	396	C	404	368	NC
1655	1691.67	436	432	408	396	C	404	368	NC
1656	1693.33	436	432	408	392	NC	404	368	NC
1800	1800.00	436	432	408	392	NC	404	368	NC
1900	1900.00				392	NC		368	NC

TOC concentrations in mg/L (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	46.26	49.28	45.06	48.06	NC	48.61	50.29	NC
744	773.33	46.26	49.28	45.06	48.06	NC	48.61	50.29	NC
745	775.00	46.26	49.28	45.06	48.06	NC	48.61	49.51	C
802	803.33	46.26	49.28	45.06	48.06	NC	48.61	49.51	C
803	805.00	46.26	49.28	45.06	48.32	C	48.61	49.51	C
825	841.67	46.26	49.28	45.06	48.32	C	48.61	49.51	C
826	843.33	46.26	49.28	45.06	48.98	NC	48.61	49.51	C
1155	1191.67	46.26	49.28	45.06	48.98	NC	48.61	49.51	C
1156	1193.33	46.26	49.28	45.06	51.62	C	48.61	49.51	C
1200	1200.00	46.26	49.28	45.06	51.62	C	48.61	49.51	C
1201	1201.67	45.4	46.98	47.34	51.62	C	49.09	49.32	C
1340	1366.67	45.4	46.98	47.34	51.62	C	49.09	49.32	C
1341	1368.33	45.4	46.98	47.34	49.37	NC	49.09	49.32	C
1502	1503.33	45.4	46.98	47.34	49.37	NC	49.09	49.32	C
1503	1505.00	45.4	46.98	47.34	47.74	C	49.09	49.32	C
1616	1626.67	45.4	46.98	47.34	47.74	C	49.09	49.32	C
1617	1628.33	45.4	46.98	47.34	47.74	C	49.09	44.82	NC
1655	1691.67	45.4	46.98	47.34	47.74	C	49.09	44.82	NC
1656	1693.33	45.4	46.98	47.34	43.94	NC	49.09	44.82	NC
1800	1800.00	45.4	46.98	47.34	43.94	NC	49.09	44.82	NC
1900	1900.00				43.94	NC		44.82	NC

BOD concentrations in mg/L (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	2.8	1.5	1.4	1.3	NC	1.9	1.5	NC
744	773.33	2.8	1.5	1.4	1.3	NC	1.9	1.5	NC
745	775.00	2.8	1.5	1.4	1.3	NC	1.9	1.2	C
802	803.33	2.8	1.5	1.4	1.3	NC	1.9	1.2	C
803	805.00	2.8	1.5	1.4	2.5	C	1.9	1.2	C
825	841.67	2.8	1.5	1.4	2.5	C	1.9	1.2	C
826	843.33	2.8	1.5	1.4	1.6	NC	1.9	1.2	C
1155	1191.67	2.8	1.5	1.4	1.6	NC	1.9	1.2	C
1156	1193.33	2.8	1.5	1.4	2.1	C	1.9	1.2	C
1200	1200.00	2.8	1.5	1.4	2.1	C	1.9	1.2	C
1201	1201.67	1.5	2	1.6	2.1	C	1.4	1.5	C
1340	1366.67	1.5	2	1.6	2.1	C	1.4	1.5	C
1341	1368.33	1.5	2	1.6	1	NC	1.4	1.5	C
1502	1503.33	1.5	2	1.6	1	NC	1.4	1.5	C
1503	1505.00	1.5	2	1.6	2.1	C	1.4	1.5	C
1616	1626.67	1.5	2	1.6	2.1	C	1.4	1.5	C
1617	1628.33	1.5	2	1.6	2.1	C	1.4	0.9	NC
1655	1691.67	1.5	2	1.6	2.1	C	1.4	0.9	NC
1656	1693.33	1.5	2	1.6	1.9	NC	1.4	0.9	NC
1800	1800.00	1.5	2	1.6	1.9	NC	1.4	0.9	NC
1900	1900.00				1.9	NC		0.9	NC

Fecal Coliform concentrations in cfu/100mL (8/15/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
600	600.00	900	1000	1500	200	NC	1400	200	NC
744	773.33	900	1000	1500	200	NC	1400	200	NC
745	775.00	900	1000	1500	200	NC	1400	1000	C
802	803.33	900	1000	1500	200	NC	1400	1000	C
803	805.00	900	1000	1500	2400	C	1400	1000	C
825	841.67	900	1000	1500	2400	C	1400	1000	C
826	843.33	900	1000	1500	2800	NC	1400	1000	C
1155	1191.67	900	1000	1500	2800	NC	1400	1000	C
1156	1193.33	900	1000	1500	1200	C	1400	1000	C
1200	1200.00	900	1000	1500	1200	C	1400	1000	C
1201	1201.67	0	0	1100	1200	C	2300	1800	C
1340	1366.67	0	0	1100	1200	C	2300	1800	C
1341	1368.33	0	0	1100	900	NC	2300	1800	C
1502	1503.33	0	0	1100	900	NC	2300	1800	C
1503	1505.00	0	0	1100	600	C	2300	1800	C
1616	1626.67	0	0	1100	600	C	2300	1800	C
1617	1628.33	0	0	1100	600	C	2300	300	NC
1655	1691.67	0	0	1100	600	C	2300	300	NC
1656	1693.33	0	0	1100	2700	NC	2300	300	NC
1800	1800.00	0	0	1100	2700	NC	2300	300	NC
1900	1900.00				2700	NC		300	NC

Nitrate concentrations in mg/L (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	2.02	2.7	1.4	1.87	NC	2.25	2.03	NC
915	925.00	2.02	2.7	1.4	1.87	NC	2.25	2.03	NC
916	926.67	2.02	2.7	1.4	1.87	NC	2.25	2.14	C
950	983.33	2.02	2.7	1.4	1.87	NC	2.25	2.14	C
951	985.00	2.02	2.7	1.4	1.87	NC	2.25	2.08	NC
1005	1008.33	2.02	2.7	1.4	1.87	NC	2.25	2.08	NC
1006	1010.00	2.02	2.7	1.4	2.03	C	2.25	2.08	NC
1020	1033.33	2.02	2.7	1.4	2.03	C	2.25	2.08	NC
1021	1035.00	2.02	2.7	1.4	2.03	NC	2.25	2.08	NC
1025	1041.67	2.02	2.7	1.4	2.03	NC	2.25	2.08	NC
1026	1043.33	2.02	2.7	1.4	2.03	NC	2.25	2.31	C
1040	1066.67	2.02	2.7	1.4	2.03	NC	2.25	2.31	C
1041	1068.33	2.02	2.7	1.4	2.03	NC	2.25	2.15	NC
1300	1300.00	2.02	2.7	1.4	2.03	NC	2.25	2.15	NC
1301	1301.67	2.03	2.71	1.31	2.03	NC	2.12	2.15	NC
1305	1308.33	2.03	2.71	1.31	2.03	NC	2.12	2.15	NC
1306	1310.00	2.03	2.71	1.31	2.03	NC	2.12	2.15	NC
1530	1550.00	2.03	2.71	1.31	2.03	NC	2.12	2.15	NC
1531	1551.67	2.03	2.71	1.31	2.03	NC	2.12	2.18	NC
1555	1591.67	2.03	2.71	1.31	2.03	NC	2.12	2.18	NC
1556	1593.33	2.03	2.71	1.31	2.02	C	2.12	2.18	NC
1615	1625.00	2.03	2.71	1.31	2.02	C	2.12	2.18	NC
1616	1626.67	2.03	2.71	1.31	2	NC	2.12	2.18	NC
1748	1780.00	2.03	2.71	1.31	2	NC	2.12	2.18	NC
1749	1781.67	2.03	2.71	1.31	2.06	C	2.12	2.18	NC
1800	1800.00	2.03	2.71	1.31	2.06	C	2.12	2.18	NC
1801	1801.67	2.03	2.71	1.31	2.04	NC	2.12	2.18	NC
1900	1900.00	2.03	2.71	1.31	2.04	NC	2.12	2.18	NC
1930	1950.00				2.04	NC			

Ammonia concentrations in mg/L (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.13	NC
915	925.00	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.13	NC
916	926.67	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.12	C
950	983.33	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.12	C
951	985.00	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.08	NC
1005	1008.33	ND<0.01	ND<0.01	ND<0.01	0.09	NC	ND<0.01	0.08	NC
1006	1010.00	ND<0.01	ND<0.01	ND<0.01	0.14	C	ND<0.01	0.08	NC
1020	1033.33	ND<0.01	ND<0.01	ND<0.01	0.14	C	ND<0.01	0.08	NC
1021	1035.00	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.08	NC
1025	1041.67	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.08	NC
1026	1043.33	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.17	C
1040	1066.67	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.17	C
1041	1068.33	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.01	NC
1300	1300.00	ND<0.01	ND<0.01	ND<0.01	ND<0.01	NC	ND<0.01	0.01	NC
1301	1301.67	0.09	0.16	0.12	ND<0.01	NC	0.17	0.01	NC
1305	1308.33	0.09	0.16	0.12	ND<0.01	NC	0.17	0.01	NC
1306	1310.00	0.09	0.16	0.12	ND<0.01	NC	0.17	0.01	NC
1530	1550.00	0.09	0.16	0.12	ND<0.01	NC	0.17	0.01	NC
1531	1551.67	0.09	0.16	0.12	ND<0.01	NC	0.17	0.24	NC
1555	1591.67	0.09	0.16	0.12	ND<0.01	NC	0.17	0.24	NC
1556	1593.33	0.09	0.16	0.12	0.11	C	0.17	0.24	NC
1615	1625.00	0.09	0.16	0.12	0.11	C	0.17	0.24	NC
1616	1626.67	0.09	0.16	0.12	0.01	NC	0.17	0.24	NC
1748	1780.00	0.09	0.16	0.12	0.01	NC	0.17	0.24	NC
1749	1781.67	0.09	0.16	0.12	0.04	C	0.17	0.24	NC
1800	1800.00	0.09	0.16	0.12	0.04	C	0.17	0.24	NC
1801	1801.67	0.09	0.16	0.12	0.13	NC	0.17	0.24	NC
1900	1900.00	0.09	0.16	0.12	0.13	NC	0.17	0.24	NC
1930	1950.00				0.13	NC			

Total Solids concentrations in mg/L (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	376	336	304	316	NC	396	332	NC
915	925.00	376	336	304	316	NC	396	332	NC
916	926.67	376	336	304	316	NC	396	352	C
950	983.33	376	336	304	316	NC	396	352	C
951	985.00	376	336	304	316	NC	396	356	NC
1005	1008.33	376	336	304	316	NC	396	356	NC
1006	1010.00	376	336	304	320	C	396	356	NC
1020	1033.33	376	336	304	320	C	396	356	NC
1021	1035.00	376	336	304	332	NC	396	356	NC
1025	1041.67	376	336	304	332	NC	396	356	NC
1026	1043.33	376	336	304	332	NC	396	336	C
1040	1066.67	376	336	304	332	NC	396	336	C
1041	1068.33	376	336	304	332	NC	396	300	NC
1300	1300.00	376	336	304	332	NC	396	300	NC
1301	1301.67	360	340	280	332	NC	328	300	NC
1305	1308.33	360	340	280	332	NC	328	300	NC
1306	1310.00	360	340	280	304	NC	328	300	NC
1530	1550.00	360	340	280	304	NC	328	300	NC
1531	1551.67	360	340	280	304	NC	328	344	NC
1555	1591.67	360	340	280	304	NC	328	344	NC
1556	1593.33	360	340	280	340	C	328	344	NC
1615	1625.00	360	340	280	340	C	328	344	NC
1616	1626.67	360	340	280	316	NC	328	344	NC
1748	1780.00	360	340	280	316	NC	328	344	NC
1749	1781.67	360	340	280	340	C	328	344	NC
1800	1800.00	360	340	280	340	C	328	344	NC
1801	1801.67	360	340	280	308	NC	328	344	NC
1900	1900.00	360	340	280	308	NC	328	344	NC
1930	1950.00				308	NC			

