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North Carolina Forestry BMP Implementation Survey Results 2006-2008

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Final Report

North Carolina Forestry BMP Implementation Survey Results 2006 – 2008

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List of Acronyms

BMP(s)	Best Management Practice(s)
CWA	Federal Clean Water Act
ESF	Educational State Forest
FIA	Forest Inventory and Analysis
FPGs	Forest Practices Guidelines Related to Water Quality
NCDFR	N.C. Division of Forest Resources
NIPF(L)	Non-Industrial Private Forest (Landowner)
NPS	Nonpoint Source
QAQC	Quality Assurance Quality Control
SMZ(s)	Streamside Management Zone(s)
SPCA	N.C. Sedimentation Pollution Control Act
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
WQF	NCDFR Water Quality Forester

EXECUTIVE SUMMARY

In March 2008, the N.C. Division of Forest Resources (NCDFR) completed a two-year survey to evaluate the implementation of voluntary forestry Best Management Practices (BMPs) on active logging sites statewide. The BMP Implementation Survey (Survey) continues to be an integral part of NCDFR's efforts to assess, develop, and promote BMPs for the protection of North Carolina's water resources during forestry operations.

This report summarizes the results of 212 site survey field evaluations conducted between May 2006 and March 2008 and represents the second statewide survey of active logging sites. The previous report, titled *Final Report for the North Carolina Forestry BMP Implementation Survey 2000-2003* (2005 BMP survey report, NCDFR 2005), established a baseline of BMP implementation in the state.

The Division's field surveyors only evaluated BMPs that applied to each site at the time of the Survey. A qualitative assessment of water quality risk was also noted in association with implementation or non-implementation of a BMP. Additionally, an assessment of compliance with North Carolina's Forest Practices Guidelines Related to Water Quality (FPGs) was completed to determine the influence of BMP implementation on FPG compliance.

Statewide, BMP implementation was 85 percent. Implementation during this Survey period increased slightly from the 2000-2003 period, which had an overall implementation rate of 82 percent. When compared to the previous survey, implementation of BMPs increased in the Coastal Plain and Piedmont and decreased in the Mountains.

BMP implementation was 66 percent in the Mountains, 88 percent in the Piedmont, and 91 percent in the Coastal Plain. On average statewide, when BMPs were properly implemented, there was no risk to water quality nearly 100 percent of the time. Conversely, when BMPs were not implemented, it resulted in a risk to water quality 54 percent of the time. Regionally, risk to water quality resulting from non-implementation of BMPs was the highest in the Mountains (70%) followed by the Coastal Plain (61%) and Piedmont (30%).

On average statewide, BMPs for streamside management zones (SMZs), stream crossings, debris entering streams, rehabilitation of the project site (rehab), and skid trails represent 73 percent of the non-implemented BMPs and 94 percent of the observed risk to water quality. BMPs for rehab and stream crossings had the lowest implementation in all regions of the state. Implementation of BMPs for skid trails was notably lower in the Mountains, compared to other regions.

FPG compliance was more common on harvest sites with higher BMP implementation. Conversely, as BMP implementation decreased, the number of compliant FPG standards also decreased (more non-compliant standards). Similar to the FPG program data, violation of (.0201) Streamside Management Zones, (.0202) Prohibition of Debris entering streams and Waterbodies, (.0203) Access Road and Skid Trail Stream Crossings, and (.0209) Rehabilitation of Project Site represented the majority of the non-compliant FPG standards on surveyed sites. These data clearly indicate that implementation of BMPs can yield higher FPG compliance on forestry sites and lower implementation of BMPs can yield a larger number of non-compliant FPG standards.

Where applicable, riparian buffer rule compliance was equal to or greater than 90 percent across the state. BMP implementation was notably lower in river basins that are largely located within the Mountains (e.g., Broad, French Broad, Hiwassee, Little Tennessee, New, and Watauga), and risk to water quality was higher in these river basins. These data indicate high riparian buffer rule compliance (for the assessed rules) and also highlight the challenges and value of implementing BMPs in the mountainous areas of the state.

Average SMZ width was estimated in the field for each surveyed SMZ. Surveyors qualitatively evaluated all SMZ widths to determine if BMP recommendations were followed and whether there was a risk to water quality associated with the width of the SMZ. This large scale evaluation of SMZ widths on active logging sites is possibly the first instance of such an assessment in North Carolina. Data indicate that a SMZ greater than 10 feet in width notably reduces risk to water quality when compared to SMZ widths of less than 10 feet. Also, the average width of all SMZs surveyed statewide that had no risk to water quality was 50 feet on perennial streams and 36 feet on intermittent streams.

BMP implementation was higher and risk to water quality was lower on sites that received technical assistance and / or preharvest planning. While BMP implementation was lower in Districts with Water Quality Foresters (WQFs), risk to water quality was also lower. BMP implementation was higher on sites harvested by ProLoggers and risk to water quality was lower. FPG compliance was higher when technical assistance, preharvest planning, WQFs, and / or ProLoggers were associated with a harvest site. These data clearly indicate that technical assistance, preharvest planning, and training can increase BMP implementation and FPG compliance and decrease risk to water quality.

BMP implementation and risk to water quality varied by ownership and forest management type. While implementation was higher on forest industry land, so was risk to water quality. In contrast, "intensively managed forests" had higher BMP implementation and lower risk to water quality when compared to "passively managed forests." Therefore, the influence of ownership and forest management on BMP implementation and risk to water quality may not be as important as harvest site characteristics (e.g., streams, soils, slope, etc.) and other factors related to the harvest sale and operation (e.g., timber buyer, logger, etc.).

BMP implementation was higher and risk to water was lower on sites with less topographic slope. Sites with medium textured soils and soils with higher erodibility generally exhibited a lower BMP implementation and higher risk to water quality. These data clearly indicate the influence of site geographic features on BMP implementation and risk to water quality. Also, the influence of slope, soil texture, and soil erodibility on BMP implementation and risk to water quality closely aligns with regional implementation and water quality risk data (i.e., Mountains, Piedmont, and Coastal Plain).

Survey results indicate that improving BMP implementation of stream crossing BMPs will have the most positive influence on reducing the risk to water quality on active harvest sites, followed by BMPs for rehabilitation, debris entering streams, skid trails, and SMZs.

In summary, the results of the Survey indicate that adherence to a three-phased approach to implementing BMPs can reduce risk to water quality and provide appropriate protection for water quality during forest harvesting operations.

- Phase 1 – Plan for BMPs
  - Evaluate the characteristics of a proposed harvest site in advance of conducting harvesting operations, identifying potential hazards and BMP implementation needs. This planning could be a brief site walk-through or a detailed preharvest plan.
- Phase 2 – Implement Applicable BMPs
  - Implement BMPs identified during Phase 1, adding implementation of other applicable BMPs as needed based on harvest site characteristics. Where applicable, emphasis should be placed on BMPs where operations are closest to streams / waterbodies (e.g., stream crossings, debris entering streams, SMZs, etc.) and where high traffic areas could expose soil and produce accelerated erosion (e.g., skid trails).
- Phase 3 – Conduct Rehabilitation
  - Conduct rehabilitation activities where needed as early as possible with emphasis on operational areas closest to streams / waterbodies and where the potential for accelerated erosion is high.

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1.0 INTRODUCTION

The objective of the Federal Water Pollution Control Act (a.k.a. Clean Water Act [CWA]) is "…to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." To achieve this objective, the U.S. Environmental Protection Agency (USEPA) called on states to develop and implement water quality management measures for nonpoint source (NPS) pollution. The N.C. Division of Forest Resources (NCDFR) primarily works to achieve the CWA objectives through forestry Best Management Practices (BMPs) education and field demonstration, with the following three core components:

1) Identify BMPs to protect water quality during forestry operations.
2) Educate and train forestry practitioners and forest landowners to facilitate the implementation of BMPs.
3) Monitor forestry operations to determine the level of BMP implementation.

Furthermore, forestry operations in North Carolina are subject to regulation under the N.C. Sedimentation Pollution Control Act (SPCA) of 1973 (Article 4-GS113A). However, forestry operations may be exempt from specific requirements of the SPCA if the operations comply with the performance standards outlined in the Forest Practices Guidelines Related to Water Quality (FPGs; 15A NCAC 1I .0100 - .0209) and General Statutes regarding stream and ditch obstructions (GS 77-13 and GS 77-14).

Forestry BMPs in North Carolina are voluntary recommendations that can assist with achieving compliance with state FPGs and General Statutes, while meeting the nonpoint source pollution prevention objectives of the CWA. In North Carolina, these BMPs are outlined in the *North Carolina Forestry Best Management Practices Manual to Protect Water Quality*, as amended in September 2006.

The North Carolina Forestry BMP Implementation Survey 2006 – 2008 (hereafter referred to as the "Survey") was designed to monitor forestry BMP implementation on active logging sites throughout the state. The results described herein provide a general assessment of the level of success achieved through BMP education and field demonstration for the implementation of forestry BMPs for protecting water resources during forestry operations.

1.1 Survey Background

In March 2008, the NCDFR completed a two-year survey (Survey) to evaluate the implementation of voluntary forestry BMPs statewide. The BMP Implementation Survey continues to be an integral part of NCDFR's efforts to assess, develop, and promote BMPs for the protection of water resources during forestry activities in North Carolina.

This report summarizes the results of 212 surveys (field evaluations) conducted between May 2006 and March 2008 and represents the second statewide survey of active logging sites. The previous report, titled *Final Report for the North Carolina Forestry BMP Implementation Survey 2000-2003* (2005 BMP survey report; NCDFR, 2005), established a baseline of BMP implementation in the state.

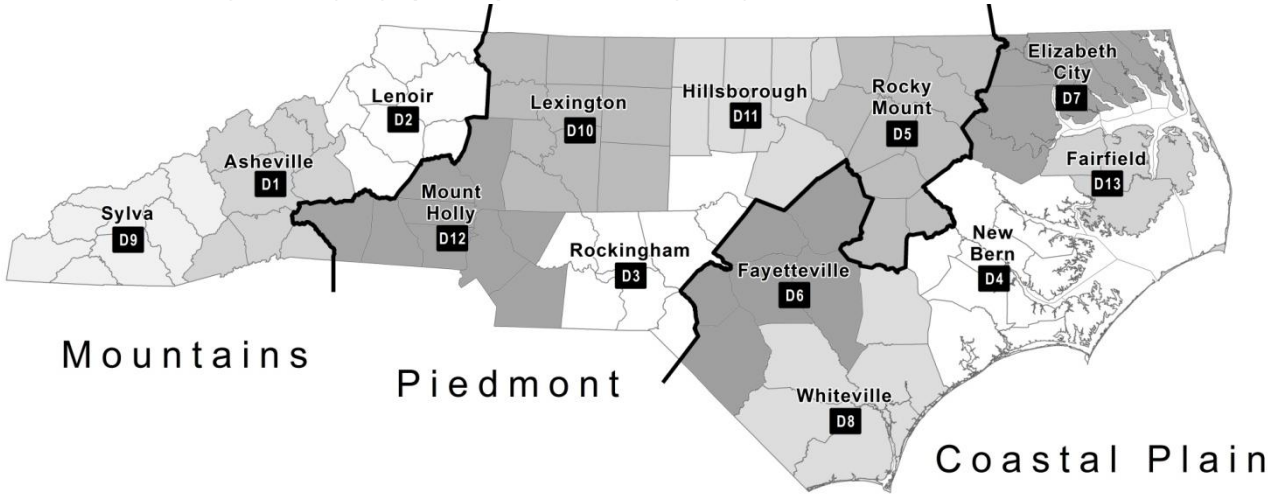
The primary goals of this Survey were to:

- Determine the level of BMP implementation occurring on active (or recently active) logging sites throughout North Carolina.
- Assess the implemented BMP practices for strengths and weaknesses with regard to water quality protection.

While the term "survey" is used, the actual process involves a thorough on-the-ground site evaluation and assessment of the harvesting operation. The Survey is not a question and answer "survey" of the logger, but a qualitative and quantitative evaluation of BMP implementation and risk to water quality due to non-implementation at the site.

The Survey was conducted in all three physiographic provinces of the state (Mountains, Piedmont, and Coastal Plain) and included 98 of the 100 counties. As with the 2005 BMP survey report, Survey data was aligned by NCDFR Districts to approximate the state's physiographic areas (see below, Figure 1). Based on NCDFR's re-assignments for county operations, this alignment differs from the 2005 BMP survey report by one county (Rutherford). For the 2005 BMP survey report, Rutherford County was summarized with Mountains regional data. In this report, it was summarized with Piedmont regional data.

Figure 1. Physiographic Map of the State Aligned by NCDFR District Boundaries



1.2 Follow-up from Previous Survey

Among the most notable accomplishments since the 2005 BMP survey report was the first-ever complete revision of North Carolina's forestry BMP manual. These revisions included modifications and additions to the previous BMP manual that were compiled and published in 2006 after nearly four years of work by a multi-disciplinary technical committee.

As noted in the *Recommendations* section of the 2005 BMP survey report (NCDFR, 2005), several actions were taken to emphasize or encourage landowners to conduct preharvest planning and obtain technical assistance, including:

- Creating and including a comprehensive chapter on planning forestry operations in the 2006 revision to the North Carolina Forestry BMP Manual (NCDFR, 2006), including a preharvest checklist and additional information specifically for forest owners.
- Distributing 15,000 copies of "Call Before You Cut" brochure that describes the process and benefits of preharvest planning. This brochure was revised, updated, and republished for distribution in September 2010.
- Revising the NCDFR web site to include information in a new section entitled "Beginning Steps," which describes fundamental elements for a landowner regarding the management and harvest of timber.
- Producing three BMP videos to address topics that warranted further training and implementation, including *Forestry Stream Crossings with Bridgemats*, *Forestry Stream* Crossings, and *BMPs for Logging Skid Trails*. Each of the videos was incorporated into one of the N.C. Forestry Association's ProLogger Program annual continuing education modules, reaching an estimated 1,500 loggers annually. In 2010, a fourth BMP video on the topic of soil / site stabilization was produced and has been incorporated into the ProLogger annual education module for the 2010 / 2011 training year.

Also noted in the 2005 BMP survey report were the challenges of implementing BMPs in the Mountains, largely due to the steepness of slope and associated increased erosion hazard, as well as a higher drainage density (e.g., higher number of streams per unit area). The following actions were taken in an effort to address this issue:

- A color-illustrated pocket-sized BMP Field Guide (NCDFR, 2007) was produced in 2007 for use across North Carolina. While this field guide is not intended solely for use in the Mountains, an emphasis was placed on issues commonly encountered in steep terrain.
- Two BMP demonstration areas were developed in an effort to demonstrate the proper implementation of forestry BMPs. These demonstration areas are located at Rendezvous Mountain Educational State Forest (ESF) in Wilkes County and DuPont State Forest in Transylvania / Henderson counties. Additional BMP demonstrations were installed at Jordan Lake ESF in Chatham County, and are planned for Mountain Island ESF in Lincoln / Gaston counties.
- The 2006 skid trail BMP video was mailed to 150 loggers, sawmill operators, and timber procurement personnel across the Mountains.

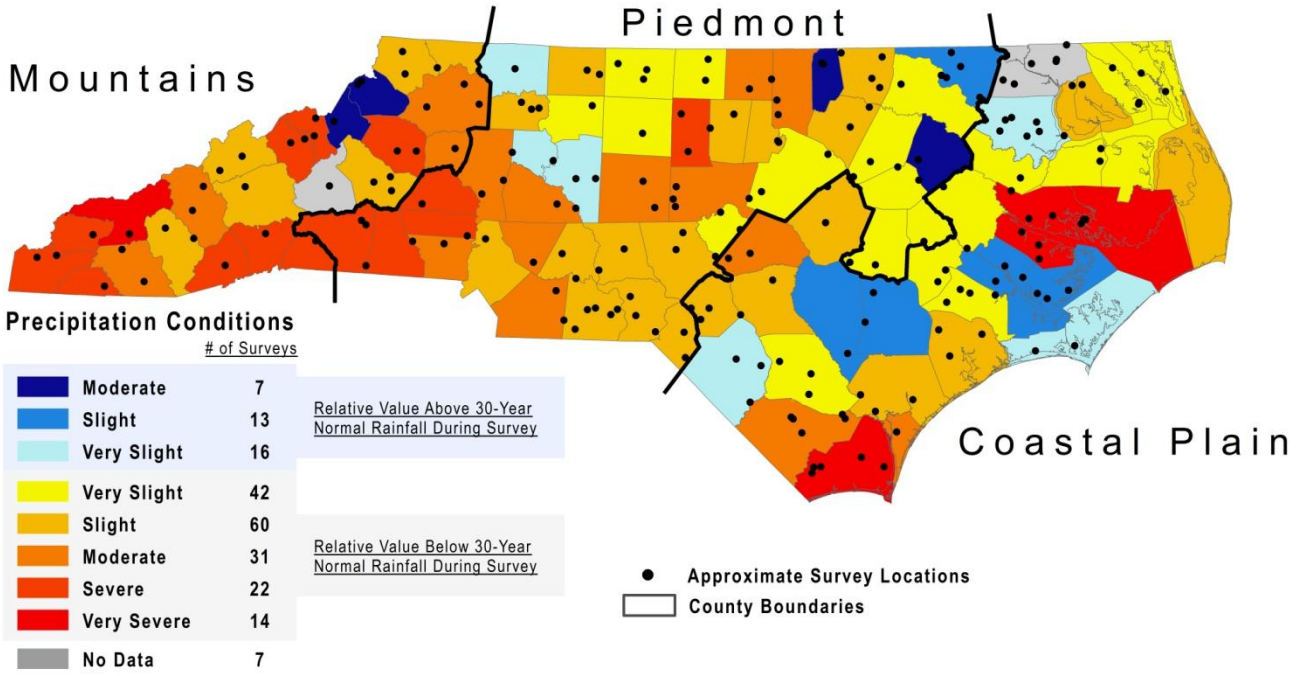
Stream crossings, debris entering streams, and streamside management zones (SMZs) were identified as BMP categories in need of improvement. The following actions were taken to address these topics:

- Additional bridgemats were obtained through grants awarded to the NCDFR. At this time, bridgemats are available for use statewide, with four NCDFR Districts having multiple sets of bridgemats to meet customer needs. A bridgemat project summary report was produced in 2009 and is available on the NCDFR publications webpage (NCDFR, 2009).
- An emphasis was made when training NCDFR personnel on identifying debris obstructions and taking appropriate administrative actions to resolve problems on a case-by-case basis. Preventing debris in the stream has also been emphasized during logger training workshops, including discussions of using bridgemats, harvesting in SMZs, and establishing stream crossings.
- The benefits, functions, and implementation of SMZs are described in the 2006 Forestry BMP Manual. A table of recommended SMZ widths was included to identify the multiple-use management options when establishing a SMZ.
- A new series of water quality Forestry Leaflets were produced that highlight state FPG regulations (NCDFR, 2007a), erosion and sediment control (NCDFR, 2007b), stream crossings (NCDFR, 2007c), and SMZs (NCDFR, 2007d).
- The N.C. BMP Effectiveness Monitoring Watershed Study was initiated to evaluate the effectiveness of forestry BMPs, including the Neuse River Riparian Buffer Rule as it applies to forest management operations.
- In 2005, three additional Water Quality Foresters were employed by the NCDFR, bringing the statewide total to 10. However, in 2009 one vacant Water Quality Forester position was eliminated due to the state's budgeting and financial constraints. As of December 2010, there were Water Quality Foresters in nine of NCDFR's 13 Districts, plus four water quality and nonpoint source support personnel based in the NCDFR central office (CO). The CO personnel provide water quality protection and NPS pollution prevention services on a statewide basis.

