

# **North Carolina Stormwater Compliance Evaluation for the 20 Coastal Counties**

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## ABSTRACT

Stormwater is one of the largest sources of pollutants in the United States and contributes sediment, heavy metals, oil, pesticides, fertilizers, bacteria, and other contaminants to coastal waters. Water quality is critical to coastal areas for commercial fishery health and recreational activities. To minimize the introduction of water quality pollutants, North Carolina implemented the State Stormwater Program (SSP) for post construction stormwater management. A study in 2005 identified low compliance rates with the SSP (30.7%) and a follow-up in 2009 found that only 20% of noncompliant sites had rectified their violations. There are currently no studies documenting recent compliance rates with the SSP. This study addressed three objectives: (1) Update the compliance study to include recent trends in compliance and reasons for violations (2) Determine the perceptions of the strengths and opportunities for improvement, and (3) Conduct a program analysis of the SSP. These objectives were achieved by analyzing compliance data from the Division of Energy, Mineral, and Land Resources, conducting interviews with a small sample of entities that interact with the SSP, and reviewing applicable compliance literature. The results of our study show potential areas for improvement and were used to make policy recommendations for North Carolina to increase compliance with these regulations. Our results indicate that compared to the 2005 estimate, compliance in 2012 increased to 50%, and was lower in coastal counties than noncoastal counties. In total there were 2,838 compliance inspections between 2008 and 2012. Yearly inspections increased between 2008 and 2010, but decreased sharply in 2011 and remained low in 2012. The majority of violations were due to reporting and maintenance issues. Interview respondents indicated that the main impediments to compliance are maintenance and education, and that compliance could be improved through increased maintenance checks and public outreach efforts. The program analysis showed that while the stormwater program generally has clear regulations, it could benefit from increased visibility of the regulating agency, engagement, as well as education. Potential avenues for improvement are discussed, and are considered within the context of our findings.

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## LIST OF ABBREVIATIONS

A list of abbreviations consistently used throughout our paper.

- BMP                      Best Management Practice
- BUA                      Built upon area
- CAMA                    Coastal Areas Management Act
- Class SA Waters              Shellfish harvesting waters
- CWA                      Clean Water Act
- DEMLR                  Division of Energy, Mineral and Land Resources
- DMF                      Division of Marine Fisheries
- DWQ                      Department of Water Quality
- DWR                      Department of Water Resources
- LID                        Low Impact Development
- MS4                        Municipal Separate Storm Sewer System
- NC DENR                  North Carolina Department of Environment and Natural Resources
- NOD                        Notice of Deficiency
- NOV                        Notice of Violation
- NPDES                    National Pollutant Discharge Elimination System
- ORW                        Outstanding Resource Water
- SSP                        State Stormwater Program

# 1. INTRODUCTION

Stormwater runoff is one of the largest sources of pollutants in the United States. Stormwater is excess precipitation which flows over land and into ponds, creeks, rivers and oceans. Impervious surfaces from development including roads, parking lots, buildings, and sidewalks, greatly increase the amount of stormwater runoff because they prevent the natural infiltration process (Booth and Jackson, 1997). When water is unable to infiltrate into the ground, it flows down gradient and often to a stormwater drain that leads directly into a receiving waterbody (Arnold and Gibbons, 1996; Mallin et al, 2000).

Coastal areas such as the twenty coastal counties of North Carolina are extremely susceptible to negative impacts from stormwater pollution because of their proximity to water and their reliance on coastal ecosystems. The fishing, shellfish harvesting, and tourism industries are all dependent on the coastal resources of the state, directly tying water quality to the livelihoods of residents. According to a 2004 study by Crossett et al, coastal areas cover merely 17% of the United States, but are home to over half of the population. As the U.S. population continues to rise, so will the amount of people and development on the coast. If unmanaged, this will increase the amount of stormwater runoff reaching coastal waters. Increased water flow can alter the hydrology and geomorphology of rivers and streams (Faustini et al, 2009). As this water flows over impervious surfaces it can encounter and transport a myriad of pollutants, which can have negative impacts on both humans and animals.

## 1.1 STORMWATER IMPACTS AND POLLUTANTS

Impervious surfaces associated with development can dramatically increase the speed and amount of discharge into rivers and streams (Barker et al, 1994; Booth and Jackson, 1997) which can alter river widths and depths (Leopold 1973; Faustini et al, 2009). Increased flow can also intensify erosion resulting in higher sediment transport rates (Thillinghast et al, 2011 for a review).

Sediment is one of the most pervasive stormwater pollutants, as it is both readily available in the natural environment and can easily enter the system when land is disturbed during construction. This sediment can attach to and convey other pollutants such as heavy metals (Jeng et al, 2005), pesticides, fertilizers (Hageman et al, 2006), oil (McKenzie et al, 2009), and dangerous chemicals such as polycyclic aromatic hydrocarbons (PAHs) (Hwang and Foster, 2008; Kamalakkannan et al, 2004). Stormwater has also been found to contain bacteria resulting from human and animal waste such as *E. coli* (Parker et al, 2010) and fecal coliform (Mallin et al, 2000) which can cause major effects on animal and human health.

#### *IMPACTS ON HUMANS AND ANIMALS*

Stormwater pollutants pose threats to both fish species and humans; excess nutrients can cause eutrophication and dead zones in aquatic habitats (Lapointe and Matzie, 1996), heavy metals can interrupt sensory cues in fish, and PAHs cause birth defects and embryo mortality in herring and pink salmon (McCarthy et al, 2008). The accumulation of heavy metals also makes fish, crabs and shellfish unsafe for human consumption (Lewis and Chancy, 2008). One of the most ubiquitous pollutants, fecal coliform, can cause disease outbreaks in commercially harvested aquatic species, in particular shellfish and can prevent them from being harvested (Parker et al, 2010).

Shellfish are important assets in coastal North Carolina because of their economic value for commercial fisheries (oyster, clam, and mussel) as well as their ecosystem services such as filtering water (Ward et al, 1994), creating habitat (Grabowski and Powers, 2004) and protecting against erosion (Meyer et al, 1997). In coastal North Carolina, fecal coliform has been found to drastically exceed recreational water quality guidelines due to inputs from stormwater runoff (Parker et al, 2010) and results in the permanent and temporary closure of many shellfish harvesting areas (see Appendix 1 for an in depth analysis of closure days). Because of their reliance on these coastal resources (Corridore, 2001), North Carolina was one of the first states to address stormwater

pollution through policy and today there are federal, state and local stormwater regulations applicable in North Carolina.

## 1.2 NORTH CAROLINA STORMWATER POLICY

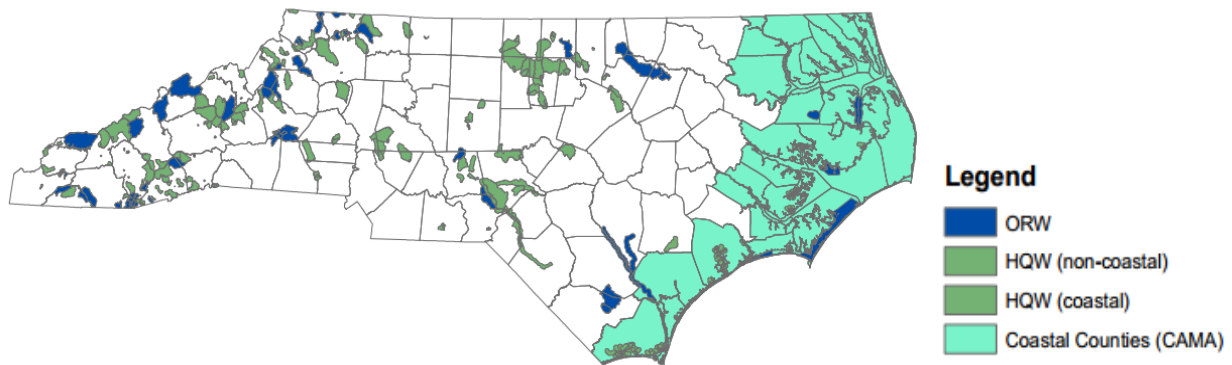
### FEDERAL AND STATE REGULATIONS

There are a number of laws in place at the federal, state, and local levels in North Carolina to protect surface water quality from stormwater inputs. The Federal Clean Water Act (CWA) Section 402 authorizes the federal laws while the state regulations are authorized under the State Administrative and General Codes. In 1987, CWA Section 402 created the National Pollutant Discharge Elimination System (NPDES) Phase I permitting program for multiple sewer sanitary system (MS4) servicing areas with populations greater than 100,000. The introduction of NPDES Phase II permits in 2003 expanded the scope of NPDES regulations to include nonpoint source pollution. NPDES Phase II permits are applicable to specific industrial practices and smaller municipalities with populations of 50,000. However, the administration of these programs are the responsibility of individual states. In North Carolina, areas not regulated by NPDES Phase I or II, must follow the NC State Stormwater Laws. These programs include the Nutrient Sensitive Waters Management Program, the State Stormwater Program (SSP) amongst others specified within the NC Administrative Code (15A NCAC §§02H .1000-1020). A number of North Carolina state agencies are responsible for the development, implementation, and enforcement for the SSP. Implementation of the rules falls to the Division of Energy Minerals and Land Resources (DEMLR), part of the North Carolina Department of Environment and Natural Resources (NC DENR). This includes the responsibility of issuing permits and conducting compliance inspections. Local governments may elect to adopt their own stormwater programs and ordinances as long as these programs meet the requirements of the state.

## STATE STORMWATER PROGRAM IMPLEMENTATION & ENFORCEMENT

### *Conditions for Potential Permit Applicants*

The SSP is designed to mitigate stormwater generated by construction and development projects by requiring the installation of post construction stormwater management techniques. The program requires a stormwater permit for any construction project that 1) adds 10,000 square feet or more of built upon area (BUA) within the 20 coastal counties or 2) disturbs more than one acre or requires a sedimentation & erosion control plan, or 3) requires a CAMA major permit (15A NCAC §§02H .1000-1020). These regulations (adopted in 2008 as a portion of the State Stormwater Management Program in effect since the 1980's) have design specifications that must be met by construction and redevelopment projects. The requirements that a particular project must meet are determined based on proximity to state-designated Outstanding Resource Waters (ORW), High Quality Waters (HQW) or Commercial Shellfish Waters (Class SA Waters) and if the project is within the 20 coastal counties (Figure 1). Permits include options based on the amount of built upon area (BUA, the total percentage of the site that contains impervious cover) for the site (high density if BUA > 12.5%, low density if BUA < 12.5%). Once a potential permit holder determines the appropriate permit type, he or she must choose a stormwater mitigation method or Best Management Practice (BMP) to incorporate into the site's design.



**Figure 1: State Stormwater Program Applicable Areas, including Outstanding Resource Waters (ORW), High Quality Waters (HQW), and 20 Coastal Counties, From NC DEMLR**



### ***Selection of Best Management Practices***

The BMP Manual published by DENR, contains pre-approved BMPs, which are categorized as either structural (e.g. detention ponds and infiltration systems) or nonstructural (e.g. education efforts and litter removal programs) (NCDWQ, 2007). The manual notes that BMP installation and design is both an art and a science and instructs professionals to use it as a guide but to defer to their professional judgment and the law for any specific requirements.

Individuals may choose to install a BMP which is not preapproved by the state, but they must prove with “convincing evidence” that the proposed BMP meets all regulations or is better than preapproved BMPs (NCDWQ, 2007). The manual stresses that proposing a new BMP will slow down the permit approval process, which may already take more than three months. This more difficult route can often discourage the use of new and innovative BMPs including low-impact development (LID) techniques, which aim to mimic natural hydrologic conditions through vegetated conveyances and natural infiltration (Coffman, 2000). Although LID techniques can provide a range of economic, ecologic, and social benefits, they are rarely implemented (Thurston, 2011).

### ***Compliance Inspections and Enforcement***

Approved permits are subject to compliance inspections, both routine, or based on complaints. During a compliance inspection, a DEMLR employee will visit the permit site and ensure that the site meets all specified requirements. These requirements range from proper paperwork to BMP installation, maintenance, and BUA as specified in the permit (DWQ, 2005; Dohrman, 2009). Examples of paperwork requirements include certification from the engineer and signed deed restrictions (DWQ, 2005). Maintenance requirements can encompass the height, type, and condition of vegetation as well as the presence of trash. Installation requirements refer to design specifications such as the slope, and the location of swales and outfalls. Examples of BUA

requirements include the location, grading, and amount of BUA in accordance with the approved permit. After a site visit, the permit holder is notified of any potential issues and is given a grace period to respond to and rectify the issues. DEMLR employees work directly with the permit holder to aid them in becoming compliant. If violations are unaddressed after this period, DEMLR may issue a notice of deficiency (NOD), notice of violation (NOV) or take steps to issue a fine for noncompliance. Currently fines can be assessed at up to \$27,500 a day (Barnes, 2008).

#### STORMWATER COMPLIANCE RATES IN COASTAL NORTH CAROLINA

Despite the laws put in place to protect water quality for the state of North Carolina, previous studies indicate very low rates of compliance with the permitting system. In 2005, there was a 26.9% rate of compliance for detention ponds, and 30.7% for all stormwater BMPs in five coastal counties within the Wilmington Region (DWQ, 2005). A follow up study in 2009 investigated a random sample of high density detention pond that were noncompliant in the 2005 study, and showed that only a 20% had rectified their compliance issues (Dohrman, 2009). Currently, these are the only two studies that address compliance to permits issued through the SSP within the 20 coastal counties. Neither study is directly applicable to the stormwater program today, as the 2005 study was conducted before the 2008 regulation changes, and the 2009 paper was only based on incompliant sites. An updated compliance study and further knowledge about perceptions of improving the stormwater program are needed to aid in water quality management within North Carolina's coastal counties.

