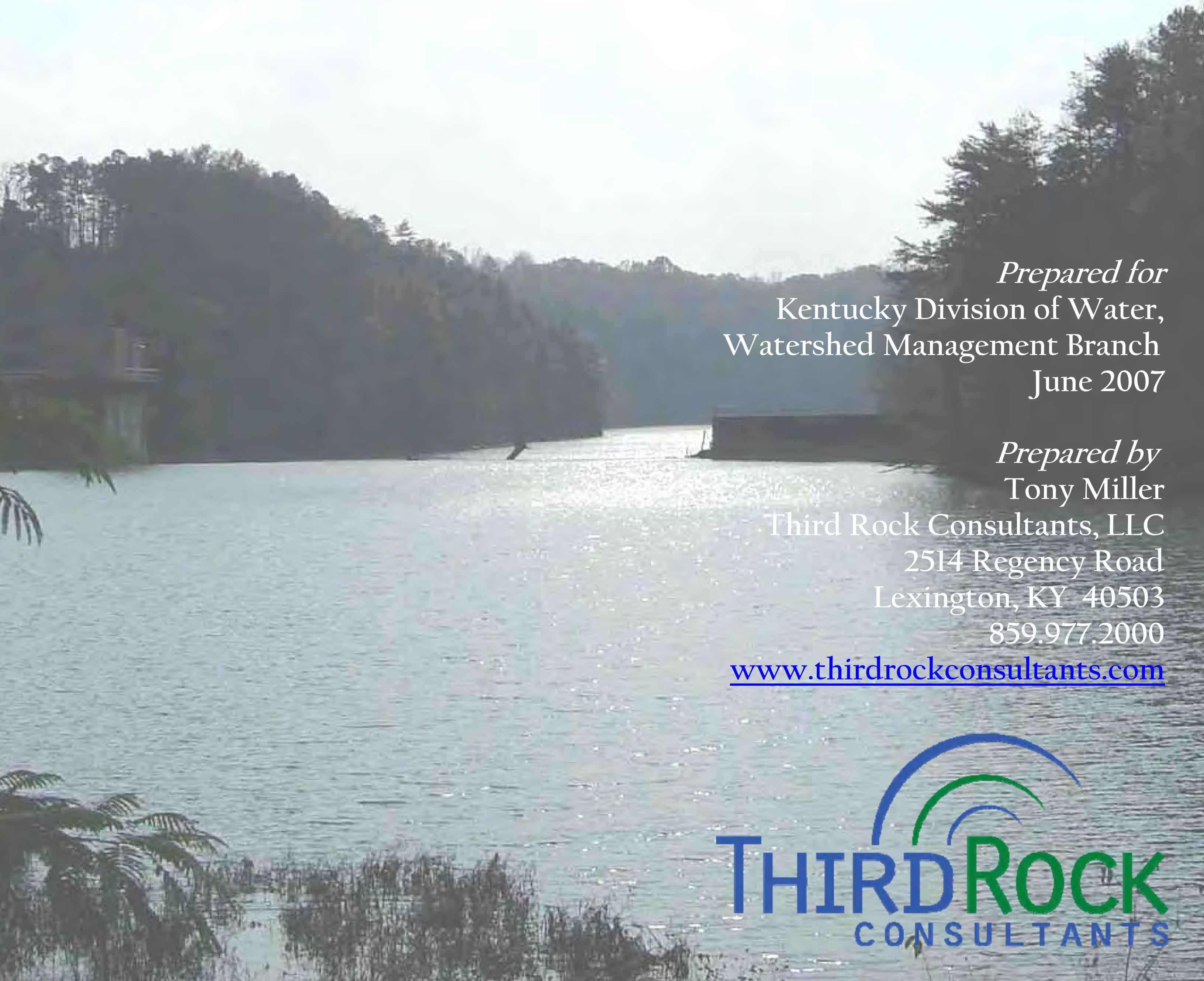
CORBIN CITY RESERVOIR
Watershed Plan



Prepared for
Kentucky Division of Water,
Watershed Management Branch
June 2007

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Watershed Plan

for

Kentucky Division of Water
Watershed Management Branch
14 Reilly Road
Frankfort, KY 40601-1190

June 2007

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THIRD ROCK CONSULTANTS

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Environmental Analysis & Restoration

Executive Summary

Third Rock Consultants, LLC (Third Rock) was awarded an U.S. Environmental Protection Agency (US EPA) 319(h) grant in 2004 to develop a Watershed Plan to identify and rank the sources of impairment in the Corbin City Reservoir watershed. Additionally, specific recommendations for remediation were considered.

The following Watershed Plan for the Corbin City Reservoir watershed details the coordinated biological, chemical, and physical surveys of the watershed and identifies the major sources of impairments found. Additionally, this report prioritizes impairments based on practicality and presents recommendations for remediation, targeting the most critical areas in order to most efficiently and economically reduce pollution within the watershed.

The information presented in this report substantiates the concern that upstream landuse practices are directly contributing to impairments in the Corbin City Reservoir. Though potential internal nutrient cycling and sedimentation issues exist within the reservoir, sources of pollution in the watershed must be addressed before any direct remediation efforts are explored to alleviate taste and odor problems, aquatic life issues, and the accelerated sedimentation within the reservoir.

The most immediate sources of impairment to the Corbin City Reservoir found were nutrient addition and sedimentation. The primary sources of nutrients are London's wastewater treatment plant (WWTP) discharge and sanitary sewer overflows (SSOs). Nutrient additions from cattle waste runoff also occur. Regarding sedimentation, the entire watershed shows evidence of accelerated sediment input to the reservoir.

Remediation recommendations for nutrients and sediment control in the Corbin City Reservoir are multi-tiered. For nutrients, recommendations concentrate on nonpoint source (NPS) pollution reduction. These include methods for reducing stormwater discharge to streams and facilitating improvements to the current SSO problem in London and reducing inputs associated with cattle grazing in the rural portions of the watershed. For sediment issues, recommendations focus on limiting the erosive effects of high flow storm events. In addition, further study is imperative to determining the location and degree of sediment source contribution.

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1. INTRODUCTION

1.1. *Scope and Purpose*

Watershed planning is a comprehensive effort to evaluate the condition of a watershed, identify natural assets within the watershed, determine deficiencies in watershed functions, and recommend appropriate restoration, protection, and management measures. In 2004, Third Rock Consultants, LLC (Third Rock) received a U.S. Environmental Protection Agency (US EPA) 319(h) grant through the Kentucky Division of Water (KDOW) to develop a Watershed Plan for the Corbin City Reservoir watershed.

The reservoir and many stream reaches within the watershed are listed as 1st priority impaired water bodies/streams in the 2004 Kentucky Division of Water's 303(d) list of impaired waters. In 2004 through 2006, Third Rock extensively monitored the watershed to identify the main sources of nonpoint source (NPS) water pollutants (pollutants coming from many different sources rather than from one place), estimate nutrient loadings from found sources, and determine practical solutions for improving water quality. Data from this sampling effort and an array of additional watershed information were used to develop this comprehensive and dynamic Watershed Plan. The plan identifies and addresses sources of pollution/degradation and provides solutions to enhance the water resources of this watershed.

This plan is a guide for watershed-scale remediation that will protect and enhance the water resources of the Corbin City Reservoir watershed. The remediation solutions presented in the watershed plan target critical areas in order to most efficiently and economically reduce nonpoint source pollution within the watershed. A 2007 US EPA 319(h) Grant was awarded to Third Rock (through the KDOW) to implement these remediation solutions.

Implementing the Watershed Plan should be an iterative approach, combining implementation projects and further study as information becomes available. The Watershed Plan should expand and evolve as more information is gathered and improvement projects are implemented in order to reach the overall goal of improving water quality in the Corbin City Reservoir and streams within the watershed.

1.2. *Partners*

A fundamental part of the planning approach is the formation of a partnership between a number of local organizations, agencies, governments, and citizen groups. A local Watershed Partners Council was established in November 2004 to provide guidance for the development of the Watershed Plan. The team was comprised of representatives from Third Rock, KDOW, Kentucky Department of Fish and Wildlife Resources (KDFWR), U.S. Army Corps of Engineers (USACE), local governments, area schools and colleges, environmental groups, and interested citizens. A list of watershed partners is included in Appendix A.

Members of the council attend meetings to stay updated on the monitoring, planning, and improvement activities within the watershed. Four partners meetings have been held to date (November 1, 2004; April 21, 2005; March 29, 2006; June 19, 2006). Stakeholder involvement is critical for providing local insight into the complex issues surrounding watershed-scale planning. Partners provided insight for determining local concerns, locating aquatic sampling sites, report development, review of data/reports, and exploring opportunities for community outreach.

The partners group is constantly seeking input and involvement from interested members of the watershed and pursuing new members. It is especially important to add local citizens and landowners to the partner's council as the implementation projects begin. Local participation will be essential for locating and securing sites for water quality improvement projects.

2. WATERSHED DESCRIPTION

2.1. Location

The Corbin City Reservoir – the drinking water supply for the city of Corbin – Kentucky, impounds the Laurel River and is located just upstream of Laurel Lake. The 130-acre reservoir is within the Laurel River hydrologic unit. The reservoir watershed is 127 square miles and contains over 450 miles of streams. The Corbin City Reservoir watershed is within Laurel County, Kentucky.

2.2. Population

According to the U.S. Census Bureau, Laurel County is one of the most rapidly growing counties in the state. The county population growth from April 1, 2000 to July 1, 2005 was 6.9%, while the state's population growth was only 3.2%. In 2005, the population of Laurel County was estimated at 56,338 people (U.S. Census Bureau 2000). The largest urban areas are London (2005 population estimated 7,787) and Corbin (2005 population estimated 8,230), but Corbin is downstream of the Reservoir watershed. As this area continues to grow and population density increases, pressures on the streams and reservoir will intensify. Additionally, with continued population growth and city annexation of property, London is on the verge of becoming a "Phase II community", or a community outside of an urbanized area with a population of at least 10,000 and a population density of at least 1,000 people per square mile. The EPA's Stormwater Phase II rule applies to such communities and regulates their operation of small municipal separate storm sewer systems (MS4s). Discussions within the KDOW indicate that London is likely to be designated a Phase II community soon.

2.3. Subwatersheds

The reservoir is located just downstream from the convergence of three 4^{th} order streams, the Laurel and Little Laurel Rivers and Robinson Creek (Exhibit 1). The Laurel River, Little Laurel River, and Robinson Creek subwatersheds are 57.5 square miles, 42.4 square miles, and 27.2 square miles in area, respectively. These subwatersheds represent 45.2%, 33.4%, and 21.4% of the total reservoir drainage area. Water quality data was analyzed and reported for these subwatersheds to more precisely reflect existing and potential stresses to the reservoir. Presenting information for the subwatersheds allows for a more accurate approach to managing the entire area and making recommendations.

The Laurel River and Robinson Creek subwatersheds are dominated by rolling pastureland with scattered rural residences. Though evidence of past strip mining was found throughout the entire watershed, the Laurel River and Robinson Creek subwatersheds contain the most abundant areas of past strip mining. Also, three deep mine portals are located within the Robinson Creek subwatershed (Exhibit 1). Alternatively, the Little Laurel River subwatershed has a variety of both point and NPS pollution contributors. The Little Laurel River receives polluted runoff from the city of London, populated residential areas, sanitary sewer overflows (SSOs), two stockyards within the city limits of London that pile waste along the stream, and dense cattle grazing. Additionally, the Little Laurel River receives point source pollution from several industries, a landfill, and the London wastewater treatment plant (WWTP).

EXHIBIT 1 – CORBIN CITY RESERVOIR WATERSHED

Robinson Creek at Station 2B, Near Subwatershed Outlet

Laurel River at Station Laurel River, Near Subwatershed Outlet

Little Laurel River at Station 2A, Near Subwatershed Outlet

2.4. Geology

Most of the watershed area is underlain by sedimentary rocks of Pennsylvanian age consisting of the Breathitt and Lee formations (Stager 1963). These sedimentary rocks consist of sandstone, siltstone, shale and coals of varying thickness. The sandstone and coal layers frequently produce a sufficient amount of water for domestic supply. In areas of Laurel County not served by public water, about 90% of the households use wells and 10%t rely on other sources (Cobb *et al*. 2005). No areas within the watershed are identified as karst prone on the Geologic Map of Kentucky (Cobb *et al.* 2005)

2.5. Soils

The dominant soil series across the entire watershed in order of prevalence are Shelocta (27%), Whitley (23%), Lily (16%), Latham (12%), Stendal (11%), and Bonnie (3%; Ross *et al*. 1981). The distribution of soils across the entire watershed and the predominance of soil types within each subwatershed are presented in Figure 1 (page 5). Each soil series is described in the text below and the corresponding taxonomic classification is presented in Table 1 (page 5).

FIGURE 1 – PREDOMINANT SOIL TYPES FOUND IN EACH SUBWATERSHED

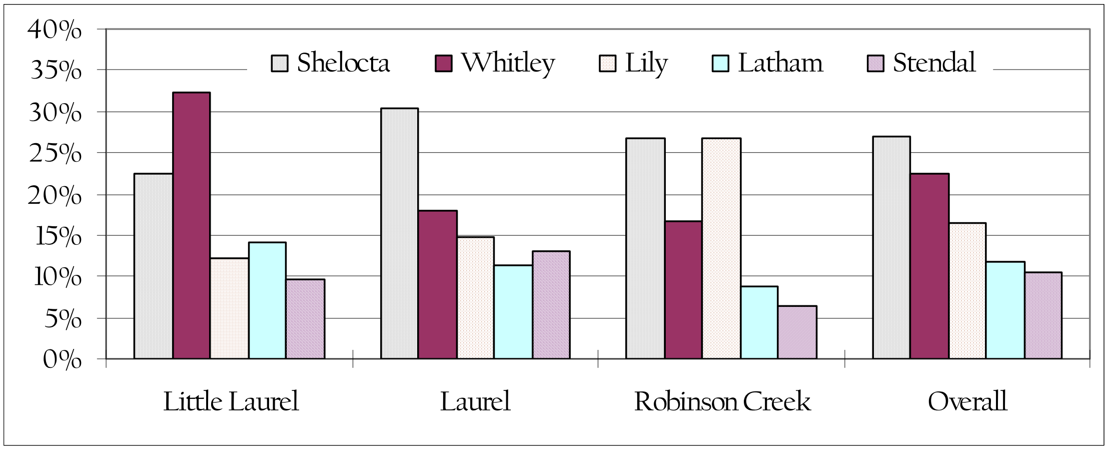


Figure derived from analysis of data from the Soil Survey Geographic (SSURGO) database for Laurel and Rockcastle Counties (USDA NRCS 2005).

TABLE 1 – TAXONOMIC CLASSIFICATION OF PREVALENT SOILS IN THE WATERSHED

Soil Series	Taxonomic Classification
Whitley	Fine-silty, mixed, semiactive, mesic Typic Hapludults
Shelocta	Fine-loamy, mixed, active, mesic Typic Hapludults
Latham	Fine, mixed, semiactive, mesic Aquic Hapludults
Stendal	Fine-silty, mixed, active, acid, mesic Fluventic Endoaquepts
Lily	Fine-loamy, siliceous, semiactive, mesic Typic Hapludults
Bonnie	Fine-loamy, siliceous, semiactive, mesic Typic Hapludults

Deep, well-drained soils characterize the Shelocta series. These soils were mainly formed in loamy colluvium derived from upland soils underlain by siltstone, sandstone, and shale. The Shelocta series is found on upland side slopes and colluvial toe slopes. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content.

The Whitley series is comprised of very deep, well-drained, moderately permeable soils. These soils are located on stream terraces, foot slopes and alluvial fans. They formed in mixed alluvium weathered from siltstone, shale and sandstone. In this watershed, these silt loam soils are found on slopes ranging from 2 to 20%. Areas of with this soil series located on lower slopes (2 to 10%) are better suited to cultivation and pasture due to lower erosion hazard. This series is often found near the Latham, Shelocta, and Lily soils. It is less clayey in the B horizon than the Latham soils and it is deeper to bedrock than the Lily soils. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content.

Moderately deep, well-drained soils formed in residuum weathered from sandstone characterize the Lily series. These loam soils are found on ridgetops and side slopes. In this watershed, these soils are found mainly on slopes ranging from 2 to 12%. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content. These soils are suited for cultivation and pasture.

Most of the soils from the Latham series (silt loam) within this watershed are on 6 to 20% slopes. Moderately deep, moderately well-drained soils formed in residuum weathered predominately from acid shale (but also could be partly from interbedded siltstone) characterize this series. These soils are present on upland ridgetops and side slopes. The Latham soils are more clayey in the B horizon than the Shelocta or Whitley soils. The areas of this soil on lower slopes (6 to 12%) are better suited to cultivation and pasture than those with higher slopes, which are better suited for pasture or woodland. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content.

A predominant soil type in the Robinson Creek subwatershed is the Shelocta-Latham silt loam complex. Typically, the Shelocta soils make up 65% of the complex. These soils exist on steep slopes (20 to 50%), which limits the use of these areas for pasture/cultivation due to high erosion hazard. This soil complex is most suited to woodland habitat (mixed hardwoods, such as oaks, gum, maple, yellow poplar).

Very deep, somewhat poorly drained soils that formed in acid, loamy alluvium characterize the Stendal series. These soils are on floodplains and floodplain steps. In the Laurel River subwatershed these silt loam soils are on narrow flood plans with 0 to 4 % slope. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content. This soil is somewhat poorly drained, but is better drained than the Bonnie soils that often occur nearby. If drained, this soil is suited to most crops and pasture.

The Bonnie series is comprised of very deep, poorly drained and very poorly drained soils formed in silty alluvium on floodplains. These silt loam soils are located on stream floodplains, or a few feet above the floodplain on a stream terrace. The slope range for these soils is 0 to 2%. According to the Soil Survey issued in 1981, these soils have medium natural fertility and low organic matter content. If these soils are not drained, the season high water table can be within 6 inches of the soil surface. If drained, these soils can be cultivated or used for pasture.

There are also areas indicated by the soil survey mapping that have been altered by strip mining. According to the soil survey (issued in 1981), strip mined areas represent approximately 1%, 0.9%, and 5.5% of the total area for the Little Laurel, Laurel, and Robinson Creek subwatersheds, respectively. Strip mining removes the material above a coal seam, and then after the coal is removed, the mixture of earth and rock is used to fill the area. Proportions of sand, silt, and clay vary greatly from place to place and layer to layer where strip mining has occurred.

2.6. Ecoregion

Areas of similar ecosystems and environmental resources are designated by ecoregions. In Kentucky, ecological and biological diversity is connected to geologic, physiographic, landuse, and soil characteristics.

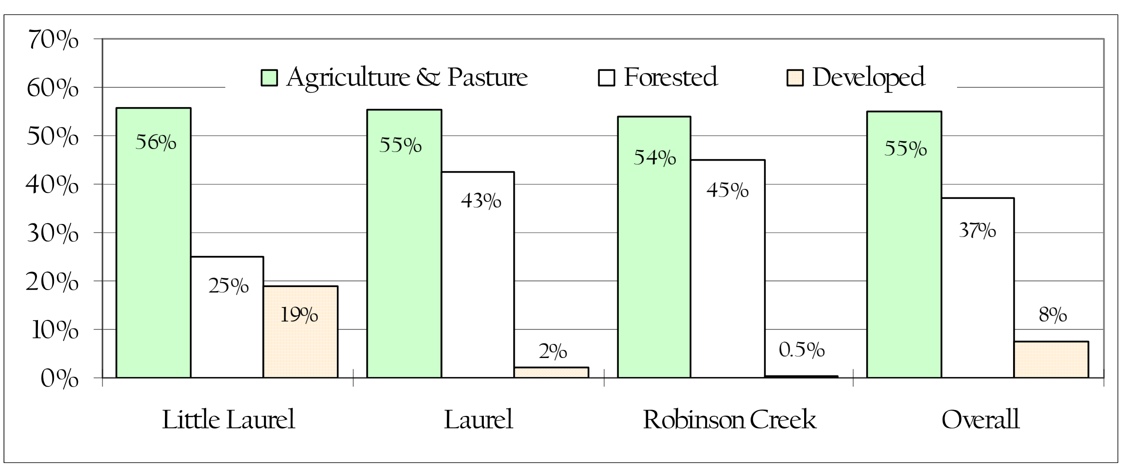
The Corbin City Reservoir watershed falls into the Level III ecoregion known as the Southwestern Appalachians, and more specifically, the Level IV ecoregion identified as the Cumberland Plateau (Woods *et al*. 2002). This watershed is characterized by hills, ridges, rolling uplands, and intervening valleys. This watershed is within the Cumberland River basin. Moderate to low gradients characterizes streams. Well-drained, acidic Ultisols are common upland soils. At the time of European settlement, deciduous forests dominated the landscape, but current forest age and composition are variable due to a history of logging, mining, and grazing. In general, acidic drainage and sedimentation associated with coal mining has decreased the biological productivity of many streams.

The Cumberland Plateau is characterized by a mean annual precipitation of 47 to 51 inches and mean annual growing season, or number of frost-free days ranges from 170 to 185 days (Woods *et al*. 2002). Similarly, the mean annual rainfall is reported in the Laurel County Soil survey is 47 inches and the average growing season is reported to average approximately 181 days (Ross *et al*. 1981).

2.7. Landuse

The primary landuse in the watershed are typical for the region and include agriculture (55%), natural forest (37%), and housing and development (8%). Agriculture, especially agriculture/pasture land, dominates each subwatershed (Figure 2). Agricultural areas are primarily used for grazing beef and dairy cows. Regarding livestock production, cattle are the most significant animal in Laurel County. Overall, Kentucky has been experiencing an apparent decline in cattle production since 1975 when cattle production was approximately 3.7 million head. Last year, Kentucky was the 11th largest total cattle producer in the US with 2.4 million head; 8th in beef cattle production and 23rd in milk cows. Laurel County had 21,700 head last year (11,300 beef cows). Though not a significant commodity (?) for Laurel County, Kentucky ranks 20th for hogs and pigs production with 370 head, 17th for total chicken production with 6,590 head, and 7th for broilers with 297,800 head. Most of the development within the watershed is in the Little Laurel subwatershed (generally associated with London). An aerial image of the watershed with each subwatershed delineated is included in Appendix B to show the distribution of landuse.

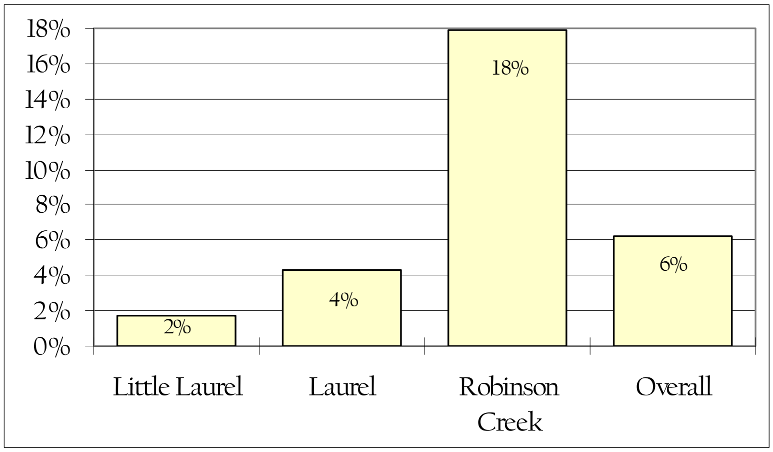
FIGURE 2 – PREDOMINANT LANDUSES IN EACH SUBWATERSHED



Source: Kentucky GAP data (KDFWR and USGS 2002), complemented with aerial photography (USDA-FSA-APFO 2004).

The data used to analyze landuse (KDFWR and USGS 2002) also identified areas previously mined. This data indicates that most mining activity has occurred in the Robinson Creek subwatershed, where mining has impacted approximately 18% of the subwatershed area (Figure 3).

FIGURE 3 – PERCENTAGE OF SUBWATERSHED AREA PREVIOUSLY MINED



Source: Kentucky GAP data (KDFWR and USGS 2002)

2.8. Water Supply Resources

The Corbin City Reservoir serves as the source of drinking water for the City of Corbin and parts of Laurel County. Within the Corbin Reservoir watershed is another reservoir that serves as a source of drinking water for the town of London, the Dorthea Reservoir. This is a small reservoir that is likely to be discontinued as a source for drinking water due to sedimentation and other problems. It is a small reservoir, approximately 250 feet wide by 900 feet long and six to eight feet deep in the center. Downstream of the Corbin Reservoir is Laurel River Lake, which serves as a drinking water supply (Indian Camp Creek of Laurel River Lake). London is also served by the Woods Creek Water District, which draws water from Woods Creek Lake, located outside of the Corbin Reservoir watershed.

2.9. Current Watershed Regulatory Requirements

Federal regulations require permitting of runoff from construction sites as part of the nationwide stormwater program. In Kentucky, this program falls under the Kentucky Pollutant Discharge Elimination System (KPDES) permit program administered by the KDOW. These regulations are implemented by the KPDES Construction General Permit. This permit requires operators of construction projects in Kentucky disturbing one acre or more to (1) submit a signed Notice of Intent (NOI) form to KDOW, (2) submit a copy of the NOI to the operator of any MS4 system to which the site discharges, (3) develop, implement, and continuously update a construction site best management practices (BMP) plan, (4) inspect and document the conditions of the BMPs every seven days and after rains of one-half inch or more, and (5) submit a signed notice of termination from to KDOW after the site has been stabilized. The regulations apply to disturbed sites where groundcover and/or topsoil is removed, but not to areas where only tree or shrub clearing occurs. Visit http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/ for more information about KPDES permits.

Pertaining to sanitary sewer overflows (SSOs), KPDES has drafted the following information:

> *"…If waters are discovered discharging from the collection system, this event would be considered a Sanitary Sewer Overflow and is prohibited by Clean Water Act. State law under KRS 224.70-110 contains a general prohibition of pollution of Waters of the Commonwealth. 401 KAR 5:031 Section 2 states that discharges to all surface waters will be free from substances that float as debris, scum, oil or other matter to form a nuisance, and that produce objectionable, color, odor, taste, or turbidity. The collection system is subject to regulation under 401 KAR 5:065 Section 1 which has requirements for proper operation and maintenance, as well as a duty to mitigate, which states that the permittee shall take all reasonable steps to minimize or prevent a discharge in violation of the permit which has a reasonable likelihood of adversely affecting human health or the environment. Finally, sanitary wastewater is subject to the minimum of secondary treatment prior to discharge as proscribed in 401 KAR 5:045 Section 2."*

Construction activities occurring in the 100-year floodplain require a Kentucky Floodplain Construction Permit. The Floodplain Management Section of the Water Resources Branch of the KDOW has the primary responsibility for the approval or denial of proposed construction (*i.e.* residential and commercial buildings) and other activities (*i.e.* placement of fill or stream alterations) in the 100-year floodplain of all streams in the Commonwealth. For more information visit http://www.water.ky.gov/floodplainmanagement/floodplainconstruction/.

Additionally, a USACE Section 404 permit and a KDOW Section 401 Water Quality Certification Permit may be required for activities that result in physical disturbances to wetlands or streams. For more information about these permits and the activities that require them, visit http://www.water.ky.gov/permitting/wqcert/.

In 1998, the Kentucky General Assembly passed KRS 149.330 to 149.355, known as the Kentucky Forest Conservation Act (KFCA). The act places proper forestry management on loggers and private forestland owners but also places an emphasis on the responsibilities of Kentucky's Environment and Public Protection Cabinet. More information can be found at http://www.forestry.ky.gov/

The Kentucky General Assembly passed the Kentucky Agriculture Water Quality Act in 1994 with the goal of protecting surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities. More information can be found at:
http://www.ca.uky.edu/enri/awqa/Index.htm

As required in 401 KAR 5:037, anyone engaged in activities that have the potential to pollute groundwater must develop and implement a Groundwater Protection Plan (GPP). The following is an excerpt from the Laurel County GPP completed by the Cumberland Area Development District:

> *"…for <u>land and coverage:</u> (1) Monitor to ensure compliance with Forestry Conservation Act; and (2) Require BMP (Best Management Practices) implementation per the Forest Landowners Handbook. <u>Agriculture:</u> (1) Monitor annually to ensure compliance with Agriculture Water Quality Act (AWQA); (2) Encourage implementation of voluntary Best Management Practices (BMPs) above the minimum required by the AWQA. BMP manuals for specific types of operations are available; (3) Monitor annually to ensure implementation of Nutrient Management Plans (NMPs); (4) Encourage development and implementation*

of Resource Management Systems (RMS) on agricultural operations per USDS-Natural Resource Conservation Service (NRCS) specifications; and (6) No storage or use of pesticides. Highway maintenance and runoff/Railroads: (1) Require the adoption and application of highway maintenance and runoff BMPs (Best Management Practices); (3) Limit highway construction or avoid waterways. Modify designs to limit runoff, especially drain-spouts on bridges to minimize salt de-icing runoff to waterways; and (4) Encourage posting of signs indicating presence of source water protection area on major roads. Permitted Wastewater Point Sources: (1) Eliminate permitted sewage systems (such as package treatment plants) with a history of noncompliance with permit requirements; (2) Review existing sewage systems biannually to ensure compliance with all applicable Department of Environmental Protection (DEP) permitting requirements; (3) Monitor systems biannually to ensure proper ongoing maintenance and operation; (4) Seek regionalization of all wastewater discharges or elimination of other discharges to eliminate point sources, to the extent possible (if they exist); and (5) Discharge or ban any new wastewater point source discharges. Onsite/Decentralized/Septic Systems, Straight Pipes: (1) Eliminate and prevent new straight pipes and failing septic systems; (2) Prepare and implement Groundwater Protection Plan; conduct monitoring activities to assess effectiveness; (3) Connect properties with failing onsite systems to sanitary sewers where feasible; (4) Ensure proper maintenance of systems; (5) Replace failing onsite systems with systems that are most appropriate/protective of the environment; (6) Reduce generation of wastewater; (7) Conduct education and training for local officials, contractors and/or the general public regarding onsite wastewater issues; and (8) Adopt region or county-wide sanitation district for planning and management wastewater. Landfills, Dumps, Landfarms: (1) No new permitted landfills or landfarms; (2) Review existing operations biannually to ensure compliance with all applicable DEP permitting requirements (e.g., KPDES, Groundwater Protection Plans, Solid Waste Landfills, etc.); and (3) Cleanup all dumps. Waste Storage Tanks/Storage Tank Leaks Petroleum/Chemical (Above ground) (Underground): (1) Remove existing and prevent new installation of above-or underground waste storage tanks."

With road construction (using state or federal funds), erosion control is also required and the guidelines are provided by the Kentucky Transportation Cabinet (KYTC). In October 2006, London passed an erosion control ordinance for all construction.

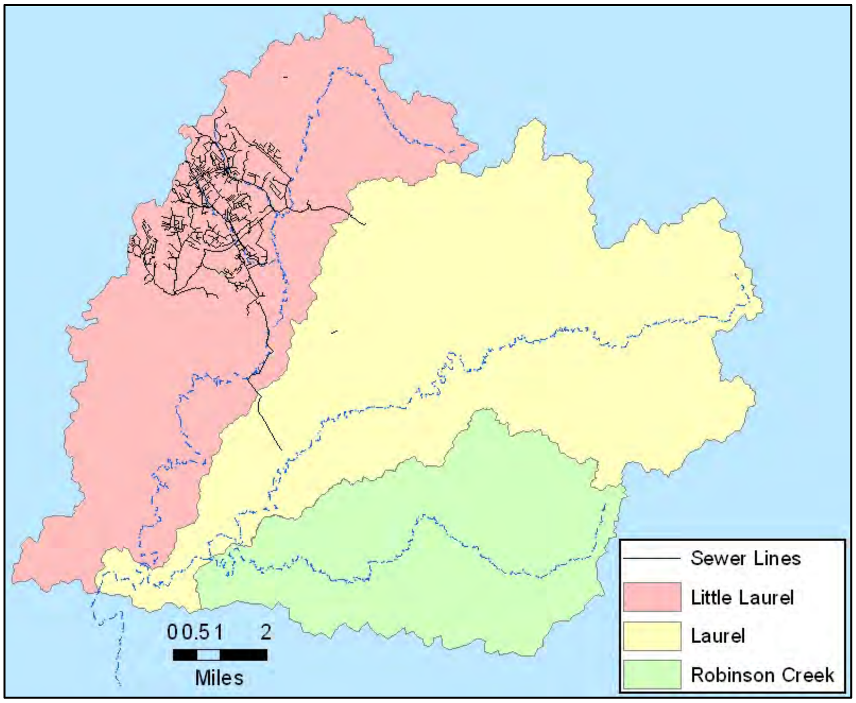
Kentucky requires local governments to adopt a "comprehensive plan" regarding landuse regulations. A "comprehensive plan" is under development by the London/Laurel County Joint Planning and Zoning Commission. The plan should encourage London to devise a vision of its future and to apply landuse regulations and planning to implement that vision.

Currently, no Total Maximum Daily Load (TMDL) calculations have been performed for streams in this watershed, but monitoring that will support TMDL development has been initiated (November 2006). Information from the TMDL will be incorporated into this watershed plan upon completion.

2.10. Wastewater Infrastructure

Most of the watershed is rural and is not connected to a municipal sewer system. Figure 4 (page 11) shows how most sewer lines radiate from the city of London. This mapping is not current (Water Resources Information System, 2002), but still illustrates that residents of the entire watershed, and especially Laurel and Robinson Creek watershed residents, primarily rely on septic tanks. Specific septic tank numbers were not available at the time of document preparation, but additional study will be completed to identify their extent of use. The London Wastewater treatment plant is located south of London and discharges to Whitley Branch, a tributary to the Little Laurel River.

