

**Mud Creek Watershed
Nonpoint Source Pollution Inventory
and
Pollutant Load Estimates**

Prepared for

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Executive Summary

The Tennessee Valley Authority developed a set of Integrated Pollutant Source Identification (IPSI) tools to aid the North Carolina Wetlands Restoration Program, Department of Environment and Natural Resources, identify and prioritize water quality improvement and protection measures within the Mud Creek Watershed. The tools include a nonpoint source (NPS) inventory, desktop Geographic Information System (GIS), and pollutant loading and sediment models. The NPS inventory is a unique geographic database that consists of information on watershed features such as land use/land cover, streambank erosion sites, and livestock operations that are known or suspected to be nonpoint pollution sources. The NPS inventory for the Mud Creek Watershed was generated by interpretation of low-altitude, color-infrared aerial photography taken March 8, 2001. The desktop GIS uses ArcView software, developed and supported by Environmental Systems Research Institute, Inc., for managing and viewing the data generated by the NPS inventory. The desktop GIS is a powerful mapping system that allows the user to investigate relationships among various geographic features that are known or suspected to contribute NPS pollution to a selected waterbody. The pollutant loading and sediment models use Microsoft Excel software to estimate pollutant loadings based on the data generated by the NPS inventory. The pollutant loading model estimates pollutant loads to Mud Creek and its tributaries for total suspended solids, five-day biochemical oxygen demand, total nitrogen, and total phosphorous from the following sources: residential, commercial, industrial, transportation, cropland, pasture, orchards, forests, clear-cuts, mining, disturbed areas, beef cattle, and horses. The sediment model estimates sediment loads to streams from the above-mentioned land use categories, as well as, from animal access sites, eroding streambanks, eroding road surfaces and associated features including eroding cuts and fills and eroding banks and ditches.

Mud Creek is a direct tributary to the French Broad River in Henderson County. The Mud Creek Watershed (Hydrologic Unit Code 06010105-030) encompasses approximately 72,082 acres (113 square miles). This report documents the remote

sensing methods used to produce the NPS inventory and summarizes the data from the NPS inventory. The report also describes the pollutant loading and sediment models and summarizes estimated pollutant loads for the Mud Creek Watershed.

The Mud Creek Watershed was divided into twenty-five watersheds for inventory and reporting purposes. The predominant land cover in the Mud Creek Watershed is forest (44.6 percent) followed by pasture (13.4 percent), orchard (8.1 percent) and cropland (3.2 percent). Twenty percent of the watershed is characterized by low, medium, or high density residential use. Commercial and industrial land use was identified on 5.9 percent of the landscape. Not surprisingly, the watersheds with the greatest areas of 25 percent slope or steeper also had the largest areas in forest. For example, the Cox Creek Watershed (030401) has 55 percent of its land area with 25 percent slope or steeper and 81 percent of the watershed is forested. Almost half (46 percent) of all cropland is located in Bat Fork (0503), Devils Fork (050201) and the Lower Mud Creek (01) Watersheds. Lewis Creek Watershed (030301) contains 23 percent of all orchard acreage in the Mud Creek Watershed followed by Devils Fork Watershed (050201) with 15.3 percent and Clear Creek Watershed (0304) with 13.3 percent. A third of all identified wetlands is located in Lower Mud Creek Watershed (01).

There were 87 beef cattle sites identified in the Mud Creek Watershed; 54 percent were adjacent to a perennial or intermittent stream. Eighty percent of all cattle operations are classified as small. Seventeen watersheds have at least one cattle operation. There were no swine or poultry operations identified. One medium-sized dairy was identified in the Clear Creek Watershed (0302) adjacent to an intermittent stream; but, according to Henderson County Soil and Water Conservation staff, the dairy is no longer active. There were 54 horse sites identified, most (49) of which are small and non-adjacent to streams.

The remote sensing process identified 118.8 miles of perennial streams within the Mud Creek Watershed and another 249.3 miles of intermittent streams. More than 121 stream miles are channelized. Excessive streambank erosion was identified along 14 percent of the total length of perennial streams while 7 percent of intermittent streambanks are eroded. Livestock are directly accessing 0.05 percent of the perennial and intermittent stream length throughout the Mud Creek Watershed.

There are 1070 miles of road within the Mud Creek Watershed: 272 unpaved miles and 798 paved miles. Nearly fifteen percent of road banks along unpaved roads are eroding while only 3.5 percent of paved roads have eroding banks.

The percent of imperviousness within the Mud Creek Watershed varies greatly. Mud Creek Watershed (05) which includes the City of Hendersonville is 43.1 percent impervious with commercial and industrial land use accounting for 30.8 percent of impervious surfaces. Commercial development in the Bat Fork Watershed (0501) accounts for 29 percent of imperviousness. Meanwhile, headwater watersheds including Clear Creek (0302, 0303, 0304), Cox Creek (030401), Upper Mud Creek (08), and Little Mud Creek (0801) have less than 5 percent imperviousness respectively.

On a per acre basis, Mud Creek Watersheds (06, 03, 05) and Wash Creek Watershed (0601) sustain the highest soil loss rates from the various land use classes. Residential land use, commercial sites under construction, and eroding unpaved roads contribute the greatest sediment load to streams throughout the Mud Creek Watershed.

Introduction

The North Carolina Wetlands Restoration Program (NCWRP) contracted with the Tennessee Valley Authority (TVA) to produce Integrated Pollutant Source Identification (IPSI) products for the Mud Creek Watershed. IPSI is designed as a unique geographic database and set of tools for a watershed to aid water quality agencies in implementing a water-quality-based approach to pollution control. The geographic database consists of information on watershed features such as land use/land cover (LU/LC), streambank erosion sites, and livestock operations that are known or suspected to be nonpoint pollution sources. This information is generated by interpretation of low-altitude, color-infrared aerial photography. TVA has used aerial remote sensing techniques, developed over the last 15 years, to provide reliable, high resolution land use and Nonpoint Source (NPS) pollution information in several watersheds. The data are managed using commercially available Geographic Information System (GIS) software. The corresponding set of tools includes atlases that summarize and display the information about nonpoint pollution sources within the watershed, a desktop GIS that allows the user easy access to the database, and computer models for estimating pollutant and sediment loadings by sources and tributary watersheds.

The desktop GIS uses ArcView software, developed and supported by Environmental Systems Research Institute, Inc. (ESRI), for managing and viewing the data generated by the NPS inventory. The desktop GIS is a powerful mapping system that allows the user to investigate relationships among various geographic features that are known or suspected to contribute NPS pollution to a selected waterbody. For example, the user can examine the proximity of different nonpoint sources of pollution to waterbodies of interest. The IPSI Desktop GIS can be used to target specific sources and sites for pollution reduction, prioritize watersheds for protection and cleanup, track implementation of best management practices (BMPs), and assist in designing and managing water quality monitoring programs to evaluate the effectiveness of BMPs. TVA used the desktop GIS to summarize and analyze the data generated by the NPS inventory.

The IPSI Pollutant Loading Model is a desktop computer model that uses Microsoft Excel software to estimate pollutant loadings based on the data generated by the NPS inventory. The model uses delivery ratios originally generated for the Flint Creek Watershed Project (Morgan County Soil and Water Conservation District, 1995). The model allows the user to estimate pollutant loadings by watershed and source at varying delivery rates. It also allows the user to determine pollutant loadings as a function of BMP implementation. Various BMP implementation strategies can be evaluated. TVA used this model to estimate pollutant loads to Mud Creek for total suspended solids (TSS), five-day biochemical oxygen demand (BOD5), total nitrogen (TN), and total phosphorous (TP). The Sediment Loading Model also uses Microsoft Excel software to estimate sediment loads from various land uses, animal access locations, eroding streambanks, and eroding roads and road banks.

The report documents the remote sensing methods used to produce the NPS inventory and summarizes the data from the NPS inventory. The report also describes the pollutant loading and sediment models and summarizes estimated pollutant loads for the Mud Creek Watershed.

Description of the Watershed

The Mud Creek Watershed in Henderson County, North Carolina, encompasses 113 square miles of rural and urban landscape (Figure 1). The diversity of land uses ranges from apple orchards, tomato farms, and beef cattle operations to residential and urban development. Segments of Mud Creek and two of its major tributaries, Bat Fork Creek and Clear Creek, are impaired Class “C” streams which empty into the French Broad River. These streams do not meet their designated uses for secondary recreation, fishing, wildlife, and aquatic life propagation and survival. Mud Creek from its source to the French Broad River is not supporting due to habitat degradation and potential sources of impacts include both point and nonpoint pollution. Bat Fork Creek from its source to Johnson Drainage Ditch and Clear Creek from its source to Lewis Creek are partially supporting due to nonpoint sources of pollution (North Carolina Department of Environment and Natural Resources, December 1999).

North Carolina’s Division of Water Quality (DWQ) has identified the Mud Creek Watershed as one of eleven high priority watersheds in the entire State and is the only one designated as such in the French Broad River Basin. In June 2000, DWQ began an intensive biological and chemical monitoring program to determine the extent of water quality impairment and aquatic habitat degradation in the Mud Creek Watershed. Monitoring will be completed in December 2001. Volunteer Water Information Network (VWIN) samples collected on lower Mud Creek indicate elevated levels of nutrients, TSS, turbidity, and conductivity. VWIN ranks Lower Mud Creek as “poor” based upon data collected monthly during the last several years (Maas, et al. 2001).



Figure 1. Location of the Mud Creek Watershed.

Methods

An inventory of potential sources of nonpoint pollution within the Mud Creek Watershed was developed using remote sensing techniques. Remote sensing can be defined as the acquisition of information about an object without physical contact. The term, remote sensing, usually refers to the gathering and processing of information about the earth's environment, particularly its natural and cultural resources, through the use of photographs and related data acquired from an aircraft or satellite.

The process generated a unique database for the Mud Creek Watershed. In the absence of stream water quality data, the inventory data can be used as surrogate indicators for potential stream impacts associated with NPS activities. By coupling the remotely-sensed data with a GIS, the data can be analyzed for selected areas and incorporated into decision-making and problem-solving processes. A GIS is a computer system designed to allow the users to collect, manage, and analyze large volumes of spatially-referenced and associated data. Geographic Information Systems are used for solving complex research, planning, and management problems. The major components of a GIS are: a user interface, system/database management capability, database creation/data-entry capacity, spatial data manipulation and analysis package, and display generation function. The GIS software package used for this database was ESRI's ARC/INFO software.

A desktop GIS based on ESRI's ArcView software was constructed for managing and viewing the data generated by the NPS inventory. The desktop GIS provides a user-friendly means to investigate relationships among various geographic features that are known or suspected to contribute NPS pollution to a selected waterbody. The desktop GIS can also be used to target specific sources and sites for pollution reduction, prioritize watersheds for protection and cleanup, track implementation of BMPs, and assist in designing and managing water quality monitoring programs to evaluate the effectiveness of BMPs.

Two models were developed for estimating pollutant and sediment loads to Mud Creek from the various nonpoint sources generated by the inventory. Pollutant load is defined as the amount of a particular pollutant delivered to a waterbody over a specific time period from a specific source. The models use Excel spreadsheet software developed by Microsoft for Windows 95 (Version 7.0a). The Pollutant Loading Model was used to estimate NPS pollutant loads for TSS, BOD5, TN, and TP. The model can also be used to demonstrate the effect of potential NPS management strategies on pollutant loads. The Sediment Loading Model estimates the amount of sediment delivered to streams from various land uses and erosion features.

The remote sensing technology used for generating the NPS inventory and the data layers included in the GIS are described in this report. Also described are the assumptions and equations used in the pollutant loading model.

Aerial Photography Acquisition

Aerial photography provides an alternative means to view, interpret, and understand natural and altered features and their complex relationships. The flight plan parameters were determined by analysis of project requirements. Considerations such as season, weather conditions, time of day, scale, and film type (color infrared, normal color, or black and white) were considered. Vertical aerial photographs were taken on March 8, 2001. The photograph scale was 1:24,000. The exposures were overlapping to enable the interpreter to use specialized equipment to view the landscape in three dimensions. The film type or emulsion was color infrared (CIR). The makeup of CIR film is unique in that one of the three layers of the film's emulsion is sensitive to the near infrared portion of the light spectrum. Because the film is sensitive only to the near infrared portion of the spectrum, and not the longer wavelength emitted or thermal portion of the spectrum, it provides information to the interpreter that is not part of the normal visible spectrum of the human eye. The near infrared is particularly important in assessment of vegetation condition. The chlorophyll of plants is highly reflective in the near infrared; this characteristic allows the interpreter to make inferences on the vigor and type of vegetation not possible with color or black and white film.

Field Verification and Photography Signature

A significant component of an NPS inventory is knowledge of the natural and cultural characteristics of the study area. This knowledge can then be correlated to the "signatures" on the imagery being used to identify NPS features. The remote sensing scientist's primary role is to use a limited amount of field work to verify what to interpret and determine what inferences can reliably be made from the imagery. A site visit accomplishes two things. Initially, the scientist sees the relationships, terrain, and land uses in the Mud Creek Watershed. Secondly, the interpreter correlates the photography signature to the ground features. This correlation helps the interpreter produce photo "keys" that can be extrapolated to the Mud Creek Watershed. Photo keys for this project were based on discussions with the Natural Resources Conservation Service (NRCS) staff, experience gained from other projects, and field visits to verify photo signatures.

Hydrologic Unit and Subwatershed Mapping

A hydrologic unit or subwatershed is a hydrologically correct area within the project area. The unit defines a topographically correct area contributing to the surface runoff at a defined point on a stream. The point on the stream may be a tributary intersection, sampling site, stream gage, or accessible point for future sampling.

Land Use and Land Cover

The Mud Creek Watershed was divided into unique polygons based on LU/LC as interpreted from the aerial photograph. Each polygon was assigned a LU/LC code. Such mapping provides a baseline characterization of the watershed and allows relationships between land use and water quality impairment to be evaluated. The classification scheme used was a hierarchical system based in part on the classification developed by the United States Geological Survey (USGS) for use with remotely sensed data (Anderson, et al.). The classification system was tailored to the Mud Creek Watershed while maintaining the ability to aggregate the land cover to Anderson Level 1 or 2 classes. For example, the LU/LC classification scheme was modified to further identify lands that contribute sediment to streams. Such LU/LC include crop fields with different residue cover and conservation tillage practices. The land use classification scheme used for this study is shown in Table 1.

Table 1. Land Use Classification for the Mud Creek Watershed.

1. Urban and built-up
 11. Residential
 1103. Single family residential, high density (> 6/acre), predominantly cleared
 1112. Single family residential, medium density (2-5/acre), predominantly forested
 1113. Single family residential, medium density (2-5/acre), predominantly cleared
 1122. Single family residential, low density (< 2/acre), predominantly forested
 1123. Single family residential, low density (< 2/acre), predominantly cleared
 1152. Apartment/condominium complex, predominantly forested
 1153. Apartment/condominium complex, predominantly cleared
 1183. Farmstead with accompanying structures, predominantly cleared
 12. Commercial, service, institutional
 1207. Golf course
 1221. Athletic field
 1224. Commercial, service, institutional, recreational, educational
 1234. Landfill, capped
 1235. Water treatment
 1237. Water tank
 1238. Dumpsites
 1251. Educational
 1253. Religious
 1255. Cemetery
 13. Industrial
 14. Transportation, communication, utility
 140. Airport
 1401. Airport, grass runway
 142. Major highway right-of-way
 145. Electric transmission right-of-way
 1461. Transmission facility, substation
2. Agriculture
 21. Cropland and Pasture
 2101. Row crop: no residue (0 to 10%)
 2102. Row crop: with residue (>30%)
 2104. Row crop: medium residue (10 to 30%)
 212. Good pasture: well maintained
 213. Fair pasture: uneven growth and condition, minimal maintenance
 215. Heavily overgrazed pasture
 22. Orchards, Vineyards, and Nurseries
 220. Nursery
 224. Orchard
 2241. Orchard in transition
 226. Christmas tree plantation
 32. Shrub and brush: old field with volunteer woody growth
4. Forest land
 45. Forest land: clear cut
5. Water
7. Disturbed Land
 75. Mining, quarries and borrow areas
 76. Disturbed area: little or no cover, nonagriculture area

Modifier

G. Gullied

Wetland Classification

PEM.	Palustrine emergent
PFO/SS.	Palustrine forested/scrub-shrub
PSS.	Palustrine scrub-shrub
PSS/EM.	Palustrine scrub-shrub/emergent

Livestock Operations

Livestock and poultry operations were mapped by interpretation of facilities and their relationships or associations with the landscape. Examples of the relationships were: soil compaction, soil staining, soil moisture content, size and presence of barns and other structures, presence of hay bales, animal trails, water sources, fencing, and feedlots. These relationships and associated land cover were used to determine the relative size and type of livestock operation. Other potential impacts identified include: proximity to streams; whether a site has critical impact factors, such as a large concentration of animals, poor or no waste management; presence of waste management ponds or lagoons; and whether the animals are confined. The type of operation was identified by looking at clues such as exercise rings for horse operations, silos and loafing areas at dairies, large open pastures for cattle operations, and large buildings for confined poultry operations.

Stream Network and Order

The stream network is based on the blue line streams from the 7½ minute USGS maps. The streams were entered into the GIS either by loading the USGS, Digital Line Graphics (DLG) or by digitizing the stream network from the maps. This base level of streams was then enhanced by photo interpretation. Streams were added or alignment modified as appropriate to accommodate loading of the photo-interpreted information. The order of streams is based on the blue line stream network on the standard 7½ minute 1:24,000 scale, USGS topographic map series. Stream order is a number representing the streams relationship to the overall stream network of a watershed. Headwater tributaries are first-order streams. The convergence of two first-order streams create a second-order stream. A third-order stream results when two second-order streams converge, this numbering continues until all the streams of a watershed are ordered. Streams that were added from photo interpretation were assigned a zero order but are defaulted to a first order stream for analysis purposes.

Drainage Conditions

Pollutants from nonpoint sources enter the aquatic environment through surface runoff and groundwater seepage. Drainage conditions associated with the various land uses and livestock operations were mapped. The drainage features mapped are listed in Table 2.

Table 2. Drainage Features Mapped for the Mud Creek Watershed.

Feature	Description
Perennial Stream	Water is present throughout most years. Stream usually has a base flow.
Intermittent Stream	Water is not present at all times. Stream does not have a base flow throughout most years. The stream has a well-defined channel.
Ephemeral Stream	Drainage ways which flow during an individual storm event. There is not a well-defined channel.
Channelized Stream	Perennial or intermittent stream altered by straightening or dredging.
Eroded Streambank	Stream segments that are eroding with visible collapsed banks.
Grassed Waterway	Stream channel that has been planted in vegetation as an erosion control measure or practice.
Animal Access	Stream segments where livestock have direct, constant access. Animals are not restricted from the stream by natural or artificial constraints, and there is evidence that animals are entering the stream. Such segments may be small sites where the animals drink or longer segments such as streams through confined feedlots.
Probable Animal Access	Stream segments through areas where there is direct evidence of presence of animals, and there is no physical barrier to the stream. Barriers could be fences or high banks. Livestock have access to the entire segment but, in most instances, are using isolated access points for entry to the stream.
Potential Animal Access	Stream segment through areas that exhibit no direct evidence of current animal activity. An example is a hay field that may be used in a pasture rotation. The stream has no physical barrier to livestock.

Road Conditions

Base information for road coverage was the road network on the standard 1:24,000 USGS topographic maps. The road network was updated to the date of the photography (March 8, 2001). Road conditions interpreted for the NPS inventory were the surface type and the significant erosion features associated with the road. Road surfaces were attributed as either paved (impervious) or unpaved. Unpaved roads included all classes of unpaved surface from well-maintained gravel to off-road vehicle trails. The significant erosion features associated with the road included eroding cuts and fills, eroding banks along the road, and eroding ditches.

On-Site Septic Systems

Stressed on-site septic systems can contribute contaminants to the surface water through overland flow, particularly when saturated soil conditions exist. The intent of the NPS inventory was to identify signatures on the aerial photography which are associated with on-site systems and may indicate the conditions of a stressed or potentially stressed system. The four conditions identified are listed in Table 3.

Table 3. On-Site Septic System Features Mapped for the Mud Creek Watershed.

Feature Observed	Description/Implication
Distinctive moisture pattern	Effluent plume from visible drain field pattern or prominent ponding down slope from the drain field.
Suspicious moisture pattern	Visible plume pattern, but no drain field apparent; can be straight-pipe from septic system, roof drainage, gray water disposal or natural seepage/spring.
Distinctive drain field	Visible drain field pattern, but no plume evident; may indicate slow leaching, but no apparent breakout of a seasonally- or hydraulically-stressed system, or evapotranspiration characteristics of a functioning system or newly-installed system.
Suspect location	No plume or drain field visible; home sites on very steep slopes, small lots, visible rock outcrops, or in close proximity to streams or reservoirs, especially those on heavily-wooded lots.

Riparian Features and Conditions

The riparian condition in the NPS Inventory is a characterization of the land cover buffer adjacent to a stream. Benefits of a well-managed riparian buffer include: reducing erosion of streambanks; filtering nutrients, soil and pesticides from runoff; providing food and habitat for aquatic life and other wildlife; and providing shade and protecting the stream from thermal degradation.

The riparian conditions are mapped in two landscape categories: open or areas lacking in appreciable woody vegetation and closed or areas dominated by woody vegetation. The following riparian buffer features were mapped for the left and right descending banks of perennial streams: vegetation type and its percent coverage, and quality of the vegetative cover and the width of the vegetation. Vegetative type was identified as

either woody (trees, shrub), grass or urban. Three ranges of percent coverage were delineated for woody vegetation: 0 to 33 percent, 34 to 66 percent, and 67 to 100 percent. Grass cover quality was rated as poor, moderate, or good. The vegetation type was identified for 5 width zones: 0 to 15 feet, 16 to 30 feet, 31 to 50 feet, 51 to 100 feet, or greater than 100 feet.

A riparian buffer classification matrix (Table 4) was used to rate the condition or ability of the riparian buffer to filter runoff. The assumption is that the quality and extent of the buffer zone has a direct relationship to the potential ecological health and water quality of a stream by reducing NPS pollutants entering the stream. The riparian buffer was rated either adequate, marginal, or inadequate with regard to the ability to remove pollutants.

Table 4. Riparian Buffer Classification Matrix.

Woody Vegetation			
Width/Cover	0 to 33 percent	34 to 66 percent	67 to 100 percent
0 to 15 feet	Inadequate	Inadequate	Inadequate
16 to 30 feet	Inadequate	Inadequate	Inadequate
31 to 50 feet	Marginal	Marginal	Marginal
51 to 100 feet	Marginal	Marginal	Adequate
Over 100 feet	Marginal	Marginal	Adequate
Grass Vegetation			
Width/Cover	Poor Quality	Moderate Quality	Good Quality
0-15 feet	Inadequate	Inadequate	Inadequate
16-30 feet	Inadequate	Inadequate	Inadequate
31-50 feet	Marginal	Marginal	Marginal
51-100 feet	Marginal	Marginal	Adequate
Over 100 feet	Marginal	Marginal	Adequate

Geologic Features

The term, geologic features, is better described as geomorphology. The NPS inventory identifies subsidence features. Subsidence features may be well-defined sinkholes or subtle features only a few feet or inches in depth. These subtle features are photo-identifiable due to soil moisture characteristics or vegetation changes.

Impervious Cover

The natural surface runoff characteristics of a watershed can be altered by impervious surfaces. Impervious surfaces prevent rainfall from infiltrating into the soil and result in greater surface runoff. Impervious surfaces include roads, parking lots, sidewalks, rooftops, and other impermeable surfaces of the urban landscape. Imperviousness is defined as the percent of the total area of the mapped unit that is covered by impervious surface. A percent imperviousness, excluding paved roads, was assigned to each LU/LC polygon based on interpretation of the photography. For example, a low-density residential area might have a percent imperviousness of 20 percent based on the estimated coverage of structures, driveways, and sidewalks. The percent of area covered by paved roads was calculated from the roads' coverage layer in the database. The percent imperviousness for each watershed was then calculated by summing the percent imperviousness for each polygon and the roads within the watershed.

Soil Loss Estimates

Soil loss for selected land use classes and other high impact erosion features was calculated. The amount of soil loss estimated was the total potential soil movement for the feature. For example, the soil loss for a particular agricultural field was an estimate of the amount of soil movement on the field, in tons per acre per year (T/A/Y), based on the Universal Soil Loss Equation (USLE). The soil loss from unpaved roads was calculated by establishing an average erosion rate of 100 tons per acre per year and assuming an average width of 15 feet. The USLE data and erosion rates used for the Mud Creek Watershed were established through consultation with the NRCS district conservationist (Carter, 2001). The soil erosion rates and USLE factors provided by the NRCS are listed in Appendix A.

Pollutant Loading Model

A model was developed to estimate NPS pollutant loads based on the NPS inventory. The model can be used to estimate pollutant loads for TSS, BOD5, TN, and TP from the following sources: residential, commercial, industrial, transportation, nurseries, cropland, pasture, beef cattle, dairy cattle, swine, horses, and poultry.

The model uses a Microsoft Excel for Windows 95 (Version 7.0a) workbook to perform the calculations and display the results in tabular and graphical form. The workbook consists of six sections: Introduction, Inputs, Outputs, NPS Inventory Data, Calculations,

and Macros. The Introduction Section consists of a Title Sheet and Instruction Sheet. The Inputs Section consists of the Landscape Inputs Sheet, USLE Inputs Sheet, Pollutant Load Inputs Sheet and BMP Implementation Sheet. These sheets require the user to input certain variables that are used in the USLE and the pollutant loading equations. The user can vary the input values, and the output table and graphs will automatically update. The BMP Implementation Sheet allows the user to enter assumptions about the effectiveness of BMPs in order to evaluate management strategies for reducing pollutant loads. The Outputs Section consists of the Soil Loss Estimate Sheet, TSS Table Sheet, TSS Graphs Sheet, BOD5 Table Sheet, BOD5 Graphs Sheet, TN Table Sheet, TN Graphs Sheet, TP Table Sheet, and TP Graphs Sheet. These sheets summarize in tabular and graphical form the estimated soil loss and estimated pollutant loads by source and watershed. The NPS Inventory Section consists of the NPS Inventory Data Sheet and the Land Use Graph Sheets. These sheets contain the data derived from the NPS inventory and used in the soil loss and pollutant loading calculations. The Calculations Section consists of the TSS Load Calculation Pre-BMP Sheet, TSS Load Calculation Post-BMP Sheet, BOD5 Load Calculation Pre-BMP Sheet, BOD5 Load Calculation Post-BMP Sheet, TN Load Calculation Pre-BMP Sheet, TN Load Calculation Post-BMP Sheet, TP Load Calculation Pre-BMP Sheet, and TP Load Calculation Post-BMP Sheet. These sheets contain the equations used to estimate pre- and post-BMP pollutant loads for the various pollutants. The equations used in the model are discussed later. The Macros Section consists of several sheets that contain the macros used to reset the model inputs to default settings.

Pollutant Loads From Urban Land Classes

The pollutant load from the urban land uses within the Mud Creek Watershed was estimated using a method described by the U.S. Environmental Protection Agency (USEPA, 1990). This USEPA method uses the following equation:

$$M = \text{RainV} \times \text{Rv} \times \text{Area} \times \text{Conc} \times 0.0001135 \quad \text{Equation (1)}$$

Where:

M	=	mass load (tons)
RainV	=	rainfall amount (inches)
Rv	=	runoff coefficient (unitless)
Area	=	drainage area (acres)
Conc	=	average concentration in runoff (mg/L)
0.0001135	=	unit conversion factor

This equation was used to estimate the annual pollutant load for the following land classes: residential, commercial, industrial, and transportation. The areas used for each land class were generated by the NPS inventory. The values shown in Table 5 were used in the model. Annual rainfall estimates were obtained from the District Conservationist. Runoff coefficients for the different land classes were estimated using the following equation taken from the USEPA report, "Urban Targeting and BMP Selection" (USEPA, 1990):

$$R_v = 0.050 + 0.009 (PI) \quad \text{Equation (2)}$$

Where:

PI is percent imperviousness estimated from the remote sensing process

The values used for PI by land use/land cover class were determined by remote sensing. The concentration of pollutant in the runoff was taken from the USEPA's National Urban Runoff Study (USEPA, 1982).

Pollutant Loads From Crop, Pasture, Forest, Mining, and Disturbed Lands

The first step in estimating pollutant loads from pasture, crop, forest, mining and disturbed lands was determining the soil loss for each class using the USLE:

$$A = R \times K \times LS \times C \times P \quad \text{Equation (3)}$$

Where:

- A = soil loss (tons/acre/year)
- R = rainfall energy factor
- K = soil erodibility factor
- LS = slope-length factor
- C = cropping management factor
- P = erosion control practice factor

Table 5. Values Used to Estimate Pollutant Loads From Urban Land Classes.

Land Class		Residential, Medium Density	Residential, Low Density	Commercial, With Impervious Cover	Commercial, Without Impervious Cover	Industrial	Transportation
Annual Rainfall	inches/year	60	60	60	60	60	60
Runoff Coefficient	unitless	0.33	0.23	0.67	0.07	0.65	0.05
TSS Concentration	mg/L	180	180	180	180	180	180
BOD5 Concentration	mg/L	12	12	12	12	12	12
TN Concentration	mg/L	2.76	2.76	2.76	2.76	2.76	2.76
TP Concentration	mg/L	0.42	0.42	0.42	0.42	0.42	0.42

The soil loss factors used for the various land classes identified by the NPS inventory are listed in Appendix A as provided by the NRCS (Carter, 2001).

The pollutant load from these lands within the Mud Creek Watershed was estimated using the soil loss values calculated from Equation (3) and the following equation:

$$M = A \times \text{Area} \times \text{DR} \times \text{PC} \times 0.0005 \quad \text{Equation (4)}$$

Where:

- M = pollutant loading (tons/ year)
- A = soil loss (tons/acre/year)
- Area = land class area (acre)
- DR = sediment delivery ratio (unitless)
- PC = pollutant coefficient (pound pollutant/ton soil)
- 0.0005 = unit conversion factor

The acreage used for the various land classes were determined by the NPS inventory. The sediment delivery ratio was estimated from the United States Department of Agriculture, National Engineering Handbook, Section 3 - Sedimentation, Chapter 6 - Sediment Sources, Yields and Delivery Ratios, Figure 6-2 (USDA, 1978).

Figure 6.2 is based on the following equation:

$$\text{DR} = 0.417762 \times (\text{A}^{-0.134958}) - 0.127097 \quad \text{Equation (5)}$$

Where:

- DR = Delivery Ratio (unitless)
- A = Area (sq miles)

Table 6 lists the sediment delivery ratio used for each tributary watershed in the Mud Creek Watershed. The following pollutant coefficients were used in the model for the Mud Creek Watershed :

Total Nitrogen	2.2 pounds pollutant/ton soil
Phosphorus	0.16 pounds pollutant/ton soil
Total Suspended Solids	1400.0 pounds pollutant/ton soil
Biochemical Oxygen Demand	8.0 pounds pollutant/ton soil

Table 6. Sediment Delivery Ratio for Watersheds Within the Mud Creek Watershed.

Watershed	ID	Sediment Delivery Ratio
Lower Mud Creek, mouth to Featherstone Creek	01	0.186
Mud Creek, Featherstone Creek to Clear Creek	02	0.249
Featherstone Creek	0201	0.219
Mud Creek, Clear Creek to Brittain Creek	03	0.296
Clear Creek, mouth to Henderson Creek	0301	0.171
Clear Creek, Henderson Creek to Lewis Creek	0302	0.197
Henderson Creek	030201	0.219
Clear Creek, Lewis Creek to Cox Creek	0303	0.205
Lewis Creek	030301	0.197
Clear Creek, Cox Creek to head	0304	0.196
Cox Creek	030401	0.236
Mud Creek, Brittain Creek to Bat Fork	04	0.419
Brittain Creek	0401	0.227
Mud Creek, Bat Fork to Wash Creek	05	0.295
Bat Fork, mouth to Devils Fork	0501	0.334
Bat Fork, Devils Fork to King Creek	0502	0.254
Devils Fork	050201	0.186
Bat Fork, King Creek to head	0503	0.198
King Creek	050301	0.191
Mud Creek, Wash Creek to Shepherd Creek	06	0.339
Wash Creek	0601	0.250
Mud Creek, Shepherd Creek to Little Mud Creek	07	0.193
Shepherd Creek	0701	0.208
Upper Mud Creek, Little Mud Creek to head	08	0.205
Little Mud Creek	0801	0.237

Nutrient characteristics were based on measurements of soils on 12 pasture sites in the Sand Mountain region of Alabama (Kingery, et al., 1994). TP was estimated to be four times the extractable phosphorus (soil test phosphorus). The NRCS recognizes the general relationship to estimate phosphorus from a soil test. TSS were estimated to be 70 percent of the eroded soil that reaches the stream. The biochemical oxygen demand was based on the amount of organic nitrogen in the topsoil.

