Assessment Report: Biological Impairment in the Morgan Mill and Peter Weaver Creek Watershed

French Broad River Basin
Transylvania County, N.C.

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North Carolina Department of Environment and Natural Resources
Division of Water Quality
Planning Branch

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Executive Summary

Introduction

This report presents the results of the Peter Weaver and Morgan Mill Creek water quality assessment, conducted by the North Carolina Division of Water Quality (DWQ) with financing from the Clean Water Management Trust Fund (CWMTF). Peter Weaver and Morgan Mill Creeks are considered impaired by the DWQ because they are unable to support acceptable communities of aquatic organisms. The goal of the assessment was to provide the foundation for future water quality restoration activities in the Peter Weaver and Morgan Mill Creek watershed by: 1) identifying the most likely causes of biological impairment; 2) identifying the major watershed activities and pollution sources contributing to those causes; and 3) outlining a general watershed strategy that recommends restoration activities and best management practices (BMPs) to address the identified problems.

Study Area and Stream Description

Peter Weaver and Morgan Mill Creeks are small tributaries of the French Broad River located in central Transylvania County (see map in Section 1) in DWQ subbasin 040301. The watershed drains approximately 2.5 square miles (6.5 km^2). The upper two-thirds of the watershed is on largely forested slopes, and the stream valleys have been cleared for homes and a few businesses. The lower third of the watershed is in the French Broad River valley, where flat land has been cleared for a number of residences, small businesses, and pasture and crop land. The streams in this valley area are generally incised and laterally unstable. Since 1984, the Morgan Mill Trout Farm has been operating on Morgan Mill Creek and runs much (or all, at times during low flows) of the creek through its trout raceways and ponds.

Results from historical benthic monitoring demonstrate a marked decline in integrity of the benthic macroinvertebrate community in lower Peter Weaver Creek between the late 1970s and 1997. Morgan Mill Creek below the trout farm and US 64 and Peter Weaver Creek below its confluence with Morgan Mill Creek are impaired. The stream bed in lower Peter Weaver Creek is sandy and stream banks are unstable.

Approach

A wide range of data was collected to evaluate potential causes and sources of impairment. Data collection activities included: benthic macroinvertebrate sampling; assessment of stream habitat, morphology, and riparian zone condition; water quality sampling to evaluate stream chemistry and toxicity; and characterization of watershed land use, conditions and pollution sources. Data collected during the study are presented in Sections 2, 4, 5 and 6 of the report.

Conclusions

The cumulative causes of impairment, based upon an evaluation of all available data, are the following (see Section 7 for additional discussion):

1. Organic loading from Morgan Mill Trout Farm.
2. The prevention of downstream movement of aquatic invertebrates at the water intake dam of the trout farm on Morgan Mill Creek.

3. Habitat degradation, manifested by sediment deposition and substrate instability. The source of excess sediment is largely unstable stream banks, although upland erosion from house sites and roads in the upper part of the watershed is also significant.

High levels of metals may contribute to the degradation of the biotic community in tributaries to Peter Weaver Creek and a small section of the mainstem.

Management Strategies

The objective of efforts to improve stream integrity is to create water quality and habitat conditions to support a diverse and functional biological community in this rural watershed. The following actions are necessary to address current sources of impairment in Peter Weaver and Morgan Mill Creeks and prevent future degradation. Actions one and two are essential to restoring and sustaining aquatic communities in the watershed. Even if actions one and two are achieved, the biotic integrity of these streams will remain extremely limited unless actions three and four are implemented. Actions five through nine are secondary but important watershed-wide solutions. Action ten is an important step that would reduce future risk to streams from new development.

1. The waste management plan of the Morgan Mill Trout Farm should be reexamined and efforts to control organic loading implemented, including:
    a. removal of settled solids and repair of dam in lowest settling pond;
    b. review of fingerling nursery and processing facilities; and
    c. determination and elimination of the source of the periodic white fishy substance.
2. The dam at the water intake at the trout farm should be retrofitted to allow permanent flow and drift of aquatic invertebrates below the dam.
3. Farmers should be encouraged to fence livestock out of streams and redirect runoff from barns away from streams.
4. Stream segments with unstable morphology should be restored, with priority given to Peter Weaver and Morgan Mill Creeks in the French Broad River valley. At a minimum, the headcuts in Peter Weaver and Morgan Mill Creeks should be stabilized.
5. Unpaved roads in the upper portion of the watershed should be retrofitted or paved. If unpaved roads are retrofitted, unstable areas should be stabilized and best management practices (BMPs) used to remove coarse sediments from runoff. If roads are paved, runoff water velocity should be controlled.
6. Eroding bare areas along road banks and at home sites should be stabilized with vegetation or regraded to an appropriate slope so that vegetation can be established.
7. Sources of high metal concentrations in area tributaries should be identified and eliminated, if possible.
8. Transylvania County or the NC Division of Environmental Health should survey residences for straight pipes and work with owners to eliminate them.
9. A watershed education program should be developed and implemented with the goal of targeting homeowners in order to reduce current stream damage and prevent future degradation. At a minimum, the program should include elements to address the following issues:
    a. Importance of riparian vegetation. Landowners should be encouraged to plant native woody riparian vegetation along stream banks and protect current riparian vegetation.
    b. Repair of unstable stream banks.
    c. Responsible use of pesticides in gardens and along stream banks.

10. In order to prevent future water quality deterioration related to new construction activities, sediment and erosion control practices should be improved. Either the NC Division of Land Resources or Transylvania County should develop guidelines that better protect waters from the impacts of home and road development on steep slopes. Improved mechanisms for addressing the impacts of disturbances of less than one acre should also be developed. Staffing levels sufficient to support effective enforcement are essential.

Section 1
Introduction

This report presents the results of the Morgan Mill and Peter Weaver Creek water quality assessment, conducted by the North Carolina Division of Water Quality (DWQ) with financing from the Clean Water Management Trust Fund (CWMTF). Morgan Mill and Peter Weaver Creeks are considered impaired by the DWQ because they are unable to support acceptable communities of aquatic organisms. Prior to this study, the reasons for this condition were unknown, inhibiting the development of water quality improvement efforts in this watershed.

Part of a larger effort to evaluate impaired streams across North Carolina, this study was intended to evaluate the causes of biological impairment and to suggest appropriate actions to improve stream conditions. The CWMTF, which allocates grants to support voluntary efforts to address water quality problems, is seeking DWQ's recommendations regarding the types of activities it could fund in these watersheds to improve water quality. Both the DWQ and the CWMTF are committed to encouraging locally based initiatives to protect streams and to restore waters that are degraded.

Morgan Mill and Peter Weaver Creeks are small tributaries of the French Broad River located in central Transylvania County west of Brevard (Figure 1.1). The watershed drains approximately 2.5 mi^2 (6.5 km^2) within DWQ subbasin 040301. North Carolina's 2000 303(d) list designates Morgan Mill Creek as impaired from US 64 to its confluence with Peter Weaver Creek (0.3 mi or 0.5 km, DWQ index number 6-10-1b) (NC DWQ, 2000b). Peter Weaver Creek is impaired from its confluence with Morgan Mill Creek to the French Broad River (0.8 mi or 1.3 km, DWQ index number 6-10b).

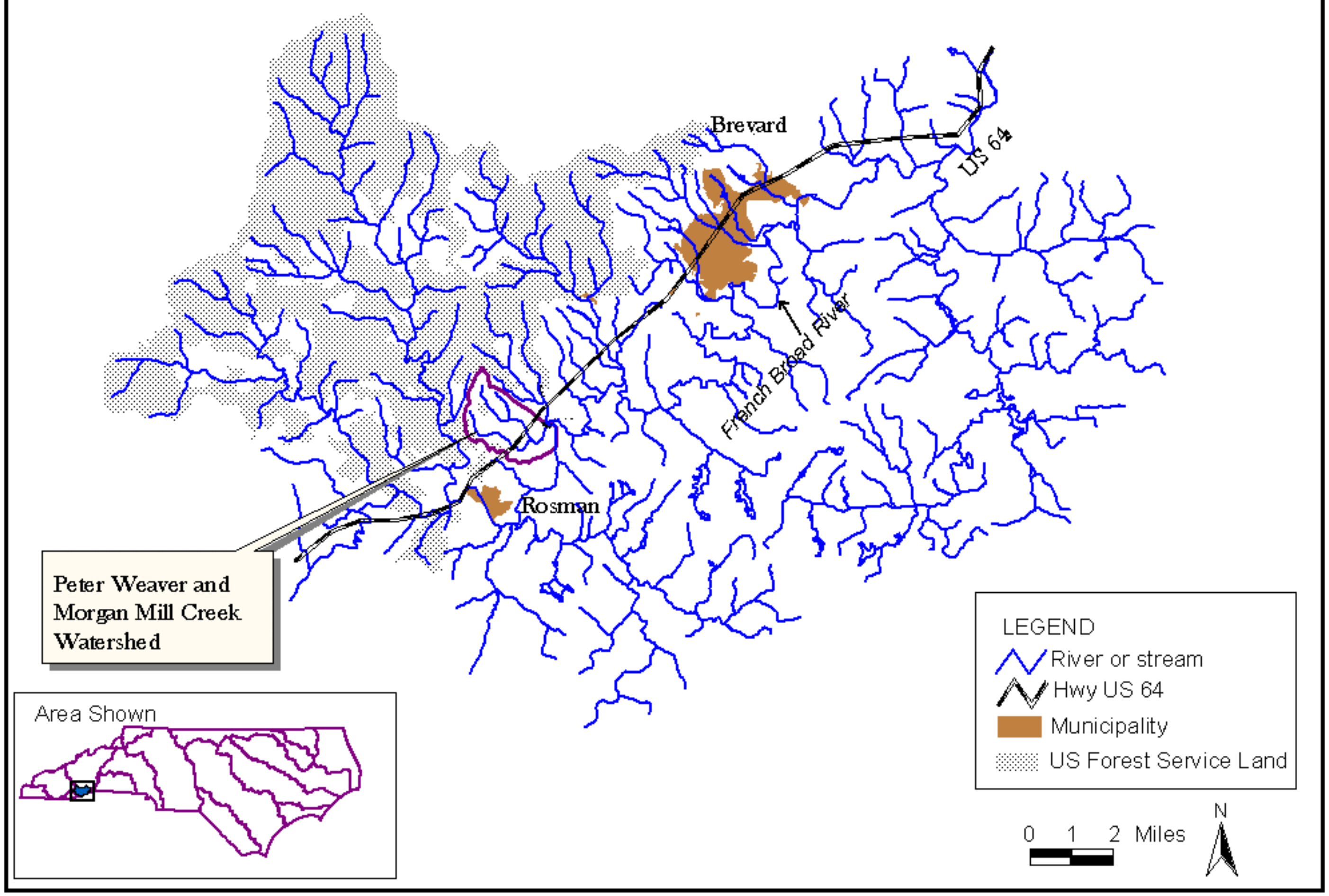
1.1 Study Purpose

The Morgan Mill and Peter Weaver Creek assessment is part of the Watershed Assessment and Restoration Project (WARP), a study of eleven watersheds across the state being conducted from 2000 to 2002 with funding from the CWMTF (Table 1.1). The goal of the project is to provide the foundation for future water quality restoration activities in the eleven watersheds by:

1. Identifying the most likely causes of biological impairment (such as degraded habitat or specific pollutants).
2. Identifying the major watershed activities and sources of pollution contributing to those causes (such as stormwater runoff from particular urban or rural areas or stream bank erosion).
3. Outlining a watershed strategy that recommends restoration activities and best management practices (BMPs) to address the identified problems and improve the biological condition of the impaired streams.

This investigation focuses primarily on issues related to aquatic life use support (biological impairment). It was not intended to be a comprehensive effort to assess the full range of water quality and water quantity concerns that may exist in the Morgan Mill and Peter Weaver Creek watershed, though it could serve as a critical component of such a comprehensive undertaking.

Figure 1.1. The Peter Weaver and Morgan Mill Creek Watershed in French Broad Subbasin 040301



While the study was not designed to address other important issues such as bacterial contamination, water supply or flooding, we have made an effort to discuss these concerns where existing information allows.

Table 1.1 Study Areas Included in the Watershed Assessment and Restoration Project

Watershed	**River Basin**	**County**
Toms Creek	Neuse	Wake
Upper Swift Creek	Neuse	Wake
Little Creek	Cape Fear	Orange, Durham
Horsepen Creek	Cape Fear	Guilford
Little Troublesome Creek	Cape Fear	Rockingham
Upper Clark Creek	Catawba	Catawba
Upper Cullasaja River/ Mill Creek	Little Tennessee	Macon
Morgan Mill/Peter Weaver Creeks	French Broad	Transylvania
Mud Creek	French Broad	Henderson
Upper Conetoe Creek	Tar-Pamlico	Edgecombe, Pitt, Martin
Stoney Creek	Neuse	Wayne

1.2 Study Approach and Scope

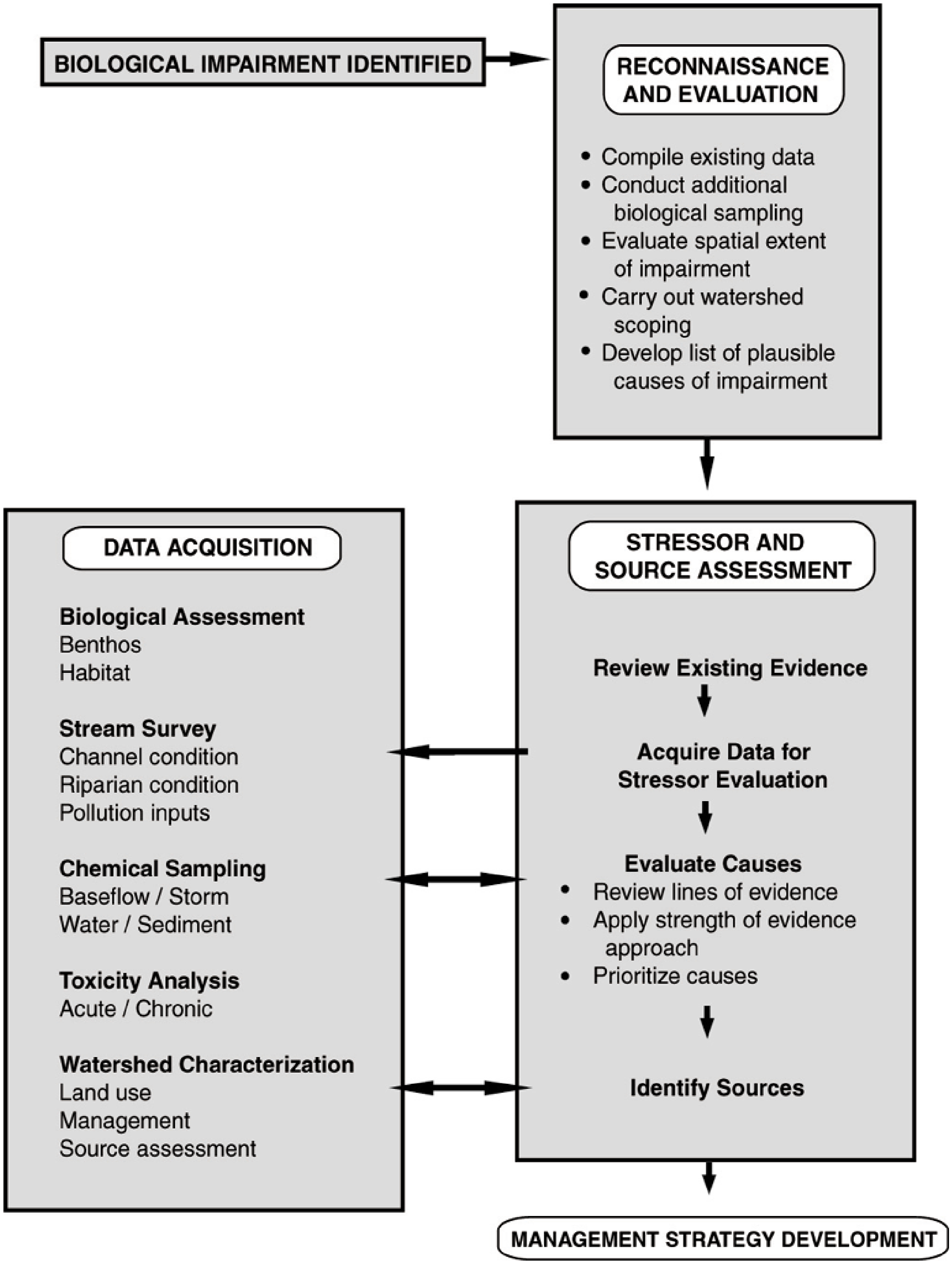
Of the study's three objectives, identification of the likely cause(s) of impairment is a critical building block, since addressing subsequent objectives depends on this step (Figure 1.2). Determining the primary factors causing biological impairment is a significant undertaking that must address a variety of issues (see background note "Identifying Causes of Impairment" for additional details). While screening level assessments can be used to attempt to identify potential causes of impairment, we have taken a more detailed approach in order to maximize the opportunity to reliably and defensibly identify causes and sources of impairment within the time and resource framework of the project. This provides a firmer scientific foundation for the collection and evaluation of evidence, better enables us to prioritize problems for management, and offers a more robust basis for the commitment of resources. EPA's recently published guidance for stressor identification envisions that causes of impairment be evaluated in as rigorous a fashion as is practicable (USEPA, 2000).