1.3 Precipitation Conditions During the Survey

The Survey was conducted during one of the state's most severe droughts on record. During this drought, numerous streams and waterbodies were observed at record low levels. Eighty percent of the Survey sites were located in a county that was cumulatively below normal rainfall during the Survey period (see below, Figure 2). These precipitation conditions and resulting low stream and waterbody levels are believed to have influenced the perceived risk to water quality on some sites.

Figure 2. Precipitation Conditions Above or Below 30-Year Normal for the Survey Period by County



During the drought, many streams that typically flow year round were without water. This H-flume is located on a perennial stream in the Piedmont of North Carolina and was installed to monitor streamflow and water quality as part of the NC BMP Effectiveness Monitoring Watershed Study (www.dfr.state.nc.us/water_quality/BMP_effectiveness_study.htm).

2.0 METHODS

2.1 Survey Procedure

The Survey was designed to assess practices found in NCDFR's 1989 BMP manual that were developed to play an integral role in conserving soil and protecting water quality during timber harvesting operations. While the Survey contained some BMPs that were under development during the BMP manual revision, the 2006 Forestry BMP manual (NCDFR, 2006) was not fully evaluated. The Survey generally follows the guidance developed by the Southern Group of State Foresters Water Resources Committee for conducting BMP implementation monitoring (Appendix A; SGSF, 2007). Survey questions were answered with a "Yes" response if a BMP was correctly implemented and a "No" response for failure or improper BMP implementation. Non-applicable BMPs received a "N/A" response. When assessing a risk to water quality, a "Yes" response was observed if any of the following were observed or expected to occur:

1) Sediment was delivered to stream / waterbody;
2) Sediment was likely to be delivered to stream / waterbody during a rainfall event ($\leq$ one inch over 24 hours);
3) Sediment was likely to be delivered to stream / waterbody via wind gusts;
4) Adverse stream / waterbody temperatures were a result of the harvest;
5) Logging debris and / or other logging byproducts were left in stream / waterbody;
6) Chemical or petroleum products had a high potential to reach the stream / waterbody.

A risk was interpreted to mean either a severe or potentially severe water quality problem. A "No" response for risk to water quality was selected if the implementation or non-implementation of the BMP posed no threat to water quality. The Survey form can be found on the Division's web site.

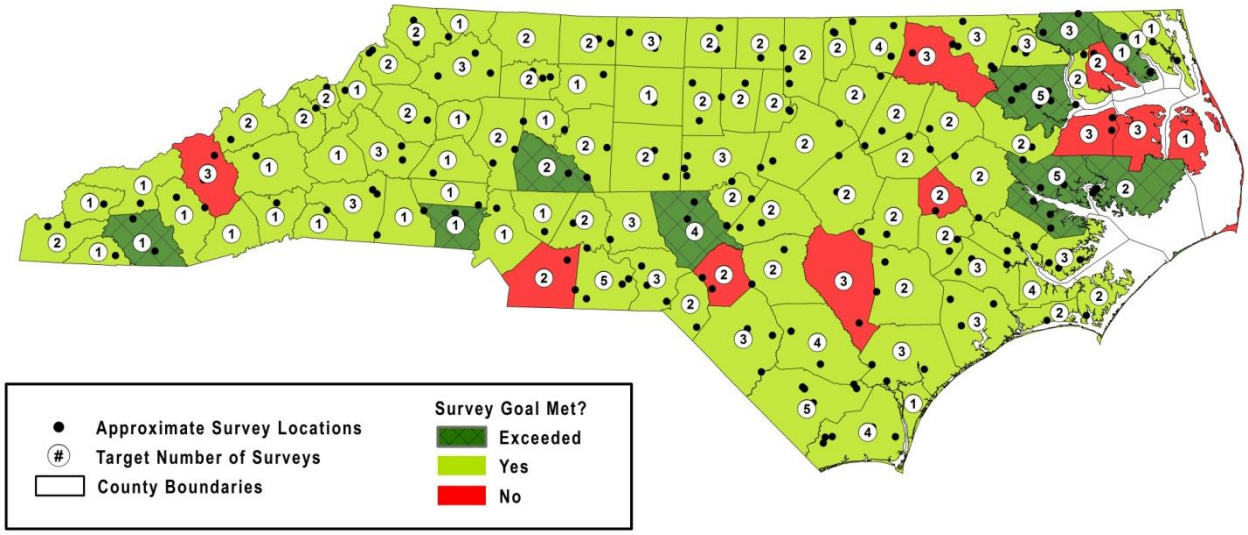
2.2 Survey Implementation

The Survey was only conducted on "active" harvest sites equal to or greater than five acres in size. Active was defined to be the ongoing operation of tree felling or transport / loading of equipment at the time the survey was conducted. Active also included preharvest activities such as forest road, access road, and skid trail construction and post-harvest site rehabilitation efforts. The sites had either intermittent or perennial streams and / or waterbodies located in the harvest or within 50 feet of the harvest operation boundaries.

Each county that had active forestry operations was targeted for a minimum of one survey. The remaining surveys were divided among the 100 counties based on the volume of timber cut as estimated by USDA Forest Service Forest Inventory and Analysis (FIA) data (Brown et al., 2006). The site selection procedure included a non-stratified method from the air and / or ground using the DeLorme® North Carolina Atlas and Gazetteer, Topo Maps of the Entire State (DeLorme®, 1999). The detailed Survey procedure can be found on the Division's web site.

Figure 3 on the next page illustrates the targeted number of surveys per county, the number of surveys completed, and the approximate survey locations.

Figure 3. Targeted Surveys by County, Number of Surveys Completed, and Approximate Survey Locations



2.3 Quality Assurance and Quality Control

Quality assurance and quality control (QAQC) measures were taken before, during, and after the Survey was complete. The detailed Survey procedure was provided to and discussed with all surveyors in advance of conducting surveys. Periodic random Survey audits were performed in the field by the project manager to evaluate surveyor consistency throughout the Survey period. Once all surveys were complete, random data entry audits were performed to ensure data entry accuracy. The data was entered and stored in a Microsoft Access® database. In advance of conducting final data analysis, numerous QAQC measures were taken to determine the consistency of field survey form data and the electronic database entries. All improperly completed survey form data was identified and filtered out of the data analyzed in this report. No assumptions were made about the surveyors intended response in the field.

2.4 Data Analysis and Summary

BMP implementation summary data was generated using the following formula:

$$\text{BMP Implementation Percent} = \frac{\text{Number of Implemented BMPs}}{\text{Number of Applicable BMPs}} * 100$$

This formula summarizes "observed" BMP implementation with no statistical adjustment. Information related to sample size and statistically significant confidence intervals for BMP implementation data can be found in Appendix B. In addition to BMP implementation percent, there were two BMP implementation scenarios with associated risk to water quality summarized throughout the report: 1) "Yes" the BMP was implemented and there was "No" risk to water quality observed, and 2) "No" the BMP was not properly implemented and "Yes" there was a risk to water quality. Scenario (1) documents how often a BMP successfully provided the intended water quality protection when it was implemented, and scenario (2) documents how often there was an observed risk to water quality when the BMP was not properly implemented. These three metrics are presented throughout the report as: "BMP Implementation," "Properly Implemented BMP and No Risk to Water Quality," and "Improperly Implemented BMP and Risk to Water Quality." Percentage data presented throughout this report was rounded up or down to the nearest percent using standard rounding conventions. As a result, percentages that should sum to 100 may vary based on rounding error.

General statements regarding increases or decreases in BMP implementation by region since the 2005 BMP survey report are stated in each BMP category section of this report. However, the increase or decrease was not statistically analyzed. An increase or decrease in BMP implementation percent of equal to or greater than five percent is denoted with an up or down arrow ($^{\uparrow\downarrow}$) in many tables. These trends are intended to provide a general indication of where BMP implementation has improved and where it has not since the 2005 BMP survey report. Detailed statistical analysis of trend data were not conducted due to small variations in survey procedure and protocol as well as small samples sizes for some specific BMPs at the regional scale.

3.0 SURVEY RESULTS

3.1 Overall BMP Implementation

Across the state there were 7,661 BMPs assessed, including 1,482 in the Mountains (19%), 3,515 in the Piedmont (46%), and 2,664 in the Coastal Plain (35%). There were 212 active harvest sites evaluated across the state with 36 located in the Mountains (17%), 93 in the Piedmont (44%), and 83 in the Coastal Plain (39%).

Overall BMP Implementation

Statewide BMP implementation was 85 percent. Implementation during this Survey increased slightly from the 2000-2003 survey period, which had an overall implementation rate of 82 percent. The Coastal Plain had the highest overall implementation (91%) followed by the Piedmont (88%) and Mountains (66%). When compared to the previous survey, implementation of BMPs decreased in the Mountains and increased in the Piedmont and Coastal Plain.

Key Findings – Overall BMP Implementation

- ✓ Overall BMP implementation was 85 percent statewide, 66 percent in the Mountains, 88 percent in the Piedmont, and 91 percent in the Coastal Plain (Table 1).
- ✓ When compared to the previous survey, implementation of BMPs decreased in the Mountains and increased in the Piedmont and Coastal Plain.
- ✓ On average statewide, when BMPs were properly implemented, there was no risk to water quality nearly 100 percent of the time. Conversely, when BMPs were not implemented, it resulted in a risk to water quality 54 percent of the time (Table 1).
- ✓ A risk to water quality was most frequently observed in all regions of the state when BMPs associated with the following categories were not implemented (Table 1):
  - Streamside Management Zones (SMZs)
  - Stream Crossings
  - Debris Entering Streams
  - Rehabilitation of the Project Site
  - Skid Trails
- ✓ BMPs for rehabilitation (rehab) of the project site and stream crossings had the lowest implementation in all regions of the state (Table 1).
- ✓ Implementation of BMPs for skid trails was notably lower in the Mountains (Table 1).
- ✓ On average statewide, BMPs for SMZs, stream crossings, debris entering stream, rehab, and skid trails represent 73 percent of the non-implemented BMPs and 94 percent of the risk to water quality (Table 2).

Best Management Practice Categories

There were nine categories of BMPs evaluated during this Survey. The ***key-letter/word(s)*** emphasized in each statement below correspond with the labels used in Table 1 (below) and Table 2 (next page).

Categories of Evaluated BMPs

- ***S***treamside ***M***anagement ***Z***one***s***
- ***Stream Crossings***
- ***Debris*** Enter***ing*** ***Streams***
- ***Waste*** Enter***ing*** Stream, ***Water*** Bodies or Groundwater
- Stream ***Temperature***
- ***Skid Trails***
- Access ***Road Entrances***
- ***Forest*** Access ***Roads***
- ***Rehabilitation*** of Project Site

Table 1 below summarizes regional BMP implementation by BMP category and the frequency of an implemented or non-implemented BMP to be associated with a risk to water quality. In addition, an increase or decrease in BMP implementation when compared to the 2005 BMP survey report of at least five percent (notable) is denoted with an up or down arrow ($^{\uparrow\downarrow}$). Data presented in Table 1 can be interpreted accurately using the following example sentences, while substituting text in *underlined italics* with the corresponding data for each region, percent, and BMP category:

- **BMP Implementation:** Implementation of BMPs for *SMZs* in the *Coastal Plain* was *94* percent, and represents a notable *increase* from the previous survey.
- **Properly Implemented BMP and NO RISK to Water Quality (WQ):** In addition, when BMPs for *SMZs* were properly implemented in the *Coastal Plain*, there was no risk to water quality *100* percent of the time.
- **Improperly Implemented BMP and RISK to Water Quality (WQ):** However, when BMPs for *SMZs* were not properly implemented in the *Coastal Plain*, a risk to water quality was observed *69* percent of the time.

Table 1. Overall Implementation of BMPs by BMP Category and Region

BMP Category	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
OVERALL	**85**	**66**	**88**	**91$^{\uparrow}$**	**100**	**98**	**100**	**100**	**54**	**70**	**30**	**61**
SMZs	91	70	96$^{\uparrow}$	94$^{\uparrow}$	100	99	100	100	78	86	62	69
Stream Crossings	72$^{\uparrow}$	52	77$^{\uparrow}$	78$^{\uparrow}$	98	93	99	100	75	87	57	84
Debris in Streams	86	77	87$^{\downarrow}$	89	100	100	100	100	72	77	51	93
Waste in Water	92	79$^{\downarrow}$	93	95	100	100	100	100	12	6	0	40
Temperature	90	71$^{\downarrow}$	96$^{\uparrow}$	92	100	100	100	100	28	22	0	50
Skid Trails	82$^{\uparrow}$	58	88$^{\uparrow}$	92$^{\uparrow}$	99	96	100	100	60	77	34	57
Road Entrances	89	90	84$^{\downarrow}$	93	100	99	100	100	4	23	0	3
Forest Roads	84	70	83	96$^{\uparrow}$	100	100	100	100	14	23	5	36
Rehabilitation	44	20$^{\downarrow}$	67$^{\uparrow}$	69$^{\uparrow}$	100	100	100	100	67	82	31	25
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

$^{\uparrow\downarrow}$Indicates a change in implementation of ± 5 percent compared to the previous survey report. Note: Numeric values as percents.

Table 2 below summarizes the percent of all non-implemented BMPs and the percent of all risks to water quality by BMP category and region. Data presented in Table 2 can be interpreted accurately using the following example sentences, while substituting text in *underlined italics* with the corresponding data for each region, percent, and BMP category:

- **Non-Implemented BMPs:** *Statewide*, *14* percent of all non-implemented BMPs were associated with the *SMZ* category. In the *Coastal Plain*, *16* percent of all non-implemented BMPs in the region were associated with the *SMZ* category.
- **Risk to Water Quality:** *Statewide*, *20* percent of all risks to water quality were associated with non-implementation of BMPs for *SMZs*. In the *Coastal Plain*, *18* percent of all risks to water quality were associated with non-implementation of BMPs for *SMZs*.

Table 2. Non-Implementation of BMPs and Risk to Water Quality by BMP Category and Region

BMP Category	Percent of ALL Non-Implemented BMPs				Percent of ALL Risk to Water Quality			
	S	M	P	C	S	M	P	C
SMZs	14	19	7	16	20	23	13	18
Stream Crossings	21	17	21	28	30	22	41	39
Debris in Stream	9	6	9	13	11	7	16	19
Waste in Water	4	3	4	4	1	0	0	3
Temperature	1	2	1	3	1	1	0	2
Skid Trails	23	28	21	15	26	31	24	14
Road Entrances	9	3	15	13	1	1	0	1
Forest Roads	13	12	19	5	3	4	3	3
Rehabilitation	6	10	3	3	7	11	3	1
TOTAL	100	100	100	100	100	100	100	100

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Numeric values as percents.

Discussion – Overall BMP Implementation

As illustrated in the BMP Implementation column of Table 1, out of a possible 27 total BMP implementation category combinations (nine BMP categories [x] three regional groups), there were 10 in which BMP implementation increased by five percent or more since the 2005 BMP survey report. Conversely, BMP implementation decreased by five percent or more for five of the BMP implementation category combinations. While the increase or decrease in BMP implementation was not statistically analyzed, it does provide a general indication of where BMP implementation has improved and where it has not since the previous survey. The BMP categories where implementation increased notably in more than one geographic area of the state – with no region notably decreasing – were SMZs, stream crossings, and skid trails. Most of the improvements occurred in the Piedmont or Coastal Plain, with a majority of the decreasing implementation trends occurring in the Mountains. This downward trend is concerning because the 2005 BMP survey report also indicated the challenges of implementing BMPs in the Mountains. While emphasis has been placed since the 2005 BMP survey report on certain BMP categories and within the Mountains, these data indicate a need for additional improvement.

The consistency with which BMPs can protect water quality is noteworthy, as illustrated by high values in the ***Properly Implemented BMP & NO RISK to WQ*** column found in many tables of this report. The benefits of BMP implementation for the protection of water quality during forestry operations has also been well documented in BMP implementation reports from other southeastern states as well as in scientific study (Edwards and Williard, 2010).

The information presented in Table 1 under the column ***Improperly Implemented BMP & RISK to WQ*** varies by BMP category and region. Higher percentages in this column indicate that a risk to water quality was more frequently observed when BMPs were not implemented. While a majority of these data indicate that surveyors often noted a risk to water quality when BMPs were not used (higher percentages in this column), there are several instances in which low (or no) risk to water quality was noted (lower percentages in this column). The low percentages are not easily explained. Many of these situations occurred in the Piedmont; as noted in Section 1.3 of this report, a large portion of central and western North Carolina was experiencing drought conditions during the Survey period. This could have influenced the perceived risk to water quality during a site evaluation. When BMPs were not used and there was no water in the nearby stream / waterbody, surveyors may have concluded that there was no risk to water quality. Some of the results presented in this report appear to have been influenced by this assumption. These data indicate that additional investigation and training may be warranted to define how to evaluate BMPs and potential water quality risk when there is not water in a stream / waterbody or when these hydrologic features are not in close proximity to the BMP being evaluated. Also, when zeros are present in this column, BMP implementation was high in many instances. The few occurrences in which the BMP was not implemented, a risk to water quality was not present. Therefore, many zeros are simply a factor of having a small number of non-implemented BMPs where no risk to water quality was observed. This does not necessarily indicate that implementation of these BMPs are less critical.

As indicated in Table 2, 94 percent of the risk to water quality was associated with non-implementation of BMPs for SMZs, stream crossings, debris entering streams, rehab, and skid trails. These data indicate that when BMPs associated with these five categories are not implemented, the risk to water quality is notably higher.

Key Findings – SMZs

- ✓ BMP implementation for SMZs was 91 percent statewide, 70 percent in the Mountains, 96 percent in the Piedmont, and 94 percent in the Coastal Plain (Figure 4).
- ✓ When BMPs for SMZs were properly implemented statewide, there was no risk to water quality nearly 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 78 percent of the time (Figure 4).
- ✓ When evaluating BMPs for SMZs during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 3):
  - Overall SMZ width was adequate to provide effective sediment protection to waterbodies (Statewide)
  - Roads or trails minimized in the SMZ (Statewide)
  - No visible sediment from operations traveling through the SMZ and entering stream (Statewide)
  - Skidders and other equipment use was minimized in SMZ (Mountains)
  - Machinery kept out of SMZ in areas where ephemeral streams intersect intermittent / perennial waters (Piedmont and Mountains)
  - Logging decks / sawmill sites located outside of SMZ (Mountains)
- ✓ The average width of all SMZs surveyed statewide that had no risk to water quality was 50 feet on perennial streams and 36 feet on intermittent streams (Table 4).
- ✓ On average statewide, a risk to water quality was observed on 56 percent of the surveyed SMZs that had a width less than or equal to 10 feet (Table 5).