TOC concentrations in mg/L (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	48.26	48.9	46.81	48.56	NC	48.71	49.9	NC
915	925.00	48.26	48.9	46.81	48.56	NC	48.71	49.9	NC
916	926.67	48.26	48.9	46.81	48.56	NC	48.71	50.02	C
950	983.33	48.26	48.9	46.81	48.56	NC	48.71	50.02	C
951	985.00	48.26	48.9	46.81	48.56	NC	48.71	50.51	NC
1005	1008.33	48.26	48.9	46.81	48.56	NC	48.71	50.51	NC
1006	1010.00	48.26	48.9	46.81	49.12	C	48.71	50.51	NC
1020	1033.33	48.26	48.9	46.81	49.12	C	48.71	50.51	NC
1021	1035.00	48.26	48.9	46.81	47.69	NC	48.71	50.51	NC
1025	1041.67	48.26	48.9	46.81	47.69	NC	48.71	50.51	NC
1026	1043.33	48.26	48.9	46.81	47.69	NC	48.71	51.18	C
1040	1066.67	48.26	48.9	46.81	47.69	NC	48.71	51.18	C
1041	1068.33	48.26	48.9	46.81	47.69	NC	48.71	48.75	NC
1300	1300.00	48.26	48.9	46.81	47.69	NC	48.71	48.75	NC
1301	1301.67	47.12	48.48	43.82	47.69	NC	47.76	48.75	NC
1305	1308.33	47.12	48.48	43.82	47.69	NC	47.76	48.75	NC
1306	1310.00	47.12	48.48	43.82	47.76	NC	47.76	48.75	NC
1530	1550.00	47.12	48.48	43.82	47.76	NC	47.76	48.75	NC
1531	1551.67	47.12	48.48	43.82	47.76	NC	47.76	49.27	NC
1555	1591.67	47.12	48.48	43.82	47.76	NC	47.76	49.27	NC
1556	1593.33	47.12	48.48	43.82	47.3	C	47.76	49.27	NC
1615	1625.00	47.12	48.48	43.82	47.3	C	47.76	49.27	NC
1616	1626.67	47.12	48.48	43.82	47.38	NC	47.76	49.27	NC
1748	1780.00	47.12	48.48	43.82	47.38	NC	47.76	49.27	NC
1749	1781.67	47.12	48.48	43.82	48.78	C	47.76	49.27	NC
1800	1800.00	47.12	48.48	43.82	48.78	C	47.76	49.27	NC
1801	1801.67	47.12	48.48	43.82	48.21	NC	47.76	49.27	NC
1900	1900.00	47.12	48.48	43.82	48.21	NC	47.76	49.27	NC
1930	1950.00				48.21	NC			

BOD concentrations in mg/L (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	1.34	1.14	1.94	1.64	NC	2.24	1.84	NC
915	925.00	1.34	1.14	1.94	1.64	NC	2.24	1.84	NC
916	926.67	1.34	1.14	1.94	1.64	NC	2.24	1.74	C
950	983.33	1.34	1.14	1.94	1.64	NC	2.24	1.74	C
951	985.00	1.34	1.14	1.94	1.64	NC	2.24	1.24	NC
1005	1008.33	1.34	1.14	1.94	1.64	NC	2.24	1.24	NC
1006	1010.00	1.34	1.14	1.94	2.64	C	2.24	1.24	NC
1020	1033.33	1.34	1.14	1.94	2.64	C	2.24	1.24	NC
1021	1035.00	1.34	1.14	1.94	1.14	NC	2.24	1.24	NC
1025	1041.67	1.34	1.14	1.94	1.14	NC	2.24	1.24	NC
1026	1043.33	1.34	1.14	1.94	1.14	NC	2.24	2.14	C
1040	1066.67	1.34	1.14	1.94	1.14	NC	2.24	2.14	C
1041	1068.33	1.34	1.14	1.94	1.14	NC	2.24	1.44	NC
1300	1300.00	1.34	1.14	1.94	1.14	NC	2.24	1.44	NC
1301	1301.67	1.84	1.54	1.84	1.14	NC	1.94	1.44	NC
1305	1308.33	1.84	1.54	1.84	1.14	NC	1.94	1.44	NC
1306	1310.00	1.84	1.54	1.84	0.64	NC	1.94	1.44	NC
1530	1550.00	1.84	1.54	1.84	0.64	NC	1.94	1.44	NC
1531	1551.67	1.84	1.54	1.84	0.64	NC	1.94	1.64	NC
1555	1591.67	1.84	1.54	1.84	0.64	NC	1.94	1.64	NC
1556	1593.33	1.84	1.54	1.84	0.74	C	1.94	1.64	NC
1615	1625.00	1.84	1.54	1.84	0.74	C	1.94	1.64	NC
1616	1626.67	1.84	1.54	1.84	1.54	NC	1.94	1.64	NC
1748	1780.00	1.84	1.54	1.84	1.54	NC	1.94	1.64	NC
1749	1781.67	1.84	1.54	1.84	1.64	C	1.94	1.64	NC
1800	1800.00	1.84	1.54	1.84	1.64	C	1.94	1.64	NC
1801	1801.67	1.84	1.54	1.84	1.34	NC	1.94	1.64	NC
1900	1900.00	1.84	1.54	1.84	1.34	NC	1.94	1.64	NC
1930	1950.00				1.34	NC			

Fecal Coliform concentrations in cfu/100mL (9/26/97)

time(cst)	Ab. time	control	pasture 1	tributary	pasture 2M	2m event	pasture 3	pasture 3M	3m event
700	700.00	2500	2500	1000	1800	NC	1900	2900	NC
915	925.00	2500	2500	1000	1800	NC	1900	2900	NC
916	926.67	2500	2500	1000	1800	NC	1900	400	C
950	983.33	2500	2500	1000	1800	NC	1900	400	C
951	985.00	2500	2500	1000	1800	NC	1900	2700	NC
1005	1008.33	2500	2500	1000	1800	NC	1900	2700	NC
1006	1010.00	2500	2500	1000	2700	C	1900	2700	NC
1020	1033.33	2500	2500	1000	2700	C	1900	2700	NC
1021	1035.00	2500	2500	1000	1300	NC	1900	2700	NC
1025	1041.67	2500	2500	1000	1300	NC	1900	2700	NC
1026	1043.33	2500	2500	1000	1300	NC	1900	200	C
1040	1066.67	2500	2500	1000	1300	NC	1900	200	C
1041	1068.33	2500	2500	1000	1300	NC	1900	600	NC
1300	1300.00	2500	2500	1000	1300	NC	1900	600	NC
1301	1301.67	600	600	800	1300	NC	500	600	NC
1305	1308.33	600	600	800	1300	NC	500	600	NC
1306	1310.00	600	600	800	800	NC	500	600	NC
1530	1550.00	600	600	800	800	NC	500	600	NC
1531	1551.67	600	600	800	800	NC	500	1200	NC
1555	1591.67	600	600	800	800	NC	500	1200	NC
1556	1593.33	600	600	800	1900	C	500	1200	NC
1615	1625.00	600	600	800	1900	C	500	1200	NC
1616	1626.67	600	600	800	800	NC	500	1200	NC
1748	1780.00	600	600	800	800	NC	500	1200	NC
1749	1781.67	600	600	800	1300	C	500	1200	NC
1800	1800.00	600	600	800	1300	C	500	1200	NC
1801	1801.67	600	600	800	1100	NC	500	1200	NC
1900	1900.00	600	600	800	1100	NC	500	1200	NC
1930	1950.00				1100	NC			

Storm Samples

Total Solids Concentrations in mg/L.

Location		storm		mean conc
	02/13/97	03/14/97	02/08/98	(n=3)
Pasture 1	364	428	327	373
Tributary	382	482	316	393
Pasture 2	415	513	413	447
Pasture 3	416	536	371	441

Macroinvertebrates - Johnson Branch and Clear Fork (Ref. Site)

Taxa	Pasture 1		Pasture 2		Pasture 3		Clear Fork (Ref. Site)	
	No./3m2	Qual	No./3m2	Qual	No./3m2	Qual	Semi-Quantitative	Qual
Insecta								
Ephemeroptera								
Baetidae								
Baetis spp.	104	•	181	•	138	•		•
Acentrella ampla	5	•	30	•	25	•		
Acentrella spp.							34	•
Acerpenna spp.								•
Centroptilum spp.								•
Diphetor spp.							8	•
Caenidae								
Caenis spp.								•
Heptageniidae								
Epeorus spp.								•
Leucrocuta spp.							2	•
Stenonema spp.							5	•
Stenacron interpunctatum	51	•	6	•	4	•		
Ephemeridae								
Hexagenia munda				•		•		
Ephemerellidae								
Ephemerella spp.								•
Eurylophella sp.	30	•	5	•	4	•		
Isonychiidae								
Isonychia spp.							1	•
Leptophlebiidae								
Habrophlebiodes spp.								•
Paraleptophlebia spp.							9	•
Plecoptera								
Leuctridae								
Leuctra spp.							46	•
Nemouridae								
Amphinemura nigritta/delosa	8	•	5	•	9	•		
Amphinemura spp.								•
Perlidae								
Perlesta spp.								•
Perlodidae								
Clioperla clio		•	1	•	4			
Isoperla spp.								•
Trichoptera								
Brachycentridae								
Micrasema sp. (case only)		•	4	•	1			
Glossosomatidae								
Glossosoma spp.								•
Und. spp. (pupa)								•
Helicopsychiidae								
Helicopsyche borealis	18	•	30	•	74	•		•
Hydroptilidae								
Hydroptila sp.	2	•	1		3			
Hydrosychidae								
Ceratopsyche spp.								•
Cheumatopsyche sp.	16	•			2	•	1	•
Hydropsyche betteni/depravata		•	4	•				
Leptoceridae								
Triaenodes sp.		•						•
Limnephilidae								
Pycnopsyche spp.								•
Polycentropodidae								
Cerotina spp.								•
Ryacophilidae								
Rhyacophilia ledra/fenestra	9	•	12	•	13	•		

Macroinvertebrates - Johnson Branch and Clear Fork (Ref. Site)-continued

Taxa	Pasture 1 No./3m2	Qual	Pasture 2 No./3m2	Qual	Pasture 3 No./3m2	Qual	Clear Fork (Ref. Site) Semi-Quantitative	Qual
Uenoidae								
Neophylax spp.								•
Odonata								
Calopterygidae								
Calopteryx sp.		•		•		•		•
Aeshnidae								
Boyeria vinosa		•						
Boyeria spp.								•
Diptera								
Blephariceridae								
Blepharicera spp.								•
Chironomidae								
sub-family Chironominae								
tribe Chironomini								
Chironomus sp.	4	•						
Cricotopus sp.					1			•
Cryptochironomus sp.					3			
Microtendipes sp.	1				2			•
Paratendipes spp.								•
Polypedilum sp.	2						3	•
Strictochironomus sp.				•		•		
Unidentified spp.	1	•	25	•	32	•		
sub-family Diamesinae								
Potthastia sp.	1							
sub-family Orthocladiinae								
Brillia spp.								•
Corynoneura spp.							1	•
Crico/Ortho spp.							11	•
Eukiefferiella spp.							2	•
Orthocladius spp. (pupa)							3	•
Paraphaenocladius spp.								•
Tvetenia bavarica gp. (larvae)							3	•
Tvetenia spp. (pupa)							2	•
Parametriocnemus lumbecki	3				1			
sub-family Tanypodinae								
Conchapelopia spp.							3	•
Larsia spp.								•
Thienemannimyia sp.					1			
tribe Tanytarsini								
Micropsectra spp.								•
Rheotanytarsus spp. (larvae)							2	•
Rheotanytarsus spp. (pupa)								•
Stempellinella spp.							2	•
Dixidae								
Dixella spp.								•
Empididae								
Chelifera spp.							1	•
Und. juvenile							1	•
Simuliidae								
Simulium sp.		•	16	•	21	•	7	•
Tabanidae								
Chrysops sp.	1				3			
Tipulidae								
Antocha spp.								•
Hexatoma sp.	3		1		2			
Pseudolimnophila sp.			2					
Tipula "abdominalis"		•						
Tipula sp.	8	•	4	•	3	•		•