FIGURE 4 – MUNICIPAL SEWER LINE DISTRIBUTION IN EACH SUBWATERSHED



Source: Water Resources Information System, 2002

3. PRIORITY WATER RESOURCES

The Corbin City Reservoir is listed as a 1st priority impaired water body in Kentucky's 2004 303(d) Report (KDOW 2005). The report cites the impaired uses as drinking water supply (non-support) and aquatic life (partial support). The pollutants of concern are nutrients, organic enrichment, low dissolved oxygen, taste and odor, and algal growth. In addition to the reservoir, the KDOW has assessed approximately 50 miles of streams in this watershed for designated uses; of the streams surveyed, about 35 miles (eight stream segments) are currently impaired by pollution (Table 2, page 12) and are listed as 1st Priority 303(d) streams (Exhibit 1, page 3). NPS pollutants, which primarily consist of pathogens, sediment, and nutrients, impair 63% of these stream miles (22 miles). The sources of these pollutants are varied and widespread throughout the watershed with the primary suspects being construction, agriculture, and failing septic tanks. In addition to the NPS pollution, London's WWTP and failing sanitary sewer system affect the remaining impaired stream miles. The combined impact of these pollutants has made streams, and ultimately the Corbin City Reservoir, unsafe for recreation, poor habitat for aquatic life, and problematic as a drinking water source.

The entire Laurel River watershed upstream of the Corbin City Dam is part of the source-water protection area for Corbin City Utilities and Laurel Water District #2. The Ground-Water Protection Plan is described in Section 2.9 of this document. The implementation phase of this project (Phase II) will incorporate many of the recommendations alluded to in the GPP that encourage the reduction of existing and potential pollutions to the Corbin City Reservoir.

TABLE 2 – 303(d) LISTED STREAM IMPAIRMENTS IN THE CORBIN CITY RESERVOIR (KDOW 2005)

WATERBODY	IMPAIRED STATUS	IMPAIRED REACH	IMPAIRED USE	POLLUTANTS	SOURCES
Corbin City Reservoir	1st priority	193 acres	Drinking water supply (Nonsupport), aquatic life (Partial Support)	Nutrients, Organic Enrichment/Low DO, Taste and Odor, Algal Growth/ Chlorophyll *a*	Municipal Point Sources (Major Municipal Point Sources), Agriculture, Internal Nutrient Cycling
Whitley Branch	1st priority	RM 1.0-2.5	Swimming (Nonsupport)	Pathogens	Collection System Failure
Laurel River	1st priority	RM 36.6-46.3	Aquatic Life (Nonsupport)	Nutrients, Siltation	Agriculture (Crop-related Sources, Non-irrigated Crop Production, Grazing-related source, Upland), Intense Extraction (Surface Mining)
Little Laurel River	1st priority	RM 0.0-8.3	Aquatic Life (Nonsupport)	Nutrients	Municipal Point Source (Major Municipal Point Sources)
Little Laurel River	1st priority	RM 8.3-12.4	Swimming (Nonsupport), Aquatic Life (Nonsupport)	Pathogens, Organic Enrichment/Low DO, Siltation, Habitat Alterations other than flow	Construction (Land Development), Municipal Point Sources, Agriculture
Little Laurel River	1st priority	RM 12.4-14.6	Swimming (Nonsupport), Aquatic Life (Nonsupport)	Pathogens, Nutrients, Organic Enrichment/Low DO	Municipal Point Sources, Agriculture
Little Laurel River	1st priority	RM 14.6-22.8	Swimming (Nonsupport)	Pathogens	Agriculture (Grazing-related Sources)
Unnamed Tributary of Little Laurel River at RM 15.8	1st priority	RM 0.0-1.4	Aquatic Life (Nonsupport)	Siltation, Habitat Alterations (Other than Flow)	Habitat Modification (Other than Hydromodification) - Removal of Riparian Vegetation

In order to properly target solutions or BMPs, this watershed-based plan identifies and ranks NPS and point source pollution, develops practical solutions, and prioritizes projects for future funding for impaired stream reaches and the Corbin City Reservoir. Ultimately, this report will initiate the remediation of Corbin City Reservoir and the tributaries within the watershed to make them safe for overall recreation and aquatic life and to ensure a continued safe drinking water supply.

3.1 Planned TMDLs

Currently, no Total Maximum Daily Load (TMDL) calculations have been performed for streams in this watershed, but monitoring that will support TMDL development has been initiated (November 2006). Sampling will continue for one year. Pollutant sampling will be specific to listed impaired segments, but includes nitrate/nitrite, ammonia, total Kjeldahl nitrogen (TKN), total phosphorus (TP), ortho-phosphorus (OP), total organic carbon (TOC), and 5-day Biochemical Oxygen Demand (BOD_5). It will also include pathogen sampling during the primary contact recreation season (May-October). TMDL findings and needed load reductions will be incorporated into the watershed plan upon completion.

4. WATERSHED CHARACTERIZATION AND ASSESSMENT METHODS

4.1 Watershed Survey

Using Hydrolab probe to measure stream pH, conductivity, dissolved oxygen, and temperature during a pedestrian survey, Site 15B

Using input from the project team, a pedestrian survey was performed in January 2005 to characterize the landuse and sources of impairment in the watershed and determine areas for additional sampling. Four teams of 6 to 8 student volunteers were led by Tony Miller (Third Rock Biologist), Rob Miller (KDOW Upper Cumberland Basin coordinator), Brett Kuss (Cumberland College Professor, Department of Biology), Marci Schneider (environmental student, University of Kentucky), Steve Jewel (Teacher, Corbin High School), and Rick McClure (Teacher, Corbin High School). Tony Miller administered training to all team leaders watershed assessment and how to complete the (1) Physical Characterization/Water Quality Field Data Sheet, (2) Watershed Survey Visual Assessment Sheets, and (3) the Habitat Assessment Field Data Sheets or Rapid Bioassessment Protocol (RBP) data sheets. Samples of these data forms are found in Appendix C. All team leaders were deemed competent prior to the pedestrian surveys.

The volunteer survey team assessed landuse across the entire watershed with particular attention given to NPS issues (*e.g.* straight pipes, construction sites, failing sanitary sewers, and large dense cattle grazing). Additionally, the survey team documented the physical and physiochemical integrity at 50 stream stations across the watershed. The number of stations was evenly distributed between the Laurel River and the Little Laurel River subwatersheds (26 and 24 stations, respectively indicated on Exhibit).

The potential for biological support at these stations was determined by completing RBP worksheets in addition to measuring water pH, dissolved oxygen, and conductivity. These worksheets describe the ability of a stream to support aquatic life based on physical parameters, such as epifaunal substrate, embeddedness, bank stability, and riparian width. Streams are scored (from 0-20, where higher score indicates higher quality) for each parameter, then scores are summed. Total scores are related to established regional ranges (ranges applicable to the

Southwestern Appalachian ecoregion) as they correlate with supporting aquatic life. Stream stations are then assigned a category of *Fully Supporting (165 and above)*, *Supporting But Threatened (164-156)*, P*artially Supporting (155-145)*, or *Not Supporting (144 and below)* based on total RBP scores. These rankings are used for overall indicators of stream "physical health". Additional watershed characterization forms were completed at each site to document surrounding landuse and potential pollution sources (*e.g.* straight pipes, cattle access).

Using the information gathered from the pedestrian surveys, a subset of sites was chosen for chemical and biological sampling to further categorize the extent of impairment (see "Results" section). Since the focus of this project is to elucidate the extent and source of impairment within the watershed, sites with the lowest RBP scores and most altered pH and conductivity were selected for the additional sampling. These stream reaches represent the areas most in need of remediation. Biological and chemical data was not collected at all sites due to logistical and monetary constraints. Representative fish data was not collected from all subset sites due to the absence of fish at some stream reaches during the time of survey.

4.2 Biological Sampling (Fish and Macroinvertebrates)

Fish and macroinvertebrates (aquatic insects) were sampled according to KDOW protocol (KDOW 2002). Fish and macroinvertebrates have varying tolerances to water pollution, thus they can be evaluated as indicators for overall water quality.

Fish were identified in the field and macroinvertebrate samples were collected and brought back to the laboratory for sorting and identification. Biotic health indices were calculated at 20 stations for macroinvertebrates and 12 stations for fish (not all macroinvertebrate sites contained fish) from spring sampling events.

The fish community was evaluated using eight metrics that demonstrate the fish community response to disturbance. Metrics have a positive (+) or negative (-) relationship to higher water quality. These metrics include native species richness (+); darter, madtom, and sculpin richness (+); intolerant species richness (+); proportion of tolerant individuals (-); proportion of insectivore individuals (+); proportion of facultative headwater (FHW) individuals (-); and simple lithophile species richness (+). Based on these metrics and expected regional assemblages (estimated from reference reaches in the Mountain physiographic region), each station was assigned an Index of Biotic Integrity (IBI) score ranging from 0 (worst) to 100 (best) and designated with a water quality rating of *Very Poor* (<19), *Poor* (19-38), *Fair* (39-58), *Good* (59-70), or *Excellent* (>71).

The macroinvertebrates collected were also assessed by metrics that have a positive (+) or negative (-) relationship to higher water quality. These metrics include richness (+), Ephemeroptera-Plecoptera-Trichoptera (EPT) richness (mayfly, stonefly, and caddisfly richness; +), modified Hilsnehoff biotic index (MHBI; -), modified percent EPT abundance (+), percent Ephemeroptera (+), percent Chironomidae plus Oligochaeta (-), and percent primary clingers (+). The abundance and diversity of sampled species were used to calculate these metrics. Results from community metrics at each station were combined to compute a Macroinvertebrate Bioassessment Index (MBI) score ranging from 0 (worst) to 100 (best). Expected regional species assemblages, estimated from reference reaches in the Mountain physiographic region, were used as a basis for metric development. MBI scores were used to designate a water quality rating of *Very Poor* (<23), *Poor* (24-

47), *Fair* (48-71), *Good* (72-82), or *Excellent* (>83) for wadeable streams or *Very Poor* (<24), *Poor* (25-49), *Fair* (50-73), *Good* (74-80), or *Excellent* (>81) for headwater streams.

4.3 Chemical Sampling

Water samples were taken at each site during the biological sampling to determine pertinent parameter concentrations. Samples were collected, properly preserved, and transported within established hold times to Envirodata Group laboratory for processing. Samples were analyzed for nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), orthophosphate (OP-P), total phosphorus (TP), iron (Fe), and manganese (Mn) using standard methods (American Public Health Association [APHA] 1998). TN was calculated as TKN plus NO_3-N. Also, during the fall (November 2005) and spring (January and March 2006), water samples were taken at these sites (and additional listed in next section) for fecal coliform (FC) analysis to determine areas with the greatest concentration of bacteria.

4.4 Measured Pollutant Load Determination

The information provided by the project team, the pedestrian survey, and the biological and chemical surveys was scrutinized to locate specific sources of point and NPS nutrient and total suspended solids (TSS) addition. To specifically quantify and rank the nutrient addition attributed to these sources, additional monthly water sampling was performed in January, February, and March 2006. Additionally, one high flow storm event was sampled using rising stage samplers in March 2006.

Thirteen stations were chosen in the immediate vicinity of suspected nutrient sources using a combination of existing and new sites (Exhibit 1). The stations within the Little Laurel subwatershed were 2A, River Bend, 12A, 20A, 25A, 19A, KY25@92, WWTP, 16A, and 13A. The Laurel River subwatershed was sampled at the Laurel River station. The Robinson Creek subwatershed was sampled at station 2B. Stations selected are located immediately downstream of agriculture/cattle field runoff, development activities, known SSOs, the London WWTP, and the London landfill.

Like the samples collected during biological sampling, these samples were collected, properly preserved, and transported within established hold times to Envirodata Group laboratory for processing. Samples were analyzed for NO_3-N, NH_3-N, TKN, OP-P, TP, Fe, and TSS using standard methods (APHA 1998). TN was calculated as TKN plus NO_3-N. Also, during this sampling effort, samples were taken in January and March 2006 at stations 2A (Little Laurel), Laurel River, and 2B (Robinson Creek) for FC analysis (FC results in Appendix D).

For nutrient loading determination, stream discharge and nutrient concentration were measured together on three occasions at six of the stations (2A, Laurel River, 2B, 12A, 13A, and WWTP indicated by unique marker in Exhibit 1). To compute stream discharge for three representative flow levels at these stations:

- Stream cross-sections were surveyed at the locations where stage was monitored.
- The six streams were waded during sample collection to determine velocity.
- Water level was continuously monitored for eight weeks (January 17 – March 14, 2006) at the six locations using a pressure transducer water level recorder (Infinities USA).

Pressure Transducer Water Level Recorder

Surveying Stream Cross Section

Velocity and water depth were measured at intervals across the stream sufficient to characterize discharge. At each station, velocity was measured with a General Oceanic current meter mounted on a rod within a selected cross-section. According to the USGS method, velocity was measured at six-tenths of total stream depth when the depth was less than 2.5 feet. When the stream was deeper than 2.5 feet, velocity was measured at two-tenths and eight-tenths of the total depth and the average of the two readings were used as the average velocity at that point for discharge calculations. Discharge was calculated for each interval of the stream where velocity and depth were measured and total stream discharge was calculated at the summation of the discharge from each interval.

When the stream was too deep to wade with the current meter, stream velocity was roughly estimated using a floating object. The object was allowed to travel a given distance and the travel time was recorded. The surface velocity values obtained by this method were corrected to represent mid-depth velocity (mid-depth velocity = 0.80*surface velocity); (Daughtery *et al*. 1985).

Nutrient contribution at each station was estimated using a combination of grab and passive high-flow stage sampling (Subcommittee on Sedimentation 1961). The passive sample collection, or rising stage sampling, captured the "first flush" of storm flow using three staggered bottles mounted on an in-stream post. One bottle was located just above normal flow, one approximately six inches above normal flow, and the third bottle was approximately 12 inches above normal flow. At each station where passive storm sampling was performed, the three samples collected were recovered from the field as soon as possible after filling, composited into a stainless steel bucket, and then poured into labeled sample bottles. Grab samples were collected with the same stainless steel bucket and then poured into labeled sample bottles. All samples were transported to EnviroData Group laboratory for analysis according to proper preservative and transportation requirements.

When analyzing concentration data, if any analyte concentration was reported as "below detectable limit", a value of one-half the detection limit was substituted. Instantaneous contaminant loadings were calculated for six sites using measured or estimated flow values (m^3/sec) and measured contaminant concentrations (mg/L). One low, two normal (or baseflow), and one high flow event were measured with corresponding water quality data. Load values were estimated for the six stations where stage loggers were installed. Load values were calculated on a mass per unit time basis (kg/hr). Load per unit watershed area was also computed.

$$Load = Flow \times Concentration$$

$$Load / Area = Flow \times Concentration \div Watershed\ \ Area$$

For the three subwatersheds (Little Laurel, Laurel, and Robinson Creek), the load values for each contaminant were summed, so that the proportion of load from each subwatershed could be determined. For example, during low flows, 61% of the TN load is from the Little Laurel River subwatershed, nearly 20% is from the Laurel River subwatershed, and the remaining 19% is from the Robinson Creek subwatershed.

Measuring Stream Velocity

Passive High-Flow Stage Sampling Device

4.5 Predicted Pollutant Loads and Reductions

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL, Version 3.0; US EPA 2005) was used to predict N, P, BOD_5, and sediment delivery loads for each subwatershed given inputs on landuses and management practices. The model predicts annual nutrient loading based on runoff volume and pollutant concentrations in the runoff as influenced by landuse and management practices. Additionally, for a combination of potential BMPs, load reductions were predicted by the model using BMP efficiencies within the model. Inputs to the model are summarized in Appendix E. In the STEPL model, groups of BMPs were evaluated (specific BMPs modeled are listed in Appendix E). Annual pollutant load reductions for each subwatershed were predicted by applying BMPs to the urban areas (10, 25, 25, 75, and 100%), the rural areas (10, 25, 25, 75, and 100%), and to both the urban and rural areas (10, 25, 50, 75, and 100%). This is specified in more detail in Appendix E.

4.6 Public Outreach/Education

The public outreach and education components were intended to reach several audiences: (1) students in the Laurel and Corbin school systems, (2) area planning and utility officials, and (3) adults throughout the Cumberland region.

The first educational outreach effort involved students from the Laurel County and Corbin school systems to assist biologists in performing the pedestrian surveys throughout the watershed. Students teamed up with Third Rock biologists to characterize the landuse and sources of impairment in the watershed and to determine areas for additional sampling. Students were educated on NPS pollution origins and the consequences to water resources. They also assisted with collecting water samples and determining the physical and physiochemical integrity of streams.

The second visit to the field involved collection of fish and macroinvertebrate samples to determine biotic indices, as well as collection of water samples to determine nutrient concentrations and presence of FC bacteria. Students assisted the biologists and were instructed on correct sampling protocol. They learned the difference between pollution-tolerant and intolerant fish and macroinvertebrate species and the significance their presence has within an aquatic resource.

Five teachers within the Laurel County and Corbin school systems met with the project team to discuss how to present the project materials to the student body. Initially, it was anticipated that the project team would create its own education module consistent with the Personal Responsibility in a Desirable Environment (PRIDE) program and have all teachers in the Laurel County and Corbin school systems present it to their students. A field trip to the reservoir was also planned. However, after meeting with the teachers, it became clear that the school curriculum is very structured and that there were already instructional modules in place that could be modified by teachers to present data. In addition, the logistics of transporting students to the reservoir presented too many legal and other difficulties to make this practical. Therefore, at a meeting with the teachers in August 2005, it was determined that Third Rock would create a website that contained updated information about the project, together with portfolio prompts that teachers could use for student instruction. The intent of the website was that teachers could use the information and tailor it to their classes in keeping with Kentucky education requirements. The website was created and launched in the winter of 2005. To date, it has received several hundred unique hits. The website will continue to be updated as the project moves to the implementation phase.

Student Volunteers with Third Rock Biologist

Third Rock Biologist Conducting Meeting

Meeting with local planning officials was also an important component of developing the Watershed Plan. Officials from local government and utilities were recruited to be members of the project team. At each of four meetings, topics of discussion included NPS pollution, the consequences of NPS pollution to the watershed and reservoir, and updates on the watershed monitoring progress. At the June 2006 project team meeting, which involved a number of government and utility officials, the draft Watershed Plan was distributed and discussed, and a short presentation prepared by KDOW on the Growth Readiness project was made. This presentation was customized for the Corbin Reservoir project to summarize the results of the first phase.

Project Team Meeting, June 2006

Project Team Meeting, June 2006

Another adult education component was the distribution of educational materials to the 500-member Cumberland River Compact. These materials included a discussion of the project, its goals, and a link to the project website.

Future education and outreach efforts will continue in the implementation phase of this project (Phase II) for both students and adults. Specific tasks include the following:

- Involve the project partners group to further develop project ideas and details, establish locations for BMPs, and help to gain widespread community support for projects.
- Add citizen members to partners group.
- Utilize Kentucky Community Water Education Project's public service announcements.
- Send participant(s) to applicable Watershed-Based training, if available.
- Involve area junior high and high school classes in sampling tasks, tree planting, and other various field activities
- Present project developments to area environmental events (e.g. Earth Day events).

5. WATERSHED CHARACTERIZATION AND ASSESSMENT RESULTS

5.1 Physical Stream Assessment

Physical habitat scores (RBP) were consistently very low across the entire watershed (Appendix F). Forty-one sites of the fifty sites survey scored *Not Supporting*. The other nine sites scored *Partially Supporting*.

Poor Physical Habitat at 22A

Severely unstable banks and subsequent sedimentation were abundant throughout the watershed. Significant differences of physical impairment were not apparent between the three subwatersheds, though the Little Laurel River subwatershed contained six of the nine

Partially Supporting sites. As a result of the overall degraded nature of the streams, physical habitat assessment was not adequate for ranking significant areas of impairment in the watershed. On a watershed scale, stream sites consistently lacked adequate buffers, exhibited heavy sedimentation, lacked epifaunal substrate, and exhibited signs of severe bank instability. These results are consistent with the extent of development, both urban and agricultural, across the entire watershed. The overall degraded nature of the streams is characteristic of the extensive development and agriculture found upstream of the Corbin City Reservoir. Increased runoff from cleared land, channelization, and impervious surfaces has caused scouring and habitat degradation. The impact of extensive cattle production, described in section 2.7, on stream physical integrity is apparent. Cattle access to streams is directly responsible for impacting physical features such as bank stability and general habitat destruction. Evidence of past mining was also apparent in the Robinson Creek subwatershed, where a higher percentage of land area has been mined compared to the other subwatersheds (KDFWR and USGS 2002). Iron precipitate, high conductivity, and low pH were apparent at several locations associated with deep mine locations in the subwatershed.

Cattle with Access to Rough Creek at 14B

Cattle with Access to Little Robinson Creek at Site 5B

Iron Precipitate in Robinson Creek Subwatershed

Close-Up of Iron Precipitate at Station 9B, Robinson Creek Subwatershed

5.2 Erosion

More sources of sediment associated with erosion from development and construction sites were observed in the Little Laurel River subwatershed. Several sites with no erosion control were observed during the landuse characterization survey. Recently disturbed and exposed soil was commonplace. Also, the dumping of fill into floodplains was frequently observed during the watershed assessment. The high potential for erosion from these sites is compounded by the increased runoff from impervious surfaces and channelized streams in the subwatershed. In addition to overland erosion, it is likely that high levels of stream sediment can be attributed to stream bank erosion. Many of the streams are impacted and channel dimension is unstable. High levels of sediment in the streams (monitored by measuring TSS) also correlates with high measured Fe concentrations.

Erosion from Construction Site Adjacent to WWTP Outfall

High Turbidity in the Little Laurel River - Result of Erosion

Construction Near Site 23A

Bare Soil Next to 19A

5.3 Stream Channelization

Many of the streams across the entire watershed have been channelized, making them deeper and straighter. This is done primarily to facilitate conveyance of water downstream. Channelization was commonly used in the past to increase available land for development or farming. When a stream has been straightened and its natural channel pattern disrupted, the velocity of the stream increases causing an increase in erosion and lowering of the streambed elevation. When a stream is channelized, the stream upstream of the channelized reach will adjust to the lower bed elevation in the channelized section. Thus, channelizing a section of stream can create a headcut that moves upstream with severe erosion until a new, stable bed slope is achieved. Excess sedimentation from the erosion upstream causes downstream deposition. When this occurs, the stream requires "maintenance" (dredging) in order to facilitate conveyance of water downstream. Many streams within the watershed are actively dredged by London or Laurel County to maintain a desired level of conveyance. Most of the "stormwater network" within London consists of channelized streams.

Another result of channelization is channel deepening. The stream becomes cut off from its floodplain, except during large storm events. Water flowing in a channelized stream is deeper during a storm than in a natural channel, because water cannot spill out onto the floodplain where it dissipates energy. Deeper water inherently has greater shear stress and therefore is more erosive to the stream banks. The increased flow capacity gained through channelization reduces the travel time of storm flows in a stream, making it "flashier". Downstream effects include higher flood peaks and associated higher loadings of sediment, nutrients, and contaminants.

Floodplain Fill Adjacent to the Little Laurel River

Channelized Section of Sampson Branch (Little Laurel Subwatershed) with Indications of Bank Erosion

Heavy Sedimentation and Bar Formation

Unstable Substrate and Bar Formation

Channelization impacts riparian vegetation by directly destroying vegetation or indirectly by compacting the soil through the use of heavy equipment, which prevents root development within the riparian zone. Moving the stream channel to a new location creates an immediate impact because no natural riparian vegetation exists. As the channel tries to reach equilibrium (as described above), the channel deepens, lowering the water table. Lowering the water table in the riparian zone and reducing the frequency of overbank flow further stresses riparian vegetation.

5.4 Biological Stream Assessment

Biological survey results were mixed but most reflected the poor physical habitat. As with RBP scores, no apparent distinction was found between the three subwatersheds for MBI or IBI metric scores. For macroinvertebrate metrics, most stations scored *Very Poor* and *Poor* with the exception of some stations located in the uppermost portions of the watershed. Three of these sites exhibited healthier communities with scores in the *Fair* category. Communities at most stations were dominated by tolerant taxa in the Chironomidae and Oligochaeta groups. The stations in the *Fair* category had greater abundance of less tolerant Ephemeroptera, Plecoptera, and Trichoptera taxa (Appendix G and Table 3).

TABLE 3 – KENTUCKY MACROINVERTEBRATE BIOASSESSMENT INDEX (MBI) SCORES AND CORRESPONDING RATINGS (*FOR AQUATIC INSECTS*)

Wadeable Stations				
Subwatershed	**Station**	**Collection Date**	**MBI Score**	**Rating**
Laurel	10B	5/11/05	43	Poor
Laurel	16B	5/11/05	43	Poor
Robinson Creek	2B	5/11/05	60	Fair
Robinson Creek	9B	5/11/05	29	Poor
Little Laurel	12A	5/11/05	30	Poor
Little Laurel	17A	5/11/05	18	Very Poor
Little Laurel	24A	5/11/05	56	Fair
Headwater Stations				
Subwatershed	**Station**	**Collection Date**	**MBI Score**	**Rating**
Laurel	20B	5/11/05	40	Poor
Laurel	21B	5/11/05	42	Poor
Laurel	24B	5/11/05	39	Poor
Laurel	26B	5/11/05	53	Fair
Robinson Creek	4B	5/11/05	33	Poor
Robinson Creek	8B	5/11/05	26	Poor
Robinson Creek	Mine Site	5/11/05	14	Very Poor
Little Laurel	13A	5/11/05	42	Poor
Little Laurel	18A	5/11/05	40	Poor
Little Laurel	19A	5/11/05	13	Very Poor
Little Laurel	22A	5/11/05	24	Poor
Little Laurel	3A	5/11/05	24	Poor
Little Laurel	WWTP	5/11/05	31	Poor

Generally, fish community metrics were higher: four stations scored *Fair* or *Good*. The remaining six fish sampling stations scored *Poor*. As with the macroinvertebrates, most of the "healthier" fish stations were in the upper reaches of the watershed above urban development or large cattle populations and were characterized by fish with lower impairment tolerances or those needing sediment-free habitat for spawning (*i.e.* simple lithophiles) (Appendix H and Table 4).

TABLE 4 – KENTUCKY INDEX OF BIOTIC INTEGRITY (IBI) SCORES AND CORRESPONDING RATINGS (*FOR FISH*)

Subwatershed	Station	Collection Date	IBI Score	Rating
Laurel	16B	5/23/2005	47	Fair
Laurel	20B	5/23/2005	27	Poor
Laurel	21B	5/23/2005	34	Poor
Laurel	25B	5/23/2005	45	Fair
Laurel	26B	5/23/2005	61	Good
Robinson Creek	2B	5/23/2005	34	Poor
Robinson Creek	4B	5/23/2005	27	Poor
Robinson Creek	8B	5/23/2005	31	Poor
Robinson Creek	9B	5/23/2005	35	Poor
Little Laurel	12A	5/23/2005	24	Poor
Little Laurel	24A	5/23/2005	42	Fair
Little Laurel	25A	5/23/2005	27	Poor

5.5 Other Stream Assessment

Conductivity, pH, and FC frequently exceeded acceptable limits for Warmwater Aquatic Habitat throughout the entire watershed. Metals (Fe, Mn) were also found in elevated concentrations in both the Laurel and Little Laurel subwatersheds. Elevated nutrients (constituents of phosphorous [P] and nitrogen [N]) were observed below London's WWTP, below suspected SSO locations and also in the upper reaches of the Laurel River watershed (Appendix I). The elevated nutrients below London's WWTP were measured and consistent with the treatment plant's monitoring data.

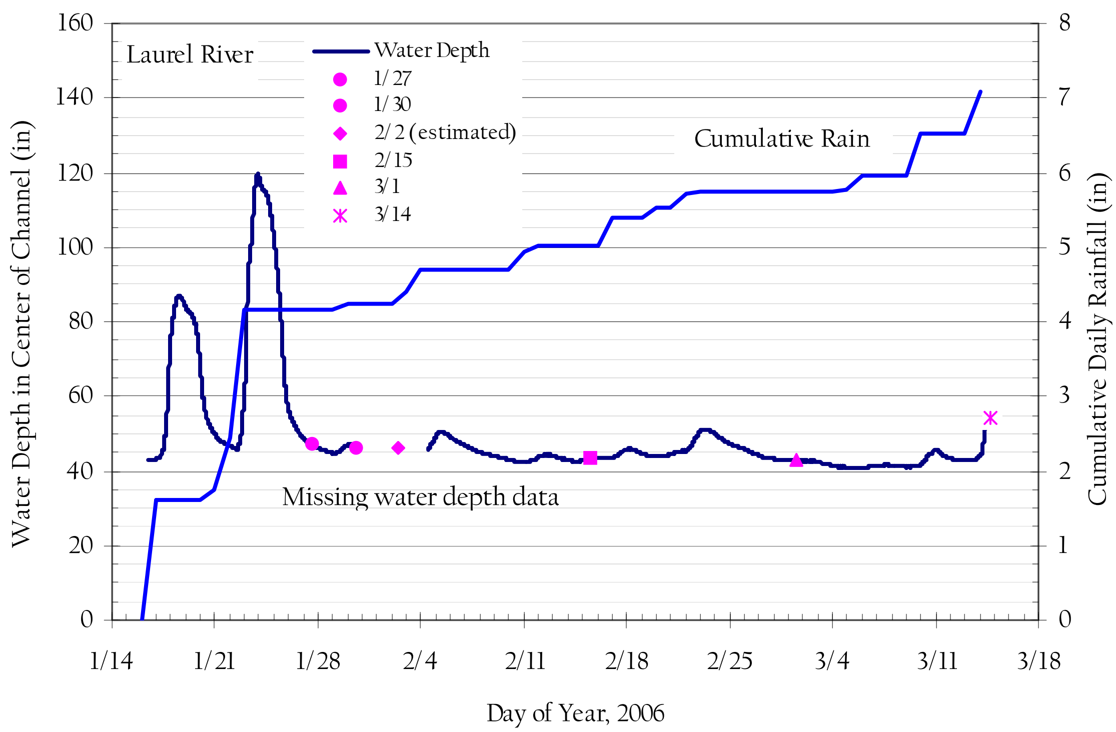
London WWTP

Effluent from London WWTP

5.6 Hydrology and Water Quality

The data from the January through March 2006 hydrology and water quality sampling study provided greater insight into the specific sources of impairment to the watershed and the Corbin City Reservoir. Regarding the specific problems within the reservoir, this information is most useful for guiding remediation efforts. Nutrient concentration data was obtained for four sampling events (two normal flow, one low flow, and one high flow event). It should be noted that a true low flow event was never seen during the period of sampling, as water levels never fell appreciably lower than the normal flow. Also, due to the unpredictability of storm sampling (high flow), only one high flow event was sampled. An example of the stream water level response to rainfall in the Laurel River is shown (Figure 5) with water quality sampling dates indicated by unique markers. Precipitation data presented is cumulative daily rainfall measured by the nearby WWTP in London. Similar graphs for five other stations are included in Appendix J.

FIGURE 5 – WATER DEPTH AND CUMULATIVE RAINFALL (LAUREL RIVER)



Discharge did not exhibit a strong correlation with drainage size. Though the areas varied from 27.2 square miles to 57.5 square miles (Table 5, page 26), discharge was very similar among the subwatersheds during low-flow events (Table 6, page 26).

During normal flow sampling, discharge was similar between the two less developed watersheds (Robinson Creek and Laurel River), but the developed area of Little Laurel River exhibited significantly higher flow values (Table 6). This trend was even more pronounced during the high-flow event. However, these representative flow values are based upon a rather limited amount of measured data. The WWTP discharge and the downstream measured discharge are also included in Table 6 to illustrate the percentage of flow in Whitley Branch that is comprised of the WWTP discharge.

TABLE 5 – SUBWATERSHED AREA

Site	Area (mi^2)	% of Total
Little Laurel River	42.4	33.4%
Laurel River	57.5	45.2%
Robinson Creek	27.2	21.4%
Total	*127.1*	*100.0%*

TABLE 6 – FLOW ATTRIBUTED TO EACH SUBWATERSHED (THE FLOW MEASURED AT STATION WWTP AND AVERAGE PLANT DISCHARGE TO THAT STATION IS INCLUDED)

Representative Flow Values (ft^3/sec) from Study Period					
Flow Level	**Little Laurel (2A)**	**Laurel River**	**Robinson Creek (2B)**	**WWTP (Our Station)**	**Average WWTP Discharge**
Low	36	35	32	9	4
Med	57	38	34	13	5
High	155	85	97	36	9
Drainage Area, mi^2	42.4	57.5	27.2	2.4	

Stream nutrient data collected were used to calculate loads for the three subwatersheds, but it is of interest to view a selection of the concentration data. Concentration data were correlated with flow, particularly for TSS, Fe, TP and OP-P. Total phosphorus loads at station 2A on the Little Laurel River (upstream of the confluence with the Laurel River) went from approximately 0.04 mg/L at normal flow to 0.63 mg/L at high flow (Figure 6, page 27). Total nitrogen (Appendix K) and TSS concentrations exhibited a similar response to storm flow at this station (Figure 3, page 8). A TSS concentration of 1.5 mg/L was measured at normal flow and TSS increased to more than 400 mg/L during the high flow event. Likewise, the response was noted at other stations. At the Laurel River station, Fe concentration increased from 0.4 mg/L at normal flow to 2.3 mg/L during the high flow event (Figure 4, page 11). Additional water quality data are tabulated in Appendix L and graphs presented in Appendix K.

Consistently, TN, NO_3, OP-P, and P concentrations were elevated at station WWTP on Whitley Branch (located below the discharge point for the London WWTP) compared to the other stations. This trend for TN can be seen in Figure 9 (page 29); measured TN concentration was higher at WWTP than at the other six sites for all events sampled. Consistently high levels of P were measured at the WWTP station also (Appendix K). In addition, stream conductivity and temperature were also consistently higher at the WWTP station than at other stations (Figure 10 [page 29], Appendix K).

For many stations, the first flush sample (collected using the rising stage samplers, March 14, 2006) contained a higher concentration of pollutants than the grab sample collected as the water level receded, as expected. This trend is exemplified by comparing the TSS storm surge concentrations to the subsequent TSS grab sample concentrations for stations located on tributaries to the Little Laurel River (Figure 11, page 30). Storm samples included in Figure 9 (page 29) for TN indicate that measured TN concentrations from the storm samples were higher than for the later collected grab sample. Other figures indicating that first flush contains higher nutrient concentrations are included in Appendix K (Figures K10-K11).