3.2 Implementation of Specific Best Management Practices

Section 3.2.1

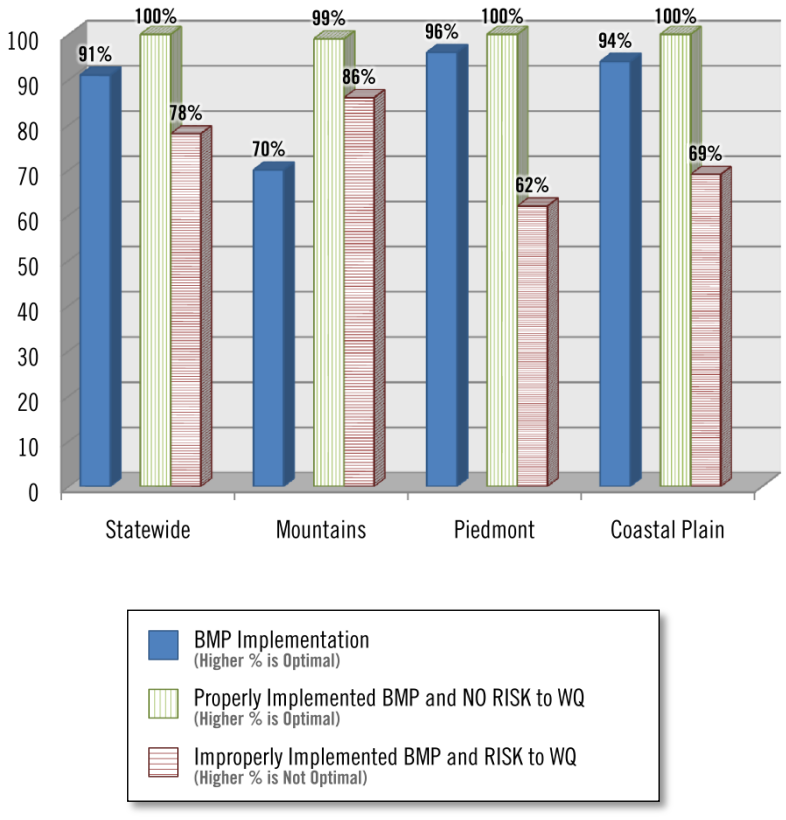
Streamside Management Zones

Across the state, there were 1,795 BMPs assessed for streamside management zones (SMZs), including 316 in the Mountains (17%), 801 in the Piedmont (45%), and 678 in the Coastal Plain (38%). Statewide, there were 517 SMZs surveyed on 204 sites. A majority of the SMZs evaluated were associated with 1st and 2nd order streams (88%). There were 273 surveyed SMZs located on perennial streams and 243 located on intermittent streams, with one SMZ undetermined. For this Survey, the definitions for perennial and intermittent streams follow those found in the *North Carolina Forest Practices Guidelines Related to Water Quality* (15A NCAC 01I .0102).

BMP Implementation

When applicable, 91 percent of the BMPs for SMZs were properly implemented statewide. The Piedmont had the highest implementation (96%) followed by the Coastal Plain (94%) and Mountains (70%) (Figure 4). When compared to the previous survey, implementation of BMPs for SMZs increased in all regions.

Figure 4. Implementation of BMPs for Streamside Management Zones by Region



Best Management Practices for Streamside Management Zones

Where applicable, the 10 BMPs listed below were evaluated to determine if BMPs for SMZs were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 3.

Evaluated BMPs for Streamside Management Zones

- Overall SMZ ***width*** was adequate to provide effective sediment protection to waterbodies.
- SMZ uniformly ***maintained*** along intermittent & perennial streams/waterbodies (i.e., without large gaps).
- ***Roads or trails*** minimized in SMZ.
- ***Trees*** were ***felled*** away from stream channel.
- Skidders and other ***equipment*** use was minimized in SMZ.
- Forest floor/***ground cover*** is adequately maintained - no more than 20 percent bare ground for perennial streams; 40 percent for intermittent streams.
- No visible ***sediment*** from operations traveling through the SMZ and entering stream.
- ***Machinery*** kept ***out*** of SMZ in areas where ephemeral streams intersect intermittent/perennial waters.
- Logging ***decks*** and/or sawmill sites located ***out***side of SMZ.
- When no other feasible option exists, logging ***decks*** and/or sawmill sites in SMZ $\geq$ ***10 feet*** from stream/waterbody.

Surveyors qualitatively evaluated all BMPs for SMZs (Table 3) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 3 as percentages.

Table 3. Implementation of BMPs for Streamside Management Zones by Region

BMPs for SMZs	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
OVERALL	**91**	**70**	**96↑**	**94↑**	**100**	**100**	**100**	**99**	**78**	**86**	**62**	**69**
Width	93	70	98	97	100	100	100	100	100	100	100	100
Maintained	87↑	58	94	90↑	100	100	100	100	74	86	60	63
Roads or Trails	95	79	98	99	99	96	100	100	100	100	100	100
Trees Felled	82	55	87	88	100	100	100	100	51	47	45	67
Equipment	92	74	96	95	100	100	100	100	88	100	67	75
Ground Cover	95↑	79↑	100↑	96↑	100	100	100	100	80	86	N/A*	67
Sediment	91	64	96	97	100	100	100	100	94	100	75	100
Machinery Out	90↑	72↑	99↑	88↑	100	100	100	100	75	88	100	57
Decks Out	94	74↓	99	96	100	100	100	100	85	100	0	67
Decks 10 Feet	85↓	75↓	100	100↑	97	93	100	100	80	80	N/A*	N/A*
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

SMZ Width

Average SMZ width was estimated in the field for each surveyed SMZ. Surveyors qualitatively evaluated all SMZ widths to determine if BMP recommendations were followed and whether there was a risk to water quality associated with the width of the SMZ. The average SMZ width in feet by stream type and risk to water quality is summarized in Table 4. These data include all sites where SMZs were evaluated, including sites with BMP implementation and sites without implemented BMPs.

Table 4. Average SMZ Width by Region and Stream Type – Risk or No Risk to Water Quality

Region	Perennial (Average Width)		Intermittent (Average Width)	
	NO RISK to WQ	RISK to WQ	NO RISK to WQ	RISK to WQ
Statewide	50 feet (241)	15 feet (32)	36 feet (229)	6 feet (14)
Mountains	61 feet (50)	18 feet (24)	33 feet (22)	3 feet (4)
Piedmont	45 feet (122)	5 feet (1)	29 feet (124)	7 feet (6)
Coastal Plain	50 feet (69)	3 feet (7)	48 feet (83)	8 feet (4)

(X) Represents the number of SMZs evaluated that were used to calculate the average SMZ width.

Table 5 summarizes the frequency at which a given SMZ width (grouped into SMZ width classes) posed a risk to water quality. Data presented in Table 5 can be interpreted accurately using the following example sentence, replacing the words in *underlined italics* with the corresponding values in Table 5: When an SMZ was between *0 – 10* feet, there was a risk to water quality on *56 percent* of the surveyed SMZs.

Table 5. SMZ Width That Posed a Risk to Water Quality by SMZ Width Class

SMZ Width Class	SMZs Surveyed (Count)	Risk to WQ (Count)	Frequency of Risk to WQ (Percent)
0 – 10 feet	57	32	56 %
11 – 30 feet	196	12	6 %
31 – 50 feet	169	2	1 %
> 50 feet	95	0	0 %

Trout Waters

Thirty-eight surveyed SMZs were located on streams classified as trout waters. When applicable, 66 percent of the BMPs for SMZs were correctly implemented along streams classified as trout waters. When BMPs for SMZs were properly implemented, there was no risk to water quality 96 percent of the time. Conversely, when these BMPs were not properly implemented, it resulted in a risk to water quality 77 percent of the time.

Public Water Supply Waters

One-hundred surveyed SMZs were located on streams classified as public water supply waters. When applicable, 91 percent of the BMPs for SMZs were correctly implemented along streams classified as public water supply waters. When BMPs for SMZs were properly implemented, there was no risk to water quality 99 percent of the time. Conversely, when these BMPs were not properly implemented, it resulted in a risk to water quality 22 percent of the time.

SMZ Stream Canopy Cover

The pre- and post-harvest percent stream canopy cover provided by each surveyed SMZ was estimated and placed into one of the following percent categories: 0-25, 26-50, 51-75, and 76-100. There was no reported loss in SMZ canopy cover on 72 percent of the surveyed sites. On 18 percent of the sites there was a 25 percent loss, eight percent of the sites there was a 50 percent loss, and two percent of the sites there was a 75 percent loss in stream canopy cover.

Discussion – SMZs

Streamside Management Zones, or SMZs, are frequently established (91 percent implementation statewide) on forest harvest sites in North Carolina to slow and filter runoff, capture sediment, provide shade, and maintain streambank stability. While the establishment of a SMZ is required on forestry sites in North Carolina along intermittent and perennial streams, the governing FPG standard (15A NCAC 01I .0201) provides the flexibility to determine the appropriate width of each SMZ. The BMPs for SMZs offer detailed recommendations regarding SMZ width and how to conduct forestry operations with minimal impact on water quality. The large scale evaluation of SMZ widths on active logging sites during this Survey is possibly the first instance of such an assessment in North Carolina. Data presented in Tables 4 and 5 indicate that a SMZ width greater than 10 feet notably reduces the risk to water quality when compared to SMZ widths of less than 10 feet. Also, the average width of all SMZs surveyed statewide that had no risk to water quality was 50 feet on perennial streams and 36 feet on intermittent streams. These data indicate that on average statewide, SMZ widths that ranged from 30 to 50 feet were sufficient to prevent risk to water quality on a majority of Survey sites. However, non-implementation of applicable BMPs upslope of the SMZ may require widths in excess of this range to ameliorate potential harvest site characteristics (e.g., soil erosion hazard) and future activities associated with site preparation or other forestry operations. While risk to water quality was notably higher for SMZ widths less than 10 feet and lower for widths greater than 30 feet, further investigation is needed to determine at what distance between 10 and 30 feet risk is notably reduced.

The difference between average perennial and intermittent SMZ width, where no risk to water quality was observed (50 feet and 36 feet, respectively), could be attributed to a number of factors. Generally, forestry practitioners establish wider SMZs on larger streams that have water in the channel, and narrower SMZs on smaller streams that do not have water. This could explain why perennial streams received larger SMZs on average, given that they generally have larger channels and flow more consistently throughout the year than intermittent streams. In addition, the FPGs require that shade be provided for natural perennial streams (15A NCAC 01I .0208). This could also have influenced the larger average SMZ widths on perennial streams.

Some BMPs for SMZs were consistently implemented at a high rate, but frequently resulted in a risk to water quality when not properly implemented, such as SMZ ***width***, keeping visible ***sediment*** out of the SMZ, and minimizing ***roads or trails*** in the SMZ. Conversely, the BMP recommending that ***trees*** be ***felled*** away from the stream channel infrequently resulted in a risk to water quality when not implemented.

Aerial photograph illustrating properly implemented BMPs for SMZ width along streams in the Piedmont of North Carolina.

Key Findings – Stream Crossings

- ✓ BMP implementation for stream crossings was 72 percent statewide, 52 percent in the Mountains, 77 percent in the Piedmont, and 78 percent in the Coastal Plain (Figure 5).
- ✓ When BMPs for stream crossings were properly implemented statewide, there was no risk to water quality 98 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 75 percent of the time (Figure 5).
- ✓ When evaluating BMPs for stream crossings during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 6):
  - Stream crossings do not impede or obstruct streamflow (Statewide)
  - Debris and soil movement into stream channel at crossing is minimized or prevented (Statewide)
  - Road surfaces and cut banks (all bare soil) within SMZ stabilized as soon as is practical using effective measures (gravel, mulch, seed, etc.) (Coastal Plain and Mountains)
  - Stream crossing approachways have water control devices to minimize erosion and control runoff (turnouts, sediment pits, check dams, etc.) (Mountains)
  - Stream channel use as access road or skid trail avoided (Coastal Plain and Piedmont)
  - When temporary stream crossings are removed, the stream channel is cleared of debris and banks and approachways are properly stabilized (Coastal Plain and Mountains)
- ✓ Of all crossing types, installation or use of bridgemats had the fewest observed risks to water quality when compared to the number of times assessed (Table 7).

Section 3.2.2

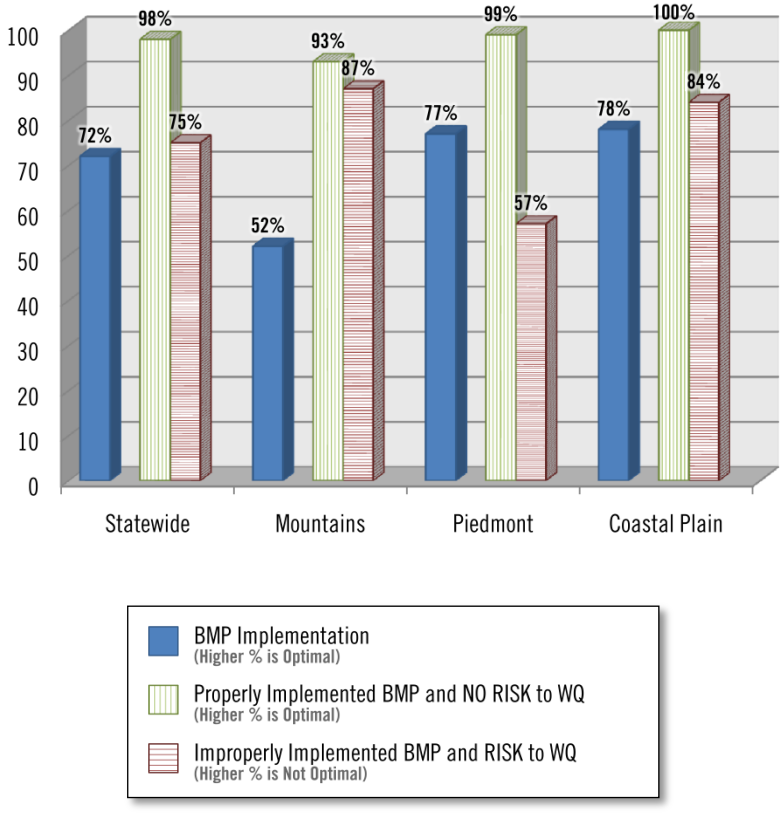
Stream Crossings

Across the state, there were 886 BMPs assessed for stream crossings, including 183 in the Mountains (21%), 404 in the Piedmont (45%), and 299 in the Coastal Plain (34%). The assessed BMPs for stream crossings were located on 128 sites statewide, including 28 in the Mountains, 55 in the Piedmont, and 45 in the Coastal Plain. There were 15 sites with permanent crossings, 92 sites with temporary crossings, and 21 sites with both permanent and temporary crossings. A majority of the stream crossings were wood or steel bridgemats (34%), followed by culverts (29%), pole crossings (23%), fords (11%), and other (3%).

BMP Implementation

When applicable, 72 percent of the BMPs for stream crossings were properly implemented statewide. The Coastal Plain had the highest implementation (78%) followed by the Piedmont (77%) and Mountains (52%) (Figure 5). When compared to the previous survey, implementation of BMPs for stream crossings increased in all regions.

Figure 5. Implementation of BMPs for Stream Crossings by Region



Best Management Practices for Stream Crossings

Where applicable, the seven BMPs listed below were evaluated to determine if BMPs for stream crossings were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 6.

Evaluated BMPs for Stream Crossings

- Roads or trails intersect stream and SMZ at as close to a ***right angle*** as possible.
- Road surfaces and cut banks (all bare soil) within SMZ ***stabilized*** as soon as is practical using effective measures (gravel, mulch, seed, etc.).
- Stream crossing approachways have ***water control*** devices to minimize erosion and control runoff (turnouts, sediment pits, check dams, etc).
- Stream ***channel*** use as access road or skid trail ***avoided***.
- Stream crossings do not impede or ***obstruct stream*** flow.
- Debris and ***soil*** movement into stream channel at crossing is ***minimized*** or prevented.
- When temporary stream crossings are removed, the stream channel is ***cleared*** of ***debris*** and banks and approachways are properly stabilized.
- Specific recommendations for stream ***crossing type*** followed.

Surveyors qualitatively evaluated all BMPs for stream crossings (Table 6) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 6 as percentages.

Table 6. Implementation of BMPs for Stream Crossings by Region

BMPs for Stream Crossings	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**72↑**	**52**	**77↑**	**78↑**	**98**	**93**	**99**	**100**	**75**	**87**	**57**	**84**
Right Angle	99↑	96	100	100↑	93	71	96	100	0	0	N/A*	N/A*
Stabilized	51	21↓	58	65	100	100	100	100	70	89	40	91
Water Control	39↓	23↓	45↓	43↓	98	100	96	100	62	95	39	59
Channel Avoided	97	92	98	98	100	100	100	100	75	50	100	100
Obstruct Stream	80↑	87↑	81	75↑	100	100	100	100	88	100	80	91
Soil Minimized	63	25	74	71	100	100	100	100	87	94	79	85
Cleared Debris	72	33	74	75	100	100	100	100	71	100	43	100
Crossing Type	69	31	82	79	99	100	100	99	83	43	95	100
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

Stream Crossing Type

Surveyors qualitatively evaluated 136 stream crossing installations to determine if BMP recommendations were followed and whether there was a risk to water quality associated with the type of stream crossing installed (some sites had multiple crossings). Table 7 summarizes the frequency at which a given stream crossing type posed a risk to water quality. Data presented in Table 7 can be interpreted accurately using the following example sentence, replacing the words in *underlined italics* with the corresponding values in the table: When BMPs for *bridgemat* stream crossings were not properly implemented, there was a risk to water quality *9 percent* of the time.

Table 7. Stream Crossing Types That Posed a Risk to Water Quality

Stream Crossing Type	Stream Crossings Surveyed (Count)	Risk to WQ (Count)	Frequency of Risk to WQ (Percent)
Bridgemat	46	4	9 %
Culvert	39	19	49 %
Pole Crossing	31	7	23 %
Ford	15	4	27 %
Other*	5	2	40 %
*Other stream crossings surveyed included a barge, concrete pillar, construction I-beam, and logging debris.			