1.2.1 Study Approach

The general conceptual approach used to determine causes of impairment in Morgan Mill and Peter Weaver Creeks was as follows (Foran and Ferenc, 1999; USEPA, 2000):

- *Identify the most plausible potential (candidate) causes* of impairment in the watershed, based upon existing data and initial watershed reconnaissance activities.
- *Collect a wide range of data* bearing on the nature and impacts of those potential causes.
- *Characterize the causes of impairment* by evaluating all available information using a *strength of evidence approach*. The strength of evidence approach, discussed in more detail in Section 7, involves a logical evaluation of multiple lines (types) of evidence to assess what information supports or does not support the likelihood that each candidate stressor is actually a contributor to impairment.

Figure 1.2 Overview of Study Activities



Background Note: Identifying Causes of Impairment

Degradation and impairment are not synonymous. Many streams and other waterbodies exhibit some degree of degradation, that is, a decline from unimpacted conditions. Streams that are no longer pristine may still support good water quality conditions and function well ecologically. When monitoring indicates that degradation has become severe enough to significantly interfere with one of a waterbody's designated uses (such as aquatic life propagation or water supply), the Division of Water Quality formally designates that stream segment as impaired. It is then included on the State's 303(d) list, the list of impaired waters in North Carolina.

Many impaired streams, including those that are the subject of this study, are so rated because they do not support a healthy population of fish or benthic macroinvertebrates (aquatic bugs visible to the naked eye). While standard biological sampling can determine whether a stream is supporting aquatic life or is impaired, the cause of impairment can only be determined with additional investigation. In some cases a potential cause of impairment is noted when a stream is placed on the 303(d) list, using the best information available at that time. These noted potential causes are generally uncertain, especially when nonpoint source pollution issues are involved.

A cause of impairment can be viewed most simply as a stressor or agent that actually impairs aquatic life. These causes may fall into one of two broad classes: 1) chemical or physical pollutants (e.g., toxic chemicals, nutrient inputs, oxygen-consuming wastes); and 2) habitat degradation (e.g., loss of in-stream structure such as riffles and pools due to sedimentation; loss of bank and root mass habitat due to channel erosion or incision). Sources of impairment are the origins of such stressors. Examples include urban and agricultural runoff.

The US Environmental Protection Agency defines causes of impairment more specifically as "those pollutants and other stressors that contribute to the impairment of designated uses in a waterbody." (USEPA, 1997, p 1-10). When a stream or other waterbody is unable to support an adequate population of fish or macroinvertebrates, identification of the causes of impairment thus involves a determination of the factors most likely leading to the unacceptable biological conditions.

All conditions which impose stress on aquatic communities may not be causes of impairment. Some stressors may occur at an intensity, frequency and duration that are not severe enough to result in significant degradation of biological or water quality conditions to result in impairment. In some cases a single factor may have such a substantial impact that it is the only cause of impairment, or clearly predominates over other causes. In other situations several major causes of impairment may be present, each with a clearly significant effect. In many cases, individual factors with predominant impacts on aquatic life may not be identifiable and the impairment may be due to the cumulative impact of multiple stressors, none of which is severe enough to cause impairment on its own.

The difficulty of developing linkages between cause and effect in water quality assessments is widely recognized (Fox, 1991; USEPA, 2000). Identifying the magnitude of a particular stressor is often complex. Storm-driven pollutant inputs, for instance, are both episodic and highly variable, depending upon precipitation timing and intensity, seasonal factors and specific watershed activities. It is even more challenging to distinguish between those stressors which are present, but not of primary importance, and those which appear to be the underlying causes of impairment. Following are examples of issues which must often be addressed.

- Layered impacts (Yoder and Rankin, 1995) may occur, with the severity of one agent masking other problems that cannot be identified until the first one is addressed.
- Cumulative impacts, which are increasingly likely as the variety and intensity of human activity increase in a watershed, are widely acknowledged to be very difficult to evaluate given the current state of scientific knowledge (Burton and Pitt, 2001; Foran and Ferenc, 1999).
- In addition to imposing specific stresses upon aquatic communities, watershed activities can also inhibit the recovery mechanisms normally used by organisms to 'bounce back' from disturbances.

For further information on use support and stream impairment issues, see: the web site of DWQ's Basinwide Planning Program at http://h2o.enr.state.nc.us/basinwide/index.html; A *Citizen's Guide to Water Quality Management in North Carolina* (NCDWQ, 2000); EPA's *Stressor Identification Guidance Document* (USEPA, 2000).

Project goals extend beyond identifying causes of impairment, however, and include the evaluation of source activities and the development of recommendations to mitigate the problems identified. In order to address all three objectives, activities conducted in the Morgan Mill and Peter Weaver Creek watershed during this study were divided into three broad stages:

1. An initial *reconnaissance stage*, in which existing information was compiled and watershed reconnaissance conducted. At the conclusion of this stage, the most plausible candidate causes of impairment were identified for further evaluation.
2. A *stressor-source evaluation stage* that included: collection of information regarding candidate causes of impairment; evaluation of all available information using a strength of evidence approach; investigation of likely sources (origins) of the critical stressors.
3. The *development of strategies* to address the identified causes of impairment.

1.2.2 Approach to Management Recommendations

One of the goals of this assessment is to outline a course of action to address the key problems identified during the investigation, which will provide local stakeholders, the CWMTF and others with the information needed to move forward with water quality improvement efforts in this watershed. It is our intent that the recommendations included in this document provide guidance that is as specific as possible given available information and the nature of the issues to be addressed. Where problems are multifaceted and have occurred over a long period of time, the state of scientific understanding may not permit all actions necessary to mitigate those impacts to be identified in advance with any certainty. In such situations, an iterative process of adaptive management is required (Reckhow, 1997; USEPA, 2001), which uses the following steps:

- implement an initial round of management actions;
- monitor the results of those activities over time;
- use the resulting information as the basis for planning subsequent efforts; and
- implement additional measures as needed.

In this report, we recommend an initial set of actions that should be undertaken and discuss a framework for evaluating and implementing additional measures.

Protection of streams from the imposition of additional damage from future watershed development or other planned activities is a critical consideration. In the absence of such protection, efforts to restore water quality by mitigating existing impacts will often be ineffective or have only a temporary effect. These issues will be examined during the course of the study and addressed in the management recommendations.

Most management recommendations included in this document are general in nature. This report is not intended to specify particular administrative or institutional mechanisms for implementing remedial practices, but only to describe the types of actions that should be taken to place Morgan Mill and Peter Weaver Creeks on the “road to improvement”. It is our hope that county government and other stakeholders in the Morgan Mill and Peter Weaver Creek watershed will work cooperatively with state agencies to implement these measures.

The study did not develop TMDLs (total maximum daily loads) or pollutant loading targets. For many types of problems (e.g., most types of habitat degradation), a TMDL may not be an appropriate mechanism for initiating water quality improvement. Where specific pollutants are identified as causes of impairment, TMDLs may be appropriate and necessary if the problem is not otherwise addressed expeditiously. In any case, TMDL development is beyond the scope of this investigation.

1.2.3 Data Acquisition

While project staff made use of existing data sources during the course of the study, these were not adequate to fully address the goals of the investigation. Extensive data collection was necessary in order to develop a more adequate base of information. The types of data collected during the study included:

1. Macroinvertebrate sampling.
2. Assessment of stream habitat, morphology, and riparian zone condition.
3. Stream surveys--walking stream channels to identify potential pollution inputs and obtain a broad scale perspective on channel condition.
4. Chemical sampling of stream water quality.
5. Suspended sediment sampling during storm events.
6. Watershed characterization--evaluation of watershed hydrologic conditions, land use, land management activities, and potential pollution sources.

Section 2
Description of the Morgan Mill and Peter Weaver Creek Watershed

2.1 Introduction

Morgan Mill and Peter Weaver Creeks originate on a forested ridge, course down to the broad, relatively flat French Broad River valley where they meet and empty into the French Broad River (Figure 2.1). Highway US 64 cuts through the lower part of the 2.5 mi^2 (6.5 km^2) watershed in a NE-SW direction, roughly defining the edge of the French Broad River floodplain.

This section summarizes watershed hydrography and topography, describes current and historical land use, and discusses potential pollutant sources. Stream and riparian conditions will be addressed in subsequent sections.

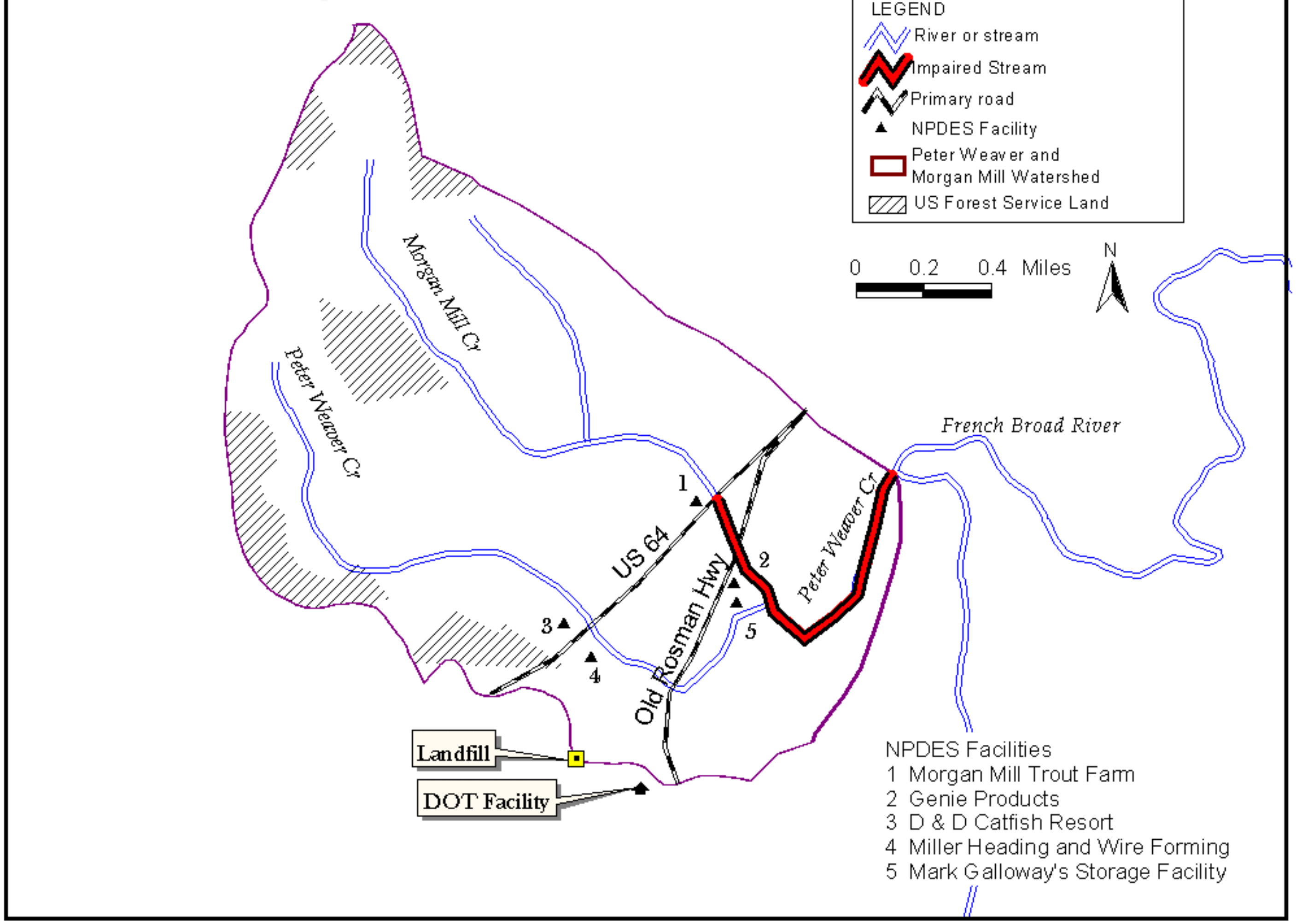
2.2 Streams

This watershed can be divided into two distinct areas—an upper section of forested slopes and a lower section in the French Broad River valley. This French Broad River valley section is relatively flat and is characterized by low gradient streams. The western edge of the watershed is the headwaters section and is defined by the ridge of Double Springs Mountain and Big Mountain Ridge. The eastern edge is defined by the French Broad River, while the northern and southern edges are defined by small dividing ridges. The Morgan Mill and Peter Weaver Creek watershed makes up a portion of hydrologic unit 06010105010050 and DWQ subbasin 040301, which also includes Cherryfield Creek.

Morgan Mill Creek is 2.4 miles (3.9 km) long, is classified B Trout, and has one indexed tributary, Crow Branch (C Trout). It originates on a forested ridge and is dammed to create a small lake (Kaiser Lake) at a children's camp. Downstream, it is dammed again for a non-functioning mill viaduct. Below this, much of its flow is diverted through Morgan Mill Trout Farm raceways and three ponds before being returned to the creek channel (during periods in 2000 and 2001, all of its flow was diverted to the trout farm). The intake structure for the farm is a dam about three feet high. It joins Peter Weaver Creek in the French Broad River valley.

Peter Weaver Creek is 3.1 miles (5.0 km^2) long and is classified C Trout. It begins on a forested ridge, but remains unimpounded except for a few low (less than 1 m high) dams used to pond water for in-stream trout production and for an intake for a catfish pond. Below this, Peter Weaver Creek converges with Morgan Mill Creek and then flows into the French Broad River east of Rosman.

Figure 2.1. NPDES Facilities and Impaired Stream Sections in the Peter Weaver and Morgan Mill Creek Watershed



The watershed is located within hydrologic area HA10, the mountain region, as defined by the US Geological Survey (USGS). USGS regional low flow equations for this area (Giese and Mason, 1991) predict a 7Q10 flow of approximately 1.2-1.4 cubic feet per second (cfs) at the mouth of Peter Weaver Creek. Typical mean annual flows in this part of the state are approximately 3-3.5 cfs/mi^2.

The watershed is not gauged. Precipitation in nearby Rosman averages 80 inches per year (2,030 mm/yr) (State Climate Office of NC at NC State University). Western North Carolina has been in drought conditions since mid-1998; in 1999, 2000 and 2001, the rainfall at Rosman was 77 percent, 60 percent and 68 percent of the annual average, respectively (numbers for 2001 were estimated using only January through November data).

2.3 Topography and Geology

The headwaters of this watershed begin on ridges with elevations of 3000-3200 feet (914-975 m) above mean sea level (msl), and the confluence of Peter Weaver Creek with the French Broad River is at 2150 feet (655 m) above msl. The upper sections of Peter Weaver and Morgan Mill Creek drop 150 and 225 feet per mile (28 and 43 m/km), respectively. The lower sections of these creeks in the French Broad River valley drop approximately 25 feet per mile (16 m/km).

The Peter Weaver and Morgan Mill Creek watershed consists of three soil associations that are underlain by metamorphic formations. In the lower French Broad floodplain section, the soils are in the Rosman-Toxaway-Transylvania association, which are well to poorly drained soils; these soils are typical of the French Broad River floodplain and are formed from alluvial deposits (USDA, 1974). Above the floodplain area, the watershed is characterized by soils of the Talladega-Fletcher-Fannin association, which are well-drained soils formed from mica gneiss or schist under forest vegetation. Further upslope from this association are soils of the Chandler-Fannin-Watauga association, which are somewhat excessively to well-drained soils formed from mica gneiss under forest vegetation.

2.4 Land Use in the Watershed

The upper section of the Morgan Mill drainage is largely forested and sparsely populated except for a trout farm and homes in the small stream valley and a children's camp at the headwaters of Morgan Mill Creek. The upper section of the Peter Weaver drainage is forested in its headwaters, but some recent construction of roads and homes has occurred. The stream valley has been cleared for homes and small farms as well as for D & D Catfish Resort, a catfish farm and RV resort. The lower sections of both creeks in the French Broad River valley drain relatively flat land that hosts a number of residences, small businesses, and pasture and crop land. Notable commercial operations include a convenience store, auto body shop, heading and wire forming factory, and a metalizing supply company. Houses in the watershed are served by groundwater wells and septic systems.

The geographic information systems coverage for land cover developed via 1993-95 LANDSAT imagery by the NC Center for Geographic Information Analysis classifies 78 percent of the land in the study area as forest, 10 percent as cultivated or managed herbaceous cover, and 12 percent as developed. During the formation of this geographic dataset, developed land was identified using the proportion of synthetic cover (e.g., concrete, rooftops) present; low density developed was 50-80 percent synthetic cover, and high density developed was 80-100 percent synthetic cover (Earth Satellite Corporation, 1997). Assuming that synthetic cover is impervious and that all non-developed land cover classes have one percent impervious cover, this watershed has seven to ten percent impervious surface.