FIGURE 6 – WATER LEVEL, TP, AND OP-P CONCENTRATIONS (STATION 2A, LITTLE LAUREL RIVER)

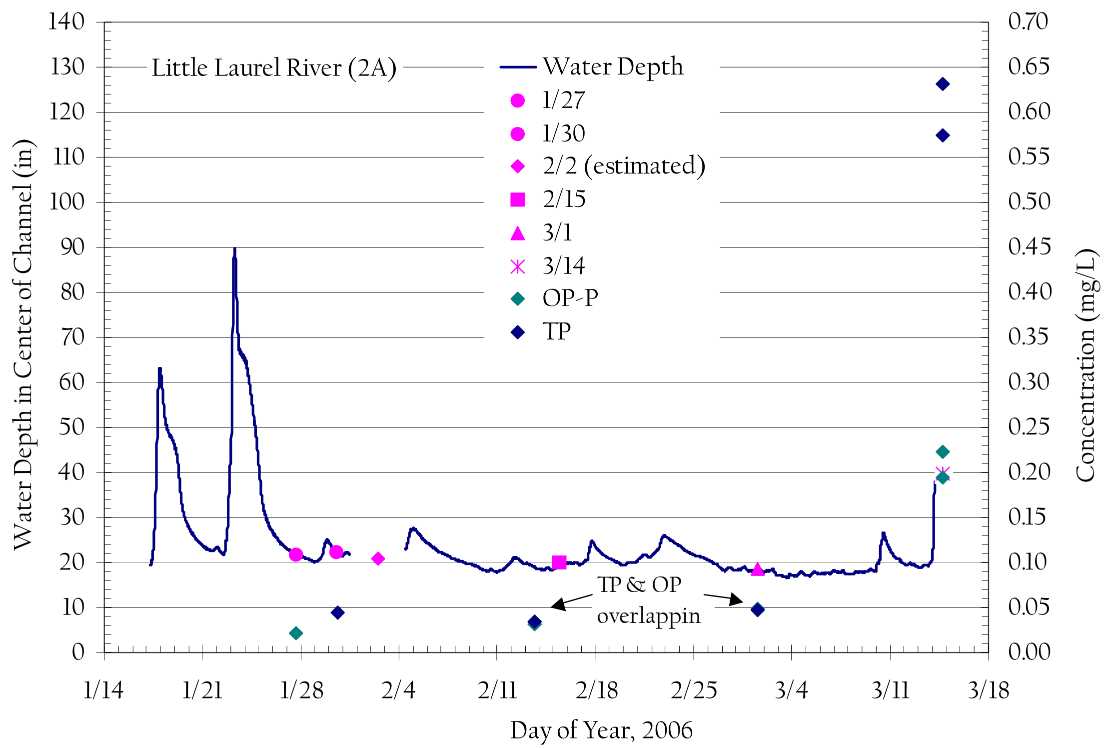


FIGURE 7 – WATER LEVEL AND TSS CONCENTRATIONS (STATION 2A, LITTLE LAUREL RIVER)

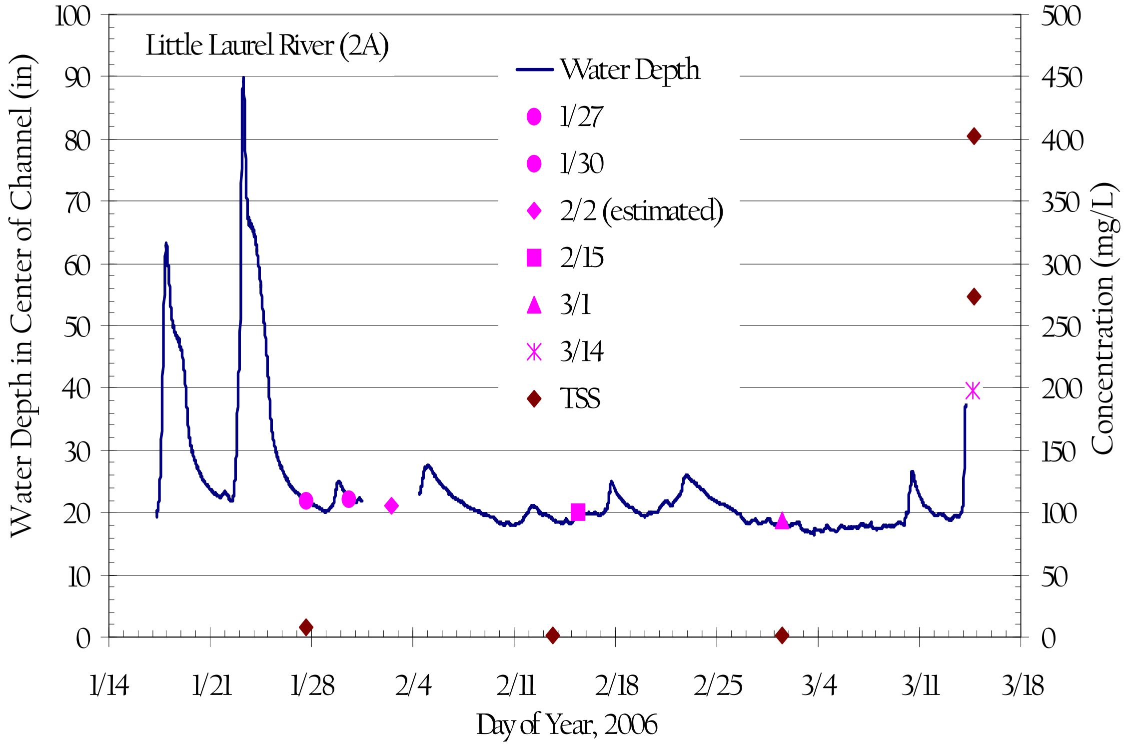


FIGURE 8 – WATER LEVEL AND FE CONCENTRATION (LAUREL RIVER STATION)

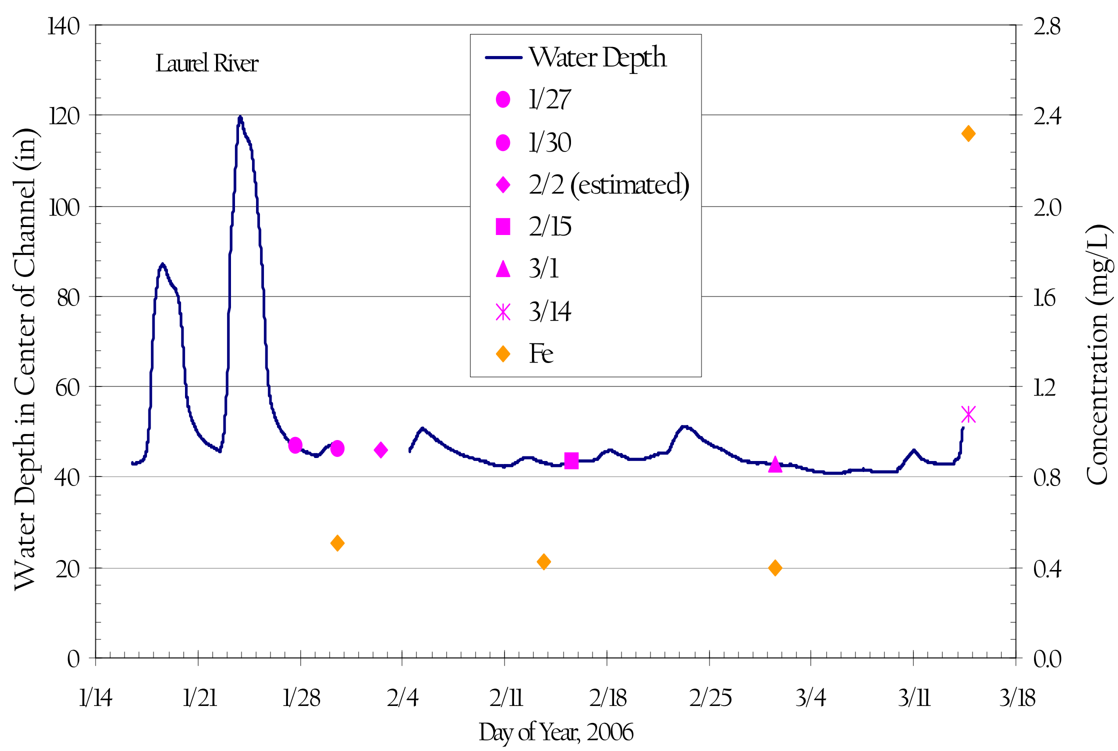


FIGURE 9 – TOTAL NITROGEN CONCENTRATION AT 6 STATIONS ACROSS THE WATERSHED FOR THE FOUR SAMPLING EVENTS

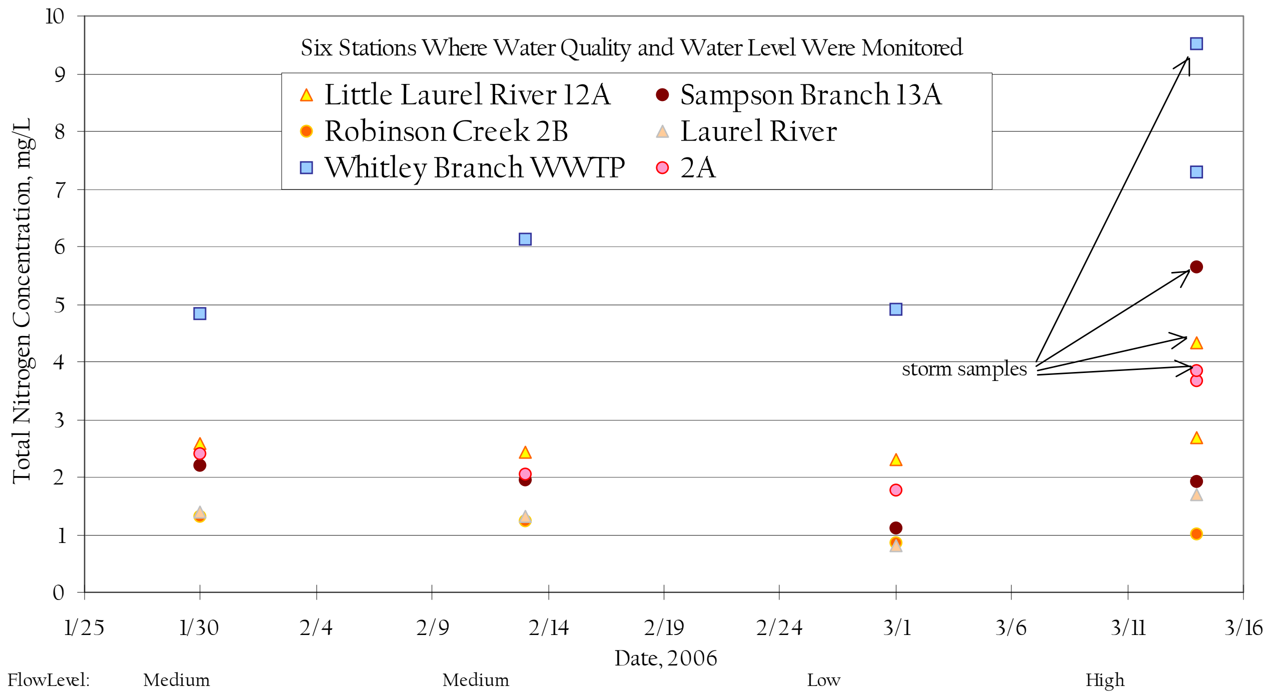


FIGURE 10 – WATER PH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY FOR ONE SAMPLING EVENT

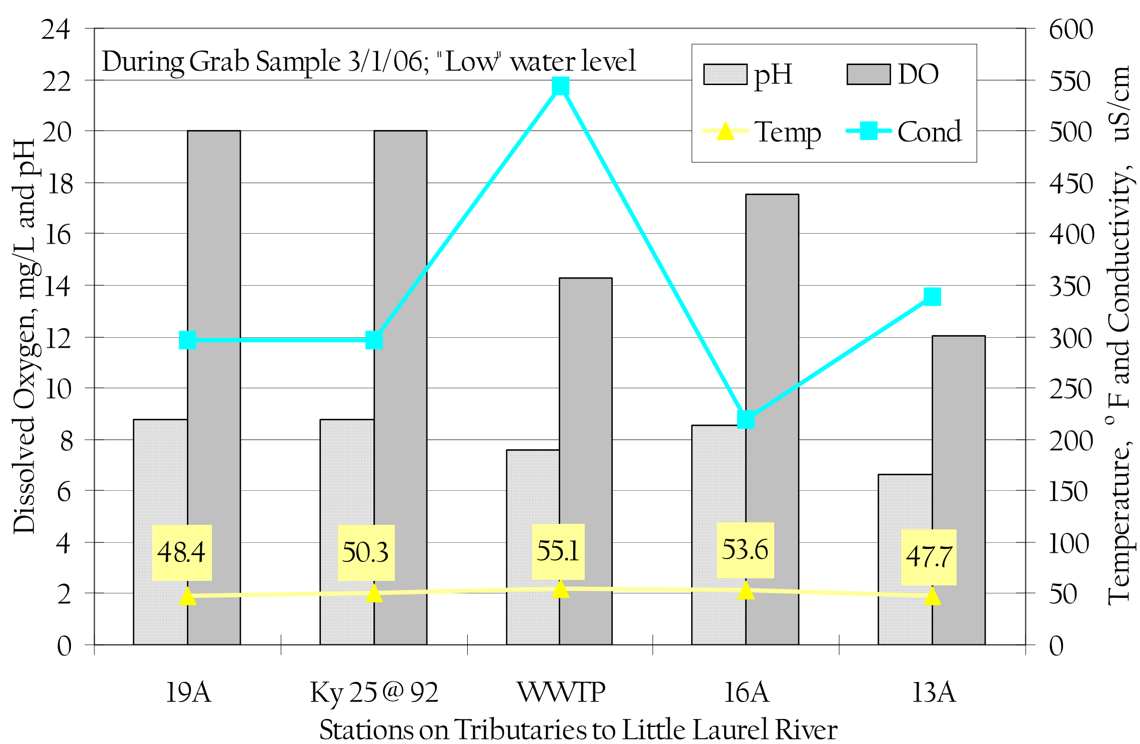
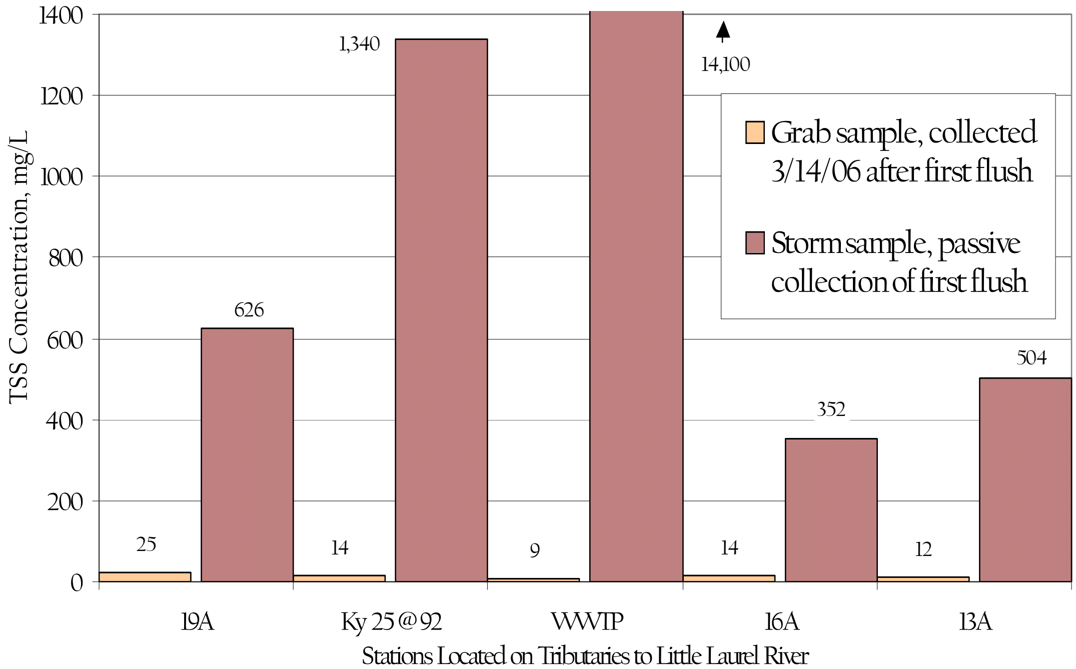
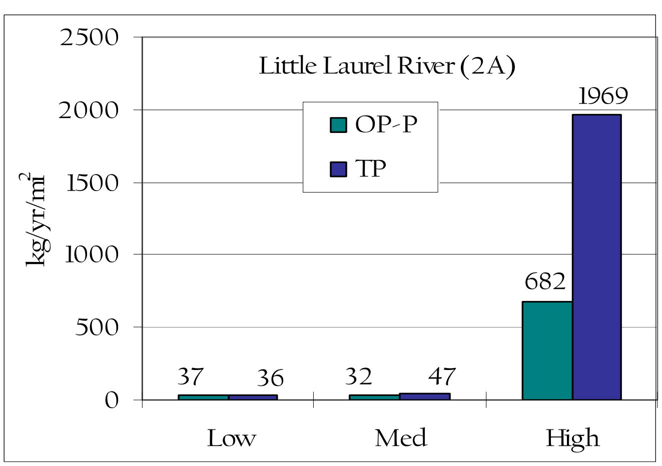


FIGURE 11 – TSS CONCENTRATION FOR FIRST FLUSH AND GRAB SAMPLE COLLECTED AFTER THE FIRST FLUSH WHEN WATER LEVEL WAS RECEEDING



Nutrients loads (concentration X flow) increased with increased flow level. At the three subwatershed stations, the load of N and P constituents, TSS, and Fe increased with high flow levels (Figures 12 - 23). Load data are presented per unit watershed area for events measured. Noting that the scale on the bar charts is different for each station, the Little Laurel River subwatershed contributes more pollutant load (generally) per unit area than the other two subwatersheds. By and large, the Laurel River contributes less pollutants per area than either the Little Laurel or Robinson Creek subwatersheds.

FIGURE 12 AND FIGURE 13 – ESTIMATED NUTRIENT LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT STATION 2A NEAR THE MOUTH OF THE LITTLE LAUREL RIVER



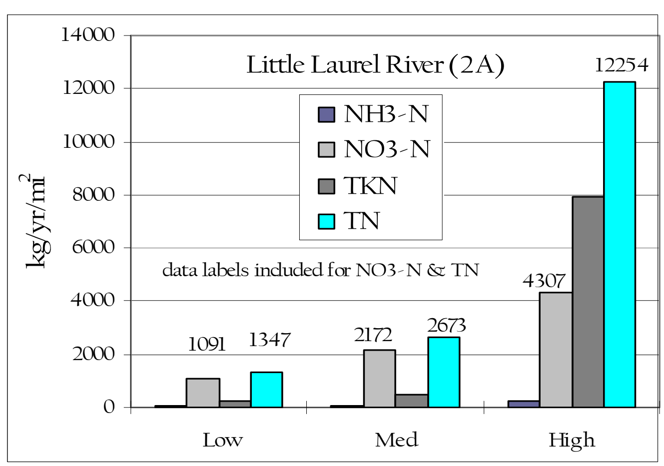
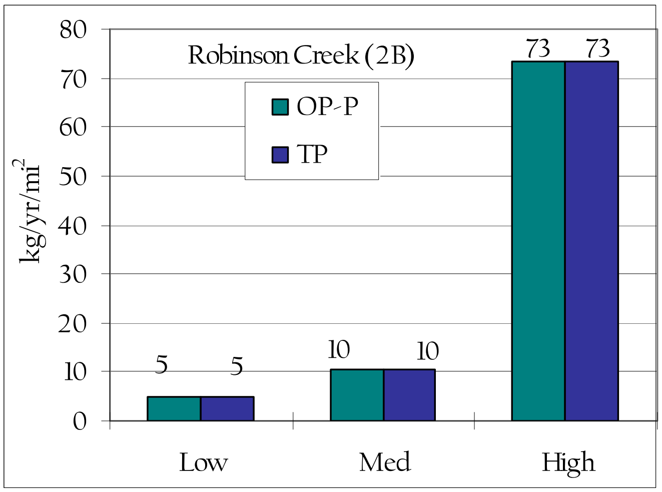


FIGURE 14 AND FIGURE 15 – ESTIMATED NUTRIENT LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT STATION 2B NEAR THE MOUTH OF ROBINSON CREEK



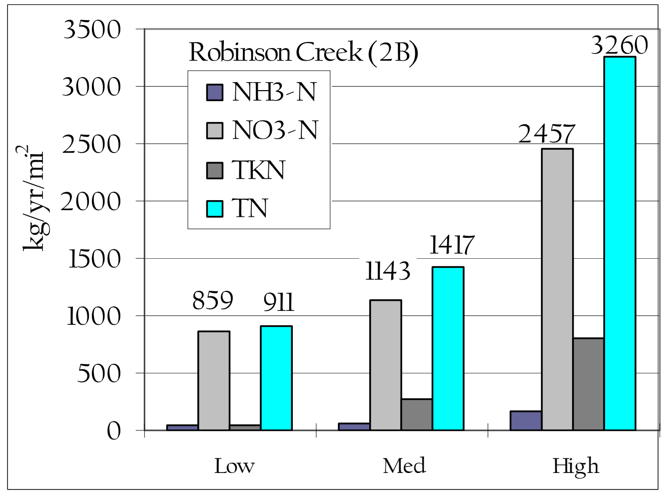
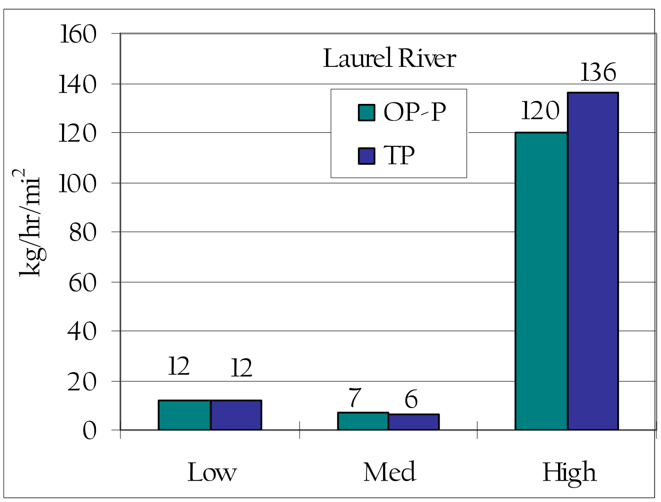
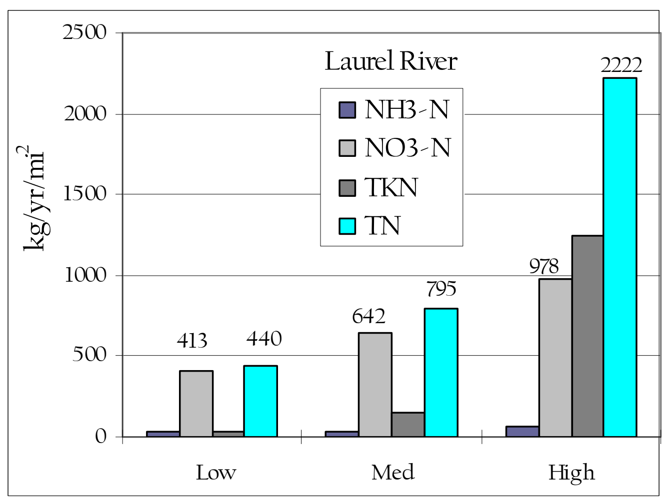


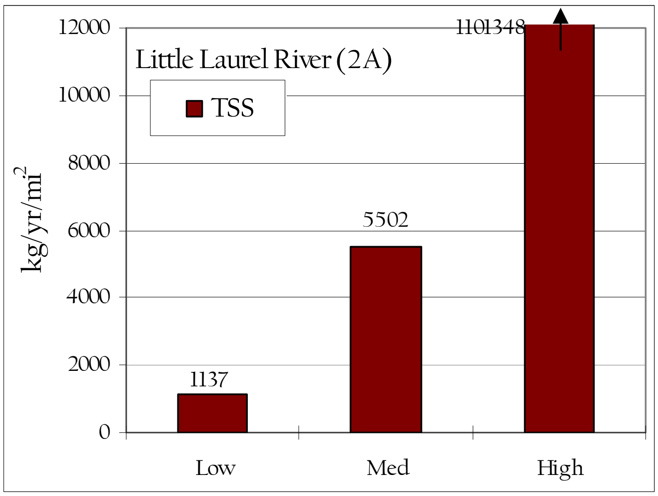
FIGURE 16 AND FIGURE 17 – ESTIMATED NUTRIENT LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT THE STATION NEAR THE MOUTH OF THE LAUREL RIVER





TSS and Fe loads were elevated during the high flow event at all three subwatershed stations (2A, Laurel River, and 2B) (Figures 18 - 23). This result was expected due to the degraded nature of the streams. Heavy erosion occurring during storm events, either from overland runoff or streambank erosion, contributes an abundance of sediment (indicated by TSS measurement) to the streams. It is likely that the Fe and P levels are associated with the sediment load, as phosphate ions adhere to soil particles by reacting with elements in the soil such as iron. Like with N and P exports, the Little Laurel River subwatershed contributes more TSS and Fe load per unit area to the Corbin City Reservoir than the other two subwatersheds (particularly at higher flow levels). At lower flow levels, the Robinson Creek subwatershed contributed the highest TSS and Fe loads/area, compared to the other two subwatersheds.

FIGURE 18 AND FIGURE 19 – ESTIMATED TSS AND FE LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT STATION 2A NEAR THE MOUTH OF THE LITTLE LAUREL RIVER



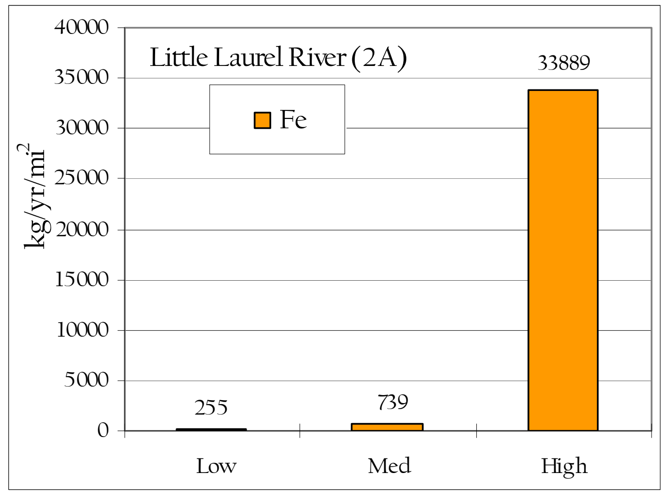
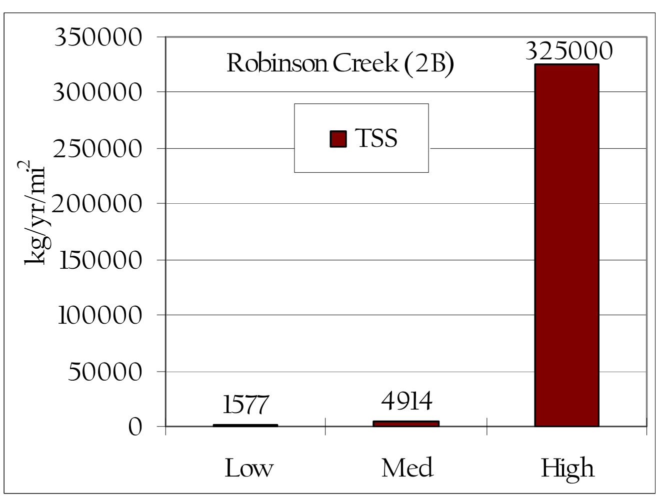


FIGURE 20 AND FIGURE 21 - ESTIMATED TSS AND FE LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT STATION 2B NEAR THE MOUTH OF ROBINSON CREEK



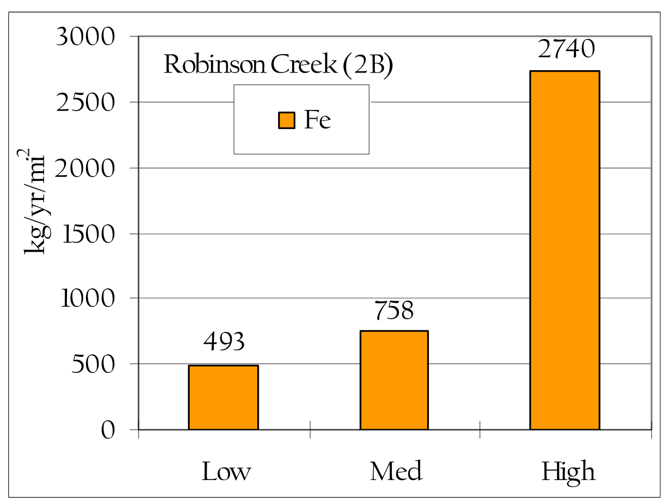
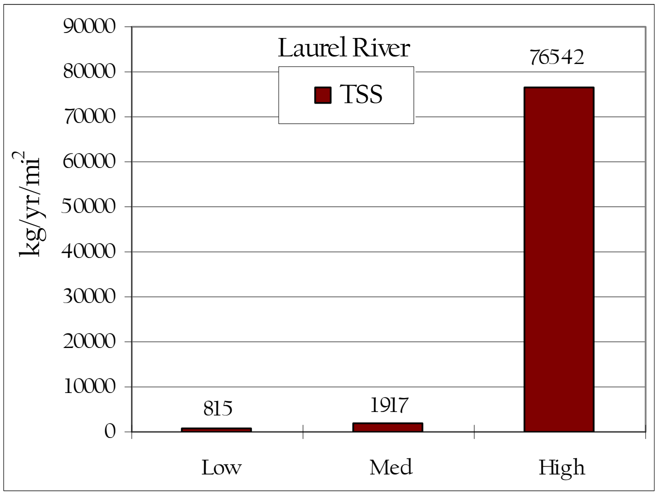
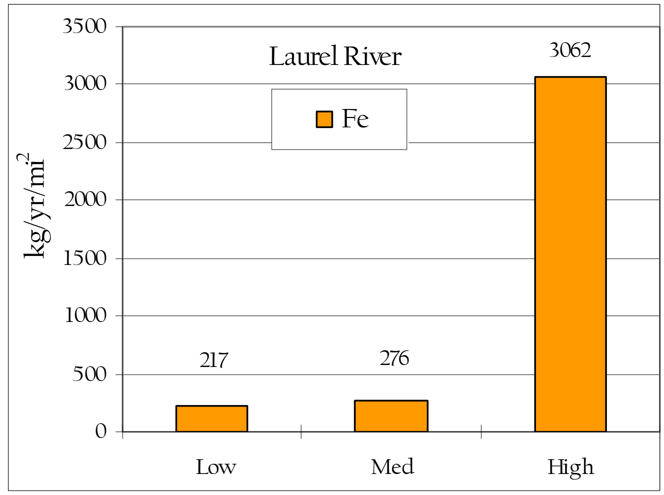


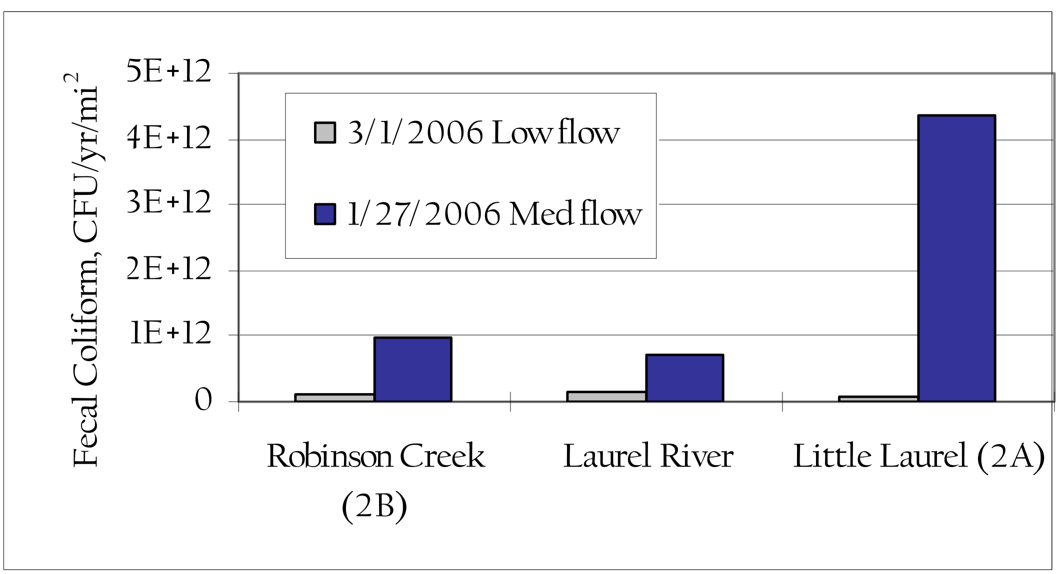
FIGURE 22 AND FIGURE 23 - ESTIMATED TSS AND FE LOADS PER UNIT WATERSHED AREA DURING THREE FLOW LEVELS AT THE STATION NEAR THE MOUTH OF THE LAUREL RIVER





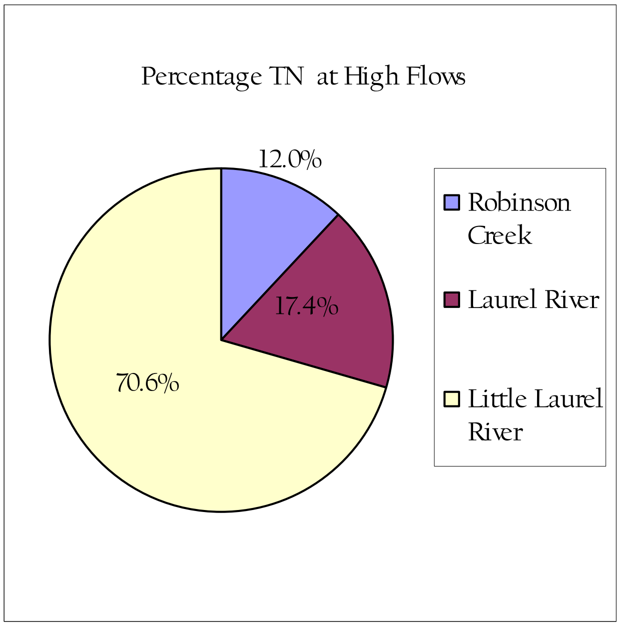
Fecal coliform loadings followed the same load/flow relationship. Though only two flow regimes (low and normal) were sampled at the three subwatershed stations (Little Laurel River, Laurel River, and Robinson Creek), the positive correlation with increased flow was apparent (Figure 24).