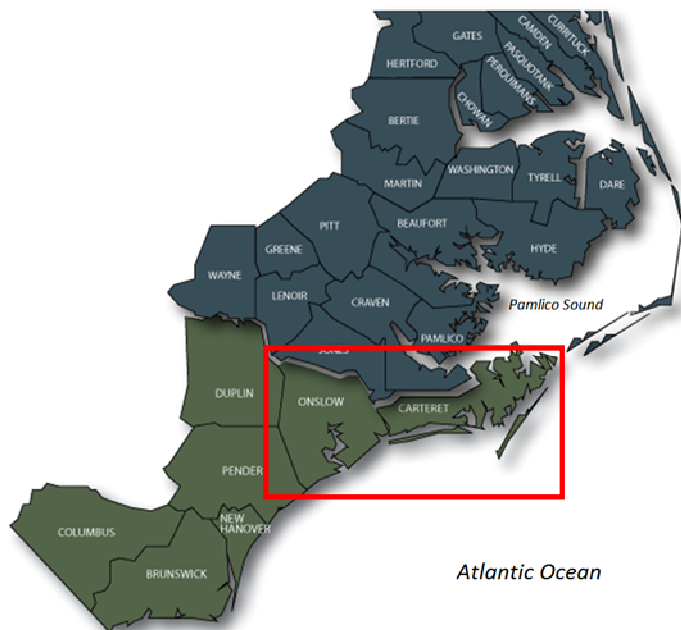
## 2. PURPOSE OF STUDY AND OBJECTIVES

The coastal waters of North Carolina serve as both biologic and economic resources. The SSP attempts to protect these resources from stormwater impacts through the permitting of post-construction stormwater BMPs. The goals of this study are to 1) identify recent trends in compliance rates and determine reasons for violations 2) identify the strengths and opportunities for improvement, and 3) provide an analysis of the state stormwater program.

## 3. METHODS

To address our research questions, we developed a three-pronged approach to our analysis study consisting of:

1. Statistical analysis of stormwater compliance data obtained from DEMLR
2. Qualitative analysis of the interviews with those who interact with the permitting program
3. Development of a program analysis rubric based on our findings and literature review



**Figure 2** The twenty coastal counties of North Carolina, with special focused area of Onslow and Carteret County, NC DENR.

### 3.1 STUDY AREA

The 20 coastal counties of North Carolina, designated by the Coastal Area Management Act (CAMA) are the focus of our study (Figure 2). All of the 20 coastal counties are either in contact with the Atlantic Ocean, or drain to Albemarle or Pamlico Sounds, which ultimately lead to the Atlantic Ocean. Noncoastal counties are discussed as a point of reference. To provide insight to how the SSP operates

on a day to day basis we focused our interviews specifically on Onslow and Carteret Counties.

In the selection of Onslow and Carteret for further analysis, we considered four items:

- Number of compliance checks between 2008 -2012 must be at least 40
- Rate of development
- Compliance rate in 2012
- Presence of Class SA waters

Both Carteret County and Onslow County contain areas of active farmland, forests, and lands exposed to fresh and ocean water representing the range of environments presented within the coastal counties. These counties both contain lands previously developed as well as undergoing development. This is important because the primary triggers for stormwater permits are construction and development activities, suggesting the presence of both new and old permit holders. Between 2000 and 2010, the population density increased by 18.2% in Onslow County and 11.9% in Carteret County, although population increased by 9% and 13%, respectively (US Census). The growth in population density for both counties falls within the middle 50% (inter quartile range) of all coastal counties, with Onslow slightly above and Carteret below the median (13.2%). Finally, the data obtained from DWR indicate that compliance checks occurred regularly within both counties throughout the period of 2008-2013.

Individual characteristics of each county are described below:

- **Onslow County:** The land faces the ocean with a few barrier islands close to shore. The county holds a relatively stable resident population throughout the year, and does not receive as much tourist attention as seen in other places along North Carolina's coast. One of the most prominent characteristics of Onslow County is the presence of Camp Lejeune, a military base.
- **Carteret County:** Characterized by a mix of different landscapes including, barrier islands, sound access, forests and highly developed city areas. Unlike some of the other coastal counties with barrier islands, the county maintains a considerable year round population with a reputation as a popular summertime tourist destination.

## 3.2 STATISTICAL ANALYSIS OF DEMLR DATA

### *DESCRIPTIVE STATISTICS & COMPLIANCE RATES*

We obtained compliance records from all state stormwater permit inspections conducted by the Department of Water Quality between January 1<sup>st</sup>, 2008 to July 31<sup>st</sup>, 2013 from DEMLR. The records for each inspection included:

- **Administrative region:** Washington, Wilmington, Fayetteville, Mooresville, Raleigh, or Winston-Salem
- **Permit number:** Permit number issued by SSP
- **Permit type:** Major or minor
- **Inspection type:** Stormwater, compliance evaluation, complaint, modification offsite, or transfer renewal
- **Owner:** Name of the permit holder or company
- **Facility:** Site registered for stormwater permit
- **Location:** Address of the facility
- **County:** Name of the located county
- **Inspection date:** Date of inspection from January 1<sup>st</sup>, 2008 to July 31<sup>st</sup>, 2013
- **Reason for inspection:** Routine, follow-up, complaint, or other
- **Inspection type:** Compliance evaluation, transfer renewal, modification offsite, complaint, or stormwater
- **Compliance determination:** Compliant, non-compliant, or neither

The inspection type of either “stormwater” or “compliance evaluation” are routine compliance checks. Inspection types labeled “complaints,” are those initiated due to referrals from citizens or other government agencies. “Modification offsite” indicates that the permit holder chose to manage stormwater at a different location, while “transfer renewal” means that the site was being inspected due to the renewal or modification of the permit. The reasons for inspection are more intuitive, as “routine” denotes a routine inspection, “follow-up” indicates that a site is being re-visited after an initial compliance evaluation, and a “complaint” is initiated by a complaint.

Because the compliance evaluations did not constitute a random sample, to prevent bias in the analysis we considered only inspection types of “stormwater” and “compliance evaluation” and reasons for inspection being “routine”. While this is still not a completely random sample, it limits

bias by excluding visits prompted by previous noncompliance or complaints. We referred to the filtered data as “routine” compliance inspections and the unfiltered data as “all” inspections. We considered sites with a compliance determination of “neither” to be noncompliant as they were in violation of one or more permit requirements and therefore could not be considered fully compliant. Additionally, because the 2013 data did not represent an entire year, only data from 2008 to 2012 was used for the analysis. Due to low sample sizes of major permits (n=2) we did not analyze differences between major and minor permits.

We analyzed the DEMLR data to determine:

- The number of routine, non-routine, and total inspections per year
- The number of routine inspections in each county for the study period
- The average number of counties inspected (routine) per year in coastal and noncoastal counties
- The number of counties inspected (routine) per year for coastal and noncoastal counties
- Percent compliance for routine inspections during the study period for coastal, noncoastal, and all counties
- Average yearly compliance for routine inspections within the coastal and noncoastal counties
- Percent compliance and number of routine inspections in 2012

We calculated the percent compliance for the study period by dividing the total number of compliant permits by the total number of routine inspections. Averages between coastal and noncoastal counties were tested for significant differences using two-tailed t-tests.

### *ANALYSIS OF VIOLATION TYPES*

In order to determine the most frequent reasons for noncompliance, we used responses from thirteen yes or no questions answered during every compliance inspection (Appendix 2). We categorized these questions into six types of violations. We based four of the categories (“maintenance”, exceeding built upon area “BUA”, “reporting”, and “installation”) on the 2005 DWQ study. The two remaining categories (“other permit” and “other water quality”) we based on additional questions within the data. Similar to the 2005 study, examples of maintenance violations encompassed BMPs that did not meet the permit requirements for trash removal and height, type,

or condition of vegetation. Examples of BUA violations included more BUA than was specified in the permit, or incorrect grading. The reporting category was used for incomplete records such as missing engineer's certifications, signed operation and maintenance agreements, or deed restrictions. Installation violations pertained to the construction of BMPs, such as if the inlet and outlet structures were built as per the approved plans. The "other permit" and "other water quality" categories were used at the discretion of DEMLR employees and were used as a catch-all for not complying with other permit or water quality specifications, respectively.

We coded each compliance inspection in 2012 with either a "Yes" or a "No" for each of the six categories. A "Yes" indicated that the inspected site was compliant with all questions within the category, while a "No" designated that at least one violation occurred within the group. We calculated percentages for each violation type for all sites inspected in 2012, and further separated the data into routine evaluations for both compliant and noncompliant sites in coastal and noncoastal counties. We also compiled data on how many notices of violation (NOVs) were cited during the study period as well as the percentages of active stormwater permits inspected during 2012. The number of active stormwater permits inspected was determined by dividing the number of total inspections within the DEMLR dataset, by the number of active permits in the public record (DEMLR, 2014). For this calculation, we used only state stormwater permits that were active, had an original issue date prior to 2013, and excluded duplicate permits.

#### *LINEAR REGRESSION ANALYSIS*

In order to examine possible correlations between percent compliance and other variables, we compiled additional geographic and demographic data that could be correlated with compliance. We calculated the coverage of Class SA waters in each county based on DENR's State Stormwater Program GIS reference layer publically available on their website (Division of Water Resources, 2013). The number of square miles in each county we obtained from 2010 US census data and the estimated populations were collected from the North Carolina Office of State Budget and

Management. Population density was then calculated by dividing the estimated population by the area (population/square mile). The number of NOVs, total inspections, as well as the percentage of routine visits per county and were obtained directly from information provided by DEMLR. Data were compiled for each county by year and were also consolidated into yearly totals for coastal and noncoastal counties. We then performed simple linear regressions between each variable and percent compliance for the full dataset (by county/year), as well as the consolidated dataset (by year/coastal or noncoastal). R squared values were considered to be correlated if greater than 0.5.

### 3.3 QUALITATIVE INTERVIEWS

#### INTERVIEW SAMPLING, DESIGN, AND RECRUITMENT

Our qualitative survey explored the experiences and perspectives of a diverse group of those involved with the SSP in the coastal counties. We inquired about participants opinions regarding strength, compliance, and opportunities for improvement. The sampling design was stratified to include broad views in the state administration agency, local government, permit holders, engineers, and environmental organizations (Table 1).

Our interview protocol utilized open-ended interview questions to allow participants to elaborate on their unique experiences following a structured format for qualitative comparison across interviews (Marshall and Rossman, 2011). Interview questions focused on five topics, including 1) perception of program effectiveness, 2) compliance and enforcement, 3) program strength and opportunities for improvement 4) local development drivers, and 5) suggestions for improvement. Interviews consisted of nine questions total, seven standard questions regardless of interview group and two questions based on group membership. Questions were developed by considering previous studies concerning BMP effectiveness, compliance enforcement (DWQ, 2005; Dohrman 2009; Bruce and Barnes, 2008), confusion with requirements of the program (DWQ, 2007), and studies linking rapid development to water quality impairment (Mallin et al, 2000; Line et al, 2013). The North Carolina Coastal Federation reviewed the interview protocol and provided feedback on



intended questions. Our protocol was approved by the Duke Institutional Review Board as Project # B0991 (Appendix 3).

**Table 1: Interview group classification, potential interviewees and their job relationship with stormwater management**

<b>Interview Classification</b>	<b>Potential Interviewees</b>	<b>Relationship to Stormwater Program</b>
<b>State Government</b>	Department of Mineral, Energy, Land and Resources regional offices of Wilmington and Washington.	State Stormwater Program administration, responsibilities include permit application review, permitting, and enforcement
<b>Local Government</b>	Town, city, and county governments.	Local governments may elect to create and administer complementary stormwater management programs and may also hold permits.
<b>Permit Holder</b>	Developers, land and business owners.	Regulated constituency: this group primarily consists of those who own property which requires a state coastal stormwater permit.
<b>Industrial Engineer and Contractor</b>	Industrial engineers and consultants for stormwater management; contractors for stormwater BMP construction.	Plan, design, construct, and/or maintain stormwater BMPs
<b>Environmental Organization</b>	Environmental groups and organizations with particular interests in protecting the environment.	Public education of stormwater related topics; ensuring the protection of environment.

We identified potential interviewees and contact information through web based searches for engineering firms, environmental groups, local government employees, and active permit holders based in Onslow and Carteret Counties. To contact State Government employees we interacted with the Public Information Officer. Potential interviewees were first contacted between February 22<sup>nd</sup> and March 15<sup>th</sup>, 2014 through a combination of phone and e-mail correspondence. When possible, initial contact with interviewees occurred via email (Appendix D) and where necessary followed up via telephone. An Informed Consent form (Appendix E) was sent to the participants before an interview and consent was confirmed before starting the interview. We conducted interviews over the phone and in person, each lasting between 20 and 40 minutes. Interviews were recorded and

later transcribed. In effort to keep participant information confidential, each respondent was assigned a unique identifier designating interview group membership and location. Group membership is denoted as: LG, PH, ENV, and IND signifying Local Government, Permit Holder, Environmental Group, and Industry, respectively. Location is then denoted by either an O or C for Onslow or Carteret County. The identifier LGC1 can be read as Local Government, Carteret County #1.

### INTERVIEW ANALYSIS

To aid our interpretation of interview transcripts we used the computer program NVivo version 10 (QSR, 2012). NVivo assists in the organization and classification of qualitative data for textual analysis based on a system of user defined topics or “nodes”. The analysis of our interviews took place in two distinct steps: coding interviews with specific “nodes” and querying interviews for response analysis.

In order to code the interviews, we created a list of thematic codes representing commonalities across our interviews and created a coding manual (Appendix 7). Transcripts were then reviewed, and any quotations supporting a theme were then coded as such. To ensure consistency between researchers, we conducted preliminary coding until we achieved a 95% similarity rating within the same transcripts. We then used the coded transcripts and NVivo’s query functions to analyze and identify trends across questions and individual interviews.

### 3.4 PROGRAM ANALYSIS

To conduct a program analysis, we reviewed stormwater permitting literature to identify the main factors that influence compliance rates. Studies were identified by using the search terms “Stormwater” AND “Permit”, “Compliance”, “Permit Compliance Rate”, or “Enforcement”. To focus the review on general components of compliance, studies dealing exclusively with the technical ability of individual structural BMPs to meet water quality standards were excluded.

Using the results of the literature review we designed a rubric to highlight the important factors that aid compliance, and ultimately determine areas in which a stormwater permitting program excels or needs improvement. Across the studies, we observed four different components that affect the rate of compliance: clarity of regulations, community engagement with regulations, education and outreach, and finally visibility of enforcement action or regulatory agency. We then used this rubric to assess the performance of the NC SSP (Table 2). Each element received a score of high, medium, or low. In scoring the SSP we utilized feedback from DEMLR data, interviews, as well as knowledge of current events and media analysis.

**Table 2: Program Analysis rubric for North Carolina coastal Stormwater Permit Compliance**

<b>Metric</b>	<b>Rating Elements</b>
<b>Clarity</b>	Refers to how clear a program is expressed. Elements measured within this category include frequency and directness of communication, and ease at which permit requirements are understood.
<b>Level of Engagement</b>	The element of engagement references the amount of outside involvement with the program. This element can refer to the presence of active special interest groups, concerned citizens, the presence of local ordinances, and active management of permits
<b>Education and Outreach</b>	This element measures attempts by the program to educate those subject to the rules. This can take the form of public outreach campaigns, educational materials or the provision classroom workshops.
<b>Visibility of Regulating Agency/ Enforcement Action</b>	This element attempts to capture permit holders' conceptions on how likely they are to experience an inspection. It evaluates the overall visibility of the agency pertaining to checking in on permits and or the public awareness of enforcement actions.