Macroinvertebrates - Johnson Branch and Clear Fork (Ref. Site)-continued

Taxa	Pasture 1 No./3m2	Qual	Pasture 2 No./3m2	Qual	Pasture 3 No./3m2	Qual	Clear Fork (Ref. Site) Semi-Quantitative	Qual
Hemiptera								
Gerridae								
Gerris remigis		•		•		•		
Megaloptera								
Corydalidae								
Nigronia spp.								•
Sialidae								
Sialis sp.						•		
Coleoptera								
Unidentified spp.								
Dytiscidae sp.		•		•				
Elmidae (adult)								
Optioservus sp.		•					5	•
Dubiraphia spp.								•
Stenelmis crenata	8	•	1	•	7			
Stenelmis spp.							1	•
Elmidae (larva)								
Optioservus sp.	12	•	27	•	14	•		
Haliplidae								
Peltodytes sp.		•		•		•		
Psephenidae								
Psephenus herricki (larva)	4	•	1		1			
Psephenus spp.							4	•
Scirtidae								
Cyphon spp.								•
ARTHROPODA								
Crustacea								
Amphipoda								
Crangonyctidae								
Crangonyx sp.	148	•	36	•	9	•		
Gammaridae								
Gammarus spp.							4	•
Decapoda								
Cambaridae								
Orconectes sp.	5	•	5	•		•		
Und. spp.								•
Isopoda								
Asellidae								
Lirceus sp.	187	•	108	•	33	•		
Arachnida								
Acarina								
Und. spp.								•
MOLLUSCA								
Gastropoda								
Ancylidae								
Ferrissia spp.								•
Physidae								
Physella sp.		•				•		
Pleuroceridae								
Elimia laqueata laqueata	65	•	57	•	14	•		
Pleurocera spp.								•
Pelecypoda								
Corbiculidae								
Corbicula fluminea		•	5	•	2	•		
Sphaeridae								
Sphaerium sp.		•	2	•	1			

Macroinvertebrates - Johnson Branch and Clear Fork (Ref. Site)-continued

Taxa	Pasture 1		Pasture 2		Pasture 3		Clear Fork (Ref. Site)	
	No./3m2	Qual	No./3m2	Qual	No./3m2	Qual	Semi-Quantitative	Qual
ANNELIDA								
Clitellata								
Subclass Oligochaeta								
Aeolosomatidae								
Aeolosoma spp.							1	*
Branchiobdellida								
Und. spp.							1	*
Lumbriculida								
Lumbriculidae								
Lumbriculus sp.	2	*	14	*	3	*		
Naididae								
Chaetogaster spp.							2	*
Nais spp.							3	*
Pristina spp.							1	*
Haplotaxida								
Tubificidae								
Limnodrilus hoffmeisteri			1					
Tubificidae w.o.h.c.								
Tubificidae w.h.c.	8	*						
Tubificidae sp.			93	*	58	*		
PLATYHELMINYHES								
Turbellaria								
Tricladida								
Planariidae sp.	1		8	*	1			
Cura spp.							1	*
Nemadoda								
Mermithidae								
Und. spp.								*
Total Density	707		685		489		170	

Fish - Johnson Branch and Leiper's Creek (Ref. Stream)

Species	Common Name	Johnson Br.	Leiper's Cr.
CYPRINIDAE			
Campostoma anomalum	central stoneroller	16	11
Clinostomus funduloides	rosyside dace		4
Cyprinella galactura	whitetail shiner		31
Luxilus chrysocephalus	striped shiner	28	29
Lythrurus ardens	rosefin shiner	4	40
Notropis telescopus	telescope shiner		13
Pimephales notatus	bluntnose minnow	77	5
P. vigilax	bullhead minnow		3
Rhinichthys atratulus	blacknose dace		1
Semotilus atromaculatus	creek chub	29	2
PERCIDAE			
Etheostoma blenniodes	greenside darter	2	
E. caeruleum	rainbow darter		3
E. crossopterum	fringed darter	6	7
E. flabellare	fantail darter	14	14
E. flavum	saffron darter	6	14
E. luteovinctum	redband darter	14	
CATOSTOMIDAE			
Hypentelium nigricans	northern hogsucker		3
ICTALURIDAE			
Noturus exilis	slender madtom	3	5
FUNDULIDAE			
Fundulus catenatus	northern studfish	2	3
F. notatus	blackstripe topminnow	2	
COTTIDAE			
Cottus carolinae	banded sculpin	10	7
CENTRARCHIDAE			
Lepomis cyanellus	green sunfish	12	2
L. megalotis	longear	1	4
L. macrochirus	bluegill	14	
Micropterus dolomieu	smallmouth bass		2
M. salmoides	largemouth bass		1
POECILIDAE			
Gambusia affinis *	mosquito fish	1	
	TOTAL SPECIES	18	22

APPENDIX C.

DATA SUMMARY

Mass Calculations for Automated Samplers-Nitrate Mass Summary

Date	Station	Time	conc (mg/L)	Q (cfs)	Mass (lbs/x hrs)	Mass (lbs/sampleday)	Mass (lbs/day)
10/26/96	control	0700-1100	1.08	0.70	0.677		
	control	1101-1500	1.04	0.55	0.518		
	control	1501-1900	1.11	0.55	0.553	1.747	3.49
	pasture 1	0700-1100	1.3	0.70	0.815		
	pasture 1	1101-1500	1.38	0.55	0.687		
	pasture 1	1501-1900	1.35	0.55	0.672	2.174	4.35
	tributary	0700-1100	1.25	0.25	0.275		
	tributary	1101-1500	1.39	0.19	0.243		
	tributary	1501-1900	1.25	0.19	0.219	0.737	1.47
	*pasture 3	0700-1100	1.49	0.94	1.262		
	pasture 3	1101-1500	1.51	0.75	1.016		
	pasture 3	1501-1900	1.47	0.75	0.989	3.267	6.53
02/13/97	control	0800-1159	2.35	4.16	8.775		
	control	1200-1800	2.38	4.16	8.887	17.661	42.39
	pasture 1	0800-1159	2.57	4.16	9.596		
	pasture 1	1200-1800	2.33	4.16	8.700	18.296	43.91
	tributary	0800-1159	2.3	1.46	3.017		
	tributary	1200-1800	2.21	1.46	2.899	5.917	14.20
	pasture 3	0800-1159	2.6	5.62	13.119		
	pasture 3	1200-1800	2.26	5.62	11.403	24.522	58.85
04/12/97	control	0700-1300	1.55	1.21	2.529		
	control	1301-1830	1.54	1.21	2.304	4.833	10.15
	pasture 1	0700-1300	1.42	1.21	2.317		
	pasture 1	1301-1830	1.76	1.21	2.633	4.950	10.39
	tributary	0700-1300	1.72	0.43	0.986		
	tributary	1301-1830	2.81	0.43	1.477	2.463	5.17
	pasture 3	0700-1300	1.55	1.64	3.418		
	pasture 3	1301-1830	2.07	1.64	4.184	7.602	15.96
06/27/97	control	0600-1230	2.13	2.13	6.637		
	control	1231-1930	1.49	2.13	5.000	11.638	20.95
	pasture 1	0600-1230	2.34	2.13	7.292		
	pasture 1	1231-1930	2.03	2.13	6.812	14.104	25.39
	tributary	0600-1230	0.89	0.75	0.974		
	tributary	1231-1930	0.89	0.75	1.049	2.024	3.64
	pasture 3	0600-1230	1.88	2.88	7.917		
	pasture 3	1231-1930	1.75	2.88	7.936	15.853	28.54
08/15/97	control	0600-1200	1.08	0.57	0.836		
	control	1201-1800	1.04	0.57	0.873	1.709	3.42
	pasture 1	0600-1200	1.37	0.57	1.149		
	pasture 1	1201-1800	1.22	0.57	1.024	2.173	4.35
	tributary	0600-1200	1.53	0.20	0.451		
	tributary	1201-1800	0.51	0.20	0.150	0.601	1.20
	pasture 3	0600-1200	2.1	0.78	2.381		
	pasture 3	1201-1800	2.53	0.78	2.868	5.249	10.50
09/26/97	control	0700-1300	2.02	2.13	5.810		
	control	1301-1900	2.03	2.13	5.839	11.650	23.30
	pasture 1	0700-1300	2.7	2.13	7.766		
	pasture 1	1301-1900	2.71	2.13	7.795	15.562	31.12
	tributary	0700-1300	1.4	0.75	1.415		
	tributary	1301-1900	1.31	0.75	1.324	2.739	5.48
	pasture 3	0700-1300	2.25	2.88	8.746		
	pasture 3	1301-1900	2.12	2.88	8.241	16.987	33.97

* concentration is adjusted

Mass Calculations for Automated Samplers-Ammonia Mass Summary

Date	Station	Time	conc (mg/L)	Q (cfs)	Mass (lbs/x hrs)	Mass (lbs/sampleday)	Mass (lbs/day)
10/26/96	control	0700-1100	0.01	0.70	0.0063		
	control	1101-1500	0.02	0.55	0.0100		
	control	1501-1900	0.19	0.55	0.0946	0.1108	0.22
	pasture 1	0700-1100	0.01	0.70	0.0063		
	pasture 1	1101-1500	0.02	0.55	0.0100		
	pasture 1	1501-1900	0.04	0.55	0.0199	0.0361	0.07
	tributary	0700-1100	0	0.25	0.0000		
	tributary	1101-1500	0.01	0.19	0.0017		
	tributary	1501-1900	0.04	0.19	0.0070	0.0087	0.02
	*pasture 3	0700-1100	0.11	0.94	0.0932		
	pasture 3	1101-1500	0.09	0.75	0.0605		
	pasture 3	1501-1900	0.13	0.75	0.0875	0.2412	0.48
02/13/97	control	0800-1159	0.02	4.16	0.0747		
	control	1200-1800	0	4.16	0.0000	0.0747	0.18
	pasture 1	0800-1159	0.03	4.16	0.1120		
	pasture 1	1200-1800	0	4.16	0.0000	0.1120	0.27
	tributary	0800-1159	0.07	1.46	0.0918		
	tributary	1200-1800	0.08	1.46	0.1574	0.2493	0.60
	pasture 3	0800-1159	0.11	5.62	0.5550		
	pasture 3	1200-1800	0.13	5.62	0.9839	1.5389	3.69
04/12/97	control	0700-1300	0.04	1.21	0.0653		
	control	1301-1830	0.04	1.21	0.0598	0.1251	0.26
	pasture 1	0700-1300	0.03	1.21	0.0490		
	pasture 1	1301-1830	0.03	1.21	0.0449	0.0938	0.20
	tributary	0700-1300	0.13	0.43	0.0745		
	tributary	1301-1830	0.06	0.43	0.0315	0.1061	0.22
	pasture 3	0700-1300	0.08	1.64	0.1764		
	pasture 3	1301-1830	0.1	1.64	0.2021	0.3786	0.79
06/27/97	control	0600-1230	0.07	2.13	0.2181		
	control	1231-1930	0.02	2.13	0.0671	0.2852	0.51
	pasture 1	0600-1230	0.06	2.13	0.1870		
	pasture 1	1231-1930	0	2.13	0.0000	0.1870	0.34
	tributary	0600-1230	0.05	0.75	0.0547		
	tributary	1231-1930	0.06	0.75	0.0707	0.1255	0.23
	pasture 3	0600-1230	0.05	2.88	0.2106		
	pasture 3	1231-1930	0.05	2.88	0.2267	0.4373	0.79
08/15/97	control	0600-1200	0	0.57	0.0000		
	control	1201-1800	0.04	0.57	0.0310	0.0310	0.06
	pasture 1	0600-1200	0.01	0.57	0.0077		
	pasture 1	1201-1800	0.07	0.57	0.0542	0.0620	0.12
	tributary	0600-1200	0.03	0.20	0.0082		
	tributary	1201-1800	0.1	0.20	0.0272	0.0354	0.07
	pasture 3	0600-1200	0.09	0.78	0.0942		
	pasture 3	1201-1800	0	0.78	0.0000	0.0942	0.19
09/26/97	control	0700-1300	0	2.13	0.0000		
	control	1301-1900	0.09	2.13	0.2589	0.2589	0.52
	pasture 1	0700-1300	0	2.13	0.0000		
	pasture 1	1301-1900	0.16	2.13	0.4602	0.4602	0.92
	tributary	0700-1300	0	0.75	0.0000		
	tributary	1301-1900	0.12	0.75	0.1213	0.1213	0.24
	pasture 3	0700-1300	0	2.88	0.0000		
	pasture 3	1301-1900	0.17	2.88	0.6608	0.6608	1.32