The Peter Weaver and Morgan Mill Creek watershed is located in what local residents call the Cherryfield area. The French Broad valley in the Cherryfield area was settled in the late 1700s. The French Broad River floodplain was "cherry swamp" bottomland and drained in the 1800s; the earliest farming by European-Americans took place in the early 1800s. When European-Americans settled the ridges in the Cherryfield area, much of the land was cleared and farmed. These ridges were logged again in 1910 by the Gloucester Timber Company.

Within the French Broad River valley area, the lower section of the watershed (down gradient of Calvert Road) has been in cattle pasture for a long period of time. The upper part of the valley area has changed from crop and pasture land to residential and commercial use in the last 30-40 years; this conversion was accelerated by the construction of US 64 in 1980. Home building in the forested upper part of the watershed has been occurring at an accelerated rate during the past ten years. This will continue due to land availability and popularity of the area for homebuilding by local people as well as retirees and second homeowners moving into the area.

2.5 Sources of Pollution

2.5.1 Wastewater Discharges

There are seven facilities with National Pollutant Discharge Elimination System (NPDES) permits in the watershed, but only five facilities--Morgan Mill Trout Farm (NC permit 0081001), Genie Products (G550995), Mark Galloway's Storage Facility (G550879), D & D Catfish Resort (0086223), and Miller Heading and Wire Forming (G550692)--are discharging at this time (Figure 2.1). The first two of these facilities discharge to Morgan Mill Creek, and the last three discharge to Peter Weaver Creek. Genie Products, Mark Galloway's Storage Facility, and Miller Heading and Wire Forming are operating under general permits and are treating and discharging domestic waste. According to the DWQ Asheville Regional Office, these three facilities are operating without notable problems. See Appendix D for permit limits and monitoring requirements for NPDES permitted facilities.

The Morgan Mill Trout Farm (Figure 2.2) is operating under a general permit for trout farm facilities, which requires annual monitoring of flow, total suspended solids, settleable solids, and dissolved oxygen. This permit prescribes no discharge of fish parts, floating solids or visible foam in other than trace amounts. This farm began trout production in 1984 and produced up to 70,000 lbs/yr until 1999, when it cut production to 15,000 lbs/yr. The farm draws water from Morgan Mill Creek, sending it through trout raceways and three settling ponds, after which it returns the water to the creek. According to an aquaculture extension agent, there have been heavy growths of aquatic plants in the past in the settling ponds; the trout farmer has noted that he has treated these with copper sulfate. The farm currently has a trout fingerling nursery and fish processing facility. Waste from the processing facility is disposed in a septic system.

Figure 2.2 Morgan Mill Trout Farm

In July 2001, a Notice of Violation (NOV) was sent to the Morgan Mill Trout Farm for dewatering Morgan Mill Creek. The trout farm facility was removing the entire stream flow to operate the farm and returning the water once it proceeded through the trout raceways and three settling ponds. After the NOV was received, the farm added water to the dewatered creek bed with piped groundwater. Later, the sediment above the dam was cleaned out and a small amount of water allowed to pass through an outflow structure at the base of the dam. Groundwater addition was discontinued.

The D & D Catfish Resort, which rents cabins and RV sites and maintains a catfish pond, has an individual NPDES permit to treat domestic waste. This permit requires daily to bi-weekly monitoring of physical characteristics of the effluent, such as flow and temperature, and pollutants, such as ammonia and fecal coliform bacteria. This facility began discharging to Peter Weaver Creek in 2001. It received a NOV for high ammonia levels in June and July 2001, with monthly averages of 35 and 14.1 mg/L reported (permitted levels are 5.6 mg/L in summer). Since then, the facility has been in compliance.

2.5.2 Nonpoint Source Inputs

<u>Recent Development</u>
Development associated with home sites and commercial ventures (e.g., D & D Catfish Resort) has resulted in increased sedimentation in creeks in the watershed. Severe problems with soil erosion during storms have been observed during road building along steep slopes above US 64. Once in place, gravel and dirt roads in the steep areas of this watershed continue to be a significant source of sediment. Both paved and unpaved roads and driveways are problematic if eroding bare slopes are not stabilized (Figure 2.3). Home sites both during and after construction are a source of sediment, as well; after construction, any bare slopes that have been cut into hill sides and have not been stabilized with vegetation continue to erode. When construction is sited near a creek, the stream banks are often cleared of vegetation, exposing bare banks and promoting future bank instability. Much of this development is taking place in the upper portion of Peter Weaver Creek's watershed, above US 64.

Figure 2.3 Dirt road in upper part of Peter Weaver Creek watershed

Highway US 64 was built about twenty years ago, and runoff from this large road may be a source of pollutants and increased stormflows. These increased flows may contribute to destabilization of downstream channels.

Agriculture

Cropland is only a minor land use in the watershed and is not considered a large source of nonpoint pollution. Cattle pasture is important in the lower portion of the watershed, and there are a few small farms in the upper watershed where cattle and horses have access to streams. Waste from a dairy barn drains to a ditch that feeds Peter Weaver Creek in the lower part of the watershed, near Calvert Road. Direct input of animal waste where animals have stream access and runoff from pasture and feeding areas are sources of nutrients and fecal contamination.

NC Department of Transportation Rosman Maintenance Facility

The NC Department of Transportation (DOT) Rosman maintenance facility is located on the edge of the lower Peter Weaver watershed. This facility has documented petroleum (incident 13752, DWQ UST incident management database) and chloride (incident 9263, DWQ groundwater incident management database) groundwater contamination incidents. In 1992, an adjacent landowner to the Rosman maintenance facility tested his water supply well for chlorides and found levels in excess of the groundwater standards. The source of these chlorides was found to be an uncovered road-salt pile at the DOT facility. Consultants for the DOT assessed the extent of chloride contamination and eventually obtained an NPDES permit from the NC Department of Environment and Natural Resources to discharge untreated chloride contaminated groundwater to the French Broad River. The pumping system has discharged 3.4 million gallons (12.9 million liters) of groundwater with an approximate chloride concentration of 3300 parts per million (ppm) to date. The salt pile is now covered.

On May 18, 1993, a petroleum release was discovered during the closure of four underground storage tanks (USTs) containing gasoline, diesel and kerosene. Approximately 320 cubic yards (245 m^3) of petroleum-impacted soils were excavated and spread on the eastern shoulder of US 64. Consultants for the NCDOT assessed the extent of contamination and eventually installed an air-sparging groundwater remediation system on the subject site. The system was operated until the levels of petroleum constituents in monitoring wells on site were below NC standards for groundwater. Currently the site is monitored semi-annually for petroleum constituents; however, the remediation effort to address the road salt (chloride) contamination problem has dried up most of the UST incident monitoring wells.

Other Sources

A closed unlined county landfill is located northwest of the Rosman DOT facility and evidence of leachate from the landfill has been found in groundwater wells at the DOT facility; organic contaminants including vinyl chloride and tetrachloroethane have been measured. It is possible that leachate is reaching the surface water of Peter Weaver Creek tributaries.

Activities near streams by residential landowners are also nonpoint sources of pollution. The use of pesticides to control stream bank vegetation and in gardens can be problematic. Homes and buildings such as barns and kennels are sited along the streams in the upper and lower portions of the watershed, and runoff and piped waste are a source of nutrients, fecal contamination and other pollutants. A small trout pond is maintained near Calvert Road, and drainage from this is routed to Peter Weaver Creek; this drainage may provide a source of nutrients, as well.

Conversations with landowners in the watershed suggested the possibility of straight-piping in tributaries and the mainstems of Morgan Mill and Peter Weaver Creeks. Straight pipes, or pipes carrying untreated domestic waste, can be the source of a variety of pollutants, including nutrients, fecal contamination, detergents and pesticides. However, staff were unable to walk all sections of the mainstem creeks and their tributaries; stream sections were surveyed only if permission from landowners was obtained.

Due to past channelization and removal of stream side vegetation, stream banks in this watershed are unstable and provide a significant source of sediment to the streams.

2.6 Regulatory Issues and Local Water Quality Activities

There are no local buffer, zoning or erosion control ordinances for the Peter Weaver watershed. Transylvania County does have a floodplain ordinance that limits activity in the 100-year floodplain.

There are currently no local water quality initiatives in the area. NC Cooperative Extension for Transylvania County, the Transylvania County Soil and Water Conservation District, and the Upper French Broad Training Center have active programs that promote voluntary stream stabilization and riparian vegetation restoration.

Section 3
Potential Causes of Biological Impairment

The study identified those factors that were plausible causes of biological impairment in the Morgan Mill and Peter Weaver Creek watershed using both biological assessment and watershed-based approaches. An evaluation of benthic community data and other biological and habitat indicators can point toward general types of impacts that may likely impact aquatic biota. These stressors were flagged for further investigation. Land uses and activities in the watershed were also examined to identify potential stressors for further evaluation.

3.1 Key Stressors Evaluated in the Morgan Mill and Peter Weaver Creek Watershed

Organic enrichment and habitat degradation were evaluated as the most plausible candidate causes of impairment in Morgan Mill and Peter Weaver Creeks:

1. <u>Organic enrichment.</u> Organic matter in the form of leaves, sticks and other materials provide a food source for microbes in streams and serve as the base of the food web for many small streams. When microbes feed on organic matter, they consume oxygen in the process and make nutrients available to primary producers, especially periphyton. Macroinvertebrates feed on the periphyton and microbial community and are, in turn, consumed by fish.

   Excessive amounts of organic matter from human or animal waste (organic enrichment) can increase the microbial activity to levels that significantly reduce the amount of oxygen in a stream. Adequate dissolved oxygen is essential to aquatic communities; only certain aquatic invertebrates are able to tolerate low oxygen levels. These organic materials also serve as food for certain aquatic invertebrate groups that can dominate the invertebrate community. Therefore, excess organic loading can result in a distinct change in community composition due to both a change in food source and low dissolved oxygen levels. Evaluation of the benthic community indicated possible impacts from organic loading by the trout farm. Watershed reconnaissance illuminated other possible nutrient sources, including livestock and other aquaculture.

2. <u>Habitat degradation due to sediment deposition and substrate instability.</u> Habitat degradation manifests itself in the loss of pools, burial of riffles, and high levels of substrate instability. Due to the level of habitat degradation noted upon initial reconnaissance, further evaluation of sedimentation issues and identification of sediment sources were clearly warranted.

Section 4
Biological Conditions and Stream Habitat

Bioassessment involves the collection of stream organisms and the evaluation of community diversity and composition to assess water quality and ecological conditions in a stream. Evaluation of habitat conditions at sampling locations is an important component of bioassessment.

DWQ's Biological Assessment Unit has a dataset from the Peter Weaver and Morgan Mill Creek watershed that spans several decades. As part of a study on the impacts of the construction of US 64, benthic macroinvertebrates (or benthos) were sampled in 1978-80 in Peter Weaver Creek at SR 1195, Morgan Mill Creek just below US 64, and Morgan Mill Creek at SR 1331 (Camp Kahdalea Road, above US 64 and Morgan Mill Trout Farm). The benthic communities in these creeks were relatively healthy, with a diverse set of taxa, including a number of pollution intolerant taxa. Relatively diverse benthic communities were observed both up and downstream of US 64; however, increases in sand were seen at downstream sites. Benthic macroinvertebrates were again collected from Peter Weaver Creek at SR 1195 (Calvert Road) in 1997. The benthic community was considerably different from that of twenty years before, with an increase in pollution tolerant taxa and a decrease in pollution intolerant taxa. The 1997 benthic community was rated as Fair, and the stream was placed on the 2000 303(d) list. These two studies (1978-80 and 1997) bracket the building of the Morgan Mill Trout Farm and some commercial and residential development that occurred after the construction of US 64.

Additional benthic community sampling was conducted during the present study to serve several purposes:

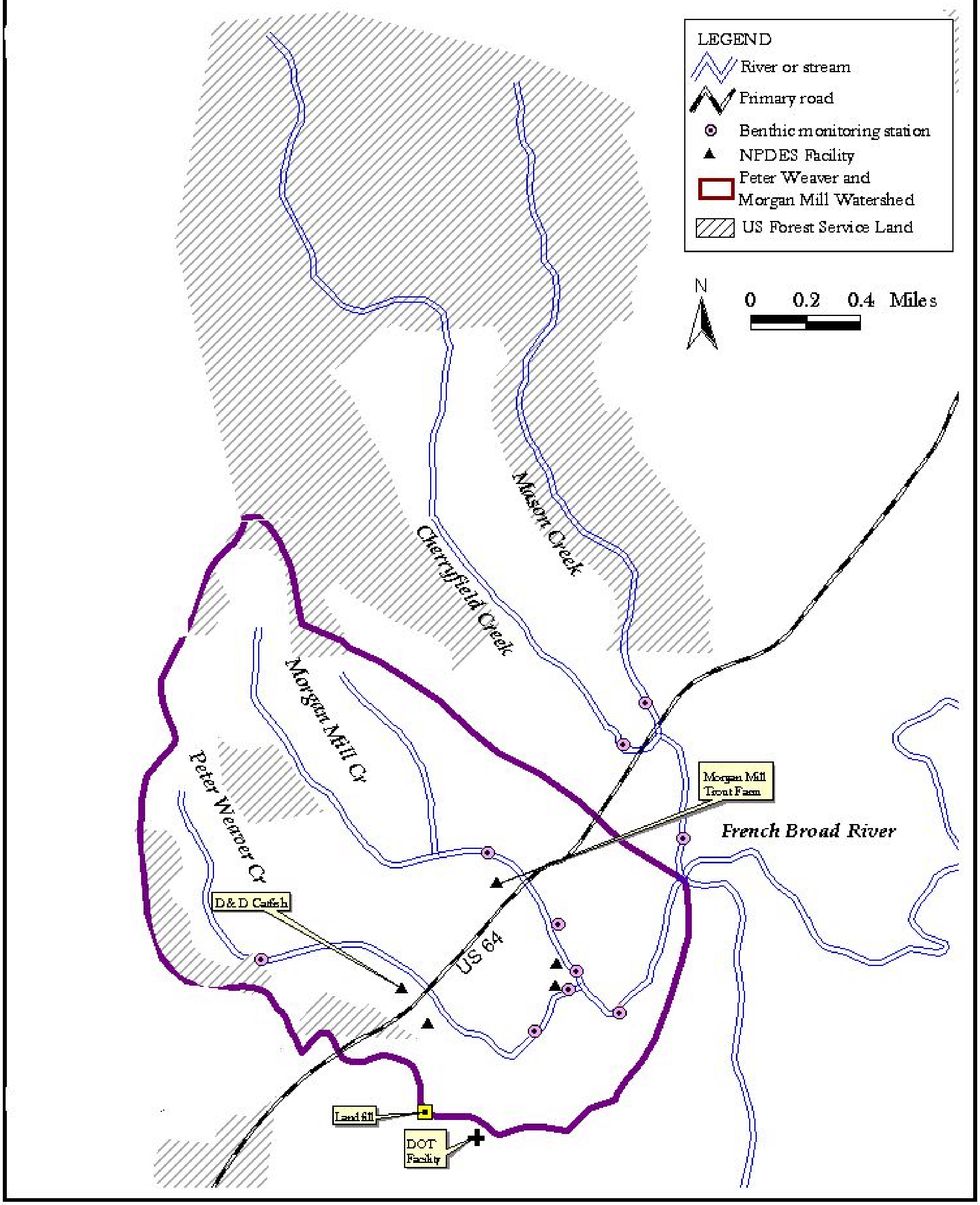
- To account for any changes in biological condition since Peter Weaver Creek was last sampled in 1997.
- To obtain more specific information on the actual spatial extent of impairment than is possible with existing data.
- To better understand which portions of the watershed may be contributing to biological impairment and which areas are in good ecological condition.
- To collect additional information to support a biologically-driven identification of likely stressors.

This section describes the approach to bioassessment used during the study and summarizes the results of this work. A more detailed analysis of the condition of aquatic macroinvertebrate communities in the Peter Weaver and Morgan Mill Creek watershed may be found in Appendix A.

4.1 Approach to Biological and Habitat Assessment

Benthic macroinvertebrate community samples were collected at seven sites in the watershed, with three locations on Morgan Mill Creek and four locations on Peter Weaver Creek (Figure 4.1). In order to compare study streams to relatively unimpacted streams, reference sties were

Figure 4.1. Benthic Monitoring Stations in the Peter Weaver and Morgan Mill Creek Watershed



chosen in the adjacent Cherryfield Creek watershed. These reference streams were of similar gradient and watershed size but drained primarily forested catchments. Due to the large area of pasture and residences in the sampled area, the lowest Cherryfield Creek site was not a typical reference site. It was sampled, however, in order to provide a comparison site for the lowest site on Peter Weaver Creek, which is also in the French Broad River valley. All sampling was performed in May and August 2000 and July 2001.