Discussion – Stream Crossings

Implementation of BMPs for stream crossings increased in all regions of the state by five percent or more when compared to the previous survey. However, implementation of stream crossing BMPs was lower on average when compared to other BMP categories, and non-implementation frequently resulted in a risk to water quality. While implementation of BMPs for stream crossings has increased on average across the state, there is still room for improvement. This is particularly true for the BMPs recommending that 1) stream crossing approachways have ***water control*** devices to minimize erosion and 2) road surfaces and cut banks within the SMZ are ***stabilized*** as soon as practical. Implementation of these two BMPs decreased notably in the Mountains region, where non-implementation frequently resulted in a risk to water quality. As expected, a risk to water quality was frequently observed when use of the stream ***channel*** as an access road or skid trail was not ***avoided*** and when specific recommendations for a given stream ***crossing type*** were not used. When these BMPs were not implemented in the Mountains, however, a risk to water quality was less frequently observed. This could have been related to how surveyors perceived a risk to water quality in dry stream channels. Guidance and methodology on how to access risk to water quality in dry stream channels will be incorporated into future surveys.

Of the four most commonly used stream crossing types (bridgemat, culvert, pole crossing, and ford), installation or use of bridgemats had the fewest observed risks to water quality when compared to the number of times they were assessed. Conversely, improper or lack of BMP implementation on culvert crossings resulted in a risk to water quality nearly half the time. The components associated with installing culverts that led to relatively high risk to water quality were not assessed with this Survey. Future surveys will more closely assess individual aspects of different stream crossing alternatives in an attempt to identify the specific components that pose the greatest risk to water quality.

These data indicate there are challenges to implementing stream crossing BMPs and non-implementation is frequently a water quality stressor. Therefore, avoiding stream crossings on harvest sites when feasible will provide notable water quality protection. However, when installation of stream crossings is unavoidable, the use of bridgemats would seem to provide the greatest water quality protection when compared to other crossing alternatives. The NCDFR has provided bridgemats on loan to loggers for establishing temporary crossings since the mid-1990's. These bridgemats are intended to serve as a demonstration tool for loggers to observe and experience the operational and environmental benefits of using bridgemats. Survey data generally validates the usefulness of NCDFR's bridgemat loan program.

Section 3.2.3

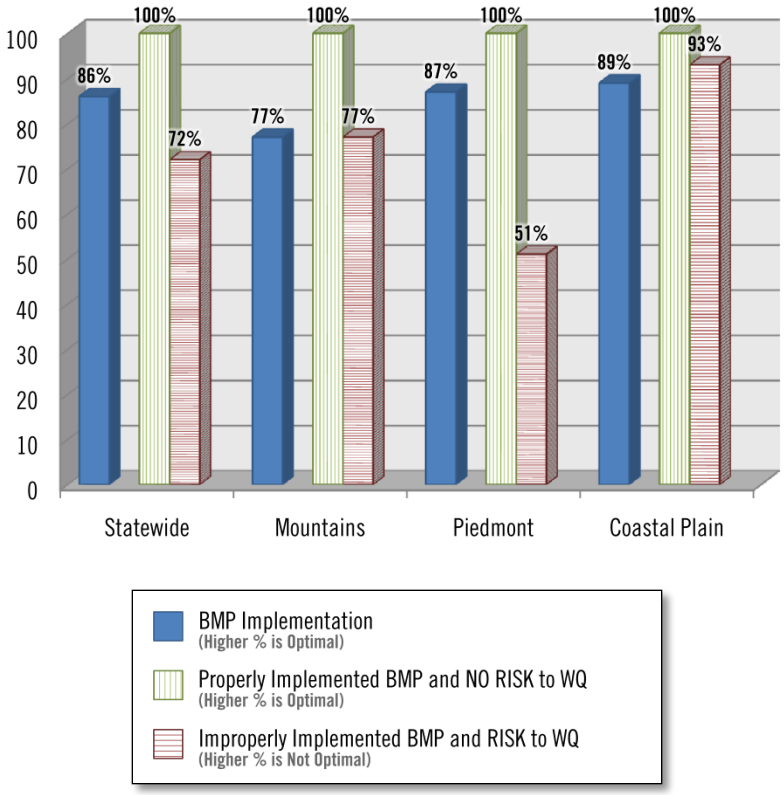
Debris Entering Stream

Across the state, there were 724 BMPs assessed for debris entering the stream, including 137 in the Mountains (19%), 319 in the Piedmont (44%), and 268 in the Coastal Plain (37%). The assessed BMPs for debris entering streams were located on 186 sites statewide, with 35 in the Mountains, 83 in the Piedmont, and 68 in the Coastal Plain.

BMP Implementation

When applicable, 86 percent of the BMPs for debris entering streams were properly implemented statewide. The Coastal Plain had the highest implementation (89%) followed by the Piedmont (87%) and Mountains (77%) (Figure 6). When compared to the previous survey, implementation of BMPs for debris entering the stream decreased in all regions.

Figure 6. Implementation of BMPs for Debris Entering Streams by Region



Key Findings – Debris Entering Streams

- ✓ BMP implementation for debris entering streams was 86 percent statewide, 77 percent in the Mountains, 87 percent in the Piedmont, and 89 percent in the Coastal Plain (Figure 6).
- ✓ When BMPs for debris entering streams were properly implemented statewide, there was no risk to water quality 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 72 percent of the time (Figure 6).
- ✓ When evaluating BMPs for debris entering streams during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 8):
  - Stream obstructions or impairment from soil / sediment from forestry operation(s) nonexistent (Statewide)
  - Stream obstructions or impairment from logging debris from forestry operation(s) nonexistent (Statewide)
  - Logging and site preparation debris kept out of stream channels or when introduced is removed promptly (Coastal Plain and Mountains)
  - Stream channel / course has not been altered by obstruction(s) (Coastal Plain and Mountains)

This picture illustrates non-implemented BMPs for debris entering streams. The stream is severely obstructed by tree tops and limbs.

Best Management Practices for Debris Entering Streams

Where applicable, the four BMPs listed below were evaluated to determine if BMPs for debris entering streams were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 8.

Evaluated BMPs for Debris Entering Streams

- Logging and site preparation ***debris kept out*** of stream channels or when introduced is removed promptly.
- ***Stream*** channel / course has ***not*** been ***altered*** by obstruction(s).
- Stream obstructions or impairment from ***soil*** / sediment from forestry operation(s) ***none***xistent.
- Stream obstructions or impairment from logging ***debris*** from forestry operation(s) ***none***xistent.

Surveyors qualitatively evaluated all BMPs for debris entering streams (Table 8) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 8 as percentages.

Table 8. Implementation of BMPs for Debris Entering Streams by Region

BMPs for Debris Entering Streams	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**86**	**77**	**87↓**	**89**	**100**	**100**	**100**	**100**	**72**	**77**	**51**	**93**
Debris Kept Out	82↑	74	80	88↑	100	100	100	100	55	67	31	88
Stream Not Altered	95	88↓	94	99	100	100	100	100	56	75	25	100
Soil None	86↓	71↓	92↓	87↓	100	100	100	100	92	90	86	100
Debris None	81	76	83	82	100	100	100	100	76	75	64	92
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report. Note: Numeric values as percents.

Discussion – Debris Entering Streams

While implementation of BMPs for debris entering streams was on average relatively high, implementation during this Survey period decreased from the previous survey in all regions of the state, with a five or more percent decrease in the Piedmont region. When BMPs for debris entering streams were properly implemented, there was a high degree of water quality protection in all regions of the state. Conversely, non-implementation often resulted in a risk to water quality. However, risk to water quality was unusually low when BMPs related to keeping ***debris out*** of the stream and ***not alter***ing the stream course were not implemented in the Piedmont. As stated previously, drought conditions during the Survey may have influenced how surveyors perceived risk to water quality on dry stream channels when BMPs were not implemented.

Implementation of the BMP recommending that stream obstructions from ***soil*** / sediment be prevented from entering the stream decreased by five or more percent in all regions of the state. Non-implementation of this BMP is likely related to relatively low implementation of the stream crossing BMP recommending that debris and ***soil*** movement into the stream channel be ***minimized*** or prevented at the crossing location. According to routine FPG program inspections throughout the state, many instances which produce debris in the stream occur in association with stream crossings. Future BMP surveys may require better methods of identifying the operational source of debris entering streams in order to maintain a high level of implementation of these BMPs.

Section 3.2.4

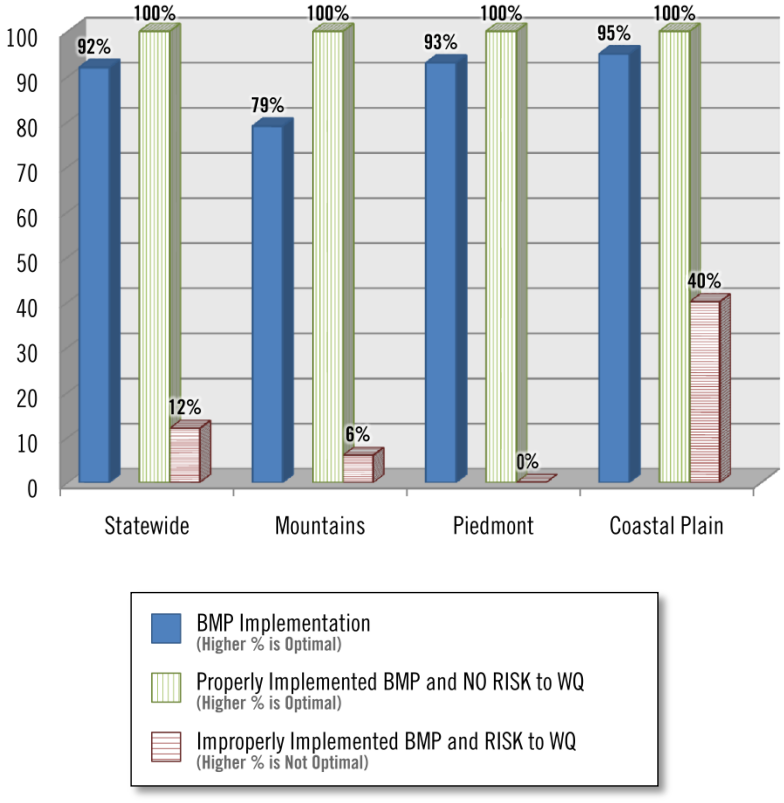
Waste Entering Water

Across the state, there were 515 BMPs assessed for waste entering streams, water bodies or ground water (waste entering water), including 82 in the Mountains (16%), 231 in the Piedmont (45%), and 202 in the Coastal Plain (39%). The assessed BMPs for waste entering water were located on 180 sites statewide, with 27 in the Mountains, 82 in the Piedmont, and 71 in the Coastal Plain.

BMP Implementation

When applicable, 92 percent of the BMPs for waste entering water were properly implemented statewide. The Coastal Plain had the highest implementation (95%) followed by the Piedmont (93%) and Mountains (79%) (Figure 7). When compared to the previous survey, implementation of BMPs for waste entering water did not change for the statewide average, decreased for the Mountains and Piedmont, and increased in the Coastal Plain.

Figure 7. Implementation of BMPs for Waste Entering Water by Region



Key Findings – Waste Entering Water

- ✓ BMP implementation for waste entering water was 92 percent statewide, 79 percent in the Mountains, 93 percent in the Piedmont, and 95 percent in the Coastal Plain (Figure 7).
- ✓ When BMPs for waste entering water were properly implemented statewide, there was no risk to water quality 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 12 percent of the time (Figure 7).
- ✓ When evaluating BMPs for waste entering water during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 9):
  - Equipment servicing was done in a way that avoids fluid leakage or spills (Coastal Plain)
  - All petroleum and chemical containers were removed from logging site (Coastal Plain)
  - Chemical and fuel loading and storage was conducted outside of SMZ (Mountains)

This picture illustrates well implemented BMPs for preventing waste from entering water. Equipment fluid is stored outside the SMZ and off the ground.

Best Management Practices for Waste Entering Water

Where applicable, the four BMPs listed below were evaluated to determine if BMPs for waste entering water were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 9.

Evaluated BMPs for Waste Entering Water

- Equipment ***servicing*** was done in a way that avoids fluid leakage or spills.
- Forest ***chemical***s (herbicide or fertilizer) appear to be stored and applied in a way that avoids fluid ***leak***age or spills.
- All petroleum and chemical ***containers*** were ***remove***d from logging site.
- Chemical and ***fuel*** loading and storage was conducted ***outside*** of ***SMZ***.

Surveyors qualitatively evaluated all BMPs for waste entering water (Table 9) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 9 as percentages.

Table 9. Implementation of BMPs for Waste Entering Water by Region

BMPs for Waste Entering Water	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**92**	**79↓**	**93**	**95**	**100**	**100**	**100**	**100**	**12**	**6**	**0**	**40**
Servicing	98	100	99	96	100	100	100	100	25	N/A*	0	33
Chemical Leak	94↓	100	83↓	100	100	100	100	100	0	N/A*	0	N/A*
Containers Remove	79	58↓	79↓	89↑	100	100	100	100	10	0	0	60
Fuel Outside SMZ	95	77↓	100	97	100	100	100	100	13	17	N/A*	0
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

Discussion – Waste Entering Water

Keeping waste and equipment fluids out of a stream can be accomplished in many ways. The most obvious method is to conduct equipment ***servicing***, maintenance, and re-fueling in a manner that avoids spillage or depositing of fluids or waste material. The BMP related to this aspect of waste and fluid management was consistently implemented with high frequency across all regions. However, once the work is completed, the need to ***remove containers*** from the site is important to assure no subsequent leakage or spillage; implementing this BMP proved challenging on Survey sites in the Mountains region (58%).

Low values in the ***Improperly Implemented BMP and Risk to WQ*** column of Table 9 are more frequent than expected. Three possible explanations are: 1) assessed streams / waterbodies were without water at the time of the Survey and a risk to water quality due to non-implementation was not observed, 2) indicators of a possible risk to water quality from fluids or waste were not easily observable at the time the Survey was conducted onsite, and 3) potential spilled fluids were not in close proximity to a stream / waterbody and did not qualify as a risk to water quality based on the methods used in this Survey (Section 2.1). Future BMP surveys may require better indicators of waste entering water in order to accurately assess risk to water quality due to non-implementation of these BMPs.

Section 3.2.5

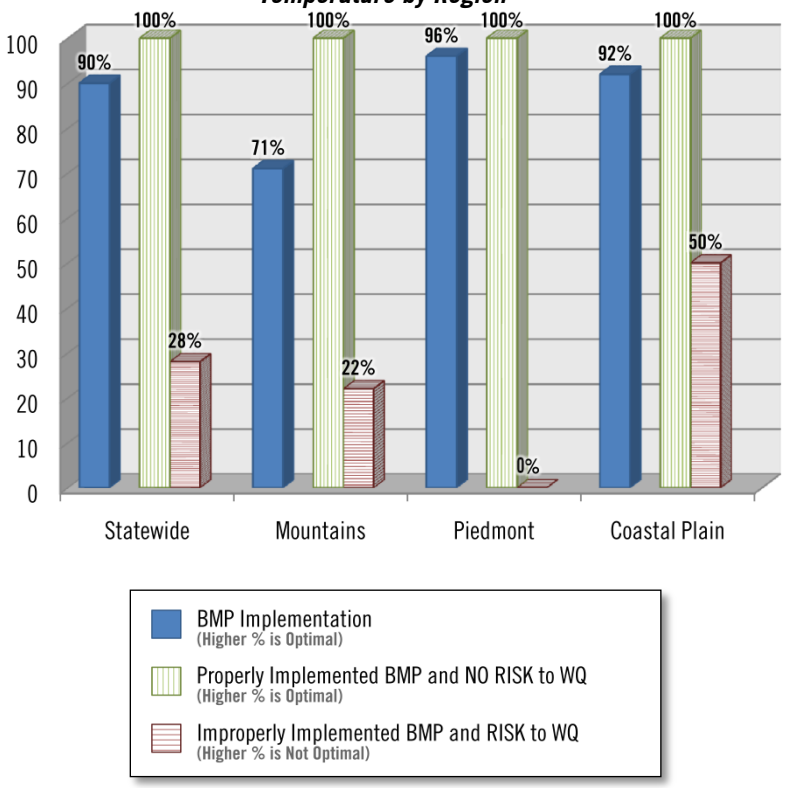
Stream Temperature

Across the state, the one BMP for stream temperature was assessed on 184 sites, including 31 in the Mountains (17%), 82 in the Piedmont (44%), and 71 in the Coastal Plain (39%).

BMP Implementation

When applicable, the one BMP for stream temperature was properly implemented 90 percent of the time statewide. The Piedmont had the highest implementation (96%) followed by the Coastal Plain (92%) and Mountains (71%) (Figure 8). When compared to the previous survey, implementation of the BMP for stream temperature increased in all regions, with the exception of the Mountains, where it decreased.

Figure 8. Implementation of the BMP for Stream Temperature by Region



Key Findings – Stream Temperature

- ✓ BMP implementation for stream temperature was 90 percent statewide, 71 percent in the Mountains, 96 percent in the Piedmont, and 92 percent in the Coastal Plain (Figure 8).
- ✓ When the BMP for stream temperature was properly implemented statewide, there was no risk to water quality 100 percent of the time. Conversely, when the BMP was not implemented, it resulted in a risk to water quality 28 percent of the time (Figure 8).
- ✓ When evaluating the BMP for stream temperature, a risk to water quality was most frequently observed when the BMP was not implemented in the Coastal Plain followed by the Mountains and Piedmont (Table 10).
- ✓ As discussed in Section 3.2.1 of this report, only 10 percent of the surveyed SMZs were observed to have lost more than 25 percent stream canopy cover (shade) as a result of the timber harvest.

This SMZ in the Piedmont of North Carolina provides adequate shade to the stream, preventing adverse stream temperature fluctuations.

Best Management Practices for Stream Temperature

Where applicable, the BMP listed below was evaluated to determine if the BMP for stream temperature was implemented. The ***keyword(s)*** emphasized in the statement below corresponds with the label used in Table 10.

Evaluated BMP for Stream Temperature

- ***Adequate shade*** (≥ 75 percent pre-harvest shade) maintained on the stream channel to protect perennial / intermittent streams from adverse temperature fluctuations.

Surveyors qualitatively evaluated the BMP for stream temperature (Table 10) to determine if the BMP recommendation was followed and whether there was a risk to water quality. The Survey results are summarized in Table 10 as percentages.

Table 10. Implementation of the BMP for Stream Temperature by Region

BMP for Stream Temperature	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Adequate Shade*	90	71↓	96↑	92	100	100	100	100	28	22	0	50
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*Also represents "Overall" values.

Note: Numeric values as percents.

BMP for Stream Temperature and Trout Waters

Data was collected on the BMP for stream temperature at 10 of the 38 SMZs located on streams classified as trout waters and was properly implemented eight times (80%). There were no observed risks to water quality associated with implementation or non-implementation of the BMP for stream temperature on trout waters.

Discussion – Stream Temperature

Implementation of the single BMP related to stream temperature was at or above 90 percent on Survey sites, with the exception of those sites in the Mountains region (71%). As noted in Section 3.2.1 of this report, only 10 percent of all SMZ's evaluated in this Survey were observed to have lost more than 25 percent of pre-harvest canopy cover as a result of the timber harvest.