Pollutant Loads From Beef Cattle Operations

The pollutant load from the beef cattle operations identified within the Mud Creek Watershed was estimated using the following equation:

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NSn \quad \text{Equation (6)}$$

Where:

- M = pollutant loading (tons/year)
- NA = number of animals (number/site)
- WT = animal weight (pounds)
- PR = pollutant production rate (lbs/day/1000 lb live weight)
- 0.0001825 = unit conversion factor
- DR = delivery ratio (unitless)
- NSn = number of sites of type n

The values used to calculate the pollutant loads for beef cattle are given in Table 7. The number and type of cattle sites within the Mud Creek Watershed were identified by the NPS inventory. The cattle sites were identified as small, medium, or large and adjacent or nonadjacent to the stream. The (as excreted) pollutant production rates (PR) for BOD5, TN, and TP were obtained from the NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The production rate for TSS was based on values derived from “Livestock Manure Characterization Values from the North Carolina Database” (Barker, et al., 1990).

Table 7. Values Used to Estimate Pollutant Loads From Beef Cattle Operations.

Type of Operation		Units	Beef Cattle
Number of Animals per Site	Large	Number	75
	Medium	Number	35
	Small	Number	15
Animal Weight		lbs/animal	800
Delivery Ratio - Adjacent Site	TSS	unitless	0.0437
	BOD5	unitless	0.0342
	TN	unitless	0.0444
	TP	unitless	0.0437
Delivery Ratio - Nonadjacent Site	TSS	unitless	0.0415
	BOD5	unitless	0.0286
	TN	unitless	0.0351
	TP	unitless	0.0415
Pollutant Production	TSS	lb/day/1000 lb live wt	3.39
	BOD5	lb/day/1000 lb live wt	1.36
	TN	lb/day/1000 lb live wt	0.31
	TP	lb/day/1000 lb live wt	0.11

Analyzing cattle behavior and producer management were critical in selecting delivery ratios for beef cattle operations. The delivery ratio for each pollutant was based on

information collected as part of the Flint Creek Watershed Project (Morgan County Soil and Water Conservation District, 1995). Pollutant delivery to the stream depends on: (1) where the cattle are in the watershed and (2) the fate of the pollutant once it is introduced into the environment (i.e., movement, adsorption, volatilization, etc.). For those sites adjacent to the stream, it was estimated that the cattle spent time in one of three general areas as follows:

- 2.5 percent of the time in the perennial stream
- 16.7 percent of the time near the perennial stream
- 80.8 percent of the time in the pasture away from the perennial stream

For those sites nonadjacent to the stream, the following estimates were made for time spent:

- 0 percent of the time in the perennial stream
- 40 percent of the time near intermittent drain
- 60 percent of the time in the pasture away from intermittent drain

These times were derived based on the following estimates about cattle behavior:

1. The time spent in the stream is primarily in June through September.
2. Minimal time spent in stream at night, and essentially no waste is deposited.
3. Potential stream access occurs 12 hours per day June through September.
4. One-third of 12 hours is spent in stream or near stream (four hours per day).
5. One-sixth of 12 hours is spent in stream (two hours per day June through September).
6. For April, May, October, and November, one-half hour per day spent in stream.
7. For December, January, February, and March, minimal time spent in stream, and essentially no waste deposited.

8. Estimate half of the cattle are not environmentally sensitive (Brahmin mix, etc.) and are 50 percent less likely to be in the stream than stated in the above estimates.
9. Percent of time spent in stream is averaged over the year (0.833 hours per day for environmentally-sensitive animals and 0.417 hours per day for not sensitive animals). This gives average for all animals of 0.625 hours per day or 2.6 percent. For delivery ratio calculation, assume 2.5 percent for time spent in stream.

The following estimates were made about the fate of the pollutant once it was introduced into the environment:

When the animal is in the stream, 100 percent of all pollutants enters the stream with no losses.

1. When the animal is near the stream, 10 percent of BOD5, nitrogen, and phosphorus enters the stream.
2. In addition, 25 percent of the ammonia is lost due to volatilization prior to it entering the stream, and 10 percent of the organic nitrogen is converted to ammonia prior to entering the stream. A portion of the BOD5 is consumed before it reaches the stream. The following losses of BOD5 were applied: for sites defined as adjacent, 50 percent; for nonadjacent sites, 30 percent.
3. When the animal is in the pasture, 0.1 percent of BOD5, 0.85 percent of the nitrogen, and 0.25 percent of the phosphorus enters the stream. These numbers are based on values for land applied poultry litter (Kingery, et al., 1994).
4. The delivery ratio used for TSS was 0.6 percent.

The delivery ratio was calculated by summing the products of the time spent in the general areas and the respective fates.

Pollutant Loads From Dairy Operations

Although one dairy was identified by the photo analyst, it was determined by Soil & Water Conservation District (SWCD) staff that the dairy is no longer active. The model contains information needed to compute pollutant loads from dairy operations in the event that a dairy operation is initiated in the Mud Creek Watershed. The pollutant load from dairy operations was estimated using the following equation:

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NSn \quad \text{Equation (7)}$$

Where:

- M = pollutant loading (tons/year)
- NA = number of animals (number/site)
- WT = animal weight (pounds)
- PR = pollutant production rate (lbs/day/1000 lb live weight)
- 0.0001825 = unit conversion factor
- DR = delivery ratio (unitless)
- NSn = number of sites of type n

The values loaded to estimate pollutant loads from dairy operations are listed in Table 8. The (as excreted) PRs for BOD5, TN, and TP were obtained from the USDA Agricultural Waste Management Field Handbook (USDA, 1996). The PR for TSS was based on values derived from the “Livestock Manure Characterization Values from the North Carolina Database” (Barker, et al., 1990).

The delivery of pollutants from dairy operations vary greatly from operation to operation. Factors which influence delivery of pollutants to the stream include type and amount of confinement, management of lagoons or waste storage ponds, proximity of cows to streams, and timing and amount of land application of wastes. The delivery ratio consists of two components: a management component and a stream access component. A certain amount of waste enters streams from inadequate waste management systems (overflowing lagoons, runoff from land application, runoff loafing areas). Only those sites specified as adjacent sites have a stream component. A closer look at the individual operations would be needed to refine these values. For example, distance to the stream and management style would need to be considered.

Table 8. Values Used to Estimate Pollutant Loads From Dairy Operations.

Type of Operation		Units	Dairy
Number of Animals per Site	Large	Number	150
	Medium	Number	100
	Small	Number	50

Animal Weight		lbs/animal	1400
Delivery Ratio - Adjacent Site	TSS	unitless	0.0750
	BOD5	unitless	0.0625
	TN	unitless	0.0750
	TP	unitless	0.0750
Delivery Ratio - Nonadjacent Site	TSS	unitless	0.025
	BOD5	unitless	0.0125
	TN	unitless	0.025
	TP	unitless	0.025
Pollutant Production	TSS	lb/day/1000 lb live wt	5
	BOD5	lb/day/1000 lb live wt	1.6
	TN	lb/day/1000 lb live wt	0.45
	TP	lb/day/1000 lb live wt	0.07

The delivery ratio for the stream access component for all pollutants was estimated to be 0.05. This is based on the assumption that dairy cows with stream access spend 5 percent of their time in the stream. See rationale for this assumption under beef cattle, assuming dairy cows are "environmentally sensitive."

Pollutant Loads From Swine Operations

There were no swine sites identified by TVA using aerial remote sensing techniques. The pollutant load model contains the information needed to compute pollutant loads from swine operations in the event a swine operation locates within the Mud Creek Watershed. The following equation was loaded into the model

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NS_n \quad \text{Equation (8)}$$

Where:

M	=	pollutant loading (tons/year)
NA	=	number of animals (animals/site)
WT	=	animal weight (pounds)
PR	=	production rate (lb/day/1000 lb live weight)
0.0001825	=	unit conversion factor (unitless)
DR	=	delivery ratio (unitless)
NS _n	=	number of sites of type n

The PR for BOD5, TN, and phosphorus were obtained from the NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The production rate for TSS was based on values derived from "Livestock Manure Characterization Values from the North Carolina Database" (Barker, et al., 1990).

The delivery of pollutants from swine operations vary greatly from operation to operation. Factors which influence delivery of pollutants to the stream include type and amount of confinement, management of lagoons or waste storage ponds, proximity of hogs to the stream, and timing and amount of land application of wastes. A certain amount of waste enters streams from inadequate waste management systems (overflowing lagoons, runoff from land application, runoff from uncovered confinement areas).

Delivery ratios for the swine production facilities were based on those used for the Flint Creek Watershed Project (Morgan County Soil and Water Conservation District, 1995). These ratios represent average conditions. A closer look at individual operations would be needed to refine the values. For example, the distance to the stream and management style would have to be considered.

Pollutant Loads From Horse Operations

The pollutant load from the horse operations identified within the Mud Creek Watershed was estimated using the following equation:

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NSn \quad \text{Equation (9)}$$

Where:

M	=	pollutant loading (tons/ year)
NA	=	number of animals (number/site)
WT	=	animal weight (pounds)
PR	=	pollutant production rate (lb pollutant/day/1000 lb live wt)
0.0001825	=	unit conversion factor
DR	=	delivery ratio (unitless)
NSn	=	number of sites of type n

The values used to calculate the pollutant loads for horses are given in Table 9. The number and type of horse sites within the Mud Creek Watershed were identified by the NPS inventory. The horse sites were identified as small, medium, or large and adjacent or nonadjacent to the stream. The (as excreted) PR for BOD5, TN, and TP were obtained from the NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The production rate for TSS was based on values derived from "Livestock Manure Characterization Values from the North Carolina Database" (Barker, et al., 1990). The delivery ratio for each pollutant was assumed to be the same as for beef cattle.

Table 9. Values Used to Estimate Pollutant Loads From Horse Operations.

Type of Operation		Units	Horse
Number of Animals per Site	Large	Number	25
	Medium	Number	15
	Small	Number	5
Animal Weight		lbs/animal	1000
Delivery Ratio - Adjacent to Stream	TSS	unitless	0.0437
	BOD5	unitless	0.0342
	TN	unitless	0.0444
	TP	unitless	0.0437
Delivery Ratio - Nonadjacent to Stream	TSS	unitless	0.0415
	BOD5	unitless	0.0286
	TN	unitless	0.0351
	TP	unitless	0.0415
Pollutant Production	TSS	lb/day/1000 lb live wt	6.2
	BOD5	lb/day/1000 lb live wt	1.36
	TN	lb/day/1000 lb live wt	0.31
	TP	lb/day/1000 lb live wt	0.16

Pollutant Loads From Poultry Operations

There were no poultry sites identified by TVA using aerial remote sensing techniques. The pollutant load model contains the information needed to compute pollutant loads from poultry operations in the event a poultry operation locates within the Mud Creek Watershed. The following equation was loaded into the model:

$$M = NA \times WT \times PR \times Cn \times Ct \times 0.0000005 \times DR \times PH \quad \text{Equation (10)}$$

Where:

- M = pollutant loading (tons/year)
- NA = number of birds (birds/house)
- WT = bird weight (pounds)
- PR = production rate (lb/day/1000 lb live weight)
- Cn = number of cycles (cycles per year)
- Ct = cycle time (days per cycle)
- 0.0000005 = unit conversion factor
- DR = delivery ratio (unitless)
- PH = number of poultry houses

The values loaded into the model to calculate the site pollutant coefficients for poultry houses are listed in Table 10. The broiler PR for TN, phosphorus, TSS, and BOD5 for poultry flocks that use a litter system were based on data in the 1996 NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The number of birds per house assumes six flocks per year.

Delivery ratios were taken from the Flint Creek Watershed Study (Morgan County Soil and Water Conservation District, 1995). These delivery ratios were determined by dividing the expected amounts of pollutant in the pasture runoff by the total pollutant. Litter was estimated to be applied at 4 tons per acre on a 4 percent slope pasture. Nutrient runoff from pasture is based on studies by B. M. Hall (Hall, 1993). The edge of field runoff of nitrogen-phosphorous-potassium is 3.3-0.8-9.6 pounds per acre for pasture.

Table 10. Values Used to Estimate Pollutant Loads from Poultry Houses.

Type of Operation		Units	Broiler
Birds per House		Birds/house	3500
Bird Weight		pounds	2.5
Number of Cycles per Year		cycles/year	6
Cycle Time		days/cycle	45
Pollutant Production	TSS	lb/day/1000 lb live wt	20
	BOD5	lb/day/1000 lb live wt	5.1
	TN	lb/day/1000 lb live wt	1.1
	TP	lb/day/1000 lb live wt	0.34
Delivery Ratio	TSS	unitless	0.002
	BOD5	unitless	0.001
	TN	unitless	0.008
	TP	unitless	0.002

Nonpoint Source Inventory Summary

A NPS inventory is a geographic database of LU/LC and features that contribute or are suspected to contribute NPS pollution within a watershed. The database is generated from the interpretation of low-altitude, color-infrared aerial photography. A large amount of unique data was generated by the inventory for the Mud Creek Watershed. The data were loaded into and managed using ESRI's ARC/INFO. A copy of this ARC/INFO database was provided to the NCWRP. Appendix C contains a dictionary of the data contained in the ARC/INFO database. The data were loaded into a desktop GIS using ESRI's ArcView software. A copy of the desktop GIS was provided to NCWRP. The results of the NPS inventory are summarized here.

Land Use/Land Cover

Table 11 and Figures 2 and 3 show the general LU/LC for the Mud Creek Watershed. The predominant land cover is forest (44.6 percent) followed by pasture (13.4 percent), orchards (8.1 percent) and cropland (3.2 percent). Commercial and industrial land use was identified on 5.9 percent of the landscape. Commercial and industrial use covers nearly half (47.7 percent) of the Mud Creek (05) Watershed and Bat Fork (0501) Watershed (42.7 percent). Not surprisingly, the watersheds with the greatest areas of 25 percent slope or steeper were dominated by forest cover (Figure 4). Twenty percent of the Mud Creek Watershed is characterized by low, medium, or high density residential use. The watersheds with the greatest percentage of their landscape in residential use includes Wash Creek (0601) with 53.9 percent, Mud Creek (06) with 54.0 percent, Brittain Creek (0401) with 51.7 percent, and Shepherd Creek (0701) with 38.1 percent. Two hundred acres of wetlands were identified in Lower Mud Creek (01) or 3.7 percent of the watershed. Mud Creek (05) and Bat Fork (0502) Watersheds have 82 acres and 64 acres of wetlands respectively. Twenty percent of the total cropland is located in the Devils Fork (050201) Watershed. Twenty-seven percent of all pasture is located in the Clear Creek (0301) and Devils Fork (050201) Watersheds. Table 12 shows a breakdown of pasture by condition as determined by the photo interpreter. Eighty-eight percent of all pasture was characterized as being in fair condition while 7 percent was considered heavily overgrazed.

Table 11. General Land Use/Land Cover for the Mud Creek Watershed.

Watershed	ID	General Land Use/Land Cover Class (Acres)													
		Total	Residential	Commercial	Industrial	Transportation	Cropland	Pasture	Orchards	Forest	Mining	Disturbed Area	Wetlands	Water	Other
Lower Mud Creek	01	5427	1272	337	146	112	299	573	1	2219	6	6	200	37	219
Mud Creek	02	1394	294	80	15	68	17	297	0	441	39	3	59	26	55
Featherstone Creek	0201	2599	492	23	0	15	0	149	4	1872	0	0	1	13	30
Mud Creek	03	587	162	92	41	7	0	109	0	91	0	0	30	8	47
Clear Creek	0301	7822	1507	321	69	109	240	1348	506	3305	66	15	39	51	246
Clear Creek	0302	4228	397	17	0	0	153	588	354	2692	0	2	0	9	16
Henderson Creek	030201	2603	491	75	20	6	131	532	491	789	0	0	0	13	55
Clear Creek	0303	3538	251	16	0	0	104	533	751	1854	0	0	0	16	13
Lewis Creek	030301	4153	552	126	0	0	209	596	1342	1204	0	5	5	12	102
Clear Creek	0304	4286	195	3	0	0	16	434	775	2806	0	2	0	6	49
Cox Creek	030401	1825	61	3	0	2	7	130	145	1476	0	0	0	1	0
Mud Creek	04	88	25	1	8	0	0	32	0	4	0	0	2	0	16
Brittain Creek	0401	2195	1135	218	4	12	0	64	0	713	0	0	20	11	18
Mud Creek	05	593	144	211	72	22	4	32	0	13	0	0	82	0	13
Bat Fork	0501	307	33	127	4	17	0	59	0	29	0	0	29	1	8
Bat Fork	0502	1262	256	226	8	67	53	247	1	138	0	0	64	3	199
Devils Fork	050201	5476	1308	219	32	54	466	1213	890	1104	0	0	37	47	106
Bat Fork	0503	4074	992	440	56	66	304	760	530	782	3	1	3	22	115
King Creek	050301	4859	1220	479	44	17	106	495	0	2312	0	0	16	69	101
Mud Creek	06	285	154	22	0	0	27	30	0	48	0	0	0	2	2
Wash Creek	0601	1378	742	252	6	0	0	19	0	337	0	0	0	4	18
Mud Creek	07	4591	1117	148	0	3	48	487	22	2652	0	2	2	44	66
Shepherd Creek	0701	3246	1236	205	1	0	11	342	2	1392	0	1	2	44	10
Upper Mud Creek	08	3504	337	44	0	7	131	497	0	2391	0	4	0	22	71
Little Mud Creek	0801	1762	116	37	0	13	0	72	12	1469	0	0	0	43	0
Total		72,082	14,489	3,722	526	597	2,326	9,638	5,826	32,133	114	41	591	504	1,575

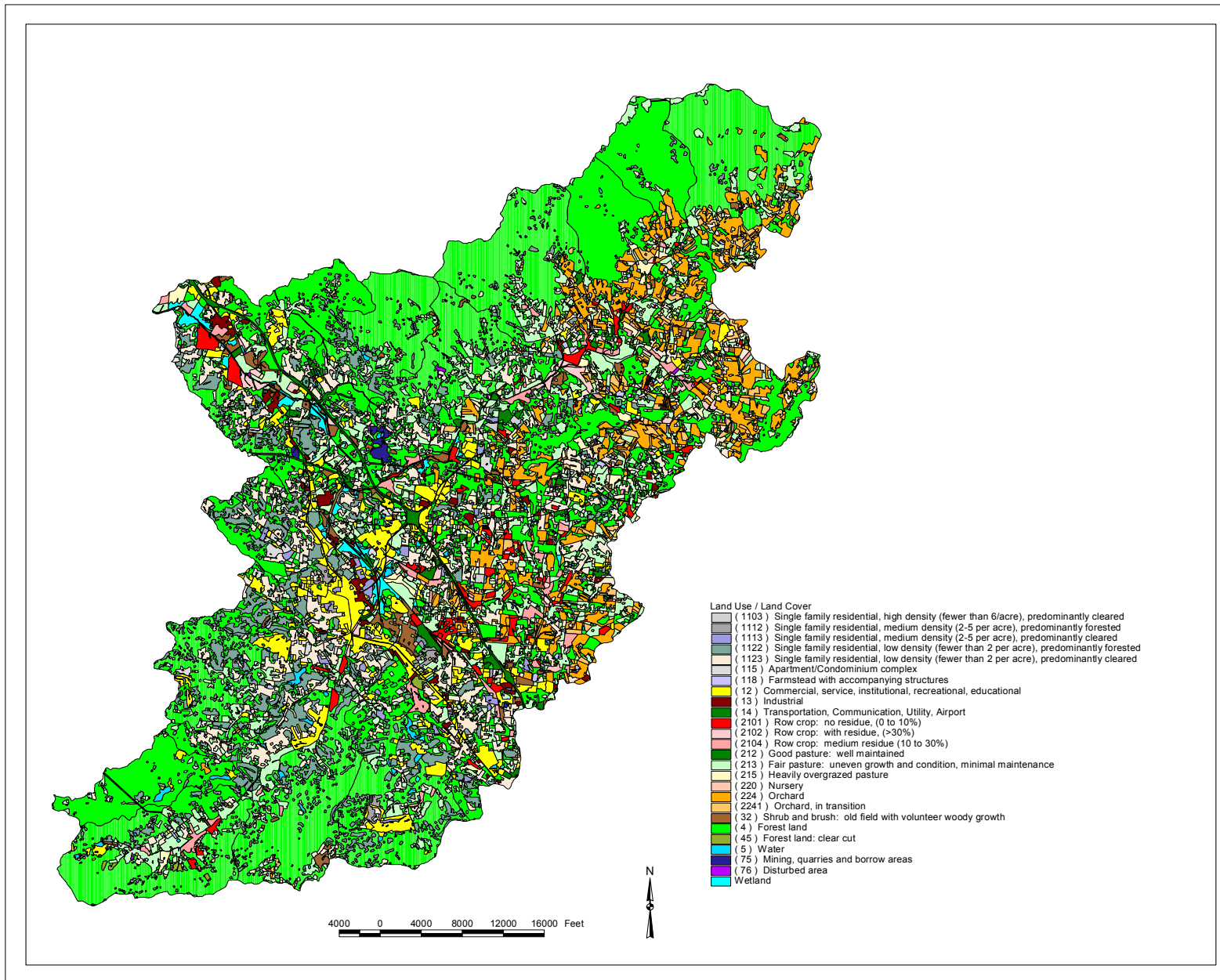


Figure 2. Distribution of land use/land cover for the Mud Creek Watershed.

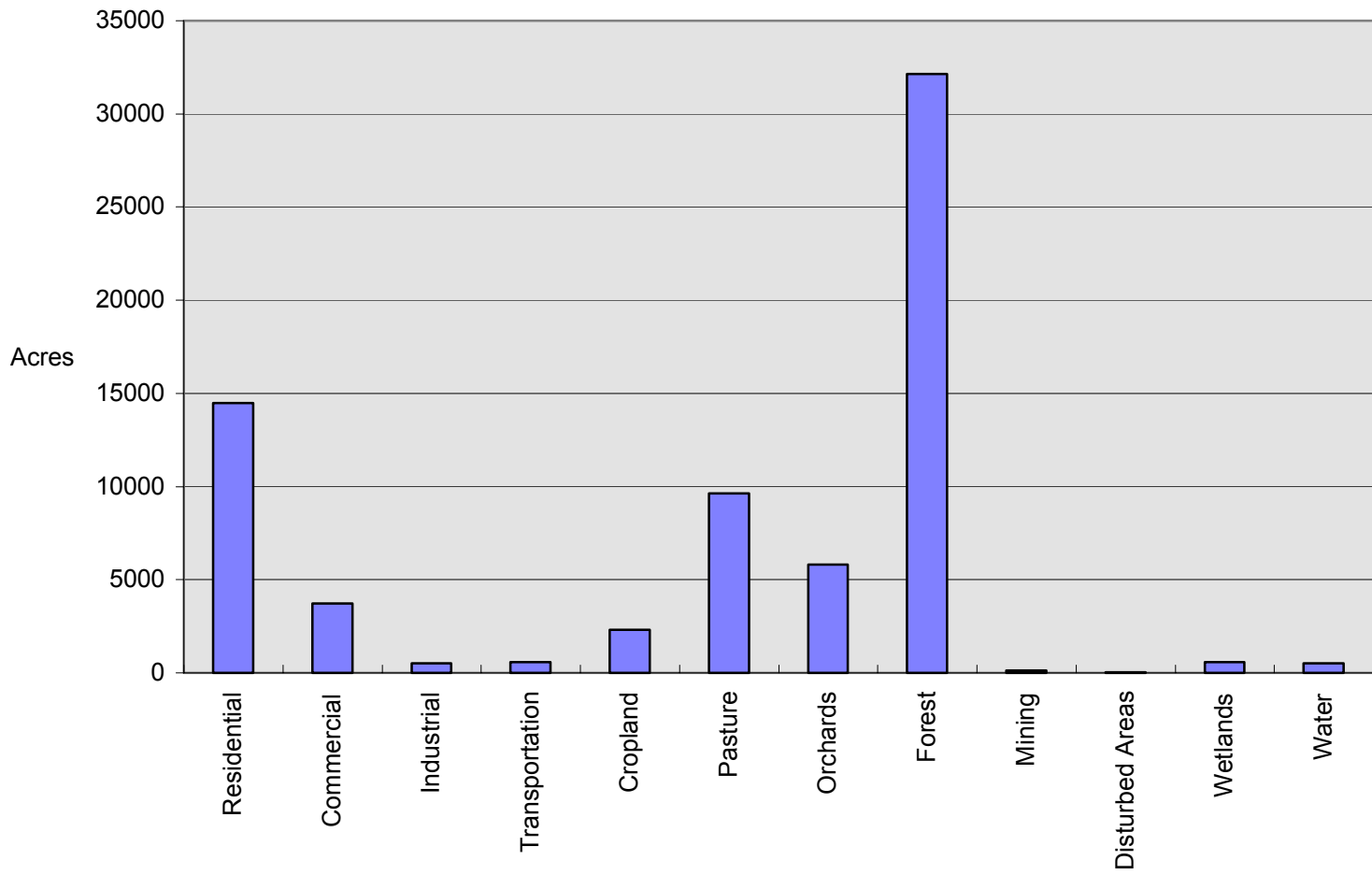


Figure 3. General land use/land cover for the Mud Creek Watershed.

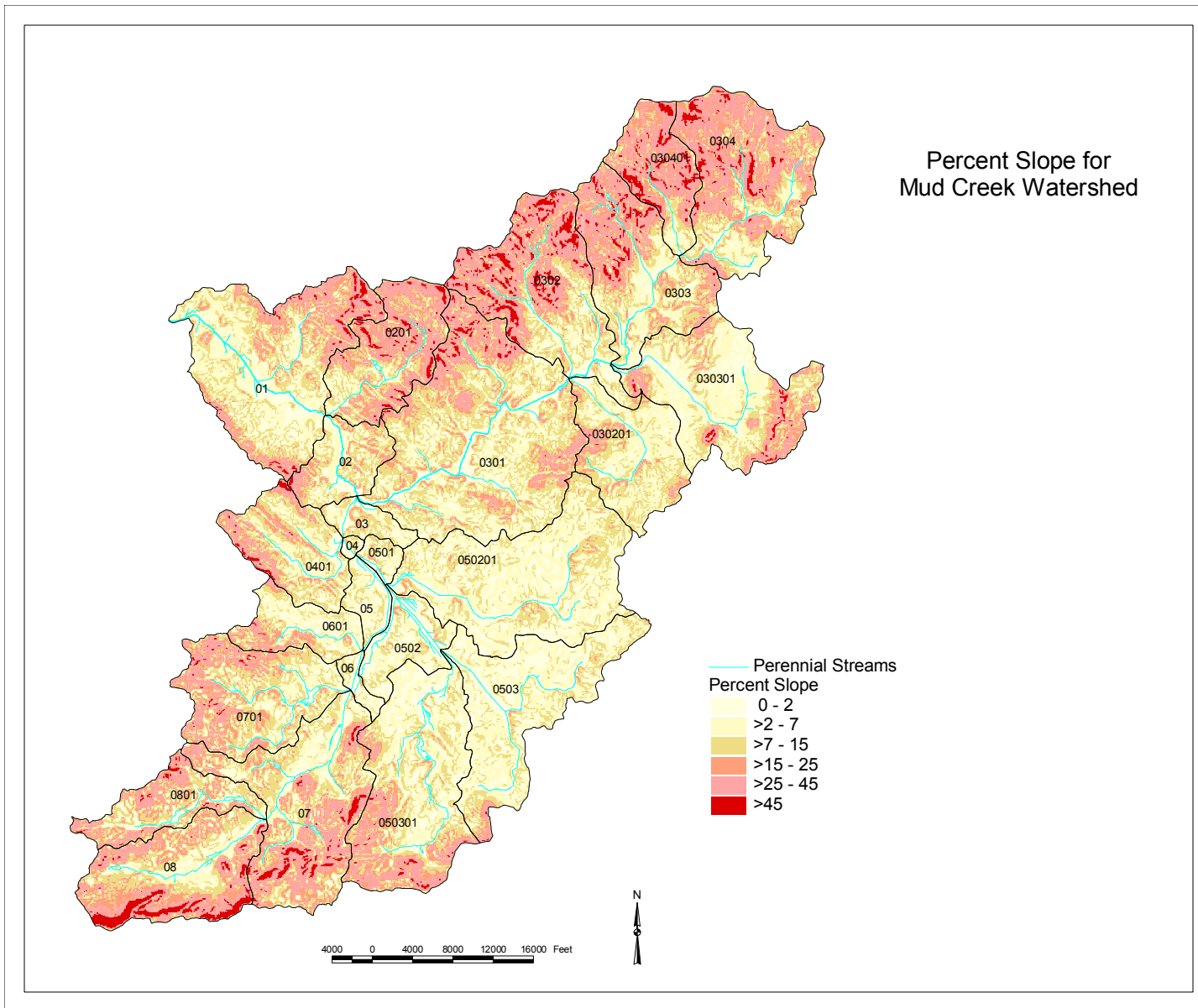


Figure 4. Percent slope ranges of landscape within the Mud Creek Watershed.

Table 12. Condition of Pasture Within the Mud Creek.

Watershed			Pasture Condition (Acres)				
	ID	Total Area	Good	Fair	Heavily Overgrazed	Poor	Feedlots
Lower Mud Creek	01	5427.5	47.0	463.3	63.2	0	0
Mud Creek	02	1393.7	8.6	258.9	29.1	0	0
Featherstone Creek	0201	2599.5	38.1	104.3	7.2	0	0
Mud Creek	03	587.1	0	108.8	0	0	0
Clear Creek	0301	7821.8	103.5	1165.0	79.1	0	0
Clear Creek	0302	4228.1	34.9	476.8	76.0	0	0
Henderson Creek	030201	2603.1	12.0	444.3	76.0	0	0
Clear Creek	0303	3537.7	15.5	421.7	95.5	0	0
Lewis Creek	030301	4152.8	23.4	520.8	51.8	0	0
Clear Creek	0304	4286.0	1.6	412.3	19.7	0	0
Cox Creek	030401	1825.4	0	130.1	0	0	0
Mud Creek	04	88.4	0	31.9	0	0	0
Brittain Creek	0401	2195.0	0	63.8	0	0	0
Mud Creek	05	592.5	4.5	27.3	0	0	0
Bat Fork	0501	307.5	0	58.5	0	0	0
Bat Fork	0502	1261.8	7.5	197.9	42.0	0	0
Devils Fork	050201	5475.8	105.7	1056.6	50.5	0	0
Bat Fork	0503	4073.7	72.1	664.0	23.8	0	0
King Creek	050301	4858.7	0	478.3	16.5	0	0
Mud Creek	06	284.8	0	29.7	0	0	0
Wash Creek	0601	1377.6	0	18.7	0	0	0
Mud Creek	07	4591.0	0	475.1	12.0	0	0
Shepherd Creek	0701	3246.5	0	314.6	27.2	0	0
Upper Mud Creek	08	3503.7	3.5	454.8	38.8	0	0
Little Mud Creek	0801	1762.4	0	66.6	5.6	0	0
Total		72082.1	477.9	8444.1	714.0	0	0

Livestock Operations

Table 13 shows the numbers and type of beef cattle operations within the Mud Creek Watershed. There were 87 beef cattle sites identified; 54 percent were adjacent to a perennial or intermittent stream. Eighty percent of all cattle operations are classified as small. The classification of small, medium, or large as reported here is a relative relationship among sites within the Mud Creek Watershed. The classification is assigned by the photo interpreter for the purpose of comparing potential water quality impacts among sites and watersheds. It is not consistent with any regulatory definitions regarding livestock operations. The location of all livestock operations is shown on Figure 5. Seventeen watersheds have at least one cattle operation. There were no

Table 13. Number and Type of Beef Cattle Sites Within the Mud Creek Watershed.