FIGURE 24 – FECAL COLIFORM LOAD PER UNIT WATERSHED AREA AT LOW AND MEDIUM FLOW LEVELS FOR THE THREE SUBWATERSHED STATIONS



On a mass loading basis, most of the pollutants contributed to the Corbin City Reservoir come form the Little Laurel River subwatershed, particularly during high flow. During the high flow sample on March 14, 2006, the Little Laurel River subwatershed accounted for 71% of the TN, 78% of the TSS, 85% of the Fe, and 90% of the TP from the entire Corbin City Reservoir watershed (Figures 25 - 28).

FIGURE 25 AND FIGURE 26 –TN AND TSS EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING HIGH FLOW EVENT



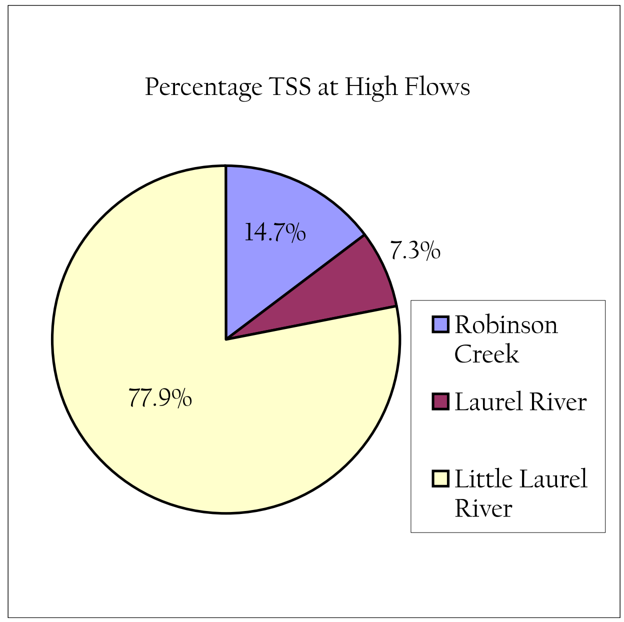
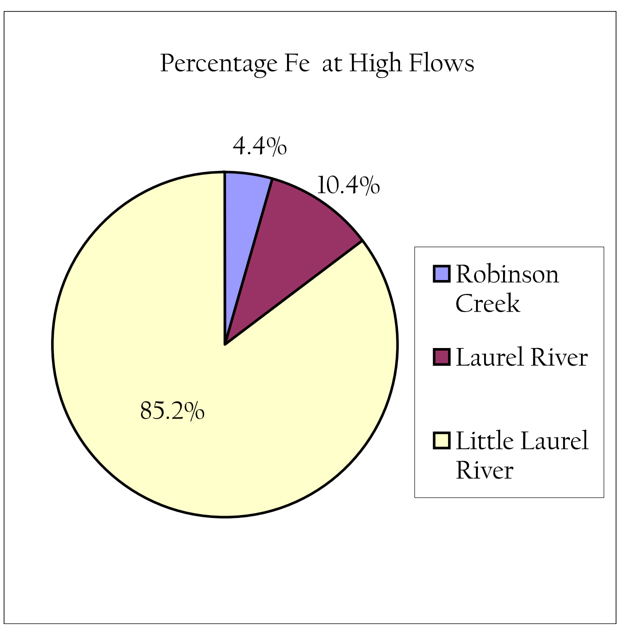
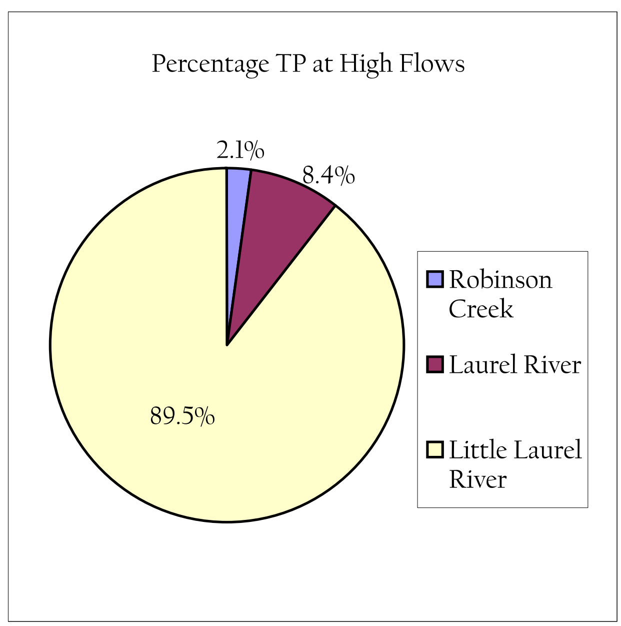


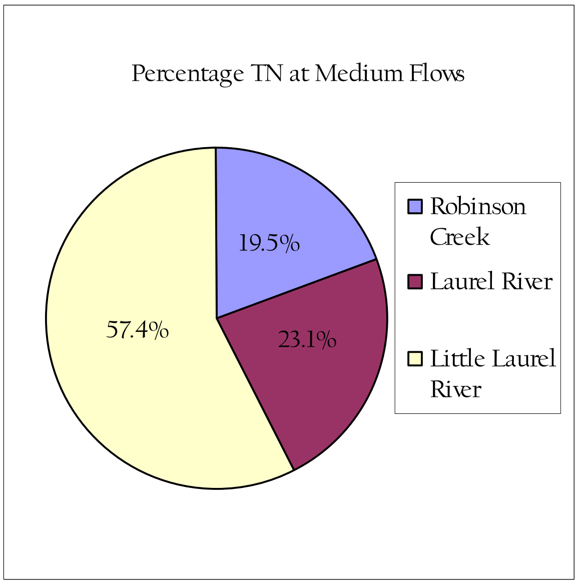
FIGURE 27 AND FIGURE 28 – FE AND TP EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING HIGH FLOW EVENT





The average of the two medium flow levels samples yielded similar trends (Figures 29-32). The Little Laurel River accounted for 57% of TN, nearly 50% of the TSS, 46% of Fe, and 76% of TP export from the Corbin City Reservoir watershed. For TN and TP, the Laurel River subwatershed was the next largest contributor, contributing 23% and 14% of the total load during the medium flows, respectively. For TSS and Fe, the Robinson Creek subwatershed was the next largest contributor, contributing 28% and 30% of the total load during the medium flows, respectively.

FIGURE 29 AND FIGURE 30 – TN AND TSS EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING MEDIUM (BASE) FLOW EVENT



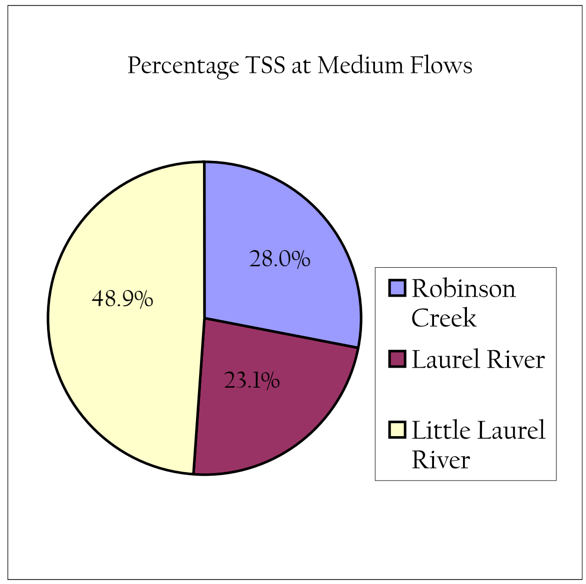
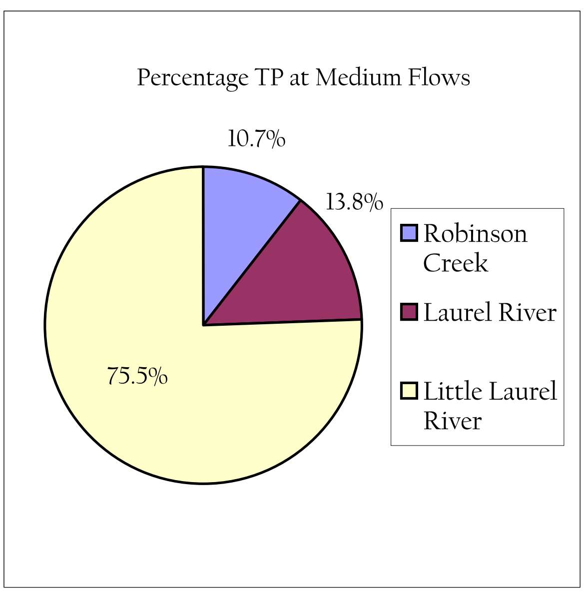
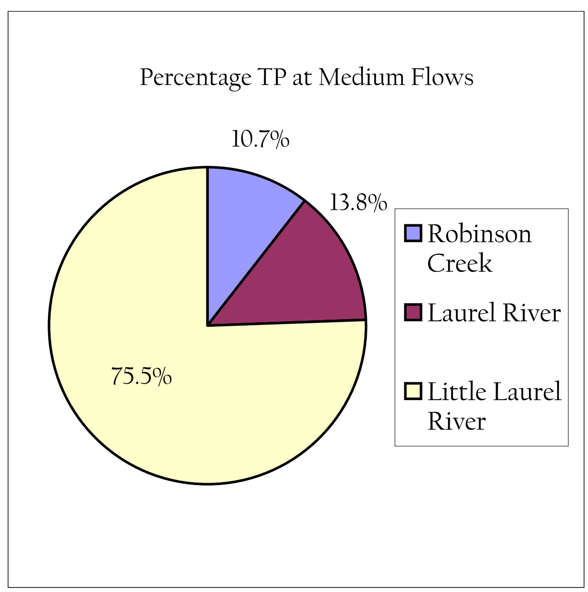


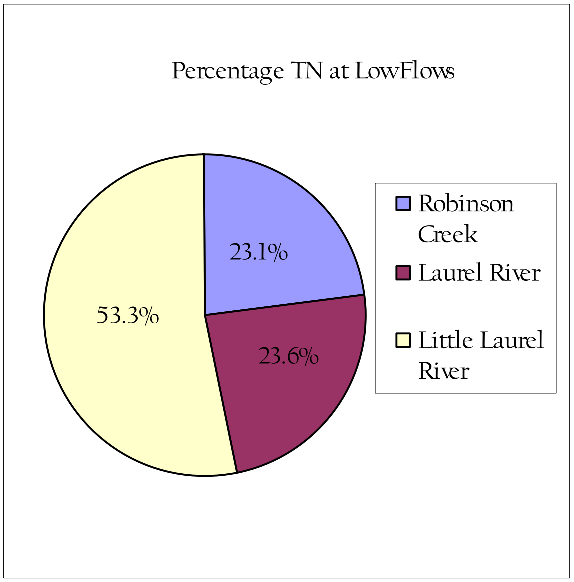
FIGURE 31 AND FIGURE 32 – FE AND TP EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING MEDIUM (BASE) FLOW EVENT





During the low flow event (Figures 33-36), the highest proportions of TN, TSS, and TP were again from the Little Laurel River subwatershed (53%, 35%, and 84%, respectively). The contributions of Fe were nearly equally split between the three subwatersheds, however the Robinson Creek subwatershed (37%) contributed the most, followed by Laurel River (34%), and then Little Laurel River (30%) subwatersheds.

FIGURE 33 AND FIGURE 34 – TN AND TSS EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING LOW FLOW EVENT



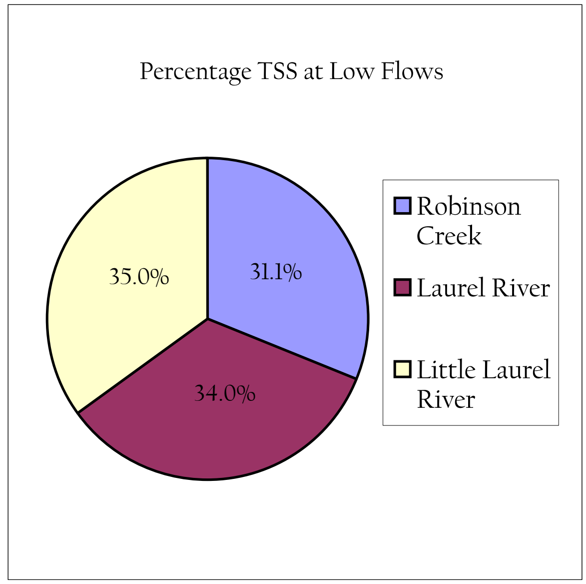
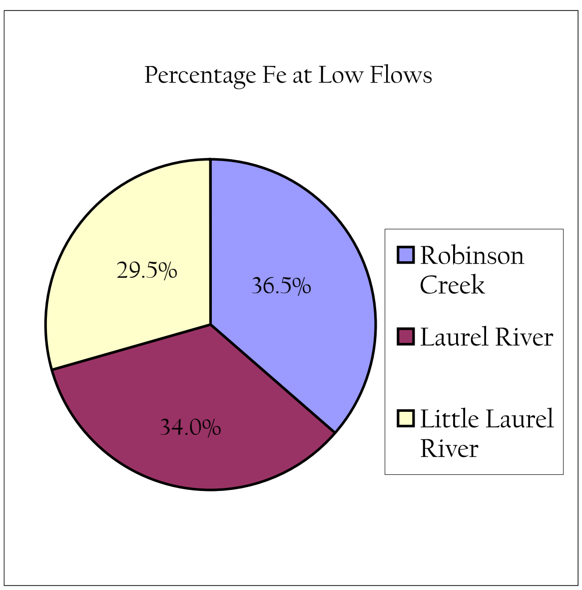
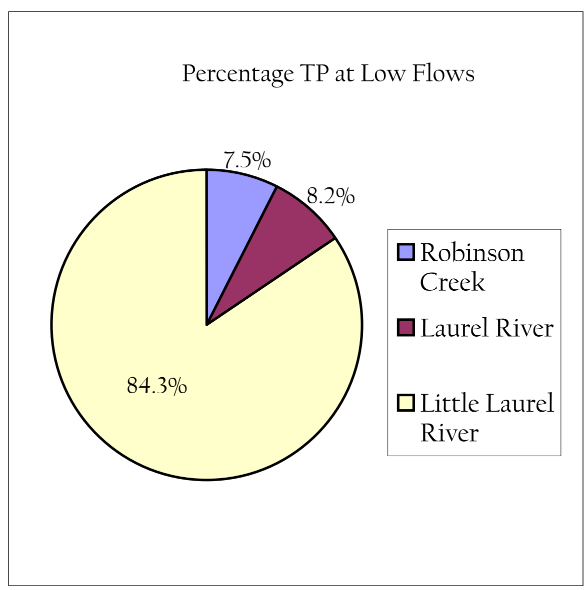


FIGURE 35 AND FIGURE 36 – FE AND TP EXPORT ATTRIBUTED TO EACH SUBWATERSHED DURING LOW FLOW EVENT





5.7 Predicted Pollutant Loads and Reductions

STEPL modeling was used to predict the percent reductions in annual N, P, BOD_5 and sediment load for each subwatershed. It is difficult to precisely predict the performance of management measures on the watershed scale, but these estimates are still helpful for watershed planning. This modeling was accomplished by simplifying the subwatersheds; model inputs are summarized in Appendix E. In the STEPL model, groups of BMPs were evaluated (specific BMPs modeled are listed in Appendix E). Annual pollutant load reductions for each subwatershed were predicted by applying BMPs to the urban areas (10, 25, 25, 75, and 100%), the rural areas (10, 25, 25, 75, and 100%), and to both the urban and rural areas (10, 25, 50, 75, and 100%). This is specified in more detail in Appendix E. The maximum predicted reduction in annual N, P, BOD_5, and sediment load is for the scenario where BMPs are applied to both the urban and rural (agricultural and forest) portions of all subwatersheds (Table 7). The model, which is based on landuse inputs, predicts that most of the reduction is due to BMPs implemented in the agricultural and forested portions of the watershed, which is the predominate landuse in all subwatersheds. For instance, a 55% N annual reduction is predicted for the Little Laurel subwatershed when BMPs are applied across 100% of the subwatershed, but the model predicts that a 52% N annual reduction can be achieved by applying BMPs to 100% of the agricultural and forested areas and none of the urban areas within this subwatershed.

TABLE 7 – MAXIMUM PREDICTED ANNUAL REDUCTION IN POLLUTANTS WHEN BMPS ARE APPLIED ACROSS THE ENTIRE WATERSHED

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	55	64	28	73
Laurel	64	67	25	74
Robinson Creek	65	68	28	74
Total	61	66	27	74

The STEPL modeling data indicates that annual reduction in nutrient loads can be achieved with BMP implementation, but does not specifically predict the concentration of nutrients or sediment that can be expected in a stream for a given event. Predictions of in-stream water quality response to BMP implementation would require a higher level of modeling.

Currently, few surface water quality standards for warm water aquatic habitat exist for nutrients and suspended solids (sediment), though high nutrient and sediment concentrations can adversely impact aquatic systems. Kentucky is in the process of developing standards that would specify the concentration of nutrients (i.e. nitrogen and phosphorus) allowed in the water while supporting warm water aquatic habitat. Currently, the allowable in-stream concentration of NO_3-N for meeting human health standards for a Domestic Water Supply Source is 10 mg/L. This standard was not exceeded by any water samples collected during the development of this plan. The EPA recommends that total phosphates should not exceed 0.05 mg/L (as P) in a stream at a point where it enters a lake or reservoir (Mueller and Helsel 1996). Total phosphorus concentrations greater than 0.01 to 0.02 mg/L are considered levels at which eutrophication will occur in P-limited surface waters (Daniel *et al*. 1998). During the high flow water quality measurement obtained during the development of this plan, TP concentrations near the outlet of all three subwatersheds were high enough to support eutrophication. The data collected during the development of this plan indicate that TP load to surface waters needs to be reduced to improve water quality.

Currently, no Total Maximum Daily Load (TMDL) calculations have been performed for streams in this watershed, but monitoring to support TMDL development is underway (November 2006). As new surface water quality standards are specified and TMDLs are developed within this watershed, load reductions necessary to achieve water quality standards will be calculated. Subsequently, the TMDL will indicate point and nonpoint sources of nutrients that must be changed (reduced) for a given stream to achieve water quality standards. TMDL findings and needed load reductions will be incorporated into the watershed plan. The TMDLs developed in this watershed will further guide and prioritize the implementation of BMPs and landuse changes needed to improve water quality within the three subwatersheds.

6. DISCUSSION

Very few areas within the boundary of the Corbin City Reservoir watershed were without some form of significant impairment. In the rural areas, impairment resulting from Fecal coliforms were elevated across the watershed from either excessive cattle production (detailed in Section 2.7) and resultant runoff, failing septic systems or overflowing sewers; stream vegetation buffers were typically very narrow or absent; stream integrity was compromised from landscape modification, stream channelization and cattle with access to streams (*e.g.* entrenched channels, sedimentation, bank instability); affects of past mining were noted (*e.g.* elevated conductivity, low pH, and iron precipitant); elevated nutrients were apparent; and erosion from land modification occurred unchecked. Independent of these upstream problems, the reservoir most likely experiences internal nutrient cycling (though this was not empirically determined by our sampling).

Physical stream degradation was consistently severe throughout the watershed. Though not listed in the 303(d) report as a pollutant source, sediment accumulation is significant in the Corbin City Reservoir according to utility personnel (Herd 2006). Sedimentation in streams was documented in the RBP assessments, the result of which is evidenced by frequent flooding events occurring commonly in the city of London. Flooding on Sampson Branch, a tributary within the London city limits, has increased significantly in recent years according to affected residents. The stream flow response to rainfall events is a high peak flow rate maintained for a short duration (flash events). This effect is likely due to the increase in upstream development in the watershed (London area) that has occurred with minimal, if any, stormwater management. Flood events bring sewage (from SSOs), trash, and other debris into resident's yards. Current management for flood reduction is limited to sediment dredging in and around the city of London.

The extent of water pollutants was not as evenly distributed throughout the watershed as physical degradation. Though most of the measured pollutants were elevated in both Robinson Creek and the Laurel River during high flow, the pollutant concentrations were higher in the Little Laurel River during all flow events. The Little Laurel River subwatershed contains all types of NPS pollution that contribute to the reservoir impairment. Even though this subwatershed contains the most concentrated urban area, it also contains areas of dense cattle grazing and stockyards (where waste has been noted piled along streambanks) and resultant stream fecal contamination. Straight pipes and failing septic systems were not observed in great abundance though some were apparent near sampling stations.

Flooding on London Street

Flooding at Levi Jackson State Park

Cattle Operation within London City Limits

Stockyard Off East 4th Street in London

The higher discharge measured in the Little Laurel River is most likely a direct result of the higher percentage of impervious surface associated with development exacerbated by previous stream channelization. Parking lots, rooftops, roads, and other anthropogenic landscape modifications reduce the amount of rainfall infiltration, equating to more runoff. Increased runoff has led to streambank erosion, greater overall stream impairment, and increased incidence of downstream flooding. Though not reflected by lower RBP habitat scores than the other subwatersheds, the impairment of the Little Laurel River is evident in the water sampling results. The dominant contribution of TSS from the Little Laurel River subwatershed to the Corbin City Reservoir is a direct measure of the sediment loss through erosion (either streambank or overland). The high iron concentrations measured in this subwatershed are also likely linked to erosion. Iron is commonly complexed in soil minerals and subsequently Fe and TSS (and additionally P) results are highly correlated.

Example of Large Impervious Parking Lot

Impervious Parking Lot and Rooftop at North Laurel High School

6.1 Measured Nutrient Concentrations

Nutrient concentrations in the Corbin City Reservoir watershed follow the same pattern as the other pollutants. According to our monitoring results, all three subwatersheds exceeded ideal nutrient concentrations during high flow (KY Water Quality Standards 2006), but the concentrations measured in the Little Laurel River subwatershed exceeded those measured in the other basins. Likewise, the Little Laurel River subwatershed contributed greater nutrient loads compared to the other subwatersheds. Regarding TP, the highest TP concentrations are measured in the Little Laurel River subwatershed and this subwatershed contributes the majority of P input to the reservoir regardless of flow condition (low, normal, and high flow).

In 1992, the EPA reported that accelerated eutrophication was one of the leading problems facing the Nation's lakes and reservoirs. Eutrophication caused by the overabundance of nutrients in water can result in a variety of water-quality problems, including fish kills, noxious tastes and odors, clogged pipelines, and restricted recreation. No national criteria have been established for concentrations of P compounds in water; however, to control eutrophication, the EPA makes the recommendations that total phosphates should not exceed 0.05 mg/L (as P) in a stream at a point where it enters a lake or reservoir (Mueller and Helsel 1996). In freshwater systems, P is typically the limiting nutrient in primary production (*i.e.* algae growth) and thus the nutrient responsible for eutrophication. Total phosphorus concentrations greater than 0.01 to 0.02 mg/L are considered levels at which eutrophication will occur in P-limited surface waters (Daniel *et al*. 1998). During the high flow water quality measurement, TP concentrations at all three of the tributaries that supply water to the Corbin City Reservoir were high enough to support eutrophication. During the high flow event, measured concentrations of TP in grab samples collected after the first flush of pollutants for the Little Laurel River, Laurel River, and Robinson Creek were 0.58, 0.10, and 0.02 mg/L, respectively. Measured TP concentration often exceeded the recommended limits to prevent eutrophication (Appendix L).

Higher nutrient concentrations in the Laurel River and Robinson Creek were measured during the high flow event than during the normal and low flow events. Measured TP concentrations exceeded EPA guidelines and therefore necessitate further characterization and remediation. Although the TP concentrations were elevated in the Laurel River and Robinson Creek subwatersheds, our results (concentration and loading data) indicate that, during all measured flow events, the primary source of all measured pollutants (especially P) to the Corbin City Reservoir is the Little Laurel River subwatershed. Results from strategically placed sampling stations indicate that the specific sources of nutrient addition in this subwatershed are point and nonpoint sources in and around the city of London. Isolating suspected nutrient sources was difficult due to the location of sources relative to each other. For instance, station 12A on the Little Laurel River was directly below a large cattle farm, yet it was also the first station placed on the main stem of the river below the WWTP outfall. In this instance the nutrient contribution from the cattle was masked based on the elevated nutrient concentrations measured during the high flow event at the WWTP site (on a tributary just upstream of 12A) and additional monitoring data acquired from the treatment plant. This data was sufficient to account for the elevated nutrient concentration seen at 12A. The pollutant concentration data from more isolated stations located below areas of dense cattle pasture (stations 25A and 20A) were indeed elevated during high flow runoff, yet the extent of this contribution was overshadowed by the high concentrations of nutrients measured directly below areas of failing sanitary sewers and the London WWTP.

Sanitary sewer overflow (SSO) is a common problem in many municipalities. The EPA estimates that between 23,000 and 75,000 SSOs occur each year in the United States, resulting in the release of 3 to 10 billion gallons of untreated wastewater throughout the United States (US EPA 2004). During heavy rainfall, damaged sanitary sewer lines are infiltrated with stormwater runoff. As a result, overwhelmed sewer lines overflow adjacent to or directly into streams. As seen in London, this influx of untreated sewage results in elevated bacteria, nutrients, and biochemical oxygen demand (BOD, not measured) in the Little Laurel River. The extent of deteriorating sewer lines in London is unknown. Currently, the city of London is assessing and repairing damage in a sequential manner. No assessment of the entire collection system has been done, instead damage is repaired as it is identified.

Sanitary Sewer Overflow

Sanity Sewer Overflow on Whitley Branch

During the time of the pollution loading survey, the contribution of P from the London WWTP to the Little Laurel River varied directly with raw water input concentrations. Phosphorus outputs varied on average below 0.5 mg/L in the winter months of January and February 2006 to approximately 3 mg/L in March 2006. Phosphorus values from the WWTP sampling station indicated a significant P increase during high flow events, which could be attributed to a suspected sanitary sewer overflow upstream of the WWTP outfall. Results from sampling stations indicated that TP increased from 0.21 mg/L and 0.07 mg/L during low and medium flow respectively to 2.79 mg/L during the high flow sample in March.

7. REMEDIATION AND PROTECTION STRATEGIES

The information presented in this report substantiates the concern that upstream landuse practices are directly contributing to the impairments seen in the Corbin City Reservoir. Though potential internal nutrient cycling and sedimentation issues exist within the reservoir, sources of pollution in the watershed must be addressed before any direct remediation efforts are explored to alleviate taste and odor problems, aquatic life issues, and the accelerated sedimentation within the reservoir.

The most immediate sources of impairment to the Corbin City Reservoir were found to be nutrient addition and sedimentation. Sources of nutrients are London's WWTP and sanitary sewer overflows (SSOs associated with excessive stormwater runoff), failing septic systems, cattle waste runoff, fertilized fields and lawns. Regarding sedimentation, the entire watershed shows evidence of sediment input to the reservoir.

Stormwater runoff management is needed to reduce peak stormflows, pollutant loadings, and physical stream degradation. A stream will respond to increased development in the watershed by eroding to form a new dimension, pattern, and profile in order to carry the resultant higher flow. As streams change, their movement (lateral or down cutting) increases stream sediment load and can cause property loss. Stormwater BMPs should be implemented to reduce the peak flow rate of runoff to receiving streams in order to lessen flooding, stream erosion, and the transport of nutrients, sediment, and other pollutants. Methods for abatement include increased runoff retention and infiltration. Retention can be employed to capture and retain stormwater runoff before it contributes to SSOs and/or enters receiving streams. Stormwater retention reduces the peak downstream discharge, provides opportunity for sediment and solids to settle out of suspension, and reduces nutrients and other pollutants transported downstream. Increased runoff infiltration can be promoted through strategically placed bioretention areas in urban areas. Infiltration prevents water from entering streams and as a result, reduces stream water impacts most significantly.

A remediation strategy for nutrient and sediment control in the Corbin City Reservoir should be multi-faceted and include further study, public education, ordinance advocacy, preservation, BMP implementation, and restoration.

7.1 Preservation

In addition to remediation and restoration, preservation is an important management measure that can protect water quality. Any areas in the watershed meeting current uses or could offer future protections should be preserved. Protecting areas from development or intensive agriculture eliminates sources of pollutants and does not contribute as much additional runoff to flood-prone areas.

One area for protection within the Laurel River subwatershed is the Levi Jackson State Park. The park encompasses more than 800 wooded acres. It is one of the largest contiguous forests in the entire watershed. Much of the park drains to Lick Creek and Locke Branch, tributaries of the Laurel River.

Other areas to consider for preservation include undeveloped floodplains. Protecting the natural and beneficial functions of active floodplains (where stream is not incised and can access its floodplain) can provide water quality benefits and help to alleviate downstream flooding. One option for preserving land is to purchase the property or to obtain a very precise easement that restricts the future use of the property. For example, an easement agreement could ensure that the only future land disturbance on a property was for stream or wetland restoration. An easement or deed could be held by the city of London or other entity.

7.2 Public Outreach and Education

Outreach efforts must be continued and relationships with watershed partners maintained as this watershed moves from the assessment phase to the remediation and protection phase. The project team is an important means of public involvement, allowing the exchange of ideas and providing local insight for the implementation of water quality improvement projects. The information exchanged during team meetings will allow members to advocate watershed protection and raise awareness about the value of such efforts within the community. Expanding the watershed partners group, particularly to include more local citizens and landowners (not just public officials and agency personnel), will be an important way to get participation in selecting, locating, implementing, and maintaining NPS pollution management measures.

To increase public awareness regarding the implementation of projects for improving reservoir and watershed water quality, the current project website should be maintained. The website created during production of the watershed plan that describes the monitoring and assessment of the watershed can be updated and publicized by the project partners group to raise community awareness. Likewise, an informative project newsletter can be produced and disseminated to project team members, for their use or distribution.

Educational signs describing BMP and watershed goals should be installed at BMP project sites where the setting is appropriate (*i.e.* public settings). The information supplied will increase water quality awareness throughout Laurel County. The BMP construction and function should be related to the water quality goals of the community and featured prominently in the local or regional newspaper.

Arrangements can be made to get Kentucky's Commonwealth Water Education Project (CWEP) public service announcements into local newspaper, radio, and/or television outlets. The CWEP materials were developed to target Kentucky's citizens and educate them about the sources of and solutions to NPS pollution. This component of "social marketing" will encourage citizens to improve the quality of local streams and rivers by changing small behaviors that collectively have large impacts on water quality.

The Kentucky Growth Readiness project, offered through the CWEP, aims to help communities maintain water quality as they grow. Specifically, this project offers training and presentation materials that focus on building awareness of the connection between landuse and water quality, how to build a foundation for water quality friendly development rules, and how to comply with new regulatory requirements.

When opportunities arise, members of the watershed partners group should attend workshops on current watershed and water quality issues. Workshops topics such as preventing and managing stormwater runoff, low impact development (LID) and landuse planning, BMPs for improving water quality, or preventing and managing NPS pollution would be appropriate and beneficial to enhancing their understanding of water quality issues.

Educational outreach may also be achieved through working with teachers and staff at a local middle or high school. For example, if it is possible to build a rain garden or stormwater wetland on school property, some elements of construction could involve teachers, students, and parents. The project construction could be combined with educational sessions to teach students/teachers/parents about the importance of our water resources, ways water is impaired, ways problems can be remediated, and the role wetlands and bioretention play in protecting our water resources.

7.3 Advocate Ordinances

The watershed partners should continue to provide support and information for creating and enforcing local and county-level ordinances related to stormwater management and smart growth. The partners group should cooperate to advocate city and county ordinances for preserving pervious surfaces, requiring stormwater management, and implementing erosion and sediment controls. Proper ordinances can lessen the impacts of additional growth and development and protect the quality of water resources. Educating local council and committee members on topics such as low impact development (LID), stormwater reduction and treatment, the watershed approach to water quality, Phase II Stormwater Regulations, etc. can be beneficial for enacting longterm change in the watershed.

7.4 Riparian Vegetation

Planting or enhancing the riparian zone of streams within the watershed should be done to provide the stream with necessary shading, bank stability, a supply of woody debris and leaf material, habitat, and the enhanced potential for water quality improvement.

Adequate riparian buffers can function as stabilizing filters that increase infiltration as well as photorespiration and evapotranspiration. A riparian buffer acts as a filter for removing sediment/particulate and sediment-bound nutrients (particularly P) from surface runoff moving across them (Daniels and Gilliam 1996). Buffers infiltrate some runoff and lower the velocity of water moving across them, which enables soil particles (particularly sand and silt) to settle out of suspension and become trapped in the buffer. This deposition of sediments and organic material can result in improvement of water quality downstream. Also, riparian buffers physically stabilize the area along a stream channel and the streambank itself, helping to prevent bank erosion that can produce a large sediment load to the stream and degrade downstream water quality. In this watershed, many agricultural streams could benefit from riparian planting.

7.5 Removing Livestock from Streams

Fencing livestock (cattle) from streams within pastures reduces a source of nutrients and bacteria to water bodies. It also eliminates the physical degradation livestock have to streambanks and riparian vegetation. Livestock can be provided alternative water sources, such as an upland pond or watering trough. If providing an alternative water source is not feasible, cattle access to streams could at least be restricted to specific access points for drinking rather than giving them access to an entire waterway. Landowners willing to incorporate such practices into an overall management plan can become more efficient producers and improve the quality and value of their land.