Risk to water quality when the stream temperature BMP was not implemented was relatively low in comparison to other BMP categories, which may indicate that the BMP recommendation of maintaining greater than or equal to 75 percent pre-harvest shade is more than necessary. The current 2006 Forestry BMP Manual (to be assessed in future Surveys) has the following SMZ shade recommendation:

> "Maintain approximately half of the pre-harvest vegetation canopy cover within the SMZ in order to provide adequate shade" (NCDFR, 2006; page 45).

The results of this Survey appear to substantiate the BMP for stream temperature found in the 2006 Forestry BMP Manual.

Section 3.2.6

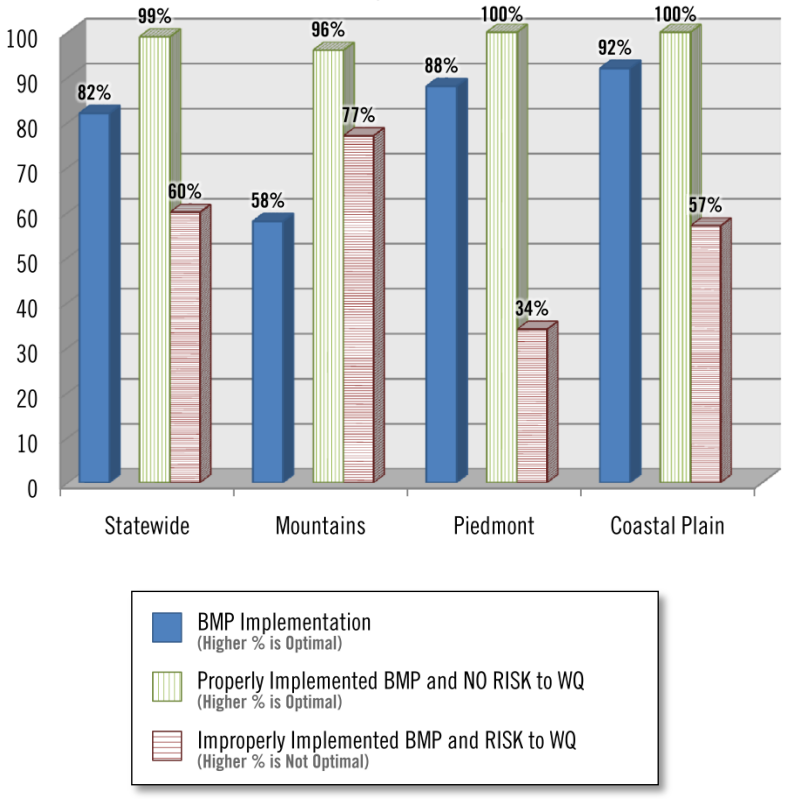
Skid Trails

Across the state, there were 1515 BMPs assessed for skid trails, including 335 in the Mountains (22%), 738 in the Piedmont (49%), and 442 in the Coastal Plain (29%). The assessed BMPs for skid trails were located on 205 sites statewide, with 36 in the Mountains, 88 in the Piedmont, and 81 in the Coastal Plain.

BMP Implementation

When applicable, 82 percent of the BMPs for skid trails were properly implemented statewide. The Coastal Plain had the highest implementation (92%) followed by the Piedmont (88%) and Mountains (58%) (Figure 9). When compared to the previous survey, implementation of BMPs for skid trails increased in all regions.

Figure 9. Implementation of BMPs for Skid Trails by Region



Key Findings – Skid Trails

- ✓ BMP implementation for skid trails was 82 percent statewide, 58 percent in the Mountains, 88 percent in the Piedmont, and 92 percent in the Coastal Plain (Figure 9).
- ✓ When BMPs for skid trails were properly implemented statewide, there was no risk to water quality 99 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 60 percent of the time (Figure 9).
- ✓ When evaluating BMPs for skid trails during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 11):
  - Skidder traffic concentrated on primary trails that are laid out in a way that minimizes site impact (Piedmont and Mountains)
  - Skid trails are located outside of SMZ, except at stream crossings (Coastal Plain and Mountains)
  - Skid trails do not follow along the natural drainageway of a dry hollow (Mountains)
  - Excessive "rutting" was avoided (Mountains)
  - Long steep grades avoided where possible (Piedmont and Mountains)
  - Water bars / water diversions constructed where needed (Coastal Plain and Mountains)
  - Logging slash and debris placed on bare ground to prevent erosion (Coastal Plain)
  - Skid trails follow contours when possible (Mountains)
  - "Closed" skid trails protected by adequate waterbars or brush piles (Mountains)

Best Management Practices for Skid Trails

Where applicable, the 10 BMPs listed below were evaluated to determine if BMPs for skid trails were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 11.

Evaluated BMPs for Skid Trails

- Skidder ***traffic*** concentrated on primary trails that are laid out in a way that ***minimize***s site impact.
- Skid trails are located ***outside*** of ***SMZ*** (except at stream crossings).
- Skid trails do ***not*** follow ***along*** the natural ***drainage***way of a dry hollow.
- Excessive "***rutting***" was ***avoided***.
- Long ***steep grade***s ***avoid***ed where possible.
- ***Water bars*** / water diversions constructed where needed.
- Logging slash and debris placed on bare ground to ***prevent erosion***.
- Skid trails ***follow contours*** when possible.
- Skid trails do ***not*** exceed ***grade***s of ***25*** percent.
- "Closed" ***skid trails protect***ed by adequate waterbars or brush piles.

Surveyors qualitatively evaluated all BMPs for skid trails (Table 11) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 11 as percentages.

Table 11. Implementation of BMPs for Skid Trails by Region

BMPs for Skid Trails	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**82↑**	**58**	**88↑**	**92↑**	**99**	**100**	**100**	**96**	**60**	**77**	**34**	**57**
Traffic Minimize	95↑	82↑	99↑	96↑	99	93	100	100	70	100	100	0
Outside SMZ	94	77	98	99↑	99	93	100	100	82	88	50	100
Not Along Drainage	92	68	99	100	100	100	100	100	83	91	0	N/A*
Rutting Avoided	90↑	82↑	93↑	89↑	100	100	100	100	57	100	33	44
Steep Grade Avoid	90	82	92	100	100	100	100	100	83	100	67	N/A*
Water Bars	44	32	57↑	13↓	93	82	97	100	56	78	23	86
Prevent Erosion	74↑	18	81↑	91↑	100	100	100	100	50	59	25	71
Follow Contours	87	85↑	85↓	100↑	99	97	100	100	59	100	42	N/A*
Not Grade 25	61↓	22↓	80↓	77↓	100	100	100	100	53	57	42	67
Skid Trails Protect	63↑	19↓	69	87↑	100	100	100	100	64	86	33	40
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

Discussion – Skid Trails

Implementation of BMPs for skid trails and risk to water quality due to non-implementation ranges widely across regions and with respect to individual BMPs. Overall, implementation remained relatively high in the Piedmont and Coastal Plain, increasing by at least five percent since the previous survey. However, implementation of BMPs for skid trails remains a challenge in the Mountains. Skid trail BMPs recommending that ***traffic*** be ***minimized*** and ***rutting avoided*** increased in all regions of the state. However, similar to stream crossing approachways, implementation of the BMP recommending the use of ***water bars*** / water diversions on skid trails was relatively low. The use of water bars or similar measures to control surface runoff is fundamental to preventing accelerated erosion and sedimentation into streams, particularly in high traffic areas such as skid trails, stream crossing approachways, and forest access roads.

Despite training and information outreach efforts (e.g., "BMPs for Logging Skid Trails" training video), Survey data indicate that continued improvements are needed for the implementation of skid trail BMPs. This is particularly true in the Piedmont and Mountains where soil type and increased slope often result in higher soil erosion potential.

Applicable BMPs for skid trails are well implemented in this picture. Logging slash is matted as the skid trail slopes down toward a stream crossing; providing sufficient ground cover to prevent runoff, erosion, and sedimentation.

Applicable BMPs for skid trails are not implemented in this picture. The skid trail is deeply rutted and located next to a stream. Erosion and sedimentation are expected. Rehabilitation will be more difficult and costly than if BMPs had been implemented from the beginning.

Key Findings – Access Road Entrances

- ✓ BMP implementation for access road entrances was 89 percent statewide, 90 percent in the Mountains, 84 percent in the Piedmont, and 93 percent in the Coastal Plain (Figure 10).
- ✓ When BMPs for access road entrances were properly implemented statewide, there was no risk to water quality nearly 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 4 percent of the time (Figure 10).
- ✓ When evaluating BMPs for access road entrances during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 12):
  - Excessive soil on the highway adjacent to access was avoided (Coastal Plain and Mountains)

Wooden mats used within the first 100 feet of a public access road can prevent loose sediment from being deposited on the public road surface. While this BMP is designed to reduce nonpoint source pollution runoff, it also helps reduce traffic hazards.

Section 3.2.7

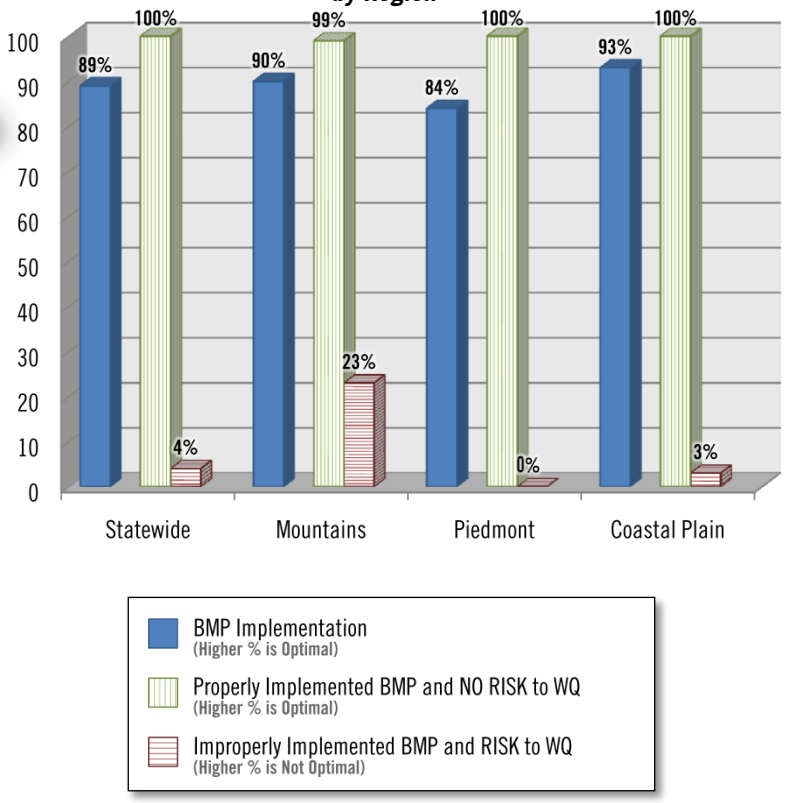
Access Road Entrances

Across the state, there were 959 BMPs assessed for access road entrances, including 127 in the Mountains (13%), 413 in the Piedmont (43%), and 419 in the Coastal Plain (44%). The assessed BMPs for access road entrances were located on 191 sites statewide, with 31 in the Mountains, 84 in the Piedmont, and 76 in the Coastal Plain.

BMP Implementation

When applicable, 89 percent of the BMPs for access road entrances were properly implemented statewide. The Coastal Plain had the highest implementation (93%) followed by the Mountains (90%) and Piedmont (84%) (Figure 10). When compared to the previous survey, implementation of BMPs for access road entrances decreased in all regions.

Figure 10. Implementation of BMPs for Access Road Entrances by Region



Best Management Practices for Access Road Entrances

Where applicable, the six BMPs listed below were evaluated to determine if BMPs for access road entrances were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 12.

Evaluated BMPs for Access Road Entrances

- Gravel, wooden mats or other similar device placed within ***first 100 feet*** of public road entrance.
- ***Excess***ive ***soil*** on the highway adjacent to access was ***avoided***.
- Logging ***debris*** or trash on the highway adjacent to access was ***avoided***.
- ***Drain***age easement/ditch between main highway and access road ***bridged*** by appropriate means.
- ***Drain***age easement/ditch between main highway and access road properly ***stabilized***.
- ***Drain***age easement / ditch between main highway and access road not impeding storm ***water flow***.

Surveyors qualitatively evaluated all BMPs for access road entrances (Table 12) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 12 as percentages.

Table 12. Implementation of BMPs for Access Road Entrances by Region

BMPs for Access Road Entrances	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**89**	**90**	**84↓**	**93**	**100**	**99**	**100**	**100**	**4**	**23**	**0**	**3**
First 100 Feet	64	66	60	68	99	100	100	98	3	20	0	0
Excess Soil Avoided	90	90↓	86↓	95	100	100	100	100	11	33	0	25
Debris Avoided	97	100	94	100	99	97	100	100	0	N/A*	0	N/A*
Drain Bridged	96	100↑	89	100↑	100	100	100	100	0	N/A*	0	N/A*
Drain Stabilized	93↑	100↑	86	98	100	100	100	100	0	N/A*	0	0
Drain Water Flow	96↑	100↑	94↑	97↑	100	100	100	100	0	N/A*	0	0
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

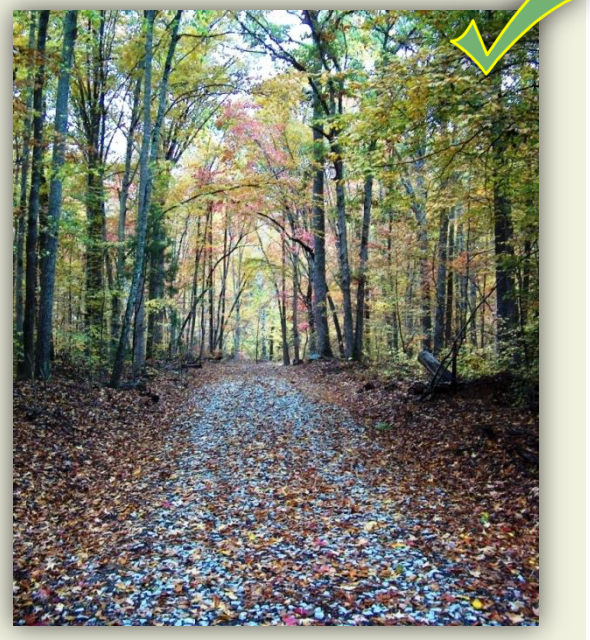
Discussion – Access Road Entrances

Entering onto a public road with a log truck from a forest harvest area can result in the deposition of loose sediment onto the public road surface. This deposited sediment may result in nonpoint source pollution if the material washes into nearby streams or waterbodies. Implementation of BMPs for access road entrances was on average high across the state, with higher implementation rates in the Mountains and Coastal Plain regions. However, implementation was relatively low in all regions for the BMP recommending the use of gravel, mats or some other means of surface hardening be placed within the ***first 100 feet*** of the public road entrance. The risk to water quality due to non-implementation of BMPs for access road entrances was relatively low when compared to other BMP categories.

Assessing the risk to water quality for these BMPs can be challenging, given that it can be difficult to determine the proximity of streams or waterbodies to the road entrance, while also evaluating the potential of deposited sediment to wash off of the road surface and into streams or waterbodies. This may explain the abundance of zeros in the ***Improperly Implemented BMP & Risk to WQ*** column found in Table 12.

Key Findings – Forest Access Roads

- ✓ BMP implementation for forest access roads was 84 percent statewide, 70 percent in the Mountains, 83 percent in the Piedmont, and 96 percent in the Coastal Plain (Figure 11).
- ✓ When BMPs for forest access roads were properly implemented statewide, there was no risk to water quality 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 14 percent of the time (Figure 11).
- ✓ When evaluating BMPs for forest access roads during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 13):
  - Roads follow contour lines (Coastal Plain)
  - Drainage and diversion structures implemented where necessary to maintain good road drainage and stabilize road surface (Coastal Plain and Mountains)



This forest access road is well maintained and has a stable surface of crushed stone that helps to control runoff.

Section 3.2.8

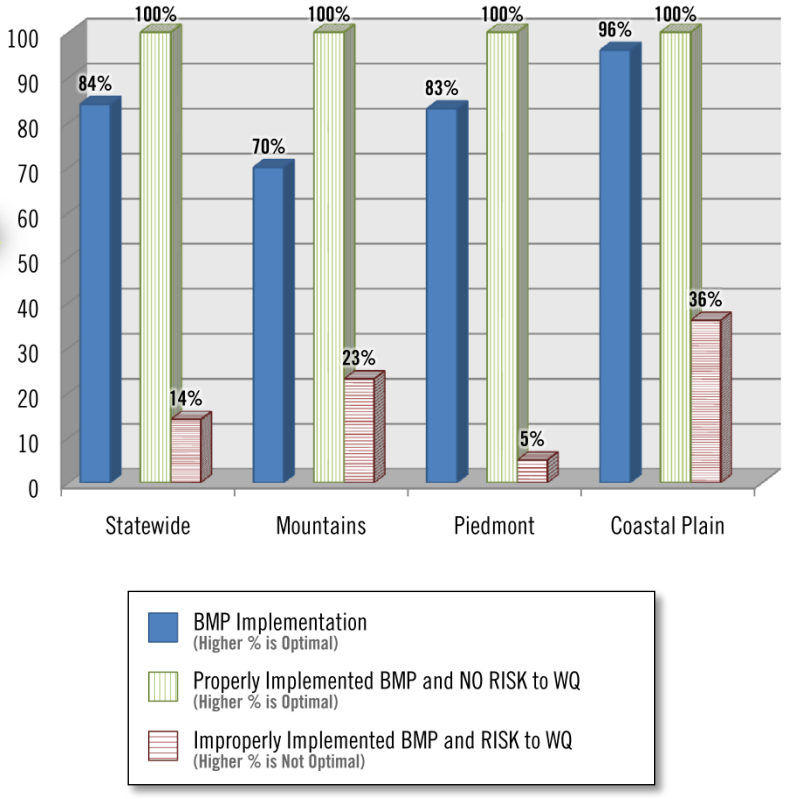
Forest Access Roads

Across the state, there were 954 BMPs assessed for forest access roads, including 207 in the Mountains (22%), 488 in the Piedmont (51%), and 259 in the Coastal Plain (27%). The assessed BMPs for forest access roads were located on 138 sites statewide, with 24 in the Mountains, 58 in the Piedmont, and 56 in the Coastal Plain.

BMP Implementation

When applicable, 84 percent of the BMPs for forest access roads were properly implemented statewide. The Coastal Plain had the highest implementation (96%) followed by the Piedmont (83%) and Mountains (70%) (Figure 11). When compared to the previous survey, implementation of BMPs for forest access roads decreased in the Mountains and Piedmont and increased in the Coastal Plain.

Figure 11. Implementation of BMPs for Forest Access Roads by Region



Best Management Practices for Forest Access Roads

Where applicable, the seven BMPs listed below were evaluated to determine if BMPs for forest access roads were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 13.