4.1.1 Benthic Community Sampling and Rating Methods

Macroinvertebrate sampling followed procedures outlined in the Division's standard operating procedures (NCDWQ, 2001). Standard qualitative methods were used for streams with a width of at least four meters. This method includes ten composite samples: two kicks, three sweeps, one leafpack, one sand sample, two rock/log washes, and a visual collection. The Qual 4 sampling procedure was used for sites under four meters wide in 2000. This procedure involves four composite samples: one kick, one sweep, one leafpack sample and visual collections. The Qual 5 method was used for sites under four meters wide in 2001, and includes the four composite samples collected with a Qual 4 plus a rock/log wash, which was added to obtain a better sample of the midge community. Organisms were identified to genus and/or species. Sampled reaches were approximately 100 meters in length. Details of the methods used at each sampling station are included in Appendix A.

Two primary indicators or metrics are derived from macroinvertebrate community data: 1) the diversity of a more sensitive subset of the invertebrate fauna is evaluated using EPT taxa richness counts; and 2) the pollution tolerance of those organisms present is evaluated using a biotic index (BI). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera (mayflies, stoneflies and caddisflies), insect groups that are generally intolerant of many kinds of pollution. *Generally, the higher the EPT number, the healthier the benthic community*. A low BI indicates a community dominated by taxa that are relatively sensitive to pollution and other disturbances (*intolerant*). A high BI indicates greater dominance by organisms that are pollution and disturbance insensitive (*tolerant*). *Thus, the lower the BI number, the healthier the benthic community*. Biotic index numbers were combined with EPT taxa richness ratings to produce a final bioclassification (Good, Fair, Poor, etc).

Streams that are at least four meters wide are formally rated with standard qualitative criteria. Streams less than four meters wide may be rated if certain conditions are met. If an unimpacted, high quality stream is sampled with Qual 4 procedures, a size correction factor is applied and a rating given. If a stream is sampled using Qual 4 procedures but is impacted by human disturbance, it is rated as Not Impaired (NI) if it meets the criteria for a Good-Fair or higher rating using the standard qualitative criteria. If this stream would not be Good-Fair or higher using standard qualitative criteria, it is listed as Not Rated (NR). All streams sampled with Qual 5 methods are considered NR because Qual 5 rating methods are still being developed.

Streams under four meters in width are generally not formally rated but are evaluated qualitatively using BI and EPT numbers, based on staff experience and professional judgment. However, if a mountain ecoregion stream is less than four meters in width and drains a relatively undeveloped watershed, bioclassifications are also given.

Final bioclassifications are used to determine if a stream is impaired. Streams with bioclassifications of Excellent, Good, and Good-Fair are all considered to be supporting their designated uses. Those with Fair and Poor ratings are considered impaired and are typically added to the State's 303(d) list.

4.1.2 Habitat Assessment Methods

At the time benthic community sampling was carried out, stream habitat and riparian area conditions were evaluated for each reach using DWQ's standard habitat assessment protocol for piedmont streams (NCDWQ, 2001). This protocol rates the aquatic habitat of the sampled reach by adding the scores of a suite of local (reach scale) habitat factors relevant to fish and/or macroinvertebrates. Total scores range from zero (worst) to 100 (best). Individual factors include (maximum factor score in parenthesis):

- channel modification (5);
- in-stream habitat variety and area available for colonization (20);
- bottom substrate type and embeddedness (15);
- pool variety and frequency (10);
- riffle frequency and size (16);
- bank stability and vegetation (14);
- light penetration/canopy coverage (10); and
- riparian zone width and integrity (10).

4.2 Results and Discussion

4.2.1 Description

Selected habitat and biological characteristics for each site sampled during the study are shown in Table 4.1. Some streams were too small to be given a formal rating (bioclassification). See Appendix A for additional details. A narrative summary of conditions at each current site follows.

Peter Weaver Creek

- *Peter Weaver Creek at Homer Israel Road (SR 1329)* (MMPW07). This reach was the most upstream site, above D & D Catfish Resort, farms, and many residences. This site had substrate characteristic of higher gradient mountain streams, with boulder, cobble, and gravel riffles and a relatively intact riparian zone of *Rhododendron* and other native woody species. Although there were plentiful undercut banks and root mats, these were not accessible by benthos due to low flows. Banks were low and stable. A gravel road runs less than six meters away from the east bank, and this and other unpaved roads farther upstream likely provide a source of fine sediment to the creek. However, this site had the best biological condition in the study watershed, with high EPT richness (24) for a small stream and the lowest BI (2.46). It was characterized by a community of pollution intolerant and long-lived invertebrates. Although this site could not be rated due to sampling methods, the biological community was characteristic of clean mountain streams.

- *Peter Weaver Creek at Peter Weaver Creek Drive* (MMPW15). This reach was sampled to evaluate the impacts of D & D Catfish Resort, farms, and many residences. It is located in the French Broad River valley and runs through a residential area. The banks were vertical and very high (2.5 m) and had frequent exposed areas; there was no forested riparian buffer. Gravel-cobble riffles were frequent but embedded with fine sediments. Sticks and leafpacks were present. This site clearly showed signs of degradation compared with the upstream site, with EPT richness decreasing to 14 and the BI increasing to 4.59. There was a mix of intolerant and tolerant invertebrates, including tolerant dragonflies and damselflies that need stream edge or sandy habitat often associated with habitat degradation. It was rated as Not Impaired (at least Good-Fair).
- *Peter Weaver Creek above confluence with Morgan Mill Creek* (MMPW16). This reach was sampled in order to measure all potential impacts to the creek before it joins Morgan Mill Creek. This reach is bordered by hayfield and residential land, and the banks were unstable and high, with limited vegetation, and there was no forested riparian buffer. Gravel and cobble riffles were present, but relatively embedded. Undercut banks and root mats were common, but sticks and leafpacks were rare. This site was more taxonomically rich than the site immediately upstream at Peter Weaver Creek Drive, with 24 EPT taxa and a BI of 5.42. Again, there was a mix of intolerant and tolerant invertebrates, with many tolerant EPT taxa. There were some taxa present that can indicate organic enrichment. It was not rated due to sampling methods used.
- *Peter Weaver Creek at Calvert Road (SR 1195)* (MMMM01). This was the farthest downstream sampling site, below the confluence with Morgan Mill Creek. It is bordered by a hayfield and residences and had high and eroding banks with limited vegetation. There was no forested riparian buffer except for a forested knoll that borders the northern bank. Gravel riffles and cobble and boulders were present, but sand and silt were dominant substrates. Embeddedness was clearly worst at this site and the lowest Morgan Mill Creek site. Some microhabitats (leafpacks, sticks, snags, undercut banks) were plentiful. This site was sampled in July 1997, May and August 2000, and July 2001. It had the worst biological condition in the watershed, with EPT richness fluctuating in the range of 12 to 21 taxa, and the BI ranging from 5.35 to 6.39. It was characterized by a lack of long-lived and intolerant taxa and an abundance of tolerant taxa. Taxa that can be indicative of organic enrichment were dominant. Tolerant dragonflies and damselflies that need edge or sandy habitat often associated with habitat degradation were present. It was rated Fair in 1997, but not rated due to sampling methods in August 2000 and July 2001. The May 2000 sample was rated Not Impaired (at least Good-Fair), but this is not considered typical for the site, because spring EPT taxa inflated the bioclassification.

<u>Morgan Mill Creek</u>

- *Morgan Mill Creek at Camp Kahdalea Road (SR 1331)* (MMMM02). This reach served as an upstream reference site, above Morgan Mill Trout Farm and many residences and commercial operations. It was nestled in a healthy riparian forest of *Rhododendron* and other woody species. It had low, stable banks and embedded cobble-gravel riffles were common. Bottom substrate was a mix of cobble, gravel and sand, and there was a notable amount of sand deposition. Like at the upper Peter Weaver site, low flow conditions isolated undercut banks and root mats, so that they could not be colonized by the benthos. Sticks and leafpacks were common. This site was characterized by a healthy benthic community, with the same number of EPT taxa (24) as the upstream site on Peter Weaver Creek and a slightly higher BI

(3.00). There was an abundance of long-lived and intolerant invertebrates, including some rare caddisflies. It was rated as Not Impaired (at least Good).

- *Morgan Mill Creek at Old Rosman Highway (SR 1388)* (MMMM17). This reach was sampled in order to evaluate the impacts of the Morgan Mill Trout Farm. It was located in residential and commercial land and was characterized by a thin line of trees along the banks. Banks themselves were unstable and steep. Riffles were embedded cobble and gravel and sand, and silt were predominant substrates. Undercut banks, root mats, leafpacks and sticks were common. This site showed clear signs of degradation from the upstream site, with an EPT richness of 20 and a much higher BI of 5.74. Intolerant and long-lived invertebrates were still present, raising the EPT richness numbers, but tolerant taxa were very dominant, including those taxa that can be indicative of organic enrichment. It was rated as Not Impaired (at least Good-Fair).
- *Morgan Mill Creek above confluence with Peter Weaver Creek* (MMMM09). This reach was sampled in order to evaluate the cumulative impacts of upstream watershed activities to the creek before joining Peter Weaver Creek. It was bordered by hayfield and residential land. The banks were unstable and high, with limited vegetation, and there was a thin strip of trees and shrubs on the top of the bank. Gravel-cobble riffles were frequent but embedded. This area is just below a headcut through organic clay. This substrate type was dominant throughout much of the reach. This site hosted a low number of EPT taxa (14) and a community with the highest BI (6.19). Few invertebrates were found here, and many were tolerant of low flows, organic enrichment or multiple stressors. This site was not rated due to sampling methods used.

<u>Reference Sites</u>

- *Mason Creek at Cherryfield Road (SR 1392)* (CCMC01). This reach was a reference site for upper Morgan Mill and Peter Weaver Creeks above US 64. Although most of the watershed is in US Forest Service land, the sampled reach was bordered by residential and agricultural land. It had high banks with variable vegetation; some bank areas were covered in a good mix of native woody and herbaceous vegetation and others were bare. There was little riparian woody vegetation. Substrate was a mix of boulder, cobble, gravel and sand, and riffles were common and slightly embedded. A high number of EPT taxa (31) and some of the lowest BIs seen in this study (2.38 in 2000, 2.94 in 2001) characterized this reference site. A high number of intolerant and rare taxa were found, but a few tolerant taxa were also present. It was rated as Excellent in 2000, but not rated in 2001 due to changes in sampling methods.
- *Cherryfield Creek at Cherryfield Creek Road (SR 1332)* (CCCC02). This was also a reference site for upper Morgan Mill and Peter Weaver Creeks above US 64. Most of the watershed is in US National Forest and fallow field. This site was surrounded by a mix of forest and fallow fields, and there was a wooded riparian zone of moderate width. Banks were vegetated with a mix of native woody and herbaceous species. The bottom substrate was a mix of boulder, cobble, gravel and sand, and riffles were common and somewhat embedded. It was also rated as Excellent, with a high number of EPT taxa (36) and a low BI (2.46). It had a high number of intolerant, rare, and long-lived taxa, but there were also a few tolerant taxa found, including those that can indicate enrichment.
- *Cherryfield Creek at Whitmire Road (SR1128)* (CCCC03). This was a reference site for the lowest Peter Weaver Creek site at Calvert Road and is also in the French Broad River valley. Its upper watershed consists of forested land, but its lower watershed has scattered residences and pasture. This site was surrounded primarily by active pasture, and there was no wooded

riparian zone. The stream banks were somewhat unstable, vegetated in some areas but bare in others. Bottom substrate was mostly cobble, gravel and sand, and riffles were common and somewhat embedded. This site had the highest number of EPT taxa sampled in the study (30 in 2000, 39 in 2001) but higher BIs than the two other Cherryfield watershed sites (3.89 in 2000, 4.22 in 2001). It did host a high number of long-lived and intolerant taxa, but there were some tolerant taxa found as well, including those that can indicate organic enrichment and low flow. It was rated as Not Impaired (at least Good) in 2000, but not rated in 2001 due to a change in sampling methods.

4.2.2 Summary of Conditions and Nature of Impairment

It is clear that all Peter Weaver and Morgan Mill Creek sites in the French Broad River valley area below US 64 had compromised biological communities. However, those in Morgan Mill Creek below US 64 and Peter Weaver Creek below the confluence with Morgan Mill Creek are clearly the most impacted. The biological integrity of the lowest site on Peter Weaver Creek and Morgan Mill Creek below US 64 has declined over the past twenty years. The benthic communities in these stream segments are dominated by taxa tolerant of organic enrichment. Watershed-wide declines in biological health as both Peter Weaver and Morgan Mill Creeks flow from forested, higher gradient areas to developed, lower gradient landscapes are also apparent.

The upper sites on Peter Weaver and Morgan Mill Creeks have similar habitat and biological communities to the upper reference sites (Cherryfield Creek at Cherryfield Creek Road and Mason Creek). They do lack some intolerant EPT taxa that were found in the upper reference sites, however.

The lower impaired site on Peter Weaver Creek is quite different from lower Cherryfield Creek. Habitat was poorer in Peter Weaver Creek, with total habitat scores averaging 15 points below those of Cherryfield Creek, sandier substrate (mean sand and silt averaging 15% higher), and much higher riffle embeddedness. Basic water parameters measured during the same benthic sampling trips indicated higher specific conductance (averaging about double that of Cherryfield Creek) and higher temperature (2-4 degrees Celsius) in Peter Weaver Creek. Although there were indicators of organic enrichment in Cherryfield Creek, they were not dominant as they were in Peter Weaver Creek, and the abundance of intolerant and long-lived EPT seen in Cherryfield Creek was not observed in Peter Weaver Creek.

Table 4.1 Selected Benthic Community and Habitat Characteristics at Study Sites in the Peter Weaver and Morgan Mill Creek Watershed

Site	Date	Substrate % sand and silt[1]	In-stream Structure Score (of 20)[2]	Embedded-ness Score (of 15)[3]	Habitat Score Total (of 100)[4]	EPT Richness[5]	EPT Biotic Index[5]	Biotic Index[5]	Bioclassification[5]
Peter Weaver Cr. at Homer Israel Rd.	7/24/01	20	16	12	84	24	1.93	2.46	Not Rated*
Peter Weaver Cr. at Peter Weaver Creek Dr.	8/30/00	60	9	11	56	16	4.15	4.59	Not Impaired (at least Good-Fair)
Peter Weaver Cr. above confluence with Morgan Mill Cr.	7/27/01	45	13	11	61	24	4.49	5.42	Not Rated*
Peter Weaver Cr. at Calvert Rd.	7/7/97	65	NA	NA	NA	12	5.35	5.35	Fair
	5/16/00	50	12	8	53	21	4.67	6.39	Not Impaired (at least Good-Fair)[6]
	8/30/00	55	14	8	69	18	5.19	5.91	Not Rated**
	7/24/01	60	11	4	58	10	4.79	5.82	Not Rated*
Morgan Mill Cr. at Camp Kahdalea Rd.	8/30/00	35	16	11	90	24	2.29	3.00	Not Impaired (at least Good)
Morgan Mill Cr. at Old Rosman Hwy.	8/30/00	55	15	11	73	20	3.99	5.74	Not Impaired (at least Good-Fair)
Morgan Mill Cr. above confluence with Peter Weaver Cr.	7/27/01	25	11	6	63	14	5.38	6.19	Not Rated*
Reference Streams									
Mason Cr. at Cherryfield Rd.	8/31/00	30	12	12	65	31	1.88	2.38	Excellent
	7/23/01	25	15	14	78	31	1.52	2.94	Not Rated*
Cherryfield Cr. at Cherryfield Creek Rd.	8/31/00	30	15	13	84	36	2.09	2.46	Excellent
Cherryfield Cr. at Whitmire Rd.	8/31/00	49	16	11	73	30	2.85	3.89	Not Impaired (at least Good)
	7/24/01	40	15	14	77	39	3.15	4.22	Not Rated*

1 Based on visual estimate of substrate size distribution. Morgan Mill Cr. above confluence also had 40% organic clay, which is considered poor habitat.
2 Visual quantification of the of in-stream structures present, including leafpacks and sticks, large wood, rocks, macrophytes, and undercut banks/root mats.
3 Estimation of riffle embeddedness.
4 See text for a list of component factors.
5 See text for description.
6 Due to time of sampling, this sample had an inflated number of EPT taxa, which inflated the bioclassification. This rating is not typical for the site. EPT richness and biotic index scores were seasonally corrected for spring Plectoptera.
* Sampled with Qual 5 method, which currently has no rating method.
** Sampled with Qual 4 method. Impacted, but too small to rate.

Section 5
Chemical Conditions

Water quality assessment provides information to evaluate whether chemical and physical conditions negatively affect benthic communities. DWQ does not have an ambient station in this watershed and historical data on stream chemistry are extremely limited. In this study, ambient conditions were assessed in the field and surface water samples were collected for laboratory analysis to evaluate water quality. Two broad purposes of this monitoring were:

1. To characterize water quality conditions in the watershed.
2. To collect a range of chemical, physical and toxicity data to help evaluate the specific causes of impairment and to help identify the sources.