7.6 Stream Restoration

Some level of stream restoration or enhancement would improve the biological integrity and water quality of streams throughout the watershed. Restoration that provides stable morphology, in-stream cover, appropriate riparian zone, a riffle-pool sequence, quality stream substrate, and overhead tree canopy will result in an enhanced habitat where fish and macroinvertebrates thrive and water quality is enhanced (The River Institute 2006). For example, a riffle-pool sequence provides a variety of habitat niches for aquatic insects and fish and also has a role in the transport of sediment and addition of dissolved oxygen to the stream. The entire watershed could benefit from restoration applied to the small streams of the watershed. Data suggests that small streams have the most potential to process and retain N (Peterson *et al.* 2001) and that benthic macroinvertebrate populations in headwater streams are critical to a functioning downstream aquatic community (Dobson 2003).

7.7 Streamside Wetlands

Like a natural wetland, a constructed wetland has the capacity to store floodwater and release it slowly and to improve the quality of water passing through. As the benefits of wetlands have become more recognized and quantified, they are increasingly used for water treatment, and have often been used for sediment, P, and N removal (Mitsch and Gosselink 1993).

In conjunction with natural stream channel restoration, a streamside wetland can be designed and constructed to provide storage that can ameliorate downstream flooding and enhance pollutant removal. By enhancing the floodplain and including depressions, vegetation, and woody debris, a streamside wetland has the capability to store runoff and filter out sediment and other particulate. Some water may be infiltrated by the depressions and recharge groundwater, therefore not contributing a nutrient load to the surface water. Locating stream-side wetlands in lower order streams near sources of polluted runoff, such as near the border of an agricultural field, disturbed land, channelized stream or impervious area can help to maximize the wetland functions and improve water quality (Gilliam *et al.* 1997; Mitsch and Gosselink 1993). Natural wetlands found higher in the watershed have a larger capacity to reduce peak storm flows downstream in the watershed and reduce sediment and nutrient concentrations in downstream reaches (Gilliam *et al.* 1997; Mitsch and Gosselink 1993). The same placement theory holds true for constructed wetlands. For effective wetland performance, the wetland area should be 1-3% of the area of the contributing watershed (Bass 2000).

The streamside wetland can be planted with native species, which may include appropriate hardwoods. Plants serve many functions in a constructed wetland. Thick vegetation can prevent "short-circuiting" within the wetland, ensuring more uniform water treatment. An abundance of vegetation is effective at slowing runoff coming into a wetland, which gives sediment/particulates the opportunity to settle out and become immobilized in the wetland. Settling of suspended solids reduces particle-bound nutrients (such as Fe and P) in wetland outflows. Eventually, dead-fall vegetation can trap sediment underneath, forming a layer where the non-degradable P is bound (Payne and Knight 1997). Immobilization of sediment and organic matter may be permanent, or this particulate may be re-suspended and washed through the wetland in a large storm event. Plants cyclically recover nutrients from a wetland. Brix (1994) noted that emergent macrophytes uptake around 50-150 kg of P per hectare per year and 1000-2500 kg of N per hectare per year. But, if the vegetation is not harvested, the nutrients are released back into the wetland when the vegetation dies/decomposes and are used for new growth, or extra nutrients may be released from the wetland. Ideas for creating a nutrient-reducing wetland would include planning for long-term success at nutrient removal and financial sustainability.

Streamside constructed wetlands (as well as stormwater wetlands, described below) offer passive, low-maintenance treatment of nonpoint source pollution, as well as the aesthetic benefit of unique habitat for vegetation, birds, animals, and aquatic life. A constructed wetland can be used to effectively treat runoff. Wetlands are becoming increasingly popular for runoff storage and treatment, and have been used for sediment, P, N, and metals removal (Bastviken *et al.* 2003; Blahnik and Day 2000; Braskerud 2002; Carter; Casey and Klaine 2001). Like a natural wetland, a constructed wetland has the capacity to store floodwater, releasing it slowly, and to improve the quality of water passing through.

One example of ideal stream-side constructed wetland placement is on Whitley Branch just below the London WWTP near its confluence with the Little Laurel River. This is an undeveloped area where a wetland could be incorporated into the floodplain.

7.8 Stormwater BMPs and LID

Many options exist for incorporating stormwater mitigation into existing and future development within the watershed. Bioretention areas, stormwater wetlands, grass swales, sand filters, permeable (porous) pavement, and green roofs are all BMPs that can reduce and/or treat stormwater runoff. Low Impact Development (LID) is the term used to describe development that utilizes comprehensive land planning and engineering design aimed at maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. LID can incorporate a variety of stormwater BMPs, as well as concepts such as shared driveways and parking lots and reduced use of curb and gutter.

Opportunities exist for incorporating BMPs into new development (*i.e.* new hospital or school facility), as well as retrofitting some areas with BMPs. For example, traditional parking lots can be reconfigured with tree-planted infiltration swales within the lots to capture runoff. Or where land is available, rooftop and parking lot runoff can be routed to a bioretention area or stormwater wetland instead of directly to the nearest stream.

Bioretention and stormwater wetlands are described more thoroughly below. The Regional Best Management Practices Draft Manual (KY Sanitation District No. 1) can provide additional information about stormwater and its pollutants, how BMPs function to minimize and treat stormwater, and matrices on selecting suitable BMPs for a given situation.

In more highly developed areas, bioretention areas or rain gardens can be used to effectively treat stormwater runoff in a rather inconspicuous way (Hunt 2003). A rain garden has the capacity to treat and store runoff, but has the appearance of an attractive landscape feature without using large areas of land. Runoff from small rainfall events is infiltrated by the rain garden and treated as it flows through the permeable profile. Applicable sites are typically 5 acres or less (drainage area).

In lieu of traditional stormwater management techniques (collecting runoff and routing it directly to nearby creek without any pollutant treatment), a rain garden can be designed to capture the "first flush", or the first one-inch of rainfall produced by a storm event. This is the runoff that carries the greatest amount of NPS pollutants (nutrients, sediment, other chemicals), thus a bioretention area is an effective tool for improving water quality.

A stormwater wetland can be designed and constructed to treat stormwater runoff from a developed area, where more land is available for stormwater mitigation. Stormwater runoff can be routed into a wetland that includes shallow and deep zones, a long sinuous flow path, and native hydrophytic vegetation to achieve water storage, infiltration, and water quality improvement. Like a bioretention area, a stormwater wetland can be designed to capture the "first flush" of rainfall produced by a storm event. A stormwater wetland also provides a biologically diverse ecosystem with aesthetic and educational purposes as well as the potential to hold and treat stormwater (as described above for stream-side wetlands).

7.9 London Wastewater Treatment Plant

During the preparation of this document, new regulations for London's WWTP were imposed by the KPDES. Effective May 2006, the average monthly export concentration of TP from the London WWTP is limited to 1 mg/L during the growing season, which averages 181 days in Laurel County (Ross *et al.* 1981). KPDES has given London six months to meet this limit; already, the treatment plant is in compliance. The plant has reduced TP concentrations from approximately 3 mg/L to approximately 0.3 mg/L using an in-line alum coagulant.

Though effective, the alum treatment is expensive. To offset the cost of the additional chemical treatment, the London WWTP is working to reduce P in their source water. London has identified two industrial sources of P upstream of the treatment facility and is working directly with the facilities to reduce their nutrient export to Whitley Branch. This is a significant step toward improving the water quality of Whitley Branch, the Little Laurel River, and the Corbin City Reservoir.

7.10 London Sanitary Sewer Overflows

Though P reductions associated with the London WWTP's new permit limits are substantial, SSOs around the city of London (such as Sampson Branch and Whitley Branch) continue to be a source of nutrients and bacteria. SSOs are a source of P to the Corbin Reservoir, therefore direct actions should be taken to correct the deteriorating sanitary sewers and reduce the stormwater runoff that is generating the overflows. Families downstream of the SSOs are experiencing flooding of their property with increasing frequency. The health risks associated with bacteria, intestinal parasites, viruses, and molds carried in raw sewage are substantial and have forced citizens to contact county officials seeking solutions.

The solution to SSOs in the London area is two-fold: repair and abate. In an attempt to prevent public health issues, the city of London is currently repairing and maintaining damaged and neglected sewer lines in obvious overflow areas. To address the issue of SSOs on a broader scale, a thorough assessment of the sanitary sewer collection system must be completed. Using a combination of smoke testing and dye tracing, the most significant areas of inflow and infiltration problems could be determined and comprehensive repair plans could be developed. As an abatement measure, stormwater runoff contributing to the SSOs in this developed area must be reduced.

7.11 Sedimentation

The root of accelerated stream and reservoir sedimentation, increased runoff, can be directly attributed to increased impervious surfaces in the watershed, stream channelization, and an absence of riparian buffer strips that filter and slow overland flow. The impact of development was apparent in the flow data gathered from four sampling events. A variety of relatively low-cost methods exist for reducing the amount of runoff from parking lots, rooftops, roads, and other large impervious surfaces. The best initial step would be to identify the largest concentrated areas of impervious surface (using GIS) and subsequently implement management strategies and projects to capture and retain stormwater runoff. Projects could include retention basins, constructed stormwater wetlands, bioretention areas (rain gardens), green roofs, sand filters, or other structures designed to hold runoff and increase infiltration of rainwater.

To reduce sediment transport to the Corbin Reservoir watershed, specific tasks should be carried out to determine the primary source and location of sediment input. Search criteria should be developed to determine if the source of sedimentation is from the stream itself (*i.e.* bank erosion) or from overland erosion. An inventory of stream banks (representing Laurel and Little Laurel Rivers, Robinson Creek, and tributaries) should be rated for erosion potential. Using criteria such as Bank Erosion Hazard Index (BEHI) and near-bank shear stress along with measured bank erosion and stream sediment concentration, assessment of stream can be completed and the sources of sediment carried to the Corbin Reservoir can be clarified. Subsequently, contributing stream reaches can be ranked for restoration/stabilization. Additionally, the data can be used to produce a relationship between BEHI, near-bank shear stress, and observed annual erosion that can be used as a tool for predicting streambank erosion for similar streams in the future. No such relationships exist for streams in Kentucky and a predictive model developed in this watershed could be compared to those found in other states (Jennings and Harman 2001; Rosgen 2001; Van Eps *et al.* 2004).

By more thoroughly evaluating and prioritizing streams across the watershed, areas that would benefit most from BMPs could be identified and the application of remediation techniques such as bank stabilization, riparian zone establishment, or cattle fencing would have the greatest effect of overall water quality. A subset of areas in significant need of agricultural BMPs and/or streambank stabilization were determined during stream assessments and are shown on Exhibit 1, page 3.

Though streambank instability is a source of sediment in the waterways, erosion due to construction and fill is also a likely source of sediment in the streams draining the city of London. Requirements for controlling sediment for road construction projects exist through the Federal Highway Administration (1995). These methods provide guidance for BMPs that would have direct application to development projects in and around the Corbin City Reservoir watershed (Federal Highway Administration 1995). Additionally, the city of London is beginning to make progress in this area – a set of sediment and erosion control ordinances was passed in November 2006. Reducing the effects of stormwater and erosion in developing areas of the watershed could be achieved by cooperating with partners and government representatives to advocate ordinances aimed at sediment and erosion control and stormwater management for development projects. The partnership should facilitate interaction between government, citizens, and developers and include education on the importance of BMPs that will protect water resources while supporting community growth.

8. EVALUATING PROGRESS

The ultimate goal is to improve the water quality of the Corbin City Reservoir and the streams within the watershed using the guidance of this Watershed Plan. Through this project and the recently initiated (November 2006) monitoring associated with TMDL development in the watershed, extensive background monitoring data is available for the streams of this watershed. As projects are implemented and water quality awareness is achieved, the streams can continue to be monitored to assess improvement and determine if progress is being made toward attaining water quality standards. Reaching this objective requires that data generated must be of sufficient quantity and quality to determine general stream quality improvement and evaluate the ability of BMPs to remove NPS pollutants from runoff. The Quality Assurance Protection Plan (QAPP) documents specific information regarding sampling and ensuring data objectives are met.

In-stream monitoring of water quality will be performed to determine if water quality improves over time as projects are implemented. Water quality parameters may include nutrients, metals, sediment, pathogens, pH, conductivity, DO, temperature, biological indicators. This monitoring will determine if the Little Laurel River, Laurel River, and Robinson Creek fully support their uses.

The effectiveness of BMPs will be monitored on a watershed scale and at site level to evaluate the success of NPS pollution reduction. Post-construction, BMPs will be evaluated to ensure they are stable and functioning properly. Additional data will be collected to specifically evaluate the BMP performance (flow reduction and nutrient and sediment reduction). This initiative will be considered successful if water quality improvements are measured. For example, a stormwater BMP (*i.e.* bioretention area) will be monitored such that pollutant load reductions, or percent pollutant retention in the structure, will be calculated. Inflow (runoff) to the BMP will be measured by collecting and routing inflow over a weir structure or estimated using measured rainfall and an accepted method for estimating surface water runoff. Outflow from the BMP will be collected into a weir box equipped with an automated water sampler equipped with a device to measure and record flow. Flow-weighted composite samples will be taken for inflow and outflow during storm events. Water samples will be analyzed for TKN, TN, NO_3-N, NH_4-N, TP, OP-P, TSS, Zn, Cu, and Fe. Success will be indicated by the BMPs ability to reduce peak flow of runoff and to remove pollutants from the runoff.

Any enhanced or restored streams or wetlands will be monitored for sustained stability and function. Restored sections of streams will be reevaluated one to two years post-construction to quantify stability, vegetation survival, aquatic habitat present, and biological integrity. Success will be indicated by stability, high vegetation survival, and increased aquatic habitat and biologic integrity compared to pre-restoration conditions. Likewise, any enhancement through riparian buffer planting will require a vegetation survey to be completed after the buffer has been planted and subsequently in one to five years to determine percent survival.

Field observations and measurements provide data valuable for water quality assessment and modeling. Field sample collection directly affects the analytical results generated. The following standards apply:

- All field measurements and sampling are to be performed such that the sample taken is physically and chemically representative of the material or medium being sampled.
- All field data is collected by trained individuals.
- During sampling, datasheets are used to record visual status of the habitat.
- GPS positioning and photographs are taken to accurately locate the sampling stations.
- Chain of Custody forms for samples are to be properly completed and maintained
- Samples are protected by proper packing and transportation, preservation, and handling techniques before analysis.
- Flow computations for BMP inflow and outflow will be based on depth of water in a weir box, or similar device. Depending on the BMP site, inflow may be calculated using the SCS curve number approach to predict runoff depth from the impervious watershed (*i.e.* parking lot) for rainfall data measured on site.
- Continuous water level done using a pressure transducer water level recorder, or similar device.
- BMP inflow or outflow may be monitoring using automatic samples to collect flow-weighted composite samples.
- Any applicable field equipment will be calibrated regularly in accordance with the manufacturer's instructions.

9. FUTURE EFFORTS

In order to enhance the Watershed Plan and ultimately achieve the goal of improving water quality throughout the Corbin City Reservoir watershed, it is recommended that some additional assessment and activities be performed.

9.1 Identify Stormwater Sources

Continuing to identify specific sources of stormwater will be required to initiate abatement strategies. Locations that are highly impervious with little or no stormwater abatement measures in place and areas of extensive stream channelization should be targeted for remediation activities. Owners of property with potential for improvement can be recruited as watershed partners and/or approached with a strategy for remediation. BMPs to increase infiltration can be targeted to future, planned development as well. For example, connections are currently being made with Marymount Medical Center in London. This corporation is planning to build a new hospital within the watershed and efforts made during the planning and design phase can lead to the use of the best available stormwater management options for this new facility, beyond what is currently required locally.

9.2 Update Landuse Mapping

Continuing to build upon the data already collected and updating mapping to indicate landuse changes throughout the watershed is valuable. This information can be used for predicting rainfall–runoff relationships for the watershed, which can be used to predict streamflow and make predictions of water quality based on landuse. Increases in development, impervious surfaces, and stream channelization have occurred in the watershed since official landuse mapping was performed. Current landuse mapping that includes specific stormwater sources would be another tool for targeting NPS pollution BMPs. Comparing an updated map with the mapping currently available will likely reiterate the increasing imperviousness of the watershed and continue to provide support and build the case for creating and enforcing ordinances related to stormwater management and smart growth.

9.3 Preparing for Phase II Stormwater Requirements

London does not currently have a population large enough to be designated a NPDES Phase II Stormwater community, but this community is growing rapidly and should begin to develop a comprehensive stormwater program that will progress into the future.

The city can begin making efforts to prepare for the requirements and determine the allocation of resources that will be necessary to comply with regulations. Stormwater related projects can be funded by EPA 319(h) grants if the community is *not* a Phase II community. The Stormwater Phase II Rule requires the community to have a stormwater management program comprised of six elements (public outreach and education, public participation/involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping). More information on the rules can be found in the EPA's Stormwater Phase II Final Rule Fact Sheet Series, which can be accessed online at http://cfpub.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6 .

London can begin to identify where deficiencies exist in their current stormwater program. For example, in order to comply with the illicit discharge detection element, London will have to map the locations of all outfalls, landuse, landfills, NPDES permitted facilities, and structural stormwater controls. This mapping could be initiated immediately by London.

9.4 Measure and Predict Streambank Erosion

Another valuable effort is to obtain a clearer picture of the sources of in-stream sediment by prioritizing stream segments of Laurel and Little Laurel Rivers, Robinson Creek, and contributing tributaries in a streambank erosion inventory. The data collected could be used to develop a predictive model for estimating streambank erosion from Bank Erosion Hazard Index (BEHI) and near-bank shear stress.

For example, such a study could be described as follows.

Numerous streambanks representing "main stem" channel (Laurel and Little Laurel Rivers and Robinson Creek) will be rated for erosion potential, giving each streambank surveyed a quantitative rating of BEHI and near-bank shear stress. The inventory will also include streambanks representing tributaries from a range of landuses. Streambanks with indicators of accelerated erosion (*i.e.* exposed roots, unprotected surfaces, etc) will be selected for the inventory and should be located along the entire length of the main stems. The length of channel represented by each streambank surveyed will be recorded in GIS. A quantitative rating of BEHI and near-bank shear stress (both based on physical characteristics) will be obtained for each streambank surveyed. All evaluated streambanks will be photographed, the location will be recorded using GPS surveying, and data collected will be cataloged using GIS software.

In addition to rating streambanks for erosion hazard, annual streambank erosion in selected stream reaches, representing various combinations of erosion risk ratings, will be measured using bank pins at permanent survey sites. Stream cross-sections will be obtained at the permanent survey sites at the beginning of the study and after one year to determine annual streambank erosion.

Using the data collected, the source of sediment carried to the Corbin Reservoir will be clarified and contributing stream reaches ranked for restoration/stabilization. Additionally, the data will be used to produce a relationship between BEHI, near-bank shear stress, and observed annual erosion. This relationship, or model, can be used as a tool for predicting streambank erosion for similar streams in the future. A literature search indicates that no such relationships exist for streams in Kentucky and the predictive model developed through this study will be compared to those found in other states (Jennings and Harman 2001; Rosgen 2001; Van Eps *et al.* 2004).

9.5 Streams Impacted by Past Mining

Evidence of streams impacted by past mining activities exists, but additional monitoring and assessment should be done to locate specific streams with impacts. With additional information, these streams could potentially be remediated with established techniques.

9.6 Evaluate Extent of Sedimentation in Corbin City Reservoir

The extent of sedimentation in the reservoir should be determined. This can be evaluated by comparing the existing topographical map of the area before the lake was built to the current elevation of the lake bottom. A combination of lake bottom probing and core analysis may also be necessary. The areas of greatest concern (such as near water intake structure) can be probed to determine the depth of sediment. Reviewing the soils information for the watershed will provide insight to the type/size of sediments present in the reservoir. Or, sediment samples can be taken in Lexan tubes using a lake sediment core sampler (using SCUBA) to determine the type of sediment present. Subsequently, the sediment cores can be analyzed to characterize particle size distribution and the solids/water content of the sediment layer to establish the feasibility of dredging. With information on the sediments in the reservoir, the best methods of dredging and sediment storage/consolidation, such as the use of settling basins or Geotubes (geotextile tubes), can be evaluated. Dredging may be necessary to regain reservoir capacity or eliminate a source of nutrients within the reservoir. Additional sediment samples can be analyzed for TP content to evaluate the sediments as a potential source of nutrients leading to undesirable algal growth. The applicability of applying a product (*i.e.* Aquablock) to the lake sediments to "seal off" available nutrients should be evaluated.

9.7 Assessment of Future Threats

The impacts of future development within the watershed are a key concern. There is a need to evaluate how much residential and commercial development is probable in each subwatershed in coming years (5 to 10 years). Potential impacts to water resources should be quantified for various development and landuse scenarios.

There is a need for developing strategies to minimize the negative impacts of future development. This is linked to the need for public education and the development of protective ordinances.

9.8 Update Watershed Plan

As The Project Continues, New Data/Information Become Available, And Bmps Are Implemented, The Watershed Plan needs to grow and evolve. Since watershed planning is an iterative and adaptive process, reevaluating the watershed plan and making additions/revisions will be an ongoing need.

10. TECHNICAL AND FINANCIAL RESOURCES

Technical and financial assistance will have to come from a variety of sources to fully implement this watershed plan and make a positive impact in the watershed. An EPA Section 319(h) Nonpoint Source Implementation grant was awarded to Third Rock for implementing water quality improvements in this watershed following the development of this Watershed Plan. The grant includes $312,568 of federal funds. The grant requires a 40% non-federal match, which can come in the form of cash, property, personnel, etc. This brings the total of funds for implementing improvements in the watershed to $520,947. The funds will be available for use in 2007 through 2010. Additional grant funds can be pursued.

A financial need will be to achieve the 40% ($208,379) match contribution. It is intended that donated land (or easements) where BMPs are installed, personnel hours from partners and others, construction labor from London and/or Laurel County, and education/outreach activities will all be sources of match. There is a need for London and Laurel County governments, businesses, and residents to support these efforts.

Whenever someone impacts a stream or wetland as a result of development, mitigation (determined by regulatory agencies) is required to compensate for the loss of those aquatic resources. Mitigation generally involves restoring or enhancing an impaired stream or wetland to a suitable level of biological function. In Kentucky, developers can satisfy mitigation obligations by paying a fee to Mitigation Trust Fund. In this watershed, the fund is administered by the Kentucky Department of Fish and Wildlife Resources' (KDFWR) In-Lieu-Fee program. This money is used to implement stream or wetland restoration/enhancement projects within the river basin that the impacts occur. There is currently no In-Lieu-Fee money available for projects in the Upper Cumberland River Basin, but if money does become available it could possibly fund restoration projects within the Corbin City Reservoir watershed. Not only would this benefit the watershed, but also the funds could serve as non-federal match for the 319(h) grant that is being used in the watershed. There is a need to prioritize streams within the watershed for restoration and maintain a relationship with KDFWR, so that if funding becomes available, restoration can be pursued in this watershed.

Farmers in the watershed have opportunities to make a positive impact in the watershed by enrolling in United States Department of Agriculture (USDA) programs. The Laurel County Natural Resources Conservation Service (NRCS) office in London administers agricultural conservation and enhancement programs, such as the Environmental Quality Incentives Program (EQIP), the Wildlife Habitat Incentive Program (WHIP), the Conservation Reserve Program (CRP), and the Wetlands Reserve Program (WRP). These programs offer technical and financial assistance to conservation-minded farmers. For livestock or crop producers, the EQIP can currently (2006) cost-share 75% of the cost of stream fencing if a setback is included. Or, the program can cost-share 75% of an alternative watering system (pipeline and watering facility). The WHIP promotes tree plantings and sowing of warm season grasses, two practices that have been utilized in this watershed. CRP can offer farmers up to 90% cost-share to fence off a creek with a riparian setback and plant hardwood trees. Those enrolled in CRP also receive a rental rate, per acre for the particular soil type of the land enrolled and a cost-share on an alternative water source. This program currently has limited interest in the watershed due to the low rental rates and the limited amount of farmable land available. The objective of the WRP is to purchase conservation easements in order to protect, restore, and enhance wetlands (hydrology and habitat functions). In Kentucky, the WRP objective is to restore Bottomland Hardwood Forest. Eligible lands include prior converted cropland and farmed/pastured wetlands. Like with the CRP, farmers within the watershed are reluctant to give up what limited farmland they have to enroll it in the WRP. There is a need to find willing landowners whose objectives match those of the conservations programs offered by NRCS.

The Division of Abandoned Mine Lands (AML) works throughout Kentucky to protect the public from health and safety problems caused by mining that occurred prior to 1982. The money that funds AML reclamation is derived from a fee that Kentucky coal operators pay per ton of coal mined. The division of AML reclaims degraded sites, restoring them to safe and environmentally stable conditions. There is a need for further investigation within this watershed where past mining occurred to identify streams/lands that could be eligible for restoration through the division of AML.

Eastern Kentucky PRIDE is a nonprofit organization that encourages and assists citizens, local governments, schools, and others to improve water quality in the region, clean up illegal trash dumps and other solid waste problems, and promote environmental awareness and education. Activities initiated by PRIDE can have a longterm positive impact on the watershed.

11. TIMELINE AND MILESTONES

Both the implementation of water quality BMPs and education/marketing strategies for making social changes will be required for improvements within the watershed. Various combinations of BMPs can be used to achieve water quality goals; for instance after further investigating sites and finding willing participants, it could be apparent that it is more desirable or feasible to construct several bioretention areas and few constructed wetlands. Or, a phased approach could be used to implement many different BMPs. Table 8 on the following page is a schedule of potential activities that address both the education/outreach component and the BMP implementation component of this plan.

Some Project Measures of Success Include:

- A current landuse map of the entire watershed.
- Acquired property or easements for protection or implementation projects
- Quantitative data showing the efficacy of BMPs for removing NPS pollutants from runoff.
- Quantified data from additional study.
- Quantified data regarding streambank erosion.
- A list of streams segments prioritized for restoration/stabilization.
- Quantifiable lengths of stream where livestock are restricted access.
- Enactment and enforcement of city or county ordinances that require stormwater management and sediment and erosion control for small development projects.
- Growth of project partners team by 30% (focus growth on citizen participation).
- Qualitative evidence that outreach activities and public service announcements have communicated the importance of our water resources, ways water is impaired, ways problems can be remediated, etc.
- Quantitative measurement of sediment deposition within Corbin City Reservoir
- Character of sediment deposition within Corbin City Reservoir, including particle size distribution, soil/water content, and nutrient content.

TABLE 8 – SCHEDULE OF MILESTONES

Milestones	Expected Begin Date
Conduct project partners meetings (every 4 months)	Jan 2007
Send newsletters to partners mailing list (every 6 months)	Jan 2007
BMP site selections; property or easement acquisition	May 2007
Cooperate with local governments, etc. to advocate ordinances and effect positive watershed changes	May 2007
Produce updated, more detailed landuse map of the watershed	Jun 2007
Create/update website for watershed	July 2007
Design BMPs and monitoring plan	Aug 2007
Additional watershed study / monitoring	Sep 2007
Utilize Community Water Education Project's public service announcements in outreach efforts.	Dec 2007
Construction of BMPs	Dec 2007
Produce/install signs for BMP explanation & education	Jan 2008
Publicize implementation of BMPs	Jan 2008
Analyze data from additional study / monitoring	Jan 2008
Monitor BMPs	Mar 2008
Analyze data from BMP monitoring	Feb 2009
Probe Corbin Reservoir sediments & collect core samples	Jul 2009
Analyze Corbin Reservoir core samples and probing data	Aug 2009
Long-term Milestones	**Expected Begin Date**
Continued BMP implementation as directed by the watershed plan	2007-2017
Ongoing Public Education	2007-2017
Monitor and assess progress	2012
Revise Plan Based on TMDL and monitoring	2013

12. POTENTIAL SITES FOR ENHANCEMENT OR RESTORATION

Site 1

Photo Date: March 14, 2006

Location: Near station 5A; near intersection of Highways 552 and 363; southern portion of Little Laurel River subwatershed

Stream has lack of riparian vegetation and is impacted by cattle grazing. This photo is representative of typical streams found in rolling pasture areas within all subwatersheds.

Site 2a

Photo Date: March 14, 2006

Location: King's Branch in London; city-owned waste transfer station; west of intersection of KY-192 and Hwy 80; northern portion of Little Laurel River subwatershed

Stream likely has been modified/straightened. Stream is incised and floodplain on left side of stream in photo has been filled for parking lot. Adjacent property on right side of stream in photo is city-owned, undeveloped, and could be available for stream/wetland restoration.

Site 2b

Photo Date: October 16, 2006

Location: Adjacent to King's Branch in London; city-owned waste transfer station; west of intersection of KY-192 and Hwy 80; northern portion of Little Laurel River subwatershed

This is the adjacent property on right side of stream in shown in the site 2a photo. It is city-owned, undeveloped, and could be utilized in stream and wetland restoration.

Site 2c

Photo Date: October 16, 2006

Location: Portion of King's Branch located downstream of site 2a-b and downstream of KY-192

Stream passes under KY-192 in a concrete box culvert and then immediately through another circular pipe, which is likely undersized. Bank scour downstream of the pipe is evident. Property (~17 acres) adjacent to this stream is London –owned, undeveloped, and could be utilized in stream and wetland restoration.

Site 3

Photo Date: October 16, 2006

Location: Downstream of Williams Stockyard in London, near intersection of East 4th Street and railroad tracks

Property is adjacent to headwater reaches of the Little Laurel River; property owner is Bridget Dunaway; undeveloped and could be used for stream and wetland restoration

Site 4

Photo Date: October 16, 2006

Location: Whitley Branch upstream of Levi Jackson State Park and downstream of London's wastewater treatment plant discharge

Property to the right of stream in photo is undeveloped and could be used for stream and wetland restoration. Current stream elevation is well below ground surface and restoration would require excavation. Bruce Chestnut and Baxter Bledsoe are the property owners.

Site 5

Location: North Laurel Middle School; near intersection of the Hal Rogers Parkway and Johnson Road (Hwy 472), London

The stormwater (rooftop and parking lot) runoff for the property is collected and routed into a ditch behind the school, which ultimately drains to the Little Laurel River. The stormwater runoff could be re-routed to a stormwater wetland or bioretention area for infiltration and treatment.

Site 6

Photo Date: October 16, 2006

Location: Meadowbrook Subdivision, Meadowbrook Lane, London

Sampson Branch, downstream of extensive development (Walmart, Hotels, Office Depot, etc), runs through the Meadowbrook Subdivision. This reach of stream has experienced flooding that effects the adjacent homes. Upstream of this reach is a small area grazed with cattle. Channel modification and upstream development have contributed to the flashy nature of the stream and associated flooding.