* concentration is adjusted

Mass Calculations for Automated Samplers-Total Solids Mass Summary

Date	Station	Time	conc (mg/L)	Q (cfs)	Mass (lbs/x hrs)	Mass (lbs/sampleday)	Mass (lbs/day)
10/26/96	control	0700-1100	401	0.70	251.393		
	control	1101-1500	378	0.19	66.119		
	control	1501-1900	317	0.19	55.449	372.962	745.92
	pasture 1	0700-1100	326	0.70	204.375		
	pasture 1	1101-1500	398	0.19	69.618		
	pasture 1	1501-1900	326	0.19	57.023	331.016	662.03
	tributary	0700-1100	251	0.70	157.356		
	tributary	1101-1500	423	0.25	93.173		
	tributary	1501-1900	378	0.25	83.261	333.791	667.58
	*pasture 3	0700-1100	366.5	0.94	310.493		
	pasture 3	1101-1500	321	0.75	215.957		
	pasture 3	1501-1900	412	0.75	277.179	803.629	1607.26
02/13/97	control	0800-1159	337	4.16	1258.304		
	control	1200-1800	325	4.16	1820.247	3078.550	7388.52
	pasture 1	0800-1159	358	4.16	1336.714		
	pasture 1	1200-1800	364	4.16	2038.676	3375.391	8100.94
	tributary	0800-1159	316	1.46	414.557		
	tributary	1200-1800	382	1.46	751.713	1166.270	2799.05
	pasture 3	0800-1159	411	5.62	2073.794		
	pasture 3	1200-1800	341	5.62	2580.890	4654.685	11171.24
04/12/97	control	0700-1300	348	1.21	567.875		
	control	1301-1830	340	1.21	508.586	1076.461	2260.57
	pasture 1	0700-1300	404	1.21	659.258		
	pasture 1	1301-1830	284	1.21	424.819	1084.076	2276.56
	tributary	0700-1300	396	0.43	227.044		
	tributary	1301-1830	364	0.43	191.306	418.350	878.54
	pasture 3	0700-1300	544	1.64	1199.613		
	pasture 3	1301-1830	308	1.64	622.593	1822.206	3826.63
06/27/97	control	0600-1230	420	2.13	1308.780		
	control	1231-1930	408	2.13	1369.185	2677.965	4820.34
	pasture 1	0600-1230	372	2.13	1159.205		
	pasture 1	1231-1930	332	2.13	1114.141	2273.346	4092.02
	tributary	0600-1230	608	0.75	665.675		
	tributary	1231-1930	464	0.75	547.094	1212.769	2182.98
	pasture 3	0600-1230	568	2.88	2391.850		
	pasture 3	1231-1930	432	2.88	1959.088	4350.938	7831.69
08/15/97	control	0600-1200	372	0.57	288.086		
	control	1201-1800	436	0.57	365.787	653.874	1307.75
	pasture 1	0600-1200	364	0.57	305.382		
	pasture 1	1201-1800	432	0.57	362.431	667.813	1335.63
	tributary	0600-1200	536	0.20	157.997		
	tributary	1201-1800	408	0.20	120.266	278.263	556.53
	pasture 3	0600-1200	436	0.78	494.307		
	pasture 3	1201-1800	404	0.78	458.028	952.335	1904.67
09/26/97	control	0700-1300	376	2.13	1081.541		
	control	1301-1900	360	2.13	1035.518	2117.059	4234.12
	pasture 1	0700-1300	336	2.13	966.483		
	pasture 1	1301-1900	340	2.13	977.989	1944.473	3888.95
	tributary	0700-1300	304	0.75	307.235		
	tributary	1301-1900	280	0.75	282.979	590.214	1180.43
	pasture 3	0700-1300	396	2.88	1539.284		
	pasture 3	1301-1900	328	2.88	1274.962	2814.246	5628.49

* concentration is adjusted

Mass Calculations for Automated Samplers-TOC Mass Summary

Date	Station	Time	conc (mg/L)	Q (cfs)	Mass (lbs/x hrs)	Mass (lbs/sampleday)	Mass (lbs/day)
10/26/96	control	0700-1100	52.4	0.70	32.8504		
	control	1101-1500	58.4	0.55	29.0742		
	control	1501-1900	55.8	0.55	27.7798	89.704	179.41
	pasture 1	0700-1100	56.65	0.70	35.5148		
	pasture 1	1101-1500	57.97	0.55	28.8601		
	pasture 1	1501-1900	54.9	0.55	27.3317	91.707	183.41
	tributary	0700-1100	50.04	0.25	11.0222		
	tributary	1101-1500	53.04	0.19	9.2777		
	tributary	1501-1900	50.22	0.19	8.7844	29.084	58.17
	*pasture 3	0700-1100	59.54	0.94	50.4413		
	pasture 3	1101-1500	57.35	0.75	38.5830		
	pasture 3	1501-1900	61.72	0.75	41.5230	130.547	261.09
02/13/97	control	0800-1159	34.05	4.16	127.1372		
	control	1200-1800	31.13	4.16	174.3516	301.489	723.57
	pasture 1	0800-1159	33.59	4.16	125.4197		
	pasture 1	1200-1800	33.94	4.16	190.0897	315.509	757.22
	tributary	0800-1159	39.39	1.46	51.6753		
	tributary	1200-1800	38.79	1.46	76.3323	128.008	307.22
	pasture 3	0800-1159	36.84	5.62	185.8846		
	pasture 3	1200-1800	37.06	5.62	280.4920	466.377	1119.30
04/12/97	control	0700-1300	37.16	1.21	60.6387		
	control	1301-1830	36.96	1.21	55.2863	115.925	243.44
	pasture 1	0700-1300	36.51	1.21	59.5780		
	pasture 1	1301-1830	35.16	1.21	52.5938	112.172	235.56
	tributary	0700-1300	39.62	0.43	22.7159		
	tributary	1301-1830	37.15	0.43	19.5248	42.241	88.71
	pasture 3	0700-1300	37.66	1.64	83.0467		
	pasture 3	1301-1830	35.45	1.64	71.6588	154.706	324.88
06/27/97	control	0600-1230	38.18	2.13	118.9743		
	control	1231-1930	38.61	2.13	129.5692	248.544	447.38
	pasture 1	0600-1230	38.36	2.13	119.5352		
	pasture 1	1231-1930	37.04	2.13	124.3005	243.836	438.90
	tributary	0600-1230	38.68	0.75	42.3492		
	tributary	1231-1930	38.28	0.75	45.1352	87.484	157.47
	pasture 3	0600-1230	39.99	2.88	168.3980		
	pasture 3	1231-1930	38.96	2.88	176.6807	345.079	621.14
08/15/97	control	0600-1200	46.26	0.57	35.8249		
	control	1201-1800	45.4	0.57	38.0888	73.914	147.83
	pasture 1	0600-1200	49.28	0.57	41.3440		
	pasture 1	1201-1800	46.98	0.57	39.4144	80.758	161.52
	tributary	0600-1200	45.06	0.20	13.2823		
	tributary	1201-1800	47.34	0.20	13.9544	27.237	54.47
	pasture 3	0600-1200	48.61	0.78	55.1107		
	pasture 3	1201-1800	49.09	0.78	55.6549	110.766	221.53
09/26/97	control	0700-1300	48.26	2.13	138.8169		
	control	1301-1900	47.12	2.13	135.5378	274.355	548.71
	pasture 1	0700-1300	48.9	2.13	140.6579		
	pasture 1	1301-1900	48.48	2.13	139.4498	280.108	560.22
	tributary	0700-1300	46.81	0.75	47.3081		
	tributary	1301-1900	43.82	0.75	44.2863	91.594	183.19
	pasture 3	0700-1300	48.71	2.88	189.3397		
	pasture 3	1301-1900	47.76	2.88	185.6469	374.987	749.97

* concentration is adjusted

Mass Calculations for Automated Samplers-BOD Mass Summary

Date	Station	Time	conc (mg/L)	Q (cfs)	Mass (lbs/x hrs)	Mass (lbs/sampleday)	Mass (lbs/day)
10/26/96	control	0700-1100	1.22	0.70	0.765		
	control	1101-1500	0.72	0.55	0.358		
	control	1501-1900	0.42	0.55	0.209	1.332	2.66
	pasture 1	0700-1100	1.52	0.70	0.953		
	pasture 1	1101-1500	0.72	0.55	0.358		
	pasture 1	1501-1900	1.12	0.55	0.558	1.869	3.74
	tributary	0700-1100	2.12	0.25	0.467		
	tributary	1101-1500	1.32	0.19	0.231		
	tributary	1501-1900	1.62	0.19	0.283	0.981	1.96
	*pasture 3	0700-1100	1.45	0.94	1.228		
	pasture 3	1101-1500	1.2	0.75	0.807		
	pasture 3	1501-1900	1.7	0.75	1.144	3.179	6.36
02/13/97	control	0800-1159	1.47	4.16	5.489		
	control	1200-1800	1.67	4.16	9.353	14.842	35.62
	pasture 1	0800-1159	1.47	4.16	5.489		
	pasture 1	1200-1800	1.67	4.16	9.353	14.842	35.62
	tributary	0800-1159	1.57	1.46	2.060		
	tributary	1200-1800	1.87	1.46	3.680	5.740	13.77
	pasture 3	0800-1159	1.67	5.62	8.426		
	pasture 3	1200-1800	1.77	5.62	13.396	21.823	52.37
04/12/97	control	0700-1300	1.94	1.21	3.166		
	control	1301-1830	1.64	1.21	2.453	5.619	11.80
	pasture 1	0700-1300	1.34	1.21	2.187		
	pasture 1	1301-1830	1.34	1.21	2.004	4.191	8.80
	tributary	0700-1300	1.54	0.43	0.883		
	tributary	1301-1830	1.24	0.43	0.652	1.535	3.22
	pasture 3	0700-1300	1.44	1.64	3.175		
	pasture 3	1301-1830	1.14	1.64	2.304	5.480	11.51
06/27/97	control	0600-1230	1.44	2.13	4.487		
	control	1231-1930	1.24	2.13	4.161	8.648	15.57
	pasture 1	0600-1230	2.64	2.13	8.227		
	pasture 1	1231-1930	1.64	2.13	5.504	13.730	24.71
	tributary	0600-1230	1.34	0.75	1.467		
	tributary	1231-1930	1.84	0.75	2.170	3.637	6.55
	pasture 3	0600-1230	1.24	2.88	5.222		
	pasture 3	1231-1930	1.74	2.88	7.891	13.112	23.60
08/15/97	control	0600-1200	2.8	0.57	2.168		
	control	1201-1800	1.5	0.57	1.162	3.330	6.66
	pasture 1	0600-1200	1.5	0.57	1.162		
	pasture 1	1201-1800	2	0.57	1.549	2.710	5.42
	tributary	0600-1200	1.4	0.20	0.381		
	tributary	1201-1800	1.6	0.20	0.435	0.816	1.63
	pasture 3	0600-1200	1.9	0.78	1.988		
	pasture 3	1201-1800	1.4	0.78	1.465	3.454	6.91
09/26/97	control	0700-1300	1.34	2.13	3.854		
	control	1301-1900	1.84	2.13	5.293	9.147	18.29
	pasture 1	0700-1300	1.14	2.13	3.279		
	pasture 1	1301-1900	1.54	2.13	4.430	7.709	15.42
	tributary	0700-1300	1.94	0.75	1.961		
	tributary	1301-1900	1.84	0.75	1.860	3.820	7.64
	pasture 3	0700-1300	2.24	2.88	8.707		
	pasture 3	1301-1900	1.94	2.88	7.541	16.248	32.50