This section summarizes the sampling and data collection methods and discusses key monitoring results. See Appendix B for a more detailed discussion of methodology and a more comprehensive presentation of results.

5.1 Approach to Chemical and Physical Water Quality Sampling

During the study period, project staff collected grab samples in the Morgan Mill and Peter Weaver Creek watershed on twenty dates between August 2000 and November 2001, two of which represented storm samples. Sampling was geared toward evaluating in-stream oxygen levels and determining sources of organic loading and sediment. Suspended sediment was sampled during storm events with groups of stationary single stage samplers throughout the watershed.

5.1.1 General Approach

General Water Quality Characterization. One station at the downstream end of the study area was sampled on a near monthly basis to characterize water quality conditions. Because Peter Weaver Creek at Calvert Road is the lowest monitoring location and integrates most watershed impacts, this location was chosen as the integrator site. A standard set of parameters similar to those evaluated at DWQ ambient stations was used (Appendix Table B.1). Samples were collected during both baseflow and stormflow periods. Baseflow periods were defined as those in which no measurable rain fell in the watershed during the 48-hour period preceding sampling. Storm samples were collected on the rising stage of the hydrograph. Fecal coliform samples were collected only under baseflow conditions. For additional details, refer to Appendix B.

Stressor and Source Evaluation. Samples were collected at a variety of locations in order to identify major chemical/physical stressors to which aquatic biota are exposed and assess major sources. Station locations for stressor identification sampling were linked closely to areas of known biological impairment (benthic macroinvertebrate sampling stations) and to specific watershed activities believed to represent potential sources of impairment.

In order to determine the possibility of organic enrichment and its sources, a nutrient and biochemical oxygen demand (BOD) study was performed between February and October 2001. BOD is a measure of the amount of oxygen consumed by the decomposition of organic matter or chemical reactions in the water column. It is most commonly measured over a five-day period (BOD_5). Two sites on Morgan Mill Creek (above US 64 and the trout farm, and below US 64 and the trout farm) and three sites on Peter Weaver Creek (above US 64, below US 64, and the integrator location at Calvert Road) were sampled four times for BOD and nutrients. Hydrolab data sondes, multiparameter probes with a data logging capability, were used to measure dissolved oxygen, temperature, specific conductance, and pH levels in-stream. To characterize sources of sediment in the watershed, suspended sediment was also sampled during storm events with stationary multi-stage samplers at six watershed locations. Two tributaries that had high conductivity and were potential sources of contaminants were also sampled and analyzed for metals and nutrients; semi-volatile organic compounds were analyzed for one of these sites.

Field measurements (pH, dissolved oxygen, specific conductance and temperature) were taken on multiple occasions at various locations throughout the watershed to further characterize water quality conditions and to investigate potential stressor source areas.

Benchmarks. In order to help evaluate whether a significant likelihood existed that observed concentrations may have a negative impact on aquatic life, measured concentrations were compared to EPA's National Ambient Water Quality Criteria (NAWQC) for freshwater (USEPA, 1999) and Tier II benchmarks (USEPA, 1995). Metals benchmarks were adjusted for hardness where appropriate (USEPA, 1999). For chromium, the NAWQC for Cr VI was used. The use of NAWQC and other benchmarks is discussed in more detail in Appendix B. Since NAWQC criteria are for dissolved metals and samples of Morgan Mill and Peter Weaver Creek watershed were analyzed for total metals, these criteria are conservative.

Benchmarks were used for initial screening of potential impacts. Final evaluation of the likely potential for metals to negatively impact aquatic biota considered all lines of evidence available, including benthic macroinvertebrate data, in addition to data on analyte concentrations.

5.1.2 Site Selection

Sampling stations were chosen based on several criteria: accessibility, proximity to benthic sampling sites, and proximity to potential contributing land use activities. Sampling sites are shown in Figure 5.1 and listed in Table 5.1. Data and samples were collected at the following sites:

Watershed integrator sampling location

- *Peter Weaver Creek at Calvert Road* (MMMM01). This sampling location is the traditional benthic sampling location. It is downstream of the confluence of Morgan Mill and Peter Weaver Creeks and is the most downstream monitoring location that is accessible. It integrates most of the nonpoint and point source influences in the watershed.

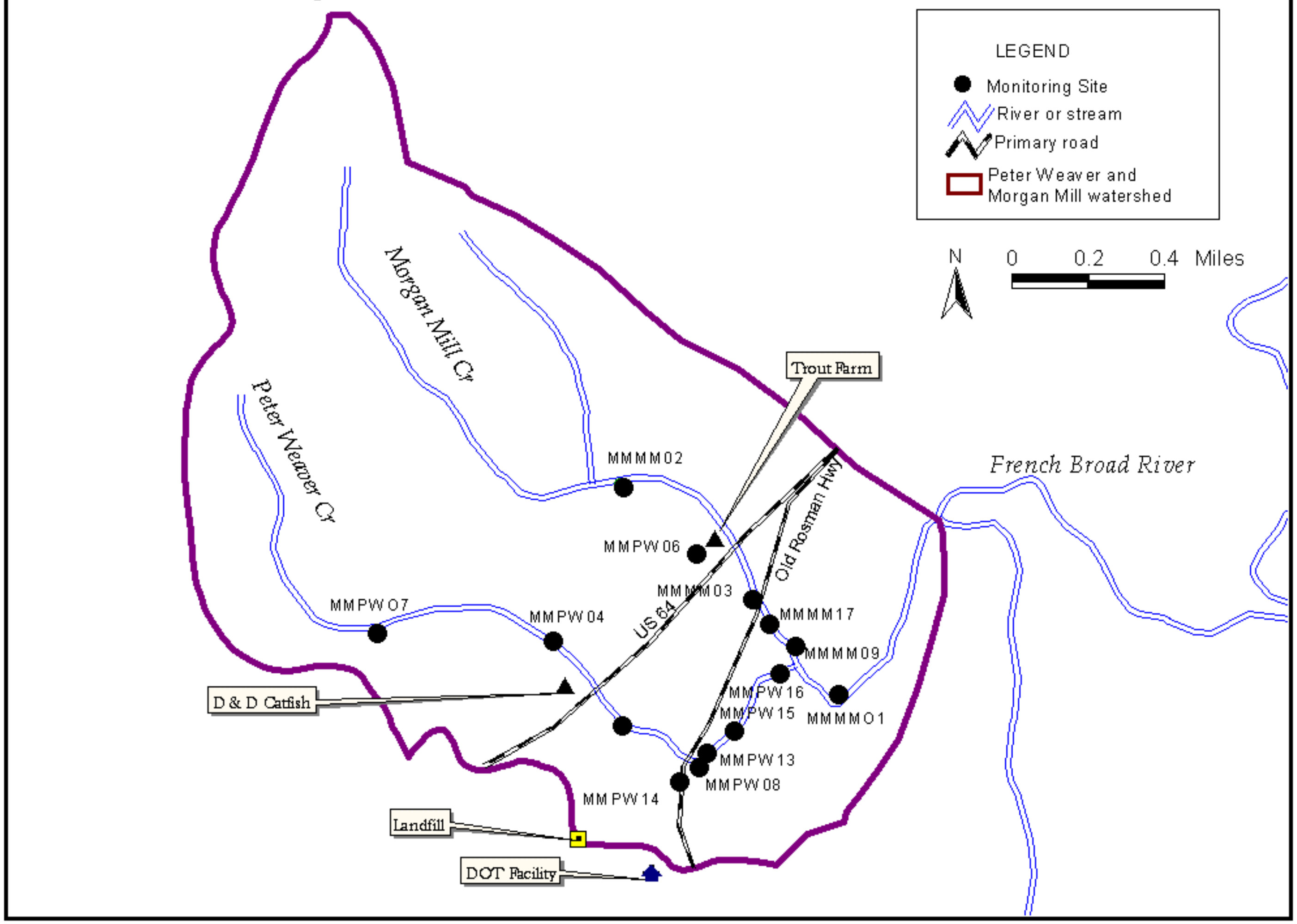
Table 5.1 Summary of Monitoring Approaches Used at Primary Sampling Sites, Peter Weaver and Morgan Mill Creek Study Area

			Monitoring Approach			
	Station Code	Location	Benthos	Water Quality[1]	Suspended Sediment	Data Sonde
Peter Weaver Creek Area	MMPW07	Peter Weaver Cr. at Homer Israel Rd.	✓		✓	
	MMPW04	Peter Weaver Cr. above D & D Catfish		✓		
	MMPW05	Peter Weaver Cr. below US 64			✓	✓
	MMPW08	Peter Weaver Cr. below Old Rosman Hwy.			✓	
	MMPW13	Tributary to Peter Weaver Cr. near greenhouse		✓		
	MMPW14	Tributary to Peter Weaver Cr. at Old Rosman Hwy.		✓		
	MMPW15	Peter Weaver Cr. at Peter Weaver Cr. Dr.	✓			
	MMPW16	Peter Weaver Cr. above Morgan Mill Cr. confluence	✓			
	MMMM01	Peter Weaver Cr. at Calvert Rd.	✓	✓+	✓	✓
Morgan Mill Creek	MMMM02	Morgan Mill Cr. at Camp Kahdalea Rd.	✓		✓	
	MMMM06	Morgan Mill Trout Farm effluent		✓		
	MMMM03	Morgan Mill Cr. below US 64		✓		
	MMMM17	Morgan Mill Cr. at Old Rosman Hwy.	✓			✓
	MMMM09	Morgan Mill Cr. above Peter Weaver Cr. confluence	✓		✓	
References	CCMC01	Mason Cr. at Cherryfield Rd.	✓			
	CCCC02	Cherryfield Cr. at Cherryfield Cr. Rd.	✓			
	CCCC03	Cherryfield Cr. at Whitmire Rd.	✓			

[1] Grab samples and/or repeated field measurements.

+ Integrator station.

Figure 5.1. Chemical and Biological Monitoring Sites in the Peter Weaver and Morgan Mill Creek Watershed



Stressor identification sampling locations: BOD and nutrient study

- *Morgan Mill Creek off Camp Kahdalea Road* (MMMM02). This site is upstream of the trout farm in a forested stretch of stream. This site was selected to provide upstream background water quality information when paired with the site below the farm.
- *Morgan Mill Trout Farm effluent* (MMPW06). This site was sampled to provide direct water quality information from the trout farm processes.
- *Morgan Mill Creek below US 64* (MMMM03). This reach is just downstream of the trout farm discharge.
- *Peter Weaver Creek upstream of the D & D Catfish Resort pond intake* (MMPW04). This was below a stretch of stream running through horse and cattle pastures.
- *Peter Weaver Creek below US 64* (MMPW05). This site is below the D & D catfish pond, package plant discharge, and resort construction activities.
- *Peter Weaver Creek at Calvert Road* (MMMM01). This sampling location was downstream off all influences targeted by other sites.

Source identification sampling locations: suspended sediment sampling locations

- *Peter Weaver Creek above the paved portion of Homer Israel Road* (MMPW07). This site is located adjacent to a gravel road and downstream of recent road and home building activities.
- *Peter Weaver Creek below US 64* (MMPW05). This site is downstream of D & D Catfish resort and development activities.
- *Peter Weaver Creek below Old Rosman Highway* (MMPW08). This site and that below US 64 bracket a recently denuded section of stream bank.
- *Morgan Mill Creek at Camp Kahdalea Road* (MMMM02). This forested site is below a residential area in the upper part of the watershed but above the trout farm.
- *Morgan Mill Creek above the confluence with Peter Weaver Creek* (MMMM09). This site is the lowest site on Morgan Mill Creek.
- *Peter Weaver Creek at Calvert Road* (MMMM01). This is the most downstream site and integrates all upstream sources of sediment.

Other source identification sampling locations

- *Tributary to Peter Weaver Creek at greenhouse* (MMPW13). This stream originates in a spring near Our Country Store, draining from the hill where the DOT maintenance facility is located. It enters Peter Weaver Creek between Old Rosman Highway and the Peter Weaver-Morgan Mill Creek confluence.
- *Tributary to Peter Weaver Creek at Old Rosman Highway* (MMPW14). This tributary runs by Cassell Road and enters Peter Weaver Creek between Old Rosman Highway and the Peter Weaver-Morgan Mill Creek confluence.

5.2 General Water Quality Characterization

Stage, or water level, was measured as the distance below a marker on the Calvert Road bridge. Baseflows were low throughout the study period, reflecting the period of severe drought since 1998. Stage measurements showed a difference of only 7 cm (3 in) between the lowest and highest baseflow measurements taken during the study. A likely bankfull event occurred on August 28, 2001, when the area received 5.6 cm (2.2 in) of rain. Based on sediment samplers filled during this event, stage rose at least 1 meter above baseflow levels.

pH appears to be stable in the study area. Values at the integrator site range between 6.6 and 7.8 standard units. Specific conductance at the integrator site (17 to 52 µS/cm) was high compared to that of the Cherryfield Creek watershed reference sites (7 to 10 µS/cm). Table 5.2 provides a summary of water quality results for the integrator location. Both nutrients and dissolved oxygen are discussed in Section 5.3.

Table 5.2 Water Quality Results for Peter Weaver Creek at Calvert Road (MMMM01)

PARAMETER	BASEFLOW					STORMFLOW	
	No. Samples	Maximum	Minimum	Median	Mean	No. Samples	Value
Nutrients (mg/L)							
Ammonia Nitrogen	9	1.1	0.1	0.2	0.3	1	<0.10
Total Kjeldahl Nitrogen	9	1.5	0.1	0.7	0.7	1	1.0
Nitrate+Nitrite Nitrogen	9	0.57	0.14	0.28	0.33	1	0.31
Total Phosphorus	9	0.13	0.01	0.07	0.07	1	0.08
Total Nitrogen	9	2.07	0.24	0.98	1.04	1	1.31
Other Parameters							
DO (mg/L)	13	10.8	7.7	8.8	9.0	1	9.7
pH (Standard Units)	13	7.8	6.6	7.1	7.1	1	7.1
Specific Cond (µS/cm)	13	52	17	36	37	1	39
Total Hardness(mg/L)	6	22.0	10.7	13.3	14.0	1	14.0
Total Suspended Residue (mg/L)	7	8.9	4.5	5.7	6.4	1	23.0
Total Dissolved Solids (mg/L)	6	47	27	39	37	1	38
Turbidity (NTU)	6	9.47	3.04	3.79	5.27	1	26.40
Calcium (mg/L)	5	3.26	2.66	2.88	2.95	1	3.20
Magnesium (mg/L)	5	0.87	0.49	0.78	0.74	1	0.99
Fecal Coliform Bacteria (colonies per 100/ml)	5	250	6	220	95[1]		
Biochemical Oxygen Demand (BOD_5) (mg/L)[2]	6	8.4	1.0	1.5	3		

[1] Value = geometric mean.
[2] BOD5 detection limit = 2; laboratory estimates values <2.

Selected metals concentrations measured in the watershed were compared to the chronic and acute EPA NAWQC and Tier II criteria (screening values) that were adjusted for mean hardness (Table 5.3, but see Appendix Table B.4 for individual sample comparisons). For Peter Weaver Creek at Calvert Road, the median baseflow concentration of aluminum exceeds the chronic screening value. The median baseflow copper concentration equals the chronic screening value, and the one stormflow sample had a copper concentration that equals the acute screening value. The means or medians of all other metals at this integrator site are below screening values.

North Carolina has standards or action levels for the protection of aquatic life for some metals. In general, these values are higher than chronic and acute EPA NAWQC criteria adjusted for the low hardness measured in Peter Weaver Creek. All individual metal values from Peter Weaver Creek at Calvert Road were below the NC's standards or action levels, except one baseflow sample that exceeded the copper action level.

Table 5.3 Metals of Concern in Peter Weaver Creek and Its Tributaries and Comparison Values of the French Broad River at Rosman and EPA Screening Levels[1]

Site	Total Metal Concentration (µg/L)							Hardness[2]
	Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Zinc	(mg/L)
Peter Weaver Cr. at Calvert Rd. (MMMM01*)*								
Stormflow 3/15/2001	324	0.1	**2**	456	1	46	10.4	12.0
Baseflow median	**151**	0.1	**1**	213	<1	46	3.0	10.7
Baseflow mean	**193**	0.1	**4**	269	<1	45	3.1	10.5
Tributaries to Peter Weaver Creek								
Baseflow MMPW13 11/1/01	**1678**	**0.7**	**5**	**7540**	**17**	56	**31.0**	10.7
Baseflow MMPW14 11/1/01	**260**	<0.1	**4**	**1380**	**3**	**751**	**29.0**	14.0
French Broad River at Rosman: median of 53 samples collected between 1/93 and 12/97	**230**		**3**	190			**16.0**	
CHRONIC benchmark[3]	87	0.4	1	1000	0.2	120	18.0	
ACUTE benchmark[3]	750	0.4	2		5	2300	18.0	

1 Baseflow values and French Broad River medians ≥ the chronic benchmark and stormflow values ≥ the acute benchmark are in bold type. Mean values were calculated using half the detection limit (DL) as the value for any value < the DL. If all values were < the DL, then the value is listed as "<DL".