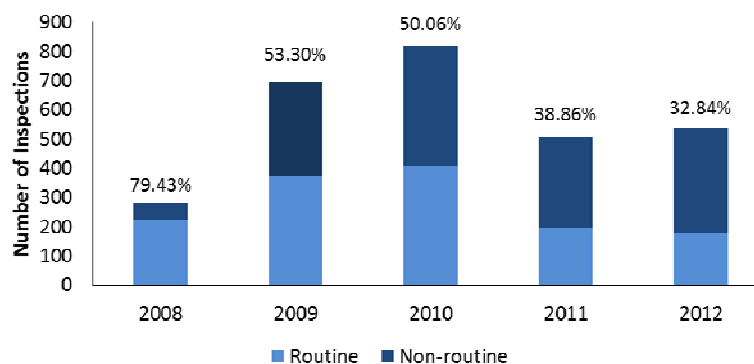
## 4. RESULTS & DISCUSSION

### 4.1 STATISTICAL ANALYSIS OF DEMLER DATA

#### DESCRIPTIVE STATISTICS & COMPLIANCE RATES

In the dataset provided by DEMLR, a total of 2,838 compliance inspections were conducted between January 1, 2008 and December 21, 2012. Of those, 1,377 met our requirements of being routine evaluations. The total number of compliance evaluations increased from 282 in 2008 to 817 in 2010. However, in 2011 this number drastically decreased to 507, and remained steady with 536 inspections in 2012 (Figure 3). This decrease in evaluations could possibly be attributed recent budget cuts within the state.

The percentage of compliance evaluations that were routine decreased over the entire study period from 79% in 2008 to 33% in 2012. This decrease in routine evaluations could be a function of decreased staff, whose available resources may be more focused on complaints. Conversely, this may be a response of a deliberate attempt by DENR to become more of a “customer service” agency as emphasized in their recent publication of customer service results (NC DENR, 2013).



**Figure 3: Number of routine and non-routine surveys for each year in the study period. Percentages above each year represent the percent of inspections that were routine.**

The number of inspections varied across all of the counties. In total, 41 of North Carolina’s 100 counties (41%) had at least one routine compliance evaluation between 2008 and 2012 (Table 3). Alexander, Columbus, Davidson, and Pitt counties had only one compliance visit over the five years,

while New Hanover County had the most, with 281 compliance visits. The 20 coastal counties are all represented within the dataset, accounting for nearly half of all of the counties surveyed. On average there were significantly more surveys per year in coastal counties ( $7.2 \pm 1.11$ ) than noncoastal counties ( $8.4 \pm 1.53$ ; 2-tailed t-test;  $p=0.002$ ; Figure 4). The larger number of compliance inspections in coastal counties may be due to the fact that there are more permits within those counties, as roughly 94% of permits were located in coastal counties in 2012. Although the number of compliance inspections have declined, the number of counties surveyed has steadily increased from 19 counties in 2008, to 31 in 2012 (Appendix 6.1)

Total percent compliance for all counties within the five year span was relatively constant between 2008 and 2010 at approximately 30%, but then increased to 49.8% in 2011 and 50% in 2012 (Figure 5). It is unclear if this increase in compliance was due to any institutional changes, but it is possible that the compliance increase in 2011 was due to a time lag in implementing 2008 rule changes. Average yearly compliance within noncoastal counties ( $58.64\% \pm 5.32$ ) was significantly higher than coastal counties ( $36.67 \pm 5.81$ ) for the study period (2-tailed t-test;  $p=0.02$ ; Figure 6). This trend is consistent from year to year, with the exception of 2011 (Figure 5). Administrative regions also varied in their rate of compliance. The Winston-Salem region had the highest rate of compliance for the study period with 67.39% while the Raleigh region had 0% (Figure 7). However, the sample sizes for Raleigh and Fayetteville were relatively low with four and nine visits respectively. Increasing the sample sizes for these regions may result in a more accurate estimate of compliance.

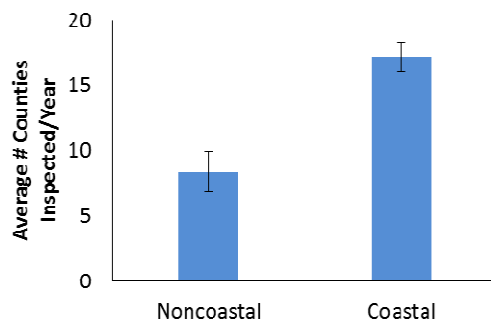


Figure 4: Average number of counties inspected per year for both noncoastal and coastal counties. Error bars represent  $\pm$  SE. noncoastal counties had significantly less counties surveyed coastal counties by 2-tailed t-test;  $p=0.002$ .

**Table 3: All counties with at least one routine survey between 2008 and 2012 and corresponding number of routine inspections in ascending order. Bolded names indicate the twenty coastal counties.**

County	Routine Inspections	County	Routine Inspections
Alexander	1	<b>Bertie</b>	10
Columbus	1	<b>Washington</b>	10
Davidson	1	<b>Camden</b>	12
Pitt	1	Watauga	12
<b>Gates</b>	2	Henderson	13
Robeson	2	<b>Hertford</b>	13
Transylvania	2	<b>Chowan</b>	15
Stokes	3	<b>Pasquotank</b>	37
Buncombe	4	Union	37
Chatham	4	<b>Perquimans</b>	38
<b>Hyde</b>	4	<b>Pamlico</b>	44
Ashe	5	<b>Pender</b>	51
Catawba	5	<b>Currituck</b>	54
Davie	5	<b>Carteret</b>	63
Forsyth	5	<b>Dare</b>	77
Randolph	5	<b>Beaufort</b>	94
Wilkes	5	<b>Onslow</b>	116
Cumberland	7	<b>Craven</b>	148
Jackson	8	<b>Brunswick</b>	165
<b>Tyrrell</b>	8	<b>New Hanover</b>	281
Cabarrus	9		

Compared to the 2005 estimate of compliance based on the Wilmington region (DWQ, 2005), North Carolina has greatly improved compliance from 30.7% in 2005 to 50.0% in 2012. However, during this time, the Wilmington region itself has actually decreased compliance to 26.5%. Although compliance from the 2009 study (Dohrman, 2009) is not directly comparable because it focused on permits that were already found to be noncompliant, our estimate of compliance in 2009 was higher than their 20% rate by almost 10% (Figure 6). The difference between the compliance rate for routine permits and those previously found to be noncompliant supports Dohrman’s (2009) finding that between 2005 and 2009, many violations were either not rectified, or were repeat offenders. One reason for this may be that permit holders do not see enough consequences to warrant keeping their BMPs in compliance. This is corroborated by the fact that in 2008, approximately only 20% of surveys had reasons for inspection being follow-ups, complaints, or other (Figure 3). This relative lack of follow-ups in 2008 might explain why many BMPs had not rectified their compliance issues, and the 2009 Dohrman follow-up study may be a reason that the

percentage of non-routine surveys increased to 47% in 2009, and 50% in 2010. This could also be due to a relatively recent increase in emphasis on customer service within NC DENR (NC DENR, 2013).

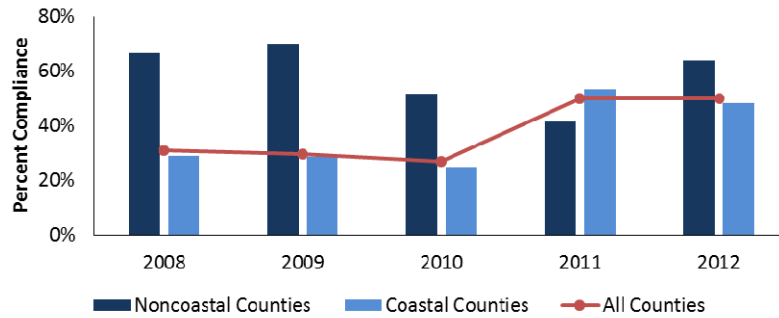


Figure 5: Total percent compliance from 2008-2012 for noncoastal, coastal, and all counties.

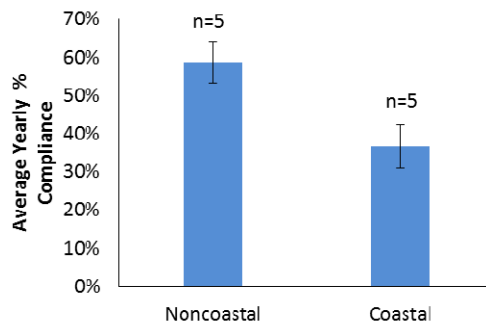


Figure 6: Average yearly compliance for both noncoastal and coastal counties from 2008-2012. Error bars represent  $\pm$  SE. Noncoastal counties had significantly higher rates of compliance than coastal counties by 2-tailed t-test;  $t=0.02$ .

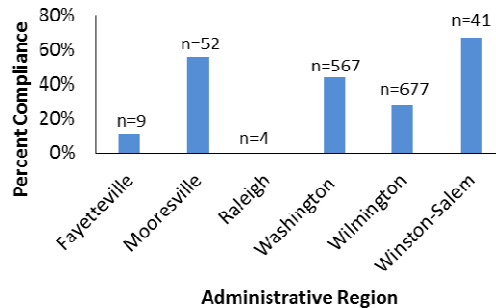


Figure 7: Percent compliance for the six administrative regions surveyed (Fayetteville, Mooresville, Raleigh, Washington, Wilmington, and Winston-Salem) 2008-2012.

## COMPLIANCE IN 2012

Because 2012 was the most recent full year of compliance testing, we specifically explored the trends present within this time period. During 2012, there were 176 routine inspections accounting for 32.84% of the total visits (Figure 3). In 2012 the total rate of compliance was 50%, coastal and noncoastal counties achieved compliance rates of 48% and 64%, respectively (Figure 5, Figure 6**Error! Reference source not found.**). A total of 31 counties were surveyed in 2012, including 19 of the 20 coastal counties. Of the coastal counties, compliance was lowest in Camden with a rate of 0% compliance (n=1) and highest in Washington and Tyrrell with 100% (n=3). However, these counties had very low sample sizes of permits inspected and it is likely that additional surveys would yield a more accurate estimate. Of the noncoastal counties, Robeson and Watauga had the lowest compliance rate with 0%, while Alexander, Ashe, Forsyth, Henderson, Pitt and Union all had 100% compliance (Table 4). It is important to note that all noncoastal counties had a sample size less than five.

In 2012 Onslow and Carteret counties exhibited differences in rate of compliance as well in the number of routine inspections. Compared to Onslow's compliance rate of 25%, Carteret had a higher compliance of 67% (Table 4). The number of inspections exhibited the opposite trend, as Onslow County had twelve inspections while Carteret only had three. With such a low sample size for Carteret in 2012, it is likely that this estimate is not completely indicative of the true compliance rate. Of the 14 NOV's issued for in 2012, two occurred in Carteret and one occurred in Onslow.



**Table 4: Percent compliance by county and corresponding number of surveys for routine compliance checks in 2012 in ascending order.**

	<b>County</b>	<b>Percent Compliance</b>	<b># Surveys</b>		<b>County</b>	<b>Percent Compliance</b>	<b># Surveys</b>
<b>Coastal Counties</b>	Camden	0%	1	<b>Noncoastal Counties</b>	Robeson	0%	1
	New Hanover	15%	27		Watauga	0%	1
	Onslow	25%	12		Catawba	33%	3
	Beaufort	30%	10		Buncombe	50%	4
	Brunswick	33%	21		Cabarrus	50%	2
	Pender	40%	5		Cumberland	50%	2
	Currituck	43%	7		Alexander	100%	1
	Dare	56%	9		Ashe	100%	1
	Hertford	60%	1		Forsyth	100%	1
	Perquimans	63%	8		Henderson	100%	2
	Carteret	67%	3		Pitt	100%	1
	Chowan	67%	3		Union	100%	3
	Pasquotank	71%	7				
	Bertie	75%	4				
	Craven	75%	16				
	Pamlico	89%	9				
	Hyde	100%	1				
Tyrrell	100%	3					
Washington	100%	3					

*ANALYSIS OF VIOLATION TYPES*

Similar to the results of the 2005 study, of the 536 inspections in 2012, the majority of violations were due to reporting errors or maintenance issues that occurred in 28.4% and 14.6% of inspections respectively (Table 5). Of these surveys, 176 were routine, with 37.5% having a reporting violation and 14.8% having a maintenance issue. Of routine inspections that were noncompliant, reporting and maintenance issues were still the most prevalent.

Of permit inspections marked noncompliant only 77.3% had at least one violation. This is an interesting result, as one would expect all noncompliant sites to have at least one violation. However, inspected sites may have failed compliance evaluations for reasons not represented in the thirteen questions with which DEMLR employees are prompted. Noncompliant coastal counties had 58.8% of inspected permits with a reporting violation, 22.5% with a maintenance issue and 8.8% with a BUA violation. Noncoastal counties had higher instances of reporting and maintenance

violations with 62.5% for each, but no BUA violations. However, noncoastal counties had more installation violations with 37.5% compared to 3.8% in coastal counties. It is unclear why coastal counties have more BUA violations and noncoastal counties have more installation violations, but it may have to do with the rapid development in coastal counties (Crossett et al, 2004) and the lower number of permits in noncoastal counties. The noncoastal counties in this category also only had 8 inspections, and increasing the sample size may give a more accurate estimate.

Although 88 routinely inspected sites found to be compliant, 17.0% still had at least one violation. One potential reason for this could be that some violations may not be enough to fail a compliance inspection. For compliant sites, noncoastal counties had many more inspections with at least one violation and had 50.0% compared to only 10.8% in coastal counties. Coastal counties had 10.8% of their evaluations with reporting violations, and only 1.4% with maintenance issues, but 4.1% with other permit violations. Noncoastal counties had much higher instances of reporting and maintenance violations with 42.9% and 14.3% respectively, but no violations in any of the other categories. The reason for more instances of violations in noncoastal counties is not known. It is possible that inspectors in noncoastal counties are more forgiving in what they consider to be compliant or the violations may not be severe enough to warrant a noncompliant designation. Alternatively, because there are less permits in noncoastal counties, there may be less expertise on permit requirements. Again, the difference in sample size between coastal and noncoastal counties could be a factor.