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APPENDICES

APPENDIX A - WATERSHED PARTNERS

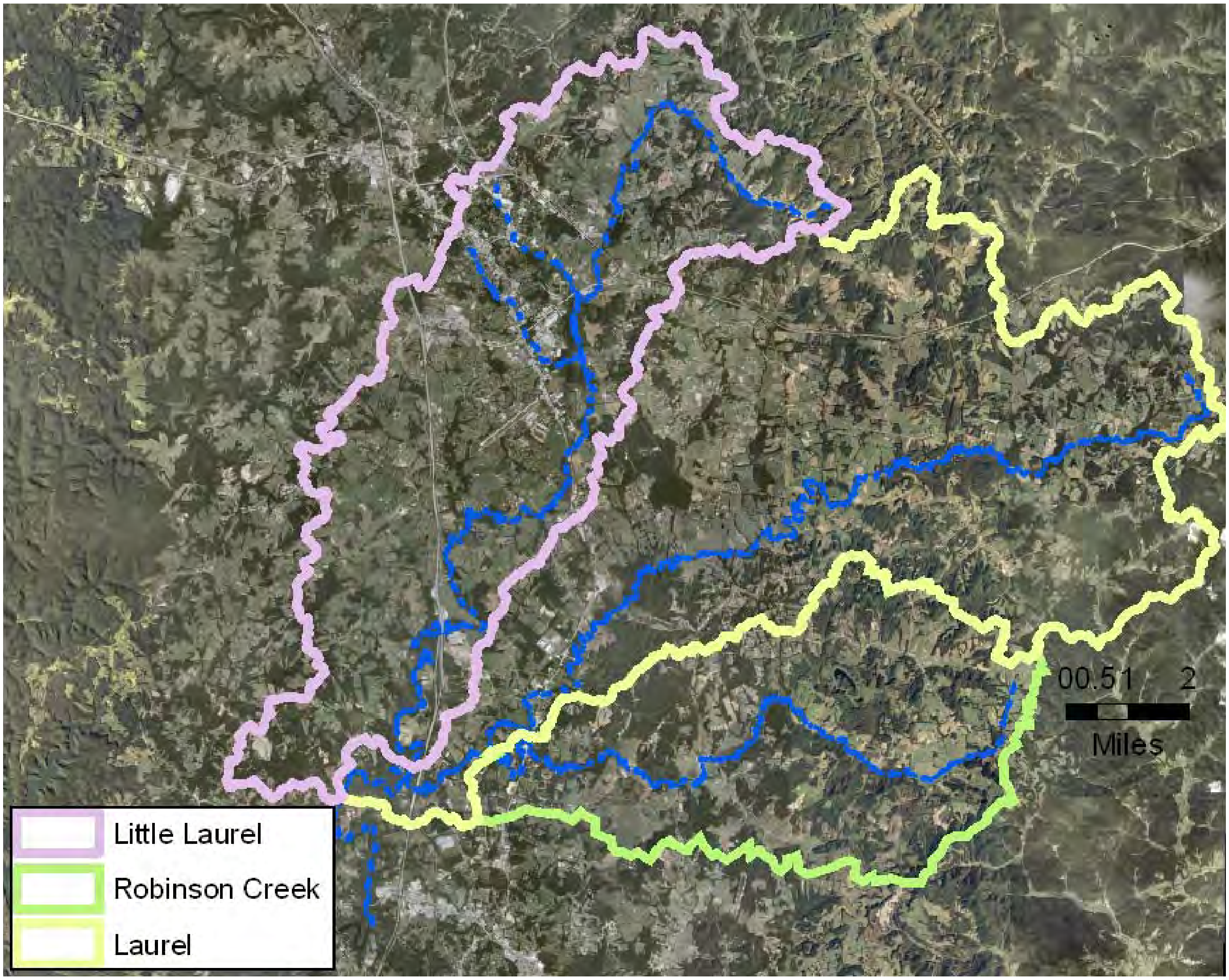
Members of the Watershed Council include (but are not limited to):

Name	Organization
Ann Hail	Corbin High School
Athena Waddell	South Laurel High School
Bill Browning	Laurel County Conservation District
Bill Dezam	London City Council
Bill Meadors	Levi Jackson Wilderness Rd. State Park
Bill Sampson	Kentucky Fish and Wildlife Resources
Billy Oakley	Magistrate
Brent Harrel	U.S. Fish and Wildlife Service
Brett Fox	Marymount Medical Center, Communications Director
Brooke Shireman	Kentucky Division of Water
Bruce Yandell	London/Laurel County Planning and Zoning Commision
Clay McKnight	Cumberland Area Development District
Col. Rick McClure	Corbin High School
Corrine Wells	Kentucky Division of Water
Dan Phelps	London City Council
Dean Croft	Department of Highways - District 11
Deb Bledsoe	Appalachia-Science in the Public Interest
Dennis Karr	London-Laurel County Industrial Development Authority
Dr. Bret Kuss	Cumberland College, Dept. of Biology
Dr. Renee Yetter	Cumberland College, Dept. of Biology
Dr. Sherry Harrell	Eastern Kentucky University, Dept. of Biological Sciences
Eddie Amos Miller	Mayor of Corbin
Erin Blount	Corbin City Clerk
Glenn Williams	Laurel County Cooperative Extension Ag. Agent
Greene Keith, PE	Department of Highways - District 11
Jack Stickney	KY Rural Water Association
James Ridener	Local Citizen
Jason Hawkins	Transportation Planner, Cumberland Valley Area Development District
Jason McWhorter	South Laurel High School
Jay Williams	Wood Creek Water District
Jeff Moore	USDA-NRCS London Field Office
Jennifer Shelby	Third Rock Consultants, LLC
Jim Hays	The Nature Conservancy
Jim Kennedy	Laurel County Schools, Facilities Director
Jim McDaniel	Laurel Co. PRIDE Co-Coordinator
Jim Roe	KY Division of Water, NPS Pollution Control Program
Joan Garrison	The Nature Conservancy; Rockcastle Conservation District
John Eisiminger	KY Division of Water, NPS Pollution Control Program
John H. Jones	KY RC&D Councils
John Strojan	Daniel Boone National Forest
John Williams	KDFWR-Southeast Fisheries District Office
Joyce Kiogora	Cumberland Valley Area Development District
Judith Peterson	Kentucky Waterways Alliance
Justin Ford	KY Division of Water, NPS Pollution Control Program

Members of the Watershed Council, CONTINUED

Name	Organization
Ken Cooke	KY Division of Water
Ken Smith	Mayor of London
Kevin Parsons	Knox County School District
Kim Whitson	Laurel County Cooperative Extension Office
Lawrence Kuhl	Laurel County Judge Executive
Lee Colten	KY Division of Water
Lindell Ormsbee	University of Kentucky, College of Engineering
Loris Sherman	Upper Cumberland River Watershed Watch
Lynn White	North Laurel High School
Mark A. Ayers	USS, Water Science Center
Martin Wheeldon	Kentucky Dept. of Fish & Wildlife Resources
Michele Kozoil	Kentucky Division of Water
Mike Bowling	North Laurel Middle School
Nancy Bishop	South Laurel High School
Randy Bingham	London Utilities Commission
Randy Smith	London-Laurel County Chamber of Commerce
Ray Barry	Sierra Club - Cumberland Chapter
Rhonda K. Cornett	North Laurel High School
Richard Thomas	Center for Rural Development
Richard Tippit	U.S. Army Corps of Engineers - Nashville District
Rob Miller	KY Division of Water, Upper Cumberland River Basin Coordinator
Robert F. Cornett	North Laurel High School
Rodney D. Hendrickson	Cumberland Valley RC&D
Ron Herd	Corbin City Utilities Commission
Samuel K. Miller	USDA-NRCS London Field Office
Sandy Wallace	Laurel County Fiscal Court
Sara Gilbert	Eastern Kentucky PRIDE
Sharon Ball	Corbin Independent Schools
Shawn Sizemore	South Laurel Middle School
Sherri M. Chappell, PE	Cumberland Area Development District
Sherry Otto	Sierra Club - Cumberland Chapter
Steve Edge	City of London
Sue Ferguson	U.S. Army Corps of Engineers - Nashville District
Sue Koplowitz	Friends of Sinking Creek
Tim Samples	Kentuckians for the Commonwealth
Tim Schwendeman	Cumberland Area Development District
Tony Miller	Third Rock Consultants, LLC

APPENDIX B - AERIAL IMAGE OF SUBWATERSHEDS



SOURCE: **MRSID IMAGE OF LAUREL COUNTY, KY** (USDA-FSA-APFO 2004)

Aerial photo showing landuse distribution for each subwatershed.
Darker green colors correspond to forested areas, lighter green is typically agriculture/pasture, and developed areas show up as white/gray.

APPENDIX C - FIELD ASSESSMENT DATA SHEETS

THIRD ROCK CONSULTANTS, LLC

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME		**LOCATION**
STATION #	**RIVERMILE**	**COUNTY** **STATE**
LAT	**LONG**	**RIVER BASIN**
CLIENT		**PROJECT NO.**
INVESTIGATORS/CREW		
FORM COMPLETED BY	**DATE** **TIME** AM PM	**REASON FOR SURVEY**

WEATHER CONDITIONS	**Now** / **Past 24 Hours** ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ ____% ☐ % cloud cover ☐____% ☐ clear/sunny ☐ **Has there been a heavy rain in the last 7 days?** ☐ Yes ☐ No Air Temperature ______°C Other______________________________________
STREAM CHARACTERIZATION	**Stream Subsystem** ☐ Perennial ☐ Intermittent ☐ Tidal **Stream Type** ☐ Coldwater ☐ Warmwater **Stream Origin** ☐ Glacial ☐ Spring-fed ☐ Non-glacial montane ☐ Mixture of origins ☐ Swamp and bog ☐ Other_________ **Catchment Area**__________km^2
WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other _______________ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☐ None ☐ Moderate ☐ Heavy
RIPARIAN ZONE	**Indicate the dominant type and record the dominant species present** ☐ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous **Dominant species present**____ **Canopy Cover** ☐ None ☐ Partly open (25-50%) ☐ Partly shaded (50-75%) ☐ Shaded (75-100%)
INSTREAM FEATURES	**Estimated Reach Length** ________m **Estimated Stream Width:** Pools:__________ Runs:__________ Riffles:__________ **High Water Mark** __m **Estimated Stream Depth:** Pools:__________ Runs:__________ Riffles:__________ **Proportion of reach represented by Stream Morphology Types** ☐ Riffle_______% ☐ Run _______% ☐ Pool _______% **Surface Velocity** __________m/sec Yes ☐ No **(at thalweg)** **Channelized** ☐ **Stream Flow:** ☐ Flooding ☐ Bankful ☐ High ☐ Normal ☐ Low ☐ Pooled ☐ Dry **Erosion:** ☐ Heavy ☐ Moderate ☐ Slight ☐ None **Dam Present** ☐ Yes ☐ No
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rotted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae **Dominant species present** ____ **Portion of the reach with aquatic vegetation** _________**%**

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THIRD ROCK CONSULTANTS, LLC

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATER QUALITY	**Temperature**__________°C **Specific Conductance**_______________ S/cm **Dissolved Oxygen**_______________mg/L **pH**_______________ (Standard Units) **Turbidity** _____________ **WQ Instrument Used**________________ ☐ YSI 54A (DO) ☐ Hanna 9024 (pH) ☐ Hanna 9033 (Cond.) ☐ Other______________	**Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other __________ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other ______________________________ **Turbidity (if not measured)** ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other _________
SEDIMENT/ SUBSTRATE	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ______________________________ **Oils** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse **Sedimentation:** ☐ Heavy ☐ Moderate ☐ Slight ☐ None **Imbeddedness:** ☐ Complete ☐ 75% ☐ 50% ☐ 25% ☐ None	**Deposits** ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☐ Sand ☐ Relict Shells ☐ Other _______________ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)

Substrate Type	Diameter	% Composition in Sampling Reach
Bedrock		
Boulder	> 256 mm (10")	
Cobble	64-256 mm (2.5"-10")	
Gravel	2-64 mm (0.1"-2.5")	
Sand	0.06-2 mm (gritty)	
Silt	0.004-0.06 mm	
Clay	< 0.004 mm (slick)	
Detritus	Sticks, wood, coarse plant materials (CPOM)	
Muck-Mud	Black, very fine organic (FPOM)	
Marl	Grey, shell fragments	

TYPE OF SAMPLING

☐ Physiochemical

☐ Sediment

☐ Periphyton

☐ Macroinvertebrates

☐ Fish

☐ Other ________________________________

Macroinvertebrate Sampling	**Quantitative Methods:** ☐ Surber ☐ Travelling-Kick ☐ Hester-Dendy Multiplates ☐ Other # Reps_____ **Qualitative Methods:** ☐ Multihabitat ☐ Qualitative Search ☐ Other ___________________ **Habitats Sampled (Qual. Methods):** ☐ Riffles ☐ Rootwads ☐ Marginal vegetation ☐ *Justicia* beds ☐ Bedrock/slabrock ☐ Leaf packs ☐ Silt (depositional areas) ☐ Woody debris
Fish Sampling	**Method:** ☐ Backpack Electrofishing ☐ Long-Line Electrofishing ☐ Seining ☐ Other ______________________ **Electrofishing time period:** _________ seconds
NOTES	

WATERSHED SURVEY VISUAL ASSESSMENT

GENERAL INFORMATION

Stream name: ______________________

Watershed name: ______________________

County: ____________ **State:** ____________

Approximate size of study area (acres): ____________

Investigators: ______________________

Site (description): ______________________

____

____

Date: ____________ **Time:** ____________

Weather in past 24 hours:

- ❑ Storm (heavy rain)
- ❑ Rain (steady rain)
- ❑ Showers (intermittent rain)
- ❑ Overcast
- ❑ Clear/Sunny

Weather now:

- ❑ Storm (heavy rain)
- ❑ Rain (steady rain)
- ❑ Showers (intermittent rain)
- ❑ Overcast
- ❑ Clear/Sunny

LAND USES IN THE WATERSHED

1. **Specific uses identified** *(check as many as apply)*

	Streamside	Within 1/4 mile of Stream	Within Watershed
Residential:			
Single-family housing	θ	θ	θ
Apartment building	θ	θ	θ
Lawns	θ	θ	θ
Playground	θ	θ	θ
Parking lot	θ	θ	θ
Other ____________	θ	θ	θ
Commercial / Industrial / Institutional:			
Commercial development (stores, restaurants)	θ	θ	θ
Auto repair/gas station	θ	θ	θ
Factory/Power plant	θ	θ	θ
Sewage treatment facility	θ	θ	θ
Water treatment facility	θ	θ	θ
Institution (e.g., school, offices)	θ	θ	θ
Landfill	θ	θ	θ
Automobile graveyard	θ	θ	θ
Bus or taxi depot	θ	θ	θ
Other ____________	θ	θ	θ
***Forest / Parkland*:**			
Recreational park	θ	θ	θ
National/State Forest	θ	θ	θ
Woods/Greenway	θ	θ	θ
Other ____________	θ	θ	θ
Agricultural / Rural:			
Grazing land	θ	θ	θ
Cropland	θ	θ	θ
Animal feedlot	θ	θ	θ
Isolated farm	θ	θ	θ
Old (abandoned) field	θ	θ	θ
Fish hatchery	θ	θ	θ
Tree farm	θ	θ	θ
Other ____________	θ	θ	θ

2. Summary of major land uses in the watershed *(use approx. percentages)*

Residential ____% Parkland/Forest ____%

Commercial/Industrial/Institutional ____% Other ____%

Agricultural/Rural ____%

3. Additional activities in the watershed *(check as many as apply)*

	Streamside	Within 1/4 mile of Stream	Within Watershed
Construction			
Building construction	θ	θ	θ
Roadway	θ	θ	θ
Bridge construction	θ	θ	θ
Other ____________	θ	θ	θ
Logging			
Selective logging	θ	θ	θ
Intensive logging	θ	θ	θ
Lumber treatment facility	θ	θ	θ
Other ____________	θ	θ	θ
Mining			
Strip mining	θ	θ	θ
Pit mining	θ	θ	θ
Abandoned mine	θ	θ	θ
Quarry	θ	θ	θ
Other ____________	θ	θ	θ
Recreation			
Biking/Off-road vehicle trails	θ	θ	θ
Horseback riding trail	θ	θ	θ
Boat ramp	θ	θ	θ
Jogging paths/hiking trail	θ	θ	θ
Swimming area	θ	θ	θ
Fishing area	θ	θ	θ
Picnic area	θ	θ	θ
Golf course	θ	θ	θ
Campground/trailer park	θ	θ	θ
Power boating	θ	θ	θ
Other ____________	θ	θ	θ

4. Comments on land uses

Use this space to explain or expand on land use descriptions you have identified above. For example, you might want to identify particular buildings, specify the location of construction sites, note the condition of streamside picnic areas, note the presence of cows in a stream, or note corrective measures such as swales or settling basins.

GENERAL STREAM AND WATERSHED CHARACTERISTICS

5. Note the number of hydrologic modifications *(structures that alter natural stream flow):*

None	___________	Waterfalls	___________
Dams	___________	Stream fords	___________
Bridges	___________	Beaver dams	___________

6. Note the approximate length of stream that is affected by the following:

Stream diversion	___________	feet or	___________	miles
Stream straightening	___________	feet or	___________	miles
Concrete streambank/bottom	___________	feet or	___________	miles

7. Check the categories that best describe the general appearance of the stream:

Litter:

- ❑ No litter visible
- ❑ Small litter occasionally (e.g., cans, paper)
- ❑ Small litter common
- ❑ Large litter occasionally (e.g., tires, carts)
- ❑ Large litter common

Erosion:

- ❑ No streambank erosion or areas of erosion very rare; no artificial stabilization
- ❑ Occasional areas of streambank erosion
- ❑ Areas of streambank erosion common
- ❑ Artificial streambank stabilization (e.g., rip rap) present

Special Problems *(note in detail in comment section below):*

- ❑ Spills of chemicals, oil, etc.
- ❑ Fish kills
- ❑ Wildlife, waterfowl kills
- ❑ Flooding
- ❑ Periods of no flow

8. Comments on general stream characteristics (e.g., date and size of fish kill, increased rate of erosion evident, litter most evident after storms)

PIPE AND DRAINAGE DITCH INVENTORY

In this section, provide information on pipes and drainage ditches found on the banks or in the stream. These pipes/ditches can be abandoned or active. Note this basic information for each pipe or drainage ditch you observe. Attach additional pages to this form.

9. This information applies to a:

❑ Pipe ❑ Drainage ditch ❑ Other __________

10. Location of pipe/ditch:

❑ In stream ❑ In streambank ❑ Near stream

Describe location:

11. Pipe/Ditch # (for mapping/locational purposes) ________________

12. Identify type of pipe (check one)

- ❑ Industrial outfall
- ❑ Sewage treatment plant outfall
- ❑ Storm drain
- ❑ Combined sewer overflow
- ❑ Agricultural field drainage
- ❑ Paddock or feedlot drainage
- ❑ Settlement basin/pond drainage
- ❑ Parking lot drainage
- ❑ Unknown
- ❑ Other ____________________

13. Approximate Diameter of Pipe: _________ inches or _________feet

14. Describe the discharge flow:

Rate of Flow: ❑ None ❑ Intermittent ❑ Trickle ❑ Steady ❑ Heavy

Appearance: ❑ Clear ❑ Foamy ❑ Turbid ❑ Oily sheen ❑ Colored _________________

Odor: ❑ None ❑ Rotten eggs/sewage ❑ Chemical ❑ Chlorine ❑ Other _________________

15. Describe the streambank/stream below pipe or drainage ditch:

- ❑ No problem evident
- ❑ Sewage litter (e.g., toilet paper)
- ❑ Litter (e.g., styrofoam, cans)
- ❑ Eroded
- ❑ Lots of algae
- ❑ Other ____________________

16. Comments on pipes and drainage ditches

Use this space to explain or expand on information provided on pipes and discharges you have identified above. For example, you may want to identify particular facilities, or discuss in more detail the condition of the stream below the discharge.

THIRD ROCK CONSULTANTS, LLC

HABITAT ASSESSMENT FIELD DATA SHEET — HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION
STATION # RIVERMILE	COUNTY STATE
LAT LONG	RIVER BASIN
CLIENT	PROJECT NO.
INVESTIGATORS/CREW	

FORM COMPLETED BY	DATE_____ TIME _____ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient.	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET — HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ration of > 25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

APPENDIX D - FECAL COLIFORM SAMPLING RESULTS

FECAL COLIFORM SAMPLING RESULTS

Corbin Fecal Coliform (FC) Sampling Results CFU/100mL						
Subwatershed	Station	Sample Date/Time	Flow level	Result	Reporting Limit	Qualifiers
Corbin Reservoir	CCR	11/17/2005 13:45		80	10	D
Laurel	16B	11/11/2005 9:14		1,000	100	D
Laurel	10B	11/11/2005 9:01		500	100	D
Laurel	Laurel River	1/27/2006 15:25	Medium	120	10	D
Laurel	Laurel River	3/1/2006 13:30	Low	30	10	D
Laurel tributary	25B	11/14/2005 14:43		< 10.0	10	D
Laurel tributary	24B	11/11/2005 10:02		<100	100	D
Laurel tributary	26B	11/11/2005 9:49		300	100	D
Laurel tributary	22B	11/14/2005 14:32		1,800	100	D
Laurel tributary	21B	11/11/2005 9:32		100	100	D
Laurel tributary	20B	11/11/2005 10:16		600	100	D
Little Laurel	25A	11/14/2005 13:50		2,900	100	D
Little Laurel	17A	11/11/2005 8:42		500	100	D
Little Laurel	12A	11/14/2005 15:16		3,200	100	D
Little Laurel	2A	1/27/2006 14:55	Medium	440	10	D
Little Laurel	2A	3/1/2006 13:08	Low	10	10	D
Little Laurel tributary	23A	11/14/2005 13:31		11,000	1,000	D
Little Laurel tributary	22A	11/11/2005 8:02		400	100	D
Little Laurel tributary	19A	11/11/2005 8:09		200	100	D
Little Laurel tributary	19A	11/11/2005 8:21		100	100	D
Little Laurel tributary	WWTP	11/14/2005 15:41		3,600	100	D
Little Laurel tributary	13A	11/17/2005 11:31		1,400	100	D
Little Laurel tributary	3A	11/17/2005 12:11		600	100	D
Robinson Creek	9B	11/11/2005 10:51		100	100	D
Robinson Creek	2B	11/11/2005 11:32		<100	100	D
Robinson Creek	2B	1/27/2006 15:45	Medium	110	10	D
Robinson Creek	2B	3/1/2006 13:45	Low	10	10	D
Robinson Creek tributary	8B	11/11/2005 10:39		200	100	D
Robinson Creek tributary	4B	11/11/2005 11:09		400	100	D
Robinson Creek tributary	Mine	11/17/2005 14:08		1,200	100	D

Flow level indicated for days when streamflow was measured during sampling. Qualifier D indicates that laboratory results were reported from dilution.

APPENDIX E - SUMMARIZED STEPL-PREDICTED LOAD REDUCTIONS FOR BMP IMPLEMENTATION

Appendix E

General Assumptions and Inputs to STEPL model:

Input watershed landuse area (ac)

These inputs derived from GIS analysis of landuse data (KDFWR and USGS 2002), complemented with aerial photography (USDA-FSA-APFO 2004) and site evaluations.

Subwatershed	Urban	Cropland	Pastureland	Forest	Feedlots
Little Laurel	5658	9572	6932	7495	2
Laurel	794	9197	12696	16900	2
Robinson Creek	182	4105	5669	8223	1

Distrubution of uses for Urban areas (%)

These inputs derived from site evaluations.

Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant Developed	Open Space
15	10	10	10	8	33.5	0.5	8	5
6	4	5	8	5	65.5	0.5	1	5
3	2	5	8	5	70.5	0.5	1	5

Input agricultural animals

These inputs derived from Laurel county agricultural statistics (Kentucky Agricultural Statistics Service 2004). Livestock numbers attributed to each subwatershed based on county and subwatershed landuse mapping (KDFWR and USGS 2002).

Subwatershed	Beef Cattle	Dairy Cattle
Little Laurel	970	970
Laurel	1776	1776
Robinson Creek	793	793
Total	3539	3539

Input septic system data

The number of septic systems in each subwatershed was estimated through review of the reported rural population for Laurel county (Kentucky Agricultural Statistics Service 2004), the non-urban landuse area for each subwaterhsed (KDFWR and USGS 2002), and the location of wastewater collection lines in watershed (Water Resource Information System 2002). Population per Septic System was dervied from US Cenus Bureau (2000) data for persons per household. The septic failure rate is a default value provided in the STEPL model (U.S. EPA 2005)

Subwatershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %
Little Laurel	1271	2.56	2
Laurel	2054	2.56	2
Robinson Creek	953	2.56	2

Appendix E

Combination of Ag., Forest, and Urban BMPs Selected for Evaluation

Agricultural and Forest BMPS:
Reduced tillage systems applied to cropland in each subwatershed
Streambank stabilization and fencing applied to pastureland in each subwatershed
Tree buffer along roads in forested areas in each subwatershed
Runoff management systems applied to feedlot areas in each subwatershed

BMPS in Urban Areas:
Low Impact Development/Bioretention applied to commerical areas in each subwatershed
Wetland detention applied to industrial areas in each subwatershed
Grass swales applied to instutional areas in each subwatershed
Low Impact Development/Bioretention applied to multi-family housing areas in each subwatershed
Grass swales applied to single-family housing areas in each subwatershed
Dry Detention applied to vacent developed areas in each subwatershed
Grass Swales applied to open space in each subwatershed

STEPL Predictions for % Reductions in Annual Nitrogen (N), Phosphorus (P), Biochemical Oxygen Demand (BOD), and Sediment Load

Percent Load Reduction = [(Load, no BMPs) - (Load, with BMPs)] / (Load, no BMPs)* 100%

If the BMPs above are distributed over **10%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	5	6	2	7
Laurel	6	6	2	7
Robinson Creek	6	7	2	7
Total	6	6	2	7

If the BMPs above are distributed over **25%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	14	16	7	18
Laurel	16	17	6	19
Robinson Creek	16	17	7	19
Total	15	16	7	18

If the BMPs above are distributed over **50%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	26	30	11	36
Laurel	31	32	9	37
Robinson Creek	31	33	10	37
Total	29	31	10	37

Predictions for Combination of Ag., Forest, and Urban BMPs CONTINUED

If the BMPs above are distributed over **75%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	39	46	16	54
Laurel	46	48	13	56
Robinson Creek	47	49	16	56
Total	43	47	15	55

If the BMPs above are distributed over **100%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	55	64	28	73
Laurel	64	67	25	74
Robinson Creek	65	68	28	74
Total	61	66	27	74

Appendix E

Combination of Urban BMPs Selected for Evaluation

Agricultural and Forest BMPS:
NONE

BMPS in Urban Areas:
Low Impact Development/Bioretention applied to commerical areas in each subwatershed
Wetland detention applied to industrial areas in each subwatershed
Grass swales applied to instutional areas in each subwatershed
Low Impact Development/Bioretention applied to multi-family housing areas in each subwatershed
Grass swales applied to single-family housing areas in each subwatershed
Dry Detention applied to vacent developed areas in each subwatershed
Grass Swales applied to open space in each subwatershed

STEPL Predictions for % Reductions in Annual Nitrogen (N), Phosphorus (P), Biochemical Oxygen Demand (BOD), and Sediment Load

Percent Load Reduction = [(Load, no BMPs) - (Load, with BMPs)] / (Load, no BMPs)* 100%

If only the Urban BMPs above are distributed over **10%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	0.4	0.5	0.5	0.2
Laurel	0.0	0.1	0.1	0.0
Robinson Creek	0.0	0.0	0.0	0.0
Total	0.2	0.2	0.3	0.1

If only the Urban BMPs above are distributed over **25%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	1.1	1.3	1.4	0.4
Laurel	0.1	0.1	0.2	0.1
Robinson Creek	0.0	0.1	0.1	0.0
Total	0.5	0.6	0.7	0.2

If only the Urban BMPs above are distributed over **50%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	2.2	2.5	2.7	0.8
Laurel	0.2	0.3	0.4	0.1
Robinson Creek	0.1	0.1	0.2	0.0
Total	1.0	1.2	1.3	0.4

Predictions for Combination of Urban BMPs CONTINUED

If only the Urban BMPs above are distributed over **75%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	3.3	3.8	4.1	1.1
Laurel	0.3	0.4	0.6	0.2
Robinson Creek	0.1	0.2	0.3	0.1
Total	1.5	1.8	2.0	0.5

If only the Urban BMPs above are distributed over **100%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	4.3	5.0	5.4	1.5
Laurel	0.4	0.5	0.8	0.2
Robinson Creek	0.2	0.2	0.4	0.1
Total	2.0	2.3	2.6	0.7

Appendix E

Combination of Ag. and Forest BMPs Selected for Evaluation

Agricultural and Forest BMPS:
Reduced tillage systems applied to cropland in each subwatershed
Streambank stabilization and fencing applied to pastureland in each subwatershed
Tree buffer along roads in forested areas in each subwatershed
Runoff management systems applied to feedlot areas in each subwatershed

BMPS in Urban Areas:
NONE

STEPL Predictions for % Reductions in Annual Nitrogen (N), Phosphorus (P), Biochemical Oxygen Demand (BOD), and Sediment Load

Percent Load Reduction = [(Load, no BMPs) - (Load, with BMPs)] / (Load, no BMPs)* 100%

If only the Agricultural and Forest BMPs above are distributed over **10%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	4.8	5.6	1.6	7.1
Laurel	6.1	6.3	1.7	7.4
Robinson Creek	6.3	6.5	2.0	7.4
Total	5.6	6.0	1.7	7.3

If only the Agricultural and Forest BMPs above are distributed over **25%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	12	14	4	18
Laurel	15	16	4	19
Robinson Creek	16	16	5	19
Total	14	15	4	18

If only the Agricultural and Forest BMPs above are distributed over **50%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	24	28	8	36
Laurel	31	32	9	37
Robinson Creek	31	32	10	37
Total	28	30	9	36

Predictions for Combination of Ag. and Forest BMPs CONTINUED

If only the Agricultural and Forest BMPs above are distributed over **75%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	35.6	41.9	12.3	53.3
Laurel	45.8	47.4	12.8	55.5
Robinson Creek	46.9	48.7	15.2	55.7
Total	41.6	45.4	13.1	54.6

If only the Agricultural and Forest BMPs above are distributed over **100%** of the specific landuse area in each subwatershed, the following load reductions are predicted:

Subwatershed	N Reduction	P Reduction	BOD Reduction	Sediment Reduction
	%	%	%	%
Little Laurel	51.8	60.4	23.0	72.3
Laurel	63.7	66.2	24.0	74.2
Robinson Creek	65.1	67.7	27.9	74.3
Total	58.9	64.1	24.3	73.4

APPENDIX F - JANUARY 2005 RESULTS FROM PEDESTRIAN SURVEYS, INCLUDING RBP SCORES

JANUARY 2005 RESULTS FROM PEDESTRIAN SURVEYS, INCLUDING RBP SCORES

Subwatershed	Station	RBP Score	% Residential	% Commercial	% Agriculture	% Forest	% Other	Pipe or Ditch	% Canopy Cover	pH	Cond (μ/S)	Temp (°C)	DO (mg/L)
Little Laurel	13A	134	40	0	60	0	0	1	35	7.4	440	-	-
Little Laurel	14A	108	80	0	20	0	0	1	10	7.4	439	6.3	13.2
Little Laurel	16A	140	50	50	0	0	0	1	65	6.7	214	0.36	14.3
Little Laurel	17A	94	20	0	80	0	0	0	60	8.7	144	3.56	12.5
Little Laurel	22A	104	30	70	0	0	0	0	65	7.8	321	5.8	11
Little Laurel	18A	118	25	75	0	0	0	1	0	7.2	330	-	-
Little Laurel	12A	100	5	0	95	0	0	1	35	7.0	190	1	13.6
Little Laurel	19A	61	0	20	60	20	0	1	10	6.8	280	-	-
Little Laurel	5A	121	0	0	100	0	0	1	10	6.5	60	-	-
Little Laurel	20A	107	10	10	70	10	0	1	100	6.5	140	-	-
Little Laurel	23A	105	10	80	5	5	0	1	35	6.8	190	-	-
Little Laurel	21A	131	20	10	50	20	0	0	35	6.3	140	-	-
Little Laurel	Unnamed	117	75	0	25	0	0	1	0	6.5	320	-	-
Little Laurel	15A	115	30	70	0	0	0	1	0	7.0	260	-	-
Little Laurel	24A	59	0	0	100	0	0	0	0	5.8	132.5	7.8	-
Little Laurel	26A	102	40	10	20	20	0	0	30	5.8	93.9	9.8	-
Little Laurel	25A	76	0	0	75	25	0	0	35	5.8	97.6	6.6	-
Little Laurel	9A	131	50	10	15	25	0	0	35	6.8	84	3.55	19.1
Little Laurel	10A	155	0	0	20	30	50	0	60	7.0	160	-	-
Little Laurel	11A	145	60	0	40	0	0	0	100	6.7	120	2.21	13.3
Little Laurel	8A	150	30	0	80	20	0	0	35	6.7	100	-	-
Little Laurel	7A	147	10	0	90	0	0	0	10	7.3	210	-	-
Little Laurel	2A	147	0	0	10	90	0	0	35	7.2	190	-	-
Little Laurel	3A	150	0	0	10	90	0	1	100	5.2	300	-	-
Laurel	11B	109	25	0	75	0	0	1	35	7.0	138	0.95	13.9
Laurel	12B	90	5	10	35	50	0	0	65	6.9	99	0.01	14.8
Laurel	10B	82	20	0	80	0	0	0	35	7.0	172	0.5	14.6
Laurel	19B	108	0	0	50	50	0	0	60	6.5	100	-	-
Laurel	26B	83	10	0	50	40	0	0	10	7.2	52	3.95	14.8
Laurel	27B	87	15	0	60	25	0	0	35	7.0	209	1.73	15.0
Laurel	16B	86	0	0	100	0	0	0	0	7.5	102	0.6	16.7
Laurel	15B	143	50	0	50	0	0	0	60	7.0	64	1.14	18.1
Laurel	21B	65	0	0	100	0	0	0	75	6.2	280	2.86	14.7
Laurel	23B	76	10	0	50	40	0	0	0	7.1	49	1.43	20.0
Laurel	25B	73	0	0	70	30	0	0	0	6.8	47	1.99	19.3
Laurel	24B	59	20	0	80	0	0	0	0	3.7	34	2.75	14.9
Laurel	22B	74	70	5	10	15	0	0	0	6.3	41	2.63	17.2
Laurel	20B	78	10	0	65	25	0	0	60	6.2	40	1.88	19.4
Laurel	18B	108	50	0	50	0	0	0	35	6.7	28	3.6	14.0
Laurel	13B	105	5	5	60	30	0	0	10	6.3	130	-	-
Laurel	14B	150	0	0	70	30	0	0	60	6.8	90	-	-
Laurel	1B	149	0	0	0	100	0	0	60	7.1	165	1.35	13.8
Laurel	17B	144	0	0	60	40	0	0	100	6.8	80	-	-
Robinson	9B	63	10	0	30	60	0	0	100	7.1	229	0.89	13.7
Robinson	6B	81	5	0	35	60	0	0	100	7.2	200	1	14.8
Robinson	5B	57	10	0	90	0	0	0	10	7.1	528	2.49	13.6
Robinson	4B	88	10	0	70	20	0	3	35	7.3	343	2.41	16.5
Robinson	2B	129	0	50	0	40	10	1	35	7.3	252	1.97	12.4
Robinson	Mine site	106	10	0	90	0	0	1	0	6.8	951	10.06	10.6
Robinson	8B	99	10	0	40	50	0	0	35	7.1	73	4.04	12.4

*Red highlights indicate parameter scores that were not conducive to aquatic life (RBP <=144 designated as not supporting). Conductivity (Cond) limits were based on professional experience. DO represents dissolved oxygen.