* concentration is adjusted

Mass Calculations for Automated Samplers-Fecal Coliform Mass Summary

Date	Station	Time	conc (cfu/mL)	Q (cfs)	Mass (cfu/4hrs)	Mass/10^8	Mass (cfu*10^8/sampleday)	Mass (cfu*10^8/day)
10/26/96	control	0700-1100	10	0.70	2846248630	28.4625		
	control	1101-1500	7	0.55	1582179386	15.8218		
	control	1501-1900	11	0.55	2486281892	24.8628	69.1471	138.29
	pasture 1	0700-1100	5	0.70	1423124315	14.2312		
	pasture 1	1101-1500	6	0.55	1356153759	13.5615		
	pasture 1	1501-1900	7	0.55	1582179386	15.8218	43.6146	87.23
	tributary	0700-1100	25	0.25	2500083256	25.0008		
	tributary	1101-1500	22	0.19	1747117005	17.4712		
	tributary	1501-1900	16	0.19	1270630549	12.7063	55.1783	110.36
	pasture 3	0700-1100	23	0.94	8846448445	88.4645		
	pasture 3	1101-1500	18	0.75	5497920645	54.9792		
	pasture 3	1501-1900	28	0.75	8552321004	85.5232	228.9669	457.93
02/13/97	control	0800-1159	2	4.16	3390384398	33.9038		
	control	1200-1800	4	4.16	10171153193	101.7115	135.6154	325.48
	pasture 1	0800-1159	6	4.16	10171153193	101.7115		
	pasture 1	1200-1800	3	4.16	7628364895	76.2836	177.9952	427.19
	tributary	0800-1159	10	1.46	5956080699	59.5608		
	tributary	1200-1800	18	1.46	16081417887	160.8142	220.3750	528.90
	pasture 3	0800-1159	7	5.62	16035601882	160.3560		
	pasture 3	1200-1800	13	5.62	44670605242	446.7061	607.0621	1456.95
04/12/97	control	0700-1300	10	1.21	7408617758	74.0862		
	control	1301-1830	50	1.21	33956164725	339.5616	413.6478	868.66
	pasture 1	0700-1300	21	1.21	15558097292	155.5810		
	pasture 1	1301-1830	60	1.21	40747397670	407.4740	563.0549	1182.42
	tributary	0700-1300	40	0.43	10412111444	104.1211		
	tributary	1301-1830	90	0.43	21474979853	214.7498	318.8709	669.63
	pasture 3	0700-1300	50	1.64	50058228096	500.5823		
	pasture 3	1301-1830	90	1.64	82596076358	825.9608	1326.5430	2785.74
06/27/97	control	0600-1230	3	2.13	4244258987	42.4426		
	control	1231-1930	0	2.13	0	0.0000	42.4426	76.40
	pasture 1	0600-1230	2	2.13	2829505991	28.2951		
	pasture 1	1231-1930	2	2.13	3047160298	30.4716	58.7667	105.78
	tributary	0600-1230	2	0.75	994150754	9.9415		
	tributary	1231-1930	32	0.75	17129982217	171.2998	181.2413	326.23
	pasture 3	0600-1230	3	2.88	5735485117	57.3549		
	pasture 3	1231-1930	5	2.88	10294460467	102.9446	160.2995	288.54
08/15/97	control	0600-1200	9	0.57	3164358771	31.6436		
	control	1201-1800	0	0.57	0	0.0000	31.6436	63.29
	pasture 1	0600-1200	10	0.57	3515954190	35.1595		
	pasture 1	1201-1800	0	0.57	0	0.0000	35.1595	70.32
	tributary	0600-1200	15	0.20	1853002884	18.5300		
	tributary	1201-1800	11	0.20	1358868782	13.5887	32.1187	64.24
	pasture 3	0600-1200	14	0.78	6651805225	66.5181		
	pasture 3	1201-1800	23	0.78	10927965727	109.2797	175.7977	351.60
09/26/97	control	0700-1300	25	2.13	32648146053	326.4815		
	control	1301-1900	6	2.13	7835555053	78.3556	404.8370	809.67
	pasture 1	0700-1300	25	2.13	32648146053	326.4815		
	pasture 1	1301-1900	6	2.13	7835555053	78.3556	404.8370	809.67
	tributary	0700-1300	10	0.75	4588388094	45.8839		
	tributary	1301-1900	8	0.75	3670710475	36.7071	82.5910	165.18
	pasture 3	0700-1300	19	2.88	33530528379	335.3053		
	pasture 3	1301-1900	5	2.88	8823823258	88.2382	423.5435	847.09

* concentration is adjusted

Mass Calculations for Manual Pump Samplers-Nitrate Mass Summary

Date	Station	Q (cfs)	Mass (lbs/sampleday)	**Time (hrs)	Mass (lbs/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	1.90	7.02	0.27	
		*0.94-0.75	0.84	3.24	0.26	
	3 IN		2.74			6.45
	2 OUT	*0.94-0.75	1.70	6.95	0.24	
	2 IN	*0.94-0.75	0.99	4.32	0.23	
	2 Total		2.69			5.72
02/13/97	3 OUT	5.62	30.56	9.93	3.08	
	3 IN	5.62	0.77	0.25	3.09	
	3 Total		31.33			73.92
	2 OUT	5.62	26.38	9.03	2.92	
	2 IN	5.62	2.00	0.63	3.18	
	2 Total		28.38			70.24
04/12/97	3 OUT	1.64	1.11	1.62	0.69	
	3 IN	1.64	4.81	9.43	0.51	
	3 Total		5.92			14.86
	2 OUT	1.64	4.44	8.39	0.53	
	2 IN	1.64	1.59	2.55	0.62	
	2 Total		6.03			12.95
06/27/97	3 OUT	2.88	6.53	7.35	1.15	
	3 IN	2.88	8.45	5.48	1.19	
	3 Total		14.98			27.82
	2 OUT	2.88	11.82	12.8	0.92	
	2 IN	2.88	0.59	0.65	0.91	
	2 Total		12.41			22.07
08/15/97	3 OUT	0.78	1.54	4.45	0.35	
	3 IN	0.78	3.28	8.5	0.39	
	3 Total		4.82			8.74
	2 OUT	0.78	1.53	8.93	0.17	
	2 IN	0.78	1.69	3.97	0.42	
	2 Total		3.22			5.07
09/26/97	3 OUT	2.88	15.36	11.12	1.38	
	3 IN	2.88	1.13	0.8	1.42	
	3 Total		16.49			33.15
	2 OUT	2.88	14.99	11.66	1.29	
	2 IN	2.88	0.96	0.73	1.32	
	2 Total		15.95			30.98

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Calculations for Manual Pump Samplers-Ammonia Mass Summary

ate	Station	Q (cfs)	Mass (lbs/sampleday)	**Time (hrs)	Mass (lbs/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	0.129	6.7	0.018	
	3 IN	*0.94-0.75	0.073	3.24	0.023	
	3 Total		0.202			0.448
	2 OUT	*0.94-0.75	0.051	6.95	0.007	
	2 IN	*0.94-0.75	0.078	4.32	0.018	
	2 Total		0.129			0.216
02/13/97	3 OUT	5.62	0.331	9.93	0.033	
	3 IN	5.62	0.002	0.25	0.088	
	3 Total		0.333			0.806
	2 OUT	5.62	0.194	9.03	0.021	
	2 IN	5.62	0.025	0.63	0.039	
	2 Total		0.219			0.515
04/12/97	3 OUT	1.64	0.04	1.62	0.026	
	3 IN	1.64	0.12	9.27	0.010	
	3 Total		0.16			0.476
	2 OUT	1.64	0.02	8.39	0.003	
	2 IN	1.64	0.02	2.55	0.008	
	2 Total		0.04			0.085
06/27/97	3 OUT	2.88	0.407	7.35	0.055	
	3 IN	2.88	0.341	5.48	0.062	
	3 Total		0.748			1.358
	2 OUT	2.88	0.125	12.76	0.010	
	2 IN	2.88	0.001	0.65	0.002	
	2 Total		0.126			0.235
08/15/97	3 OUT	0.78	0	4.45	0.000	
	3 IN	0.78	0.111	8.5	0.013	
	3 Total		0.111			0.111
	2 OUT	0.78	0.038	8.93	0.009	
	2 IN	0.78	0.081	3.97	0.010	
	2 Total		0.119			0.220
09/26/97	3 OUT	2.88	0.791	11.12	0.071	
	3 IN	2.88	0.07	0.8	0.087	
	3 Total		0.861			1.717
	2 OUT	2.88	0.314	11.64	0.027	
	2 IN	2.88	0.048	0.73	0.066	
	2 Total		0.362			0.676

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Calculations for Manual Pump Samplers-Total Solids Mass Summary

Date	Station	Q (cfs)	Mass (lbs/sampleday)	**Time (hrs)	Mass (lbs/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	489.69	7.00	69.96	
	3 IN	*0.94-0.75	209.91	3.24	64.79	
	3 Total		699.60			1662.29
	2 OUT	*0.94-0.75	443.81	6.95	63.86	
	2 IN	*0.94-0.75	299.11	4.32	69.24	
	2 Total		742.92	11.27		1555.88
02/13/97	3 OUT	5.62	5003.99	9.93	503.93	
	3 IN	5.62	118.57	0.25	474.30	
	3 Total		5122.56			12086.91
	2 OUT	5.62	4713.68	9.53	494.61	
	2 IN	5.62	280.08	0.63	444.56	
	2 Total		4993.76			11839.11
04/12/97	3 OUT	1.64	215.84	1.62	133.24	
	3 IN	1.64	1277.46	9.58	133.35	
	3 Total		1493.30			3198.81
	2 OUT	1.64	1032.01	8.39	123.01	
	2 IN	1.64	376.64	2.55	147.70	
	2 Total		1408.65			3015.20
06/27/97	3 OUT	2.88	1753.57	7.35	238.58	
	3 IN	2.88	1320.55	5.48	240.98	
	3 Total		3074.12			5739.07
	2 OUT	2.88	2656.09	12.76	208.16	
	2 IN	2.88	154.68	0.65	237.97	
	2 Total		2810.77			5015.22
08/15/97	3 OUT	0.78	288.04	4.45	64.73	
	3 IN	0.78	622.68	8.5	73.26	
	3 Total		910.72			1626.03
	2 OUT	0.78	568.83	8.93	63.70	
	2 IN	0.78	297.83	3.97	75.02	
	2 Total		866.66			1573.74
09/26/97	3 OUT	2.88	2327.74	11.12	209.33	
	3 IN	2.88	180.05	0.8	225.06	
	3 Total		2507.79			5036.50
	2 OUT	2.88	2381.64	11.64	204.61	
	2 IN	2.88	157.82	0.73	216.19	
	2 Total		2539.46			4919.09