**Table 5: Percentages of violation types (maintenance, BUA, reporting, installation, other permit, and other water quality) for all inspections, routine, noncompliant and compliant sites for 2012.**

	#Sites	≥1 Violation					Other	Other Water
		Type	Maintenance	BUA	Reporting	Installation	Permit	Quality
All	536	38.8%	14.6%	7.1%	28.4%	6.3%	8.4%	1.5%
Routine	176	47.2%	14.8%	4.0%	37.5%	3.4%	5.1%	0.0%
Noncompliant	88	77.3%	26.1%	8.0%	59.1%	6.8%	6.8%	0.0%
Coastal	80	76.3%	22.5%	8.8%	58.8%	3.8%	7.5%	0.0%
Noncoastal	8	87.5%	62.5%	0.0%	62.5%	37.5%	0.0%	0.0%
Compliant	88	17.0%	3.4%	0.0%	15.9%	0.0%	3.4%	0.0%
Coastal	74	10.8%	1.4%	0.0%	10.8%	0.0%	4.1%	0.0%
Noncoastal	14	50.0%	14.3%	0.0%	42.9%	0.0%	0.0%	0.0%

In 2012, 61.2% of all inspections had no recorded violations, 21.3% had one and 17.5% had more than one violation type (Table 6). For noncompliant sites 58.8% of routine inspections in coastal counties had one violation type and 5.7% had two. Noncoastal counties only had 25.0% with one violation types, but half of inspections in noncoastal counties had two violation types. For compliant sites 42.9% of inspections in noncoastal counties had one violation type and 7.1% had more than one violation type, while in coastal counties there were only 5.4% with one violation type and 5.4% with more than one. This shows that not only do noncoastal counties have more sites with a violation, but also have more types of violations per permit than coastal counties. When considered with the earlier result that noncoastal counties had higher average yearly rates of compliance than coastal counties, it seems contradictory that noncoastal counties had more inspections with a violation and higher numbers of violations types. This could also be attributed to low sample sizes in noncoastal counties for both average yearly compliance and the number of violation types per permit. Adding even one more permit inspection could drastically affect the results.

In 2012, 504 of 11,703 (4.3%) active coastal county permits stormwater permits were inspected. In individual counties, active inspection rates ranged from 0.8% to 9.6%, but had an average of 4.1% (Appendix 6.2). During this time period, only 14 NOV's were issued (Appendix 6.3) which may be

due to NC DENR’s commitment to customer service and helping permit holders become compliant or the amount of paperwork that comes with issuing an NOV. Since fines are rarely given, they may not be as effective at deterring noncompliance.

**Table 6: Percentage of inspections in 2012 with number of violation types per permit for all inspections, routine, noncompliant and compliant sites.**

<b>Number of Violation Types/Permit</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>&gt;1</b>
All	61.2%	21.3%	11.2%	3.5%	2.1%	0.7%	0.0%	17.5%
Routine	52.8%	33.5%	10.8%	1.7%	1.1%	0.0%	0.0%	13.6%
Noncompliant	22.7%	55.7%	15.9%	3.4%	2.3%	0.0%	0.0%	21.6%
Coastal	23.8%	58.8%	12.5%	2.5%	2.5%	0.0%	0.0%	17.5%
Noncoastal	12.5%	25.0%	50.0%	12.5%	0.0%	0.0%	0.0%	62.5%
Compliant	83.0%	11.4%	5.7%	0.0%	0.0%	0.0%	0.0%	5.7%
Coastal	89.2%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	5.4%
Noncoastal	50.0%	42.9%	7.1%	0.0%	0.0%	0.0%	0.0%	7.1%

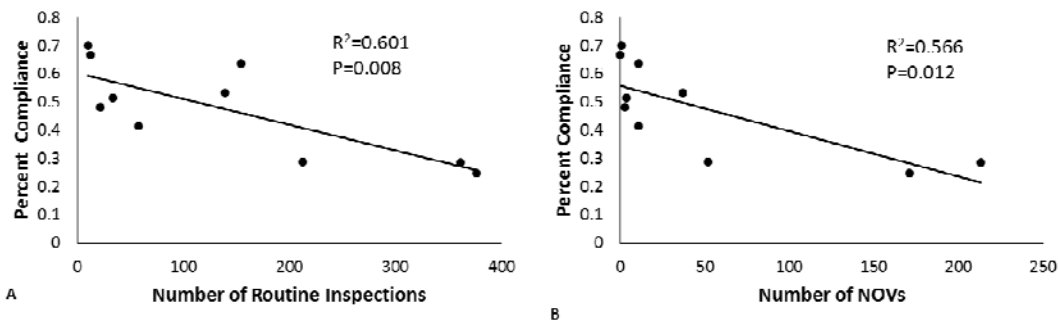
### LINEAR REGRESSION ANALYSIS

Due to the large increase in compliance in 2011 which occurred with a decrease in the number of routine inspections, we became interested in potential correlations between compliance and other variables. When we performed linear regressions on the data compiled by county for each year, none of the variables had  $R^2$  values large enough to warrant correlation with percent compliance. County did have an  $R^2$  value of 0.43, which although it is less than 0.5, is relatively high for environmental data which generally has a great deal of variation (Table 7). Due to the low sample sizes within some of the counties, percent compliance by county had a great deal of variation, which explains the low  $R^2$  values for the other variables. However when compiled by year, we found that both the number of routine inspections and the number of NOV’s were negatively correlated with percent compliance and had  $R^2$  values of 0.60 and 0.57 respectively for coastal and noncoastal counties (Table 7; Figure 8). Compiling the data by year reduced some of the variation within the data, allowing correlations to be more apparent. This decreased the sample size resulting in slightly higher p-values. Although we expected the number of routine inspections and the number of NOV’s

to be positively correlated with percent compliance because they are enforcement measures, they both had a negative correlation. However, this does not imply any causation and DEMLR employees could be conducting more routine compliance inspections and citing more violations when they become aware that compliance is low.

**Table 7: Linear regression results between percent compliance and pertinent variables of data compiled by county for each year as well as by year for coastal and noncoastal counties. Multiple R<sup>2</sup> values are shown with p-values. R<sup>2</sup> values of 0.5 or greater were considered to be correlated, and p-values of 0.05 or greater were considered to be significant. Bolded R<sup>2</sup> values are those that are considered correlated.**

	By County/Year		By Year/(Non)coastal	
	R <sup>2</sup>	p-value	R <sup>2</sup>	p-value
Number Routine Inspections	0.052	0.010	<b>0.601</b>	0.008
Population Estimate	0.012	0.227	0.250	0.141
Population Density	0.007	0.362	0.253	0.139
Total Inspections/Year	0.051	0.010	0.330	0.823
% Routine Inspections	0.026	0.067	0.060	0.494
Coastal County?	0.032	0.043	0.253	0.139
Year	0.120	0.003	0.131	0.934
Number of NOVs	0.080	0.001	<b>0.566</b>	0.012
SA Area	0.008	0.305	Same for all years	
Admin Region	0.160	0.002	n/a (by year)	
Area in County	0.030	0.049	Same for all years	
County	0.433	0.025	n/a (by year)	



**Figure 8: Correlations between percent compliance and (A) number of routine inspections and (B) number of NOVs (notice of violation).**

Because our study relied on existing data, there are limitations to our results. The compliance inspections that we used as the basis for establishing compliance rates did not come from a completely random sample and therefore could contain some artifacts of sampling. Additionally,

different employees could be inconsistent with how they code violations in the database. For example some compliance inspections have all of the relevant information within yes or no questions and no information within the comments section, while other inspections only address issues within the comments. This is further corroborated by the fact some compliant sites had violations, while some noncompliant sites had no violations listed within the prompted questions.

## 4.2 QUALITATIVE INTERVIEWS

During the interview collection period we conducted a total of 13 interviews. Due to lack of response, interviews with DEMLR compliance inspectors were not possible. At least one interview occurred with all other target groups (Table 8). Local government employees were the most available respondent type. Of the 13 active environmental groups we attempted to contact, four declined to interview citing lack of knowledge surrounding the topic of stormwater management, 6 did not respond. In contacting permit holders and private industry contacts, many did not respond, despite continued efforts. Roughly 25% of the permit holders we contacted were unaware of holding a permit.

**Table 8: Interview Response Rates**

<b>Interview Classification</b>	<b>Entities* Contacted</b>	<b>Number Interviewed</b>
<b>North Carolina State Government</b>	1	0
<b>Local Governments</b>	19	8
<b>Industrial Engineers, Consultants</b>	14	1
<b>Permit Holder</b>	29	2
<b>Environmental Organizations</b>	11	2

\* An entity is one organization. Interviews were conducted with one representative per organization.

Group membership is denoted as: LG, PH, ENV, and IND signifying Local Government, Permit Holder, Environmental Group, and Industry, respectively. Location is then denoted by either an O or C for Onslow or Carteret County. The identifier LGC1 can be read as Local Government, Carteret County #1.

## TRENDS ACROSS ALL INTERVIEWEES AND SITES

### ***Familiarity and Experience with the State Stormwater Program***

The respondents had varying levels of experience with the SSP ranging from one year of experience to over 20 years. Overall, most respondents rated their interactions with the SSP as positive (9/13). Three respondents (Local Governments: 1; Environmental: 1; Permit Holder: 1) reported their experiences as mixed, being neither positive nor negative. One environmental respondent reported negative experiences with the SSP. Those with positive experiences with the program emphasized friendly interactions staff and the presence of the program. The respondent who rated their experience as negative stated they thought the program is generally not working well. The reasons for mixed rating ranged from lower experience levels with the state program to dissatisfaction with of more recent legal revisions.

### ***Perceptions of Development Rate in Immediate Area***

We asked participants to categorize the rate of development within their town and county over the past 10 years and identify areas with particularly high or low development rates. Almost all participants stated that the economic crisis of 2007 had very negative impacts on the rate of development. The typical response pattern from participants located in Carteret County identified a relative rate of high development from 2003-2005 followed by a crash in 2007, which has only recently begun to increase again. In Onslow County however, local government employees (4) stated that over the past 10 years their growth rates have been high. Reasons cited for this were the condensing of a multiple military bases into the ones located in Onslow County, creating a demand for housing. Roughly 50% of respondents noted that development is starting to pick up again and predicted that their regions will be much more developed within the next five to ten years. The most common driver identified as taking away from development rates was the economy while residential subdivisions, commercial areas, and second home development were frequently cited as driving development.

### ***Perceptions on Water Quality and the State Stormwater Programs Influence on Water Quality***

In an effort to understand the perception of water quality we asked respondents how they would rate water quality in their area. Almost 25% of interviewees felt they were not qualified or did not have enough information to rate the water quality (Local Governments: 3; Permit Holders: 1). Of the remaining respondents, four (Local Governments: 3; Permit Holders: 1; Industry: 1) rated the water quality in a positive manner and three (Environmental Groups: 1, Local Governments: 2) gave mixed reviews. Those who gave mixed reviews of water quality focused on rating individual water bodies or a relative improvement from “terrible” over time. This question was not asked to one of the environmental groups.

When asked if the state stormwater program adds positively to the water quality, all respondents to the question (9) reported they felt that the SSP adds positively to surface water quality. In follow up, respondents were asked which aspects of the SSP added positively to water quality. Respondents focused on the presence of regulations as being a positive factor in water quality. In addition, many of the interviewees seemed to evaluate the effectiveness of the SSP in conjunction with other programs. Most interviewees did not feel that achieving 100% compliance rate to the SSP would alleviate water quality issues. Reasons supplied included sources of stormwater pollutants other than development such as: wild animals, lawn care by citizens, and roadways.

### ***Perceptions Surrounding Compliance Rates***

In asking respondents to speculate reasons for the level of compliance observed within their county in 2012 the following topics were readily discussed: enforcement action (3/13), type and age of BMP (3/13), and education levels, or a disconnect between construction and maintenance (4/13). Our respondents appear to correlate the number of inspections done with positive compliance rates. Nearly half of respondents (5/13) focused on the need for inspections to ensure compliance.



Two local government employees and one environmental group respondent mentioned the age and type of a BMP having an influence on compliance. These respondents stated that older BMPs are not subject to newer construction requirements. They also suggest that phasing out particular types of BMPs as approved options may help compliance. In addition, when asked about the best types of BMPs, the industry professional we interviewed mentioned that wet detention ponds are not favorable because they are difficult to maintain. Four local government employees focused in on the need for resources such as compliance inspectors and money to devote towards ensuring compliance.

***Aids and Impediments to Compliance***

We posed the question of what the impediments to compliance are, and respondents most frequently replied with one of the following three topics: education, difficulty in maintenance, low levels of oversight or enforcement (Table 9). While the focus of oversight and enforcement is straightforward, respondents directed educational responses at permit holders and those implementing BMPs. Maintenance difficulties were perceived as something that could be addressed through educational and enforcement efforts.

**Table 9: Most frequently identified impediments to compliance identified by interviewees**

	Question Respondents	Impediment			
		Education	Maintenance	Oversight / Enforcement	Cost
<b>Environmental Group</b>	1	1	1	1	-
<b>Private Industry</b>	1	1	-	1	-
<b>Local Government</b>	8	3	4	3	4
<b>Permit Holder</b>	2	1	1	-	1
<b>Total Respondents</b>	<b>12</b>	<b>6</b>	<b>5</b>	<b>5</b>	<b>3</b>

An important underlying element with reference to all three of these topics is the cost. Local government employees pointed out that the amount of money available to conduct compliance inspections is directly linked to the amount of oversight and education that can be provided. One permit holder we interviewed noted that the cost of maintaining a BMP is very high and might prove to be an impediment for some to meet. A local government respondent stated that they recently decided against a project because the required stormwater control would nearly double the original price of the project. The industry respondent specialized in certifying compliance and noted that in areas where there is little oversight there is very little work for their company.

When asked about what factors might contribute to people who comply, respondents cited permit holders wanting to avoid fines or wanting abide by the law. Factors that respondents identified as potentially adversely affecting compliance included general ambivalence to the program, disregard for maintenance due to lack of oversight, and confusion regarding the permit system.