2 Hardness calculation=([Ca2+] X 2.497) + ([Mg2+] X 4.118). Data not available for French Broad River.

3 Chronic and acute benchmarks for all metals except Mn are EPA NAWQC values. Those for Mn are EPA Tier II Values. Those for NAWQC values for Cd, Cu, Pb and Zn were adjusted for mean hardness of the MMMM01 site.

Data from the French Broad River at Rosman (DWQ station number 03439000) provide a comparison for selected metals of Peter Weaver Creek. Benthic macroinvertebrates at this site were sampled in 1997 and rated as Excellent; thus, metals concentrations likely do not negatively impact the macroinvertebrate community in the French Broad River. Median aluminum of the French Broad River (230 µg/L) is between the median baseflow (151 µg/L) and individual stormflow (324 µg/L) concentrations of Peter Weaver Creek at Calvert Road. Median copper (3 µg/L) in the French Broad River is also between the median baseflow (1 µg/L) and individual stormflow (4 µg/L) concentrations in Peter Weaver Creek. Median zinc levels are notably higher in the French Broad River at Rosman, but iron is higher in Peter Weaver Creek.

Two tributaries to Peter Weaver Creek, MMPW13 and MMPW14, were sampled once for metals. Total aluminum, cadmium, copper, iron, lead and zinc concentrations at MMPW13 all exceed the chronic and acute screening values. Total aluminum, iron, manganese and lead concentrations at MMPW14 exceed the chronic screening values, and copper and zinc concentrations also exceed the acute screening values. In both tributaries, the iron action level is only NC standard or action level that is exceeded. French Broad River median metal concentrations are lower than those of these tributaries for zinc. The bioavailability of these metals is not known, since parameters that may influence a metal's availability, such as hardness, pH and total suspended residue, were not analyzed.

Based on one sample taken from each of the tributaries MMPW13 and MMPW14, it is possible that metals are at levels that negatively impact aquatic life, but further sampling is needed to more fully evaluate their impact. However, there is little evidence that metals are a problem in the mainstem of Peter Weaver Creek.

5.3 Stressor and Source Identification

5.3.1 Biochemical Oxygen Demand and Nutrient Study

Nutrients and BOD_5 in Morgan Mill Creek were notably higher below the Morgan Mill Trout Farm than further upstream (Table 5.4). There were notable increases in median total phosphorus (0.04 to 0.14 mg/L), ammonia (0.08 to 0.8 mg/L), total nitrogen (0.74 to 1.53 mg/L), and BOD_5 (0.65 to 2.50 mg/L). These high levels decreased to lower levels further downstream. Peter Weaver Creek did not exhibit the high nutrient or BOD_5 levels that Morgan Mill Creek did at US 64, although ammonia levels increased from 0.05 to 0.33 mg/L between the upper and US 64 sites. These sites bracket the D & D Catfish Resort wastewater discharge, which violated ammonia permit limits during Summer 2001. In-stream levels of ammonia measured during this study are not problematic when compared to EPA's ammonia criteria (see Appendix, Section 1.3 for details).

Numerous residents below the trout farm regularly observe a change in Morgan Mill Creek, which becomes white and has a fish odor. One of these events was observed by DWQ staff, and the BOD_5 of Peter Weaver Creek at the integrator location was measured at 8.4 mg/L during this event.

Table 5.4 Median Nitrogen, Phosphorus, and BOD Concentrations in the Peter Weaver and Morgan Mill Creek Watershed*

Chemical Parameter (median for 4 events, in mg/L)	**Peter Weaver Cr above D&D Catfish Resort**	**Peter Weaver Cr below US 64**	**Morgan Mill Cr above Morgan Mill Trout Farm**	**Morgan Mill Cr below US 64**	**Peter Weaver Cr at Calvert Rd**
Total nitrogen	0.64	0.34	0.74	1.53	1.04
TKN	0.50	0.27	0.60	1.40	0.70
NO_3/NO_2	0.14	0.07	0.14	0.13	0.34
Ammonia	0.05	0.33	0.08	0.80	0.30
Total phosphorus	0.03	0.03	0.04	0.14	0.08
BOD_5	0.75	0.90	0.65	2.50	1.50

* Values used are those that were from samples taken during the BOD and nutrient study.

5.3.2 Dissolved Oxygen

Dissolved oxygen levels measured during both regular ambient monitoring and multiday data sonde deployments at the integrator location on Peter Weaver Creek were adequate, ranging from 6.5 to 10.8 mg/L during the study period (Table B.2, Appendix B). However, lower levels were found at Morgan Mill Creek below US 64. Values ranged from 4.8 to 8.6 mg/L in Morgan

Mill Creek, and 6.2 to 7.5 mg/L in Peter Weaver Creek just below US 64. The state DO standard for trout waters is 6.0 mg/L.

5.3.3 Suspended Sediment

Suspended sediment concentrations (SSCs) for stormflows were high throughout the watershed, with site mean (the mean of all samples from a specific site and storm) SSCs from various storms ranging from 281 to 28,464 mg/L (Table B.3, Appendix B). During the rain event (likely bankfull storm event) of August 8, 2001 (retrieval date of September 7, 2001 in Appendix B), the highest SSC levels were seen. This is not surprising, since bankfull storm events can carry a significant amount of the sediment transported over time (Wolman and Miller, 1960).

Suspended sediment concentrations (SSC) during storms were influenced by various watershed activities. Three out of four storms sampled at Peter Weaver Creek at Homer Israel Road had the highest SSC in the watershed, including a site mean of 28,464 mg/L during the storm of August 8, 2001 (retrieval date of September 7, 2001 in Appendix B). These high levels were likely a result of runoff from unpaved roads, driveways, and construction sites in this upper part of the watershed.

Two sites (Peter Weaver Creek at US 64 and Old Rosman Highway) closely bracketed a newly denuded stream bank on Peter Weaver Creek. Since the distance between the two sites is very small, there was likely very little difference in flow and SSCs can be compared. There were clear increases in SSC below the denuded stream bank; six out of seven storm events sampled showed an increase of 1.4 to 3.2 times that of the upper site.

5.3.4 Other Stressors and Sources

Watershed investigations illuminated problems with several tributaries to Peter Weaver Creek. The tributary to Peter Weaver Creek that drains the DOT maintenance facility hill (MMPW14) had a relatively high level of chloride for mountain streams (15 mg/L), reflecting influence from the salt pile groundwater contamination site. This level is far below NC DWQ's standard for freshwater (230 mg/L), and it is likely not a factor in benthic impairment. Semivolatile organic pollutants were all below quantification levels.

The tributary to Peter Weaver Creek that runs along Cassell Road (MMPW13) had high nutrient levels (total nitrogen 2.02 mg/L; total phosphorus 0.36 mg/L), suggesting the input of waste in the creek.

Section 6
Channel and Riparian Conditions

The characterization of stream habitat and riparian area condition at benthic macroinvertebrate sampling sites, described earlier, provides information essential to the assessment of conditions in the Peter Weaver and Morgan Mill Creek watershed. However, a perspective limited to a small number of locations in a watershed may not provide an accurate picture of overall channel conditions, nor result in the identification of pollutant sources and specific problem areas. This study therefore undertook a broader characterization of stream condition by examining large sections of the channel network of Peter Weaver and Morgan Mill Creeks. This characterization is critical to an evaluation of the contribution of local and regional habitat conditions to stream impairment and to the identification of source areas and activities.

6.1 General Approach

During the course of this study, project staff walked the entire channel of Morgan Mill Creek from Morgan Mill Trout Farm to its confluence with Peter Weaver Creek (approximately 0.5 mi or 800 m). Most of Peter Weaver Creek was walked from the end of the paved section of Homer Israel Road to Calvert Road, the lowest benthic monitoring site (approximately 1.5 mi or 2400 m). A few tributaries of Peter Weaver Creek were also walked. Stream sections were walked only where landowner permission was obtained.

Project staff walked the identified sections of channel while carrying out the following tasks:

- Observing overall channel stability, noting specific areas of sediment deposition, severe bank erosion, evidence of channelization and similar attributes.
- Observing overall riparian area condition and the nature of surrounding land use.
- Identifying wastewater discharge pipes, stormwater outfalls, other piped inputs or withdrawals, and tributary inflows.
- Observing visual water quality conditions (odors, surface films, etc).
- Noting specific areas where pollutants are or may be entering the stream (livestock access areas, dump sites, land clearing adjacent to the stream, etc).
- Identifying specific areas that may be candidates for channel restoration or best management practices.
- Providing digital photo documentation of key features.

A detailed description of channel conditions and the results of a geomorphological assessment for Morgan Mill and Peter Weaver Creeks are in Appendix C.

6.2 Channel and Riparian Area Summary

Channel condition gradually worsens within both Peter Weaver and Morgan Mill Creeks as they flow towards the French Broad River. In the higher gradient areas above US 64, substrate is a mix of sand, gravel and cobble, although signs of excess sedimentation are apparent. Where riparian areas are intact in this upper part of the watershed, banks are low and stable. Once the streams reach the French Broad River valley, they become incised, sandy and unstable. This change seems a function of both change in land use and stream gradient.

In the French Broad River valley area, the streams have experienced channelization historically and in more recent times. Landowners observed that small sections of stream have been channelized or moved in the past 20 years. Native woody riparian vegetation is generally lacking, and banks are often vegetated by a mix of invasive shrubs and herbaceous plants that do not provide much bank stabilization. These unstable banks are prone to sloughing, and recent and older bank blowouts were observed. Landowners have attempted to stabilize unstable banks with tires, wood and other materials. Where the channel is wider due to blowouts, the stream does have more room to meander through the incised channel and is likely more stable. Bare banks are likely a major source of excess sediment seen in the channels.

Soils within the valley are alluvial, and streams that course through them may be prone to more vertical instability (downcutting). Both Peter Weaver and Morgan Mill Creek are very incised in the French Broad River valley, and this is likely due to historic channelization, removal of woody riparian vegetation, and subsequent downcutting through the softer substrate. Another source of channel instability may be increased flows in Morgan Mill Creek due to US 64, which travels down a long hill and drains to the creek.

In the French Broad River valley area, Morgan Mill and Peter Weaver Creeks are in a stage of channel widening. Incised streams that have begun widening generally continue to do so until the channel width is sufficient to allow for the stabilization of slumped banks and the development of a new geomorphic floodplain within the banks (Schumm et al., 1984; Simon, 1989; Simon and Darby, 1999). There is little doubt that this scenario is being played out in Morgan Mill and Peter Weaver Creeks (NC Stream Restoration Institute, 2001).

Lack of riparian vegetation not only impacts stream bank stability, but in-stream habitat, as well. A direct impact of this is a lack of large woody debris, sticks, leafpacks, and suitable edge habitat (tree roots). Stream temperature also increases due to the lack of riparian vegetation. An indirect impact is an increase in sedimentation due to bank instability.

The lower reference site on Cherryfield Creek also has unstable and eroding banks where it was monitored for benthic macroinvertebrates in the French Broad River valley. This site is in pasture use, and there is limited woody riparian vegetation to protect bank integrity; however, there is less evidence of channelization in Cherryfield Creek than in Peter Weaver and Morgan Mill Creeks, and the stream meanders through its valley. Its banks do provide a source of sediment to the channel, but habitat scores show less problems with fine sediment deposition. This is likely a function of both sediment quantity and stream energy. Cherryfield Creek has more flow and slightly higher gradient than lower Peter Weaver Creek, both of which can aid in transport of finer sediments downstream.

Duke Energy manages vegetation below its transmission lines, one of which crosses both Peter Weaver and Morgan Mill Creeks near Old Rosman Highway. In 2001, a mix of Accord and Arsenal (which is not licensed for use over water by US EPA) was hand-applied to the right-of-way beneath transmission lines in the watershed, eliminating riparian and bank vegetation along a small section of Peter Weaver Creek.

Excess sedimentation is evident throughout the watershed. In the upper, higher gradient areas that are characterized by healthy riparian areas and biological communities, sand is present in notable amounts. This sediment is coming from unpaved roads and driveways, home sites, and some limited channel instability. The reference reaches of Mason and upper Cherryfield Creeks have less of a problem with fine sediment deposition (as measured by embeddedness), and this is likely due to the lack of upstream sources in their primarily forested watersheds. Sedimentation becomes more problematic for Peter Weaver and Morgan Mill Creeks as they move downstream; sediment sources increase with an accompanied decrease in gradient. In the French Broad River valley, stream banks themselves become a more important source of excess sediment.

Section 7
Analysis and Conclusions

This section analyzes causes of impairment in the Peter Weaver and Morgan Mill Creek watershed. The most probable reasons for the inadequate biological conditions are evaluated, drawing upon the information presented earlier in this report. The sources or origins of these key stressors are also discussed.

7.1 Analyzing Causes of Impairment

The following analysis summarizes and evaluates the available information related to each candidate cause of impairment in order to determine whether that information provides evidence that that particular stressor plays a substantial role in causing observed biological impacts. A strength of evidence approach is used to weigh the evidence for or against each stressor in order to draw conclusions regarding which are the most likely causes of impairment. Causes of impairment may be single or multiple. All stressors present may not be significant contributors to impairment. (See the sidebar "Identifying Causes of Impairment", presented in Section 1, for additional discussion.)

7.1.1 A Framework for Causal Evaluation—the Strength of Evidence Approach

A 'strength of evidence' or 'lines of evidence' approach involves the logical evaluation of all available types (lines) of evidence to assess the strengths and weaknesses of that evidence in order to determine which of the options being assessed has the highest degree of support (USEPA, 1998; USEPA, 2000). The term 'weight of evidence' is sometimes used to describe this approach (Burton and Pitt, 2001), though this terminology has gone out of favor among many in the field because it can be interpreted as requiring a mathematical weighting of evidence.

This section considers all lines of evidence developed during the course of the study using a logical process that incorporates existing scientific knowledge and best professional judgment in order to consider the strengths and limitations of each source of information. Lines of evidence to be considered include benthic macroinvertebrate community data, habitat and riparian area assessment, chemistry and toxicity data, and information on watershed history, current watershed activities and land uses and pollutant sources. The ecoepidemiological approach described by Fox (1991) and USEPA (2000) provides a useful set of concepts to help structure the review of evidence. The endpoint of this process is a decision regarding the most probable causes of the observed biological impairment and identification of those stressors that appear to be most important. Stressors are categorized as follows:

- **Primary cause of impairment**. A stressor having an impact sufficient to cause biological impairment. If multiple stressors are individually capable of causing impairment, the primary cause is the one that is most critical or limiting. Impairment is likely to continue if the stressor is not addressed. All streams will not have a primary cause of impairment.

- **Secondary cause of impairment**. A stressor that is having an impact sufficient to cause biological impairment but that is not the most critical or limiting cause. Impairment is likely to continue if the stressor is not addressed.
- **Cumulative cause of impairment**. A stressor that is not sufficient to cause impairment acting singly, but that is one of several stressors that cumulatively cause impairment. A primary cause of impairment generally will not exist. Impairment is likely to continue if the various cumulative stressors are not addressed. Impairment may potentially be addressed by mitigating some but not all of the cumulative stressors. Since this cannot be determined in advance, addressing each of the stressors is recommended initially. The actual extent to which each cause should be mitigated must be determined in the course of an adaptive management process.
- **Contributing stressor**. A stressor that contributes to biological degradation and may exacerbate impairment but is not itself a cause of impairment. Mitigating contributing stressors is not necessary to address impairment, but should result in further improvements in aquatic communities if accomplished in conjunction with addressing causes of impairment.
- **Potential cause or contributor**. A stressor that has been documented to be present or is likely to be present, but for which existing information is inadequate to characterize its potential contribution to impairment.
- **Unlikely cause or contributor**. A stressor that is likely not present at a level sufficient to make a notable contribution to impairment. Such stressors are likely to impact stream biota in some fashion but are not important enough to be considered causes of or contributors to impairment.

7.1.2 Review of Candidate Stressors

The key stressors evaluated during this study of the Peter Weaver and Morgan Mill Creek watershed were:

- Organic enrichment
- Habitat degradation due to sediment deposition and substrate instability

Additional potential stressors, including salt and metals, were identified during the course of watershed investigations and will be discussed in the following section.

7.1.3 Review of Evidence

Peter Weaver Creek is impaired below its confluence with Morgan Mill Creek, and Morgan Mill Creek declines to impaired status between Old Rosman Highway and its confluence with Peter Weaver Creek. Much of this decline occurred at some time between 1980 and 1997. Based on benthic community monitoring data collected during this study, although impacted by multiple stressors, Peter Weaver Creek above its confluence with Morgan Mill Creek is not impaired. Each stressor investigated during this study is evaluated below.