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Calculations for Manual Pump Samplers-TOC Mass Summary

Date	Station	Q (cfs)	Mass (lbs/sampleday)	**Time (hrs)	Mass (lbs/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	77.91	7.00	11.13	
	3 IN	*0.94-0.75	37.68	3.24	11.63	
	3 Total		115.59			268.74
	2 OUT	*0.94-0.75	84.87	6.95	12.21	
	2 IN	*0.94-0.75	52.19	4.32	12.08	
	2 Total		137.06			292.48
02/13/97	3 OUT	5.62	444.11	9.93	44.72	
	3 IN	5.62	11.27	0.25	45.07	
	3 Total		455.38			1073.37
	2 OUT	5.62	407.33	9.03	45.11	
	2 IN	5.62	29.37	0.63	46.62	
	2 Total		436.70			1083.59
04/12/97	3 OUT	1.64	22.09	1.62	13.64	
	3 IN	1.64	128.14	9.23	13.88	
	3 Total		150.23			329.58
	2 OUT	1.64	113.02	8.39	13.47	
	2 IN	1.64	33.20	2.55	13.02	
	2 Total		146.22			322.13
06/27/97	3 OUT	2.88	183.31	7.35	24.94	
	3 IN	2.88	136.72	5.48	24.95	
	3 Total		320.03			598.61
	2 OUT	2.88	334.14	12.76	26.19	
	2 IN	2.88	16.82	0.65	25.87	
	2 Total		350.96			628.35
08/15/97	3 OUT	0.78	36.44	4.45	8.19	
	3 IN	0.78	73.26	8.50	8.62	
	3 Total		109.70			200.22
	2 OUT	0.78	74.24	8.93	8.31	
	2 IN	0.78	34.27	3.97	8.63	
	2 Total		108.51			200.71
09/26/97	3 OUT	2.88	354.70	11.12	31.90	
	3 IN	2.88	26.10	0.80	32.62	
	3 Total		380.80			766.18
	2 OUT	2.88	361.68	11.64	31.07	
	2 IN	2.88	22.81	0.73	31.25	
	2 Total		384.49			745.81

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Calculations for Manual Pump Samplers-BOD Mass Summary

Date	Station	Q (cfs)	Mass (lbs/sampleday)	**Time (hrs)	Mass (lbs/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	1.99	7	0.28	
	3 IN	*0.94-0.75	1.34	3.24	0.41	
	3 Total		3.33			7.14
	2 OUT	*0.94-0.75	1.10	6.95	0.16	
	2 IN	*0.94-0.75	1.55	4.32	0.36	
	2 Total		2.66			4.70
02/13/97	3 OUT	5.62	24.13	9.93	2.43	
	3 IN	5.62	0.53	0.25	2.11	
	3 Total		24.66			58.24
	2 OUT	5.62	20.62	9.03	2.28	
	2 IN	5.62	1.11	0.63	1.76	
	2 Total		21.73			54.39
04/12/97	3 OUT	1.64	0.93	1.61	0.58	
	3 IN	1.64	6.42	9.23	0.70	
	3 Total		7.35			15.03
	2 OUT	1.64	5.51	8.49	0.65	
	2 IN	1.64	1.73	2.55	0.68	
	2 Total		7.24			15.68
06/27/97	3 OUT	2.88	5.79	7.35	0.79	
	3 IN	2.88	7.97	5.48	1.46	
	3 Total		13.76			22.63
	2 OUT	2.88	9.53	12.76	0.75	
	2 IN	2.88	0.46	0.65	0.71	
	2 Total		9.99			17.97
08/15/97	3 OUT	0.78	0.88	4.45	0.20	
	3 IN	0.78	2.00	8.5	0.24	
	3 Total		2.88			5.14
	2 OUT	0.78	2.35	8.93	0.26	
	2 IN	0.78	1.48	3.97	0.37	
	2 Total		3.83			6.68
09/26/97	3 OUT	2.88	11.33	11.11	1.02	
	3 IN	2.88	0.96	0.8	1.20	
	3 Total		12.29			24.62
	2 OUT	2.88	9.27	11.64	0.80	
	2 IN	2.88	0.74	0.73	1.01	
	2 Total		10.01			19.35

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Calculations for Manual Pump Samplers-Fecal Coliform Mass Summary

Date	Station	Q (cfs)	Mass (cfu*10^{6}/sampleday)	**Time (hrs)	Mass (cfu*10^{6}/hr)	***Mass (lbs/day)
10/26/96	3 OUT	*0.94-0.75	98.55	7	14.08	
	3 IN	*0.94-0.75	48.61	3.24	15.00	
	3 Total		147.16			340.90
	2 OUT	*0.94-0.75	95.38	6.95	13.72	
	2 IN	*0.94-0.75	241.83	4.32	55.98	
	2 Total		337.21			511.84
02/13/97	3 OUT	5.62	456.16	9.93	45.90	
	3 IN	5.62	31.5	0.25	126.00	
	3 Total		487.66			1121.63
	2 OUT	5.62	153.1	9.03	16.95	
	2 IN	5.62	39	0.63	61.90	
	2 Total		192.1			435.12
04/12/97	3 OUT	1.64	196.4	1.62	121.23	
	3 IN	1.64	772.23	9.25	83.48	
	3 Total		968.63			2560.33
	2 OUT	1.64	801.77	8.39	95.56	
	2 IN	1.64	372.43	2.55	146.05	
	2 Total		1174.2			2422.19
06/27/97	3 OUT	2.88	629.17	7.35	85.60	
	3 IN	2.88	21	5.48	3.83	
	3 Total		650.17			1606.30
	2 OUT	2.88	229.77	12.76	18.01	
	2 IN	2.88	10.82	0.65	16.65	
	2 Total		240.59			431.36
08/15/97	3 OUT	0.78	9.2	4.45	2.07	
	3 IN	0.78	94.23	8.5	11.09	
	3 Total		103.43			126.35
	2 OUT	0.78	134.26	8.93	15.03	
	2 IN	0.78	32.36	3.97	8.15	
	2 Total		166.62			333.41
09/26/97	3 OUT	2.88	445.1	11.12	40.00	
	3 IN	2.88	8.1	0.8	10.10	
	3 Total		453.2			936.08
	2 OUT	2.88	417.7	11.64	35.90	
	2 IN	2.88	43	0.73	59.00	
	2 Total		460.7			878.46

* denotes two flow measurements: from 0700 thru 1100, Q=0.94; from 1101 thru 1100, 0=0.75.

** Time (hrs)=time when cows were in the stream or when cows were not in the stream.

*** Mass (lbs/day)= (time in (hr)*mass in (lbs/hr)) + ((24 (hr/day)-time in (hr)) *mass out (lbs/hr)

Mass Addition Summary

Constituent	Station	10/26/96 mass (lbs/day)	10/26/96 mass added	02/13/97 mass (lbs/day)	02/13/97 mass added	04/12/97 mass (lbs/day)	04/12/97 mass added	06/27/97 mass (lbs/day)	06/27/97 mass added
Total Solids	control (ISCO)	745.9		7388.5		2260.6		4820.3	
	pasture 1 (ISCO)	662.0	-83.9	8100.9	712.4	2276.6	16.0	4092.0	-728.3
	tributary (ISCO)	667.0		2799.1		878.5		2183.0	
	pasture 2 (manual)	1555.9	226.9	11839.1	939.1	3015.2	-139.9	5015.2	-1259.8
	pasture 3 (manual)	1662.3	106.4	12086.9	247.8	3198.8	183.6	5739.1	723.9
	pasture 3 (ISCO)	1607.3		11171.2		3826.6		7831.7	
NO3	control (ISCO)	3.5		42.4		10.2		21.0	
	pasture 1 (ISCO)	4.4	0.9	43.9	1.5	10.4	0.2	25.4	4.4
	tributary (ISCO)	1.5		14.2		5.2		3.6	
	pasture 2 (manual)	5.7	-0.2	70.2	12.1	13.0	-2.6	22.1	-6.9
	pasture 3 (manual)	6.5	0.8	73.9	3.7	14.9	1.9	27.8	5.7
	pasture 3 (ISCO)	6.5		58.9		16.0		28.5	
TOC	control (ISCO)	179.4		723.6		243.4		447.4	
	pasture 1 (ISCO)	183.4	4.0	757.2	33.6	235.6	-7.8	438.9	-8.5
	tributary (ISCO)	58.2		307.2		88.7		157.5	
	pasture 2 (manual)	292.4	50.8	1083.6	19.2	322.1	-2.2	628.4	32.0
	pasture 3 (manual)	268.7	-23.7	1073.4	-10.2	329.6	7.5	598.6	-29.8
	pasture 3 (ISCO)	261.1		1119.3		324.9		621.1	
Ammonia	control (ISCO)	0.22		0.18		0.26		0.51	
	pasture 1 (ISCO)	0.07	-0.2	0.27	0.1	0.20	-0.1	0.34	-0.2
	tributary (ISCO)	0.02		0.60		0.22		0.23	
	pasture 2 (manual)	0.22	0.1	0.52	-0.4	0.09	-0.3	0.24	-0.3
	pasture 3 (manual)	0.45	0.2	0.81	0.3	0.48	0.4	1.36	1.1
	pasture 3 (ISCO)	0.48		3.69		0.79		0.79	
BOD	control (ISCO)	2.7		35.6		11.8		15.6	
	pasture 1 (ISCO)	3.7	1.0	35.6	0.0	8.8	-3.0	24.7	9.1
	tributary (ISCO)	2.0		13.8		3.2		6.6	
	pasture 2 (manual)	4.7	-1.0	54.4	5.0	15.7	3.7	18.0	-13.3
	pasture 3 (manual)	7.3	2.6	58.2	3.8	15.0	-0.7	22.6	4.6
	pasture 3 (ISCO)	6.4		52.4		11.5		23.6	
Fecal Coliform	control (ISCO)	138.3		325.5		868.7		76.4	
	pasture 1 (ISCO)	87.2	-51.1	427.2	101.7	1182.4	313.7	105.8	29.4
	tributary (ISCO)	110.4		528.9		669.6		326.2	
	pasture 2 (manual)	511.8	314.2	435.1	-521.0	2422.2	570.2	431.4	-0.6
	pasture 3 (manual)	340.9	-170.9	1121.6	686.5	2560.3	138.1	1606.3	1174.9
	pasture 3 (ISCO)	457.9		1457.0		2785.7		288.5	

Mass Addition Summary (continued)