Watershed	ID	Number of Beef Cattle Sites								
		Total	Adjacent to Stream				Nonadjacent to Stream			
			Large	Medium	Small	Subtotal	Large	Medium	Small	Subtotal
Lower Mud Creek	01	6	0	4	1	5	0	0	1	1
Mud Creek 2	02	4	0	2	0	2	0	0	2	2
Featherstone Creek	0201	0	0	0	0	0	0	0	0	0
Mud Creek 3	03	0	0	0	0	0	0	0	0	0
Clear Creek 1	0301	15	0	1	8	9	0	0	6	6
Clear Creek 2	0302	6	0	1	0	1	0	0	5	5
Henderson Creek	030201	7	0	1	3	4	0	1	2	3
Clear Creek 3	0303	5	0	2	2	4	0	0	1	1
Lewis Creek	030301	7	0	1	2	3	0	0	4	4
Clear Creek 4	0304	4	0	0	3	3	0	0	1	1
Cox Creek	030401	0	0	0	0	0	0	0	0	0
Mud Creek 4	04	0	0	0	0	0	0	0	0	0
Brittain Creek	0401	0	0	0	0	0	0	0	0	0
Mud Creek 5	05	0	0	0	0	0	0	0	0	0
Bat Fork 1	0501	1	0	0	1	1	0	0	0	0
Bat Fork 2	0502	3	0	1	2	3	0	0	0	0
Devils Fork	050201	7	0	1	1	2	0	0	5	5
Bat Fork 3	0503	5	0	1	1	2	0	0	3	3
King Creek	050301	1	0	0	0	0	0	0	1	1
Mud Creek 6	06	1	0	0	1	1	0	0	0	0
Wash Creek	0601	0	0	0	0	0	0	0	0	0
Mud Creek 7	07	1	0	0	1	1	0	0	0	0
Shepherd Creek	0701	5	0	0	2	2	0	0	3	3
Upper Mud Creek	08	9	0	1	3	4	0	0	5	5
Little Mud Creek	0801	0	0	0	0	0	0	0	0	0
Total		87	0	16	31	47	0	1	39	40

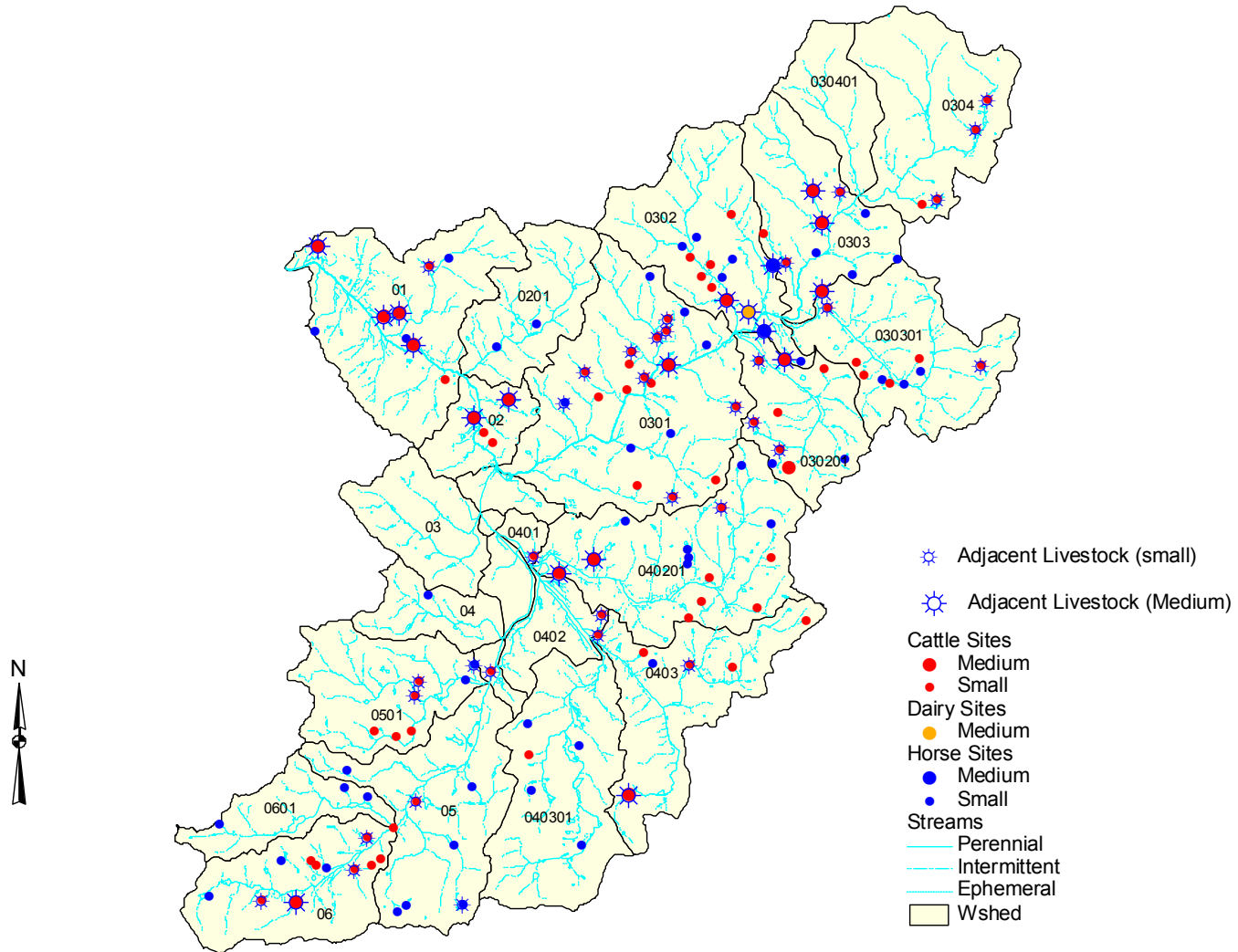


Figure 5. Location of livestock operations within the Mud Creek Watershed.

swine or poultry operations identified. One medium-sized dairy was identified by the photo analyst in the Clear Creek Watershed (0302) and it is adjacent to an intermittent stream; but, it is not active according to the SWCD staff. There were 54 horse sites identified, most (49) of which are small and non-adjacent to streams (Table 14).

Streambank Erosion

The remote sensing process identified 118.8 miles of perennial streams and 249.3 miles of intermittent streams within the Mud Creek Watershed. Total stream length by type for each watershed is shown in Table 15. Excessive streambank erosion was identified along 14 percent of perennial streams while 7 percent of intermittent streambanks are eroded. The watersheds with the largest percentages of eroding banks along perennial streams include Lewis Creek (030301) with 37.4 percent, Mud Creek (02) with 27.8 percent, Featherstone Creek (0201) with 26.1 percent, Henderson Creek (030201) with 25.4 percent, and Upper Mud Creek (08) with 24.8 percent. More than 121 miles of channelized streams were identified (Table 16).

Livestock Access to Streams

Animal access, probable animal access, and potential animal access to streams were identified by the photo analyst (Table 17). Livestock are directly accessing 901 feet or 0.05 percent of perennial and intermittent streams throughout the Mud Creek Watershed. Sixty-three percent of all stream length accessed by livestock occurs in the Lower Mud Creek Watershed (01) and the Clear Creek Watershed (0303). Livestock are probably accessing an additional 58,583 feet or 3.0 percent of streams within the Mud Creek Watershed. Potential livestock access was identified for another 42,739 feet or 2.2 percent of streams. Bat Fork Watershed (0502) had the greatest amount of probable animal access at 10,734 feet or almost 19 percent of perennial and intermittent streams in that watershed.

Table 14. Number and Type of Horse Sites Within the Mud Creek Watershed.

Watershed	ID	Number of Horse Sites									
		Total	Adjacent to Stream				Nonadjacent to Stream				
			Large	Medium	Small	Subtotal	Large	Medium	Small	Subtotal	
Lower Mud Creek	01	3	0	0	0	0	0	0	0	3	3
Mud Creek 2	02	0	0	0	0	0	0	0	0	0	0
Featherstone Creek	0201	2	0	0	0	0	0	0	0	2	2
Mud Creek 3	03	0	0	0	0	0	0	0	0	0	0
Clear Creek 1	0301	6	0	0	1	1	0	0	5	5	5
Clear Creek 2	0302	7	0	2	0	2	0	0	5	5	5
Henderson Creek	030201	3	0	0	0	0	0	0	3	3	3
Clear Creek 3	0303	4	0	0	0	0	0	0	4	4	4
Lewis Creek	030301	3	0	0	0	0	0	0	3	3	3
Clear Creek 4	0304	0	0	0	0	0	0	0	0	0	0
Cox Creek	030401	0	0	0	0	0	0	0	0	0	0
Mud Creek 4	04	0	0	0	0	0	0	0	0	0	0
Brittain Creek	0401	0	0	0	0	0	0	0	0	0	0
Mud Creek 5	05	0	0	0	0	0	0	0	0	0	0
Bat Fork 1	0501	0	0	0	0	0	0	0	0	0	0
Bat Fork 2	0502	0	0	0	0	0	0	0	0	0	0
Devils Fork	050201	6	0	0	0	0	0	0	6	6	6
Bat Fork 3	0503	1	0	0	0	0	0	0	1	1	1
King Creek	050301	4	0	0	0	0	0	0	4	4	4
Mud Creek 6	06	0	0	0	0	0	0	0	0	0	0
Wash Creek	0601	1	0	0	0	0	0	0	1	1	1
Mud Creek 7	07	6	0	0	1	1	0	0	5	5	5
Shepherd Creek	0701	2	0	0	1	1	0	0	1	1	1
Upper Mud Creek	08	3	0	0	0	0	0	0	3	3	3
Little Mud Creek	0801	3	0	0	0	0	0	0	3	3	3
Total		54	0	2	3	5	0	0	49	49	49

Table 15. Stream Types and Percent of Eroding Streambanks Within the Mud Creek Watershed.

Watershed	ID	Stream Type in Feet				
		Perennial	% Eroded	Intermittent	% Eroded	Ephemeral
Lower Mud Creek	01	43,769	11.6	140,219	6.3	4,921
Mud Creek 2	02	12,146	27.8	28,526	14.2	1,389
Featherstone Creek	0201	18,863	26.1	55,882	0.5	559
Mud Creek 3	03	7,561	18.7	4,023	0.0	1,252
Clear Creek 1	0301	61,111	17.9	147,371	7.0	8,273
Clear Creek 2	0302	38,792	14.1	79,473	3.8	5,545
Henderson Creek	030201	20,187	25.4	54,446	10.5	5,905
Clear Creek 3	0303	32,699	13.7	51,178	10.1	3,122
Lewis Creek	030301	25,268	37.4	93,986	9.3	4,313
Clear Creek 4	0304	36,623	11.0	44,672	15.1	990
Cox Creek	030401	10,681	12.1	21,788	6.0	0
Mud Creek 4	04	2,208	12.3	0	0	0
Brittain Creek	0401	20,144	5.4	24,611	3.1	327
Mud Creek 5	05	15,607	0.0	2,006	0.0	189
Bat Fork 1	0501	5,172	0.0	3,023	0.0	68
Bat Fork 2	0502	38,565	1.8	19,423	11.5	1,275
Devils Fork	050201	36,181	17.7	145,564	9.3	8,384
Bat Fork 3	0503	35,925	10.1	84,520	8.6	2,419
King Creek	050301	41,095	6.4	73,523	7.9	1,275
Mud Creek 6	06	6,332	5.1	3,137	0.0	215
Wash Creek	0601	11,352	13.5	25,736	2.5	958
Mud Creek 7	07	39,090	9.4	68,921	2.4	1,520
Shepherd Creek	0701	31,613	11.6	50,770	3.5	2,629
Upper Mud Creek	08	23,509	24.8	69,360	4.8	3,018
Little Mud Creek	0801	12,891	0.0	24,099	0.0	912
Total		627,384	14.0	1,316,257	6.9	59,458

Table 16. Length of Channelized Streams Within the Mud Creek Watershed.

Watershed Name	Watershed ID	Length of Intermittent and Perennial Channelized Stream (feet)					Total
		0-1 Order	2 Order	3 Order	4 Order	5 Order	
Lower Mud Creek	01	49,547.12	9,606.89	1,814.41	0.00	0.00	60,968.42
Mud Creek 2	02	7,367.72	0.00	0.00	0.00	0.00	7,367.72
Featherstone Creek	0201	936.41	0.00	0.00	0.00	0.00	936.41
Mud Creek 3	03	3,502.07	0.00	0.00	0.00	3,429.74	6,931.81
Clear Creek 1	0301	29,023.20	4,452.83	895.36	11,810.40	0.00	46,181.79
Clear Creek 2	0302	15,210.63	3,908.05	7,140.67	9,718.15	0.00	35,977.50
Henderson Creek	030201	16,842.61	0.00	8,305.65	0.00	0.00	25,148.26
Clear Creek 3	0303	9,447.01	3,285.43	0.00	5,719.12	0.00	18,451.56
Lewis Creek	030301	44,802.10	3,861.39	12,524.47	0.00	0.00	61,187.96
Clear Creek 4	0304	6,415.89	3,603.81	0.00	0.00	0.00	10,019.70
Cox Creek	030401	1,819.03	0.00	0.00	0.00	0.00	1,819.03
Mud Creek 4	04	0.00	0.00	0.00	0.00	2,207.59	2,207.59
Brittain Creek	0401	4,228.73	2,114.27	4,260.38	0.00	0.00	10,603.38
Mud Creek 5	05	3,113.53	0.00	0.00	12,158.02	0.00	15,271.55
Bat Fork 1	0501	1,259.17	0.00	0.00	4,799.09	0.00	6,058.26
Bat Fork 2	0502	31,923.97	13,023.41	55.77	8,453.78	0.00	53,456.93
Devils Fork	050201	70,058.90	12,696.24	17,072.19	0.00	0.00	99,827.33
Bat Fork 3	0503	50,382.76	11,721.24	12,777.99	0.00	0.00	74,881.99
King Creek	050301	19,438.25	1,154.96	12,868.86	0.00	0.00	33,462.07
Mud Creek 6	06	2,406.21	855.99	0.00	3,515.77	0.00	6,777.97
Wash Creek	0601	2,709.10	889.17	2,010.49	0.00	0.00	5,608.76
Mud Creek 7	07	12,737.49	1,720.71	0.00	8,766.32	0.00	23,224.52
Shepherd Creek	0701	7,449.87	700.63	2,817.92	0.00	0.00	10,968.42
Upper Mud Creek	08	16,286.75	3,898.23	2,125.42	0.00	0.00	22,310.40
Little Mud Creek	0801	0.00	0.00	0.00	0.00	0.00	0.00
Total		406,908.52	77,493.25	84,669.58	64,940.65	5,637.33	639,649.33

Table 17. Animal Access to Perennial and Intermittent Streams Within the Mud Creek Watershed.

Watershed	ID	Animal Access		Probable Animal Access		Potential Animal Access	
		feet	percent	feet	percent	feet	percent
Lower Mud Creek	01	262	0.14	5,211	2.83	3,933	2.14
Mud Creek 2	02	0	0.00	4,060	9.98	1,812	4.46
Featherstone Creek	0201	0	0.00	0	0.00	0	0.00
Mud Creek 3	03	0	0.00	0	0.00	0	0.00
Clear Creek 1	0301	79	0.04	6,050	2.90	9,097	4.36
Clear Creek 2	0302	59	0.05	3,306	2.80	4,000	3.38
Henderson Creek	030201	0	0.00	4,661	6.25	256	0.34
Clear Creek 3	0303	308	0.37	8,949	10.67	4,655	5.55
Lewis Creek	030301	9	0.01	1,730	1.45	2,587	2.17
Clear Creek 4	0304	0	0.00	5,102	6.28	1,227	1.51
Cox Creek	030401	0	0.00	0	0.00	0	0.00
Mud Creek 4	04	0	0.00	0	0.00	0	0.00
Brittain Creek	0401	0	0.00	0	0.00	0	0.00
Mud Creek 5	05	0	0.00	0	0.00	0	0.00
Bat Fork 1	0501	0	0.00	0	0.00	291	3.55
Bat Fork 2	0502	66	0.11	10,734	18.51	373	0.64
Devils Fork	050201	31	0.02	3,229	1.78	2,017	1.11
Bat Fork 3	0503	21	0.02	2,687	2.23	256	0.21
King Creek	050301	0	0.00	0	0.00	1,051	0.92
Mud Creek 6	06	0	0.00	0	0.00	0	0.00
Wash Creek	0601	0	0.00	0	0.00	0	0.00
Mud Creek 7	07	24	0.02	1,140	1.06	3,330	3.08
Shepherd Creek	0701	22	0.03	1,724	2.09	2,050	2.49
Upper Mud Creek	08	20	0.02	0	0.00	5,804	6.25
Little Mud Creek	0801	0	0.00	0	0.00	0	0.00
Total		901	0.05	58,583	3.01	42,739	2.20

Riparian Buffer Condition

The riparian buffers along the right and left descending banks of perennial streams were classified as either adequate, marginal, or inadequate in their ability to remove pollutants from runoff. Tables 18 and 19 show the length of each riparian buffer class by watershed.

Approximately 17 percent of the perennial streams within the Mud Creek Watershed have an adequate riparian buffer along both the right and left descending banks. Another 26 percent of streams have a marginal riparian buffer on both sides of the stream. Inadequate riparian buffers occur along both banks of 56 percent of streams. Clear Creek Watershed (0301) has the greatest length of streams with inadequate riparian buffers, but accounts for only 5.4 percent of total stream length in the Mud Creek Watershed. Only two watersheds, Cox Creek (30401) and Little Mud Creek (0801), have less than 30 percent of perennial streams with inadequate riparian buffers (Figures 6 and 7).

Dump Sites and Pesticide Loading Stations

Dump sites were identified during the remote sensing process and locations are depicted on Figure 8. A total of 165 dump sites were located in twenty-one watersheds (Table 20). Clear Creek Watershed (0301) had the largest number of dump sites (25), followed by Clear Creek Watershed (0304) with 16, Devils Fork Watershed (050201) with 15, and Bat Fork Watershed (0503) and Henderson Creek Watershed (030201) with 13 sites each.

The general location of pesticide loading stations was provided by the District Conservationist; however, the exact location was interpreted from project photography based on the shape and size of structures and the presence of related features (e.g., orchards and access roads). The watersheds with the largest combined acreage of cropland and orchards had the greatest number of pesticide loading stations. Devils Fork Watershed (050201) which contains 1,356 acres of cropland and orchards has 5 pesticide stations. Lewis Creek Watershed (030301) and Clear Creek Watershed (0303) which have significant acreage in orchards have 4 stations each.

Table 18. Riparian Buffer Classification for the Right Descending Bank of Perennial Streams in the Mud Creek Watershed.

Watershed Name	Watershed ID	Riparian Buffer Classification for the Right Bank						Total Length (feet)
		Adequate		Marginal		Inadequate		
		(feet)	(% of total)	(feet)	(% of total)	(feet)	(% of total)	
Lower Mud Creek	01	6,140	14.0	11,283	25.8	26,355	60.2	43,778
Mud Creek 2	02	2,124	17.4	2,457	20.1	7,640	62.5	12,221
Featherstone Creek	0201	2,158	10.3	8,632	41.2	10,143	48.5	20,933
Mud Creek 3	03	546	7.2	3,634	48.1	3,380	44.7	7,560
Clear Creek 1	0301	6,430	10.6	15,872	26.3	38,150	63.1	60,452
Clear Creek 2	0302	5,714	14.8	8,499	22.0	24,361	63.2	38,574
Henderson Creek	030201	486	2.4	3,606	17.9	16,090	79.7	20,182
Clear Creek 3	0303	8,404	25.3	6,242	18.8	18,515	55.8	33,161
Lewis Creek	030301	718	2.8	2,827	11.0	22,225	86.2	25,770
Clear Creek 4	0304	4,211	11.5	11,931	32.5	20,527	56.0	36,669
Cox Creek	030401	2,661	24.9	5,799	54.3	2,219	20.8	10,679
Mud Creek 4	04	0.00	0.00	0.00	0.00	2,207	100	2,207
Brittain Creek	0401	2,138	10.6	5,410	26.9	12,591	62.5	20,139
Mud Creek 5	05	1,841	11.8	4,356	27.9	9,407	60.3	15,604
Bat Fork 1	0501	1,193	23.1	2,370	45.8	1,608	31.1	5,171
Bat Fork 2	0502	4,977	12.9	11,572	30.0	22,007	57.1	38,556
Devils Fork	050201	2,166	6.2	3,509	10.1	29,142	83.7	34,817
Bat Fork 3	0503	2,765	7.8	8,619	24.4	24,006	67.8	35,390
King Creek	050301	15,180	32.6	12,672	27.2	18,705	40.2	46,557
Mud Creek 6	06	553	8.7	520	8.2	5,257	83.0	6,330
Wash Creek	0601	404	3.6	3,558	31.4	7,387	65.1	11,349
Mud Creek 7	07	9,331	22.0	17,463	41.2	15,626	36.8	42,420
Shepherd Creek	0701	5,413	15.3	10,379	29.2	19,703	55.5	35,495
Upper Mud Creek	08	2,894	12.8	4,792	21.2	14,884	65.9	22,570
Little Mud Creek	0801	12,206	68.4	2,104	11.8	3,547	19.9	17,857
Total		100,653	15.6	168,106	26.1	375,682	58.3	644,441

Table 19. Riparian Buffer Classification for the Left Descending Bank of Perennial Streams in the Mud Creek Watershed.

Watershed Name	Watershed ID	Riparian Buffer Classification for the Left Bank						Total Length (feet)
		Adequate		Marginal		Inadequate		
		(feet)	(% of total)	(feet)	(% of total)	(feet)	(% of total)	
Lower Mud Creek	01	11,338	25.9	13,017	29.8	19,384	44.3	43,739
Mud Creek 2	02	3,333	27.4	4,941	40.6	3,886	32.0	12,160
Featherstone Creek	0201	3,193	15.0	7,861	37.0	10,201	48.0	21,255
Mud Creek 3	03	1,947	25.8	2,364	31.3	3,249	43.0	7,560
Clear Creek 1	0301	14,945	24.7	13,671	22.6	31,911	52.7	60,527
Clear Creek 2	0302	8,023	20.7	6,727	17.4	24,016	62.0	38,766
Henderson Creek	030201	661	3.3	4,770	23.6	14,751	73.1	20,182
Clear Creek 3	0303	10,582	31.6	5,156	15.4	17,775	53.0	33,513
Lewis Creek	030301	3,065	11.9	1,220	4.7	21,508	83.4	25,793
Clear Creek 4	0304	14,983	40.9	7,731	21.1	13,898	38.0	36,612
Cox Creek	030401	3,215	30.1	5,437	50.9	2,026	19.0	10,678
Mud Creek 4	04	70	3.2	0	0.0	2,137	96.8	2,207
Brittain Creek	0401	789	3.9	4,631	23.0	14,719	73.1	20,139
Mud Creek 5	05	3,401	21.8	5,453	34.9	6,749	43.3	15,603
Bat Fork 1	0501	1,350	26.1	763	14.8	3,058	59.1	5,171
Bat Fork 2	0502	7,354	19.1	6,634	17.2	24,567	63.7	38,555
Devils Fork	050201	2,726	7.8	6,184	17.8	25,907	74.4	34,817
Bat Fork 3	0503	4,263	12.0	9,115	25.8	22,011	62.2	35,389
King Creek	050301	8,439	18.0	17,880	38.2	20,458	43.7	46,777
Mud Creek 6	06	1,082	17.1	942	14.9	4,306	68.0	6,330
Wash Creek	0601	0	0.0	2,835	25.0	8,515	75.0	11,350
Mud Creek 7	07	6,502	15.5	15,786	37.7	19,625	46.8	41,913
Shepherd Creek	0701	1,116	3.1	12,158	33.5	22,991	63.4	36,265
Upper Mud Creek	08	1,775	7.9	8,647	38.3	12,156	53.8	22,578
Little Mud Creek	0801	9,805	50.2	6,590	36.4	2,426	13.4	18,101
Total		123,237	19.1	170,513	26.4	352,230	54.5	645,980

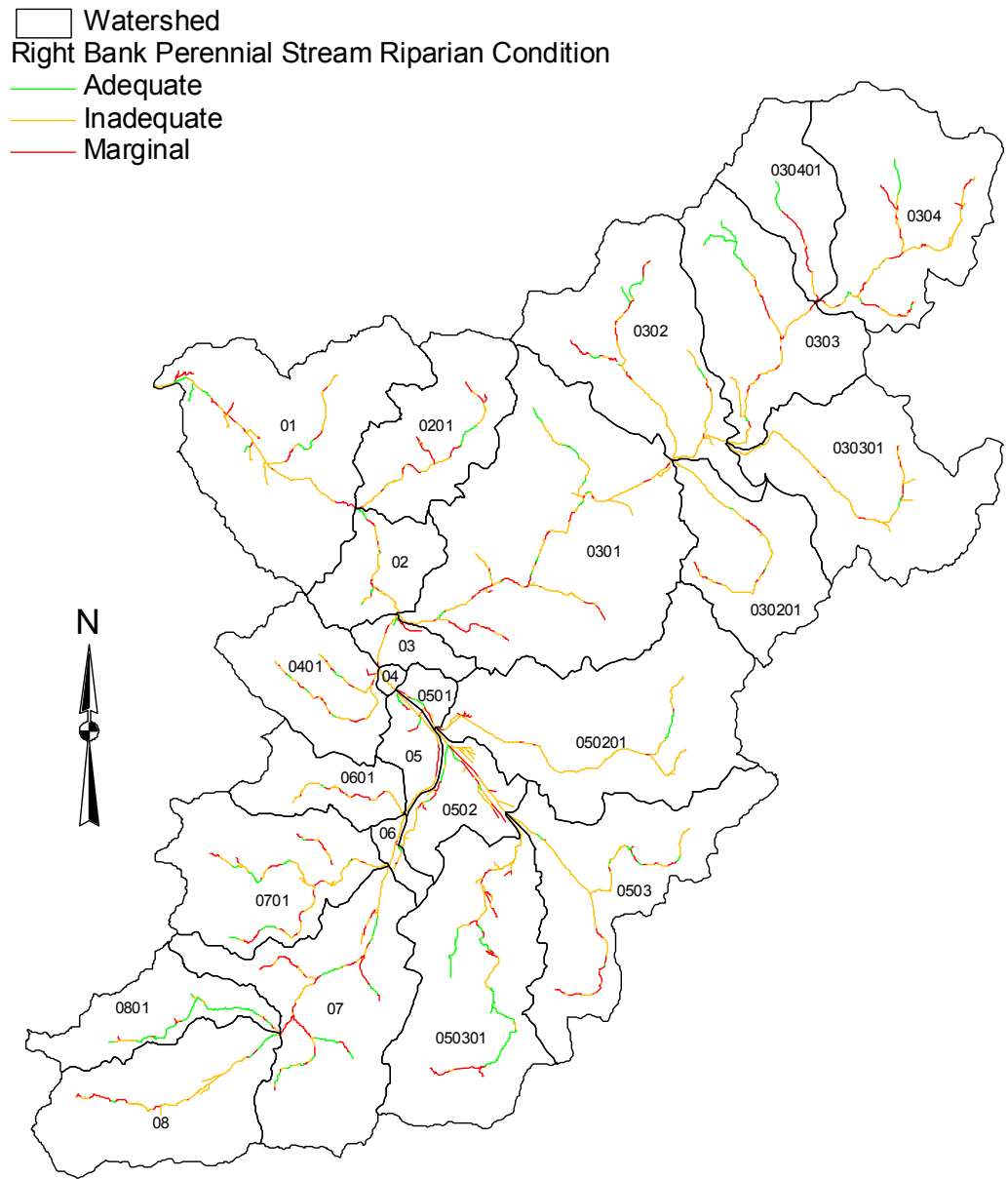


Figure 6. Condition of the riparian buffer along the right descending bank of perennial streams in the Mud Creek Watershed.

Left Bank Perennial Stream Riparian Condition

- Adequate
- Inadequate
- Marginal
- Watershed

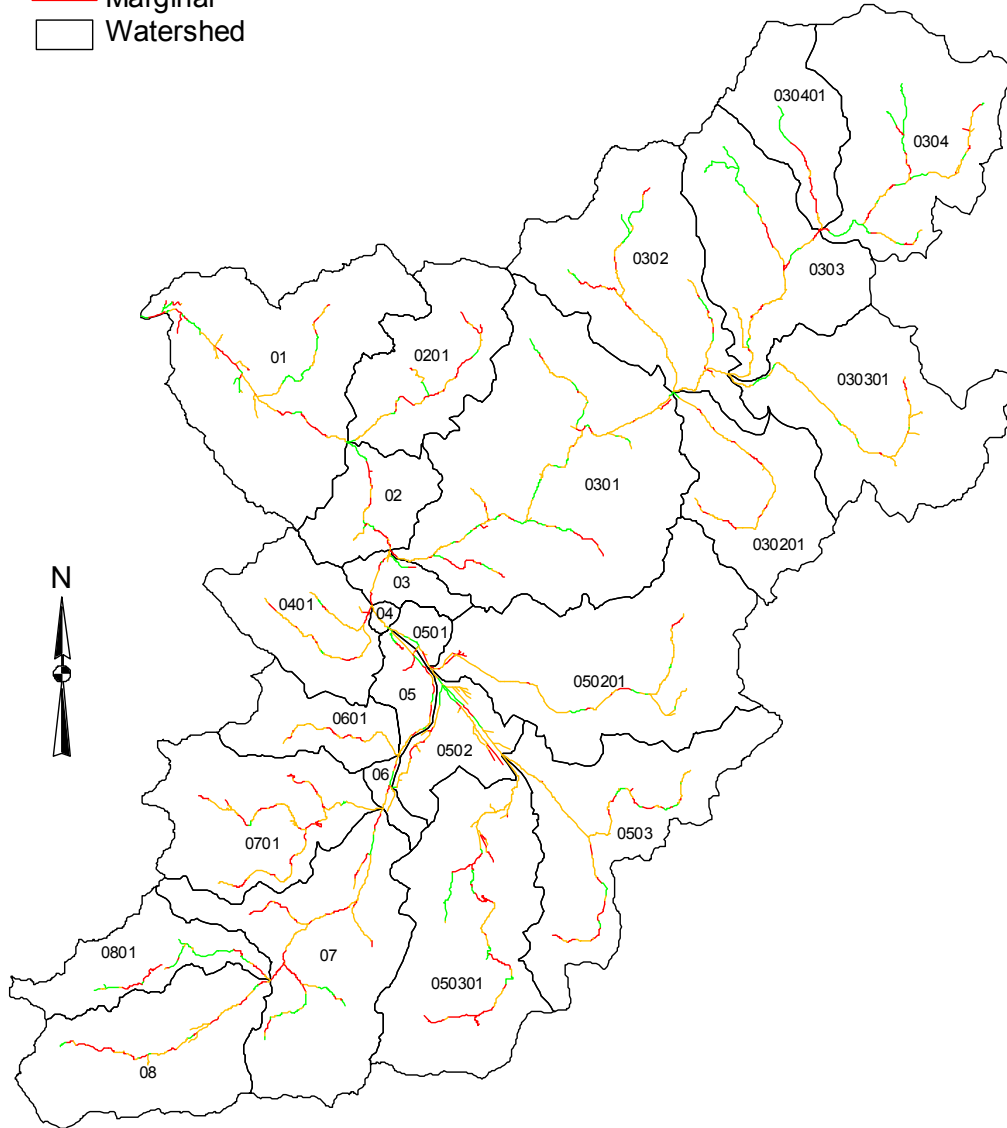


Figure 7. Condition of the riparian buffer along the left descending bank of perennial streams in the Mud Creek Watershed.