Organic enrichment. Organic enrichment is a key stressor in biological impairment in the watershed (see Section 4). A shift in the aquatic macroinvertebrate community was observed below the Morgan Mill Trout Farm; the community was indicative of organic loading at all monitoring sites downstream of the trout farm in Morgan Mill and Peter Weaver Creeks. Although some enrichment indicators were also found in the reference streams, Mason and Cherryfield Creeks, these indicators were not dominant as they were in Morgan Mill and Peter Weaver Creeks. The reference sites also hosted a large number of clean water "intolerant" taxa, which were much less common in the lower Morgan Mill and Peter Weaver Creek sites.

Biochemical oxygen demand (BOD), (a measure of organic loading) and nutrients, including total nitrogen, total phosphorus and ammonia, increased substantially below the trout farm (see Section 5). Although nutrient and BOD levels were not as high in Peter Weaver Creek above the confluence with Morgan Mill Creek, they were still high compared to undisturbed watersheds and contribute to levels found in lower Peter Weaver Creek.

Benthic communities respond to organic enrichment with a shift in community composition to taxa that feed on particulate organic matter. Increased nutrients can also result in the growth algae on stream substrates; heavy growths of these attached algae were seen at the lower Peter Weaver Creek site in 2000.

Organic enrichment often results in changes in dissolved oxygen (DO) levels, and many benthic macroinvertebrate taxa that thrive with increased organic loading can tolerate lower DO. At the lower Peter Weaver Creek site, continuous DO measurements performed in the winter and early summer indicated that DO stayed within levels that can support a healthy biological community. However, in Morgan Mill Creek (below US 64 and the trout farm), continuous DO measurement during late summer showed dips in DO to lower levels (5.2 mg/L) that could influence benthic community composition. If these low DO levels are sustained or occur frequently, they could eliminate some intolerant macroinvertebrate taxa typically found in mountain streams. Lower Peter Weaver Creek was not continuously monitored at these times, and DO levels there may also dip lower during hot periods, especially considering the fluctuations in BOD levels observed and low flows due to drought.

Habitat degradation due to sediment deposition and substrate instability. Excess sediment deposition was problematic in the lower gradient French Broad River valley section of the watershed (See Section 6). Here, riffles were embedded and sand made up a larger component of the substrate. Benthic communities were more impacted here, and invertebrates typical of sandy areas (dragonflies, damselflies) became common. The benthic monitoring site that was furthest downstream had some of the worst habitat of all monitoring sites, characterized by a dominance of sand and silt and very embedded riffles. In contrast, the corresponding reference site in the French Broad River valley, Cherryfield Creek, had less fine sediment and only moderately embedded riffles. It is clear that habitat degradation is also a contributing factor in impairment.

Salt. The potential impacts of salt-contaminated groundwater from the DOT facility was examined. Although groundwater-fed tributaries to Peter Weaver do carry higher than normal levels of chloride, these concentrations are not high enough to cause impairment.

Metals. High levels of metals were found in lower Peter Weaver Creek (see Section 5), but comparison to EPA screening levels and metal concentrations in the French Broad River at Rosman provides evidence that it is not likely that these metal concentrations are problematic. In contrast, two tributaries to Peter Weaver Creek were characterized by metal levels that were above the chronic screening values. In both tributaries, zinc, iron, lead, aluminum and copper were above chronic values, and cadmium was above the chronic screening value in one tributary. Given that these comparisons are based on only one sample, it is difficult to determine how problematic these metal levels are. It is possible, however, that metals impact benthic communities in these tributaries and perhaps within a local section of Peter Weaver Creek.

Morgan Mill Creek dam: prevention of downstream colonization. During much of this two-year study, Morgan Mill Trout Farm withdrew the entire flow of Morgan Mill Creek and ran it through its trout raceways and three settling ponds. Invertebrate and fish communities depend on upstream-downstream movement for colonization. Downstream drift is a key mechanism for the maintenance of aquatic invertebrate communities (Waters, 1972; Williams et al., 1976). When the entire flow of Morgan Mill Creek is withdrawn and sent through the trout farm, this serves as a barrier to this important source of colonization.

Recently (latter half of 2001), the dam was cleaned so that the stream flows through a small-holed grill and some water is now released through the dam bottom to the downstream creek bed. This does allow a limited amount of water to flow through the stream bed between the trout farm inflow and outflow. However, due to the structure of the dam, invertebrates may not be able to migrate through the dam system and reach the downstream section.

Other possible stressors. Other stressors could be contributing to biological impairment. Residential use, aquaculture (e.g., copper sulfate), and power line clearing pesticides could impact the biotic community. Detergents and household chemicals delivered by possible straight pipes suggested by watershed residents could also stress the biota.

The extended drought that began mid-1998 has decreased flows in the Peter Weaver and Morgan Mill Creek watershed, with annual rainfall ranging from two-thirds to three-fourths the annual mean. Low flows themselves can stress aquatic invertebrate communities by shrinking aquatic habitat (e.g., isolating edge habitat) and changing energy dynamics (e.g., slowing the current in riffles). Many studies have demonstrated substantial changes in benthic community composition due to drought (e.g., Canton et al., 1984; Cowx et al., 1984). The impacts of other stressors such as non-storm driven pollutants are likely magnified by low flows, since these are more concentrated with less stream volume. However, storm-driven nonpoint source impacts are likely reduced with lower flows. Flow-influenced impacts that occurred during this two-year study period are likely atypical.

7.1.4 Conclusion

It is clear that all sites in the Peter Weaver and Morgan Mill Creeks in the French Broad River valley area below US 64 host biological communities that are compromised. However, those in Morgan Mill Creek below US 64 and Peter Weaver Creek below the confluence with Morgan Mill Creek are clearly the most impacted. Biological and physical/chemical data provide evidence that organic enrichment is a much greater influence in these stream sections, and it is a cumulative cause of impairment. This issue must be addressed in order to restore Peter Weaver and Morgan Mill Creeks to an "unimpaired" state. Habitat degradation in the form of sediment deposition and substrate instability is considered a cumulative cause of impairment, as well. The prevention of downstream drift by the dam at the head of the trout farm is also a cumulative cause of impairment. High levels of metals may contribute to the degradation of the biotic community in tributaries to Peter Weaver Creek and a small section of the mainstem, and it is considered a potential cause or contributor. Low flows due to extended drought likely exacerbate impacts of other watershed stressors.

7.2 Sources of Impairment

Organic pollution and other sources of nutrients. It is clear that the major source of organic pollution is the Morgan Mill Trout Farm. However, nutrients are also coming from other sources, since nutrient levels were elevated in Peter Weaver Creek above US 64 and above the trout farm in Morgan Mill Creek. The most likely sources of these nutrients are from horse and cattle pasture (two farms along Peter Weaver Creek and one along Morgan Mill Creek) and possible straight pipes from residences. In lower Peter Weaver Creek, runoff from a dairy barn at Calvert Road is also a source of nutrients.

Sediment. Excess sediment deposition was notable throughout the watershed, although it was clearly more problematic in the lower gradient French Broad River valley section of the watershed.

Sources of sediment are numerous and come from both upland and in-stream sources. In the French Broad River valley section of the watershed, stream channels themselves are an important source of sediment. Streams are incised and laterally unstable. Peter Weaver and Morgan Mill Creeks have likely downcut to lower bed levels, but it is unclear if this has happened recently or hundreds of years ago. Various sections of the creeks have been channelized, which is often accompanied by incision.

Stream banks are vertical and very high, especially in the French Broad River valley, and there is little bank and riparian vegetation that is able to provide stability, resulting in frequent erosional areas. As a consequence, the stream banks themselves likely provide a significant source of in-stream sediment. The practice of clearing bank vegetation further destabilizes stream banks. Exposed loose soil erodes into streams during storm events, increasing suspended and bed load sediments.

Upland sources of sediments are important in this watershed as well. High suspended sediment levels were found in the upper part of the watershed, where a number of sources were evident. Home and road development, established home sites with eroding slopes, unpaved roads and driveways, and eroding road banks provide the major sources of sediment. Unpaved roads are present in upper watersheds for both Morgan Mill and Peter Weaver Creeks. However, there is a greater network of unpaved roads and new homes in the upper Peter Weaver Creek watershed.

Metals. The sources of problematic metals have not been determined. The old unlined landfill, which is upslope of both of the problematic tributaries, could be the source. Groundwater wells on DOT property have demonstrated movement of organic contaminants (e.g., vinyl chloride and tetrachloroethane) from the landfill towards Peter Weaver Creek. The DOT site itself may also be the source of metals; groundwater contamination by the underground storage tanks could contain metals such as lead from leaded fuel. It is possible that straight pipes from residences could contribute to the high in-stream levels seen in one of the small tributaries that runs behind houses. Metal roofs and pipes can serve as sources of zinc and perhaps cadmium. High metal levels have been found in stormwater draining old agricultural sites in other areas; it has been hypothesized that residues of old pesticides containing metals are sources in these areas (Bales et al., 1999). It is also possible that there are natural sources of some of these metals; mineralization of watershed rock can provide concentrated sources of some metals.

7.3 Other Issues of Concern

If landfill leachate is contaminating surface water, it may not only be a source of metals but other toxins, such as petroleum products and pesticides.

Through conversations with area landowners, it became clear that there are a number of potential sources of pesticides. Use of pesticides in floodplain gardens, lawns, and along stream banks could all be sources. Duke Energy's use of herbicides on transmission line crossings may also be a source, as well. The use of copper sulfate to control algae and macrophytes in fish ponds can also be problematic if high levels are used.

Both Peter Weaver and Morgan Mill Creeks have numerous small dams impounding stream flows along their lengths. Peter Weaver Creek has several small dams placed in its upper section for small-scale trout production, and D & D Catfish Resort dams the creek at its intake point for the catfish pond. Morgan Mill Creek is dammed at the children's camp to create Kaiser Lake, at the site of the now-defunct intake for an old mill, and then at the aforementioned water-intake site for Morgan Mill Trout Farm. All of these dams can contribute to stream discontinuity, disabling fish and invertebrate populations from upstream-downstream movement.

Section 8
Improving Stream Integrity in Peter Weaver and Morgan Mill Creeks: Recommended Strategies

As discussed in the previous section, there are a number of stressors acting in concert that impact Peter Weaver and Morgan Mill Creeks. Organic loading from Morgan Mill Trout Farm, habitat degradation caused by sediment deposition and substrate instability, and prevention of downstream colonization caused by the dam at the head of the trout farm are cumulative causes of impairment. High levels of metals are a potential cause or contributor, and they may contribute to the degradation of the biotic community in tributaries to Peter Weaver Creek and a small section of the mainstem. Sediment inputs from future development in this watershed will pose additional threats to Peter Weaver and Morgan Mill Creeks. This section discusses how these problems can be addressed. A summary of recommendations is included at the end of the section.

8.1 Addressing Current Causes of Impairment

The objective of stream quality improvement efforts is to create water quality and habitat conditions to support a diverse and functional biological community in this rural area. While some development has occurred since Morgan Mill and Peter Weaver Creeks were last observed to support such a community in the late 1970s, the watershed has not been so highly modified as to preclude potential for significant improvements in stream integrity. A return to pristine conditions that existed prior to human influence is not feasible, but Peter Weaver and Morgan Mill Creeks can potentially support a much healthier aquatic community than they do today.

8.1.1 Organic Enrichment

The greatest contributor of organic loading and nutrients is the Morgan Mill Trout Farm. Although fish production has been cut by 80% in the last few years, the biological community is still clearly suffering from the impacts of trout farm effluent. Waste management practices of the farm should be reviewed and improved by the trout farm owner with the help of DWQ staff and NC State University/NC Department of Agriculture aquacultural extension agents. Issues that should be addressed are the following:

- Regular removal of settled solids in lowest settling pond and replacement of dam.
- Possible removal of settled solids in the two upper ponds.
- Review of fingerling nursery and processing facilities to insure that no waste is entering Morgan Mill Creek.
- Determination of the source of periodic inputs of white fishy-smelling substance.

It is evident that there are other sources of nutrients in the watershed, and these sources should be addressed as well, including the following:

- Small farmers in the watershed should be encouraged to fence horses and cows out of Peter Weaver and Morgan Mill Creeks and offer alternative water sources to livestock.

- Drainage from the dairy barn off Calvert Road should be converted to sheet flow and redirected away from Peter Weaver Creek.
- Any straight pipes from watershed residences should be identified and eliminated.

The NC Agriculture Cost Share Program can provide funds to help farmers to install appropriate best management practices to address nutrient issues. Financial aid for elimination of straight pipes is available through the US Department of Agriculture's 504 Loan and Grant Program.

8.1.2 Hydromodification—Dam Impacts

The dam structure at the inlet for the trout farm on Morgan Mill Creek blocks all downstream drift when all water is diverted to the trout farm. Currently, some water is allowed through a bottom outlet at the foot of the dam structure (Figure 8.1). It is necessary to insure permanent water flow below the dam. This small dam should also be retrofitted to allow for the safe passage of aquatic invertebrates to the creek below the dam.

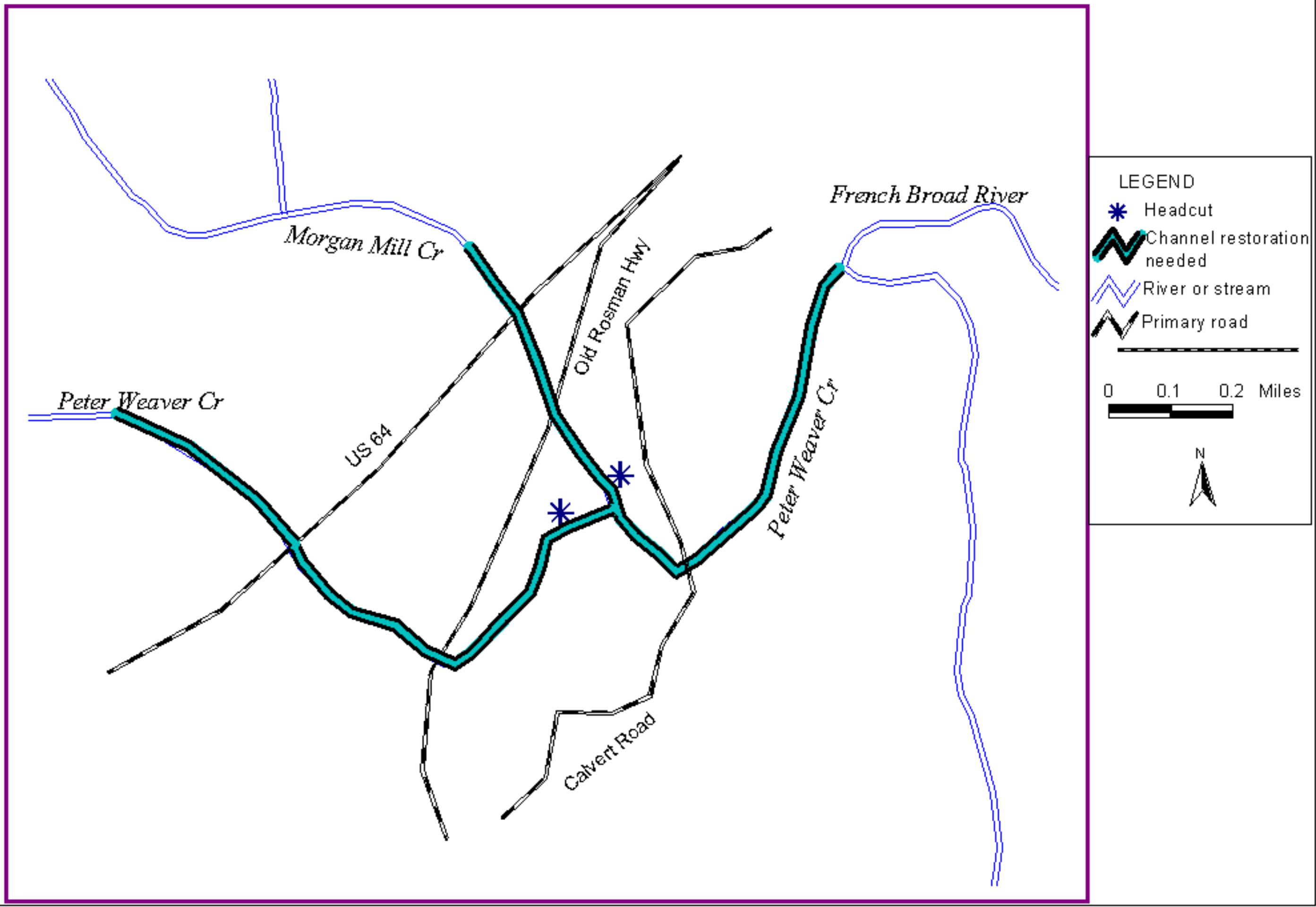
Figure 8.1 Water intake structure at the Morgan Mill Trout Farm

8.1.3 Habitat Degradation Due to Sedimentation and Substrate Instability

Currently the major sources of sediment to Peter Weaver and Morgan Mill Creeks are unstable stream banks and inputs from unpaved roads, driveways and new home sites.