Constituent	Station	08/15/97 mass (lbs/day)	mass added	09/26/97 mass (lbs/day)	mass added	average annual mass	average annual mass addition
Total Solids	control (ISCO)	1307.8		4234.1		3460	
	pasture 1 (ISCO)	1335.6	27.8	3889.0	-345.1	3393	-66.85
	tributary (ISCO)	556.5		1180.4		1377	
	pasture 2 (manual)	1573.7	-318.4	4919.1	-150.3	4653	-117.07
	pasture 3 (manual)	1626.0	52.3	5036.5	117.4	4892	238.57
	pasture 3 (ISCO)	1904.7		5628.5			
NO3	control (ISCO)	3.4		23.3		17.3	
	pasture 1 (ISCO)	4.4	1.0	31.1	7.8	19.9	2.63
	tributary (ISCO)	1.2		5.5		5.2	
	pasture 2 (manual)	5.1	-0.5	31.0	-5.6	24.5	-0.61
	pasture 3 (manual)	8.7	3.6	33.2	2.2	27.5	2.97
	pasture 3 (ISCO)	10.5		34.0			
TOC	control (ISCO)	147.8		548.7		381.7	
	pasture 1 (ISCO)	161.5	13.7	560.2	11.5	389.5	7.75
	tributary (ISCO)	54.5		183.2		141.6	
	pasture 2 (manual)	200.7	-15.3	745.8	2.4	545.5	14.48
	pasture 3 (manual)	200.2	-0.5	766.2	20.4	539.5	-6.05
	pasture 3 (ISCO)	221.5		750.0			
Ammonia	control (ISCO)	0.06		0.52		0.29	
	pasture 1 (ISCO)	0.12	0.1	0.92	0.4	0.32	0.03
	tributary (ISCO)	0.07		0.24		0.23	
	pasture 2 (manual)	0.22	0.0	0.68	-0.5	0.33	-0.22
	pasture 3 (manual)	0.11	-0.1	1.72	1.0	0.82	0.49
	pasture 3 (ISCO)	0.19		1.32			
BOD	control (ISCO)	6.7		18.3		15.12	
	pasture 1 (ISCO)	5.4	-1.3	15.4	-2.9	15.60	0.48
	tributary (ISCO)	1.6		7.6		5.80	
	pasture 2 (manual)	6.7	-0.3	19.4	-3.6	19.82	-1.58
	pasture 3 (manual)	5.1	-1.6	24.6	5.2	22.13	2.32
	pasture 3 (ISCO)	6.9		32.5			
Fecal Coliform	control (ISCO)	63.3		809.7		380.32	
	pasture 1 (ISCO)	70.3	7.0	809.7	0.0	447.10	66.78
	tributary (ISCO)	64.2		165.2		310.75	
	pasture 2 (manual)	333.4	198.9	878.5	-96.4	835.41	77.56
	pasture 3 (manual)	126.4	-207.0	936.1	57.6	1115.27	279.86
	pasture 3 (ISCO)	351.6		847.1			

Mass Addition Calculations

Nitrate

Area	Average Mass Measured (lbs/day)	Mass Added (lbs/day)
Control	17.3	
Pasture 1	19.9	2.60
Tributary	5.2	
Pasture 2	24.5	-0.61
Pasture 3	27.5	3.00

Ammonia

Area	Average Mass Measured (lbs/day)	Mass Added (lbs/day)
Control	0.29	
Pasture 1	0.32	0.03
Tributary	0.23	
Pasture 2	0.33	-0.22
Pasture 3	0.82	0.49

Total Solids

Area	Average Mass Measured (lbs/day)	Mass Added (lbs/day)
Control	3459	
Pasture 1	3393	-66
Tributary	1377	
Pasture 2	4653	-117
Pasture 3	4892	239

Mass Addition Calculations (continued)

TOC

Area	Average Mass Measured (lbs/day)	Mass Added (lbs/day)
Control	382	
Pasture 1	389	7.00
Tributary	142	
Pasture 2	546	14.48
Pasture 3	539	-7.00

BOD

Area	Average Mass Measured (lbs/day)	Mass Added (lbs/day)
Control	15.1	
Pasture 1	15.6	0.50
Tributary	5.8	
Pasture 2	19.8	-1.58
Pasture 3	22.0	2.20

Fecal Coliform

Area	Average Mass Measured (10^8cfu/day)	Mass Added (10^8cfu/day)
Control	380	
Pasture 1	447	67
Tributary	311	
Pasture 2	835	77
Pasture 3	1115	280

BIBI Metrics and Calculation

(1) *Comparative Taxa Richness (Taxa Richness)*:

$$\textbf{Comparative Taxa Richness} = \frac{\textbf{Taxa richness test site}}{\textbf{Taxa richness reference site}} * 100$$

(2) *North Carolina Biotic Index (NCBI)*:

$$\textbf{NCBI} = \sum \frac{\textbf{Xi*Ti}}{\textbf{n}}$$

where: Xi = number of individuals within a taxa

Ti = tolerance value of a taxa

n = total number of organisms in the sample

therefore: $\textbf{Biotic Index} = \frac{\textbf{NCBI at reference site}}{\textbf{NCBI at test site}} * 100$

(3) *Five Dominant Taxa in Common (DIC)*: Direct comparison of the five most common taxa, regardless of order of abundance. Dominant species usually have a relative abundance greater than seven percent of the total density.

(4) *Indicator Assemblage Index (IAI)*:

$$\textbf{IAI} = 0.5\ (\%EPT_{test\ site} / \%EPT_{ref\ site} + \%CA_{ref\ site} / \%CA_{test\ site})$$

where: IAI = Indicator Assemblage Index

0.5 = Constant

$\%EPT_{test\ site}$ = Total relative abundance of ephemeropterans, plecopterans, and trichopterans at test site

$\%EPT_{ref\ site}$ = Total relative abundance of ephemeropterans, plecopterans, and trichopterans at reference site

$\%CA_{test\ site}$ = Total relative abundance of chironomids and annelids at test site

$\%CA_{ref\ site}$ = Total relative abundance of chironomids and annelids at reference site

(5) *Community Loss Index (CLI)*: Measures the loss of taxa between the reference site and the test site.

$$\mathbf{CLI} = \frac{\mathbf{d - a}}{\mathbf{e}}$$

where: d = Total number of taxa present in reference site sample

a = Number of taxa common to both samples

e = Total number of taxa present in test site sample

(6) *Functional Feeding Group Percent Similarity (FFGPS)*:

$$\mathbf{S}_{\text{ref site, test site}} = \sum \mathbf{min}\ (\mathbf{P_{ia}}, \mathbf{P_{ib}})$$

where: S = QSI between functional feeding groups of the reference and test site

QSI (Qualitative Similarity Index) = Number of individuals in each feeding group divided by the total density

P_{ia} = the relative abundance of feeding group i at reference site

P_{ib} = the relative abundance of feeding group i at test site

i = relative feeding group (e.g., herbivore, shredder, filterer, gatherer, etc.)

min (P_{ia}, P_{ib}) = the minimum possible value of feeding group a or b in terms of relative abundance

(7) *Percent EPT Index (%EPT)*: Percent of population as Ephemeroptera, Plecoptera, and Trichoptera.

$$\textbf{EPT Index} = \frac{\textbf{Number of EPT taxa at test site}}{\textbf{Number of EPT taxa at reference site}} * \mathbf{100}$$

BIBI Summary

Taxa	*Functional Feeding Group	Family Level Pollution Tolerance Values	NCBI Metric Pasture 1	NCBI Metric Pasture 2	NCBI Metric Pasture 3
Insecta					
Ephemeroptera					
Baetidae		6.1	0.940	1.879	2.033
Baetis spp.	4				
Acentrella ampla	4				
Heptageniidae		1.5	0.172	0.024	0.025
Stenacron interpunctatum	4				
Ephemeridae		2			
Hexagenia munda	3				
Ephemerellidae		1.9	0.081	0.014	0.016
Eurylophella sp.	3				
Plecoptera					
Nemouridae		1.2	0.014	0.009	0.022
Amphinemura nigritta/delosa	1				
Perlodidae		1.6		0.002	0.013
Clioperla clio	0				
Trichoptera					
Brachycentridae		1.3		0.008	0.003
Micrasema sp. (case only)	0				
Helicopsychiidae		0	0.000	0.000	0.000
Helicopsyche borealis	4				
Hydroptilidae		2.5	0.007	0.004	0.015
Hydroptila sp.	0				
Hydrosychidae		2.9	0.066	0.017	0.012
Cheumatopsyche sp.	2				
Hydropsyche betteni/depravata	2				
Leptoceridae		2.7			
Triaenodes sp.	0				
Ryacophilidae		0.7	0.009	0.012	0.019
Rhyacophilia ledra/fenestra	5				
Odonata					
Calopterygidae		6.7			
Calopteryx sp.	5				
Aeshnidae		5.6			
Boyeria vinosa	5				
Diptera					
Chironomidae		8	0.136	0.292	0.654
sub-family Chironominae					
tribe Chironomini					
Chironomus sp.	3				
Cricotopus sp.	3				
Cryptochironomus sp.	5				
Microtendipes sp.	2				
Polypedilum sp.	3				
Strictochironomus sp.	3				
Unidentified spp.	3				
sub-family Diamesinae					
Potthastia sp.	4				
sub-family Orthocladiinae					
Parametriocnemus lumbecki	2				
sub-family Tanypodinae					
Thienemannimyia sp.	5				
Simuliidae		3.5		0.082	0.150
Simulium sp.	2				

BIBI Summary (continued)

Taxa	*Functional Feeding Group	Family Level Pollution Tolerance Values	NCBI Metric		
			Pasture 1	Pasture 2	Pasture 3
Tabanidae		8	0.011		0.049
Chrysops sp.	3				
Tipulidae		4.9	0.076	0.050	0.050
Hexatoma sp.	5				
Pseudolimnophila sp.	3				
Tipula "abdominalis"	1				
Tipula sp.	1				
Hemiptera					
Gerridae		6			
Gerris remigis	5				
Megaloptera					
Sialidae		7.2			
Sialis sp.	5				
Coleoptera					
Unidentified spp.					
Dytiscidae sp.	5	5.5			
Elmidae (adult)		3.4	0.096	0.139	0.146
Optioservus sp.	4				
Stenelmis crenata	4				
Elmidae (larva)					
Optioservus sp.	4				
Haliplidae		8.7			
Peltodytes sp.	0				
Psephenidae		3.2	0.018	0.005	0.007
Psephenus herricki (larva)	4				
ARTHROPODA					
Crustacea					
Amphipoda					
Crangonyctidae		7.9	1.654	0.415	0.145
Crangonyx sp.	3				
Decapoda					
Cambaridae		7.5			
Orconectes sp.	6				
Isopoda					
Asellidae		8.5	2.248	1.340	0.574
Lirceus sp.	3				
MOLLUSCA					
Gastropoda					
Physidae		8.8			
Physella sp.	4				
Pleuroceridae		3.4	0.313	0.283	0.097
Elimia laqueata laqueata	4				
Pelecypoda					
Corbiculidae		6.1			
Corbicula fluminea	2	4		0.029	0.016
Sphaeridae		6.6		0.019	0.014
Sphaerium sp.	2				
Misc. relic shell					
ANNELIDA					
Clitellata					
Subclass Oligochaeta					
Lumbriculida					
Lumbriculidae		7	0.020	0.143	0.043
Lumbriculus sp.	7				

BIBI Summary (continued)

Taxa	*Functional Feeding Group	Family Level Pollution Tolerance Values	NCBI Metric Pasture 1	NCBI Metric Pasture 2	NCBI Metric Pasture 3
Haplotaxida					
Tubificidae		7.1	0.080	0.964	0.842
Limnodrilus hoffmeisteri	7				
Tubificidae w.o.h.c.	7				
Tubificidae w.h.c.	7				
Tubificidae sp.	7				
PLATYHELMINYHES					
Turbellaria					
Tricladida					
Planariidae sp.	2	6.1	0.009	0.071	0.012
NCBI			5.949	5.801	4.958
Ref Stream NCBI Metric	4.132				
Metric 2. NCBI (%)			69%	71%	83%

	Pasture 1	Pasture 2	Pasture 3	Ref Site
Taxa Richness	43	35	40	68
Metric 1. Comparative Taxa Richness	63	50	59	
Metric 3. DIC	2	2	2	
EPT (%)	38	45	53	63
CA (%)	5	21	22	23
Metric 4. **IAI	2	0.9	0.9	
d				68
a	22	19	19	
e	42	35	40	
Metric 5. CLI	1.1	1.4	1.2	
Metric 6. FFGPS (%)				
0	0.3	0.9	2	1
1	2	1	2	28
2	3	5	6	6
3	53	26	17	34
4	38	49	57	24
5	1	2	4	4
6	0.7	0.7	0	0
7	1	16	12	2
QSI	65.3	60.9	56	
EPT Taxa	13	12	12	26
Metric 7. % EPT Index	50	46	46	

* Functional Feeding Group
0=Herbivore or other special feeding habits
1=Shredders
2=Collectors/Filters
3=Collectors/Gathers
4=Scrapers
5=Predators
6=Omnivores
7=Scavengers