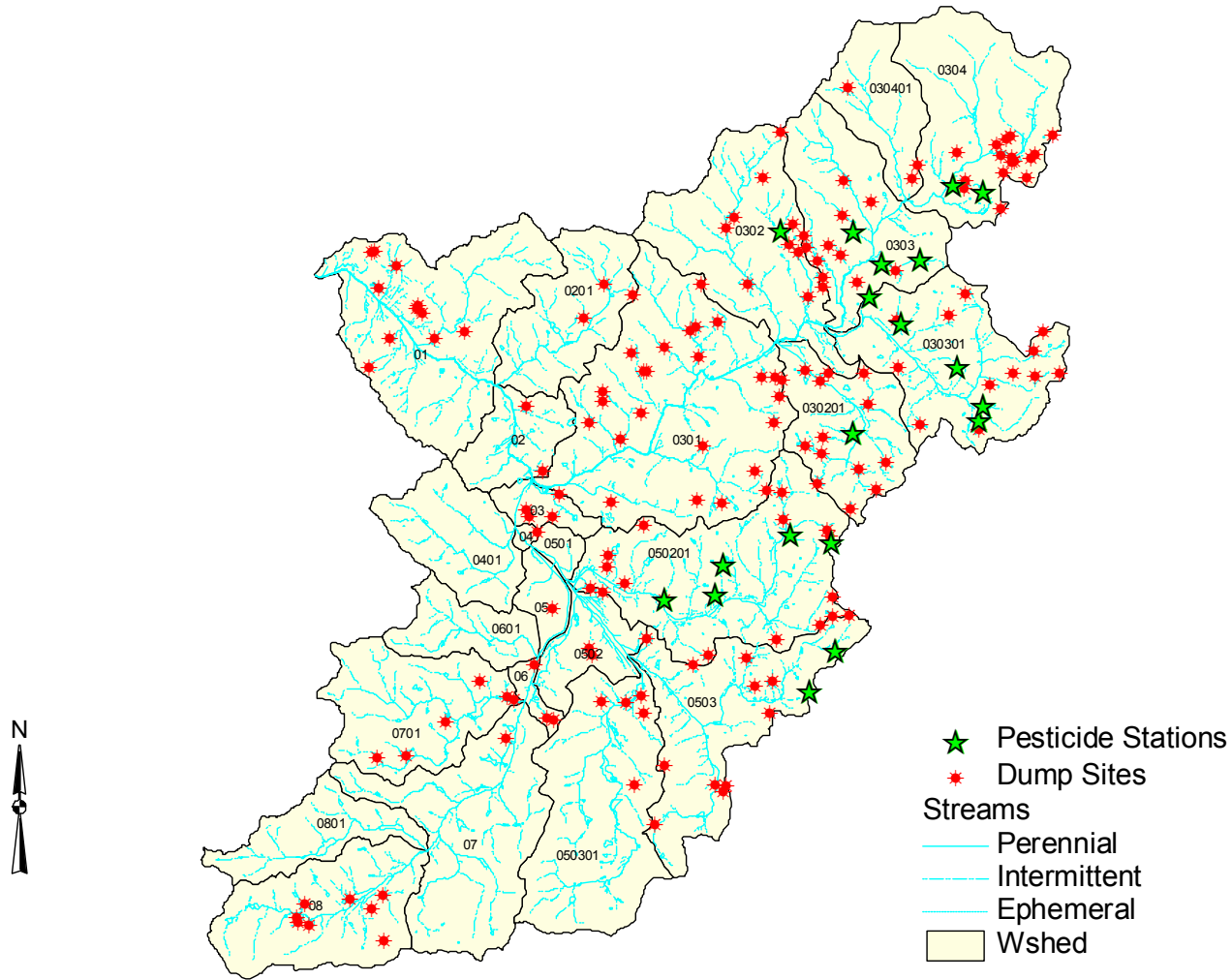


Figure 8. Location of dump sites and pesticide loading stations identified within the Mud Creek Watershed.

Table 20. Dump Sites and Pesticide Loading Stations Within the Mud Creek Watershed.

Watershed Name	Watershed ID	Dump Sites	Pesticide Stations
Lower Mud Creek	01	11	0
Mud Creek 2	02	2	0
Featherstone Creek	0201	3	0
Mud Creek 3	03	4	0
Clear Creek 1	0301	25	0
Clear Creek 2	0302	9	1
Henderson Creek	030201	13	1
Clear Creek 3	0303	12	4
Lewis Creek	030301	12	4
Clear Creek 4	0304	16	2
Cox Creek	030401	3	0
Mud Creek 4	04	1	0
Brittain Creek	0401	0	0
Mud Creek 5	05	1	0
Bat Fork 1	0501	0	0
Bat Fork 2	0502	2	0
Devils Fork	050201	15	5
Bat Fork 3	0503	13	2
King Creek	050301	5	0
Mud Creek 6	06	3	0
Wash Creek	0601	0	0
Mud Creek 7	07	1	0
Shepherd Creek	0701	6	0
Upper Mud Creek	08	8	0
Little Mud Creek	0801	0	0
Total		165	19

Roads

The miles of paved and unpaved roads by watershed are shown in Table 21. There are approximately 1,070 miles of roads within the Mud Creek Watershed: 798 paved miles and 272 unpaved miles. The length of eroding banks associated with roads was also determined. More than 28 miles of road banks along paved roads are eroding (or 3.5% of all paved roads). Additionally 40.4 miles of road banks along unpaved roads (or 14.9% of all unpaved roads) are eroding.

Suspect On-Site Septic Systems

The remote sensing process identified 1,885 sites within the Mud Creek Watershed with on-site septic systems that may be contributing contaminants to the surface water through overland flow, particularly when saturated soil conditions exist. These systems are identified as suspect and field investigations should be conducted before concluding all systems are failing. A breakdown by watershed and reason for suspicion are given in Table 22 for mobile homes, houses and commercial structures. The location of suspect septic systems for houses and mobile homes are shown in Figures 9 and 10. More than 85 percent of the suspect sites serve houses.

Of the total suspect house and mobile home sites, 17 percent of house sites and 24 percent of mobile home sites exhibited a visible plume pattern, but no drain field was apparent. This may indicate a straight-pipe from a septic system, roof drainage, gray water disposal or natural seepage/spring. Another 80 percent of house sites and 71 percent of mobile home sites showed no visible plume or drain field but were at locations that are questionable for on-site septic systems. Such locations include home sites on very steep slopes, small lots, visible rock outcrops, or close proximity to streams, especially those on heavily wooded lots. Thirty house sites and three mobile home sites exhibited an effluent plume from a visible drain field pattern or prominent ponding down slope from the drain field. Fifty-nine other house sites and fourteen mobile home sites exhibited a visible drain field pattern, but no plume was evident. This may indicate slow leaching, with no apparent breakout from a seasonally or hydraulically stressed system. It could also indicate evapotranspiration characteristics of a functioning system or newly installed system.

Table 21. Miles of Paved and Unpaved Roads and Eroding Road Banks Within the Mud Creek Watershed.

Watershed Name	Watershed ID	Total Paved	Paved Eroded	% Paved Eroded	Total Unpaved	Unpaved Eroded	% Unpaved Eroded	Total Roadbanks Eroded
Lower Mud Creek	01	69.5	2.0	2.8	18.1	1.7	9.4	3.7
Mud Creek 2	02	17.8	0.8	4.3	4.4	0.4	8.2	1.2
Featherstone Creek	0201	22.0	0.4	1.7	14.3	1.4	10.1	1.8
Mud Creek 3	03	9.6	0.0	0.5	1.2	0.1	5.1	0.1
Clear Creek 1	0301	82.9	2.9	3.5	32.3	6.2	19.2	9.1
Clear Creek 2	0302	24.8	1.1	4.5	26.7	4.9	18.5	6.0
Henderson Creek	030201	23.0	0.9	4.1	11.0	1.6	14.5	2.5
Clear Creek 3	0303	16.7	0.7	4.0	22.6	1.2	5.4	1.9
Lewis Creek	030301	26.9	1.2	4.4	22.9	6.2	27.0	7.4
Clear Creek 4	0304	13.9	1.0	7.0	29.3	3.0	10.3	4.0
Cox Creek	030401	8.9	0.0	0.2	7.2	0.3	3.9	0.3
Mud Creek 4	04	1.4	0.1	4.9	0.1	0.0	0.0	0.1
Brittain Creek	0401	46.8	0.8	1.7	2.9	0.2	7.2	1.0
Mud Creek 5	05	16.1	0	0.0	0.1	0.0	0.0	0.0
Bat Fork 1	0501	5.8	0.1	1.4	0.2	0.0	0.0	0.1
Bat Fork 2	0502	19.1	0.2	1.0	1.4	0.1	6.0	0.3
Devils Fork	050201	65.1	3.3	5.1	18.8	2.7	14.1	6.0
Bat Fork 3	0503	58.0	1.3	2.3	9.6	2.4	24.9	3.7
King Creek	050301	77.4	5.3	6.8	7.4	2.4	33.2	7.7
Mud Creek 6	06	5.7	0	0.0	0.3	0.1	33.5	0.1
Wash Creek	0601	45.5	0.1	0.3	0.0	0.0	0.0	0.1
Mud Creek 7	07	52.1	2.8	5.5	11.5	2.2	19.3	5.0
Shepherd Creek	0701	57.3	1.3	2.3	3.9	0.1	2.9	1.4
Upper Mud Creek	08	22.0	1.7	7.6	18.0	3.1	17.2	4.8
Little Mud Creek	0801	9.5	0.1	1.4	7.4	0.1	1.1	0.2
Total		797.8	28.1	3.5	271.6	40.4	14.9	68.5

Table 22. Suspect On-Site Septic Systems Within the Mud Creek Watershed.

Watershed Name	Watershed ID	Total	Mobile Homes				Subtotal	Houses				Subtotal	Commercial				Subtotal	Total
			*Condition 1	*Condition 2	*Condition 3	*Condition 4		*Condition 1	*Condition 2	*Condition 3	*Condition 4		*Condition 1	*Condition 2	*Condition 3	*Condition 4		
Lower Mud Creek	01	189	0	2	0	23	25	1	19	6	137	163	0	0	1	0	1	189
Mud Creek 2	02	28	0	1	0	5	6	0	2	0	20	22	0	0	0	0	0	28
Featherstone Creek	0201	120	0	1	0	1	2	0	10	1	106	117	0	0	0	1	1	120
Mud Creek 3	03	13	0	0	0	0	0	0	1	0	12	13	0	0	0	0	0	13
Clear Creek 1	0301	140	0	12	1	18	31	4	42	8	51	105	0	0	1	3	4	140
Clear Creek 2	0302	56	0	2	1	7	10	0	5	1	40	46	0	0	0	0	0	56
Henderson Creek	030201	34	1	2	2	12	17	1	8	2	5	16	0	0	1	0	1	34
Clear Creek 3	0303	28	0	1	0	12	13	1	4	2	8	15	0	0	0	0	0	28
Lewis Creek	030301	46	2	7	7	5	21	0	9	3	11	23	0	0	1	1	2	46
Clear Creek 4	0304	29	0	6	0	1	7	0	2	0	20	22	0	0	0	0	0	29
Cox Creek	030401	20	0	0	0	1	1	1	2	0	16	19	0	0	0	0	0	20
Mud Creek 4	04	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
Brittain Creek	0401	199	0	0	0	14	14	0	2	2	180	184	0	0	0	1	1	199
Mud Creek 5	05	6	0	0	0	0	0	0	1	0	5	6	0	0	0	0	0	6
Bat Fork 1	0501	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bat Fork 2	0502	40	0	0	0	0	0	11	5	10	14	40	0	0	0	0	0	40
Devils Fork	050201	118	0	11	3	12	26	7	39	14	31	91	0	0	0	1	1	118
Bat Fork 3	0503	119	0	14	0	33	47	2	22	5	42	71	0	1	0	0	1	119
King Creek	050301	285	0	0	0	39	39	0	10	2	233	245	0	1	0	0	1	285
Mud Creek 6	06	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
Wash Creek	0601	74	0	0	0	0	0	0	6	0	68	74	0	0	0	0	0	74
Mud Creek 7	07	140	0	1	0	0	1	0	27	0	112	139	0	0	0	0	0	140
Shepherd Creek	0701	125	0	0	0	1	1	1	9	2	111	123	0	0	0	1	1	125
Upper Mud Creek	08	64	0	0	0	4	4	1	9	1	48	59	0	0	0	1	1	64
Little Mud Creek	0801	10	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	10
Total		1885	3	60	14	188	265	30	235	59	1281	1605	0	2	4	9	15	1885

*Septic Condition

1 - Distinctive moisture pattern; identifiable plume from visible fieldline pattern or prominent plume or ponding downslope from a structure

2 - Suspicious moisture patterns, visible plume pattern but no fieldlines apparent

3 - Distinctive drainfield; fieldline pattern but no plume present

4 - Suspect locations; no plumes or fieldlines apparent; homes on very steep slopes, small lots, visible rock outcrops, in close proximity to streams or reservoirs, or heavily wooded lots

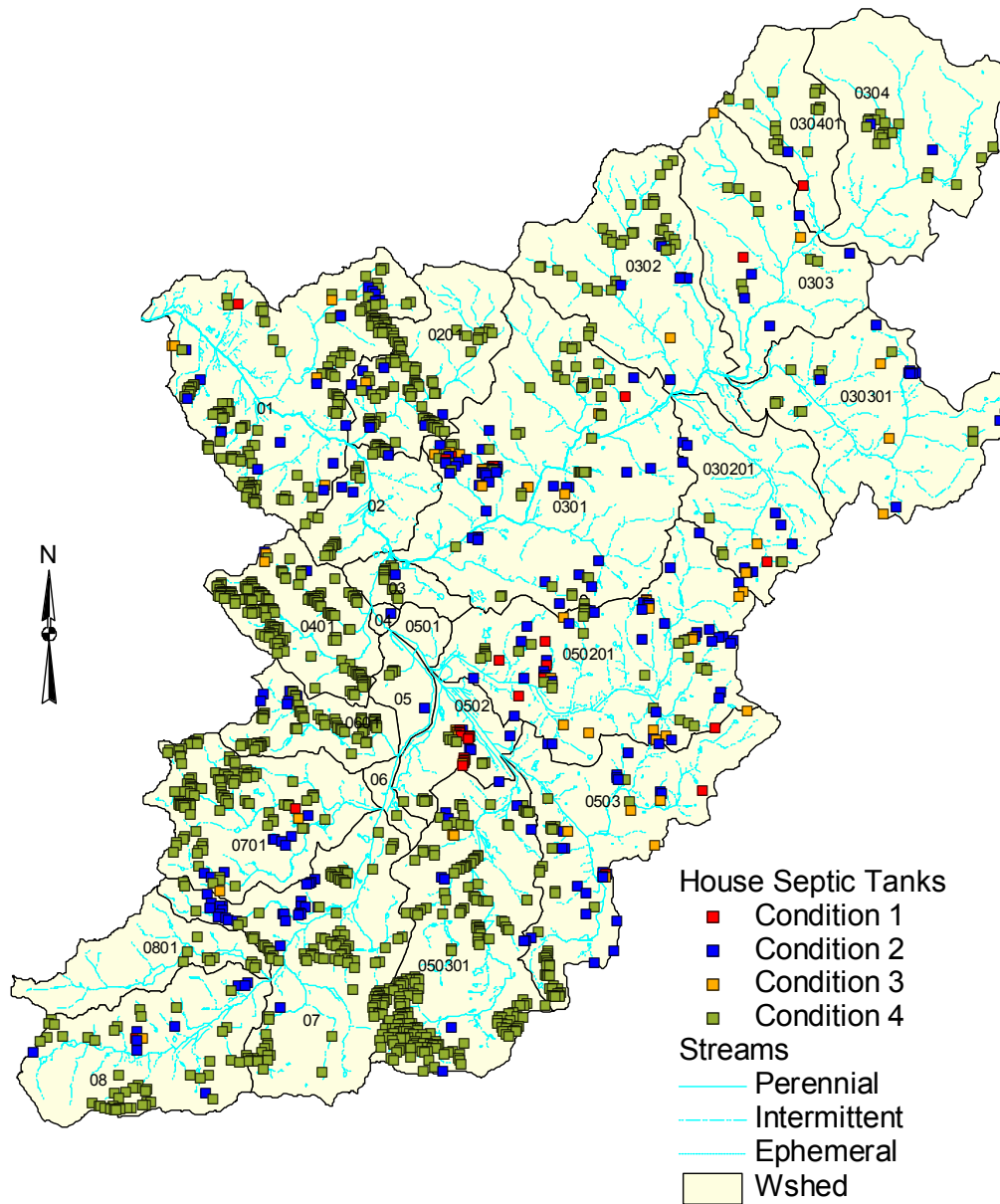


Figure 9. Location of suspect on-site septic systems for houses within the Mud Creek Watershed.

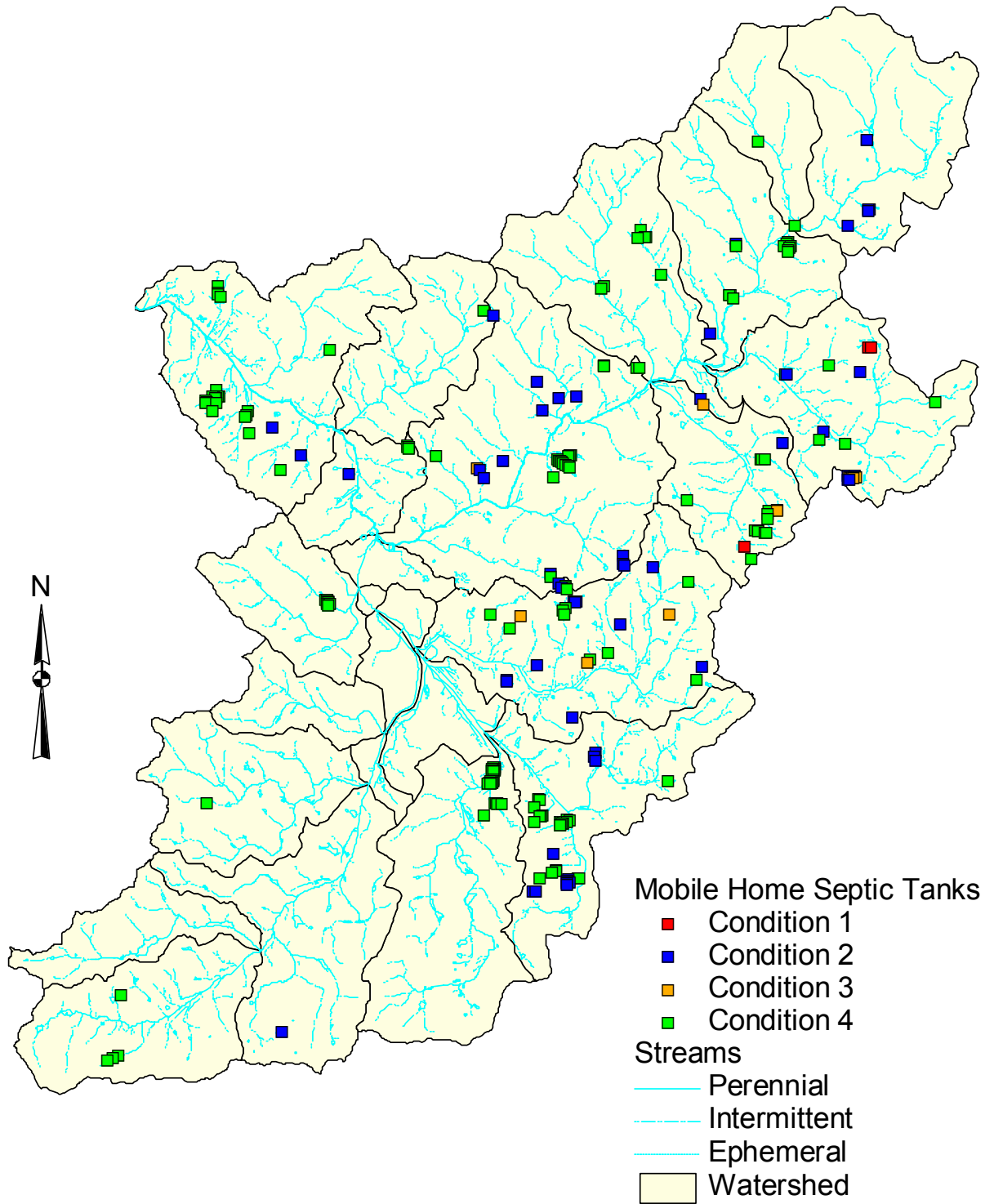


Figure 10. Location of suspect on-site septic systems for mobile homes in the Mud Creek Watershed.

Imperviousness

The literature shows that imperviousness is a useful indicator to measure the impacts of land development on water resources (Schueler, 1994). As the amount of imperviousness within a watershed increases, two things happen that impact the water resource. First, the flow characteristics within the streams that drain the watershed change. Changes include increased amounts of water the stream must carry during rain events (peak flows), increased flooding frequencies, and lower base flows. These changes occur because more storm water runoff is created by the impervious surfaces because these surfaces do not allow the water to soak into the ground. As peak stream flows increase, the stream channel becomes unstable. The stream channel becomes deeper and wider in an effort to carry the increased flow. This results in increased sediment loads and loss of aquatic and riparian habitat as soil and vegetation are scoured from the bottom and banks cave into the stream. Secondly, the amount of pollutants delivered to the stream is increased through runoff from these impervious surfaces. Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from cars, or derived from other activities. Pollutants can include nitrogen, phosphorous, bacteria, metals, and oils.

Research shows that it is extremely difficult to maintain predevelopment stream quality when watershed development exceeds 10 to 20 percent impervious cover. As the imperviousness increases beyond 10 to 20 percent, the stream becomes impacted. Fish and aquatic insect species (food for many fish, amphibians, and birds) are lost as stream temperatures increase and stream channels become unstable. Above 25 percent imperviousness, stream channels are very unstable and pollutant loads have increased to levels that threaten downstream lakes. Establishing an exact impervious threshold for protecting a given stream is not possible. However, the following thresholds are proposed for three levels of stream protection (Schueler, 1994):

Stressed streams (1 to 10 percent impervious cover)

Impacted streams (11 to 25 percent impervious cover)

Degraded streams (26 to 100 percent impervious cover)

For stressed streams, predevelopment stream quality can be maintained if strict zoning, site impervious restrictions, stream buffers, and best management practices are applied. Impacted streams can be expected to experience some degradation after development even with controls. For degraded streams, predevelopment stream quality cannot be fully maintained even when controls and retrofits are applied. Intensive stream restoration techniques, if applied, can only partially restore some aspects of stream quality.

The percent imperviousness for each watershed and selected land use/land cover classes are shown in Table 23. Figure 11 displays the estimated percent imperviousness of land use polygons and roads in the Mud Creek Watershed. The percent of imperviousness for the Mud Creek Watershed is 10.1 percent, which is the threshold at which Mud Creek should show signs of stress from urban development; but, the percent of imperviousness varies greatly throughout the watershed. Mud Creek Watershed (05) which includes the City of Hendersonville is 43.2 percent impervious with commercial and industrial land use accounting for 30.8 percent of impervious surfaces. Meanwhile, headwater watersheds including Clear Creek (0302, 0303, 0304), Cox Creek (030401), Upper Mud Creek (08), and Little Mud Creek (0801) have less than 5 percent imperviousness respectively.

Soil Loss

The estimated soil loss from selected land use/land covers within the Mud Creek Watershed is given in Table 24. The values are in tons per year and represent the total soil loss for that particular LU/LC within the respective watershed.

Residential land use contributes 42 percent of the total annual soil loss followed by commercial/industrial use at 22 percent, roads at 19 percent and pastures at 6 percent. The largest total soil loss from all land use categories occurs in Clear Creek Watershed (0303) followed by Wash Creek Watershed (0601), Little Mud Creek Watershed (0801), and Lewis Creek Watershed (030301).

The estimated soil loss per acre for each watershed is shown in Figure 12. Mud Creek Watershed (06) has the highest soil loss rate at 22.4 tons/acre/year followed by Mud Creek Watershed (03), Wash Creek Watershed (0601), and Mud Creek Watershed (05).

Table 23. Watershed Percent Imperviousness for the Mud Creek Watershed.

Watershed Name	Watershed ID	% Residential	% Commercial	% Industrial	% Roads	Imperviousness
Lower Mud Creek	01	4.6	2.9	1.8	3.4	12.7
Mud Creek 2	02	4.0	1.6	0.8	3.4	9.8
Featherstone Creek	0201	3.6	0.3	0.0	2.6	6.5
Mud Creek 3	03	6.1	10.5	5.9	4.2	26.7
Clear Creek 1	0301	3.9	2.0	0.6	3.0	9.5
Clear Creek 2	0302	2.0	0.2	0.0	2.1	4.3
Henderson Creek	030201	3.7	1.2	0.5	2.6	8.0
Clear Creek 3	0303	1.5	0.2	0.0	1.8	3.5
Lewis Creek	030301	2.6	1.6	0.0	2.2	6.4
Clear Creek 4	0304	0.9	0.0	0.0	1.5	2.4
Cox Creek	030401	0.6	0.1	0.0	1.6	2.3
Mud Creek 4	04	5.3	0.6	2.7	4.0	12.6
Brittain Creek	0401	11.2	6.4	0.1	5.3	23.0
Mud Creek 5	05	5.9	22.3	8.5	6.5	43.2
Bat Fork 1	0501	2.3	29.0	0.5	4.6	36.4
Bat Fork 2	0502	4.3	10.0	0.2	3.8	18.3
Devils Fork	050201	4.7	2.0	0.3	3.2	10.2
Bat Fork 3	0503	4.7	4.8	0.9	3.7	14.1
King Creek	050301	5.1	4.0	0.5	4.0	13.6
Mud Creek 6	06	10.9	5.9	0.0	4.9	21.7
Wash Creek	0601	11.9	11.5	0.3	7.9	31.5
Mud Creek 7	07	4.7	0.1	0.0	3.0	7.8
Shepherd Creek	0701	7.6	1.1	0.0	4.4	13.1
Upper Mud Creek	08	1.9	0.7	0.0	2.1	4.7
Little Mud Creek	0801	1.3	0.7	0.0	1.8	3.8
Total		4.0	2.5	0.5	3.1	10.1

01 02c

 02

0401 03
 04
 05c

Figure 11. Percent imperviousness of land use polygons and roads in the Mud Creek Watershed.

Table 24. Estimated Soil Loss from Selected Land Use/Land Covers and other Erosion Features within the Mud Creek Watershed.

Watershed Name	Watershed ID	Total Soil Loss (Tons/Year)	Total Residential	Commercial /Industrial	*Total Roads	Cropland	Total Pasture	Orchards Vineyards Nurseries	Forest	Mining	**Other	Disturbed Areas
								22	4	75		76
All Counties												
Lower Mud Creek	01	9067	2737	191	3473	509	913	0	516	0	230	498
Mud Creek 2	02	2539	940	158	848	0	133	6	317	0	137	0
Featherstone	0201	13893	9071	349	2691	223	599	10	572	0	178	200
Mud Creek 3	03	11769	9864	556	218	60	636	1	300	0	25	109
Clear Creek 1	0301	7788	1215	96	6316	122	28	0	10	0	1	0
Clear Creek 2	0302	14671	5803	3590	5147	0	18	0	73	0	40	0
Henderson Creek	030201	6421	1031	3067	2119	7	26	0	3	0	168	0
Clear Creek 3	0303	32143	7958	16660	4200	1357	936	245	169	47	418	153
Lewis Creek	030301	21587	9640	5708	4513	333	659	0	499	0	235	0
Clear Creek 4	0304	11172	1996	2213	5522	202	710	1	30	0	498	0
Cox Creek	030401	19448	10499	3180	1325	1876	1645	412	238	0	273	0
Mud Creek 4	04	1097	241	596	26	0	56	0	6	0	172	0
Brittain Creek	0401	918	205	59	584	0	30	0	1	0	39	0
Mud Creek 5	05	10037	8826	941	13	0	61	0	154	0	42	0
Bat Fork 1	0501	2601	1264	1029	45	0	103	0	20	0	140	0
Bat Fork 2	0502	1312	498	13	265	28	123	67	318	0	0	0
Devils Fork	050201	7401	1582	13	3718	65	636	358	605	0	112	312
Bat Fork 3	0503	6818	2036	55	1925	435	1588	348	400	0	31	0
King Creek	050301	10355	4476	554	1714	676	1140	621	260	0	235	679
Mud Creek 6	06	6375	3221	74	65	624	1401	164	581	0	43	202
Wash Creek	0601	25741	11929	6198	7	862	2102	234	713	891	885	1920
Mud Creek 7	07	9118	3976	464	2342	396	1367	227	170	0	176	0
Shepherd Creek	0701	10285	2388	5019	775	34	608	0	95	536	411	419
Upper Mud Creek	08	8371	3977	114	3500	0	194	2	404	0	129	51
Little Mud Creek	0801	24306	10246	8255	1347	1158	1231	1	479	78	734	777
Total		275233	115619	59152	52698	8967	16943	2697	6933	1552	5352	5320

*Eroding unpaved road surfaces, eroding road banks

**Range land, electric transmission, forest clear cut

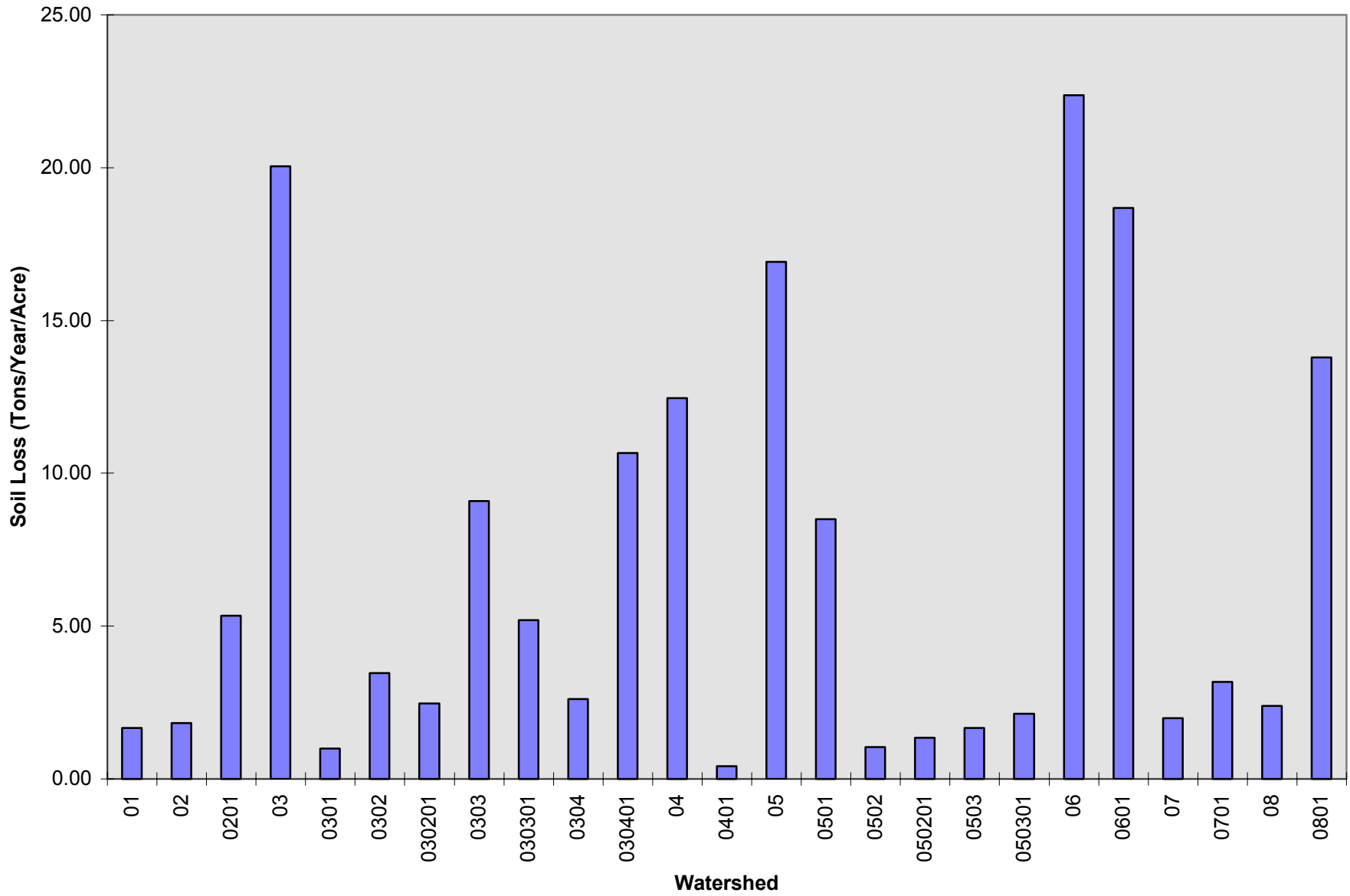


Figure 12. Estimated soil loss per acre for each watershed within the Mud Creek Watershed.