### ***Addressing Non-Compliant Sites***

We inquired as to whether or not our interview subjects knew how noncompliance was dealt with in their region. The answers of local governments depended on what type of program the group had adopted, as some are involved with ensuring compliance while others may receive local complaints which they pass on to the state. One environmental group and the two permit holders we interviewed were unaware of compliance checks occurring on a regular basis. Overall knowledge as to how the state actually deals with noncompliance is not widespread across our interviewees. When queried about the best way to address non-compliant sites, 7 of 13 respondents (Local Governments: 3; Environmental Groups: 1; Industry: 1; Permit Holders: 2) replied that active compliance checks or oversight are necessary. Local government respondents stressed direct and clear communications with the permit holder:

*“I would say upfront notification during the permit process. Making them aware of what the expectations are and communication throughout the inspection process. Take, for instance, the \_\_\_ site. I’ve visited that site at least a dozen times and usually if I go on one inspection and I see something upcoming I’ll start asking questions to make them understand that I am looking. It gets them alerted to, I need to do something about this or plan ahead for that” (LGC2)*

A permit holder supported the idea that enforcement or oversight is needed to help understand as to whether or not their permit is within compliance stating: *“The state should inspect us at least annually. Unannounced or two days notice.” (PHC1).*

Other respondents felt that fines and education are good ways to gain an increase in compliance, one local government respondent explained:

*“Again it’s not for most 85-90% of the population it’s not a matter of malice, it’s a matter of lack of education or not having the priorities in place and the threat of having a NOV makes you change your priorities a little bit especially when fines are going to incur so it’s educating and getting people to realize why they need to stay in compliance” (LGO4)*

### ***Suggestions for improving compliance***

Our final question in all interviews requested that respondents suggest one measure to improve compliance across the state. Despite the request for one way to improve compliance respondents frequently suggested a combination of approaches including: conducting more compliance checks (60%) and public outreach on BMP maintenance (45%). Respondents generally identified BMP maintenance as a challenge for permit holders but felt that public outreach could help to inspire routine maintenance.

### **TRENDS EXHIBITED IN LOCAL GOVERNMENT EMPLOYEES**

We completed eight interviews of local government employees, four in Carteret County and four in Onslow County. Local government employees were asked to describe their local stormwater program as well as what interaction, if any occurred with the state stormwater program.

Four of the eight town government employees we spoke with said their jurisdictions have adopted stormwater ordinances. Two of the government employees describe their stormwater programs as

“maintenance only” and two stated that they rely on the state for stormwater related issues. At minimum, all of the governments we spoke to require construction projects to obtain a state stormwater permit before it will issue a building permit.

***Interactions of Local Programs with the State Program:***

Regarding the interaction of state programs with local programs, employees indicated that the state program tends to guide local programs. Some local programs attempt not to become stricter than the state:

*“We may put some into our own terminology but it’s not stricter than the state. We uphold the state’s coastal rules – exemptions, conditions, definitions – our ordinance mimics that just the wording they use may be a little different” (LG02).*

Others attempt to address local specifics, expanding on elements beyond the state requirements. All of the local governments have a clear distinction between their own regulatory requirements and permits issued by the state. Any problems with state permits that are brought to the attention of local governments are referred directly to the state. One respondent said they *“will do initial fieldwork, take pictures, e-mail it and describe it to the [regional] office and then they can take it from there” (LG01).*

***Impediments to Stormwater Management in Local Governments:***

A unique impediment identified by the local government group, two of the town governments we spoke with identified stormwater easements as a problem with management. Both were concerned with their jurisdiction’s right or ability to either maintain or install structures surrounding private property.

*“The other reason they[municipalities] don’t want to get involved too much is that from the legal end it’s unclear whether the municipalities have the right to go on private property and install stormwater. The question about whether the owner has the duty to manage the stormwater or whether it’s a town function. It’s unclear and right now the way that state law reads if stormwater is running off the road crossing private property, the private property has to manage it. There’s no duty for the towns to install infrastructure across private property so that’s an issue I can never get a clear answer on” (LG03)*

*"I can show you stormwater piping that comes out of stormwater drop inlets in storm sewers that the lines go through under people's garages to get to the creek and we have no easement so we have a multitude of challenges in trying to improve in that area" (LGC1)*

**Improving Compliance According to Local Governments:**

On the topic of one suggestion to improve compliance, local government employees were almost evenly split between suggesting a need for more inspections and a need for public education. These employees also seemed more concerned than other interviewees for the state's ability to actually conduct inspections, noting that it is not easy to cover large areas with limited staff numbers. They express particular concern for recent regulatory changes, staff cuts, and time to enforce. One employee stated:

*"The strengths, the best thing that the state stormwater program did was allow the municipalities to get involved in and run interference for the state. The state does not have enough people to cover all of the counties that they cover. They don't have enough people to respond to problems and problem issues in a timely manner" (LG04)*

The concerns program funding and enforcement personnel extends to the local level. Another government expressed interest in aiding the state compliance enforcement if there was something to offset the cost to them:

*"If there were some type of mechanism, where, and funding certainly, that my local folks could be trained to help do some of that, and have additional staff to do some of that and work with the state on letting them know where some problem areas might be" (LG01)*

Three of eight employees feel that lack of compliance comes from a lack of understanding of the need for stormwater management. Local government employees do not refer only to permit holders when speaking about education. Some feel the educational process should address those working on construction sites, while others feel there is a lack of communication between those that install a BMP and those who must maintain it. This includes those who may inherit a permit through the purchase of a home.

It is important to remember that our study is based on a limited number of interviews, and can only be used anecdotally to support the statistical findings. Although interviews of local government employees reached 50% of towns and municipalities within the Counties of Onslow and Carteret, these interviews can be seen as representative of the counties and not the entire state. Interviews with all other group types were minimal and can only be seen as anecdotal and specific.

### 4.3 PROGRAM ANALYSIS

Using the rubric we developed based on the literature (Table 10), we found that the SSP performed the highest in the clarity of the program as well as in education and outreach. The areas where the program can improve the most are engagement and visibility.

**Table 10: The program analysis rubric based on the literature review, with corresponding program performance.**

Metric	Program Performance
Clarity of Regulatory Program	HIGH
Level of Engagement	MEDIUM
Education and Outreach	MEDIUM - LOW
Visibility of Regulating Agency/ Enforcement Action	LOW
Actual Compliance Record	MEDIUM

**Clarity (High):** The element of clarity addresses how easily interpreted and implemented the regulations surrounding a program are. Regulations that are clear and specific in directives leave little room for confusion, allowing a higher compliance rate (White and Boswell 2006). Those subject to the rules should be able to identify themselves and understand the regulations (Duke and Augustenborg 2006). In support of this, a 2010 study of Minnesota stormwater violations noted decreases in compliance during times of regulatory change (Alsharif). Clear and simple communications surrounding regulations from State level governments can help ease confusion surrounding layers of regulations (Tryhorn 2010).

In rating clarity, we consider:

1. how consistent the rules are from year to year,
2. how easy it is to know if a site is subject to the rules, and what those rules are, and
3. the type and frequency of communication utilized by the program administration.

Based on our interviews, the state stormwater program performs well in regards to clarity across our interviews, an aspect local governments respondents gave praise to the SSP for is how clearly expectations are presented. Before a permit approval, the permit applicant signs and agrees to a maintenance program for their BMP. The rules that a permit holder must comply with are set forward with the establishment of a permit including the expectation for maintenance. Communication is mostly driven by the applicant or permit holder. The state website helps a potential permit holder in identifying which rules are applicable to them. Despite the availability of online resources, it may be confusing and require a lot of leg-work on behalf of the permit holder to identify the appropriate programs they must comply with. We received feedback from both local government officials and some permit holders that response times in permit application can be slow, including permits applications in progress.

***Level of Engagement (Medium):*** The element of engagement references the amount of outside involvement with the program. Literature suggests that higher compliance rates occur in regions that have active local officials or environmental organizations (Morison and Brown, 2010; Alsharif, 2010), or an engaged, informed public (Taylor et al, 2007). Another study found that, the most effective measure against stormwater pollution was a state requirement of stormwater planning within towns (Taylor and Fletcher 2007). Self-enforcement requirements such as those implemented in the NPDES system provide an avenue for engaging permit holders, however provide variable levels of compliance (Duke and Augustenborg 2006). Without follow through from the regulatory agency, this technique may increase engagement of permit holders but does not

ensure compliance (Duke and Shaver 1999). A case study of Chicago rain barrel adoption found that use clustered in wealthier areas that were “attitudinally green”, close to distribution centers, and in areas near educational campaigns (Ando and Freitas 2011). This suggests that engagement on behalf of a permit holder may occur when: funds are available, they care about the outputs of their BMP or the permit holder does not need metaphorically go too far out of their way to comply.

To evaluate the level of engagement with the program we consider:

1. level of involvement and support provided by local government with stormwater policy and program implementation,
2. the presence and reputation of an environmental “champion” for the issue, and
3. the permit holder’s perception of the importance of the program.

Ultimately there are a number of towns and municipalities in coastal North Carolina with active stormwater ordinances. These local ordinances frequently work as supplemental aspects to the SSP. Some of these ordinances require setbacks or place BUA limitations for projects not large enough to require a state permit. However, across Onslow and Carteret County, local programs are distinct from state programs with little direct enforcement help. Our interview process revealed that there is a strong presence of the North Carolina Coastal Federation in Carteret and Onslow Counties, but little awareness of other environmental groups. Despite the presence of local ordinances and an environmental “champion”, the review of statistical data indicates that a very important element of engagement is missing. Due to the low response from permit holders we cannot directly gauge how important a permit holder perceives stormwater maintenance to be. Responses from local governments revealed a mixed perception of permit holders’ perceptions of permits. Many suggested that over time, those involved with permit maintenance eventually fall off. Another aspect uncovered in our research which suggests a low levels of permit holders engaging with their permit is the presence of maintenance violations within a quarter of all routine compliance inspections. While permit conditions require routine maintenance and record keeping,



the state program does not require the submission of these reports. Presumably, the only time this would be checked on is during a compliance inspection. If a permit holder perceives their permit as unimportant they may stop maintaining their permit.

***Education and Outreach (Medium-Low):*** The US EPA believes that in order to have a successful program, education and outreach are essential, as they not only build support, but increase personal and community accountability (Spellman and Drinan, 2003). Federally designated MS4s are required to maintain a public outreach and education program. Education and outreach have been shown to help change behaviors that are detrimental to the environment (Taylor et al., 2007; Bamberg and Moser, 2006). Despite this, literature frequently questions the total effectiveness of public education (Herringshaw and others 2010; Taylor and others 2007). Studies suggest that the presence of targeted outreach and marketing campaigns aimed at those who are regulated are positively associated with compliance (Morison and Brown 2010; Taylor and Fletcher 2007). Duke and Augustenborg (2006) corroborate this finding noting that after a statewide outreach effort, compliance with part of an NPDES Phase II program increased between 75 and 100%. However, educational and outreach efforts have a limited lifespan suggesting that ongoing efforts are required for ongoing results (Taylor et. al., 2007).

To evaluate education and outreach we consider:

1. the amount and quality of educational materials pertinent to the program distributed by the administrative agency
2. longevity of educational outreach and if efforts are ongoing
3. knowledge levels of the targeted regulation community.

The state provides extensive online resources for permit holders to educate themselves on the permitting program. These resources, while easily available to those who have computer access and an interest in locating them, are not always the most efficient way to disseminate information. The

state also provides a BMP manual which attempts to guide permit holders and applicants through the BMP selection process. The manual is a working document with chapters added as they are completed. Through the North Carolina State University (NCSU) Extension, individuals may sign up to take a BMP inspection and maintenance course. However, these classes are not frequently conducted within coastal counties and cost between \$165-\$265 per person. In regards to the state program, there is a higher level of education for the first permit applicant. However, it is important to note that permit applications are technical documents and provide a place for the applicant to designate a consultant as the point of contact for permit related communications. There are no specific educational requirements or efforts on the part of the state addressing the knowledge gap between a consultant and the permit holder who is ultimately responsible for BMP maintenance. This gap also appears to be lacking in the event of a property turnover, as our interviews with local governments often cited that people who inherit stormwater BMPs frequently do not understand their importance. In addition, the SSP does not reach out in the event of a permit turn-over, according to one permit holder we spoke with, their permit required them to notify the state in the event of the permit changing hands. The turnover for a permit would provide an opportunity for the state to simply reach out to the new permit holder and direct them to a class or workshop emphasizing the importance of their new BMP.

***Visibility of Regulating Agency/ Enforcement Action (Low):*** The visibility of an agency or its enforcement efforts is noted as a positively correlated with higher compliance rates (Alsharif 2010). This element attempts to capture how likely it is for a permit holder to experience a compliance audit. It also is based on whether or not there are regular compliance inspections conducted. It evaluates the overall visibility of the agency pertaining to checking in on permits and or the public awareness of enforcement actions.

In 2012, 504 of 11,703 (4.3%) active coastal county permits stormwater permits were inspected. In individual counties, active inspection rates ranged from 0.8% to 9.6%, but had an average of 4.1%

In this same period of time 14 Notice of Violations (NOVs) were issued and 38 Notice of Deficiency (NODs) were issued. The local governments we interviewed refer problems with state permits to the state offices. All were quick to point out that a way to improve compliance rates across the program would be to put more effort into state permit oversight. The perception in both Onslow and Carteret Counties is that compliance inspections occur infrequently or not enough. Once issued, the permit holder is responsible for maintaining the permit in perpetuity and they must apply to discontinue the permit. However, permits may last for up to 10 years and the lack of requirements for annual or bi-annual inspections could allow a permit to become neglected, change hands, or be forgotten. In searching for permit holders to interview, a number stated that they were unaware of holding their permit. Anecdotally, enforcement measures are not widely publicized, one of the permit holders we spoke with indicated that other, similar organizations laugh at the amount of time and money their organization spends on BMP maintenance due to low perceived levels of oversight. .

## 5. CONCLUSION & RECOMENDATIONS

Compared to 2005 our study suggests the rate of compliance has increased from 30.7% to 50% in 2012 (DWQ). However, the number of surveys decreased dramatically in 2011 and the percentage of surveys that were “routine” have been decreasing since 2008. Similar to 2005, the majority of violations are still reporting and maintenance infractions. Our interviews corroborate these findings, as respondents believe that the main impediments to compliance are maintenance issues and lack of education about the regulations. The interviewees also conveyed that people correlate more inspections with higher rates of compliance and that compliance could be improved through increased maintenance checks and public outreach. Noncompliant sites were thought to be most easily addressed through more compliance checks with clear and direct communication with the permit holder. The program analysis we conducted showed that while the state stormwater

program generally has clear regulations, it could benefit from more visibility of the regulating agency, engagement, as well as education and outreach.