<u>Unstable stream banks</u>
Stream bank instability is a watershed-wide problem due to historic and present-day practices, and it is particularly notable in the French Broad River valley part of the watershed (Figure 8.2). Here, Morgan Mill and Peter Weaver Creeks are often incised and unstable, contributing a large amount of sediment to the streams.

Figure 8.2. Stream Segments Pinpointed for Restoration



If no action is taken to stabilize Peter Weaver and Morgan Mill Creeks, these streams will widen until they have created a stable channel configuration within their current incised channels. This will occur once these streams are wide enough to allow for the natural dynamic processes of meandering and flooding. This process may take decades, and as it occurs, stream banks will contribute in-stream sediment as the channel widens. Habitat degradation will continue to be a major stressor for aquatic communities, landowners will lose property, and this watershed will serve as a continued source of sediment to the French Broad River.

In addition, if the headcuts in both creeks are not stabilized, they will gradually move up these streams, causing further incision and widening. This will not only impact the local area of the headcut, but also that further downstream, which will suffer from increased sediment inputs from these headcut areas.

If these streams are left alone, natural processes will allow these creeks to heal themselves eventually. However, the issue of habitat degradation will persist for many years and may worsen before these streams stabilize. Landowners have attempted to stabilize banks by hardening banks in place with tires, wood, and other materials; this is likely to continue. While this may stabilize local areas of the bank in the short term, it hinders and prolongs the process of stream adjustment and eventual stabilization. If the streams are left to heal themselves, then at a minimum, the headcuts should be stabilized with a set of grade control structures so that their movement up the creeks will be stopped. This would cost a minimal amount of approximately $25,000 per headcut.

The alternative to waiting decades or longer for these streams to stabilize themselves is to restore stable profile, pattern and dimension (restoration of sinuosity, width and depth to a relatively stable state) to these creeks. This would be a large undertaking involving many landowners.

The longest, most unstable section of Peter Weaver Creek is from near the northern edge of D & D Catfish Resort property (approximately 0.25 mile above US 64) to the French Broad River. The longest, most unstable section of Morgan Mill Creek is between the stream intake of the Morgan Mill Trout Farm (approximately 0.15 mile above US 64) and the confluence with Peter Weaver Creek. These areas are clearly in need of restoration.

Other areas may also benefit from restoration. Upstream of D & D Catfish, Peter Weaver Creek runs through pasture, where it is also eroding in some places. It is unclear if restoration of profile, pattern and dimension is required upstream of US 64 on D & D Catfish property and the pasture area, or if only reestablishment of buffer vegetation and spot stabilization is needed. Additional field assessment would be necessary to evaluate restoration needs in this stream section. Due to stream access issues, we were unable to walk all sections of Peter Weaver and Morgan Mill Creeks, especially above US 64. It is possible that there are additional areas of these creeks in the upper watershed that merit stream stabilization as well.

Restoring Peter Weaver Creek between US 64 and the French Broad River and Morgan Mill Creek between the stream intake of the Morgan Mill Trout Farm and the confluence with Peter Weaver Creek would involve approximately 1.8 miles of stream and 25 landowners. The restoration feasibility study by the NCSU Stream Restoration Institute (see Appendix C) indicates that either a Priority 2 or Priority 3 restoration would be possible (Rosgen, 1997), with a Priority 2 effort restoring the stream to a C stream type and a Priority 3 to a B stream type.

Both C and B stream types (Rosgen, 1996) can represent stable channel configurations. A C stream is probably more consistent with the lower slopes of the downstream portion of the watershed, but will require a broader stream corridor (belt width) to allow for sufficient channel meandering. A less meandering B stream type would be a viable alternative if the available belt width is not adequate for a C stream. Using the upper estimation of cost for either priority by NC State University (2001) of $109 per foot, this work would cost about 1.1 million dollars. *This is a rough estimate of likely total cost, including design, permitting, construction and further monitoring. The actual cost will depend on the length of stream restored, the number of landowners involved, the restoration design, and cost of acquiring conservation easements.*

In conclusion, at a minimum, grade controls should be installed to stabilize the headcuts and prevent further incision and habitat degradation. This will help prevent the situation from worsening but will not alone address the problem. A more proactive approach is to restore profile, pattern and dimension to all 1.8 miles of unstable stream and stabilize the unstable section of Peter Weaver Creek above US 64, as well. Beginning restoration work at the upper ends of these stream segments and proceeding downstream would assure greater success of channel restoration. Otherwise, sediment loading from upstream bank erosion may accumulate in restored channels downstream. This stream channel work would likely be a lengthy process; since the headcuts threaten the stability of upstream segments, they should be stabilized over the short-term until channel restoration is implemented in the area of the headcuts. *These channel restoration recommendations are preliminary; restoration design for the lower watershed should be based on a comprehensive geomorphological assessment.* It is possible that some of the stream sections discussed above could be restored while others are left to stabilize naturally, but further study would be necessary to determine the feasibility of such an approach.

Woody riparian vegetation has been removed from most sections of these two creeks up and beyond the furthest upstream sampling sites. Landowners should be encouraged to replant native woody riparian vegetation in these areas.

<u>Upland sources of sediment</u>

Unpaved roads and driveways and eroding road banks are a significant source of sediment in the upper watershed. In order to reduce the current amount of sediment from these sources, unpaved roads should either retrofitted to control erosion or paved. If unpaved roads are retrofitted, best management practices (BMPs) should be implemented, including proper grading and the construction and maintenance of sediment basins to settle out coarse sediments that erode during storm events. If roads are paved, water velocity should be slowed and allowed to infiltrate in order to control its erosive potential and volume. For both options, eroding road banks should be stabilized with vegetation.

Home sites are often built on steep slopes in the upper part of the watershed (especially that of Peter Weaver Creek), and these sites are a source of sediment both during and after construction. Post-construction, home sites sometimes continue to have eroding unvegetated slopes. Landowners should be encouraged to stabilize these eroding areas with vegetation.

8.1.4 Metals

Since the sources of high metal concentrations in the watershed are unknown, additional study is needed to pinpoint these sources. As resources allow, more surface water monitoring should be performed by NC DWQ in tributaries and mainstem creeks to further isolate problem areas. Groundwater wells already in place down gradient of the DOT site for salt plume monitoring should be used to monitor metals that could be coming from both the DOT site and the landfill.

8.1.5 Pesticides

Although pesticides are not considered a cause of impairment in Peter Weaver and Morgan Mill Creeks, they may have periodic impacts to water quality. Landowners should be educated about responsible pesticide use. Duke Power should apply approved chemicals according to its own BMPs, which prohibit herbicide application within 25 feet of a stream.

8.2 Addressing Future Threats to Stream Integrity

As discussed in Section 2, further home development is likely in the upper part of the watershed. If this development uses similar design approaches on these steep slopes (e.g., steep dirt roads and driveways, home sites, and roads with eroding bare banks), continued habitat degradation in Peter Weaver and Morgan Mill Creeks is likely. Addressing these future threats is important, or habitat quality improvement resulting from efforts to control current problems may be short-lived.

8.2.1 Sediment from New Construction

Significant future sediment inputs from upland sources will continue to degrade in-stream habitat even if existing sources of sediment are addressed. Home building will continue in steeper areas of the watershed, and if current development practices are used, roads, driveways and construction sites will provide a significant source of sediment to streams. Developers of roads and home sites should be encouraged to adhere to best management practices that control erosion in steep areas, quickly stabilizing bare areas with vegetation and limiting development of steeper areas. Roads with steep grades (>12%) are difficult to maintain and erode easily (Western North Carolina Tomorrow, 1999); construction of these roads should be discouraged.

The Erosion and Sediment Control Program administered by the NC Division of Land Resources (NC DLR) was developed to address sediment issues on a state-wide basis. Much of the mountain region of North Carolina, however, has conditions unique to the state, with steeper slopes and higher rainfall levels than elsewhere. Current management practices often do not protect streams against sediment delivery under these conditions. Additionally, many development projects in the Morgan Mill and Peter Weaver Creek watershed disturb less than one acre. Although these areas can cumulatively have a substantial impact on streams, they are generally given limited regulatory attention.

Current sedimentation and erosion control practices have not protected the Morgan Mill and Peter Weaver Creek watershed. Sediment inputs from new road and home site development will continue if control efforts are not improved. The most critical need is the development of management practices specific to the steep slopes and high rainfall (approximately 80 inches per year) of the area. This issue could be addressed either by providing the NC DLR with the resources to enhance its erosion and sediment control oversight, or by establishing a local program in Transylvania County. In either case, ensuring staffing that is adequate to provide effective enforcement and technical guidance, and to address the impacts of sites disturbing less than one acre, will be essential.

8.3 A Framework for Improving and Protecting Stream Integrity

Restoring and protecting streams is not a one shot proposition, but requires an iterative process in which sequential actions are taken over time in conjunction with an effort to monitor changes in stream condition. An organizational framework for ongoing watershed management in the Peter Weaver and Morgan Mill Creek drainage is essential in order to provide oversight over the implementation of projects, evaluate how current restoration and protection strategies are working, and to plan for the future. While state agencies can play an important role in this undertaking, planning can be much more effectively initiated and managed at the local level.

A watershed council, made up of a broad range of stakeholders, including homeowners, business people, farmers, local extension agents, and government representatives, could be an effective mechanism to address the issues revealed by this study. This council should develop a working plan, seeking to recognize diverse viewpoints in achieving the common goal of restoring and protecting Morgan Mill and Peter Weaver Creeks.

8.4 Summary of Recommendations

The objective of efforts to improve stream integrity is to create water quality and habitat conditions to support a diverse and functional biological community in this rural watershed. The following actions are necessary to address current sources of impairment in Peter Weaver and Morgan Mill Creeks and prevent future degradation. Actions one and two are essential to restoring and sustaining aquatic communities in the watershed. Even if actions one and two are achieved, the biotic integrity of these streams will remain extremely limited unless actions three and four are implemented. Actions five through nine are secondary but important watershed-wide solutions. Action ten is an important step that would reduce future risk to streams from new development.

1. The waste management plan of the Morgan Mill Trout Farm should be reexamined and efforts to control organic loading implemented, including:
    a. removal of settled solids and repair of dam in lowest settling pond;
    b. review of fingerling nursery and processing facilities; and
    c. determination and elimination of the source of the periodic white fishy substance.
2. The dam at the water intake at the trout farm should be retrofitted to allow permanent flow and drift of aquatic invertebrates below the dam.
3. Farmers should be encouraged to fence livestock out of streams and redirect runoff from barns away from streams.

4. Stream segments with unstable morphology should be restored, with priority given to Peter Weaver and Morgan Mill Creeks in the French Broad River valley. At a minimum, the headcuts in Peter Weaver and Morgan Mill Creeks should be stabilized.
5. Unpaved roads in the upper portion of the watershed should be retrofitted or paved. If unpaved roads are retrofitted, unstable areas should be stabilized and best management practices (BMPs) used to remove coarse sediments from runoff. If roads are paved, runoff water velocity should be controlled.
6. Eroding bare areas along road banks and at home sites should be stabilized with vegetation or regraded to an appropriate slope so that vegetation can be established.
7. Sources of high metal concentrations in area tributaries should be identified and eliminated, if possible.
8. Transylvania County or the NC Division of Environmental Health should survey residences for straight pipes and work with owners to eliminate them.
9. A watershed education program should be developed and implemented with the goal of targeting homeowners in order to reduce current stream damage and prevent future degradation. At a minimum the program should include elements to address the following issues:
    a. Importance of riparian vegetation. Landowners should be encouraged to plant native woody riparian vegetation along stream banks and protect current riparian vegetation.
    b. Repair of unstable stream banks.
    c. Responsible use of pesticides in gardens and along stream banks.
10. In order to prevent future water quality deterioration related to new construction activities, sediment and erosion control practices should be improved. Either the NC Division of Land Resources or Transylvania County should develop guidelines that better protect waters from the impacts of home and road development on steep slopes. Improved mechanisms for addressing the impacts of disturbances of less than one acre should also be developed. Staffing levels sufficient to support effective enforcement are essential.

Section 9
References

Bales, J.D., J.C. Weaver and J.B. Robinson. 1999. *Relation of Land Use to Streamflow and Water Quality at Selected Sites in the City of Charlotte and Mecklenburg County, North Carolina, 1993-98*. USGS Water-Resources Investigations Report 99-4180. Raleigh, NC.

Burton, G.A. and R.E. Pitt. 2001. *Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists and Engineers*. Lewis Publishers. Boca Raton, FL.

Canton, S.P., L.D. Cline, R.A. Short and J.V. Ward. 1984. *The Macroinvertebrates and Fish of a Colorado Stream During a Period of Fluctuating Discharge*. Freshwater Biology 14: 311-316.

Cowx, I.G., W.O. Young and J.M. Hellawell. 1984. *The Influence of Drought on the Fish and Invertebrate Populations of an Upland Stream in Wales*. Freshwater Biology 14: 165-177.

Earth Satellite Corporation. 1997. *Comprehensive Land Cover Mapping for the State of North Carolina*. NC Center for Geographic Information Analysis. Raleigh, NC.

Foran, J.A. and S.A. Ferenc. 1999. *Multiple Stressors in Ecological Risk and Impact Assessment*. SETAC Press. Society for Ecological Toxicology and Chemistry. Pensacola, FL.

Fox, G.A. 1991. *Practical Ccausal Inference for Ecoepidemiologists*. J Toxicol Environ Health. 33:359-373

Giese, G.L. and R.R. Mason. 1991. *Lowflow Characterics of Streams in North Carolina*. USGS Open Report 90-399. Raleigh, NC.

North Carolina Division of Water Quality. 2000a. *A Citizen's Guide to Water Quality Management in North Carolina*. First Edition. Planning Branch.

NC DWQ. 2000b. *North Carolina's 2000 303(d) List*.

NC DWQ. 2001. *Standard Operating Procedures—Biological Monitoring*. Biological Assessment Unit.

North Carolina Stream Restoration Institute. 2001. *Morphological Evaluation and Restoration Feasibility Assessment*. Morgan Mill Creek near Rosman, NC. North Carolina State University. Raleigh, NC.

Reckhow, K.H. 1997. *Adaptive Management: Responding to a Dynamic Environment*. WRRI News. Number 307. Water Resources Research Institute of the University of North Carolina.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, CO.

Rosgen, D.L. 1997. *A Geomorphological Approach to Restoration of Incised Rivers, Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*. S.S.Y Wang, E.J. Langendoen and F.D. Sheilds, Jr. (eds.).

Schumm, S.A., M.D. Harvey and C.C. Watson. 1984. *Incised Channels: Morphology, Dynamics and Control*. Water Resources Publications. Littleton, CO.

Simon, A. 1989. *A Model of Channel Response in Disturbed Alluvial Streams*. Earth Surface Processes and Landforms. 14:11-26.

Simon, A. and S.E. Darby. 1999. *The Nature and Significance of Incised River Channels*. Pp 3-18 in S.E. Darby and A. Simon (eds). *Incised River Channels: Processes, Forms, Engineering and Management*. John Wiley & Sons. Chichester, UK.

United States Environmental Protection Agency. 1995. *Final Water Quality Guidance for the Great Lakes System*. 40 CFR Parts 9, 122, 123, 131, 132. Federal Register. 60:56:15365-15425.

USDA Soil Conservation Service and Forest Service. 1974. *Soil Survey of Transylvania County, North Carolina*.

USEPA. 1997. *Guidelines for Preparation of the Comprehensive State Water Quality Assessments [305(b) Reports] and Electronic Updates: Supplement*. EPA 841-B-97-002B.

USEPA. 1998. *Guidelines for Ecological Risk Assessment*. EPA 630-R-95-002F.

USEPA. 1999. *National Recommended Water Quality Criteria--Correction*. EPA 822-Z-99-001.

USEPA. 2000. Stressor Identification Guidance Document. EPA 822-B-00-025.

USEPA. 2001. *Protecting and Restoring America's Watersheds: Status, Trends, and Initiatives in Watershed Management*. EPA 840-R-00-001.

Waters, T.F. 1972. *The Drift of Stream Insects*. Annual Review of Entomology 17: 253-272.

Western North Carolina Tomorrow. 1999. *A Mountain Home Before You Buy*. Cullowhee, NC.

Williams, D.D. and H.B. Hynes. 1976. *The Recolonization Mechanisms of Stream Benthos*. Oikos 27: 265-272.

Wolman, M.G. and J. P. Miller. 1960. *Magnitude and Frequency of Forces in Geomorphic Processes*. Journal of Geology 68: 54-74.

Yoder, C.O. and E.T. Rankin. 1995. *Biological Response Signatures and the Area of Degradation Value: New Tools for Interpreting Multimetric Data*. Pp 263-286 in W.S. Davis and T.P. Simon (eds.). *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*. Lewis Publishers. Boca Raton, FL.