Estimated Pollutant Loads

The pollutant loads presented in this report were generated using the pollutant loading model described under Methods. The model was run using default values based on best professional judgment. The accuracy of these estimates was not determined; however, the estimates should be useful for planning purposes. To determine the accuracy of these estimates, comparison with water quality monitoring data would be required. Such a comparison was beyond the scope of this study. The pollutant loading model included with this report allows for the adjustment of the default values as better information on water quality and watershed conditions becomes available. The model should prove useful to evaluate potential NPS management strategies.

Pollutant loads were estimated for the following LU/LC and livestock operations: residential, commercial, industrial, transportation, cropland, pasture, orchards, range shrub, forest, clear-cuts, mining, disturbed areas, beef cattle, and horse. Pollutant loads were estimated for the following pollutants: TSS, BOD5, TN, and TP. Comparison of pollutant loads from forest clear-cuts and disturbed areas with the other sources should be done with caution. There is no doubt that these changes in the landscape contribute to the NPS pollution load. The annual load from these sources is more variable because the sources are not long-term land covers as are the other sources. To estimate the loads from these sources, information is needed on the location and rate of clear-cutting and construction. Such information was beyond the scope of this study.

The model shows that residential and commercial land uses are the predominant sources for BOD5, TN, and TP within the Mud Creek Watershed. While residential and commercial with land uses also account for 49 percent of the total suspended solids load in the watershed, heavily overgrazed and fair pastures combined contribute another 18 percent of the total TSS load.

Estimated Annual Total Suspended Solids Load

The estimated annual TSS load from selected NPS to each watershed within the Mud Creek Watershed is shown in Table 25. The contribution of TSS by source for the Mud Creek Watershed is shown in Figure 13. Residential land use accounts for about 32 percent of the TSS load, followed by pasture at 18 percent and commercial at 17 percent.

Figure 14 shows the TSS load from each watershed within the Mud Creek Watershed. The Clear Creek Watershed (0301) has the highest annual load at over 1600 tons TSS per year followed by Lower Mud Creek Watershed (01) at over 1200 tons TSS per year. The TSS load for each watershed was divided by the respective watershed area. The result is shown in Figure 15. Mud Creek Watershed (05) and Bat Fork Watershed (0501) have the highest annual TSS load at 0.47 tons per acre. Residential and commercial land uses account for about 74 percent of the TSS load for Mud Creek Watershed (05) and 83 percent of the TSS load for the Bat Fork Watershed (0501). Cox Creek Watershed (030401) has the lowest TSS loading at 0.06 tons TSS per acre per year.

Estimated Annual Five-Day Biochemical Oxygen Demand Load

The estimated annual BOD5 load from selected nonpoint sources to each watershed within the Mud Creek Watershed is shown in Table 26. The contribution of BOD5 by source for the entire Mud Creek Watershed is shown in Figure 16. The residential, commercial, and industrial land use classes account for about 90 percent of the BOD5 load, followed by pasture at 3 percent and beef cattle at 2 percent.

Figure 17 shows the BOD5 load from each watershed within the Mud Creek Watershed. Clear Creek Watershed (0301) and Lower Mud Creek Watershed (01) account for 11 percent and 10 percent of the BOD5 load, respectively. The BOD5 load for each watershed was divided by the respective watershed area. The result is shown in Figure 18. The BOD5 load per acre for the entire Mud Creek Watershed is 0.007 tons per year per acre. Mud Creek Watershed (05) has the highest BOD5 load per year per acre at 0.030 tons. The commercial land use class accounts for 58 percent of the BOD5 load in Mud Creek Watershed (05). Cox Creek Watershed (030401) has the lowest annual BOD5 load at 0.0010 tons per acre.

Table 25. Estimated Annual Total Suspended Solids Load for the Mud Creek Watershed.

Watershed	ID	Total	Residential	Commercial	Industrial	Transportation	Elec Trans	Raw Crop	Pasture	Orchards	Range	Forest	Mining	Disturbed Areas	Beef Cattle	Dairy	Horse
Lower Mud Creek	01	1265.3	368.2	218.8	116.6	5.5	1.3	150.8	160.2	0.1	65.7	62.5	10.1	101.1	3.7	0.0	0.7
Mud Creek 2	02	458.1	82.9	40.2	11.7	2.5	1.6	6.0	106.1	0.0	21.9	16.6	93.4	73.1	2.1	0.0	0.0
Featherstone Creek	0201	271.6	140.6	19.5	0.0	0.3	0.3	0.0	29.6	0.3	8.9	63.7	0.0	7.9	0.0	0.0	0.5
Mud Creek 3	03	206.8	51.2	74.2	32.9	0.3	0.2	0.0	21.4	0.0	22.1	4.5	0.0	0.0	0.0	0.0	0.0
Clear Creek 1	0301	1622.3	458.7	223.4	54.8	4.9	1.8	103.1	251.5	28.0	64.8	88.5	106.6	229.6	5.2	0.0	1.4
Clear Creek 2	0302	545.5	111.8	13.6	0.0	0.0	0.0	86.0	192.9	22.5	5.0	80.9	0.0	27.8	2.3	0.0	2.7
Henderson Creek	030201	564.9	138.0	57.5	16.1	0.1	0.3	60.6	209.1	34.7	19.5	26.0	0.0	0.0	2.3	0.0	0.7
Clear Creek 3	0303	483.1	70.7	7.9	0.0	0.0	0.0	62.2	227.4	49.8	4.4	57.3	0.0	0.0	2.5	0.0	0.9
Lewis Creek	030301	759.9	156.0	101.4	0.0	0.0	0.0	93.4	157.6	85.8	31.7	36.8	0.0	93.9	2.6	0.0	0.7
Clear Creek 4	0304	345.5	54.9	2.4	0.0	0.0	0.0	9.0	87.3	49.2	15.4	83.1	0.0	42.9	1.3	0.0	0.0
Cox Creek	030401	108.3	17.3	2.2	0.0	0.1	0.0	4.7	20.4	11.1	0.0	52.5	0.0	0.0	0.0	0.0	0.0
Mud Creek 4	04	34.7	7.1	0.8	6.2	0.0	0.0	0.0	8.9	0.0	11.5	0.2	0.0	0.0	0.0	0.0	0.0
Brittain Creek	0401	564.8	360.5	159.5	3.4	0.7	0.0	0.0	9.6	0.0	6.7	24.4	0.0	0.0	0.0	0.0	0.0
Mud Creek 5	05	280.3	52.9	154.7	57.6	0.6	0.8	1.4	5.5	0.0	6.2	0.6	0.0	0.0	0.0	0.0	0.0
Bat Fork 1	0501	141.6	12.9	104.5	3.4	0.2	0.9	0.0	13.0	0.0	5.0	1.4	0.0	0.0	0.3	0.0	0.0
Bat Fork 2	0502	480.7	80.2	139.8	6.1	3.9	0.2	36.0	126.3	0.1	81.4	5.3	0.0	0.0	1.4	0.0	0.0
Devils Fork	050201	1127.5	380.9	140.3	25.4	3.1	0.2	243.7	213.7	53.5	31.8	30.9	0.0	0.0	2.6	0.0	1.4
Bat Fork 3	0503	1023.9	288.2	244.5	44.8	3.2	0.9	188.3	129.9	34.0	36.8	23.4	6.5	21.2	2.0	0.0	0.2
King Creek	050301	909.0	368.2	273.2	34.9	1.0	0.0	44.5	88.0	0.0	23.4	74.6	0.0	0.0	0.3	0.0	0.9
Mud Creek 6	06	103.8	47.6	17.4	0.0	0.0	0.0	29.0	6.7	0.0	0.3	2.5	0.0	0.0	0.3	0.0	0.0
Wash Creek	0601	444.4	233.0	183.2	5.1	0.0	0.0	0.0	3.1	0.0	7.1	12.7	0.0	0.0	0.0	0.0	0.2
Mud Creek 7	07	573.8	315.4	18.8	0.0	0.0	0.1	30.2	81.0	1.4	20.8	77.3	0.0	27.1	0.3	0.0	1.4
Shepherd Creek	0701	582.8	367.0	47.8	0.8	0.0	0.0	8.7	92.9	0.1	3.6	43.8	0.0	16.0	1.6	0.0	0.5
Upper Mud Creek	08	507.7	95.0	34.7	0.0	0.1	0.4	73.1	131.0	0.0	11.4	86.5	0.0	71.5	3.3	0.0	0.7
Little Mud Creek	0801	138.0	32.6	28.2	0.0	0.0	0.8	0.0	22.1	0.9	0.1	52.6	0.0	0.0	0.0	0.0	0.7
Total		13,544.3	4,291.8	2308.5	419.8	26.5	9.8	1230.7	2395.2	371.5	505.4	1008.6	216.6	712.1	34.1	0.0	13.6

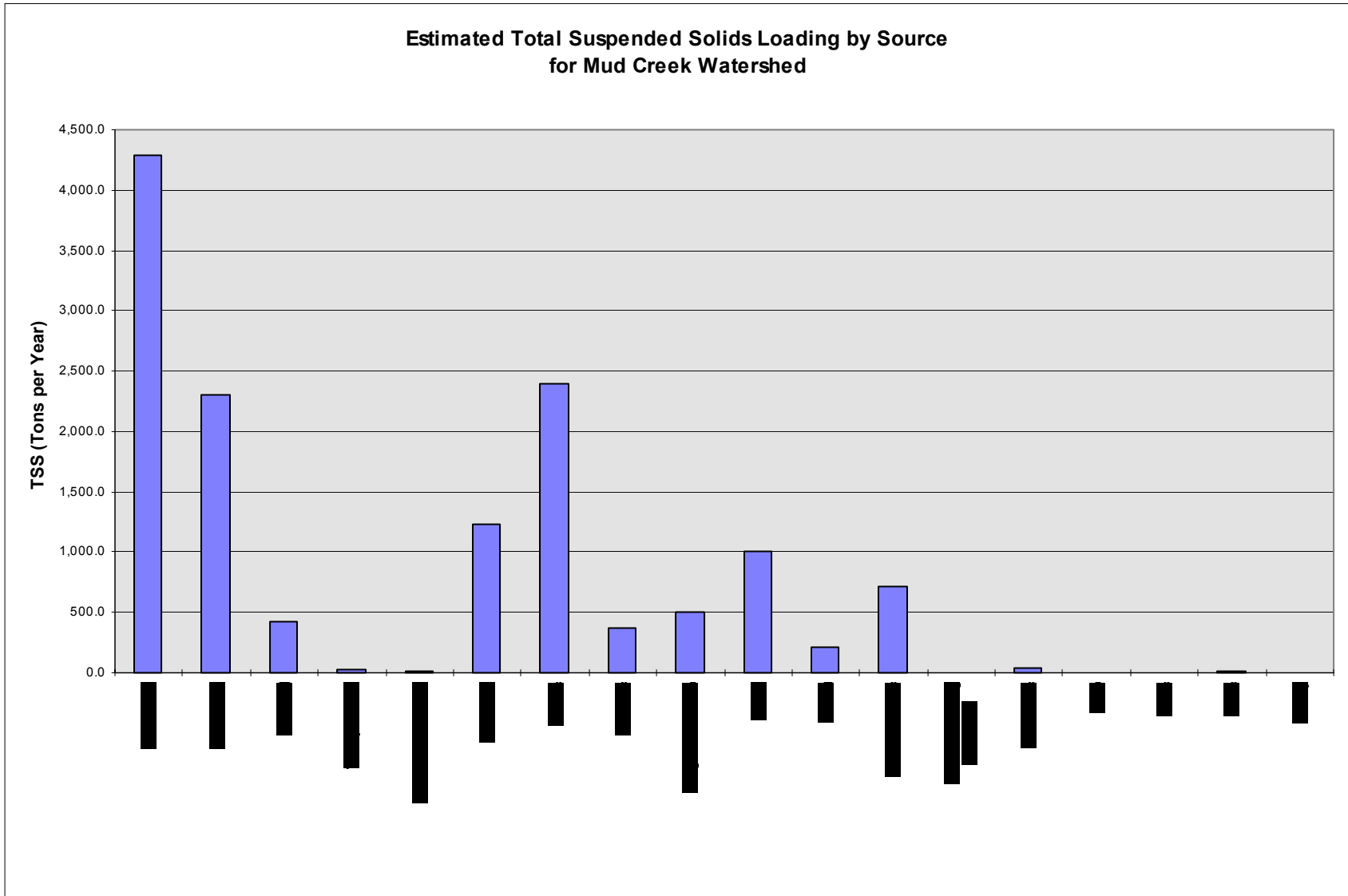


Figure 13. Estimated annual total suspended solids load by source for the Mud Creek Watershed.

**Estimated Total Suspended Solids Loading by Watershed
For Mud Creek Watershed**

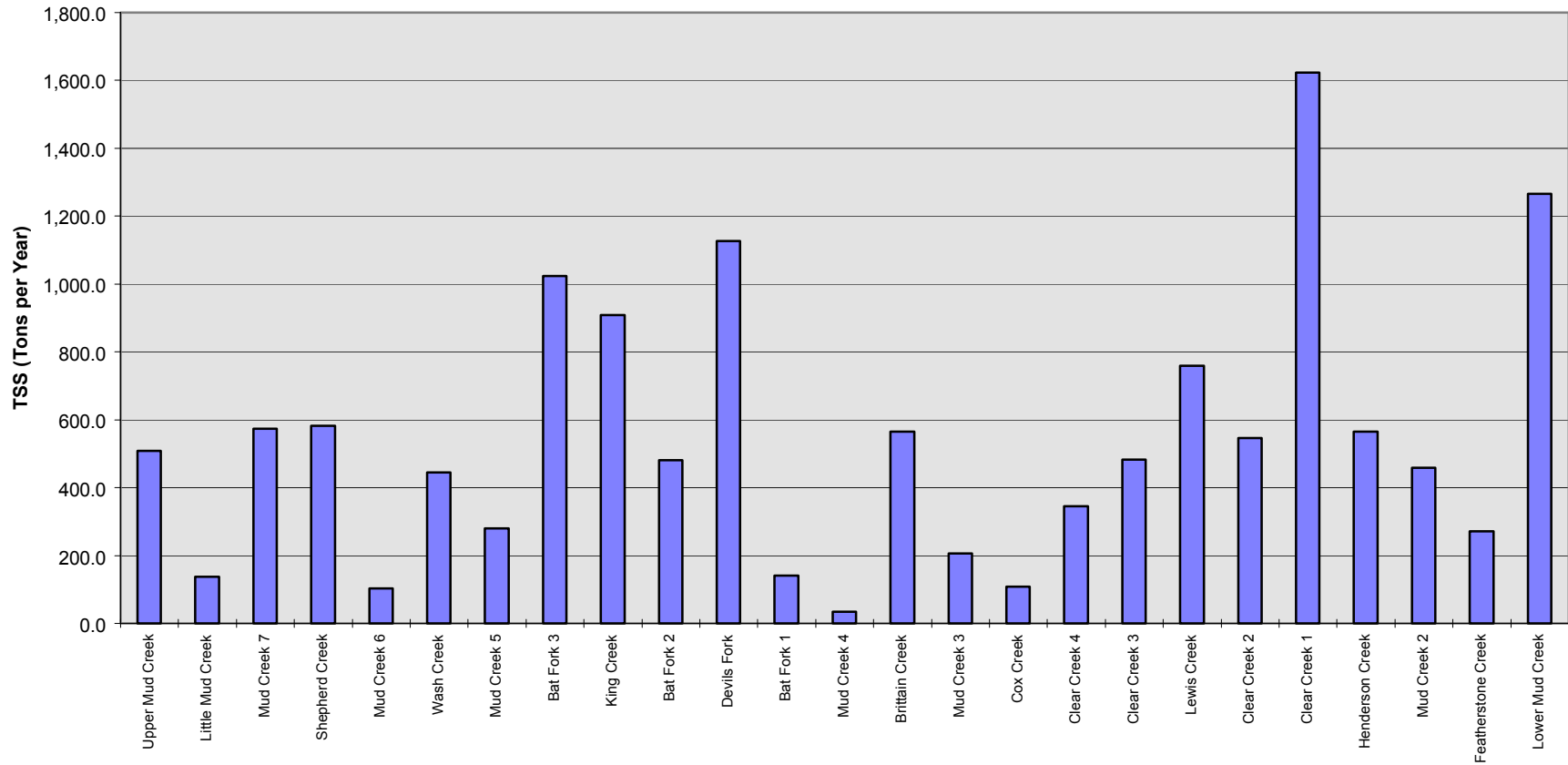


Figure 14. Estimated total suspended solids load for each watershed within the Mud Creek Watershed.

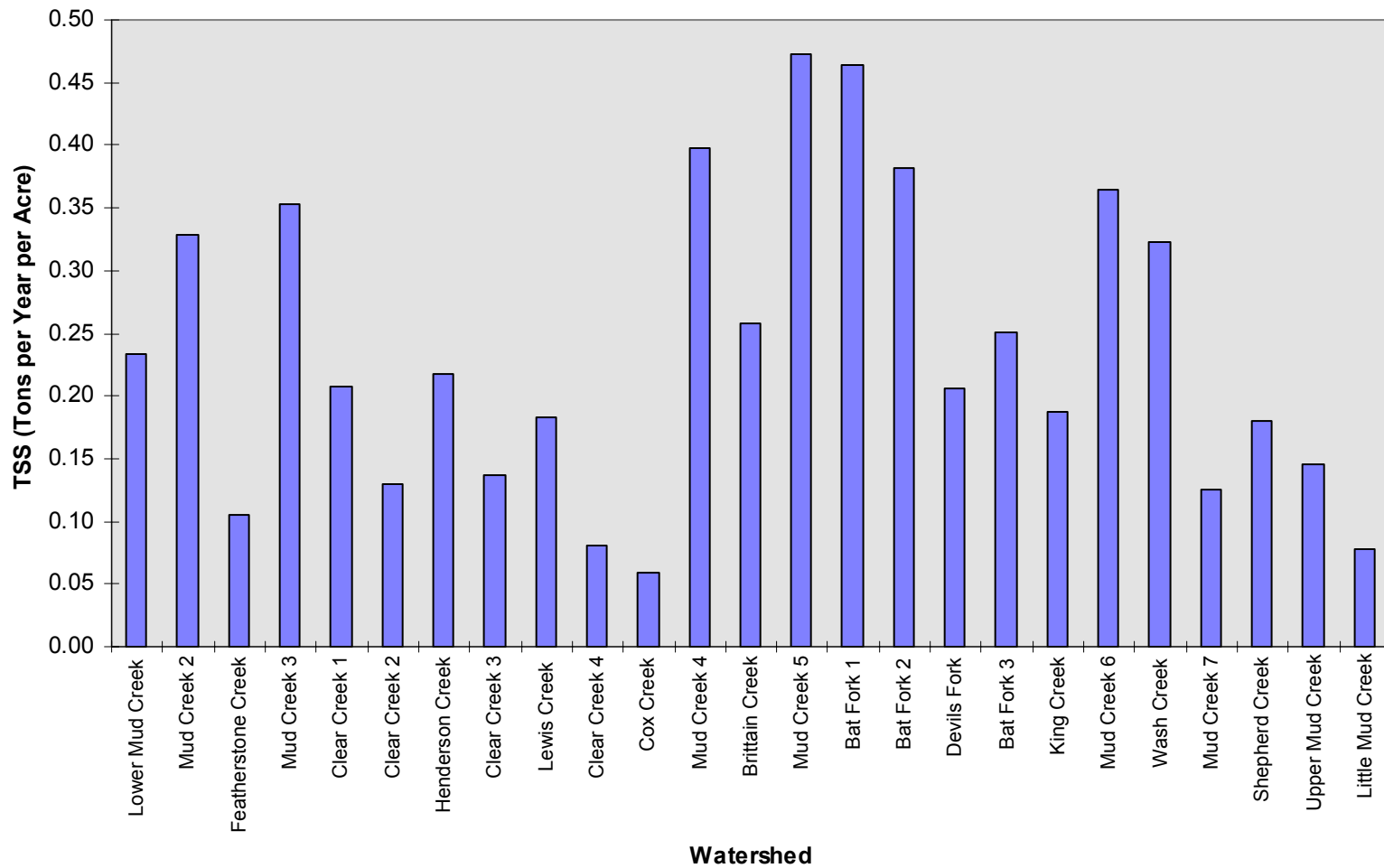


Figure 15. Estimated annual total suspended solids load per acre for each watershed within the Mud Creek Watershed.

Table 26. Estimated Annual Five-Day Biochemical Oxygen Demand Load for Mud Creek Watershed.

Watershed	ID	Total	Residential	Commercial	Industrial	Transportation	Elec Trans	Crop land	Pasture	Orchards	Range	Forest	Mining	Disturbed Areas	Beef Cattle	Dairy	Horses
Lower Mud Creek	01	51.79	24.55	14.59	7.78	0.37	0.09	0.86	0.92	0.00	0.38	0.36	0.06	0.58	1.14	0.00	0.11
Mud Creek 2	02	11.73	5.53	2.68	0.78	0.17	0.11	0.03	0.61	0.00	0.13	0.09	0.53	0.42	0.65	0.00	0.00
Featherstone Creek	0201	11.40	9.37	1.30	0.00	0.02	0.02	0.00	0.17	0.00	0.05	0.36	0.00	0.04	0.00	0.00	0.07
Mud Creek 3	03	10.86	3.41	4.95	2.19	0.02	0.01	0.00	0.12	0.00	0.13	0.03	0.00	0.00	0.00	0.00	0.00
Clear Creek 1	0301	56.36	30.58	14.89	3.67	0.33	0.12	0.59	1.44	0.16	0.37	0.51	0.61	1.31	1.56	0.00	0.22
Clear Creek 2	0302	11.82	7.45	0.91	0.00	0.00	0.00	0.49	1.10	0.13	0.03	0.46	0.00	0.16	0.66	0.00	0.43
Henderson Creek	030201	16.96	9.20	3.83	1.08	0.01	0.02	0.35	1.19	0.20	0.11	0.15	0.00	0.00	0.71	0.00	0.11
Clear Creek 3	0303	8.42	4.71	0.52	0.00	0.00	0.00	0.36	1.30	0.28	0.02	0.33	0.00	0.00	0.76	0.00	0.14
Lewis Creek	030301	20.90	10.40	6.76	0.00	0.00	0.00	0.53	0.90	0.49	0.18	0.21	0.00	0.54	0.78	0.00	0.11
Clear Creek 4	0304	5.85	3.66	0.16	0.00	0.00	0.00	0.05	0.50	0.28	0.09	0.47	0.00	0.25	0.39	0.00	0.00
Cox Creek	030401	1.82	1.15	0.15	0.00	0.01	0.00	0.03	0.12	0.06	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Mud Creek 4	04	1.06	0.48	0.05	0.41	0.00	0.00	0.00	0.05	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Brittain Creek	0401	35.18	24.03	10.64	0.23	0.05	0.00	0.00	0.05	0.00	0.04	0.14	0.00	0.00	0.00	0.00	0.00
Mud Creek 5	05	17.86	3.53	10.32	3.84	0.04	0.05	0.01	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Bat Fork 1	0501	8.33	0.86	6.96	0.23	0.01	0.06	0.00	0.07	0.00	0.03	0.01	0.00	0.00	0.10	0.00	0.00
Bat Fork 2	0502	17.22	5.34	9.32	0.41	0.26	0.02	0.21	0.72	0.00	0.47	0.03	0.00	0.00	0.44	0.00	0.00
Devils Fork	050201	40.91	25.39	9.35	1.69	0.21	0.01	1.39	1.22	0.31	0.18	0.18	0.00	0.00	0.77	0.00	0.21
Bat Fork 3	0503	41.92	19.22	16.30	2.98	0.21	0.06	1.08	0.74	0.19	0.21	0.13	0.04	0.12	0.60	0.00	0.04
King Creek	050301	46.69	24.55	18.21	2.32	0.07	0.00	0.25	0.50	0.00	0.13	0.43	0.00	0.00	0.09	0.00	0.14
Mud Creek 6	06	4.65	3.17	1.16	0.00	0.00	0.00	0.17	0.04	0.00	0.00	0.01	0.00	0.00	0.10	0.00	0.00
Wash Creek	0601	28.26	15.53	12.22	0.34	0.00	0.00	0.00	0.02	0.00	0.04	0.07	0.00	0.00	0.00	0.00	0.04
Mud Creek 7	07	23.96	21.03	1.25	0.00	0.00	0.01	0.17	0.46	0.01	0.12	0.44	0.00	0.15	0.10	0.00	0.22
Shepherd Creek	0701	29.19	24.47	3.19	0.05	0.00	0.00	0.05	0.53	0.00	0.02	0.25	0.00	0.09	0.46	0.00	0.08
Upper Mud Creek	08	11.87	6.33	2.31	0.00	0.00	0.02	0.42	0.75	0.00	0.06	0.49	0.00	0.41	0.97	0.00	0.11
Little Mud Creek	0801	4.66	2.18	1.88	0.00	0.00	0.05	0.00	0.13	0.01	0.00	0.30	0.00	0.00	0.00	0.00	0.11
Total		519.67	286.12	153.90	28.00	1.78	0.65	7.04	13.68	2.12	2.90	5.75	1.24	4.07	10.28	0.00	2.14

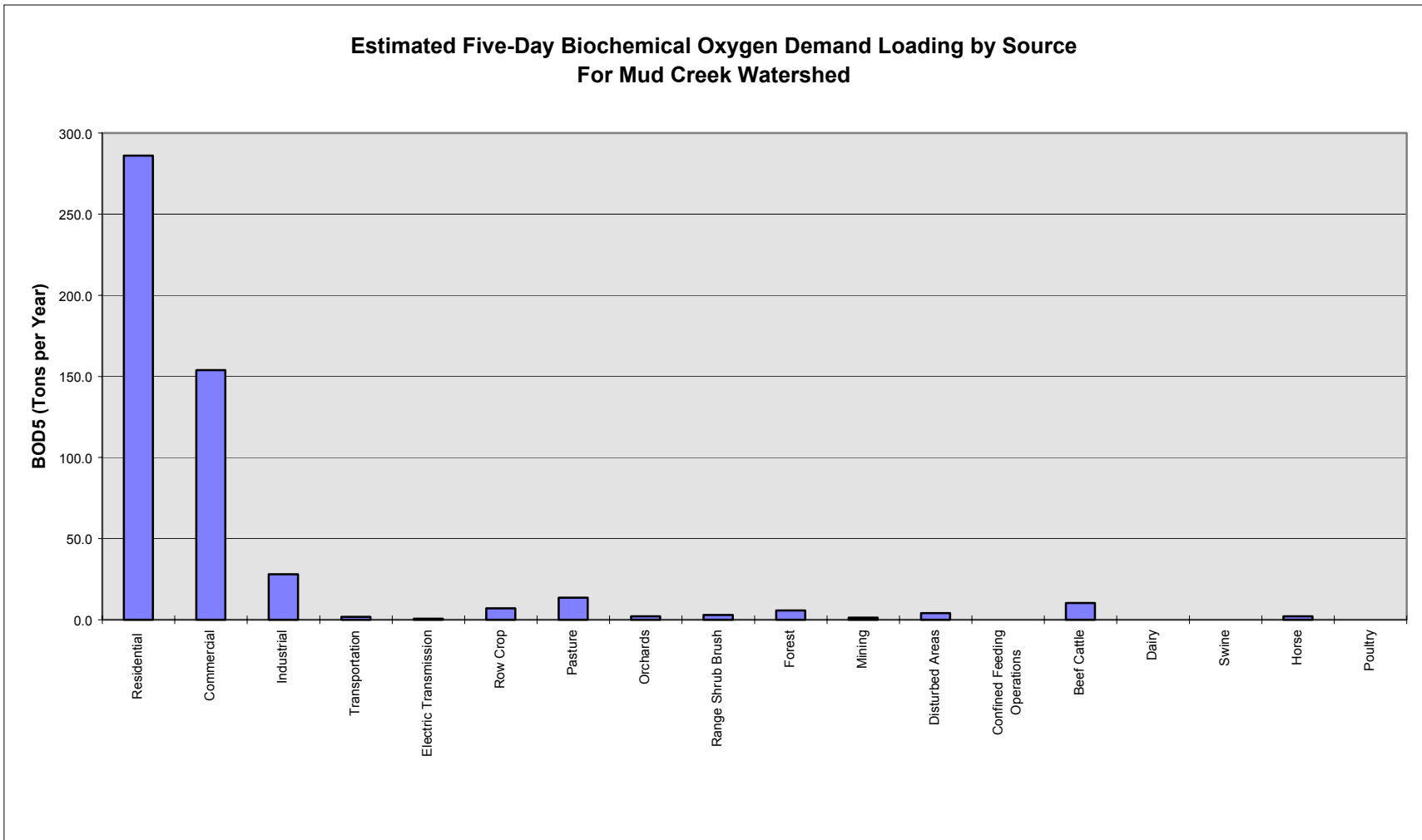


Figure 16. Estimated annual five-day biochemical oxygen demand load by source for the Mud Creek Watershed.

**Estimated Five-Day Biochemical Oxygen Demand Loading by Watershed
For Mud Creek Watershed**

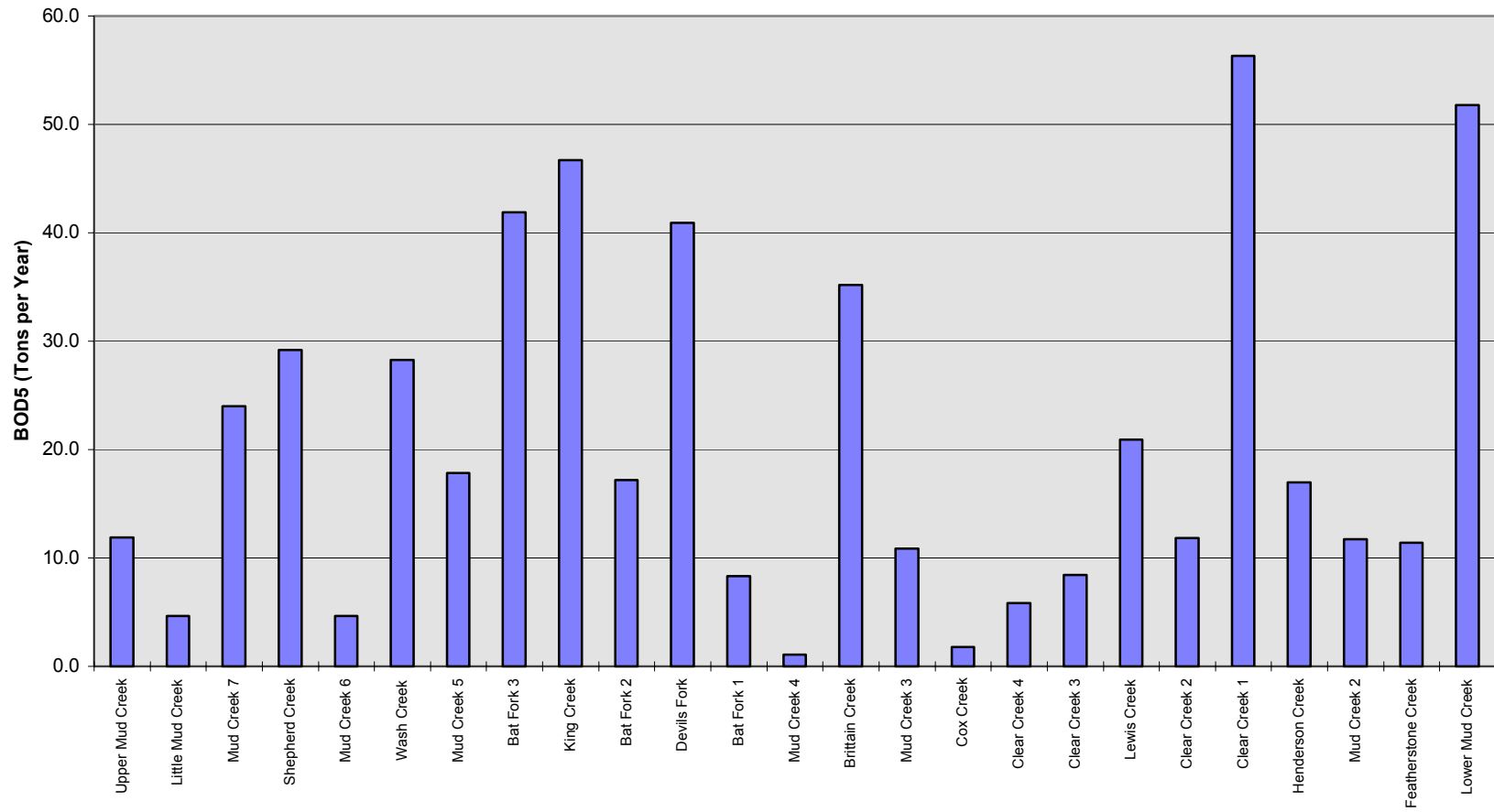


Figure 17. Estimated annual five-day biochemical oxygen demand load for each watershed within the Mud Creek Watershed.