Although our findings suggest that the implementation of more inspections and education programs could improve compliance, policy suggestions are more difficult given the current political climate in North Carolina. This is a time of rapid change for all of the agencies under NC DENR, over the course of our study the Division of Water Quality (DWQ) dissolved and DEMLR assumed responsibilities for the state stormwater program (NCDENR, 2013). During this time budgets have drastically been cut, and many staff positions have been removed (citation). The recommendation to increase the number of staff doing compliance checks, while valid, does not consider the current political and economic climate of North Carolina. There are a myriad of ways to increase visibility, engagement, and education, and some may be more feasible for immediate implementation while others may be more feasible over a longer time frame. Possible policy alternatives to increase the visibility, engagement, and education within the SSP and include:

### ***Visibility***

*Self-monitoring report submission:* Currently under the SSP North Carolina, permit holders are required to inspect their BMPs after storm events, but are not obligated to submit these records to DEMLR for systematic review. Requiring permit holders to submit reports could help ensure that BMPs are being monitored regularly and can increase permit holder accountability as well as visibility of the program. The NPDES regulations require self-monitoring reports, but have been criticized for the lack of verification through field inspections (Glicksman and Huang, 2010). Without appropriate oversight, this leaves room for falsification of records and self-reports are often more imprecise and less detailed than inspection records (Duke and Austenbourg, 2006). This approach is likely to increase paperwork for DEMLR, but can increase the visibility, and accountability of the program with little added staff or financial burden.

*Publish compliance information:* Another avenue to address the visibility of enforcement is to publish the results of compliance inspections. The state could publish these online, and or mail an annual compliance report to permit holders describing the efforts of permit holders. This would increase the visibility of compliance inspections (currently about 4%) to those who do not experience an inspection first hand. This may also increase the amount of accountability for permit holders.

*Third-party inspection requirement:* A certified third-party inspection requirement for BMPs can help ensure functionality and elevate permit holder accountability. This requires a permit holder to hire a certified third-to inspect their BMPs and periodically submit reports. Currently, annual inspections are required in the cities of Durham, Raleigh, Cary, and Apex, amongst others in NC (City of Durham, 2011). According to one of our interviewees, a stormwater BMP engineer, the program has been considered successful in these areas. Third-party inspections could potentially minimize confusion on requirements when properties are sold, and the permit changes hands. However, this approach is likely to increase paperwork for administrative staff and may add to the cost of maintaining a BMP.

*Increase the number of compliance inspections:* As mentioned by many of our interview subjects, increasing the number of compliance inspections would certainly increase the visibility of DENR. To do this, the state would need to either hire more staff, contract positions, or collaborate with municipalities. The Minnesota Pollution Control Agency collaborated with 10 counties to increase inspections for their sediment program, which coincided with an increase in compliance (Alsharif, 2009). Despite a potential for an increase in compliance, hiring more staff would require more budgetary resources.

*Increased use of fines:* In our research, we discovered that the State does not issue many fines, which corroborates a previous study conducted for municipalities within North Carolina (Barnes, 2008).

In 1999, California enacted the Clean Water Enforcement and Pollution Act, which required fines of for any serious or repeated violations of the Clean Water Act. This subsequently raised compliance by 56%, and provided more than \$6.5 million for the state (Jahagirdar and Coyne, 2003). More fines could serve as a source of revenue, but this would need to be in conjunction with a simplified system for issuing fines, as issuance requires a great deal of paperwork. Increasing the use of fines may also be difficult with the current political climate, as fines are generally perceived as harmful to businesses.

### ***Engagement***

*Encouraging Local stormwater program involvement:* Local stormwater ordinances can supplement the state stormwater program and can be independent from the state regulations, or can follow the model Universal Stormwater Management Program (USMP) established by NC DENR. The USMP is aimed at creating a unified set of stormwater laws in a jurisdiction that satisfy the both the federal and state stormwater requirements in order to simplify stormwater regulations. As of April 2014, only a few municipalities have adopted USMP and studies on the effectiveness of these programs have yet to be conducted. Virginia is currently in the process of developing local programs that they believe will improve compliance (Virginia DEQ, 2014). Benefits of local programs include a closer regulatory eye and the potential to have more people conducting inspections. Local programs could also provide more interaction within a smaller community. Although laws requiring local stormwater management have produced higher statewide compliance rates (Morison and Brown 2010), local governments may not have the necessary resources to hire adequate staff without obtaining additional funding (Tryhorn 2010).

*LID involvement:* Another solution for engagement is to promote Low Impact Development (LID), which minimizes impervious surfaces, thereby reducing stormwater runoff. Examples of LID techniques include rain gardens, vegetated swales, rain cisterns, green roofs, and pervious pavement. These can reduce impacts to natural hydrology (EPA[a], 2012) and are easier to

maintain (EPA[b], 2012). Barriers for implementing LID techniques include resistance to change, few incentives for developers to use these techniques, and a lack of guidance for construction (Roy et al, 2008).

### ***Education***

*General information dissemination:* Information dissemination can help engage the general public on stormwater management, and permit holders about the program requirements. Traditional instruments for educational opportunities include mass mailings, posters, brochures, fact sheets, and news outlets. While the NPDES program requires education and outreach to be conducted, it is not a mandatory component for the SSP. Focusing outreach on permit holders and maintenance staff in campaigns related to permit requirements, can engage stakeholders without compromising significant staff time and resources. Based on our interviewees' responses on lack of education on maintenance, checklists and reminder mailings for maintenance requirements may be helpful. However, these can be easily disregarded and would involve some printing and mailing costs.

*Training workshops and courses:* In person trainings for permit holders and maintenance staff can be used to increase knowledge of the program requirements and initiate a dialogue for questions can be addressed. The Pennsylvania Department of Environmental Protection requires six workshops each year for their Erosion and Sediment Pollution Program, which have engaged more than 2,300 contractors, plan preparers and local government officials and have led to increased compliance (Sherman, 1997). Similar workshops have occurred in Delaware (DNREC, 2014) as well as at Clemson University in South Carolina which was sponsored by two nonprofit groups (Hull, 2010). In person training is time and staff intensive and requires a great deal of planning and coordination among staff and permit holders. However, bringing stakeholders together to discuss requirements may ultimately reduce the time spent explaining regulations on an individual basis. Online training could have similar results and would be less labor intensive and require less

operating attention. But stakeholders may not receive the same level of engagement and this may exclude those without internet access.

## RECOMMENDATIONS

While the implementation of the methods discussed above could help to improve compliance, each have advantages and limitations. There is no single solution to the stormwater compliance problem, but a combination of tactics could increase compliance rates. Our findings strongly suggest that more inspections and education programs could improve compliance. As discussed above, there are advantages and limitations to each avenue of addressing compliance, a combination of approaches could help the state achieve quick results that are sustained into the future, by implementing both short-term and long-term changes.

### ***Short Term Goals (1-3 years)***

Education and outreach are often associated with short term boosts in compliance rates (Taylor et al, 2007). Therefore, for immediate effects on state compliance rates, we suggest more education and outreach in conjunction with the publication of compliance reports. Education and outreach efforts should focus on increasing the knowledge of maintenance requirements for permit holders and maintenance staff. This will increase not only the knowledge of requirements, but will begin an important dialogue between the state and permit holders. North Carolina could provide in person training similar to those provided by the NCSU extension on a quarterly or semi-annual basis both in the northern and southern portions of the coastal counties. These efforts should be relatively low cost to implement and can work to raise visibility of the entire program. Additionally, focusing on general public education would increase the awareness of the community, and use the public to increase the accountability of permit holders. This could potentially increase the likelihood that a noncompliant site is investigated. Through focusing on educational efforts, the state may be able to save time by preemptively addressing problems due to permit holder confusion.



As previously mentioned, educational efforts can have a limited life span. To bolster these efforts we suggest that the state begin to make compliance reports publically available. The publication of compliance reports does not require a great deal of resources and could be enacted relatively quickly. Additionally, this could increase awareness and elevate permit holder accountability.

### ***Long Term Goals (3-10 years)***

Over the next three to ten years, the state should focus on two things, hiring more compliance inspectors and the approval of BMPs which require less maintenance. Through the approval and encouragement of BMPs with simplified maintenance, the state will hopefully remove one of the major barriers to full compliance. Although hiring additional compliance officers is challenging due to recent budget cuts, this will be an important step towards addressing the massive workload of ensuring the issuance and compliance of over 14,000 permits. An additional method is to reduce the amount of paperwork necessary to issue a fine. The reduction of paperwork could provide an incentive to apply fines more frequently, and create an additional source of revenue that could fund ongoing permitting inspections.

Local stormwater programs, self-monitoring report submission should also be evaluated further. Many states, such as Virginia, are beginning to require local stormwater ordinances. The results of these efforts have yet to be quantified and the outcomes should be studied. The state should also consider implementing required third party inspections. This would ensure an annual or bi-annual inspection of active BMPs by a certified professional. This could simultaneously increase the rate of inspection and reduce the need for the state to hire more inspectors. The state would then only need to follow up with noncompliant sites. It is important that the SSP continues to evolve with the regulatory climate and incorporate new stormwater technology.

### ***Avenues for Future Studies***

Further studies should be conducted on a regular basis and consist of a random sample of permitted sites in order to obtain the most accurate estimate of compliance. Additionally, any attempts at improving compliance should be used as an opportunity to quantify the effects of specific actions on compliance. This will allow DEMLR to determine if their efforts were successful, and may act as a case study for other states looking to improve compliance with environmental regulations. Future studies should attempt to incorporate more interviews from a broader audience, and ensure the inclusion of compliance inspectors.

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## **APPENDIX 1: SHELLFISH CLOSURE ANALYSIS FROM 1999 TO 2012 IN 10 SELECTED SA.**

### **Introduction**

The effects of stormwater on water quality in shellfish growing areas have received public attention throughout the world. One of the main contributors to stormwater is the conversion of land from natural to developed states. Schueler et al. found that water quality is significantly reduced once the percentage of developed land use exceeds 11% (Schueler et al., 1994). Due to the higher intensity and volume, stormwater brings more anthropogenic products, naturally-originated particles and animal waste into the receiving water bodies (Nelson et al., 2001; Abramas and Prescott 1999; Williams 1999). The bacteria and viruses present in stormwater can lead to diseases in shellfish, which can affect human health when consumed (NC Department of Health and Human Services). Subsequently, shellfish growing areas may need to be closed to prevent harvest in areas unsafe for consumption. Between 1995 and 2000, North Carolina's shellfish closure increased at the speed of 12% every year (White et al., 2000), which is a major cause for concern.

In the U.S, all shellfish growing areas are classified on the basis of water quality. The National Shellfish Sanitation Program (NSSP) established a model ordinance with bacteriological standards for shellfish classification, but implementation is the responsibility of individual states. In North Carolina, the Shellfish Sanitation and Recreational Water Quality Section (Shellfish Sanitation) of the Division of Marine Fisheries, constantly monitor bacterial levels in coastal waters. Areas under "conditional" management, are immediately closed after rain events that exceed a certain rainfall threshold for a 24-hr period (the threshold ranges from 1.0 -2.5 inch depending on the specific location). In these circumstances, DMF is authorized to issue closure proclamations based on the environmental conditions and re-open the areas once biological conditions return to normal.

Although an increasing number of shellfish closures were documented in the 1990s, recent trends in shellfish closure resulted from stormwater impacts are less characterized. The objective of this study was to 1) determine the trends in the average duration of each closure event over the years, and 2) annual days for closure to assess if shellfish closure has been changed over the time.

### **Methods**

#### *Site Selection*

This study assessed ten shellfish growing areas within Onslow County and Carteret County, NC under conditional management (Figure 1). To construct average duration of closures as well as seasonal patterns, we focused on shellfish growing area D-3 (See Figure 2). Growing area D-3 is primarily located in White Oak River and its tributaries. It is considered a suitable study area because it experienced little to no change in boundary or classification during the study period.

#### *Proclamation and closure data*

The data was retrieved from NC DENR Division of Environmental Health Shellfish Sanitation Section and Recreational Water Quality for the period of January 1999 to December 2013. The data contains date of issuance, effective date, proclamation type (opening or closure), reasons for



proclamation, description of applied region and its associated shellfish growing areas. The duration is calculated based on the proclaimed closing and re-opening dates.

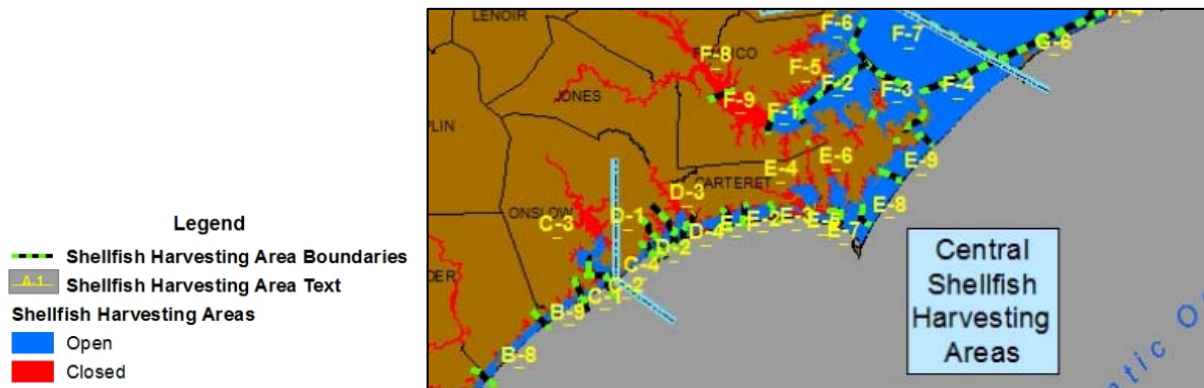


Figure 1: North Carolina Shellfish harvesting area closure map. Ten selected shellfish growing areas (B-9, C-1, D-1, D-2, D-3, E-2, E-4, E-6, E-8, and E-9) are located in Onslow County and Carteret County. Figure from Shellfish Sanitation, NC DENR.