Evaluated BMPs for Forest Access Roads

- ***Road***s established a ***year*** or more in ***advance*** of operation.
- ***Road***s are a ***min***imum ***width*** of 10-14 feet for single track road.
- Roads placed on ***gentle side slope***s and not ridge tops where possible.
- Roads are located ***outside*** of ***SMZ***.
- Roads ***follow contour*** lines.
- ***Road***s have ***grade***s of 1-10% or where steeper grades must be used, they do not exceed 200 feet.
- ***Drain***age and diversion ***structure***s implemented where necessary to maintain good road drainage and stabilize road surface.

Surveyors qualitatively evaluated all BMPs for forest access roads (Table 13) to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 13 as percentages.

Table 13. Implementation of BMPs for Forest Access Roads by Region

BMPs for Forest Access Roads	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**84**	**70**	**83**	**96↑**	**100**	**100**	**100**	**100**	**14**	**23**	**5**	**36**
Road Year Advance	56↑	30↓	40↓	86↑	100	100	100	100	4	0	3	14
Road Min Width	95	83↓	95	100	100	100	100	100	0	0	0	N/A*
Gentle Side Slope	92	74↓	98	100↑	100	100	100	100	0	0	0	N/A*
Outside SMZ	93	61↓	100	100↑	100	100	100	100	44	44	N/A*	N/A*
Follow Contour	88↑	83↑	88↓	92	100	100	100	100	18	25	0	100
Road Grade	88↑	65↑	96	100	100	100	100	100	20	25	0	N/A*
Drain Structure	82	78	78	95	100	100	100	100	30	75	13	67
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

Drainage and Diversion Structures

Surveyors qualitatively evaluated drainage and diversion structures associated with forest access roads. There were 167 structures surveyed to determine if BMP recommendations were followed and whether there was a risk to water quality associated with the type of drainage and diversion structure used. The Survey results are summarized in Table 14.

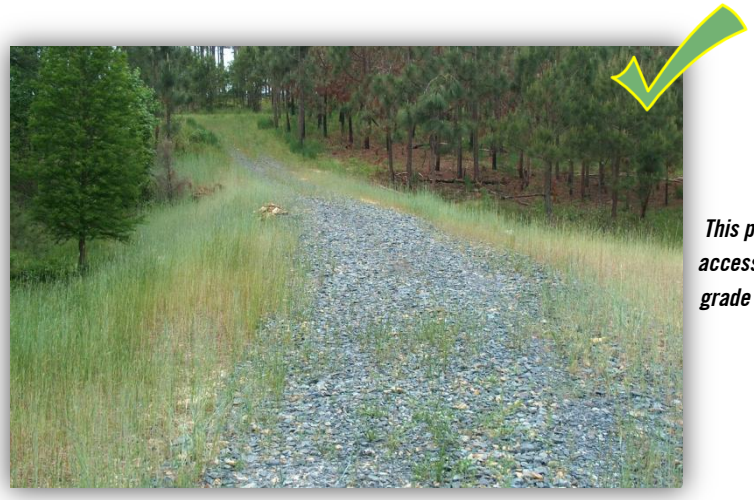
Table 14. Implementation of BMPs for Forest Access Road Drainage and Diversion Structures

Drainage and Diversion Structure Type	Total Times Assessed (Count)	BMP Implementation (Percent)	Properly Implemented BMP & NO RISK to WQ (Percent)	Improperly Implemented BMP & RISK to WQ (Percent)
Turnouts	28	89	100	33
Outsloping Road Bed	37	97	100	0
Broad Based Dips	17	82	100	0
Rolling Grade or Dips	21	90	100	0
Cross-drain Culverts	16	88	100	100
Waterbars	11	91	100	0
Crushed Stone	37	89	100	0

Discussion – Forest Access Roads

Implementation of BMPs for forest access roads and risk to water quality due to non-implementation ranges widely across regions and with respect to individual BMPs. Overall, implementation remained relatively high in the Piedmont and Coastal Plain regions, with implementation increasing in the Coastal Plain by at least five percent. However, implementation of four out of the seven BMPs for forest access roads decreased notably in the Mountains region when compared to the previous survey. Regardless, non-implementation of BMPs for forest access roads infrequently resulted in a risk to water quality; this observation is challenging to explain. Forestry research has shown that forest roads can be a significant source of erosion and sedimentation when not properly constructed or maintained, especially in steep terrain or highly erodible soils (Tew et al., 2005).

Implementation of BMPs for drainage and diversion structures associated with forest access roads was relatively high (Table 14). ***Outsloping road bed*** and ***crushed stone*** were the most frequently observed structures during the Survey. When properly implemented, all assessed drainage and diversion structures were effective at preventing a risk to water quality. Conversely, when ***cross-drain culverts*** were not properly implemented, a risk to water quality occurred 100 percent of the time. This could be due to the difficulty of properly installing ***cross-drain culverts*** and the fact that regular maintenance is often needed to remove blockages and assure the inlet / outlet does not erode the roadside ditch.



This picture illustrates properly implemented BMPs for forest access roads. The road was constructed with proper width and grade and the road surface was stabilized with crushed stone.

Section 3.2.9

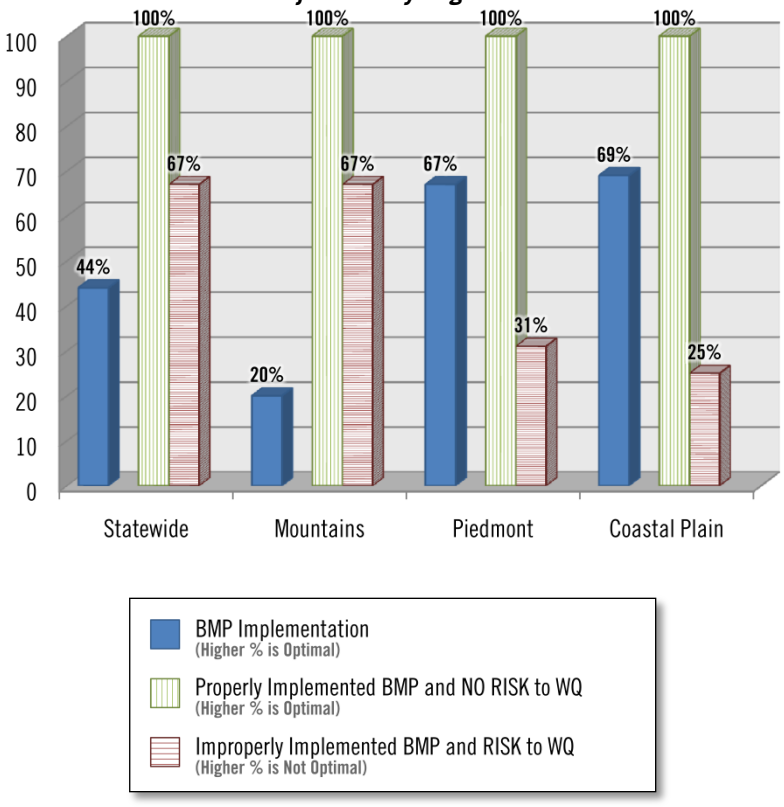
Rehabilitation of Project Site

Across the state, there were 129 BMPs assessed for rehabilitation (rehab) of the project site, including 64 in the Mountains (50%), 39 in the Piedmont (30%), and 26 in the Coastal Plain (20%). The assessed BMPs for rehab were located on 52 sites statewide, with 23 in the Mountains, 15 in the Piedmont, and 14 in the Coastal Plain.

BMP Implementation

When applicable, 44 percent of the BMPs for rehab were properly implemented statewide. The Coastal Plain had the highest implementation (69%) followed by the Piedmont (67%) and Mountains (20%) (Figure 12). When compared to the previous survey, implementation of BMPs for rehab decreased in the Mountains while increasing in the Coastal Plain and Piedmont.

Figure 12. Implementation of BMPs for Rehabilitation of Project Site by Region



Key Findings – Rehabilitation of Project Site

- ✓ BMP implementation for rehab was 44 percent statewide, 20 percent in the Mountains, 67 percent in the Piedmont, and 69 percent in the Coastal Plain (Figure 12).
- ✓ When BMPs for rehab were properly implemented statewide, there was no risk to water quality 100 percent of the time. Conversely, when these BMPs were not implemented, it resulted in a risk to water quality 67 percent of the time (Figure 12).
- ✓ When evaluating BMPs for rehab during this Survey, a risk to water quality was most frequently observed when the following BMPs were not implemented in specific regions of the state (Table 15):
  - Groundcover and / or vegetation established promptly after completion of activities on soil areas in close proximity to water bodies, and in locations where uncontrolled runoff may flow directly into waterbodies (Statewide)
  - Where ground was seeded, soils were properly prepared (Mountains)
  - Where ground was seeded, it was accomplished in an effective manner (Mountains)
  - Mulching (following seeding) allows for 25 percent ground surface visibility standard (Mountains)
  - Mulching (following seeding) allows for mulch properly anchored (Mountains)

Best Management Practices for Rehabilitation of Project Site

Where applicable, the six BMPs listed below were evaluated to determine if BMPs for rehab were implemented. The ***keyword(s)*** emphasized in each statement below correspond with the labels used in Table 15.

Evaluated BMPs for Rehabilitation of Project Site

- Ground ***cover*** and / or vegetation ***established*** promptly after completion of activities on soil areas in close proximity to water bodies, and in locations where uncontrolled runoff may flow directly into waterbodies.
- Where ground was seeded, ***soils*** were properly ***prepared***.
- Where ground was seeded, ***lime and fertilizer*** properly incorporated into soils where needed.
- Where ***ground*** was ***seeded***, it was accomplished in an effective manner.
- ***Mulching*** (following seeding) allows for 25 percent ground surface ***visibility*** standard.
- ***Mulching*** (following seeding) allows for mulch properly ***anchored***.

Surveyors qualitatively evaluated all BMPs for rehab to determine if BMP recommendations were followed and whether there was a risk to water quality. The Survey results are summarized in Table 15 as percentages.

Table 15. Implementation of BMPs for Rehabilitation of Project Site by Region

BMPs for Rehab	BMP Implementation				Properly Implemented BMP & NO RISK to WQ				Improperly Implemented BMP & RISK to WQ			
	S	M	P	C	S	M	P	C	S	M	P	C
Overall	**44**	**20↓**	**67↑**	**69↑**	**100**	**100**	**100**	**100**	**67**	**82**	**31**	**25**
Cover Established	27↓	13↓	33↓	43	100	100	100	100	66	95	40	25
Soils Prepared	58↑	33↓	100↑	100↑	100	100	100	100	100	100	N/A*	N/A*
Lime and Fertilizer	40↑	11↓	80↑	100↑	100	100	100	100	33	38	0	N/A*
Ground Seeded	59↑	22↓	100↑	100↑	100	100	100	100	86	86	N/A*	N/A*
Mulching Visibility	67↑	29↓	100↑	100↑	100	100	100	100	80	80	N/A*	N/A*
Mulching Anchored	55↑	25↑	50↑	100↑	100	100	100	100	40	67	0	N/A*
	Higher % is Optimal				**Higher % is Optimal**				**Higher % is Not Optimal**			

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

↑↓Indicates a change in implementation of ± 5 percent compared to the previous survey report.

*There were no surveys evaluated with these conditions.

Note: Numeric values as percents.

Discussion – Rehabilitation of Project Site

The number of site rehabilitation (rehab) BMPs assessed during the Survey is relatively small when compared to the number of assessed BMPs in most other categories. This is likely due to the fact that the Survey was designed to evaluate active logging sites, when rehab BMPs may not have been implemented yet. Regardless, Survey results indicate many notable trends in BMP implementation throughout the state. Of the 18 possible BMP implementation combinations (six BMPs [x] three regions), there were 11 in which BMP implementation increased by five or more percent since the 2005 BMP survey report. Conversely, BMP implementation decreased by five or more percent for six of the BMP implementation combinations. A majority of the decreasing trends in BMP implementation occurred in the Mountains, with most of the increasing trends occurring in the Piedmont and Coastal Plain.

Implementation of BMPs for rehab within the state appears to decrease with increasing slope, with the Coastal Plain (less slope) having the highest implementation and the Mountains (more slope) having the lowest implementation. Risk to water quality due to non-implementation of rehab BMPs was also notably higher in the Mountains. This is likely due to a number of factors. Given the relatively flat terrain and associated soils found in the Coastal Plain, BMPs for rehab are likely easier to implement and often more successfully achieved. The opposite is true for the Mountains. With steeper slopes, more erodible and often less fertile soil, implementation of BMPs for rehab in the Mountains is more challenging. Also, stabilizing soils on steeper slopes commonly found in the Mountains often requires structural BMPs (e.g., waterbars, turnouts, sediment traps, etc.) to control runoff, and stabilization efforts commonly exceed the simple seed and straw techniques that are often suitable on flatter terrain. Installation of these structural BMPs generally requires the use of heavy equipment (e.g., bulldozer, log skidder, etc.), which may not be readily available or are not available until the harvesting operation is complete.

While Survey results indicate an improvement in implementation of BMPs for rehab on average statewide, additional measures are required to increase implementation of these BMPs. This is particularly true in areas of the state with steeper slopes (e.g., Mountains, Foothills, portions of the Piedmont, etc.). Future surveys will assess rehab BMPs in the context of the operational stage. Identifying whether applicable rehab BMPs are promptly implemented, implemented during site close-out, or not implemented, will help target training and education efforts. For those active sites where rehab BMPs have not yet been implemented, follow-up surveys will be conducted in an effort to better document implementation of BMPs for rehab.

These pictures show well implemented BMPs for rehabilitation along skid trails in the Mountains. In both examples, the ground was seeded and mulched. Silt fence was installed as needed to slow runoff and reduce erosion.

3.3 Implementation Based on Regulations, Technical Assistance, and Training

Section 3.3.1

Forest Practices Guidelines Related to Water Quality Compliance

Forest Practices Guidelines (FPGs) compliance inspections were performed at 181 of 212 Survey sites statewide at the same time as the Survey evaluations. There were 34 sites in the Mountains (19%), 64 in the Piedmont (35%), and 83 in the Coastal Plain (46%). FPG compliance information was left blank on 31 surveys, and as a result, was not included in the data summarized below. There were 6,343 BMPs assessed on the 181 Survey sites where FPG inspections were performed, including 1,390 in the Mountains (22%), 2,289 in the Piedmont (36%), and 2,664 in the Coastal Plain (42%).

BMP Implementation

BMP implementation was 91 percent statewide on sites that were in compliance with the FPGs. Implementation was highest on FPG compliant sites in the Coastal Plain (94%), followed by the Piedmont (90%) and Mountains (81%). Survey results indicate a close relationship between implementation of BMPs and compliance with FPGs. As BMP implementation increases, so does FPG compliance. Conversely, as BMP implementation decreases, the number of non-compliant FPG standards increases per site. Table 16 below illustrates the relationship between BMP implementation and FPG compliance. Data presented in Table 16 can be interpreted accurately using the following example sentences, while substituting text in *underlined italics* with the corresponding data for each region, percent, and FPG compliance / non-compliance scenario: *Statewide*, BMP implementation was *91* percent on FPG *compliant* sites. Conversely, BMP implementation was *77* percent *statewide* on sites with *one* non-compliant FPG standard.

Table 16. Influence of BMP Implementation on FPG Compliance by Region

	Number of Non-Complaint Standards	BMP Implementation Percent			
		S	M	P	C
FPGs In Compliance	N/A	91	81	90	94
FPGs Not In Compliance	One	77	71	73	86
	Two	57	48	55	70
	Three	44	44	N/A*	N/A*
	Four	32	31	33	N/A*

*There were no surveys evaluated with these conditions.

On the Survey sites, FPG non-compliance was most frequently attributed to not meeting the following standards: (.0201) Streamside Management Zones, (.0202) Prohibition of Debris entering streams and Waterbodies, (.0203) Access Road and Skid Trail Stream Crossings, and (.0209) Rehabilitation of Project Site. These four standards represented 95 percent of the non-compliant standards on Survey sites. The remaining five FPG standards were regularly observed to be in compliance during the Survey.

Discussion – Forest Practices Guidelines (FPGs)

FPG compliance was more frequently observed on harvest sites with higher BMP implementation. Conversely, as BMP implementation decreases, the number of non-compliant FPG standards increases, resulting in more non-compliant standards. Similar to the FPG program data, violation of FPGs .0201, .0202, .0203, or .0209 represented the majority of the non-compliant FPG standards on Survey sites. These data clearly indicate that implementation of BMPs can yield higher FPG compliance on forestry sites and lower implementation of BMPs can yield a larger number of non-compliant standards.

Section 3.3.2

Riparian Buffer Rule Compliance and River Basin Data

At the time of the Survey, there were four riparian buffer rules applicable to forestry in effect within the state: 1) Neuse River Basin, 2) Tar-Pamlico River Basin, 3) Catawba River mainstem, and 4) Randleman Lake Watershed. There were 33 buffers assessed that were applicable to the Neuse River Basin rule, 28 applicable to the Tar-Pamlico River Basin rule, and one buffer applicable to the Catawba River rule. There were no buffers assessed that were applicable to the Randleman Lake Watershed rule. Compliance of the Neuse and Tar-Pamlico River Basin rules was 100 percent along perennial streams and waterbodies. Buffer rule compliance for intermittent streams was 100 percent in the Neuse and 90 percent in the Tar-Pamlico. The one buffer inspected that was applicable to the Catawba River rule was in compliance. A summary of BMP implementation and risk to water quality for all 17 river basins is presented in Table 17 below.

Table 17. BMP Implementation and Risk to Water Quality by River Basin

River Basin	Surveys		BMPs Assessed		BMP Implementation (Percent)	Properly Implemented BMP & NO RISK to WQ (Percent)	Improperly Implemented BMP & RISK to WQ (Percent)
	Count	Percent of Total	Count	Percent of Total			
Broad	5	2	169	2	77	99	67
Cape Fear	33	16	1315	17	89	100	41
Catawba	11	5	263	3	83	100	34
Chowan	9	4	296	3	95	100	27
French Broad	12	6	498	6	61	98	69
Hiwassee	3	1	142	2	51	96	81
Little Tennessee	6	3	275	4	72	96	67
Lumber	16	8	575	8	91	100	53
Neuse	26	12	818	11	91	100	18
New	3	1	123	2	72	100	68
Pasquotank	9	4	252	3	92	100	47
Roanoke	23	11	887	12	84	100	53
Savannah	0	N/A*	0	N/A*	N/A*	N/A*	N/A*
Tar-Pamlico	20	10	615	8	91	100	23
Watauga	2	1	98	1	66	100	82
White Oak	5	2	144	2	95	100	43
Yadkin-Pee Dee	29	14	1191	16	86	100	52
*There were no surveys conducted within the Savannah River Basin.					**Higher % is Optimal**	**Higher % is Optimal**	**Higher % is Not Optimal**

Discussion – Riparian Buffer Rules and River Basin Data

Where applicable, riparian buffer rule compliance was at or greater than 90 percent across the state. BMP implementation was notably lower in river basins that are largely located within the Mountains (e.g., Broad, French Broad, Hiwassee, Little Tennessee, New, and Watauga) and risk to water quality was higher in these river basins. These data highlight the challenges and importance of implementing BMPs in the mountainous areas of the state.