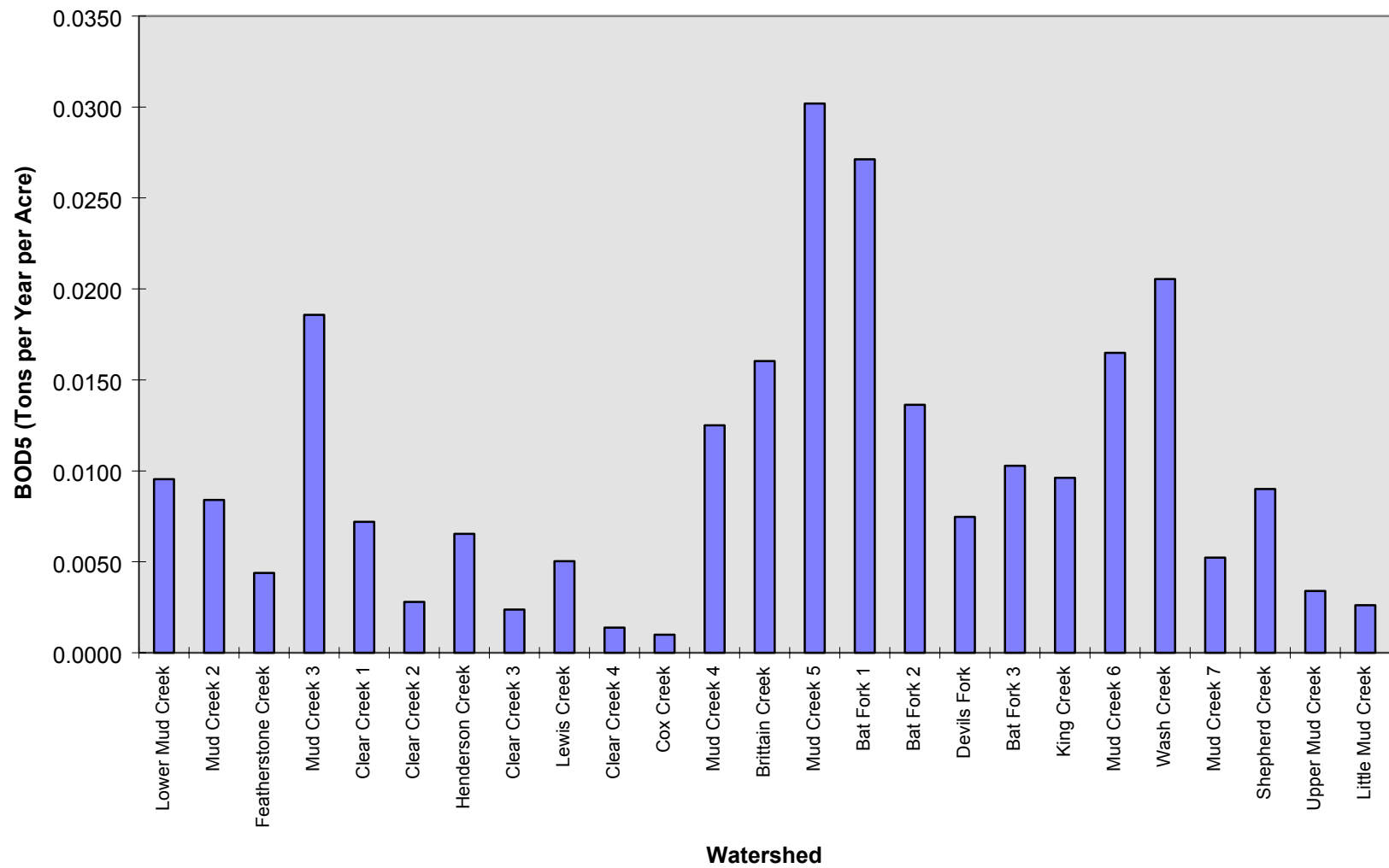


Figure 18. Estimated annual five-day biochemical oxygen demand load per acre for each watershed within the Mud Creek Watershed.

Estimated Annual Total Nitrogen Load

The estimated annual TN load from selected nonpoint sources to each watershed within the Mud Creek Watershed is shown in Table 27. The contribution of TN by source for the Mud Creek Watershed is shown in Figure 19. The major sources of the TN load are residential and commercial land uses which account for 83 percent of the total load in the watershed.

Figure 20 shows the TN load from each watershed within the Mud Creek Watershed. The Clear Creek Watershed (0301) and Lower Mud Creek Watershed (01) account for 11 percent and 10 percent of the TN load, respectively. The TN load for each watershed was divided by the respective watershed area. The result is shown in Figure 21. The annual TN load per acre for the Mud Creek Watershed is 0.0017 tons. Mud Creek Watershed (05) has the highest TN load per year per acre at 0.0069 tons, followed by Bat Creek Watershed (0501) at 0.0062 tons. Cox Creek Watershed (030401) has the lowest annual TN load per acre for the Mud Creek Watershed at 0.0002 tons.

Estimated Annual Total Phosphorous Load

The estimated annual TP load from selected nonpoint sources to each watershed within the Mud Creek Watershed is shown in Table 28. The contribution of TP by source for the Mud Creek Watershed is shown in Figure 22. Residential land use accounts for 54 percent of the TP load for the Mud Creek Watershed, while commercial accounts for 29 percent.

Figure 23 shows the TP load from each watershed within the Mud Creek Watershed. Clear Creek Watershed (0301) and Lower Mud Creek Watershed (01) account for 11 percent and 10 percent of the TP load, respectively. The TP load for each watershed was divided by the respective watershed area. The result is shown in Figure 24. The annual TP load per acre for the Mud Creek Watershed is 0.0003 tons. Mud Creek Watershed (05) has the highest TP load per acre at 0.0010 tons per year followed by Bat Fork Watershed (0501) at 0.00098 tons per year. Clear Creek Watershed (0304) has the lowest annual TP load per acre at 0.00004 tons.

Table 27. Estimated Annual Total Nitrogen Load for Mud Creek Watershed.

Watershed	ID	Total	Residential	Commercial	Industrial	Transportation	Elec Trans	Crop land	Pasture	Orchards	Range	Forest	Mining	Disturbed Areas	Beef Cattle	Dairy	Horses
Lower Mud Creek	01	12.11	5.65	3.36	1.79	0.08	0.02	0.24	0.25	0.00	0.10	0.10	0.02	0.16	0.34	0.0	0.00
Mud Creek 2	02	2.83	1.27	0.62	0.18	0.04	0.03	0.01	0.17	0.00	0.03	0.03	0.15	0.11	0.19	0.0	0.00
Featherstone Creek	0201	2.66	2.16	0.30	0.00	0.00	0.01	0.00	0.05	0.00	0.01	0.10	0.00	0.01	0.00	0.0	0.02
Mud Creek 3	03	2.50	0.79	1.14	0.50	0.00	0.00	0.00	0.03	0.00	0.03	0.01	0.00	0.00	0.00	0.0	0.00
Clear Creek 1	0301	13.37	7.03	3.42	0.84	0.17	0.03	0.16	0.40	0.04	0.10	0.14	0.17	0.36	0.45	0.0	0.06
Clear Creek 2	0302	2.90	1.71	0.21	0.00	0.00	0.00	0.14	0.30	0.04	0.01	0.13	0.00	0.04	0.19	0.0	0.13
Henderson Creek	030201	4.04	2.12	0.88	0.25	0.00	0.00	0.10	0.33	0.05	0.03	0.04	0.00	0.00	0.21	0.0	0.03
Clear Creek 3	0303	2.10	1.08	0.12	0.00	0.00	0.00	0.10	0.36	0.08	0.01	0.09	0.00	0.00	0.22	0.0	0.04
Lewis Creek	030301	4.99	2.39	1.55	0.00	0.00	0.00	0.15	0.25	0.13	0.05	0.06	0.00	0.15	0.23	0.0	0.03
Clear Creek 4	0304	1.44	0.84	0.04	0.00	0.00	0.00	0.01	0.14	0.08	0.02	0.13	0.00	0.07	0.11	0.0	0.00
Cox Creek	030401	0.43	0.26	0.03	0.00	0.00	0.00	0.01	0.03	0.02	0.00	0.08	0.00	0.00	0.00	0.0	0.00
Mud Creek 4	04	0.25	0.11	0.01	0.10	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.0	0.00
Brittain Creek	0401	8.11	5.53	2.45	0.05	0.01	0.00	0.00	0.02	0.00	0.01	0.04	0.00	0.00	0.00	0.0	0.00
Mud Creek 5	05	4.10	0.81	2.37	0.88	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.0	0.00
Bat Fork 1	0501	1.92	0.20	1.60	0.05	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.03	0.0	0.00
Bat Fork 2	0502	4.05	1.23	2.14	0.09	0.06	0.00	0.06	0.20	0.00	0.13	0.01	0.00	0.00	0.13	0.0	0.00
Devils Fork	050201	9.61	5.84	2.15	0.39	0.05	0.00	0.38	0.34	0.08	0.05	0.05	0.00	0.00	0.22	0.0	0.06
Bat Fork 3	0503	9.79	4.42	3.75	0.69	0.05	0.01	0.30	0.20	0.05	0.06	0.04	0.01	0.03	0.17	0.0	0.01
King Creek	050301	10.82	5.65	4.19	0.53	0.02	0.00	0.07	0.14	0.00	0.04	0.12	0.00	0.00	0.02	0.0	0.04
Mud Creek 6	06	1.09	0.73	0.27	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.0	0.00
Wash Creek	0601	6.50	3.57	2.81	0.08	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.0	0.01
Mud Creek 7	07	5.59	4.84	0.29	0.00	0.00	0.00	0.05	0.13	0.00	0.03	0.12	0.00	0.04	0.03	0.0	0.06
Shepherd Creek	0701	6.79	5.63	0.73	0.01	0.00	0.00	0.01	0.15	0.00	0.01	0.07	0.00	0.03	0.13	0.0	0.02
Upper Mud Creek	08	2.90	1.46	0.53	0.00	0.00	0.01	0.11	0.21	0.00	0.02	0.14	0.00	0.11	0.28	0.0	0.03
Little Mud Creek	0801	1.08	0.50	0.43	0.00	0.00	0.01	0.00	0.03	0.00	0.00	0.08	0.00	0.00	0.00	0.0	0.03
Total		121.97	65.82	35.39	6.43	0.49	0.14	1.95	3.78	0.57	0.79	1.60	0.35	1.11	2.98	0.0	0.57

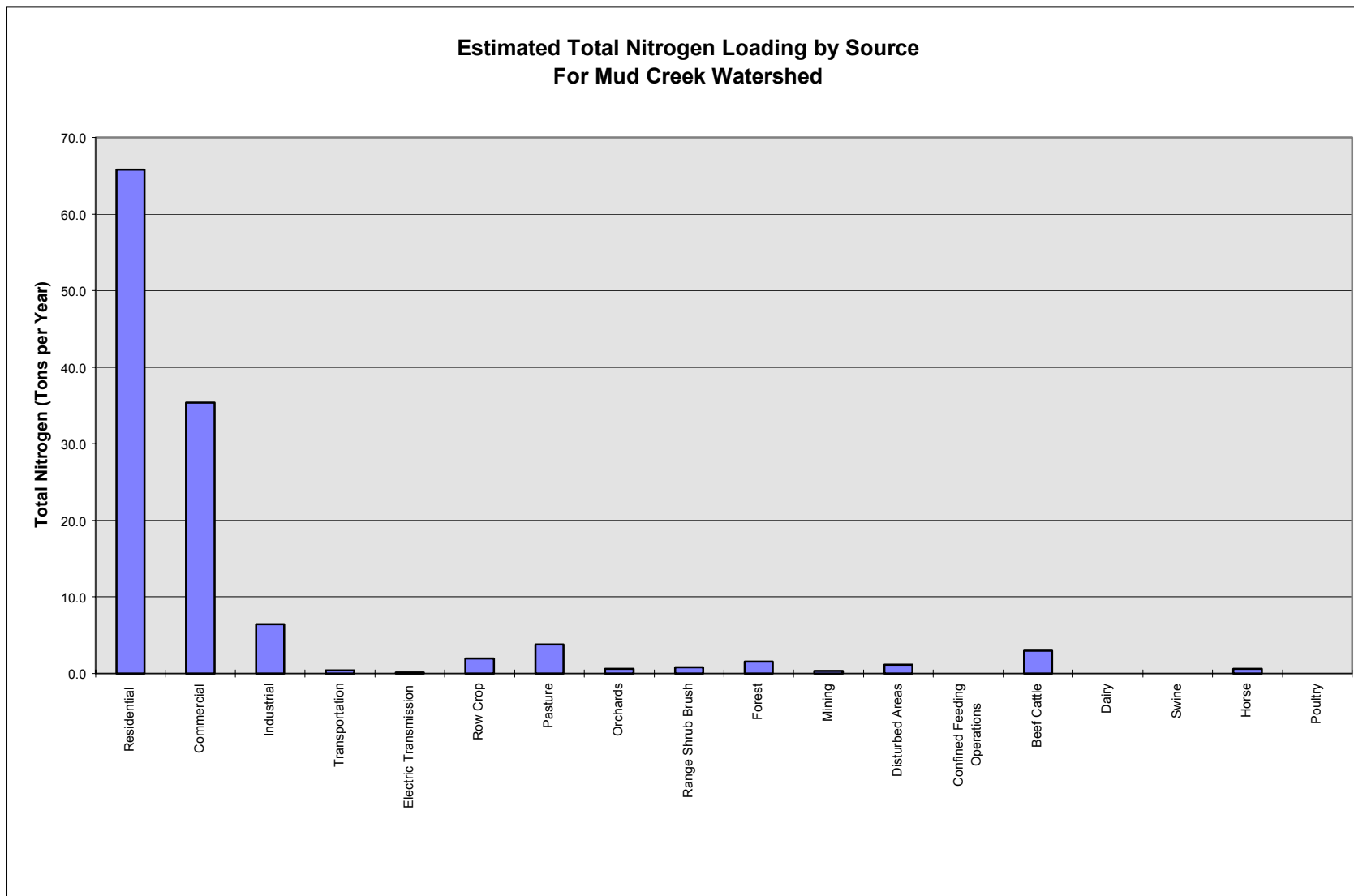


Figure 19. Estimated annual total nitrogen load by source for the Mud Creek Watershed.

**Estimated Total Nitrogen Loading by Watershed
For Mud Creek Watershed**

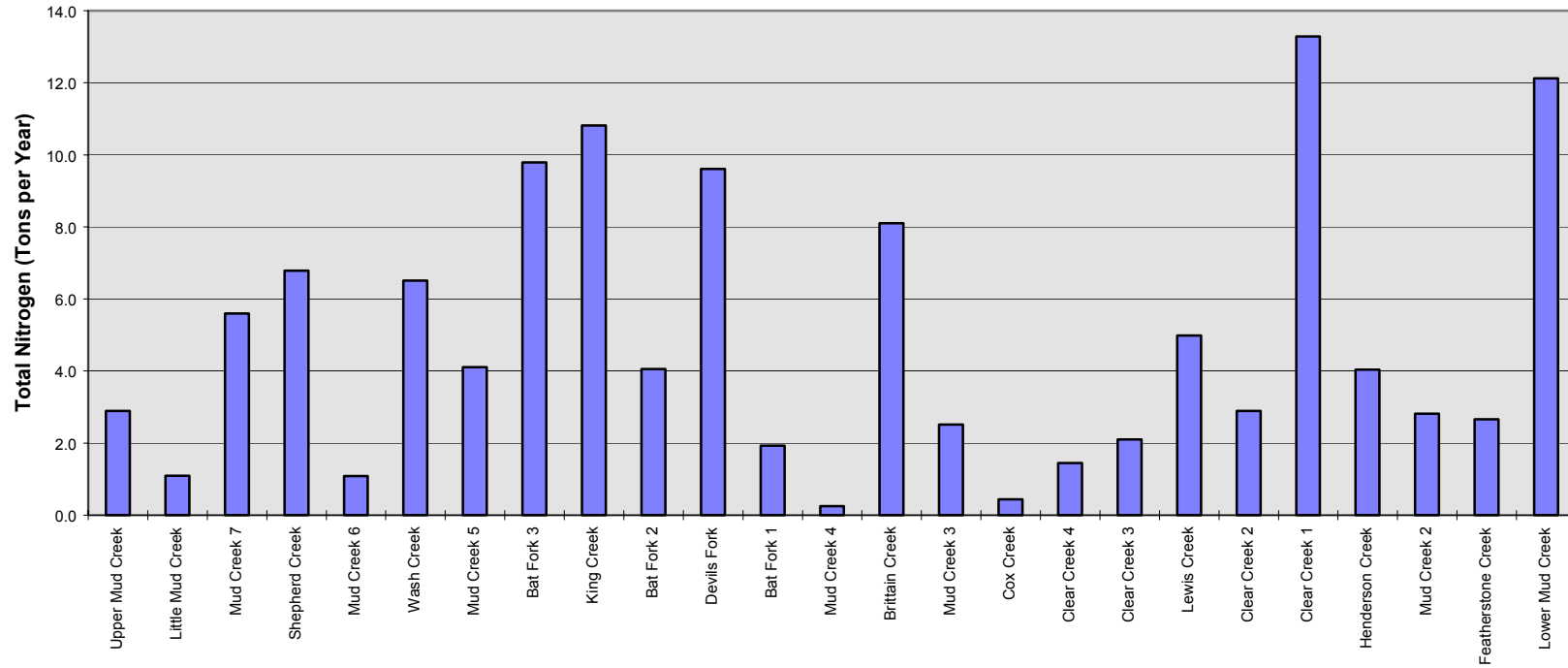


Figure 20. Estimated annual total nitrogen load for each watershed within the Mud Creek Watershed.

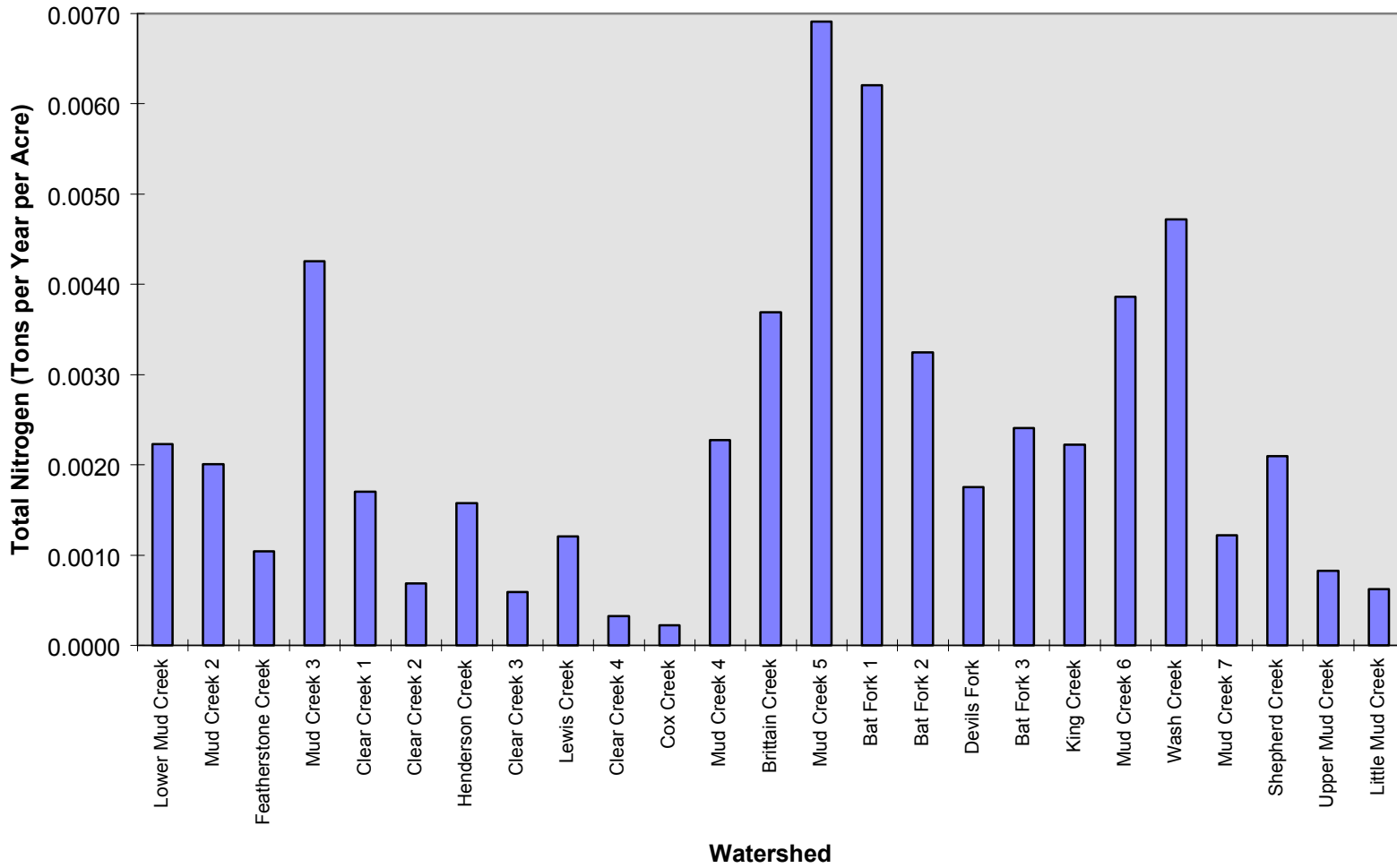


Figure 21. Estimated annual total nitrogen load per acre for each watershed within the Mud Creek Watershed.

Table 28. Estimated Total Phosphorus Load for the Mud Creek Watershed.

Watershed	ID	Total	Residential	Commercial	Industrial	Transportation	Elec Trans	Crop land	Pasture	Orchards	Range	Forest	Mining	Disturbed Areas	Beef Cattle	Dairy	Horses
Lower Mud Creek	01	1.86	0.86	0.51	0.27	0.01	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.12	0.0	0.02
Mud Creek 2	02	0.42	0.19	0.09	0.03	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.07	0.0	0.00
Featherstone Creek	0201	0.40	0.33	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.0	0.01
Mud Creek 3	03	0.37	0.12	0.17	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Clear Creek 1	0301	2.04	1.07	0.52	0.13	0.01	0.00	0.01	0.03	0.00	0.01	0.01	0.01	0.03	0.17	0.0	0.04
Clear Creek 2	0302	0.47	0.26	0.03	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.07	0.0	0.07
Henderson Creek	030201	0.62	0.32	0.13	0.04	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.08	0.0	0.02
Clear Creek 3	0303	0.34	0.16	0.02	0.00	0.00	0.00	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.08	0.0	0.02
Lewis Creek	030301	0.76	0.36	0.24	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.01	0.09	0.0	0.02
Clear Creek 4	0304	0.21	0.13	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.04	0.0	0.00
Cox Creek	030401	0.06	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.0	0.00
Mud Creek 4	04	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Brittain Creek	0401	1.22	0.84	0.37	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Mud Creek 5	05	0.61	0.12	0.36	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Bat Fork 1	0501	0.29	0.03	0.24	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.0	0.00
Bat Fork 2	0502	0.61	0.19	0.33	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.05	0.0	0.00
Devils Fork	050201	1.48	0.89	0.33	0.06	0.01	0.00	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.09	0.0	0.04
Bat Fork 3	0503	1.46	0.67	0.57	0.10	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.0	0.01
King Creek	050301	1.64	0.86	0.64	0.08	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.0	0.02
Mud Creek 6	06	0.16	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.0	0.00
Wash Creek	0601	0.99	0.54	0.43	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.01
Mud Creek 7	07	0.85	0.74	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.0	0.04
Shepherd Creek	0701	1.05	0.86	0.11	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.05	0.0	0.01
Upper Mud Creek	08	0.47	0.22	0.08	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.11	0.0	0.02
Little Mud Creek	0801	0.18	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.0	0.02
Total		18.59	10.01	5.39	0.97	0.06	0.00	0.14	0.24	0.04	0.03	0.12	0.02	0.07	1.13	0.0	0.37

Estimated Total Phosphorus Loading by Source For Mud Creek

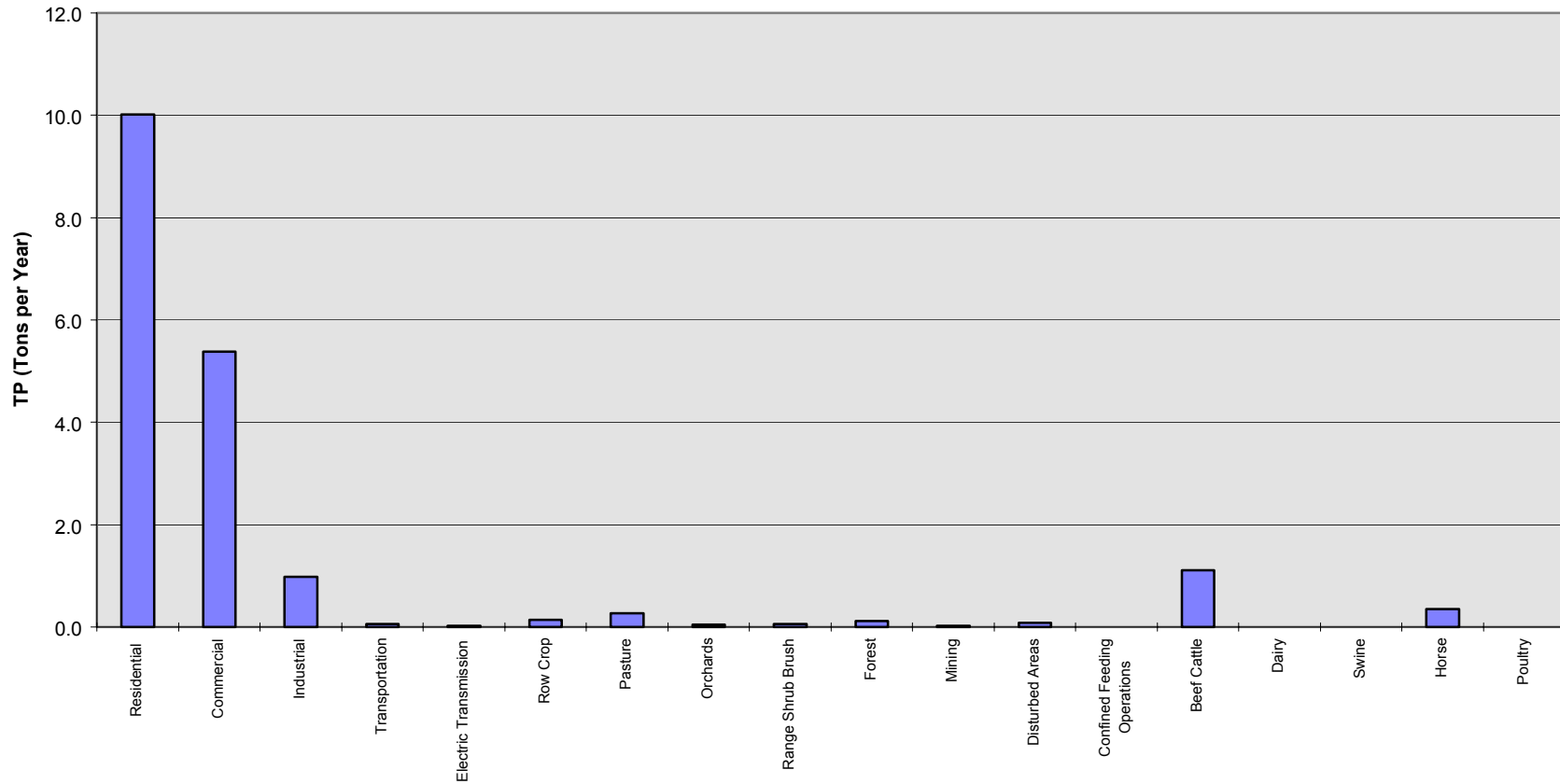


Figure 22. Estimated annual total phosphorus load by source for the Mud Creek Watershed.

**Estimated Total Phosphorus Loading by Watershed
For Mud Creek**

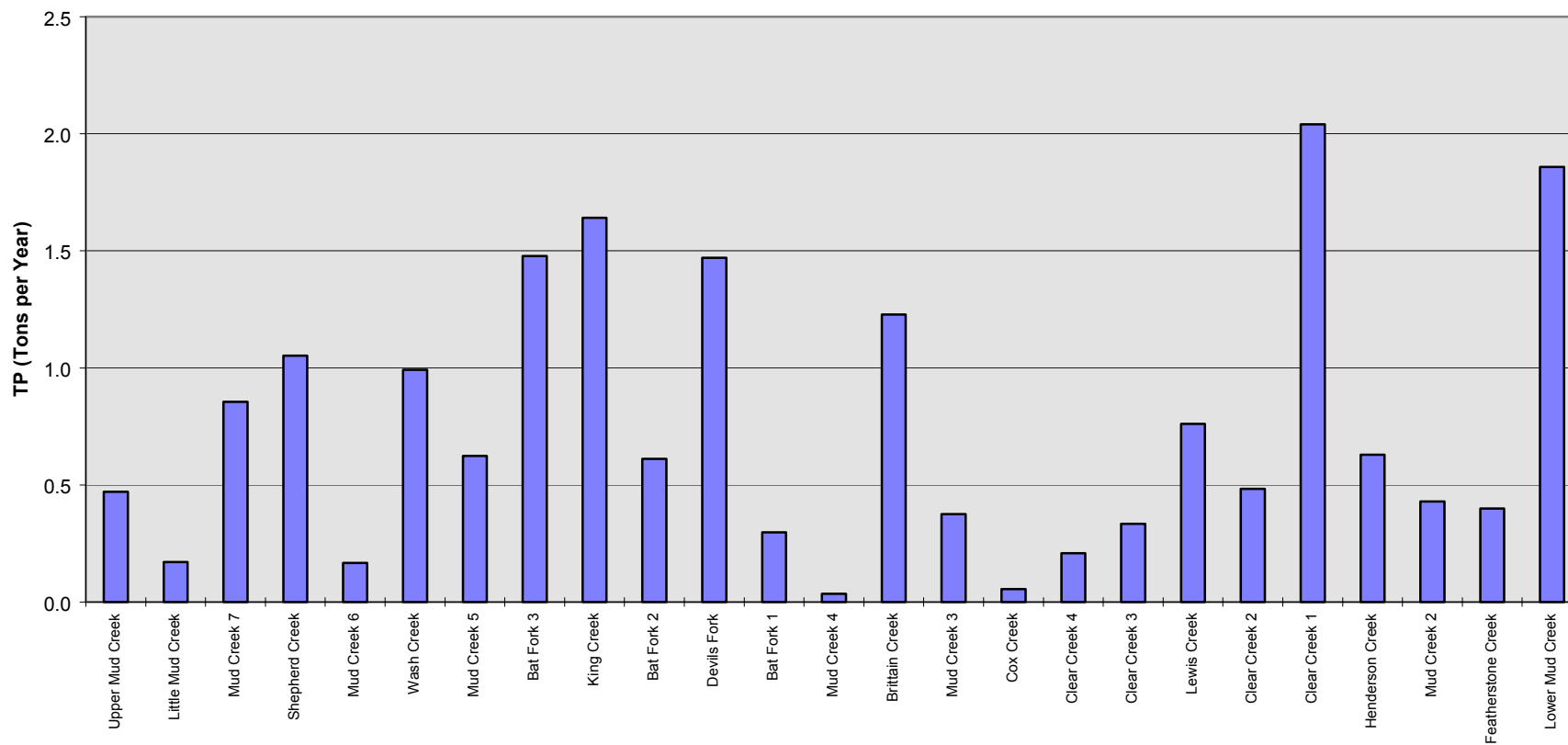


Figure 23. Estimated annual total phosphorus load for each watershed within the Mud Creek Watershed.