APPENDIX G - MACROINVERTEBRATE SAMPLING RESULTS FROM MAY 2005

Macroinvertebrate Sampling Results from May 2005

Site	# Individuals	Total Richness	EPT Richness	MHBI	Modified % EPT Abundance	% Ephemeroptera	% Chironomidae + Oligochaeta	% Primary clingers
10B	450	38	10	6.2	9	4	82	65
12A	267	18	2	6.6	2	0	83	57
13A	309	40	4	5.3	1	0	33	69
16B	350	52	10	6.5	20	13	55	24
17A	232	28	0	7.6	0	0	81	13
18A	305	32	2	1.0	1	0	70	55
19A	198	24	1	7.2	0	0	94	5
20B	363	52	16	6.4	12	10	82	43
21B	307	53	15	5.7	21	14	69	27
22A	302	29	2	5.8	0	0	76	26
24A	325	55	15	5.8	26	15	42	43
24B	343	44	13	5.9	14	10	69	38
26B	479	54	17	5.0	36	24	48	32
2B	406	48	11	5.5	40	35	47	61
3A	38	26	5	6.3	5	3	61	11
4B	332	43	10	5.3	1	0	73	30
8B	263	44	4	5.8	0	0	89	26
9B	310	32	4	6.3	3	1	93	38
Mine Site	108	30	0	7.4	0	0	91	6
WWTP	717	16	1	5.8	0	0	40	56

APPENDIX H - FISH SAMPLING RESULTS FROM JUNE 2005

Fish Sampling Results from June 2005

Fish	Functional Category					Number of Individuals for Each Station											
	Native	FHW	FG	T	BG	12A	16B	20B	21B	24A	25A	25B	26B	2B	4B	8B	9B
Ambloplites rupestris	X	X	C											2			
Ameiurus natalis	X	X	O	T			3										
Catostomus commersoni	X	X	I	T	SL		41		2	19	12		2		3		1
Etheostoma kennicotti	X		I		SL		11									2	13
Etheostoma virgatum	X		I	I									2				
Gambusia affinis	X	X	I	T			8										
Hypentelium nigricans	X		I		SL		5										3
Lepomis cyanellus	X	X	I	T		1	2	5	16		10	3	19		14	8	4
Lepomis macrochirus	X	X	I	T			32	20	13	28	13	21	2	1	33	20	1
Lepomis megalotis	X	X	I				10			12				2	17	2	1
Lepomis sp.	X	X	I						2								
Luxilus chrysocephalus	X	X	I	T	SL			1									
Lythrurus fasciolaris	X	X	I				37										
Micropterus dolomieu	X	X	C			1								1			
Micropterus punctulatus	X	X	C				2						1				1
Micropterus salmoides	X	X	C			1	9		2	4					1		
Percina maculata	X	X	I		SL		4										1
Pimephales notatus	X	X	O	T		4	20	2	5				3		8	3	10
Semotilus atromactulatus	X		O	T		2	16	12	3	36	23	41	28	1	56	29	20
					Total	9	200	40	43	99	58	65	57	7	132	64	55
Metrics																	
Native Species Richness						5	14	5	7	5	4	3	7	5	7	6	10
Darter, Madtom, Sculpin Richness						0	2	0	0	0	0	0	1	0	0	1	2
Intolerant Species Richness						0	0	0	0	0	0	0	0	0	1	0	0
Proportion of tolerant individuals						78	61	100	91	84	100	100	95	29	86	94	65
Proportion of Insectivore Individuals						0	34	0	5	12	0	0	4	29	13	6	33
Proportion of FHW						78	84	70	93	64	60	37	47	86	58	52	35
Number of Individuals						9	200	40	43	99	58	65	57	7	132	64	55
Simple Lithophile Species Richness						0	4	1	1	1	1	0	1	0	1	1	4
Drainage Area (mi^2)						23	35	3	3	8	2	1	2	27	2	0	5
Stream order						4	4	2	3	3	3	1	2	4	2	1	3

Functional Categories: Native = native species, FHW = facultative headwater species, FG = feeding guild, T = tolerance (T = tolerant; I = intolerant), BG = breeding guild

APPENDIX I - WATER QUALITY SAMPLING RESULTS FROM MAY 2005 (PLUS NOVEMBER FECAL RESULTS)

WATER QUALITY SAMPLING RESULTS FROM MAY 2005
(Plus November Fecal Results)

Subwatershed	Station	pH	Temp (°C)	DO (mg/L)	Cond (µ/S)	Spring FC (May '05)	Fall FC (Nov '05)	NH_4 (mg/L)	NO_3 (mg/L)	TKN (mg/L)	TN (mg/L)	OP-P (mg/L)	TP (mg/L)	Fe (mg/L)	Mn (mg/L)
Laurel	10B	6.5	18.6	6.6	213	-	500	-	-	-	-	-	-	-	-
Laurel	16B	6.8	19.2	7.5	170	450	1,000	0.1	0.4	0.5	0.8	0.04	0.03	0.05	0.14
Laurel	20B	6.6	16.4	8.6	62	360	600	0.1	0.2	0.5	0.7	0.01	0.02	0.05	0.11
Laurel	21B	7.2	16.1	8.4	417	2,000	100	0.1	0.2	0.4	0.6	0.01	0.02	0.05	0.16
Laurel	22B	-	-	-	-	2,000	1,800	0.1	0. 6	0.5	1.1	0.02	0.03	0.18	0.07
Laurel	23B	-	-	-	-	600	-	0.1	0.3	0.6	0.9	0.01	0.02	0.24	0.1
Laurel	24B	6.5	16.9	7.7	59	3,400	100	0.1	0.2	0.4	0.6	0.01	0.02	0.05	0.09
Laurel	25B	-	-		-	11,000	10	0.1	0.3	0.5	0.8	0.02	0.03	0.05	0.01
Laurel	26B	6.7	16.0	8.1	233	1,300	300	0.1	0.2	0.4	0.6	0.02	0.02	0.05	0.11
Robinson	2B	7.0	18.3	7.6	329	80	100	0.1	0.3	0.4	0.8	0.01	0.03	0.10	0.41
Robinson	3B	-	-	-	-	50	-	0.1	0.2	0.3	0.5	0.02	0.03	0.18	4.51
Robinson	4B	7.3	22.2	8.0	532	390	400	0.1	0.2	0.3	0.5	0.01	0.02	0.05	0.14
Robinson	6B	-	-	-	-	1,400	-	0.1	0.3	0.6	0.9	0.01	0.02	0.05	0.21
Robinson	8B	6.9	20.5	6.8	151	-	200	-	-	-	-	-	-	-	-
Robinson	9B	6.8	19.6	7.0	227	-	100	-	-	-	-	-	-	-	-
Robinson	MINE	6.7	18.4	7.4	1,170	-	1,200	-	-	-	-	-	-	-	-
Little Laurel	12A	7.0	18.5	6.9	304	800	3,200	0.1	0.4	0.8	1.2	0.15	0.10	0.05	0.13
Little Laurel	13A	6.8	15.3	7.9	284	160	1,400	0.1	0.2	0.3	0.5	0.02	0.02	0.06	0.23
Little Laurel	17A	6.6	18.0	5.3	163	-	500	-	-	-	-	-	-	-	-
Little Laurel	18A	7.5	20.5	9.5	296	-	100	-	-	-	-	-	-	-	-
Little Laurel	19A	7.0	17.3	7.7	338	430	200	0.1	0.2	0.5	0.7	0.03	0.03	0.05	0.35
Little Laurel	22A	7.0	16.3	8.5	272	-	400	-	-	-	-	-	-	-	-
Little Laurel	23A	-	-	-	-	-	11,000	-	-	-	-	-	-	-	-
Little Laurel	24A	7.0	23.6	7.8	111	1,800		0.1	0.5	0.6	1.1	0.02	0.02	0.15	0.17
Little Laurel	25A	-	-	-	-	-	2,900	-	-	-	-	-	-	-	-
Little Laurel	3A	6.8	17.1	8.2	278	-	600	-	-	-	-	-	-	-	-
Little Laurel	WWTP	7.3	20.1	8.3	555	-	3,600	-	-	-	-	-	-	-	-

* Red highlights indicate parameter scores that were not conducive to aquatic life. Conductivity limits (Cond) were based on professional experience. Missing values are the result of using several teams with multiple types of sampling equipment. DO represents dissolved oxygen and FC represents fecal coliform (# colonies/100mL).