** If IAI is > 1.0, the following criteria is used:
Score=6 use 81-100%
Score=4 use 65-80%
Score=2 use 50-64%
Score=0 use <50%

Fish, Tolerance Values, Trophic Classes, and Taxonomic Groups for the Fishes of Johnson Branch and Leiper's Creek (Ref. Stream)

Species	Common Name	Johnson Br.	Leiper's Cr.	Tolerance	Trophic Class	Taxonomic Group
CYPRINIDAE						
Campostoma anomalum	central stoneroller	16	11		herbivore	Misc.
Clinostomus funduloides	rosyside dace		4		specialist	Misc.
Cyprinella galactura	whitetail shiner		31		insectivore	Misc.
Luxilus chrysocephalus	striped shiner	28	29	Tol	omnivore	Misc.
Lythrurus ardens	rosefin shiner	4	40	Intol	specialist	Misc.
Notropis telescopus	telescope shiner		13	Intol	specialist	Misc.
Pimephales notatus	bluntnose minnow	77	5		omnivore	Misc.
P. vigilax	bullhead minnow		3		omnivore	Misc.
Rhinichthys atratulus	blacknose dace		1		omnivore	Misc.
Semotilus atromaculatus	creek chub	29	2	Tol	omnivore	Misc.
PERCIDAE						
Etheostoma blenniodes	greenside darter	2			specialist	Darter
E. caeruleum	rainbow darter		3		specialist	Darter
E. crossopterum	fringed darter	6	7		specialist	Darter
E. flabellare	fantail darter	14	14	Intol	specialist	Darter
E. flavum	saffron darter	6	14		specialist	Darter
E. luteovinctum	redband darter	14			specialist	Darter
CATOSTOMIDAE						
Hypentelium nigricans	northern hogsucker		3		insectivore	Sucker
ICTALURIDAE						
Noturus exilis	slender madtom	3	5		specialist	Misc.
FUNDULIDAE						
Fundulus catenatus	northern studfish	2	3		specialist	Misc.
F. notatus	blackstripe topminnow	2			specialist	Misc.
COTTIDAE						
Cottus carolinae	banded sculpin	10	7		generalist	Misc.
CENTRARCHIDAE						
Lepomis cyanellus	green sunfish	12	2	Tol	piscivore	Sunfish
L. megalotis	longear	1	4		insectivore	Sunfish
L. macrochirus	bluegill	14			insectivore	Sunfish
Micropterus dolomieu	smallmouth bass		2		piscivore	Misc.
M. salmoides	largemouth bass		1		piscivore	Misc.
POECILIDAE						
Gambusia affinis *	mosquito fish	1				Misc.
	TOTAL SPECIES	18	22			

Fishery IBI Metric Description and Rationale

(1) *Total number of native species*: This metric is based on the fact that the number of native fish species decreases as environmental degradation increases (Karr et al. 1986). The number of species present is also highly affected by the size of the contributing watershed and the ecoregion it is located.

(2) *Number of darter species*: Darters are benthic dwelling species that are highly influenced by siltation and oxygen depletion because they feed and reproduce on the stream bottom. The metric is reflective of good water quality and habitat conditions (Karr et al. 1986).

(3) *Number of sunfish species, less Micropterus*: Sunfish are pool dwelling species. Numbers and diversity of these species decrease as pool habitat and instream cover are depleted (Barbour et al. 1997).

(4) *Number of sucker species*: Suckers are benthic species that are sensitive to physical and chemical degradation (Karr et al. 1986). They integrate multi-year chemical and physical conditions because of their longer life spans (10-20 years).

(5) *Number of intolerant species*: Species are termed intolerant because they are typically the first species to disappear following a disturbance (chemical or physical). This metric is designed to distinguish highest quality streams (Ohio EPA 1987). For this study, species were determined by regional fish distribution maps (Etnier and Starnes 1993) and the expertise of local ichthyologist.

(6) *Percent of individuals as tolerant species*: Tolerant species show increased abundance in severely impacted streams because of their ability to survive and reproduce (Ohio EPA 1987).

(7) *Percent of individuals as omnivores*: Omnivores are species that feed on both plant and animal material. Omnivore percentages increase as the food base is disrupted resulting from physical and chemical habitat degradation (Barbour et al. 1997).

(8) *Percent of individuals as specialized insectivores*: Specialized insectivores are site-feeders that rely on clear water and feed almost exclusively on aquatic invertebrates. Insectivorous species are replaced by generalist feeders (i.e., omnivores) as invertebrate populations decline as a result of habitat degradation (Ohio EPA 1987).

(9) *Percent of individuals as piscivores:* Piscivores are species that feed, as adults, on other fish, vertebrates, and crayfish. These species discriminate between systems with high and moderate levels of integrity (Barbour et al. 1997).

(10) *Catch rate (average number of fish per 300 sq. ft. sampling unit):* Typically sites with lower integrity support lower numbers of fish but it is highly dependent on the region and stream size (Barbour et al. 1997). This metric may be modified if large catch rates are driven by tolerant taxa resulting from excessive nutrient levels or other factors (Ohio EPA 1987).

(11) *Percent of individuals as hybrids*: This metric generally detects the lack of suitable physical habitat for reproduction. Percentages of hybrid species increase as stream conditions degrade (Barbour et al. 1997).

(12) *Percent of individuals with disease, tumors, fin damage, and other anomalies*: This metric consist of visual examinations of individual fish health and condition. Anomalies such as eroded fins, lesions, external parasites, and tumors rarely occur on fish in minimally impacted streams. The Ohio EPA (1987) found a higher incidence of anomalies downstream from discharges of industrial and municipal wastewater, and areas subjected to stresses from sewers and urban runoff.

Fishery IBI Scores, Integrity Classes, and the Attributes of those Classes (Karr et al., 1986)

IBI Score	Integrity Class	Attributes
58-60	Excellent	Comparable to the 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 composition.
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 or size distribution; trophic structure shows signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or 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 regular.
0	No fish	Repeated sampling finds no fish.

Index of Biotic Integrity (IBI) Analysis for Leiper's Creek (Reference Stream).

Metric Description	Scoring Criteria			Observed	Score
	1	3	5		
Total number of native fish species	<9	9-16	>16	22	5
Number of darter species	<2	2-3	>3	4	5
Number of sunfish species, less *Micropterus*	<2	2-3	>3	4	5
Number of sucker species	0	1	>1	1	3
Number of intolerant species	<2	2	>2	3	5
Percent of individuals as tolerant species	>37%	19%-37%	<19%	16	5
Percent of individuals as omnivores	>46%	24%-46%	<24%	17	5
Percent of individuals as specialized insectivores	<22%	22%-44%	>44%	50.1	5
Percent of individuals as piscivores	<1.5%	1.5%-2.9%	>2.9%	2.5	3
Catch rate (average number of fish per 300 sq. ft. sampling unit)	<28.5	28.5-56.9	>56.9	21	1
Percent of individuals as hybrids	>1%	TR-1%	0%	0	5
Percent of individuals with disease, tumors, fin damage, and other anomalies	>5%	2%-5%	<2%	0.01	5
IBI Score					**52**
Stream Classification					**Good**

IBI Range	0	12-22	28-34	40-44	48-52	58-60
Stream Classification	No Fish	Very Poor	Poor	Fair	Good	Excellent

APPENDIX D.

SAS PROGRAMS

Nitrate Analysis

```
data no3;
  input time$ treat$ mass;
  cards;

proc univariate plot normal data=rrr;
  var _resid_;
  run;

proc mixed;
  class treat time;
  model mass=treat/predicted;
  random time;
  lsmeans treat/pdiff;
  make 'predicted' out=rrr noprint;
  run;

proc mixed noprofile data=no3;
  class treat time;
  model mass=treat time treat*time /ddf=18,18,18;
  repeated/group=time;
  parms (.003) (6.422) (.245) (.057) (.249) (2.154) / noiter;
  lsmeans treat time treat*time/pdiff df=18;
  run;
```

Ammonia Analysis

```
data ammonia;
  input time$ treat$ mass;
  cards;

proc mixed;
  class treat time;
  model mass=treat/predicted;
  random time;
  lsmeans treat/pdiff;
  make 'predicted' out=rrr noprint;
  run;

proc univariate plot normal data=rrr;
  var _resid_;
  run;

proc mixed noprofile data=ammonia;
  class treat time;
  model mass=treat time treat*time /ddf=18,18,18;
  repeated/group=time;
  parms (.0001) (.12) (.003) (.008) (.003) (.068)/noiter;
  lsmeans treat time treat*time/pdiff df=18;
  run;
```

Total Solids Analysis

```
data ts;
 input time$ treat$ mass;
 cards;

proc mixed;
 class treat time;
 model mass=treat/predicted;
 random time;
 lsmeans treat/pdiff;
 make 'predicted' out=rrr noprint;
 run;

proc univariate plot normal data=rrr;
 var _resid_;
 run;

proc mixed noprofile data=ts;
 class treat time;
 model mass=treat time treat*time /ddf=18,18,18;
 repeated/group=time;
 parms (1383) (207809) (37909) (122649) (303) (14886) / noiter;
 lsmeans treat time treat*time/pdiff df=18;
 run;
```

TOC Analysis

```
data toc;
 input time$ treat$ mass;
 cards;

proc mixed;
 class treat time;
 model mass=treat/predicted;
 random time;
 lsmeans treat/pdiff;
 make 'predicted' out=rrr noprint;
 run;

proc univariate plot normal data=rrr;
 var _resid_;
 run;

proc mixed noprofile data=toc;
 class treat time;
 model mass=treat time treat*time /ddf=18,18,18;
 repeated/group=time;
 parms (24.5) (2191) (3.8) (13.6) (.5) (10.3) / noiter;
 lsmeans treat time treat*time/pdiff df=18;
 run;
```

BOD Analysis

```
data bod;
  input time$ treat$ mass;
  cards;

proc mixed;
  class treat time;
  model mass=treat/predicted;
  random time;
  lsmeans treat/pdiff;
  make 'predicted' out=rrr noprint;
  run;

proc univariate plot normal data=rrr;
  var _resid_;
  run;

proc mixed noprofile data=bod;
  class treat time;
  model mass=treat time treat*time /ddf=18,18,18;
  repeated/group=time;
  parms (.11) (8.44) (.56) (1.56) (.07) (1.15) / noiter;
  lsmeans treat time treat*time/pdiff df=18;
  run;
```

Fecal Coliform Analysis

```
data fc;
  input time$ treat$ mass;
  cards;

proc mixed;
  class treat time;
  model mass=treat/predicted;
  random time;
  lsmeans treat/pdiff;
  make 'predicted' out=rrr noprint;
  run;

proc univariate plot normal data=rrr;
  var _resid_;
  run;

proc mixed noprofile data=fc;
  class treat time;
  model mass=treat time treat*time /ddf=18,18,18;
  repeated/group=time;
  parms (87) (14505) (23552) (46807) (678) (9472) / noiter;
  lsmeans treat time treat*time/pdiff df=18;
  run;
```

VITA

Jeffrey Russell Powell was born on February 8, 1967, in Franklin, Virginia. He grew up on the family farm in Isle of Wight County, Virginia. He graduated from Isle of Wight Academy in June of 1985. In December of 1992 he received the Bachelor's degree in Wildlife and Fisheries Science at the University of Tennessee. For the next three years he was employed by an environmental consulting firm and contracted by the Tennessee Valley Authority's Aquatic Biology Laboratory in Norris, Tennessee. In September of 1995 he received a research assistantship from the Department of Agricultural and Biosystems Engineering at the University of Tennessee. In June of 1996 he received a student internship with the U.S. Geological Survey in Knoxville, Tennessee. In December of 1998 he completed the requirements for the Master of Science degree in Agricultural and Biosystems Engineering Technology. He is presently working for the U.S. Geological Survey in Nashville, Tennessee.