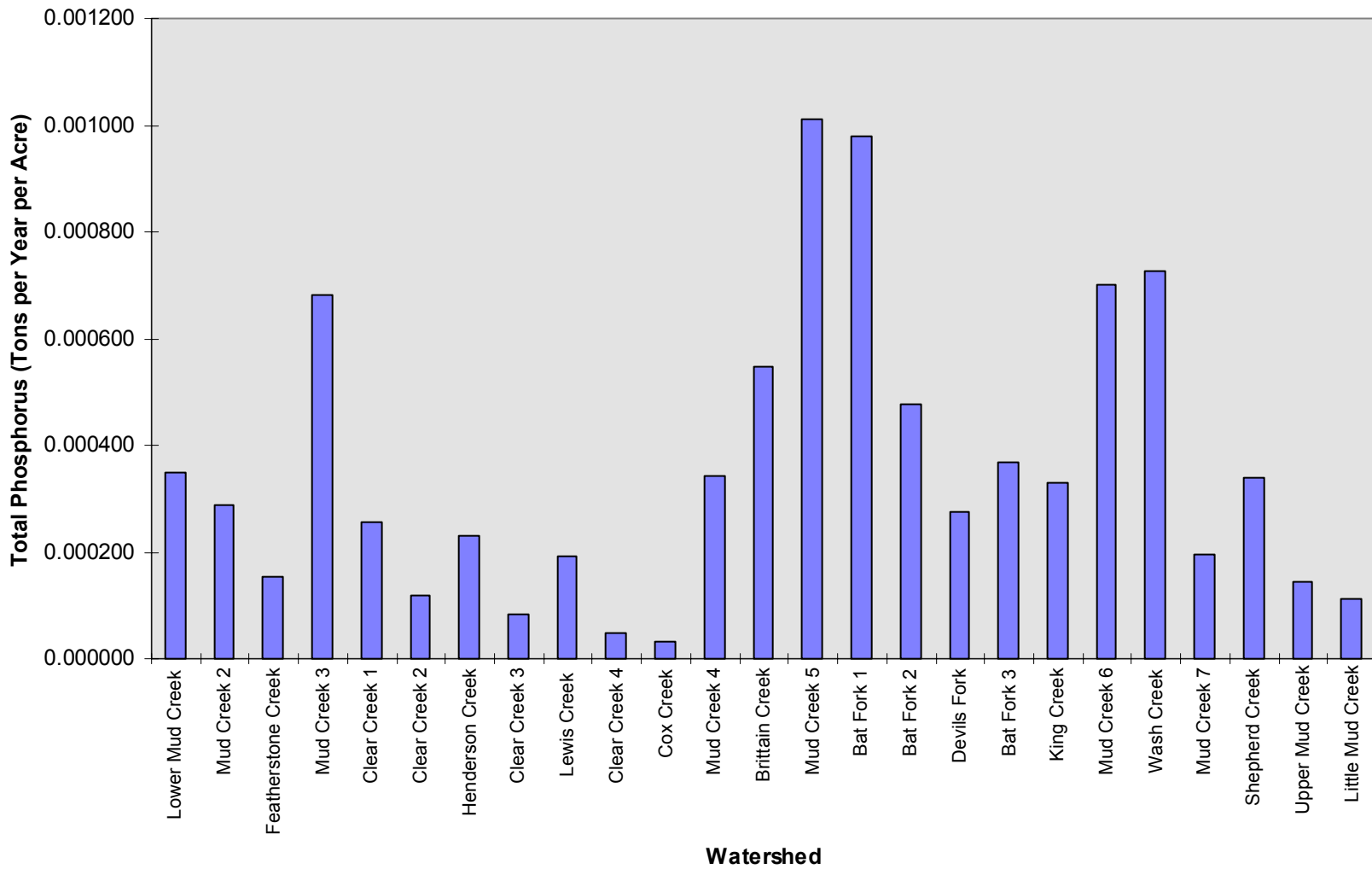


Figure 24. Estimated annual total phosphorus load per acre for each watershed within the Mud Creek Watershed.

Estimated Sediment Load

The estimated sediment loads in this report were generated using the sediment model described under Methods. The model was run using default values in consultation with the Henderson County District Conservationist. The accuracy of these estimates was not determined; however, the estimates should be useful for planning purposes. Additional water quality and soil loss studies would be required to determine the accuracy of these estimates. The sediment model allows for the adjustment of the default values as better information on water quality and watershed conditions becomes available. The model should prove useful to evaluate sediment control and management strategies.

Sediment loads were estimated for the following land use/land covers and erosion features: residential, commercial, industrial, transportation, electric transmission, cropland, pasture, orchards, shrub/brush, forest, clear-cuts, mining, disturbed areas, animal access sites, eroding streambanks, eroding unpaved roads, and road banks and ditches. The estimated annual sediment load from the above sources to each watershed within the Mud Creek Watershed is shown in Table 29. The contribution of sediment by source for the Mud Creek Watershed is shown in Figure 25. Low density residential land use and eroding unpaved road surfaces are the predominant sources of sediment at 37 percent and 16 percent, respectively, of the total load within the Mud Creek Watershed.

Figure 26 shows the sediment load from each watershed within the Mud Creek Watershed. Clear Creek Watershed (0301) has the greatest annual sediment load followed closely by Bat Fork Watershed (0503), and Lower Mud Creek Watershed (01). Residential land use contributes 33 percent of the annual sediment load in the Clear Creek Watershed (0301) and 35 percent in the Lower Mud Creek Watershed (01) while commercial land use accounts for 53 percent of the sediment load per year in the Bat Fork Watershed (0503). The sediment load for each watershed was divided by the respective watershed area. The result is shown in Figure 27. Mud Creek Watershed (05) has the greatest annual sediment load per acre at 2.19 tons, followed by Mud Creek Watersheds 02, 04, and 06 and Wash Creek Watershed (0601).

Table 29. Estimated Annual Sediment Load for the Mud Creek Watershed.

Sediment Load (Tons per Year)																				
Watershed	ID	Total	Res	Comm	Ind	Trans	Elec Trans	Crop land	Pas	Orc	Shrub/ Brush	For	Clear-cut	Mining	Disturbed Areas	Animal Access	Erd Strm	Erd Rd	Erd Rdbk	Chan Strm
Lower Mud Creek	01	5383	1906	1345	191	45	42	216	229	0	94	89	0	14	144	18	399	613	33	5
Mud Creek 2	02	2825	595	1224	26	28	71	8	151	0	31	24	0	133	104	0	223	194	13	0
Featherstone Creek	0201	1774	869	25	0	3	13	0	45	0	13	88	3	0	11	0	116	569	19	0
Mud Creek 3	03	870	374	219	86	4	9	0	31	0	32	6	1	0	0	0	42	63	2	1
Clear Creek 1	0301	6088	2039	977	83	37	54	148	359	48	93	122	5	152	328	5	551	1004	75	8
Clear Creek 2	0302	2459	634	15	0	0	0	123	276	39	7	114	1	0	40	4	181	955	58	12
Henderson Creek	030201	2121	869	70	31	6	11	87	298	60	28	37	0	0	0	0	154	436	27	7
Clear Creek 3	0303	2120	416	11	0	0	0	89	324	85	6	82	0	0	0	21	221	841	19	5
Lewis Creek	030301	2881	884	109	0	0	0	134	226	147	45	51	1	0	134	1	241	821	70	17
Clear Creek 4	0304	1979	310	3	0	0	0	13	125	84	22	119	0	0	61	0	157	1045	38	2
Cox Creek	030401	617	117	3	0	7	0	7	29	19	0	75	0	0	0	0	48	309	3	0
Mud Creek 4	04	157	86	2	23	0	0	0	13	0	16	0	0	0	0	0	6	9	1	1
Brittain Creek	0401	2441	2001	206	7	8	0	0	14	0	10	35	0	0	0	0	27	121	11	1
Mud Creek 5	05	1296	304	755	150	22	41	2	8	0	9	1	0	0	0	0	0	4	0	0
Bat Fork 1	0501	374	80	189	10	2	50	0	19	0	7	2	0	0	0	0	0	14	1	0
Bat Fork 2	0502	1805	507	549	14	263	10	52	180	0	116	8	0	0	0	5	32	64	3	2
Devils Fork	050201	4352	1949	549	42	26	5	347	305	92	45	44	0	0	0	2	246	636	54	10
Bat Fork 3	0503	6079	1579	3226	78	28	30	269	186	58	53	33	0	9	30	1	111	346	36	6
King Creek	050301	3732	1838	1030	59	28	0	63	126	0	33	95	11	0	0	0	116	256	72	5
Mud Creek 6	06	530	412	33	0	0	0	41	10	0	0	4	0	0	0	0	7	20	2	1
Wash Creek	0601	2410	1449	886	11	0	0	0	4	0	10	18	0	0	0	0	30	0	2	0
Mud Creek 7	07	2737	1751	68	0	1	5	43	116	2	30	110	0	0	39	2	116	405	48	1
Shepherd Creek	0701	2663	2057	115	1	0	0	12	132	0	5	63	0	0	23	2	90	147	14	2
Upper Mud Creek	08	2002	561	39	0	4	13	105	188	0	16	106	18	0	102	1	130	670	48	1
Little Mud Creek	0801	721	223	37	0	0	32	0	32	2	0	75	0	0	0	0	0	317	3	0
Total		60,416	23,810	11,685	812	512	386	1759	3426	636	721	1401	40	308	1016	62	3244	9859	652	87

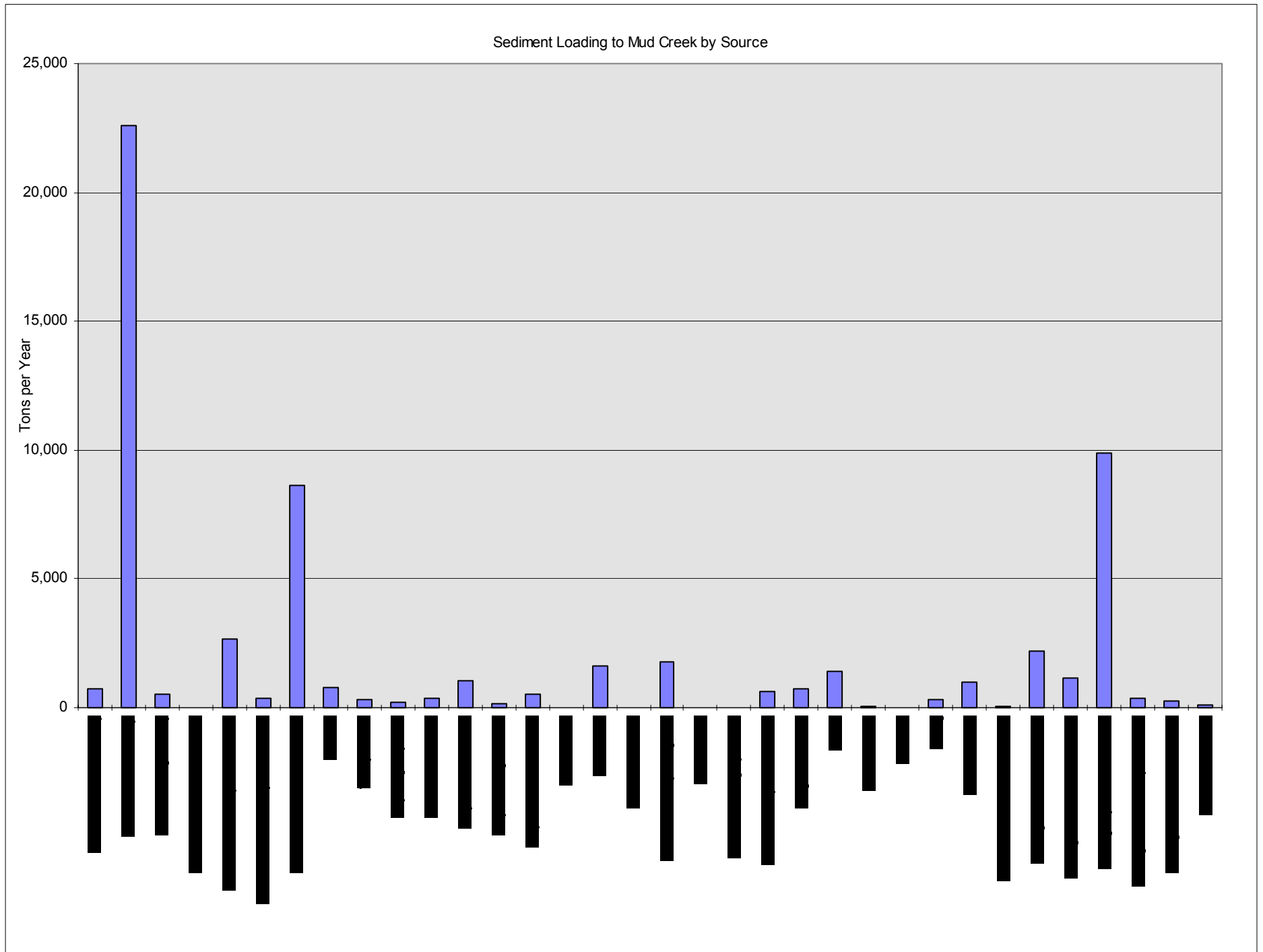


Figure 25. Estimated annual sediment load by source for the Mud Creek Watershed.

Sediment Loading to Mud Creek by Watershed

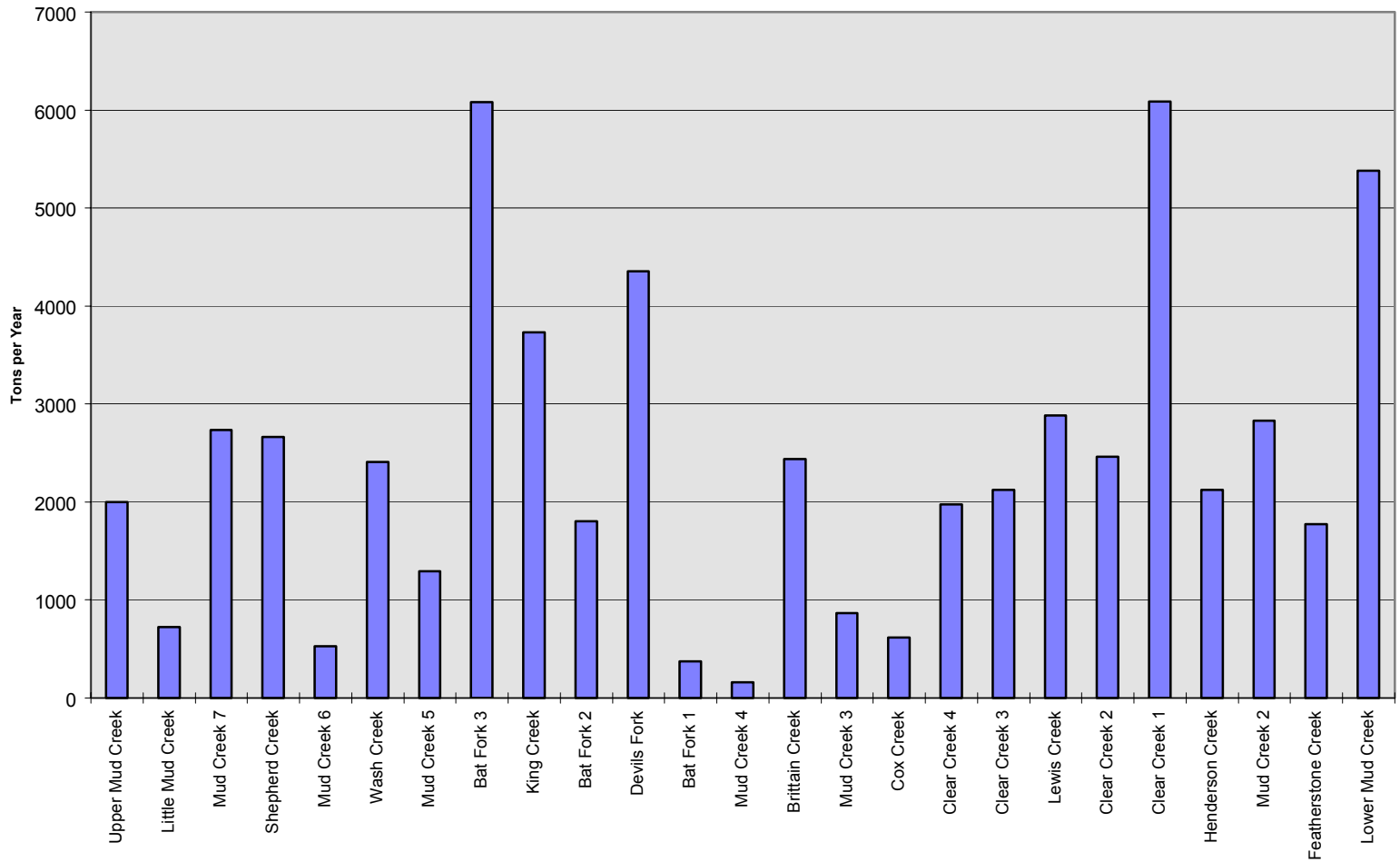


Figure 26. Estimated annual sediment load for each watershed within the Mud Creek Watershed.

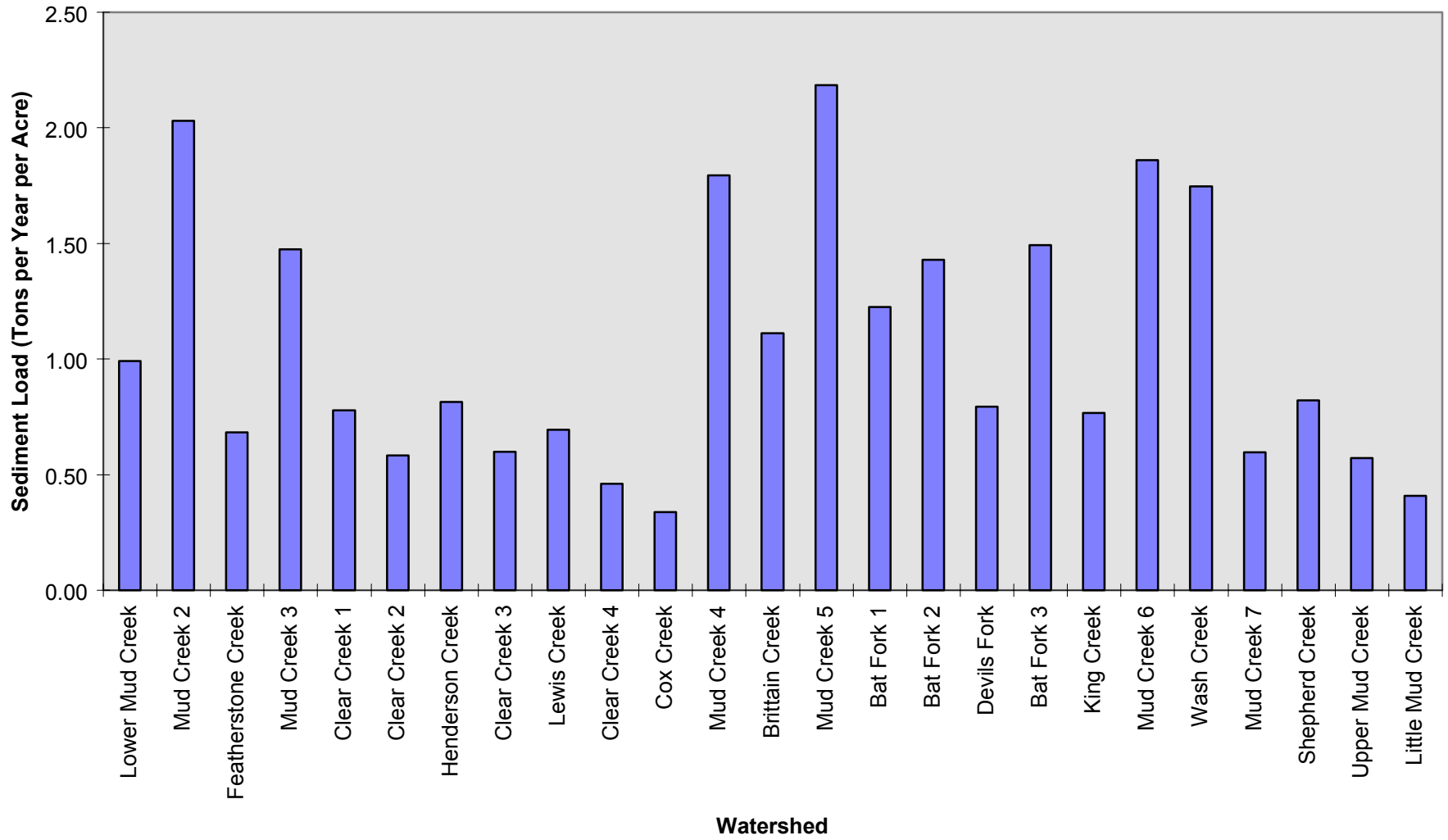


Figure 27. Estimated annual sediment load per acre for each watershed within the Mud Creek Watershed.

Tools Ready for Use

The NPS pollution inventory, desktop GIS, and pollutant loading and sediment models described in this report are tools designed to assist NCWRP in implementing water quality improvement and protection projects within the Mud Creek Watershed. This database and the desktop GIS can be used to: further pinpoint potential pollutant sources; target specific sources and sites for pollution reduction; prioritize watersheds for protection and cleanup; track implementation of BMPs; and assist in designing and managing water quality monitoring programs to evaluate the effectiveness of BMPs within the Mud Creek Watershed. The pollutant loading model can be calibrated using water quality data and/or inputs from other agencies and/or watershed partners to better estimate pollutant loads. The model can also be used to determine pollutant loads as BMP implementation proceeds. It can be used in combination with the inventory database to estimate BMP costs.

Summary

Four tools were developed by TVA to aid NCWRP in implementing water quality improvement and protection programs within the Mud creek Watershed. The tools are a NPS pollution inventory, desktop GIS, and pollutant loading and sediment models. These tools were applied to the Mud Creek Watershed in Henderson County North Carolina.

An inventory of potential sources of nonpoint pollution within the Mud Creek Watershed was developed using remote sensing techniques. This process generated a unique database for the Mud Creek Watershed based on interpretation of aerial photographs taken on March 8, 2001.

The predominant land cover in the Mud Creek Watershed is forest (44.6 percent), followed by pasture (13.4 percent), orchards (8.1 percent) and cropland (3.2 percent). Twenty percent of the watershed is characterized by residential use with commercial and industrial use occupying 5.9 percent of the landscape. The Mud Creek Watershed was divided into twenty-five watersheds. Those watersheds with the greatest contiguous areas of 25 percent slope or steeper were dominated by forest cover. For example, the Cox Creek Watershed (030401) has 55 percent of the land area with 25 percent or greater slope and 81 percent of the watershed is forested. Almost half (46 percent) of all cropland is located in Bat Fork (0503), Devils Fork (050201) and the Lower Mud Creek (01) Watersheds. Lewis Creek Watershed (030301) contains 23 percent of all orchard acreage in the Mud Creek Watershed followed by Devils Fork (050201) with 15.3 percent and Clear Creek (0304) with 13.3 percent. A third of all wetlands is located in Lower Mud Creek (01).

There were 87 beef cattle operations identified in the Mud Creek Watershed; 54 percent were adjacent to a perennial or intermittent stream. Eighty percent of all cattle operations are classified as small. Seventeen watersheds have at least one cattle operation. There were no swine or poultry operations identified. One medium-sized dairy was located in the Clear Creek Watershed (0302) adjacent to an intermittent stream; but, it is no longer active according to the SWCD staff. There were 54 horse sites identified, most (49) of which are small operations and non-adjacent to streams.

The remote sensing process identified 118.8 miles of perennial streams within the Mud Creek Watershed and another 249.3 miles of intermittent streams. Excessive bank erosion was identified along 14 percent of the total length of perennial streams while 7 percent of intermittent streambanks are eroded. Livestock are directly accessing 0.05 percent of the perennial and intermittent stream length throughout the Mud Creek Watershed. Only 17 percent of perennial streams within the Mud Creek Watershed have an adequate riparian buffer along both the right and left descending banks. Inadequate buffers occur along 56 percent of streams.

There are 1070 miles of road within the Mud Creek Watershed: 272 unpaved miles and 798 paved miles. Fifteen percent of road banks along unpaved roads are eroding while only 3.5 percent of paved roads have eroding banks.

The percent of imperviousness within the Mud Creek Watershed varies greatly across the 25 watersheds. Mud Creek Watershed (05) which includes the City of

Hendersonville is 43.2 percent impervious with commercial and industrial land uses accounting for 30.8 percent of impervious surfaces. Commercial land use in Bat Fork Watershed (0501) accounts for 29 percent of imperviousness. Meanwhile headwater watersheds including Clear Creek (0304) and Cox Creek (030401) have less than 3 percent imperviousness each.

Two models were developed to estimate the NPS pollutant loads from the sources identified by the remote sensing process. One model was used to estimate pollutant loads for TSS, BOD5, TN, and TP from the following sources: residential, commercial, industrial, transportation, electric transmission, cropland, pasture, orchards, range shrub brush, forest, clear-cuts, mining, disturbed areas, beef cattle, dairy, and horse. The model was run with user-defined input values based on best professional judgment and information collected as part of the Flint Creek Project (Morgan County Soil and Water Conservation District, 1995). The accuracy of the Mud Creek estimates was not determined; however, the estimates should be useful for planning purposes. Pollutant Load and Landscape Inputs can be adjusted to better estimate pollutant loads as more information about watershed conditions becomes available.

The second model estimates sediment loads from the above-mentioned land use categories, as well as animal access, eroding streambanks, eroding unpaved road surfaces, and eroding roadbanks and ditches. Both models can be used to evaluate potential NPS management strategies.

The models show that residential and commercial land uses are the predominant sources of BOD5, TN, and TP within the Mud Creek Watershed. Residential land use and pastures are the predominant sources of TSS followed by commercial land use. Low density residential land use and eroding unpaved road surfaces are the predominant sources of sediment within the Mud Creek Watershed.

References

- Anderson, James R., Ernest E. Hardy, and John T. Roach. A Land-Use Classification System for Use With Remote-Sensor Data. Geological Survey Circular 671.
- Barker, J. C., J. P. Zublena, and C. R. Campbell. 1990. Livestock Manure Characterization Values from the North Carolina Database. North Carolina Cooperative Extension Service.
- Carter, Robert, Natural Resources Conservation Service, Henderson County, North Carolina. October 3, 2001, fax to Burline Pullin, Tennessee Valley Authority.
- Hall, B. M. 1993. Broiler Litter Effects on Crop Production, Soil Properties, and Water Quality. Masters thesis. Auburn University.
- Kingery, W. L., C. W. Wood, D. P. Delaney, J. C. Williams, and G. L. Mullins. 1994. Impact of Long-Term Land Application of Broiler Litter on Environmentally Related Soil Properties. *Journal of Environmental Quality*. 23:139-147.
- Maas, R. P., S. C. Patch, M. J. Westphal, A. L. Alford, C. T. Glendenning. February 2001. Water Quality in the Mountains: Henderson County Volunteer Water Information Network, Year Eight Report. Environmental Quality Institute, University of North Carolina at Asheville.
- Morgan County Soil and Water Conservation District. August 1995. Pollutant Loading Estimates, The Flint Creek Watershed Project, Final Report. Hartselle, Alabama.
- North Carolina Department of Environment and Natural Resources. December 1999. French Broad River Basinwide Water Quality Plan - Draft.
- Schueler, Thomas R. Fall 1994. The Importance of Imperviousness. *Watershed Protection Techniques*. Vol. 1, No. 3.
- U.S. Department of Agriculture - Natural Resources Conservation Service. 1996. Agricultural Waste Management Field Handbook. USDA, Washington, D.C.
- U.S. Department of Agriculture - Soil Conservation Service. 1978. National Engineering Handbook.
- U.S. Environmental Protection Agency. November 1990. Urban Targeting and BMP Selection.
- U.S. Environmental Protection Agency. 1982. NURP Priority Pollution Monitoring Program -Volume 1: Findings.

Appendix A

Universal Soil Loss Factors

for the

Mud Creek Watershed

FAX

Date: 10/3/01

No. of pages including cover sheet 3

TO: Barline Pullin

FROM: Bob Carter
USDA-NRCS &
HENDERSON CO. SWCD
999 High Country Lane
Hendersonville, NC 28792

Phone:

Phone: 828-693-1629 & 697-4949

Fax Phone: 865 632-1693

Fax: 828-693-5832

CC:

REMARKS: Urgent For your review Reply ASAP Please Comment

Attached are the edits you requested. After our conversation I realized that all our dairies are outside the watershed. Also we have no swine operations in the watershed that I to know of. I indicated these on the Pollutant Load Inputs sheet. My previous LS factor estimates were based on an assumption that the 3 row crop classes assumed 0-10%, 10-30% and >30% slope. I now realize that the 0-10% etc refer to residue. I have corrected the LS factors accordingly. I also made several other changes too. I did not see factors for dirt or gravel roads. I assumed transportation was paved roads. Call if you have questions.

Bob Carter

865 632-1693
Fox to Bumble

USLE Inputs

Code	Land Class/ Land Cover	Henderson County											Soil Loss/Acre	
		Factors for Universal Soil Loss Equation												
		R	K	LS	C	P	G	H	I					
7	111 Residential, Medium Density	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
8	112 Residential, Low Density	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
9	110 Residential, High Density	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
10	113 Residential, Under Construction	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
11	12 Commercial, High Impervious	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
12	12 Commercial, Low Impervious	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
13	1224 Commercial Under Construction	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
14	13 Industrial	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
15	14 Transportation	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
16	142 Major Highway ROW	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
17	145 Electric Transmission	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
18	2101 Cropland, Low Residue	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
19	2102 Cropland, High Residue	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
20	2104 Cropland, Medium Residue	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
21	212 Pasture, Good	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
22	213 Pasture, Fair	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
23	214 Pasture, Woodland	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
24	215 Pasture, Heavily Overgrazed	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
25	216 Pasture, Poor	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
26	23 Confined Feeding Operations	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
27	22 Orchards	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
28	32 Range/Shrub/Brush	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
29	4 Forest	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
30	45 Clearcut	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
31	47 Plantation	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
32	75 Mining	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
33	76 Disturbed Areas	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000
34	P Palustrine Wetland	235	0.24	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	0.000

Dirt Roads?
Gravel Roads?