Section 3.3.3

Technical Forestry Assistance and Preharvest Planning

Technical Forestry Assistance

Technical assistance was provided on 154 Survey sites statewide (73%), including 12 sites in the Mountains, 71 sites in the Piedmont, and 71 sites in the Coastal Plain. Technical assistance was provided by at least one of the following sources: NCDFR personnel (5%), foresters employed by the forest products industry (14%), consulting foresters (37%), timber buyers (40%) or other (4%).

BMP implementation on sites that received technical assistance was 88 percent statewide, versus 77 percent on sites that did not have technical assistance. Risk to water quality was approximately 15 percent lower on sites that received technical assistance. Additionally, FPG compliance on Survey sites was higher by 14 percent when technical assistance was provided. The source of technical assistance had little influence on BMP implementation or FPG compliance. When technical assistance was provided in the Mountains, BMP implementation and FPG compliance rates increased by a larger margin than in the Coastal Plain and Piedmont regions.

Preharvest Planning

A written preharvest plan was prepared on 82 sites Statewide (39%), including four sites in the Mountains, 29 sites in the Piedmont, and 49 sites in the Coastal Plain. BMP implementation was higher statewide on sites that had a written preharvest plan; 90 percent implementation on sites where a preharvest plan was prepared versus 81 percent on sites without written preharvest plans. Risk to water quality was approximately 25 percent lower on sites that had written preharvest plans. Additionally, FPG compliance on Survey sites was 15 percent higher when a written preharvest plan was prepared. Similar to the influence of technical assistance, preparation of written preharvest plans increased BMP implementation and decreased risk to water quality most notably in the Mountains.

Section 3.3.4

Water Quality Foresters

Ten of the state's 13 NCDFR Districts had an assigned Water Quality Forester (WQF) at varying times during the Survey. The WQFs were the primary BMP Survey coordinators in Districts 1, 2, 3, 4, 5, 7, 8, 10, 11 and 12 (see Figure 1). The WQFs evaluated more than 70 percent of the Survey sites.

On average statewide, Districts with an assigned WQF exhibited a slightly lower BMP implementation as compared to those Districts without a WQF; 84 percent versus 86 percent, respectively. While BMP implementation was slightly lower on average statewide in Districts with a WQF, risk to water quality was also lower; indicating that a risk to water quality in Districts with a WQF was observed less frequently. Additionally, FPG compliance was slightly higher (3%) in Districts that had a WQF at the time of the Survey. As stated in the previous report, while this Survey provides some measure of WQF effectiveness, it is only one aspect of determining the tangible or intangible value added by these positions.

Section 3.3.5

North Carolina Forestry Association's ProLogger Program

One hundred and sixty of the Survey sites were harvested by ProLogger graduates (75%), including 13 in the Mountains, 79 in the Piedmont, and 68 in the Coastal Plain. On average statewide, BMP implementation was higher and risk to water quality was lower on sites harvested by ProLogger graduates. BMP implementation rate on ProLogger harvest sites was 88 percent and risk to water quality was 46 percent. In contrast, sites harvested by non-ProLoggers averaged 76 percent BMP implementation and risk to water quality was 64 percent. Additionally, FPG compliance was 20 percent higher on sites harvested by ProLoggers. When ProLoggers harvested sites in the Piedmont and Mountains, BMP implementation and FPG compliance rates increased by a larger margin than in the Coastal Plain.

Discussion – Technical Assistance, Preharvest Planning, WQFs, and NCFA ProLoggers

BMP implementation was higher and risk to water quality was lower on sites with technical assistance and / or preharvest planning. While BMP implementation was lower in Districts with WQFs, risk to water quality was also lower. BMP implementation was higher on sites harvested by ProLoggers and risk to water quality was lower. FPG compliance was higher when technical assistance, preharvest planning, WQFs, and / or ProLoggers were associated with a harvest site. These data clearly indicate that technical assistance, preharvest planning, and training can improve BMP implementation, reduce risk to water quality, and increase FPG compliance.

3.4 Implementation According to Ownership and Forest Management

Section 3.4.1

Forestland Ownership

Survey sites were located on forestland owned by non-industrial private forest (NIPF) landowners, forest industry or public agencies. Given that a random sampling approach was used (see Appendix A for additional information), ownership was not a criterion for selecting sites. Across the state, there were 179 sites that were located on NIPF land (84%), 31 sites on forest industry land (15%), and two sites on public land (1%). On average statewide, BMP implementation was highest for public lands (94%) followed by forest industry (90%) and NIPF (84%). However, risk to water quality was slightly higher on forest industry land (58%) when compared to NIPF land (53%). There were no observed risks to water quality on the two Survey sites located on public land.

Section 3.4.2

Forest Management Type

Surveyors categorized the site's management type based on "visible" forest management history. The management history was determined from documented management history (management plans on file at a NCDFR field office), discussions with the logger or landowner onsite, and / or the surveyor's best professional judgment based on field observation. Survey sites were located on land categorized as either "intensively managed forest" or "passively managed forest." Across the state, there were 59 sites categorized as intensively managed (28%) and 153 sites categorized as passively managed (72%). On average statewide, BMP implementation was higher (91%) and risk to water quality was lower (44%) on intensively managed sites when compared to passively managed sites (82% and 55%, respectively).

Section 3.4.3

Harvest Method

Survey sites were harvested using one of the following methods: clearcut, salvage cut, seed tree / shelterwood, selection (e.g., diameter limit), or thinning. Across the state, 145 sites were clearcut harvested (68%), 33 were selection harvested (16%), and 31 were thinned (15%). The remaining harvest methods accounted for less than one percent of the sites. On average statewide, BMP implementation was highest on thinning sites (93%), followed by clearcuts (88%) and selection harvest sites (65%). Risk to water quality was the lowest on thinning sites (36%), followed by clearcuts (43%) and selection harvest sites (70%).

Discussion – Ownership and Forest Management

BMP implementation was 84 percent on NIPF land, 90 percent on forest industry land, and 94 percent on publicly owned land. Risk to water quality was slightly lower on NIPF land than on forest industry land (five percent lower), and there were no observed risks to water quality on publicly owned land. BMP implementation was 91 percent on intensively managed sites and 82 percent on passively managed sites. Risk to water quality was lower on intensively managed sites than on passively managed sites by 11 percent. BMP implementation was 88 percent on clearcut sites, 65 percent on selection harvest sites, and 93 percent on thinning sites. Risk to water quality was considerably higher on selection harvest sites (70%) when compared to clearcuts (43%) or thinning sites (36%).

BMP implementation and risk to water quality varies by ownership and forest management type. While implementation was higher on forest industry land, so was risk to water quality. In contrast, intensively managed forest had higher BMP implementation and lower risk to water quality when compared to passively managed forests. Therefore, the influence of ownership and forest management on BMP implementation and risk to water quality may not be as significant as harvest site characteristics (e.g., streams, soils, slope, etc.) and other factors related to the harvest sale and operation, such as technical assistance or the degree of oversight conducted during the harvest by a third-party observer (i.e., non-logger).

3.5 Implementation Influenced by Geographic Features

Section 3.5.1

Physiography and Slope

The physical geography (physiography) of each Survey site was noted and one of the following was selected as the predominant landform: flatwoods, foothills, mountains, pocosin / bays, rolling, sandhills, or wetlands. Across the state, 53 sites occurred on flatwoods (25%), 25 on foothills (12%), 29 on mountains (14%), six on pocosin / bay (3%), 80 on rolling (38%), one on sandhills (<1%), and 18 on wetlands (8%). BMP implementation was highest on landforms with the least slope. On average statewide, BMP implementation was highest on pocosin / bays (94%) followed by flatwoods and wetlands (92%), sandhills (89%), rolling (88%), foothills (83%), and mountains (63%). Risk to water quality was the lowest on sandhills (0%), followed by rolling (28%), pocosin / bay (38%), wetlands (52%), foothills (53%), flatwoods (63%), and mountains (72%).

Section 3.5.2

Soil Texture

Surveyors determined the predominant soil texture present at each site using the county's USDA soil survey or the *Texture by Feel* method and recorded the texture as one of the following: clay, clay loam, loam, organic, sand, sandy clay, sandy clay loam, and sandy loam. Across the state, 25 sites occurred on clay soils (12%), 62 on clay loam (29%), 14 on loam (7%), 20 on organic (9%), four on sand (2%), one on sandy clay (<1%), 14 on sandy clay loam (7%), and 72 on sandy clay (34%). BMP implementation was generally inversely related to the amount of medium-textured soils present at the site. On average statewide, bmp implementation was the highest on sand (95%), followed by sandy loam and organic soils (91%), sandy clay loam (87%), clay (85%), sandy clay (83%), clay loam (78%), and loam (76%). Risk to water quality was the lowest on sandy clay soils (13%), followed by sandy clay loam (29%), sandy loam (45%), clay (46%), sand (50%), loam (51%), clay loam (62%), and organic (63%).

Section 3.5.3

Erosion and Erodibility

Surveyors used their best professional judgment to estimate site erodibility class and recorded it as one of the following categories: low, moderate, or high. Surveyors also noted erosion type if observed near a waterbody as one or more of the following: sheet, rill, gully, and/or wind erosion. There were 115 sites statewide categorized as having a low erodibility class (54%), 63 sites with moderate erodibility (30%), and 34 with high erodibility (16%). Across the state, there were 155 sites with no erosion observed near a waterbody (73%), 21 sites with gully erosion present (10%), 21 with sheet erosion (10%), nine with rill erosion (4%), and six with multiple types of erosion (3%). BMP implementation was lower on more erodible sites. On average statewide, BMP implementation was the highest on sites categorized as having low erodibility (92%), followed by moderate erodibility (82%) and high erodibility (70%). Risk to water quality was lowest on sites with low erodibility (37%), followed by moderate erodibility (51%), and high erodibility (67%).

Discussion – Geographic Features

BMP implementation was highest and risk to water was lowest on landforms with lower slopes. Sites with medium textured soils generally exhibited a lower BMP implementation and higher risk to water quality. Similarly, sites with higher erodibility soils had lower BMP implementation rates and higher risk to water quality. These data clearly indicate the influence of site geographic features on BMP implementation and risk to water quality. Also, the influence of slope, soil texture, and soil erodibility on BMP implementation and risk to water quality closely aligns with regional implementation and risk data (i.e., Mountains, Piedmont, and Coastal Plain).

4.0 CONCLUSIONS

Survey results indicate that when forestry BMPs are properly implemented, a risk to water quality was rarely observed during harvesting operations in North Carolina. On average statewide, when BMPs were properly implemented there was no risk to water quality nearly 100 percent of the time. Conversely, when BMPs were not implemented, it resulted in a risk to water quality a majority of the time (54%). The number of applicable BMPs varied across sites, geographic regions, and BMP categories; indicating that the design, selection, and implementation of BMPs are often a factor of site-specific conditions.

Training and information transfer have a noticeable positive influence on BMP implementation. Specifically, BMP implementation at harvest sites is noticeably higher when loggers with additional training (e.g., ProLogger) conduct the operation and when technical and / or preharvest planning assistance is provided. These topics highlight the importance of 1) forestry BMP implementation for the protection of water quality during harvesting operations and 2) BMP training and information outreach directed toward forest practitioners. As seen consistently throughout this report, implementation of forestry BMPs in the Mountains is more challenging than in other areas of the state. While there are many factors that play a role in this, steepness of slope and associated increased erosion hazard as well as higher drainage density (higher number of streams per unit area) are likely the most influential factors.

While summarized data from this Survey highlight many BMPs that are consistently well implemented, these data also highlight areas of needed BMP implementation improvement. In order to identify the BMP areas that need the most improvement, the nine BMP categories were ranked from one to nine based on BMP implementation and risk to water quality due to non-implementation. BMP implementation data was ranked based on statewide implementation averages for each category, with a score of ***one*** assigned to the ***most implemented*** and a score of ***nine*** to the ***least implemented*** category. Risk to water quality due to non-implementation was ranked based on statewide risk averages for each category, with a score of ***one*** assigned to the ***lowest risk*** to water quality and a score of ***nine*** to the ***highest risk*** to water quality. Scores from these two metrics were then added together in an effort to identify the BMP categories in need of the most implementation improvement that, when not implemented, represent the highest risk to water quality. These data are presented in Table 18 below.

Table 18. Combined Ranking of BMP Categories by BMP Implementation and Risk to WQ

Relative Order of Importance	BMP Category	BMP Implementation Score	Risk to Water Quality Score	Combined Score
1	Stream Crossings	8	8	16
2	Rehabilitation of Project Site	9	6	15
3	Debris Entering Streams	5	7	12
4	Skid Trails	7	5	12
5	Streamside Management Zones	2	9	11
6	Forest Access Roads	6	3	9
7	Stream Temperature	3	4	7
8	Access Road Entrances	4	1	5
9	Waste Entering Streams, Water Bodies, or Groundwater	1	2	3

Table 18 indicates that improving BMP implementation for the following five categories will have the most positive influence on reducing risk to water quality on active harvest sites: 1) stream crossings, 2) rehabilitation, 3) debris entering streams, 4) skid trails, and 5) SMZs.

In summary, the results of the Survey indicate that adherence to a three-phased approach to implementing BMPs can reduce risk to water quality and provide appropriate protection for water quality during forest harvesting operations.

- Phase 1 – Plan for BMPs
  - Evaluate the characteristics of a proposed harvest site in advance of conducting harvesting operations, identifying potential hazards and BMP implementation needs. This planning could be a brief site walk-through or a detailed preharvest plan.
- Phase 2 – Implement Applicable BMPs
  - Implement BMPs identified during Phase 1, adding implementation of other applicable BMPs as needed based on harvest site characteristics. Where applicable, emphasis should be placed on BMPs where operations are closest to streams / waterbodies (e.g., stream crossings, debris entering streams, SMZs, etc.) and where high traffic areas could expose soil and produce accelerated erosion (e.g., skid trails).
- Phase 3 – Conduct Rehabilitation
  - Conduct rehabilitation activities where needed as early as possible with emphasis on operational areas closest to streams / waterbodies and where the potential for accelerated erosion is high.

5.0 RECOMMENDATIONS

The following recommendations are based on an interpretation of the Survey results. Many of these recommendations are continued efforts that the NCDFR strives to deliver. Additionally, results from this Survey are similar to the results from the 2005 BMP survey report, indicating that continued program delivery is needed for several BMP areas.

1) Continue to encourage, promote, and increase technical forestry assistance and preharvest planning. Survey results clearly indicate that these actions increase BMP implementation and FPG compliance, while decreasing risk to water quality during forest harvesting operations.

   - ACTION: The NCDFR is pursuing opportunities to develop a free web-based tool to assist with harvest planning activities. The tool would be capable of summarizing pertinent site attributes such as soils, slopes, streams, waterbodies, wetlands, etc. and would provide BMP recommendations based on the geographic features of the proposed harvest site. With the development of this tool, geographic information about a proposed harvest site will be easier to obtain and understand, and could further assist forest practitioners with the implementation of forestry BMPs for the protection of water quality.
   - ACTION: Once the web-based tool is developed, NCDFR will create a new BMP training video that describes the process of harvest planning, and demonstrates the use of the new online web-based tool. This video will be provided for training through the N.C. ProLogger Program.

2) Develop new outreach programs for forest practitioners that highlight the three-phased BMP implementation approach, including 1) Planning BMPs, 2) Implementing BMPs, and 3) Conducting Rehabilitation.

   - ACTION: The NCDFR will begin delivering a new outreach program titled “BMP Tailgate for Loggers” in 2011. This program will be targeted at logging professionals and include in-the-field training at active logging sites. NCDFR personnel will meet with logging professionals for brief informal training sessions where various BMP topics will be discussed. Previously developed BMP videos as well as BMP posters will be used to discuss BMP implementation topics. Emphasis will be placed on BMP categories with low implementation and high risk to water quality.

3) Emphasize BMP implementation in the mountainous areas of North Carolina. NCDFR needs strong advocates in the mountain operating Districts who can engage loggers, landowners, and forest practitioners on the use of forestry BMPs. There is clearly a need to fill the gap of technical assistance, preharvest planning, and BMP implementation in this area of the state.

   - ACTION: NCDFR will renew efforts to conduct hands-on training workshops of agency personnel and forest practitioners, as well as increasing the number of active logging site inspections under the FPG Program. In addition, NCDFR will support the expansion of the N.C. ProLogger or similar logger training programs into this area of the state where these programs have historically not been widely delivered.
   - ACTION: Pursue funding to re-establish the Water Quality Forester (WQF) position in the Asheville District (D1) and to create a new WQF position in the Sylva District (D9). Funding these positions will be a high priority to achieve the water quality objectives defined in *North Carolina’s Forest Resources Assessment* (Bardon et al., 2010; Chapter 4f: Water Quality and Quantity, Objectives 6.1, 6.3, and 6.4.) and to provide the level of customer service this Survey indicates is needed.
   - ACTION: NCDFR will revise, reprint, and redistribute the *Laymans Guide to Private Access Road Construction in the Southern Appalachian Mountains*. This guide was last revised and printed in 2005 and complements the recommendations found in the North Carolina 2006 Forestry BMP manual.

4) Consider how to evaluate BMPs and potential water quality risk when there is not water in a stream / waterbody or when these hydrologic features are not in close proximity.

   - ACTION: Develop methods or indicators for use when evaluating risk to water quality during low flow conditions and incorporate this into subsequent BMP implementation surveys. Also, note when water is present / absent in the stream / waterbody at the time of the survey.

5.1 Proposed Changes to Next Survey

The third round of BMP implementation monitoring will begin in early 2011, and will include a number of modifications. Most significant will be the transition to assessing the BMPs found in the 2006 Forestry BMP Manual. Actions listed under the fourth *Recommendation* in Section 5 of this report will also be added to subsequent surveys. In addition, the NCDFR will utilize tablet computers to collect survey data electronically, which will greatly improve project efficiency and reduce the time needed to summarize data and prepare a survey report.

NCDFR will also be adding collateral information regarding biomass harvesting to the BMP implementation survey to accommodate a request made by the Biomass Technical Advisory Group of the N.C. Environmental Management Commission, in cooperation with the N.C. Department of Environment and Natural Resources.

Operationally, the next survey will be conducted by a smaller group of NCDFR personnel. This smaller group of surveyors is expected to produce more consistent responses in observations and should allow for a tighter control on the timeliness of conducting surveys as well as data compilation. Locating sites to be assessed will occur primarily by receiving input from the NCDFR's county personnel who will be able to provide site location and other information to the BMP surveyors in a timely manner without the need to expend time, fuel, and expenses by conducting aerial flights or drive transects across counties.

Glossary

Note: Definitions that are followed by "(FPG)" indicate that this definition is from N.C. Administrative Code rule 15A NCAC 01I .0102. Definitions that are followed by "(SPCA)" indicate that this definition is from N.C. General Statute law Chapter 113A-52.