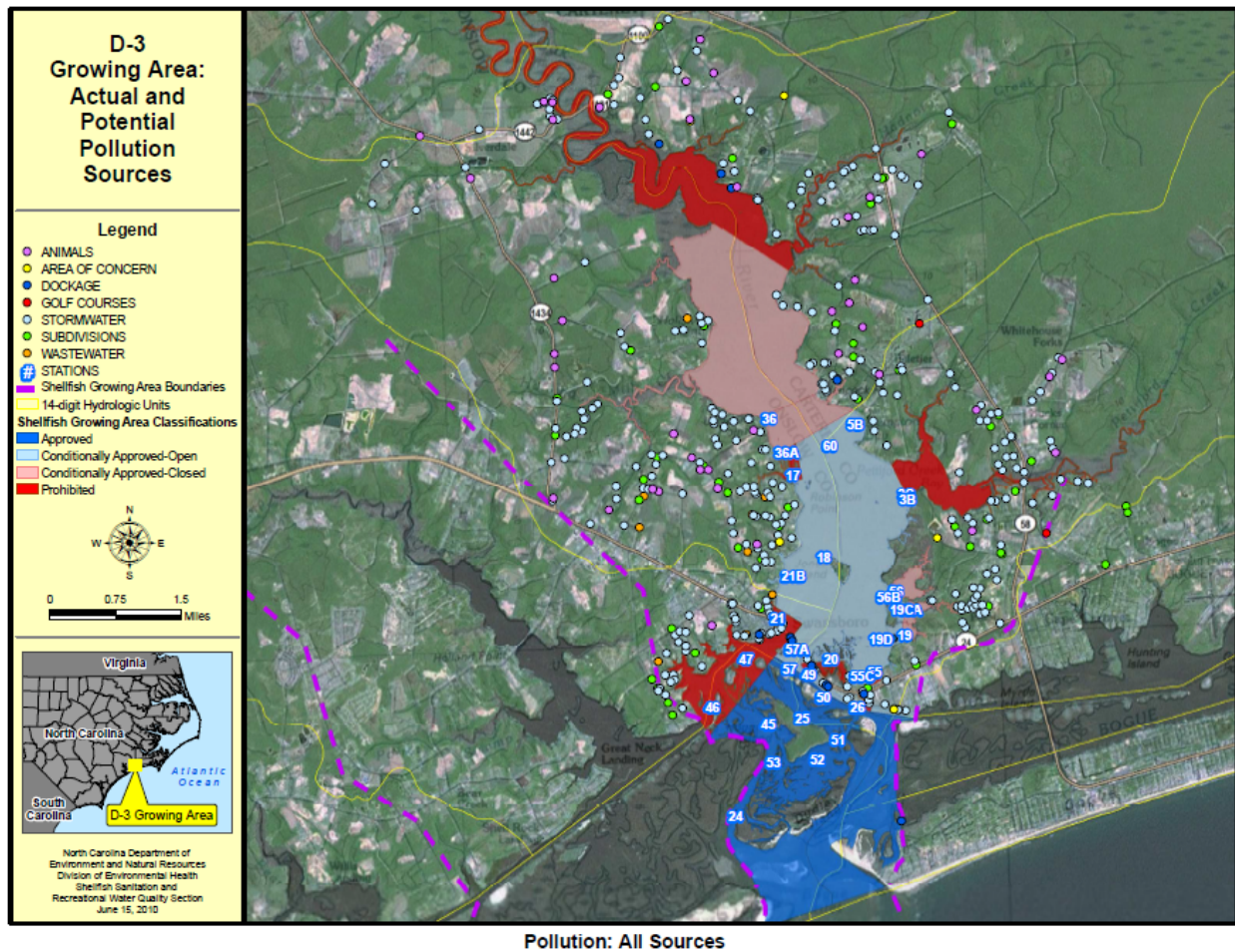


Figure 2: Shellfish growing area classifications in Area D-3. This study focused on conditionally approved-open area (light blue). Within each growing area, there could be partial prohibited or approved areas under other management approaches that were not considered in the analysis. Figure from 2010 Shoreline Survey conducted by Shellfish Sanitation.

### Linear Regression

As part of the trend analysis, linear regression functions were established to examine the relationship between the average duration for each closure event by year for each growing area.

## Results

The shellfish growing areas that we examined, exhibited high variability in annual closures. Historical records revealed that total annual closure ranged from zero (E-2 area, 2000) to 193 days (E-6 area, 2003) with the most closure proclamations issued in 2003 (18 records). The variation in annual closure is drastic. Area E-6 was closed for 29 days in 2001 and in the three succeeding years, the annual closures were 80, 193, and 62 days (Figure 3). Annual closure was not a declining or raising trend over the years in Area E-6, consistent with observations for other areas.

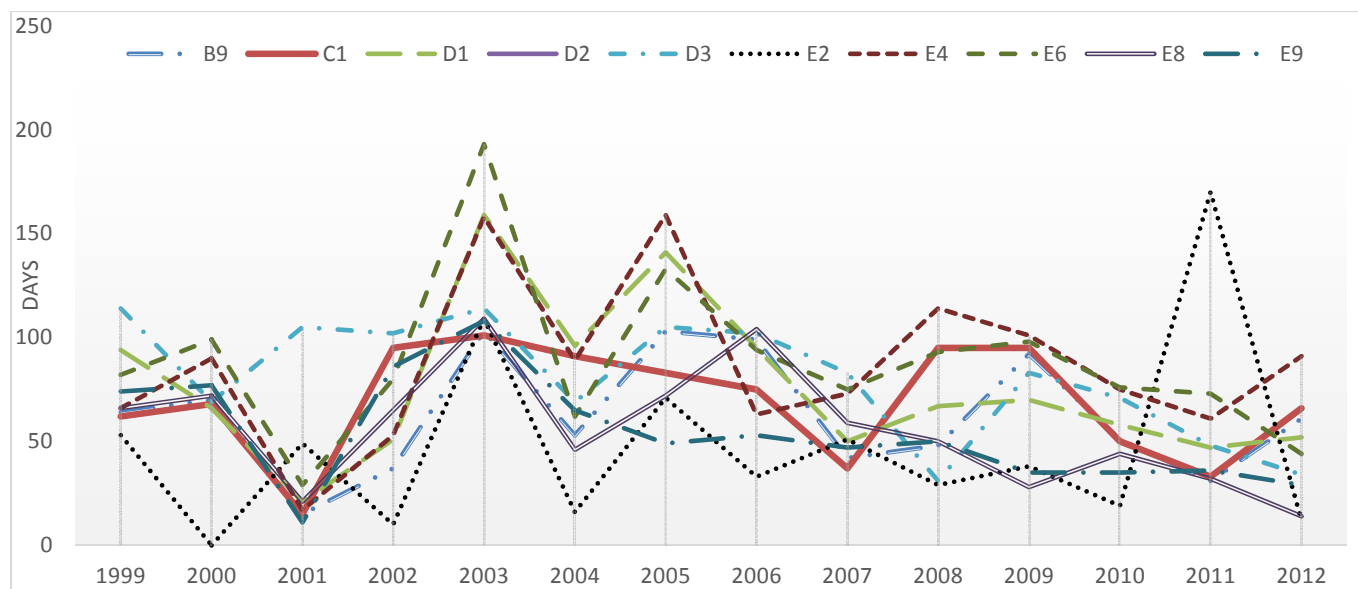


Figure 3: Annual shellfish closure in days for 10 selected areas in Onslow (B-9, C-1, D-1, D-2, and D-3) and Carteret County (E-2, E-4, E-6, E-8, and E-9). The shellfish growing areas that were studied, exhibited high variability in annual closures.

The historical proclamation records from 1999 to 2012 in the ten selected shellfish growing areas provide information on the predominance of closure, seasonal pattern and the nature of interannual variation. Within the year 2012, closure proclamations issued ranged from two to eleven records for the studied growing sites and annual closure ranged from 14 to 91 days with an average of 43.9 days. Seasonal pattern was examined with shellfish growing area D-3, with 2132.97 acres conditionally managed open from 1999 to 2012. Over the years, the annual closure ranged from 21 to 147 days, and average days for each closure event ranged from 4.86 to 13 days (Figure 4 (A) and (B)). The linear regression constructed by year and the means of closure days per event presented 18% of the closing days was explained by year ( $R^2 = 0.1811$ ).

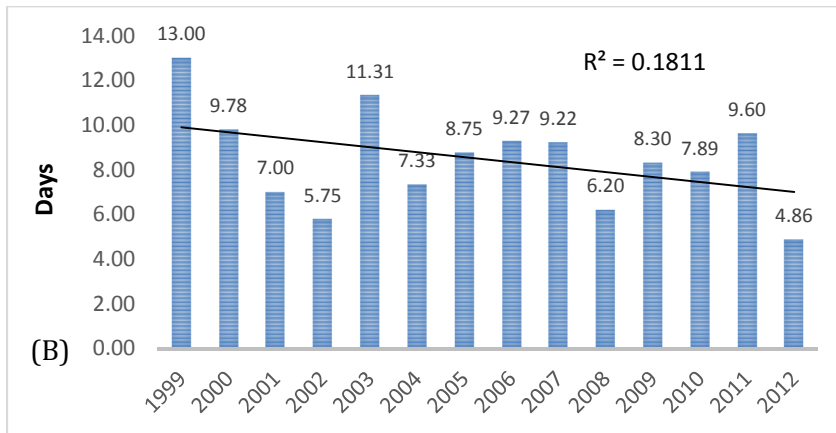
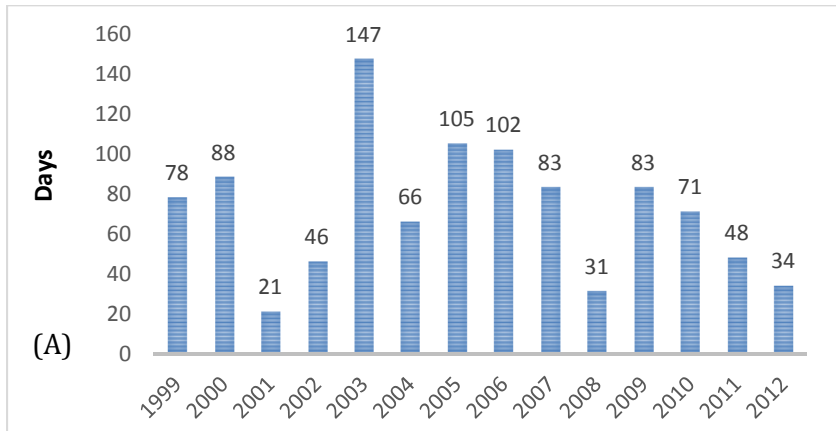


Figure 4: (A) Number of annual closure days in shellfish growing area D-3 from 1999 to 2012, with an average of 43.9 days, maximum 91 days and minimum 14 days. (B) The means of the closure days for each closure event in Area D-3. The linear regression by year and the means of closure days presented 18% of the closing days was explained by year ( $R^2 = 0.1811$ ).

In general, there were more closures during the summer and fall with September and January closure records of up to 30 days in 1999 and 2007 (Figure 5). Another seasonal pattern observed was that in a year with more closures in the spring, the closures appear less in the fall and vice versa. There were more closure days in the fall compared to the spring in all years except 2002, 2007, and 2008, which had more closure days in the spring.



Figure 5: Number of closure days per month for shellfish growing area D-3 from 1999 to 2012. Most closures were observed in summer and fall seasons, while up to 30 days of monthly closure were reported in September (1999) and January (2007). Seasonal pattern observed was that in a year with more closures in the spring, the closures appear less in the fall and vice versa.

## Discussion

Overall, the seasonal pattern of alternation, frequent proclamation, and the varying nature of annual closure over the years appear to be characteristic of the ten studied shellfish growing areas. We do not see enough evidence to suggest more shellfish closures are occurring or the closures

have been lengthened. This is surprising due to the fact that the state has undergone continuous development. This could be explained by other factors influencing the water quality in the coastal waters, including progress in stormwater management and climatic conditions. The alternating high and low shellfish closure could be due to the El Nino and La Nina, the phenomena of water temperature oscillation in Pacific Ocean with global weather impacts. El Nino was reported to bring in wet and cold winter while La Nina predicts below-average precipitation to the southeastern U.S. (Climate Prediction Center, 2014). This switching phenomenon between seasons was also observed in Moore et al.'s study on shellfish toxin induced closure, however the factors for bipolarity or if this is a new characteristic are still not clear (Moore et al., 2009). Future studies should focus on the relationship between climatic pattern and shellfish closure, where climate pattern play a significant role in the bacterial levels in water. In addition, more retrospective time series analysis for shellfish growing areas will assist the planning and management of shellfish growing areas facing future challenges. This overview of the conditional management of temporary shellfish closure is likely not the sole result of stormwater pollution but rather an aggregating consequence. Here we present an overview of temporary shellfish closure as context for efforts to improve water quality. The protection and promotion of water quality is a key remedy and the administration of state stormwater permitting and compliance is an important tool.

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## **APPENDIX 2: CLASSIFICATION OF QUESTIONS ASKED WITHIN COMPLIANCE DATABASE**

During a compliance evaluation, DWQ staff was prompted by a series of 13 yes or no questions to guide the evaluation process. The answers to these questions are stored within the state's compliance database. Using the 2005 compliance evaluation conducted by DWQ as a template, we classified these questions into one of six separate violation types. The following questions listed below as classified for violation type.

### *Violation Type: Installation*

1. Are the inlets located per the approved plans?
2. Are the outlet structures located per the approved plans?
3. Are the SW measures constructed as per the approved plans?

### *Violation Type: BUA*

1. Is the BUA (as permitted) graded such that the runoff drains to the system?
2. Is the site BUA constructed as per the permit and approval plans?

### *Violation Type: Reporting*

1. Are the SW BMP inspection and maintenance records complete and available for review or provided to DWQ upon request?
2. Signed copy of the Engineer's certification is in the file?
3. Signed copy of the Operation & Maintenance Agreement is in the file?
4. Copy of the recorded deed restrictions is in the file?

### *Violation Type: Maintenance*

1. Are the SW measures being maintained and operated as per the permit requirements?
2. Is the drainage area as per the permit and approved plans?

### *\*Violation Type: Other Permit*

1. Is the site compliant with other conditions of the permit?

### *\*Violation Type: Other Water Quality Issue*

1. Is the site compliant with other water quality issues as noted during the inspection?

\*Not included in 2005 Compliance Study

## APPENDIX 3: INTERVIEW PROTOCOLS

### Interview Script for NC Coastal Stormwater Program Evaluation

Thank you for agreeing to speak with me today, I'm working on a master's project which has the intent of discovering the areas of strengths and opportunities for improvement within the North Carolina Coastal Stormwater Program. You were selected as a point of contact because of your (professional experience, or you hold a permit). We hope to gain understanding of your perspective and personal experiences with the program over time. For the purpose of the analysis of your answers later we would like to record this interview. This survey is anonymous and the recording will be strictly for our own use in this project. This statement of confidentiality guarantees the anonymity of the interviewer and the handling of the recording. Please review it and sign it for us. Your identity will be kept confidential and once again I would like to thank you for your time. Do I have your permission to record the interview?

### GROUP 1: INDUSTRY- ENGINEERS AND CONSULTANTS

Q1. *(repeats for each group)*

Please tell me about your experience with the NC state stormwater program in the coastal counties.