Pollutant Load Inputs

No Paving
 No Swine
 No Paving
 No Swine
 No Paving
 No Swine
 No Paving
 No Swine

	A	B	C	D	E	F	G
1							
2	Livestock						
3							
4							
5	Type of Operation			Beef Cattle	Dairy	Swine	Horse
6							
7	Number of Animals per Site						
8	Large		Number	75	150	50	25
9	Medium		Number	35	100	25	15
10	Small		Number	15	50	15	5
11	Animal Weight		lbs/animal	800	1400	100	1000
12							
13	Delivery Ratio - Adjacent	TSS	unitless	0.0437	0.075	0.1	0.0437
14		BOD5	unitless	0.0342	0.0625	0.04	0.0342
15		TN	unitless	0.0444	0.075	0.09	0.0444
16		TP	unitless	0.0437	0.075	0.1	0.0437
17							
18	Delivery Ratio - Non-Adjacent	TSS	unitless	0.0415	0.025	0.05	0.0415
19		BOD5	unitless	0.0286	0.0125	0.025	0.0286
20		TN	unitless	0.0351	0.025	0.05	0.0351
21		TP	unitless	0.0415	0.025	0.05	0.0415
22							
23	Pollutant Production	TSS	lb/day/1000 lb live wt	3.39	5	3.17	6.2
24		BOD5	lb/day/1000 lb live wt	1.36	1.6	2.08	1.36
25		TN	lb/day/1000 lb live wt	0.31	0.45	0.42	0.31
26		TP	lb/day/1000 lb live wt	0.11	0.07	0.16	0.16

Factors for Computing RUSLE Equivalent
Soil Movement Potential

County Harford
R Factor 235

Cover/Practice Class

	C Factor	
2101. Row crop: no residue (0 to 10%)	<u>.423</u>	line 1
2104. Row crop: medium residue (10 to 30%)	<u>.277</u>	line 5
2102. Row crop: heavy residue (>30%)	<u>.173</u>	line 12
2103. Strip crop	<u>.128</u>	line 17
215. Heavily overgrazed pasture	<u>.092</u>	0% canopy, 30% cover, low mkt
216. Poor pasture: sparse cover, shallow soils, steep slopes, often gullied	<u>.044</u>	0% canopy, 60% cover
217. Feedlot or loafing areas	<u>.152</u>	0% can. 10% cover
2181. Tobacco	<u>.391</u>	line 2
22. Nursery: Christmas trees, orchards	<u>.002</u>	60% canopy, 70% cov. - H
45. Forest clear-cut: recent	<u>.090</u>	60% mulch, good soil cond.
76. Disturbed area (log-rd)	<u>1.0</u>	
213. Fair pasture: uneven growth and condition, minimal maintenance		assuming 1 tons acre/year 1 ton/acre/yr
212. Good pasture: well maintained		assuming .5 tons acre/year .5 ton/acre/yr

R-factor
235

Land/Cover and Land Use Modifiers

	P Factor	
T. Terraced field	<u>.7</u>	
Ct. Contour plowed and terraced	<u>.4</u>	8% Curb, mtd. 345.6
Cn. Contoured plowed	<u>.65</u>	4% Curb 6.35
Cg. Conservation cultivated	<u>.65</u>	
G. Gullied	<u>1</u>	

any thing = 1

K Factors and average LS Factors for all county soils

If possible please provide soil loss rate for Critical Erosion Features

Paved -
Unpaved -

width x depth

	Average Erosion Rate	
ADD { 2) Animal access to streams = AA	<u>100</u>	30'
3) Channeled streams = Y	<u>50</u>	
1) Eroding stream banks EB = Y	<u>200</u>	
Unpaved roads: farm, logging, driveways, or back roads	<u>100</u>	15' wide
Critically eroding road banks	<u>200</u>	2' deep

Order
0-1 3'
2 3'
3 5'
4 7'

AA = 100
AA + CC = 150
AA + EB = 300



Appendix B

Comparison of Predicted Pollutant Loadings

With

Water Quality Monitoring Pollutant Loadings

for the

Flint Creek Watershed

Comparison of Predicted Pollutant Loadings With Water Quality Monitoring Pollutant Loadings for the Flint Creek Watershed

Pollutant loads were estimated for the Flint Creek Watershed using a model similar to the one used to estimate pollutant loads for the Mud Creek Watershed. The model and the user-defined input values are described in the report “The Flint Creek Watershed Project: Pollutant Loading Estimates” (Morgan County Soil and Water Conservation District, 1995). This report was prepared by the Tennessee Valley Authority and Natural Resources Conservation Service as part of a multi-agency watershed demonstration project. The pollutant loading estimates were compared with pollutant loading estimates generated from water quality monitoring data for Flint Creek. A comparison of the two estimates is shown in Table B-1 and Figures B-1 through B-4. The monitoring estimates are based on water quality grab samples collected and analyzed monthly from February 1993 through March 1995 by the Alabama Geological Survey.

Table B-1. Pollutant Loading Estimates Generated by the Pollutant Loading Model and the Water Quality Monitoring Data for the Flint Creek Watershed

Station Description	Station	TSS		BOD5		TKN*		TP	
		Tons/year		Tons/year		Tons/year		Tons/year	
		Model	Monitoring	Model	Monitoring	Model	Monitoring	Model	Monitoring
Mouth of East Fork Creek (becomes Flint Creek)	8	382	113	13	8	4	3	1	1
Flint Creek downstream of Robinson Creek	7	2527	3761	87	163	23	64	6	7
Flint Creek downstream of Shoal Creek	6	5229	7901	250	286	60	79	18	19
Flint Creek downstream of Mack Creek	5	5683	7600	258	312	63	86	19	19
Flint Creek downstream of Crowdabout Creek	4	7808	14197	325	421	82	89	23	24
Flint Creek upstream of West Flint Creek	3	11495	6204	418	380	106	89	29	25
Flint Creek downstream of West Flint Creek	2	21689	11907	605	706	160	174	41	43
Flint Creek to Mouth of Embayment	1	30165	22840	934	963	216	209	52	40

*Total Kjeldahl nitrogen

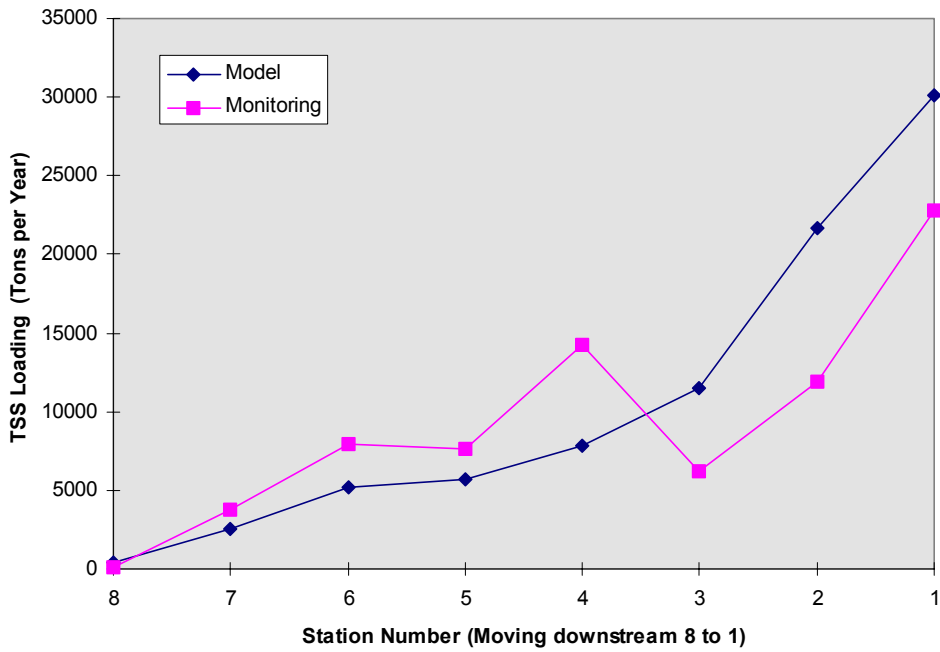


Figure B-1. Comparison of Estimated TSS Loading Generated by the Pollutant Loading Model and the Water Quality Monitoring Data for the Flint Creek Watershed

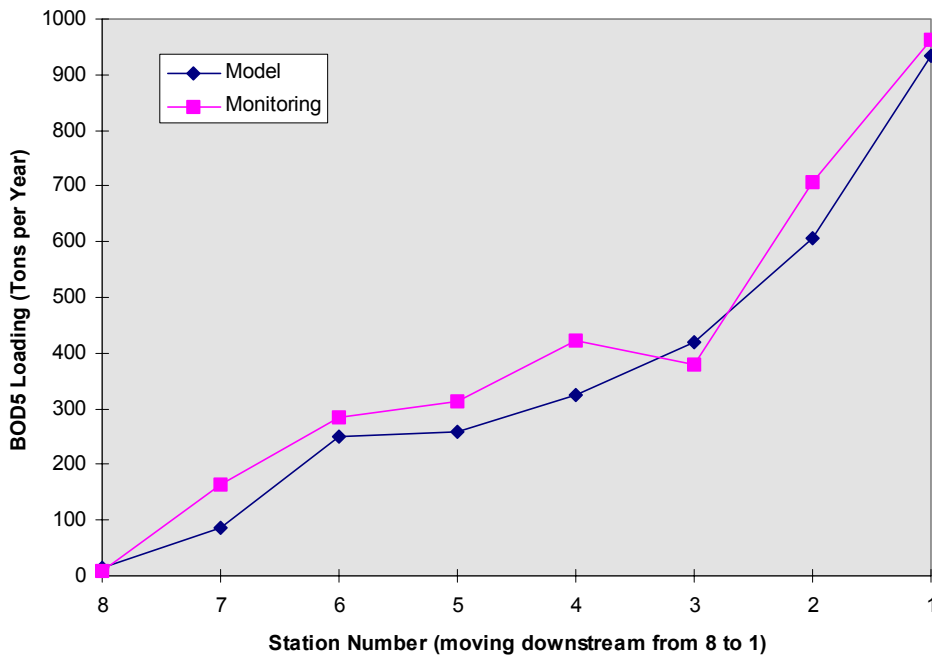


Figure B-2. Comparison of Estimated BOD5 Loading Generated by the Pollutant Loading Model and the Water Quality Monitoring Data for the Flint Creek Watershed

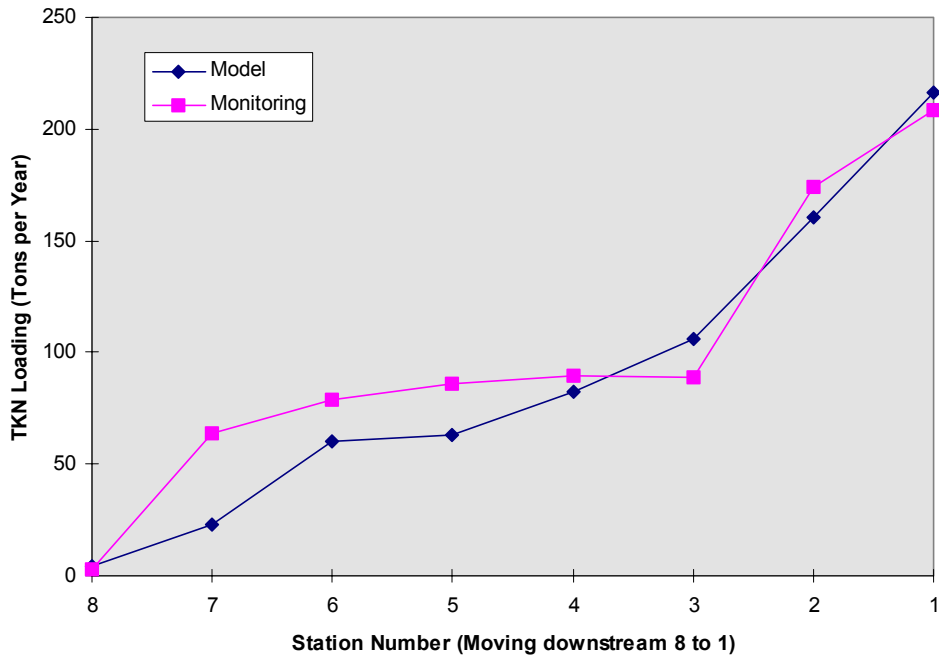


Figure B-3. Comparison of Estimated TKN Loading Generated by the Pollutant Loading Model and the Water Quality Monitoring Data for the Flint Creek Watershed

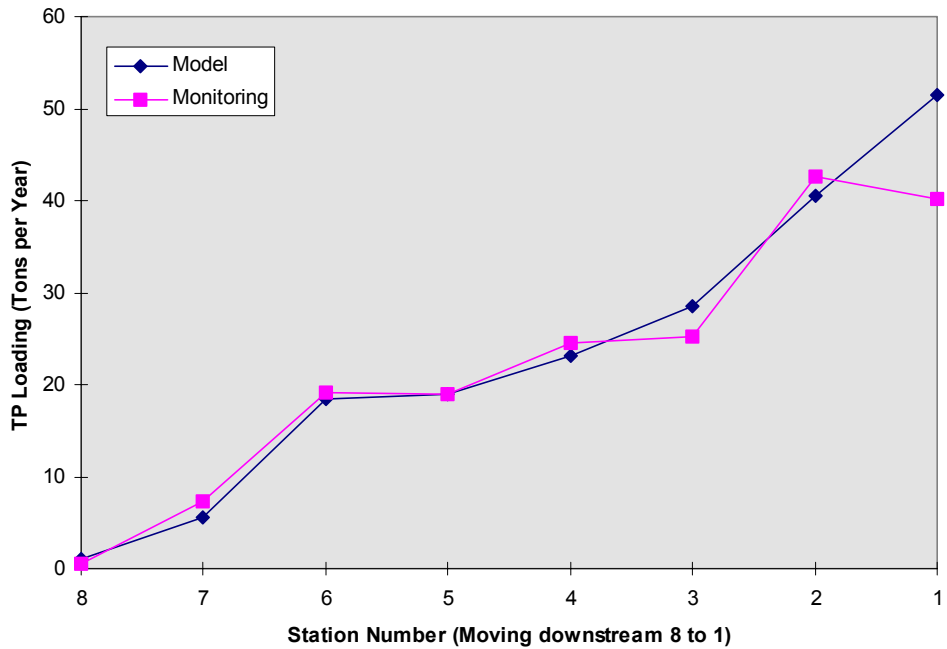


Figure B-4. Comparison of Estimated TP Loading Generated by the Pollutant Loading Model and the Water Quality Monitoring Data for the Flint Creek Watershed

Appendix C

Geographic Information System

Data Dictionary

for the

Mud Creek Watershed

Mud Creek Watershed, North Carolina

DATA DICTIONARY Non-Point Source Pollution Data

Listing of Arc/Info Coverages and Their Associated Attributes November 5, 2001

Coordinate System Description

Projection STATEPLANE
Fipszone 3200
Datum NAD83
Units Meters Spheroid Clarke 1866

COUNTY - Polygon coverage of county boundaries

county.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	COUNTY#	4	5	B	-	Arc/Info sequence number
	COUNTY-ID	4	5	B	-	Arc/Info identifier
	ACRES	4	12	F	-	Area of polygon in acres
	COUNTY	15	15	C	-	County name or abbreviation
	STATE	2	2	C	1	State abbreviation
	EDIT_FLAG	1	1	I	-	Not applicable (N/A)

(Data Source - USGS/TVA 7.5 minute topographic map series)

(7.5 Minute Topographic Maps) QUADS - Polygon coverage of 7.5 minute 1:24,000 scale map series boundaries

quads.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	QUADS#	4	5	B	-	Arc/Info sequence number
	QUADS-ID	4	5	B	-	Arc/Info identifier
	ACRES	8	10	F	1	N/A
TVA Map Number	QUADNUM	8	8	C	-	TVA 7.5 minute topographic map series ID
	EDIT_FLAG	1	1	C	-	N/A
Map Name	QUADNAME	40	40	C	-	USGS/TVA 7.5 minute topographic map series name

(Data source - USGS/TVA 7.5 minute topographic map series)

(Drain Point) DRAINPT - Label point coverage of drainage features

drainpt.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	DRAINPT#	4	5	B	-	Arc/Info sequence number
	DRAINPT-ID	4	5	B	-	Arc/Info identifier
Source Identifier	SOURCEID	1	1	C	-	Q = USGS/TVA 7.5 minute topographic map series R = TVA/GIE photointerpretation staff
	NAME	25	25	C	-	Drainage point name
	TYPE	2	2	C	-	Type of drainage feature EM = Emerging point of drain SK = Sinking point of drain SP = Spring CB = Highway culvert
	EDIT_FLAG	1	1	C	-	N/A

(Data source - TVA/GIE photointerpretation)

(Potential Pollution Source) PPOINT_SOURCE - Label point coverage of potential pollution source(s)

ppoint_source.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	PPOINT_SOURCE #	4	5	B	-	Arc/Info sequence number
	PPOINT_SOURCE -ID	4	5	B	-	Arc/Info identifier
	TYPE	1	1	C	-	I = potential point source
	SIZE	1	1	C	-	N/A
	CONFINED	1	1	C	-	Y = Confined
	ADJ	1	1	C	-	N/A
	TREATMENT	1	1	C	-	N/A
	HPIS	1	1	C	-	N/A
	HOUSES	2	2	I	-	N/A
	SQFT	8	8	I	-	N/A
	EDIT_FLAG	1	1	I	-	N/A
	MOD	4	4	C	-	N/A

(Data source - TVA/GIE photointerpretation. Potential pollution sources may include commercial, industrial, and transportation facilities as interpreted from the aerial photography. These sites have not been field verified.)

(Livestock) LIVESTOK - Label point coverage of livestock and poultry sites

livestok.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	LIVESTOK#	4	5	B	-	Arc/Info sequence number
	LIVESTOK-ID	4	5	B	-	Arc/Info identifier
	TYPE	1	1	C	-	Type of livestock operation C = Cattle P = Poultry S = Swine H = Horse D = Dairy
Relative Size	SIZE	1	1	C	-	Relative size of operation in project area S = Small animal population M = Medium animal population L = Large animal population
	CONFINED	1	1	C	-	Y = Confined: housed or confined to feedlot
Adjacent	ADJ	1	1	C	-	Y = Site is adjacent to stream or stream runs through site
Treatment Facility	TREATMENT	1	1	C	-	Y = Operation has a waste treatment strategy; (treatment facility, waste lagoon, storage pond, compost barn)
High Potential Impact Sites	HPIS	1	1	C	-	Y = High potential impact site; site with indications of poor waste management
Number of Poultry Houses	HOUSES	2	2	I	-	Number of poultry houses at site
Total Square Feet of Houses	SQFT	8	8	I	-	Total square feet of all poultry houses at site
	EDIT_FLAG	1	1	I	-	N/A
	MOD	4	4	C	-	N/A

(Data source - TVA/GIE photointerpretation)

(Natural Areas) NAT_AREAS - Polygon coverage of Henderson County, NC, natural areas

nat_areas.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	NAT_AREAS#	4	5	B	-	Arc/Info sequence number
	NAT_AREAS-ID	4	5	B	-	Arc/Info identifier
	NAME	50	50	C	-	Name of natural area
	ACRES	15	15	N	3	Area of polygon in acres

(Data source - Henderson County, NC)

(Land Use/Land Cover) LULC - Polygon coverage of Land Use/Land Cover classes

lulc.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	LULC#	4	5	B	-	Arc/Info sequence number
	LULC-ID	4	5	B	-	Arc/Info identifier
Land Use Classification	LUCLASS	7	7	C	-	Land use classification identifier (see Mud Creek Land Use Classification Scheme)
	MODIFIER	2	2	C	-	Physical feature modifier for LUCLASS G = Gully
	ACRES	4	10	F	1	Acres of a land use polygon
	RAINFALL	2	2	I	-	Average inches of rain per year
Soil Loss (T/A/Y)	SLOSSTAY	4	18	F	3	Soil loss in Tons/Acres/Year
Soil Loss (T/Y)	SLOSSTY	4	18	F	3	Soil loss in Tons/Year
Rainfall Factor	RFACT	3	3	I	-	County Rainfall Factor in USLE/RUSLE
Soil Erodibility Factor	KFACT	4	18	F	3	Soil Erodibility Factor in USLE/RUSLE
Coservation Practice	PFACT	4	18	F	3	Practice Factor in USLE/RUSLE
Cropping/Cover Factor	CFACT	4	18	F	3	Cropping/Cover Factor in USLE/RUSLE
Length Slope Factor	LSFACT	4	18	F	3	Length Slope Factor in USLE/RUSLE
Theta	THETARAD	4	12	F	3	N/A, Theta used in calculating LS factor

(Land Use/Land Cover) LULC - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Exponent	EXP	4	12	F	3	N/A, Exponent used in calculating LS factor
Field Identifier	FIELDID	4	4	I	-	N/A, Polygon identifier
Soil Type	SOILTYPE	6	6	C	-	N/A, Soil type abbreviation
Percent Impervious	PERC_IMPERV	3	3	I	-	Percent impervious of LULC polygon (measured in 5 percent increments)
Source Identifier	SOURCEID	1	1	C	-	TVA/GIE photointerpretation staff
	EDIT_FLAG	1	1	C	-	N/A

(Data source - TVA/GIE photointerpretation)

(State Hydrologic Unit) SHUC - Polygon coverage of 11-digit State Hydrologic Unit, (USGS)

shuc.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	SHUC#	4	5	B	-	Arc/Info sequence number
	SHUC-ID	4	5	B	-	Arc/Info identifier
	ACRES	4	10	F	1	Area of polygon in acres
State Hydrologic Unit	STATEHUC	11	11	C	-	USGS eleven digit hydrologic unit
	EDIT_FLAG	1	1	I	-	N/A

(Data source - USGS)

(Watershed) WSHED - Polygon coverage of subwatershed boundaries

wshed.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	WSHED#	4	5	B	-	Arc/Info sequence number
	WSHED-ID	4	5	B	-	Arc/Info identifier
	ACRES	4	10	F	1	Area of polygon in acres
Watershed	WSHED	10	10	C	-	TVA/GIE sub-hydrologic unit
	EDIT_FLAG	1	1	I	-	N/A
	NAME	75	75	C	-	Name of TVA sub-hydrologic unit

(Data source - TVA/GIE, based on USGS/TVA 7.5 minute topographic map series contours)

(Percent Slope) MUD_SLOPE_WS - Polygon coverage of slope ranges

mud_slope_ws.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	MUD_SLOPE_W S#	4	5	B	-	Arc/Info sequence number
	MUD_SLOPE_W S-ID	4	5	B	-	Arc/Info identifier
	SLOPE-CODE	4	5	B	-	Attributes that represent slope range
	ACRES	4	10	F	1	Area of polygon in acres
Watershed	WSHED	10	10	C	-	TVA/GIE sub-hydrologic unit
Watershed Name	WS_NAME	75	75	C	-	Name of TVA/GIE sub-hydrologic unit
	SLOPE-RANGE	10	10	C	-	Percent slope 1 = 0 -2% 2 = >2 - 7% 3 = >7 - 15% 4 = >15 - 25% 5 = >25 - 45% 6 = >45%

(Data Source - USGS Digital Elevation Model)

ROADS - Line coverage of road surface and erosion features

roads.aat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	FNODE#	4	5	B	-	Arc/Info from node #
	TNODE#	4	5	B	-	Arc/Info to node #
	LPOLY#	4	5	B	-	Left adjacent polygon #
	RPOLY#	4	5	B	-	Right adjacent polygon #
	LENGTH	8	18	F	5	Length of segment in feet
	ROADS#	4	5	B	-	Arc/Info sequence number
	ROADS-ID	4	5	B	-	Arc/Info identifier
Source Identifier	SOURCEID	1	1	C	-	Q = USGS/TVA 7.5 minute topographic map series (road lines) R = TVA/GIE photointerpretation staff (road lines)
	ROADCLASS	1	1	I	-	N/A, Road class based on USGS/TVA 7.5 minute topographic map series

ROADS - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Unpaved Road	UNPAVED	1	1	C	-	Road surface Y = Unpaved
Eroded Road Bank	ERODED	1	1	C	-	Y = Critically eroding road bank
	FORD	4	4	C	-	N/A, Road crossing stream
	TYPE	5	5	C	-	N/A, Road type (e.g. road or parking lot)
<i>(Data source - TVA/GIE photointerpretation)</i>						
Road Name	ROADNAME	30	30	C	-	Road name
	<i>(Data source - USGS/TVA 7.5 minute topographic map series)</i>					
	EDIT_FLAG	1	1	C	-	N/A

STREAMS - Line coverage of stream order, type, animal access, erosion condition and streamside riparian buffers

streams.pat

*Note: Streambank left or right is based on **Looking Downstream.***

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	FNODE#	4	5	B	-	Arc/Info from node #
	TNODE#	4	5	B	-	Arc/Info to node #
	LPOLY#	4	5	B	-	Left adjacent polygon #
	RPOLY#	4	5	B	-	Right adjacent polygon #
	LENGTH	8	18	F	5	Length in feet
	STREAMS#	4	5	B	-	Arc/Info sequence number
	STREAMS-ID	4	5	B	-	Arc/Info identifier
	SOURCEID	1	1	C	-	Q = USGS/TVA 7.5 minute topographic map series (stream lines) R = TVA/GIE photointerpretation (stream lines)
Stream Type	STRMTYPE	1	1	C	-	Stream type P = Perennial: base flow in most years I = Intermittent: some flow in most years, well defined channel E = Ephemeral: storm event runoff, no defined channel
Right Bank of Double Line Stream	STRMDBLR	1	1	C	-	Y = Right bank, looking downstream, Base map double line stream

Streams - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Left Bank of Double Line Stream	STRMDBLL	1	1	C	-	Y = Left bank, looking downstream, Base map double line stream
Right Shoreline	STRMSHR	1	1	C	-	Y = Right bank of a water body
Left Shoreline	STRMSHL	1	1	C	-	Y = Left bank of a water body
Stream Order	STRMORDR	2	2	I	-	Stream order of drains on 7.5 minute map series 1 = First order 2 = Second order etc.
<i>(Data source - TVA/GIE, based on the USGS/TVA 7.5 minute topographic map series blueline streams)</i>						
Animal Access	STRMACC	2	2	C	-	Type of livestock access AA = Point of animal access AX = Segments with probable animal access AP = Segments with potential animal access
Channeled	STRMCC	1	1	C	-	Y = Channeled stream
Eroding Bank	STRMEB	1	1	C	-	Y = Eroding streambank
Grassed Waterway	STRMGW	1	1	C	-	Y = Grassed waterway
Culvert	STRMCV	1	1	C	-	Y = Culvert
Sub-surface	STRMSS	1	1	C	-	Y = Sub-surface stream
Treatment Pond	STRMT	1	1	C	-	Y = Treatment pond
Left Bank Vegetation Condition	LBVEGCOND	2	2	I	-	General vegetation cover condition, Left bank, looking downstream 1 = Open (no woody vegetation) 2 = Closed (woody vegetation)
Right Bank Vegetation Condition	RBVEGCOND	2	2	I	-	General vegetation cover condition, right bank, looking downstream 1 = Open (no woody vegetation) 2 = Closed (woody vegetation)

Streams - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Left Bank Vegetation Type	LBVEGTYPE	2	2	C	-	Type of streambank vegetation, Left bank, looking downstream GR = Grass SS = Shrub/Scrub TR = Trees TS = Trees/Shrub TG = Trees/Grass SG = Shrub/Grass UB = None - Urban or bare ground
Right Bank Vegetation Type	RBVEGTYPE	2	2	C	-	Type of streambank vegetation, Right bank, looking downstream GR = Grass SS = Shrub/Scrub TR = Trees TS = Trees/Shrub TG = Trees/Grass SG = Shrub/Grass UB = None - Urban or bare ground
Left Bank Vegetation Density	LBVEGCOVER	2	2	I	-	Density or percent of streambank vegetation cover, Left bank, looking downstream <i>If LBVEGTYPE or RBVEGTYPE = SS TR TS TG SG</i> 1 = 0% to 33% 2 = 34% to 66% 3 = 67% to 100%
Right Bank Vegetation Density	RBVEGCOVER	2	2	I	-	Density or percent of streambank vegetation cover, Right bank, looking downstream <i>If LBVEGTYPE or RBVEGTYPE = SS TR TS TG SG</i> 1 = 0% to 33% 2 = 34% to 66% 3 = 67% to 100% <i>If LBVEGTYPE or RBVEGTYPE = GR UB</i> 1 = Good quality of grass cover 2 = Moderate quality of grass cover 3 = Poor quality of grass cover

STREAMS - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Left Bank Buffer Width	LBVEGWIDTH	2	2	I	-	Buffer width of vegetation type, Left bank, looking downstream 1 = 0 to 15 feet 2 = 16 to 30 feet 3 = 31 to 50 feet 4 = 51 to 100 feet 5 = greater than 100 feet
Right Bank Buffer Width	RBVEGWIDTH	2	2	I	-	Buffer width of vegetation type, Right bank, looking downstream 1 = 0 to 15 feet 2 = 16 to 30 feet 3 = 31 to 50 feet 4 = 51 to 100 feet 5 = greater than 100 feet
Left Bank Physical Feature	LBVEGFEATS	2	2	C	-	Physical features of stream as noted (Left bank, looking downstream) d = Pond
Right Bank Physical Feature	RBVEGFEATS	2	2	C	-	Physical features of stream as noted (Right bank, looking downstream) d = Pond
Left Bank Wetland Type	LBVEGWETMOD	6	6	C	-	Wetland Type, Left bank, looking downstream PFO = Palustrine forest PSS = Palustrine scrub shrub PEM = Palustrine emergent PFO/SS = Palustrine forest / PSS/EM = Palustrine scrub shrub /
Right Bank Wetland Type	RBVEGWETMOD	6	6	C	-	Wetland Type, Right bank, looking downstream PFO = Palustrine forest PSS = Palustrine scrub shrub PEM = Palustrine emergent PFO/SS = Palustrine forest / PSS/EM = Palustrine scrub shrub /
Left Bank Slope	LBVEGBANKMOD	1	1	C	-	N/A, Slope of Land Adjacent to Reservoir (Left bank, looking Downstream)

STREAMS - Continued

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
Right Bank Slope	RBVEGBANKMO D	1	1	C	-	N/A, Slope of Land Adjacent to Reservoir (Right bank, looking Downstream)
Left Bank Boat Dock	LBBOAT_DOCK	3	3	I	-	N/A, Structures (boat dock / House (Left bank, looking Downstream)
Right Bank Boat Dock	RBBOAT_DOCK	3	3	I	-	N/A, Structures (boat dock / House (Right bank, looking Downstream)
	EDIT_FLAG	1	1	I	-	N/A
	<i>(Data source - TVA/GIE photointerpretation)</i>					
	WATERSHED	10	10	C	-	Watershed Number
Left Bank Riparian Classification	LBADEQ	30	30	C	-	Left Bank Riparian Classification
Left Bank Riparian Classification Reason	LBREASON	2	2	C	-	Left Bank Riparian Classification Reason
Right Bank Riparian Classification	RBADEQ	30	30	C	-	Right Bank Riparian Classification
Right Bank Riparian Classification Reason	RBREASON	2	2	C	-	Right Bank Riparian Classification Reason
	<i>(Data source - TVA water quality staff)</i>					
	EROSION	4	10	F	3	
	<i>(Data source - Erosion rates provided by NRCS counties within the watershed)</i>					

DUMPS - Point coverage of dump sites

dumps.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	DUMPS#	4	5	B	-	Arc/Info sequence number
	DUMPS-ID	4	5	B	-	Arc/Info identifier
	<i>(Data source - TVA/GIE photointerpretation. Dump sites are interpreted from aerial photography. The sites are primarily road side dumps, many in close proximity to streams. Other sites identified include residential and farm dumpsites which are usually not accessible from public roads. The type of debris/garbage may be anything from old cars/machinery to household waste. The type of material and the size of the site is not differentiated.)</i>					

SEPTIC - Point coverage of on site septic system conditions

septic.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	SEPTIC#	4	5	B	-	Arc/Info sequence number
	SEPTIC-ID	4	5	B	-	Arc/Info identifier
Type of Structure	TYPE	12	12	C	-	Type of residence
						H = House M = Mobile Home C = Commercial building
Condition	COND	1	1	C	-	Condition of septic system
						1 = Distinctive moisture pattern: Identifiable plume from visible fieldline pattern or ponding downslope from fieldlines.
						2 = Suspicious moisture pattern: Visible plume pattern but no fieldlines visible.
						3 = Distinctive drainfield: Fieldline pattern but no plume evident
						4 = Suspect location : No fieldlines or plumes apparent; homes on steep slopes, small lots, shallow soils, close to streams, heavily wooded lots
	EDIT_FLAG	1	1	I	-	N/A
	<i>(Data source - TVA/GIE photointerpretation)</i>					

(Pesticide Stations) PESTSTATIONS - Point coverage of Pesticide Loading Station sites

peststations.pat

<u>ALIAS</u>	<u>ITEM NAME</u>	<u>WIDTH</u>	<u>OUTPUT</u>	<u>TYPE</u>	<u>N.DEC</u>	<u>DESCRIPTION</u>
	AREA	8	18	F	5	Area of polygon
	PERIMETER	8	18	F	5	Perimeter of polygon
	PESTSTATIONS#	4	5	B	-	Arc/Info sequence number
	PESTSTATIONS- ID	4	5	B	-	Arc/Info identifier
	DATE_COMPLETI ON	10	10	C	-	
Owner First Name	FNAME	15	15	C	-	Owner first name
Owner Last Name	INAME	15	15	C	-	Owner last name
	FARM_NAME	20	20	C	-	Farm name
Owner address	ADD1	20	20	C	-	Mailing address
	CITY	20	20	C	-	City location
	STATE	2	2	C	-	State location
	ZIP	10	10	I	-	Zip code
Station Number	STATION_#	2	2	I	-	NRCS identifier code

(Data source - USDA-NRCS & Henderson County SWDC, NC & TVA/GIE photointerpretation)