APPENDIX J - STAGE RESPONSE TO RAINFALL AND LEVEL DURING WATER QUALITY SAMPLING EVENTS

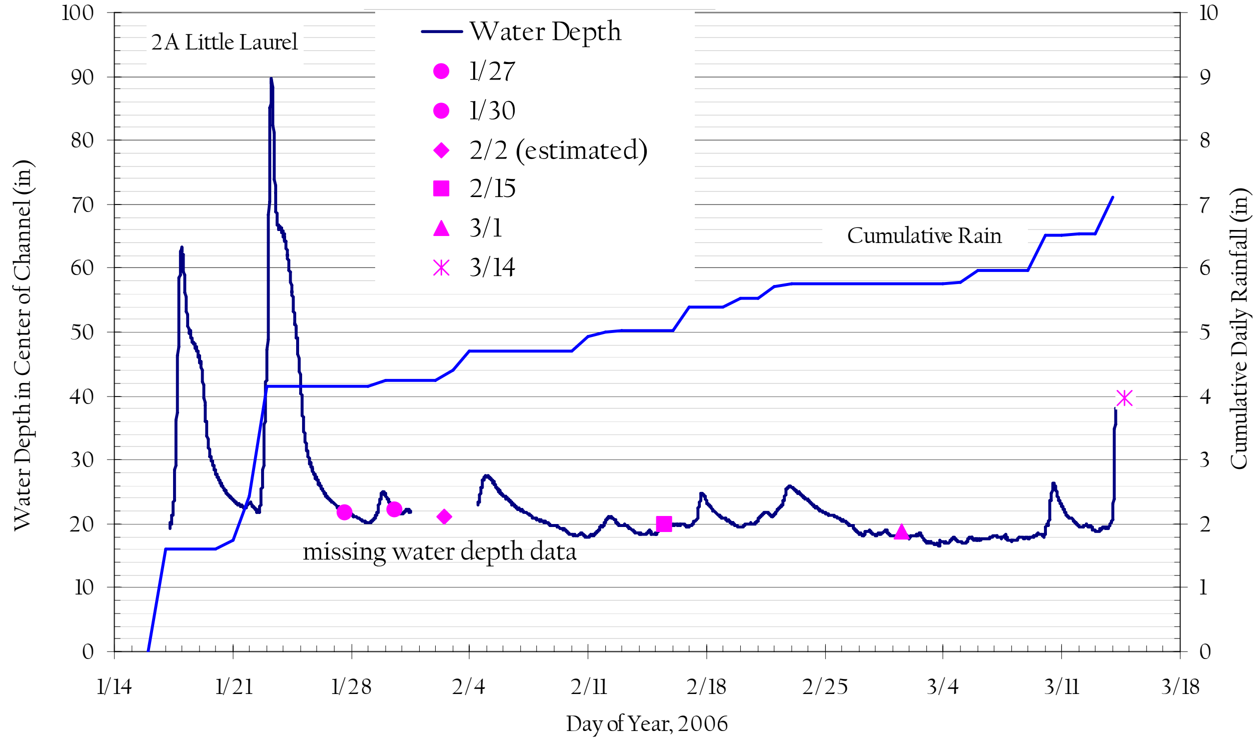

FIGURE J1 –WATER DEPTH FOR LITTLE LAUREL RIVER (2A) AND CUMULATIVE RAINFALL

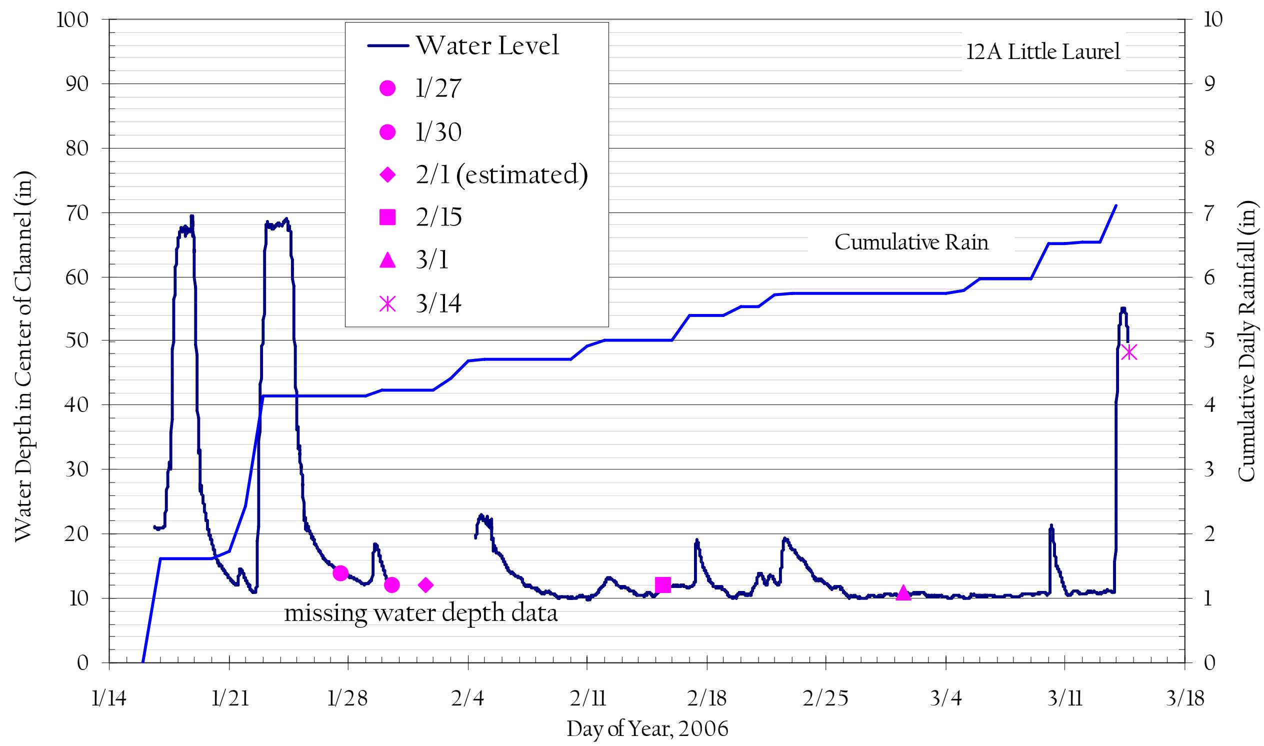

FIGURE J2 –WATER DEPTH FOR LITTLE LAUREL (12A) AND CUMULATIVE RAINFALL

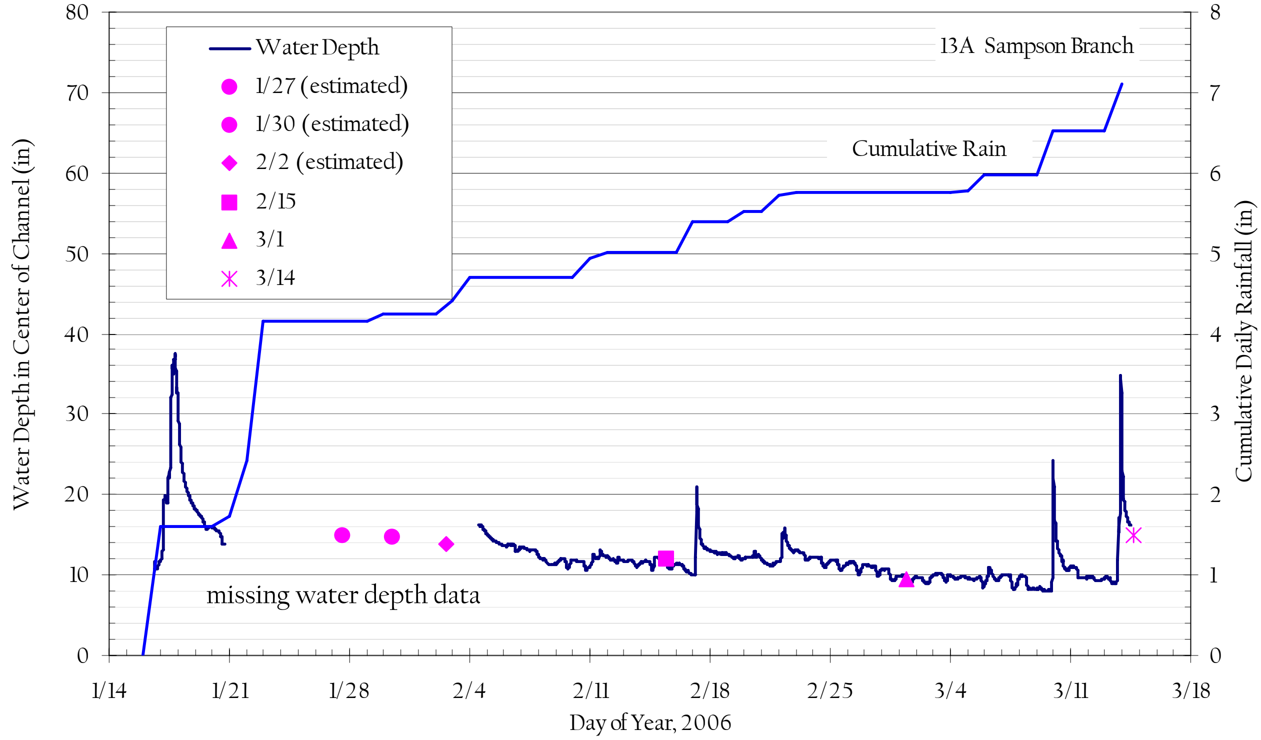

FIGURE J3 –WATER DEPTH FOR SAMPSON BRANCH (13A, LITTLE LAUREL SUBWATERSHED) AND CUMULATIVE RAINFALL

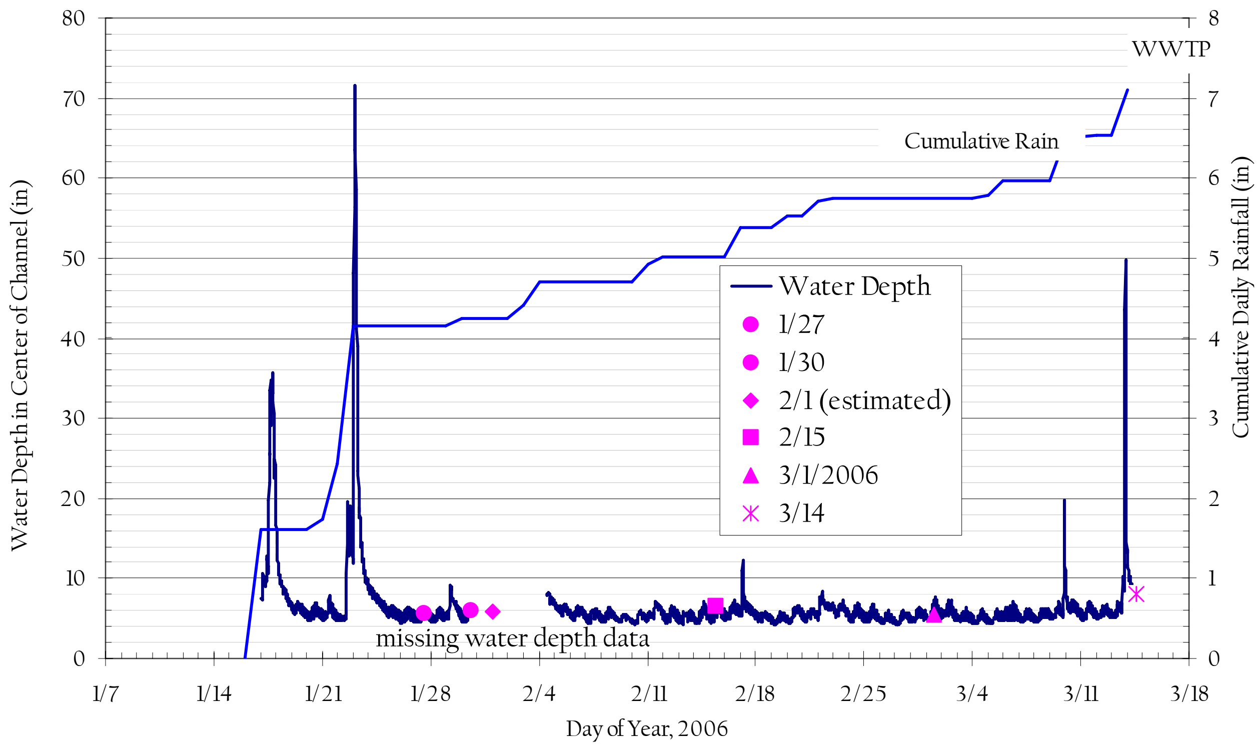

FIGURE J4–WATER DEPTH FOR WHITLEY BRANCH (WWTP, LITTLE LAUREL SUBWATERSHED) AND CUMULATIVE RAINFALL

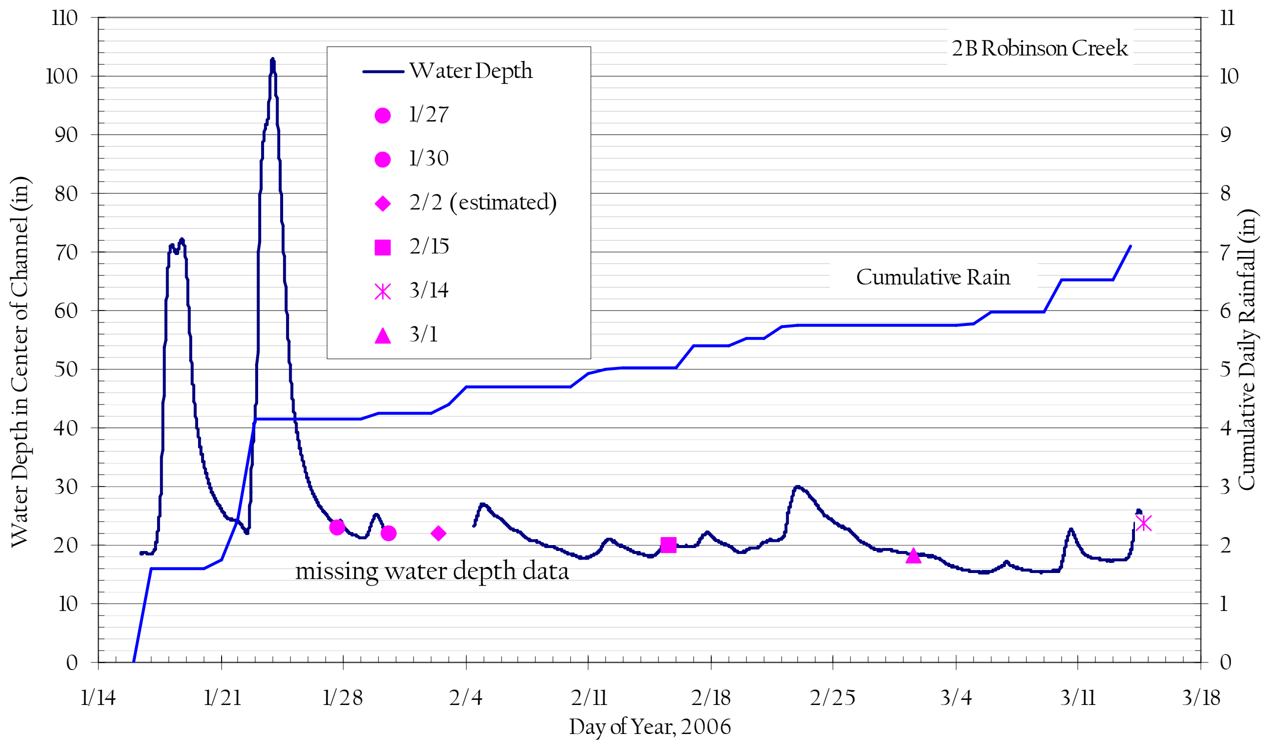

FIGURE J5 –WATER DEPTH FOR ROBINSON CREEK (2B) AND CUMULATIVE RAINFALL

APPENDIX K - FIGURES PRESENTING WATER QUALITY DATA

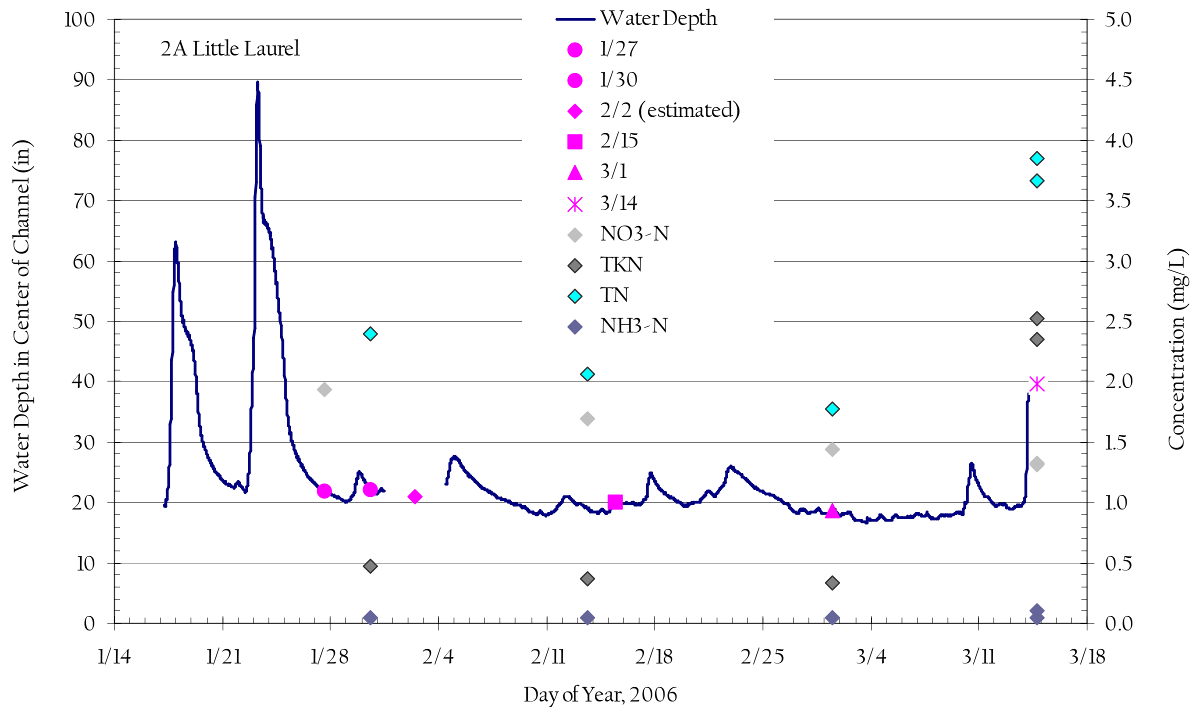

FIGURE K1 – WATER LEVEL AND NITROGEN CONCENTRATIONS AT STATION 2A ON THE LITTLE LAUREL RIVER

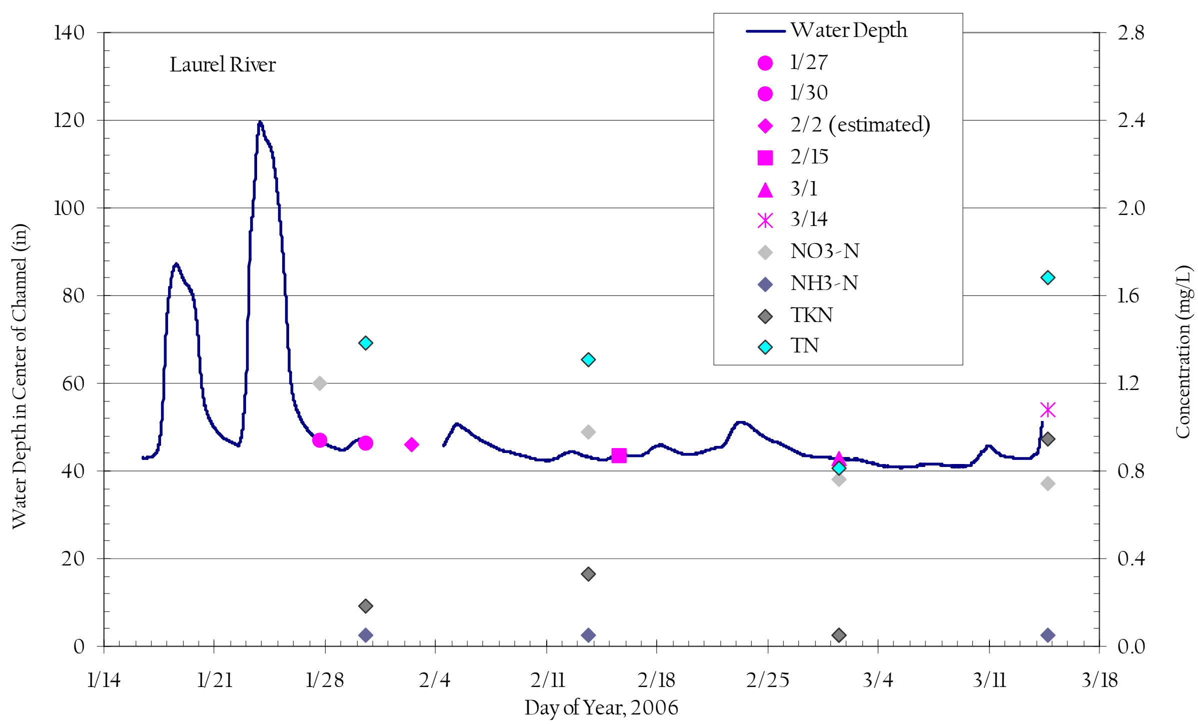

FIGURE K2 – WATER LEVEL AND NITROGEN CONCENTRATIONS AT STATION LAUREL RIVER ON THE LAUREL RIVER

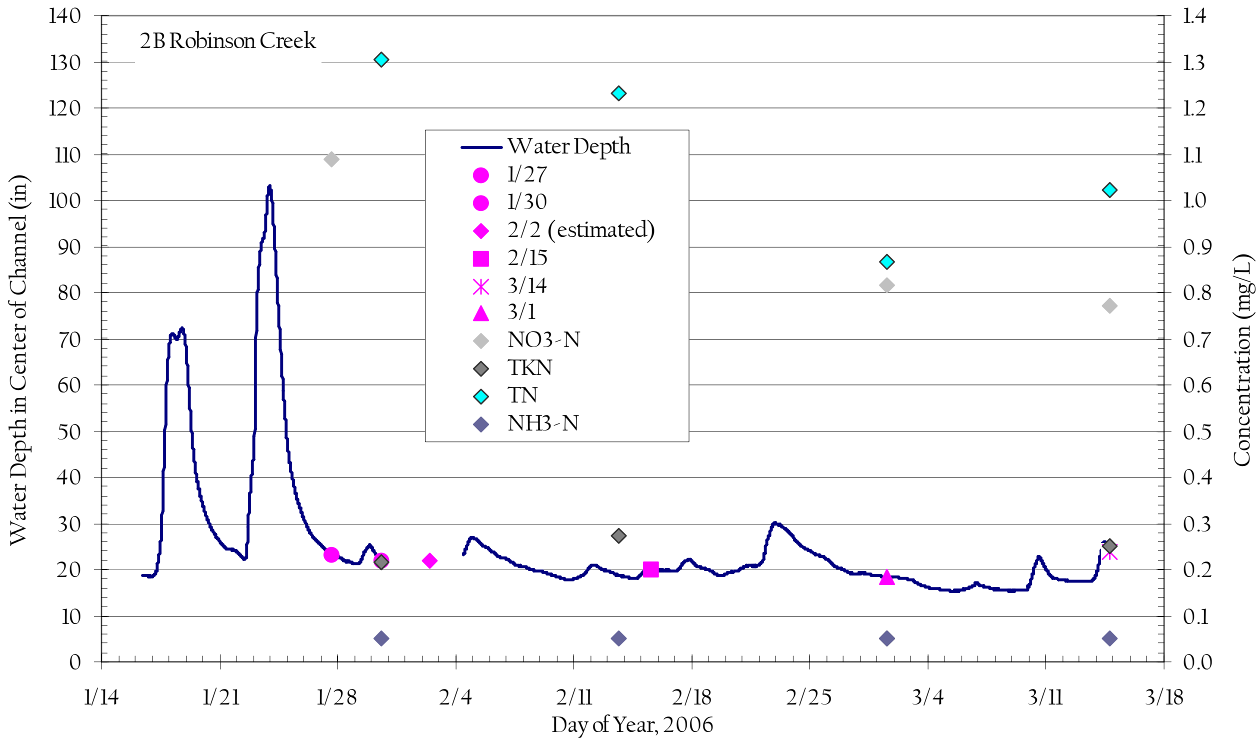

FIGURE K3 – WATER LEVEL AND NITROGEN CONCENTRATIONS AT STATION 2B ON ROBINSON CREEK

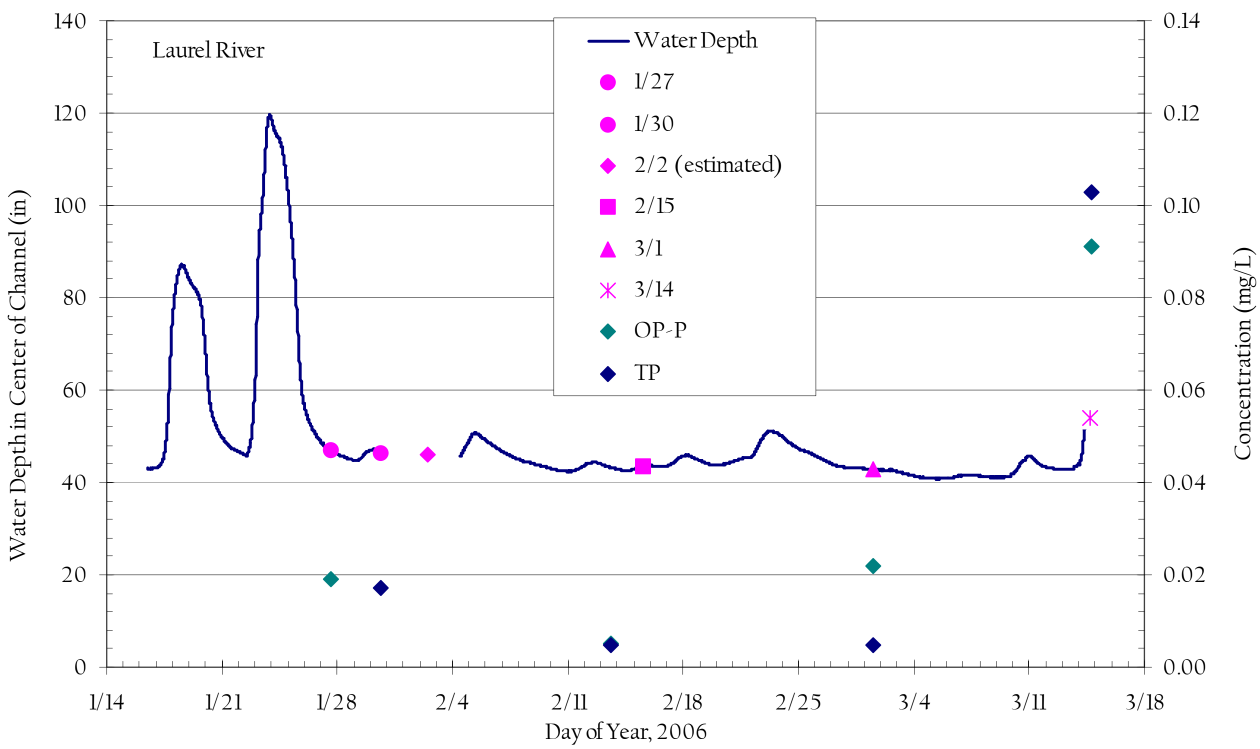

FIGURE K4 – WATER LEVEL AND PHOSPHORUS CONCENTRATIONS AT STATION LAUREL RIVER ON THE LAUREL RIVER

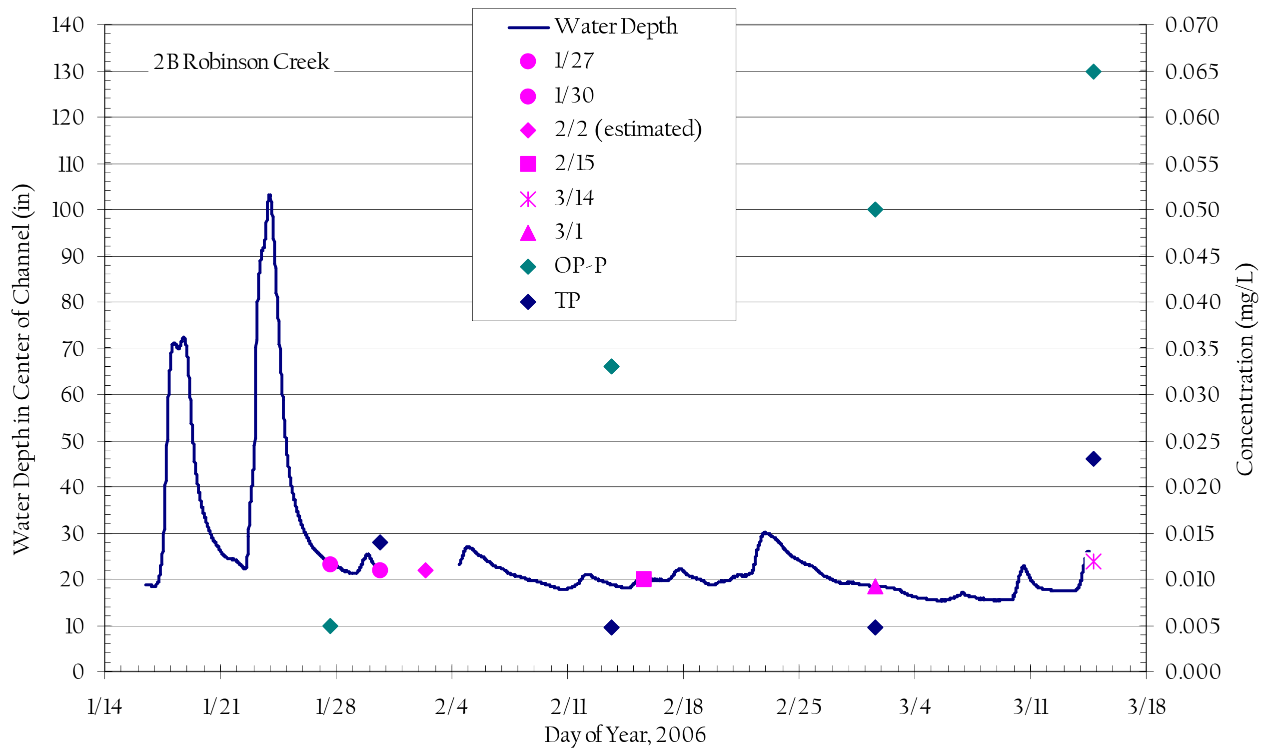

FIGURE K5 – WATER LEVEL AND PHOSPHORUS CONCENTRATIONS AT STATION 2B ON ROBINSON CREEK

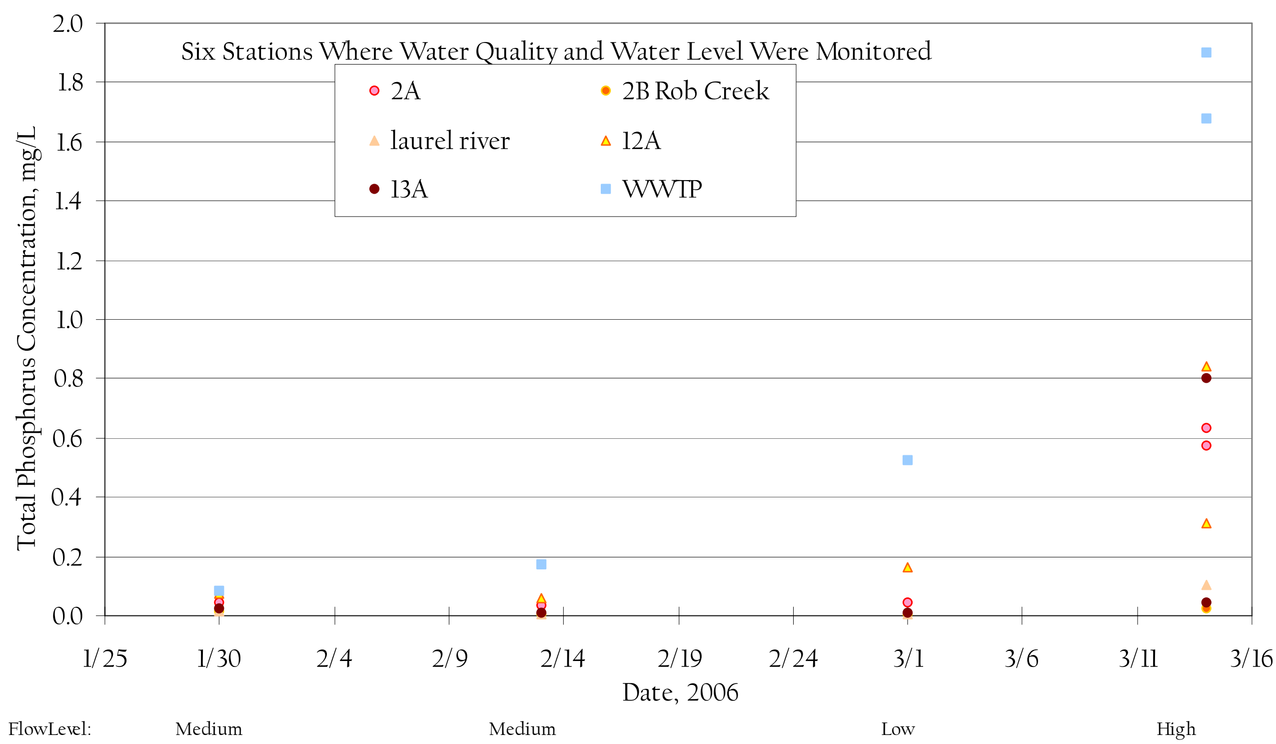

FIGURE K6 – TOTAL PHOSPHORUS CONCENTRATION AT SIX STATIONS ACROSS THE WATERSHED FOR THE FOUR SAMPLING EVENTS

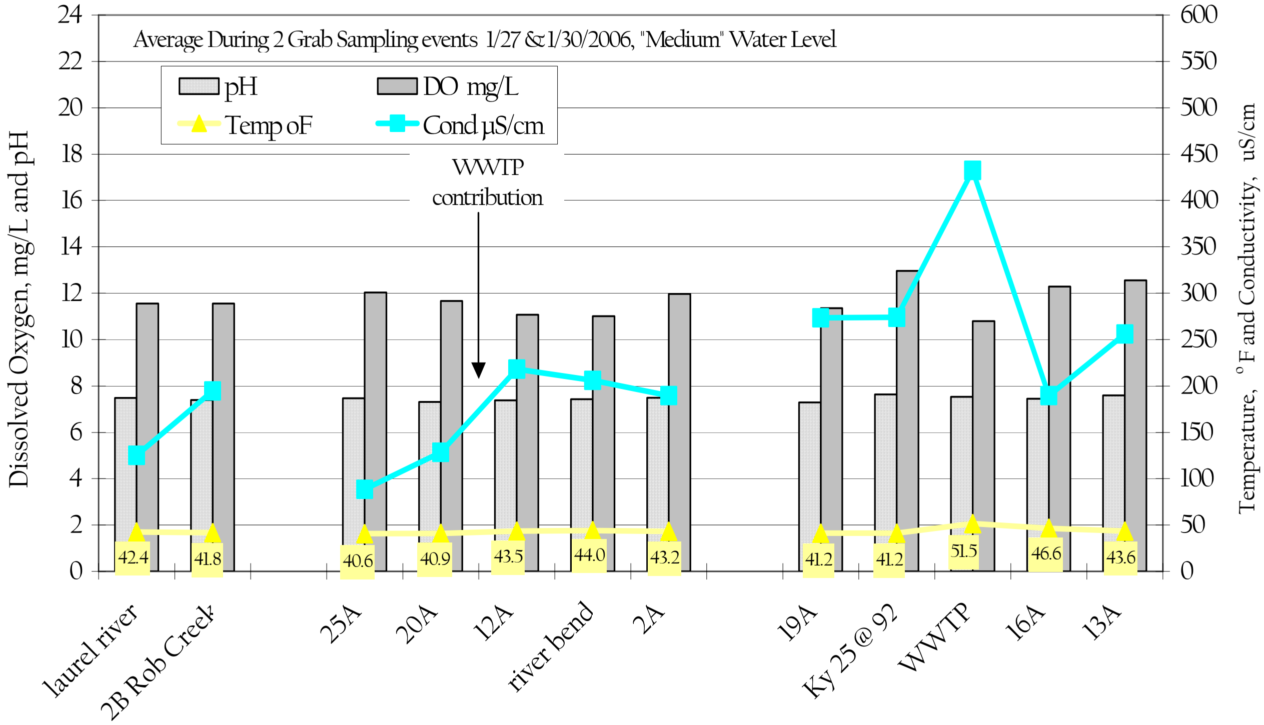

FIGURE K7 – WATER PH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY FOR MARCH 2006 SAMPLING EVENT

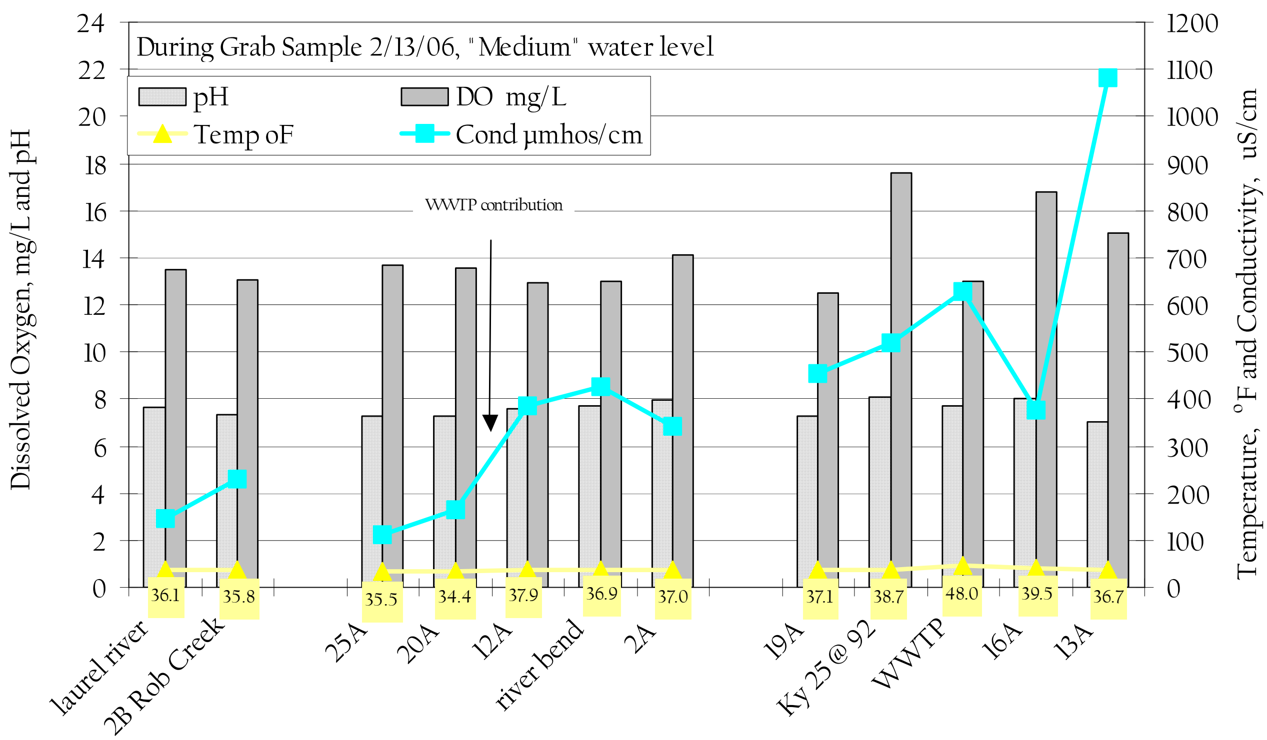

FIGURE K8 – WATER PH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY FOR FEBRUARY 2006 SAMPLING EVENT

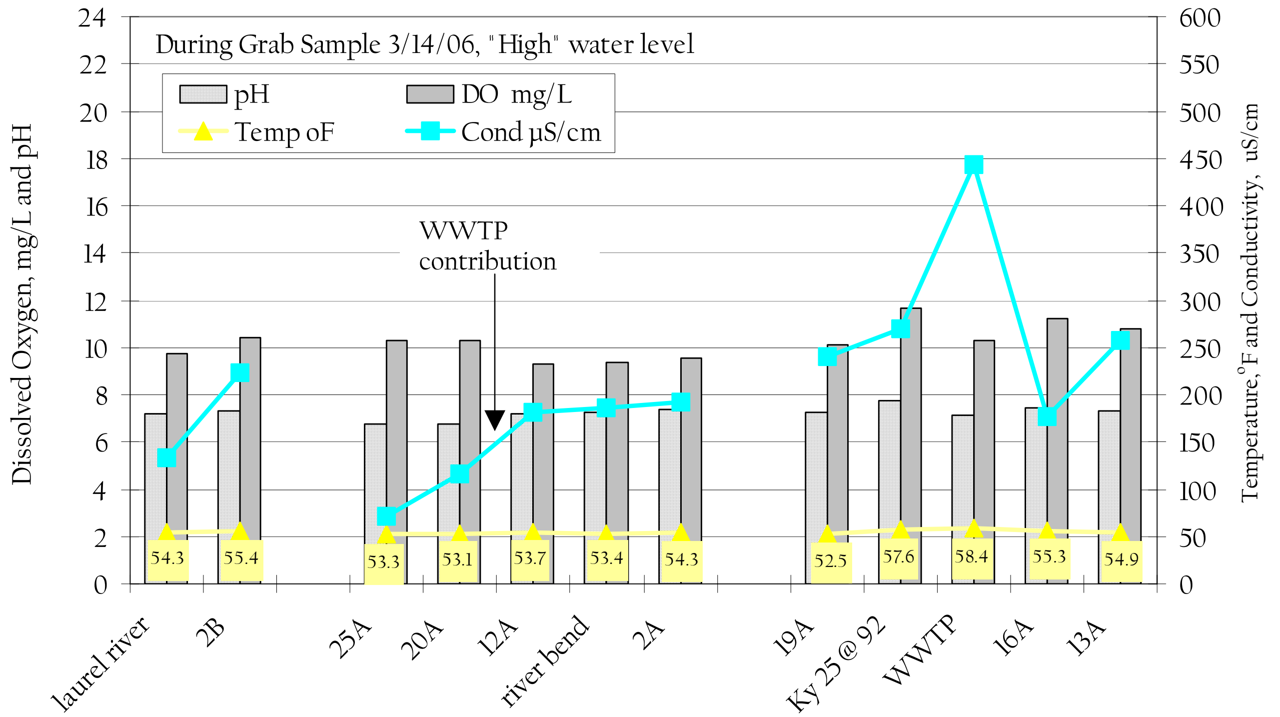

FIGURE K9 – WATER PH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY FOR MARCH 2006 SAMPLING EVENT

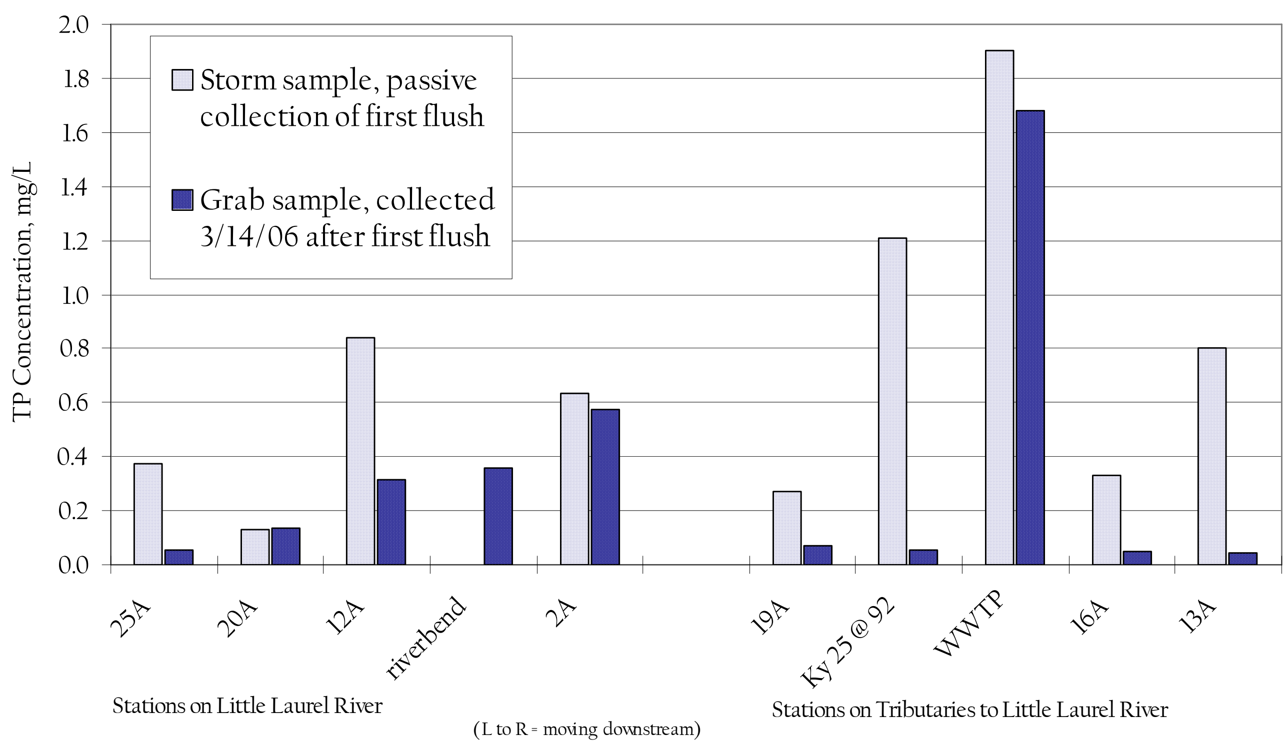

FIGURE K10 – TP CONCENTRATION FOR FIRST FLUSH AND GRAB SAMPLE COLLECTED AFTER THE FIRST FLUSH WHEN WATER LEVEL WAS RECEEDING

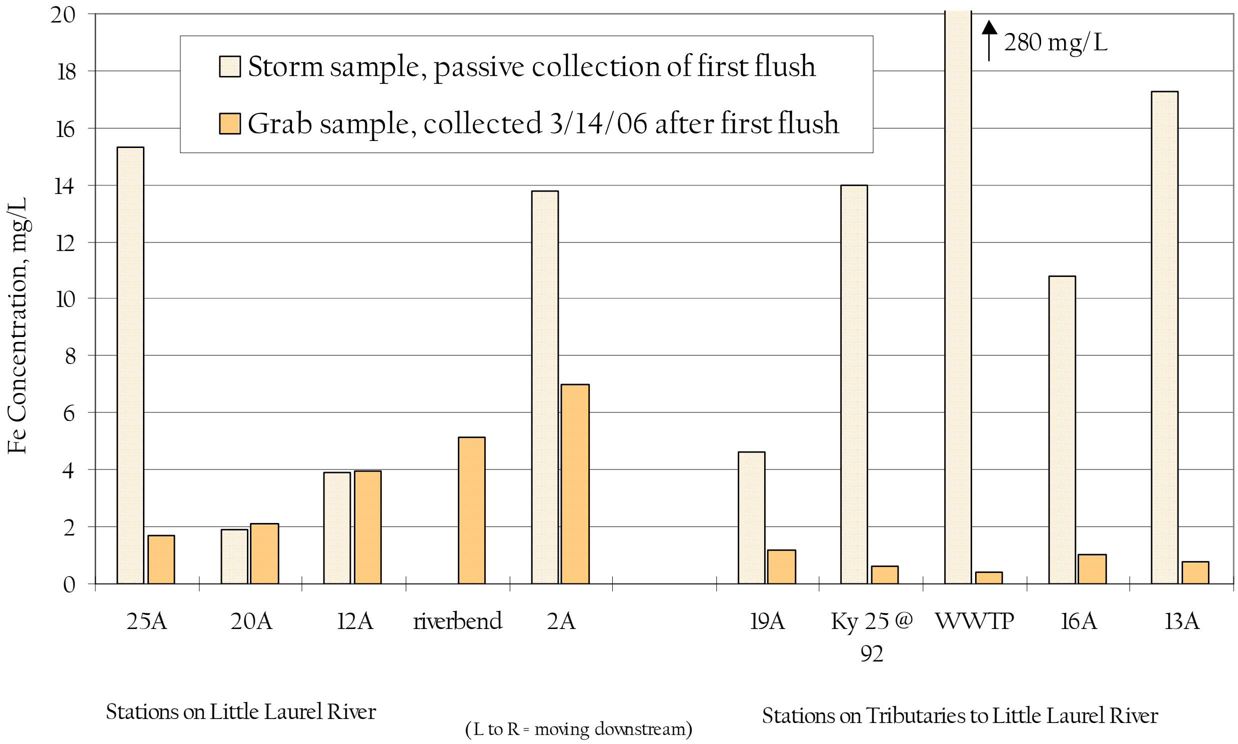

FIGURE K11 – FE CONCENTRATION FOR FIRST FLUSH AND GRAB SAMPLE COLLECTED AFTER THE FIRST FLUSH WHEN WATER LEVEL WAS RECEEDING

APPENDIX L - TABULATED WATER CHEMISTRY DATA, JANUARY – MARCH 2006

WATER CHEMISTRY RESULTS

Date	Subwatershed	Station	Type	Flow Level	Temp (°F)	DO (mg/L)	Cond (µmhos/cm)	pH	Fe (mg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	TN= TKN+ $N0_3$-N (mg/L)	OP-P (mg/L)	TP (mg/L)	TSS (mg/L)
3/14/2006	Laurel	laurel river	grab	High	54.3	9.7	134	7.2	2.3	0.7	0.1	0.9	1.7	0.09	0.10	58.0
3/14/2006	Little Laurel	12A	comp	High					3.9	2.3	0.1	2.1	4.3	0.51	0.84	156.0
3/14/2006	Little Laurel	13A	comp	High					17.3	1.0	0.1	4.6	5.6	0.09	0.80	504.0
3/14/2006	Little Laurel	16A	comp	High					10.8	0.8	0.1	2.5	3.3	0.03	0.33	352.0
3/14/2006	Little Laurel	19A	comp	High					4.6	0.8	0.1	1.7	2.5	0.08	0.27	626.0
3/14/2006	Little Laurel	20A	comp	High					1.9	0.9	0.1	1.0	1.9	0.07	0.13	97.0
3/14/2006	Little Laurel	25A	comp	High					15.3	0.1	0.1	2.5	2.6	0.11	0.37	582.0
3/14/2006	Little Laurel	2A	comp	High					13.8	1.3	0.1	2.5	3.9	0.20	0.63	273.0
3/14/2006	Little Laurel	Ky 25 @ 92	comp	High					14.0	1.1	0.8	4.3	5.5	0.34	1.21	1340.0
3/14/2006	Little Laurel	WWTP	comp	High					280.0	3.0	0.1	6.5	9.5	0.64	1.90	14100.0
3/14/2006	Little Laurel	12A	grab	High	53.7	9.3	181	7.2	3.9	1.3	0.1	1.3	2.7	0.21	0.31	120.0
3/14/2006	Little Laurel	13A	grab	High	54.9	10.8	257	7.3	0.8	1.2	0.1	0.7	1.9	0.03	0.05	12.0
3/14/2006	Little Laurel	16A	grab	High	55.3	11.3	177	7.4	1.0	1.1	0.1	0.4	1.5	0.02	0.05	13.7
3/14/2006	Little Laurel	19A	grab	High	52.5	10.1	240	7.3	1.2	1.2	0.1	0.7	1.9	0.05	0.07	24.7
3/14/2006	Little Laurel	20A	grab	High	53.1	10.3	117	6.8	2.1	1.1	0.1	0.9	2.0	0.05	0.14	91.0
3/14/2006	Little Laurel	25A	grab	High	53.3	10.3	72	6.8	1.7	0.6	0.1	0.6	1.2	0.04	0.06	50.7
3/14/2006	Little Laurel	2A	grab	High	54.3	9.6	192	7.4	7.0	1.3	0.1	2.4	3.7	0.22	0.58	402.0
3/14/2006	Little Laurel	Ky 25 @ 92	grab	High	57.6	11.6	269	7.7	0.6	1.1	0.1	0.7	1.7	0.04	0.06	13.7
3/14/2006	Little Laurel	river bend	grab	High	53.4	9.4	186	7.3	5.1	1.3	0.1	1.6	2.9	0.20	0.36	302.0
3/14/2006	Little Laurel	WWTP	grab	High	58.4	10.3	444	7.1	0.4	5.6	0.1	1.7	7.3	1.71	1.68	9.0
3/14/2006	Robinson Ck	2B	grab	High	55.4	10.4	224	7.3	0.9	0.8	0.1	0.3	1.0	0.07	0.02	102.0
3/1/2006	Laurel	laurel river	grab	Low	46.3	12.5	140	7.6	0.4	0.8	0.1	0.1	0.8	0.02	0.005	1.5
3/1/2006	Little Laurel	12A	grab	Low	49.1	13.1	293	7.4	0.6	1.8	0.1	0.5	2.3	0.14	0.16	5.3
3/1/2006	Little Laurel	13A	grab	Low	47.7	12.0	339	6.6	1.1	1.1	0.1	0.1	1.1	0.02	0.01	1.5
3/1/2006	Little Laurel	16A	grab	Low	53.6	17.5	219	8.6	0.7	0.7	0.1	0.1	0.8	0.02	0.02	3.0
3/1/2006	Little Laurel	19A	grab	Low	48.4	20.0	296	8.8	0.9	0.7	0.1	0.3	1.0	0.01	0.03	11.0
3/1/2006	Little Laurel	20A	grab	Low	47.7	11.9	146	7.6	0.7	1.1	0.1	0.2	1.3	0.06	0.03	4.7
3/1/2006	Little Laurel	25A	grab	Low	48.0	12.5	106	7.7	0.4	0.1	0.1	0.1	0.2	0.02	0.01	1.5
3/1/2006	Little Laurel	2A	grab	Low	47.5	16.2	243	8.5	0.3	1.4	0.1	0.3	1.8	0.05	0.05	1.5
3/1/2006	Little Laurel	Ky 25 @ 92	grab	Low	50.3	20.0	296	8.8	0.4	0.6	0.1	0.3	0.9	0.04	0.02	3.0
3/1/2006	Little Laurel	river bend	grab	Low	47.2	12.2	257	7.4	0.3	1.4	0.1	0.1	1.4	0.11	0.04	1.5
3/1/2006	Little Laurel	WWTP	grab	Low	55.1	14.3	544	7.6	0.1	3.7	0.1	1.2	4.9	0.44	0.53	1.5
3/1/2006	Reservoir	CCR	grab	Low	47.9	12.5	259	7.9	0.5	0.9	0.1	0.2	1.1	0.10	0.06	7.3
3/1/2006	Robinson Ck	2B	grab	Low	47.5	11.8	239	7.3	0.5	0.8	0.1	0.1	0.9	0.05	0.005	1.5
2/13/2006	Laurel	laurel river	grab	Medium	36.1	13.5	147	7.6	0.4	1.0	0.1	0.3	1.3	0.01	0.005	1.5
2/13/2006	Little Laurel	12A	grab	Medium	37.9	12.9	384	7.6	0.6	1.9	0.1	0.5	2.4	0.06	0.06	19.7
2/13/2006	Little Laurel	13A	grab	Medium	36.7	15.0	1081	7.0	0.4	1.4	0.1	0.5	2.0	0.01	0.01	5.0
2/13/2006	Little Laurel	16A	grab	Medium	39.5	16.8	376	8.1	0.8	1.1	0.1	0.4	1.4	0.05	0.01	1.5

Appendix L

WATER CHEMISTRY RESULTS - CONTINUED

Date	Subwatershed	Station	Type	Flow Level	Temp (°F)	DO (mg/L)	Cond (µmhos/cm)	pH	Fe (mg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	TN= TKN+ NO_3-N (mg/L)	OP-P (mg/L)	TP (mg/L)	TSS (mg/L)
2/13/2006	Little Laurel	19A	grab	Medium	37.1	12.5	455	7.3	0.6	1.0	0.1	0.4	1.4	0.05	0.04	6.0
2/13/2006	Little Laurel	20A	grab	Medium	34.4	13.6	164	7.3	0.6	1.5	0.1	0.3	1.9	0.07	0.01	3.7
2/13/2006	Little Laurel	25A	grab	Medium	35.5	13.7	112	7.3	0.4	0.7	0.1	0.3	1.0	0.01	0.00	8.0
2/13/2006	Little Laurel	2A	grab	Medium	37.0	14.1	343	7.9	0.7	1.7	0.1	0.4	2.1	0.03	0.03	1.5
2/13/2006	Little Laurel	Ky 25 @ 92	grab	Medium	38.7	17.6	518	8.1	0.3	1.2	0.1	0.3	1.4	0.02	0.02	1.5
2/13/2006	Little Laurel	river bend	grab	Medium	36.9	13.0	427	7.7	0.4	1.9	0.1	0.5	2.4	0.06	0.05	4.0
2/13/2006	Little Laurel	WWTP	grab	Medium	48.0	13.0	627	7.7	0.2	4.9	0.1	1.2	6.1	0.11	0.18	1.5
2/13/2006	Reservoir	CCR	grab	Medium	38.6	13.5	190	7.9	0.4	1.3	0.1	0.3	1.6	0.07	0.02	8.0
2/13/2006	Robinson Ck	2B	grab	Medium	35.8	13.1	231	7.3	0.7	1.0	0.1	0.3	1.2	0.03	0.00	1.5
1/30/2006	Laurel	laurel river	grab	Medium	45.7	10.8	133	7.5	0.5		0.1	0.2			0.02	
1/30/2006	Little Laurel	12A	grab	Medium	46.9	10.2	224	7.4	1.1		0.1	0.6			0.07	
1/30/2006	Little Laurel	13A	grab	Medium	45.5	12.2	261	7.6	0.4		0.1	0.5			0.03	
1/30/2006	Little Laurel	16A	grab	Medium	48.8	12.1	189	7.4	0.8		0.1	0.3			0.03	
1/30/2006	Little Laurel	19A	grab	Medium	44.1	10.7	278	7.2	0.6		0.1	0.4			0.04	
1/30/2006	Little Laurel	20A	grab	Medium	43.6	11.0	136	7.1	0.7		0.1	0.5			0.04	
1/30/2006	Little Laurel	25A	grab	Medium	43.1	11.3	95	7.3	0.6		0.1	0.2			0.02	
1/30/2006	Little Laurel	2A	grab	Medium	46.4	11.3	199	7.5	0.5		0.1	0.5			0.05	
1/30/2006	Little Laurel	Ky 25 @ 92	grab	Medium	43.2	12.4	281	7.6	0.4		0.1	0.2			0.02	
1/30/2006	Little Laurel	river bend	grab	Medium	46.8	10.3	216	7.4	0.6		0.1	0.5			0.05	
1/30/2006	Little Laurel	WWTP	grab	Medium	52.6	10.6	428	7.5	0.2		0.1	1.0			0.08	
1/30/2006	Reservoir	CCR	grab	Medium	43.5	12.0	147	7.5	0.5		0.1	0.4			0.03	
1/30/2006	Robinson Ck	2B	grab	Medium	45.3	10.8	203	7.4	0.7		0.1	0.2			0.01	
1/27/2006	Laurel	laurel river	grab	Medium	39.1	12.3	117	7.4		1.2				0.02		5.0
1/27/2006	Little Laurel	12A	grab	Medium	40.0	12.0	212	7.4		2.0				0.01		13.3
1/27/2006	Little Laurel	13A	grab	Medium	41.6	12.9	251	7.6		1.8				0.01		1.5
1/27/2006	Little Laurel	16A	grab	Medium	44.3	12.5	190	7.5		1.5				0.01		5.0
1/27/2006	Little Laurel	19A	grab	Medium	38.3	12.0	269	7.4		1.3				0.02		5.3
1/27/2006	Little Laurel	20A	grab	Medium	38.2	12.3	121	7.5		1.8				0.01		10.0
1/27/2006	Little Laurel	25A	grab	Medium	38.1	12.7	82	7.7		0.8				0.01		9.0
1/27/2006	Little Laurel	2A	grab	Medium	39.9	12.7	180	7.5		1.9				0.02		7.7
1/27/2006	Little Laurel	Ky 25 @ 92	grab	Medium	39.1	13.5	267	7.7		1.4				0.01		3.0
1/27/2006	Little Laurel	river bend	grab	Medium	41.2	11.7	196	7.5		2.1				0.02		26.0
1/27/2006	Little Laurel	WWTP	grab	Medium	50.3	11.0	437	7.5		3.9				0.01		1.5
1/27/2006	Reservoir	CCR	grab	Medium	41.4	12.8	128	7.7		1.3				0.02		11.0
1/27/2006	Robinson Ck	2B	grab	Medium	38.3	12.3	186	7.4		1.1				0.01		7.3