1.1 Would you rate this experience as positive or negative?

1.2 Are there aspects you particularly like and dislike about this program?

Q2. *(repeats for each group)*

How would you classify your business *county (city, town, or other jurisdiction)* in terms of development speed in the past 10 years, by which we refer to the addition of buildings and impervious surfaces?

2.1 If there are areas of rapid development in your county, where are they and what are the drivers behind it?

Q3. *(repeats for each group should)*

How would you rate the surface water quality in your county?

3.1 Do you feel that the State Stormwater Program adds positively or negatively to this rating?

3.2 Which aspects of the stormwater program contribute to or address the water quality issues?

Q4. *(repeats for each group except Group 2, DEMLER)*

We've reviewed the compliance records for all counties in North Carolina in 2012 under the stormwater permitting program. Compliance in your *county (city town or other jurisdiction)* is X percent *(filled in depending on the county)*. Can you speculate on the reasons for this?

4.1 From your experience and point of view in your *county* what are the impediments to compliance?

4.2 What factors do you think contribute to those that comply?

4.3 What factors do you think contribute to those that don't comply?

Q5. *(repeats for each group)*

The stormwater program is aimed at minimizing the degradation of water quality. Do you think that if compliance with the program grew to 100% stormwater related water quality problems would be alleviated?

5.1 What do you think needs to be changed about the program to address water quality degradation?

5.2 Regardless of your opinion of whether or not increased compliance to the program

will improve water quality, where do you think the strengths of the current program lie?

Q6. *(repeats for each group)*

Do you have a preference for permit programs across the stormwater programs? Such as the Universal Stormwater Management Program, expedited permitting, National Pollutant Discharge Elimination System phase II, a local permitting process? Why?

Q7. *(unique to this group)*

For projects that you work on, how are the majority of Best Management Practices (BMP) selected?

7.1 Are the requirements for BMP maintenance and installation clear?

7.2 From your experience, after a BMP construction project is complete, is there any education about operation and maintenance of BMP taking place?

7.3 In your opinion, does the current selection of approved BMPs effectively address water quality concerns?

Q8. *(repeats for GROUPS 4 and 5 permit holders and envt groups; modified for group 3 lcl govts; not asked to group 2 demler)*

In your experience, how is non-compliance to the stormwater program addressed?

8.1 Is it effective? Why?

8.2 In your opinion and experience, what is the most effective approach available to address non-compliant sites?

Q9. *(repeats for each group)*

As a final question, if you could suggest one thing to improve the rate of compliance across the entire state, what would it be?

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## **GROUP 2: DEMLER EMPLOYEES**

Q1. Please tell me about your experience with the state stormwater program in the coastal counties.

Q2. SAME AS GROUP 1 (development rate)

Q3. We've reviewed the compliance records for all counties in North Carolina in 2012 under the stormwater permitting program. Compliance in the (Wilmington/Washington) region varies from (X% in County A to Y% in County B and Z% in County C). Can you speculate on the reasons for this?

3.1 From your experience in your *region* what are the impediments to compliance?

3.2 What factors do you think contribute to those that comply? Don't comply?

Q4. SAME AS GROUP 1 (is there a water quality problem)

Q5. SAME AS GROUP 1 (SSWP's effectiveness)

Q6. SAME AS GROUP 1 (Favorite permitting program)

Q7. Although the permitting program is administered through your office, what is the influence of federal regulations on the state program?

Q8. Is there any interplay between state and local regulations? Could you explain how that works?

Q9. In your opinion and experience, what is the most effective approach available to address non-compliant sites?

Q10. SAME AS Q9 FROM GROUP 1 (one improvement)

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### **GROUP 3: LOCAL GOVERNMENTS**

- Q1. SAME AS GROUP 1 (experience)
  - Q2. SAME AS GROUP 1 (development rate)
  - Q3. SAME AS GROUP 1 (is there a water quality problem)
  - Q4. SAME AS GROUP 1 (is there a water quality problem)
  - Q5. SAME AS GROUP 1 (SSWP's effectiveness)
  - Q6. SAME AS GROUP 1 (Favorite permitting program)
  - Q7. What are the local stormwater programs within your jurisdiction?
    - 7.1 Is there any interplay between your program and the state level programs?
  - Q8. In your experience, how is non-compliance to the stormwater program addressed in your jurisdiction?
    - 8.1 Is it effective? Why?
    - 8.2 In your opinion and experience, what is the most effective approach available to address non-compliant sites?
  - Q9. SAME AS Q9 FROM GROUP 1 (one way to improve)
- 

### **GROUP 4: PERMIT HOLDERS**

- Q1 Please tell me about your experience with the NC Coastal Stormwater permitting program.
    - 1.1 Would you rate this experience as positive or negative?
    - 1.2 Are there aspects you particularly like and dislike about this program?
    - 1.3 How long have you held a permit for? What type of permit do you hold?
  - Q2. SAME AS GROUP 1 (development rate)
  - Q3. SAME AS GROUP 1 (is there a water quality problem)
  - Q4. SAME AS GROUP 1 (is there a water quality problem)
  - Q5. SAME AS GROUP 1 (SSWP's effectiveness)
  - Q6. Have you applied for more than one type of stormwater permit?
    - **No:** What did you think about the process of applying for the coastal stormwater permit?
      - Was it a clear and easy process?
      - Do you have any concerns or suggestions for improving the process?
    - **Yes:** Did you find the application processes similar?
      - Was one better than another? Why?
      - Do you have any concerns or suggestions for improving the process?
  - Q7. Thinking about your permit, why did you choose your particular BMP?
    - 7.1 How is the maintenance of your BMP carried out? Is it something you are actively involved in?
    - 7.2 Do you find the requirements for BMP maintenance and installation clear?
  - Q8. SAME AS Q8 FROM GROUP 1 (Compliance)
  - Q9. SAME AS Q9 FROM GROUP 1 (One Improvement)
- 

### **GROUP 5: ENVIRONMENTAL GROUPS**

- Q1. SAME AS GROUP 1 (experience)
- Q2. SAME AS GROUP 1 (development rate)
- Q3. SAME AS GROUP 1 (is there a water quality problem)
- Q4. SAME AS GROUP 1 (is there a water quality problem)
- Q5. SAME AS GROUP 1 (SSWP's effectiveness)

Q6. SAME AS GROUP 1 (Favorite permitting program)

Q7. In your opinion, are the provided BMPs for selection adequate for addressing water quality concerns?

Q8. SAME AS Q8 GROUP 1 (Compliance)

Q9. SAME AS Q9 GROUP 1 (One Improvement)

**APPENDIX 4: INTERVIEW RECRUITMENT MATERIAL**  
**Email Transcript for Recruitment**

Dear Ma'am/Sir,

We are three master's students at Duke University conducting research for a one-year master's project. Our interest is performance study on state stormwater regulations of North Carolina, with particular focus in the 20 coastal counties. As part of the study, we hope to collect opinions from water management professionals about the best management practices for dealing with North Carolina's stormwater. Your working knowledge on how the state operates on a daily basis will provide valuable insights into developing plausible solutions for next- generation stormwater management in North Carolina.

If you agree to participate, we would like to schedule a phone call or in person interview with you. The interview includes 9 questions and will take about 30 minutes. The interviewing process will take place from February 1<sup>st</sup> to March 15<sup>th</sup>. If you have any questions or need more information, please contact any of us with the contact information provided below. We appreciate your time.

**Contact Information**

Szu-Ying Chen

Email:

Mobile:

Amanda Santoni

Email:

Rachael Bishop

Email:

Szu-Ying Chen, Amanda Santoni, and Rachael Bishop

Master of Environmental Management, 2014 Candidate  
Nicholas School of the Environment  
Duke University

# APPENDIX 5: INTERVIEW PARTICIPANT INFORMED CONSENT FORM

## Consent to Participate in a Research Study

### Researchers and Institution

The survey is designed and conducted by three graduate students, Rachael Bishop, Szu-Ying Chen and Amanda Santoni with faculty advisor Brian McGlynn from Nicholas School of the Environment and Earth & Ocean Science, Duke University.

### Research Purpose

This survey is a part of a research project: An Evaluation of North Carolina Coastal Stormwater Program, which seeks a better solution to stormwater management. The purpose of this survey is to collect professionals' opinions on current state stormwater program to achieve better stormwater management. With your permission, we would like to audio-record the interview for the purpose of making an accurate transcript of the interview. We will erase the audio once the transcript has been completed. The study includes 9 questions and takes about 30 minutes to complete.

### Confidentiality

Your name and contact information will not be connected to your responses. We will not use your name in our report. We will need job information including department, organization and position for initial process, however, this information will not be disclosed in the study. The research result will be presented in a de-identified form (e.g. "Pizza is the best food" respondent anon-1) and will be made available to the North Carolina Coastal Federation.

### Storage and Future Use of Data

The de-identified individual data will be retained for 5 years and will be made available to other researchers for other studies following the completion of this research.

### Voluntary Nature of the Study

Participation in this study is voluntary. You can stop at any time during the interview. You are free to skip questions you do not wish to answer.

### Contact Information

If you have questions about the content of this research you may contact Szu-Ying Chen at ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)) or \*\*\*-\*\*\*-\*\*\*\* or contact Dr. Brian McGlynn at ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)) or \*\*\*-\*\*\*-\*\*\*\*. If you have any questions about your rights as a participant in this research, you may contact the Chair of the Duke University Institutional Review Board at ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)) or \*\*\*-\*\*\*-\*\*\*\*.

By signing this document, you agree to participate in the study. You will be given a copy of this document for your record and one copy will be kept with the study materials. For interviews conducted via telephone or through Skype, please send an email stating your consent to participate in the study to your interviewer: Rachael Bishop ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)), Szu-Ying Chen ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)), or Amanda Santoni ([\\*\\*\\*@duke.edu](mailto:***@duke.edu)).

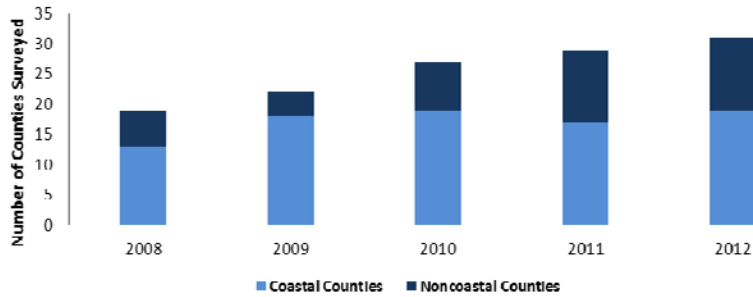
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Signature

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Date Reviewed and Signed

## APPENDIX 6: ADDITIONAL STATISTICAL GRAPHS AND TABLES



**Appendix 6.1:** Number of counties inspected for both noncoastal counties and coastal counties between 2008 and 2012. The number of counties inspected increased throughout the study period.

**Appendix 6.2:** The number of permits, inspections and percent of permits inspected in 2012 for the 20 coastal counties. The number of permits was obtained through publicly available information on the DEMLR website. The number of inspections only includes active state stormwater permits that have original issued dates prior to 2013. All duplicate permit numbers were excluded. The number of inspected sites was found in the DEMLR compliance dataset.

County	# Permits	# Inspected	% Inspected
Beaufort	583	17	2.9%
Bertie	125	12	9.6%
Brunswick	1736	112	6.5%
Camden	130	1	0.8%
Carteret	1040	18	1.7%
Chowan	124	5	4.0%
Craven	833	36	4.3%
Currituck	430	12	2.8%
Dare	713	13	1.8%
Gates	35	2	5.7%
Hertford	120	7	5.8%
Hyde	134	2	1.5%
New Hanover	2373	120	5.1%
Onslow	1748	84	4.8%
Pamlico	257	9	3.5%
Pasquotank	381	10	2.6%
Pender	598	29	4.8%
Perquimans	183	9	4.9%
Tyrrell	66	3	4.5%
Washington	94	3	3.2%
Grand Total	11703	504	4.3%

**Appendix 6.3:** Notices of Violation (NOVs) issued for the study period in coastal and noncoastal counties.

Year	NOVs		
	Coastal	Noncoastal	Total
2008	52	0	52
2009	213	1	214
2010	171	4	175
2011	37	11	48
2012	11	3	14

## Appendix 7: Coding Manual

This document depicts how to code an interview in NVivo. We developed general themes for consideration across all questions and a guide for codes to specifically keep in mind when applying codes to each question.

### Coding - General Themes

- **Development: (subnodes: Driver for development, Impediment to development)**
  - This code attempts to capture elements of a regions growth or amount of buildings and infrastructure. The general development code can be used when the interviewee refers to development projects. The rate codes to growth rates.
  - In coding this we attempt to use sentences to describe things that are not cut and dry.
  - Similar words: developer, build, fast growing, population, existing development
- **Water Quality (subnodes: nutrient, sediment, heavy metal, shellfish)**
  - This code should be utilized when the interviewee speaks about water quality. Sub-codes address specific aspects which may influence water quality.
- **Strength of the Program**
  - This code is for when an interviewee indicates a strength of the stormwater program outside of the strengths question.
- **Weakness of the Program**
  - This code is for when an interviewee indicates a strength of the stormwater program outside of the weakness question.
- **How to Improve the Program**
  - This code is utilized whenever a respondent indicates an area where the stormwater program they participate in can be improved. It should encompass responses to items that can be done better or when we interpret an area that they can improve in.
- **Compliance (subnodes: impedes compliance, aids compliance)**
  - Use this code to highlight areas in which an interviewee speaks about issues impeding or aiding compliance rates.  
Specifics sub-codes added after first reviews included: Scrutiny, Understanding of BMPs, and More Staff. These are coded in conjunction with impeding and aiding compliance.
- **Enforcement (subnodes: Notice of Violation, fine, compliance check)**
  - This code applies to the act of enforcement and activities relating to government check in activity to encourage compliance with the law. Similar to consider: Regulation, Legal Consequences.
- **Education (subnodes: public outreach, professional outreach, developers, local government, maintenance employees, permit holders)**
  - **Explanation:** Code explores the topic of teaching the public, industry participants, and government officials about stormwater program participation.

- **BMP (subnodes: LID, swale, detention pond, infiltration, bio-retention, maintenance)**
  - This code should be used whenever a respondent refers to a specific type of BMP. Introduce an individual code for each BMP mentioned.
- **Preference (subnodes: Local, NPDES, USMP)**
  - This node should be used whenever an interviewee speaks about their preference between permitting programs

To make the analysis process easier we also developed a list of attributes that may repeat across questions such as: high, medium, low, negative, positive, mixed, shifted, somewhat, no, yes.