Additional definitions of terms related to water quality and forestry operations are available from the NCDFR's online photo-illustrated "Forestry Water Quality Glossary": http://www.dfr.state.nc.us/water_quality/wqglossary.htm

Accelerated erosion – Any increase over the rate of natural erosion, as a result of land disturbing activities. (FPG)

Access Road – A temporary or permanent access route. (FPG)

Bay – Term used generally to describe a "Carolina bay" which is an isolated wetland in naturally-occurring shallow depressions that retain surface water. The source of this surface water is primarily from rain and shallow groundwater in-flow. Carolina bays usually have an elliptical shape and are oriented from northwest to southeast.

Best Management Practice (BMP) – A practice, or combination of practices, that is determined to be an effective and practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. (FPG)

Bridgemat – Some type of heavy panel which can be used in multiple to construct a temporary crossing over streams, ditches or other small waterways during logging operations. Most bridgemats are constructed either of heavy wood timbers or fabricated steel panels. Some panels are built of engineered lumber and/or composite materials. Other similar terms include dragline mat, pontoon bridge, or skidder bridge.

Channel – A natural water carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water. (FPG)

Clearcut (harvest method) – A method of regenerating an even-aged stand in which a new age class develops in a fully exposed microclimate after removal of all trees in the previous stand.

Ephemeral stream – A stream that flows only during and for short periods following precipitation and flows in low areas that may or may not have a well defined channel. (FPG)

Flatwoods – A site with flat to gently-sloping topography and relatively poorly drained, sandy soils that often have standing water during wet weather.

Foothills – Hilly land on the lower slopes of the mountains that is characterized by moderate slopes.

Ford – A submerged stream crossing which will bear intended traffic. (FPG)

Forest Practices Guidelines Related to Water Quality (FPGs) – North Carolina administrative code that was adopted in 1989 (becoming effective January 1, 1990) defining the need to protect water quality during forestry related operations. Complying with the FPG's will allow a forestry operation to remain exempt from permitting requirements under the state's Sedimentation Pollution Control Act.

Ground Cover – Any natural vegetative growth or other natural or manmade material which renders the soil surface stable against accelerated erosion. (FPG)

Intensive Forest Management – Using a wide variety of silvicultural practices to increase the capability of producing forest products. Examples may include site preparation, planting genetically-improved tree seedlings, thinning, fertilization, herbicide application, or prescribed burning, among other practices.

Intermittent stream – A stream that flows only during wet periods of the year (30 to 90 percent of the time) and flows in a continuous well defined channel. (FPG)

Land Disturbing Activity – Any use of the land by any person in residential, industrial, educational, institutional or commercial development, highway and road construction and maintenance that results in a change in the natural cover or topography and that may cause or contribute to sedimentation. (SPCA)

Log Deck – A place where logs are gathered in or near the forest for further transport, sometimes called a landing. (FPG)

Mill Site – Any place where forest products are stored, altered, or processed. (FPG)

Nonpoint Source – A type of water quality pollution that enters a waterbody from a diffuse or widespread origin in the watershed. Examples include stormwater runoff or soil erosion.

Passive Forest Management – Allowing previously harvested lands to naturally regenerate without the use of the silvicultural practices associated with intensive forest management.

Perennial stream – A stream that flows throughout a majority of the year (greater than 90 percent of the time) and flows in a well defined channel. (FPG)

Permanently Stabilized – The site is protected to the state at which no further accelerated erosion is expected to occur from the forestry activities. (FPG)

Pocosin – An upland swamp that most often occurs within the coastal plain of the southeastern United States. Generally, pocosins are characterized by poorly drained, organic soil. Vegetation is usually waxy-leaved shrubs, trees of pine species, and dense ground vegetation. Often the terms pocosin and bay are used interchangeably, but this is not always an accurate use of these terms.

Preharvest Planning – Forest preharvest planning is a process that identifies and summarizes pertinent information about a tract of land from which timber will soon be harvested. This information may include applicable environmental regulations; specific attributes related to the site such as topography, soils, and water resources; and details of the timber such as size, species, or accessibility. The primary purpose of preharvest planning is to design a harvest operation that meets landowner objectives while addressing the environmental and operational characteristics of a proposed forest harvest site.

Rolling Topography – A land form characterized by gentle to moderate slopes.

Rutting – Depressions in roads or trails made by repeated passage of vehicles or mobile equipment.

Salvage cut (harvest method) – The removal of trees that are dead, damaged or dying due to factors other than competition. This harvest method is designed to recover timber values that would otherwise be lost.

Seedtree (harvest method) – A method of regenerating an even-aged stand. In this method a new age class develops from seeds that germinate in fully exposed microenvironments after everything is removed from the previous stand except for a small number of trees left to provide seed. Seed trees are removed after regeneration is established.

Selection (harvest method) – A method of regenerating uneven-aged stands in which trees are removed and new age classes are established in small groups.

Shelterwood (harvest method) – A method of regenerating a stand in which trees are harvested in two or more cycles of cutting within a relatively short time period. The harvest allows for the residual trees to provide seed and/or protection for regeneration. A new age class of trees develops beneath the residual trees left after the harvest.

Skid Trail – A temporary pathway principally used to drag or transport felled trees or logs or other material to a landing. (FPG)

Streamside Management Zone (SMZ) – An SMZ is a designated area that consists of the stream itself and an adjacent area of varying width (one side of the stream) where management practices that might affect water quality, fish, or other aquatic resources are modified.

Thinning (harvest method) – A treatment made to reduce stand density. The main goal is to improve growth, enhance forest health or to recover potential mortality.

Visible Sediment – Solid particulate matter, both mineral and organic, which can be seen with the unaided eye that has been or is being transported by water, air, gravity, or ice from its site of origin. (FPG)

Waterbody – A natural or man-made basin that stores water, not including jurisdictional wetlands or beaver ponds. (FPG)

Wetlands – Areas that are saturated by surface or ground water sufficient enough to support most of the vegetation typically adapted for saturated or near-saturated soil conditions. In order for a wetland to be considered a "jurisdictional wetland" for regulatory purposes it must possess all of the following characteristics: (1) hydrophytic vegetation (2) hydric soils and (3) wetland hydrology.

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APPENDIX A: LIST OF SUPPLEMENTAL RESOURCES

Links to the following supplemental resources can be found on the N.C. Division of Forest Resources web site: **http://dfr.nc.gov**

1) N.C. Forestry BMP Implementation Survey 2006 – 2008: Survey Form
2) N.C. Forestry BMP Implementation Survey 2006 – 2008: Survey Procedure
3) Silviculture BMP Implementation Monitoring – A Framework for State Forestry Agencies, prepared by the Southern Group of State Foresters Water Resources Committee
4) Forest Practices Guidelines Related to Water Quality

CUSTOMER FEEDBACK SURVEY

If you wish to provide the NCDFR with comments or suggestions for how to better collect and deliver BMP implementation data in the future, please take the time to complete the five question customer survey found at the following web site:

http://www.surveymonkey.com/s/ncbmp_implementation_report_2006-2008

You may also send us an email:

forestry.npsunit@ncdenr.gov

We appreciate your feedback!

APPENDIX B: SAMPLE SIZE AND CONFIDENCE INTERVALS FOR BMP IMPLEMENTATION DATA

Binomial distribution statistics were generated in order to determine the range on the true population mean proportion of successful implementation of BMPs. The 95% confidence interval was determined using the Wilson Interval method (Ulicny, 2001). The Wilson Interval method was chosen in order to give a more reliable confidence interval for instances in which BMP implementation was very high or low and / or the number of samples was low. A z-value of 1.96 was used based on a normal distribution, two-tailed test.

Use of the Wilson Interval method adjusted some observed BMP implementation percentages up or down based on the observed proportion of success (e.g., 90% implementation equals 0.9) and the sample size. The statistical method estimates a more probable proportion of success (i.e., implementation percentage) based on these variables. Therefore, statistically adjusted implementation percentages found in Appendix B may differ from the observed implementation percentages found in the body of the report. Implementation percentages were adjusted by the statistical method when the observed implementation percentage was close to 0 or 100, and / or the sample size was small.

Confidence interval data presented in tables located in Appendix B can be interpreted accurately using the following example sentences, while substituting text in *underlined italics* with the corresponding data for each region, category / specific BMP, implementation percent, and confidence interval:

- **Overall Data by Region:** NCDFR is 95% confident that the true population mean proportion of successful BMP implementation *statewide* is *85*% ± *1*% (Table B1).
- **Data by Category & Region:** NCDFR is 95% confident that the true population mean proportion of successful implementation of BMPs for *SMZs* *statewide* is *91*% ± *1*% (Table B1).
- **Data by Specific BMP & Region:** NCDFR is 95% confident that the true population mean proportion of successful implementation of the *width* BMP for *SMZs* in the *Mountains* is *69*% ± *15*% (Table B2).

Table B1. Sample Size and Confidence Intervals for Overall Implementation of BMPs by BMP Category and Region

(Corresponds to Table 1, Page 8)

BMP Category	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	7661	1482	3515	2664	85 ± 1	66 ± 2	88 ± 1	91 ± 1
SMZs	1795	316	801	678	91 ± 1	70 ± 5	96 ± 1	94 ± 2
Stream Crossings	886	183	404	299	72 ± 3	52 ± 7	77 ± 4	78 ± 5
Debris in Streams	724	137	319	268	86 ± 3	77 ± 7	87 ± 4	89 ± 4
Waste in Water	515	82	231	202	92 ± 2	78 ± 9	93 ± 3	95 ± 3
Temperature	184	31	82	71	90 ± 4	70 ± 15	95 ± 5	91 ± 7
Skid Trails	1515	335	738	442	82 ± 2	58 ± 5	88 ± 2	92 ± 3
Road Entrances	959	127	413	419	89 ± 2	89 ± 5	84 ± 4	93 ± 2
Forest Roads	954	207	488	259	84 ± 2	70 ± 6	83 ± 3	96 ± 2
Rehabilitation	129	64	39	26	44 ± 8	21 ± 10	66 ± 14	68 ± 17

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B2. Sample Size and Confidence Intervals for Implementation of BMPs for Streamside Management Zones by Region

(Corresponds to Table 3, Page 12)

BMPs for SMZs	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	1795	316	801	678	91 ± 1	70 ± 5	96 ± 1	94 ± 2
Width	200	33	91	76	93 ± 4	69 ± 15	97 ± 4	96 ± 5
Maintained	200	33	90	77	87 ± 5	58 ± 16	93 ± 5	89 ± 7
Roads or Trails	200	34	89	77	95 ± 3	77 ± 14	97 ± 4	98 ± 4
Trees Felled	195	33	87	75	82 ± 5	55 ± 16	86 ± 7	87 ± 8
Equipment	196	34	85	77	92 ± 4	73 ± 14	95 ± 5	94 ± 6
Ground Cover	200	33	90	77	95 ± 3	77 ± 14	99 ± 3	95 ± 5
Sediment	201	33	89	79	91 ± 4	63 ± 16	95 ± 5	96 ± 5
Machinery Out	168	29	82	57	90 ± 5	71 ± 16	98 ± 4	87 ± 9
Decks Out	201	34	89	78	94 ± 3	73 ± 14	98 ± 3	95 ± 5
Decks 10 Feet	34	20	9	5	83 ± 12	73 ± 18	91 ± 20	86 ± 28

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment may differ from values in the body of the report based on the statistical method used.

Table B3. Sample Size and Confidence Intervals for Implementation of BMPs for Stream Crossings by Region

(Corresponds to Table 6, Page 16)

BMPs for Stream Crossings	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	886	183	404	299	72 ± 3	52 ± 7	77 ± 4	78 ± 5
Right Angle	124	25	55	44	98 ± 3	93 ± 11	98 ± 5	98 ± 6
Stabilized	103	24	48	31	51 ± 9	23 ± 16	58 ± 13	64 ± 16
Water Control	107	26	51	30	39 ± 9	25 ± 16	45 ± 13	43 ± 17
Channel Avoided	124	26	55	43	96 ± 4	89 ± 12	96 ± 6	96 ± 7
Obstruct Stream	119	23	52	44	80 ± 7	84 ± 15	80 ± 11	74 ± 13
Soil Minimized	123	24	54	45	63 ± 8	27 ± 17	73 ± 12	70 ± 13
Cleared Debris	50	3	27	20	71 ± 12	40 ± 37	72 ± 16	73 ± 18
Crossing Type	136	32	62	42	69 ± 8	32 ± 15	81 ± 10	78 ± 12

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B4. Sample Size and Confidence Intervals for Implementation of BMPs for Debris Entering Streams by Region

(Corresponds to Table 8, Page 19)

BMPs for Debris Entering Streams	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	724	137	319	268	86 ± 3	77 ± 7	87 ± 4	89 ± 4
Debris Kept Out	184	35	81	68	82 ± 6	73 ± 14	79 ± 9	87 ± 8
Stream Not Altered	173	34	72	67	94 ± 4	86 ± 12	93 ± 6	98 ± 4
Soil None	184	34	83	67	86 ± 5	70 ± 15	91 ± 6	86 ± 8
Debris None	183	34	83	66	81 ± 6	75 ± 14	82 ± 8	81 ± 9

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B5. Sample Size and Confidence Intervals for Implementation of BMPs for Waste Entering Water by Region

(Corresponds to Table 9, Page 21)

BMPs for Waste Entering Water	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	515	82	231	202	92 ± 2	78 ± 9	93 ± 3	95 ± 3
Servicing	172	24	79	69	97 ± 3	96 ± 10	98 ± 4	95 ± 6
Chemical Leak	35	6	12	17	92 ± 9	88 ± 25	78 ± 21	95 ± 13
Containers Remove	136	26	63	47	79 ± 7	57 ± 18	78 ± 10	87 ± 10
Fuel Outside SMZ	172	26	77	69	94 ± 4	75 ± 16	99 ± 3	96 ± 5

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B6. Sample Size and Confidence Intervals for Implementation of the BMP for Stream Temperature by Region

(Corresponds to Table 10, Page 23)

BMP for Stream Temperature	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
Adequate Shade	184	31	82	71	90 ± 4	70 ± 15	95 ± 5	91 ± 7

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B7. Sample Size and Confidence Intervals for Implementation of BMPs for Skid Trails by Region

(Corresponds to Table 11, Page 25)

BMPs for Skid Trails	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	1515	335	738	442	82 ± 2	58 ± 5	88 ± 2	92 ± 3
Traffic Minimize	203	34	88	81	95 ± 3	80 ± 13	98 ± 3	95 ± 5
Outside SMZ	199	35	88	76	94 ± 3	76 ± 14	97 ± 4	98 ± 4
Not Along Drainage	156	34	87	35	91 ± 5	67 ± 15	98 ± 4	97 ± 7
Rutting Avoided	203	34	88	81	90 ± 4	80 ± 13	92 ± 6	88 ± 7
Steep Grade Avoid	125	34	74	17	89 ± 6	80 ± 13	91 ± 7	95 ± 13
Water Bars	93	34	51	8	44 ± 10	33 ± 15	57 ± 13	20 ± 25
Prevent Erosion	192	33	83	76	74 ± 6	20 ± 13	80 ± 9	90 ± 7
Follow Contours	131	34	80	17	86 ± 6	83 ± 12	84 ± 8	95 ± 13
Not Grade 25	109	36	60	13	61 ± 9	23 ± 13	79 ± 10	73 ± 22
Skid Trails Protect	104	27	39	38	63 ± 9	21 ± 15	68 ± 14	85 ± 11

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B8. Sample Size and Confidence Intervals for Implementation of BMPs for Access Road Entrances by Region

(Corresponds to Table 12, Page 28)

BMPs for Access Road Entrances	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	959	127	413	419	89 ± 2	89 ± 5	84 ± 4	93 ± 2
First 100 Feet	181	29	80	72	64 ± 7	65 ± 16	60 ± 10	68 ± 11
Excess Soil Avoided	190	31	83	76	90 ± 4	88 ± 12	85 ± 8	94 ± 6
Debris Avoided	189	30	84	75	97 ± 3	97 ± 8	93 ± 6	99 ± 3
Drain Bridged	124	13	46	65	95 ± 4	93 ± 16	87 ± 10	99 ± 4
Drain Stabilized	132	12	56	64	92 ± 5	93 ± 16	85 ± 9	97 ± 5
Drain Water Flow	143	12	64	67	95 ± 4	93 ± 16	93 ± 7	96 ± 5

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B9. Sample Size and Confidence Intervals for Implementation of BMPs for Forest Access Roads by Region

(Corresponds to Table 13, Page 30)

BMPs for Forest Access Roads	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	954	207	488	249	84 ± 2	70 ± 6	83 ± 3	96 ± 3
Road Year Advance	131	23	57	51	56 ± 8	32 ± 18	40 ± 12	85 ± 10
Road Min Width	135	23	57	55	94 ± 4	80 ± 16	94 ± 7	98 ± 5
Gentle Side Slope	93	23	54	16	91 ± 6	72 ± 17	96 ± 6	95 ± 13
Outside SMZ	130	23	57	50	92 ± 5	60 ± 19	98 ± 5	98 ± 5
Follow Contour	88	23	52	13	87 ± 7	80 ± 16	87 ± 9	86 ± 18
Road Grade	82	23	46	13	87 ± 7	64 ± 18	94 ± 7	93 ± 16
Drain Structure	295	69	165	61	82 ± 4	77 ± 10	78 ± 6	94 ± 6

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Table B10. Sample Size and Confidence Intervals for Implementation of BMPs for Rehabilitation of Project Site by Region

(Corresponds to Table 15, Page 33)

BMPs for Rehab	Sample Size				BMP Implementation Rate & 95% Confidence Interval			
	S	M	P	C	S	M	P	C
OVERALL	129	64	39	26	44 ± 8	21 ± 10	66 ± 14	68 ± 17
Cover Established	52	23	15	14	28 ± 12	16 ± 15	35 ± 22	44 ± 23
Soils Prepared	19	12	5	2	57 ± 20	35 ± 24	86 ± 28	75 ± 39
Lime and Fertilizer	15	9	5	1	41 ± 22	18 ± 23	72 ± 31	67 ± 44
Ground Seeded	17	9	5	3	58 ± 21	27 ± 25	86 ± 28	80 ± 34
Mulching Visibility	15	7	5	3	65 ± 22	34 ± 29	86 ± 28	80 ± 34
Mulching Anchored	11	4	4	3	54 ± 25	33 ± 34	50 ± 35	80 ± 34

S: Statewide **M:** Mountains **P:** Piedmont **C:** Coastal Plain

Note: Values that exceed 100% for the upper confidence interval bound should be considered 100% implementation. Some implementation percentages in this table may differ from the observed implementation values in the body of the report due to the Wilson Interval method statistical adjustment.

Notes

Notes

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Forest Water Quality

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Making Every Drop Count

North Carolina Department of Environment and Natural Resources
Dee Freeman, Secretary
Bev Perdue, Governor