A comparative study to the 2011/2013 water quality assessments in the Pasquotank Watershed in Northeastern North Carolina with a   
sea level rise component

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*Abstract*- The Pasquotank River Watershed is found in Northeast North Carolina beginning in the Great Dismal Swamp at the Virginia/North Carolina border and flows into the Albemarle Sound. The watershed provides a transition between spawning grounds and the waters of the Albemarle Sound. The sound serves as a nursery area for many fish species and is home to numerous sport and commercial species. Due to indications of rising global temperature and the monitoring of melting ice sheets, these coastal watersheds could be a leading indicator of rising sea levels as their chemical compositions changes. The effects of sea-level rise were also taken into consideration for future monitoring.

The 2014 Research Experience for Undergraduates Pasquotank River Watershed Team completed two sets of tests of five tributaries and the river itself. These test points were derived from the 2011 and 2013 Watershed Team research projects with the addition of four points created to sample further downstream in the Pasquotank River itself. Results were compared with previous readings utilizing a Water Quality Index (WQI). The streams tested were the Pasquotank River, Newbegun Creek, Knobbs Creek, Areneuse Creek, Mill Dam Creek, and Sawyers Creek. These streams, along with the river, cover a large portion of the watershed and provide a wide area of study for the watershed.

Tests performed in the laboratory on this year’s samples included pH, salinity, total dissolved solids, and conductivity. Air/water temperature, dissolved oxygen, wind speed/direction, and turbidity/clarity measurements were taken in the field. The results collected were placed online and displayed in correlation to their position utilizing Google Maps. The data were then compared to the 2011 and 2013 project results and examined for any variations or similarities.

It was found that the water quality for some water sources remained in their respective ranges from the past years. The others, such as Knobbs Creek, varied from the previous years. Newbegun Creek, with a water quality index of 59, stayed within the two previous teams’ WQI of 50 (2011) and 66 (2013). Mill Dam Creek had a very slight increase in water quality from the previous teams’ readings 47 (2013) and 48 (2011) but still managed to acquire a bad reading of 49. Areneuse Creek increased from 49 (2011) and 47 (2013) to reach a medium water quality of 57. The Pasquotank River, ranking as the lowest, has dropped significantly from 64 (2011) to 44 (2013) and continued to be lower in 2014 standing at 41 for its WQI. Sawyers Creek remained consistent between 54 (2011) and 50 (2013) at a low medium range with this year’s water quality being 51. Knobbs Creek WQI, having the highest water quality reading, increased from the two past readings of 52 (2011) and 50 (2013) with a WQI of 63.

Keywords: Water quality, Pasquotank, watershed, dissolved oxygen, pH, salt, conductivity, clarity, turbidity, sea level rise, global warming.

# Introduction

## Overview

A watershed is a group of smaller bodies of water that flow into a larger body of water. The Targeted Local Watershed (TLW) for this year’s research was the Pasquotank Watershed, which included the Pasquotank River and several of its tributaries. The contributing waterways tested in this research were Knobbs Creek, Sawyers Creek, Areneuse Creek, Mill Dam Creek, and Newbegun Creek.

The 2014 Pasquotank Water Quality Team gathered the following data in order to evaluate the quality of the water: dissolved oxygen, turbidity, clarity, total dissolved solids (TDS), salinity, pH, and conductivity. Other items such as wind speed/direction, air/water temperature, latitude/longitude, and date/time were also recorded as factors that could influence the final analysis. This data was compared to the 2011 and 2013 summer research projects, which targeted the same waterways.

An added component to this year’s research was a focus on salinity as a result of sea level rise. As sea level rise occurs, coastal estuaries and ground water supplies are inundated with higher levels of salt affecting local plant and animal populations as well as residents living along the coast. Testing points added in the lower Pasquotank River out to the mouth of the Newbegun Creek will allow for an increase monitoring of salinity levels in the Pasquotank Watershed. [12]

## Dissolved Oxygen

Dissolved Oxygen is a key factor in marine life. Dissolved oxygen is a relative measure of the amount of oxygen that is dissolved or carried in a given medium. The volume and velocity of water flowing, the climate, the water temperature, and the types of organisms living within the water are factors to the dissolved oxygen. [1] During the summer, the water temperature has a high influence on dissolved oxygen because a high water temperature equals a lower reading in dissolved oxygen [2].

The standard unit of measurement used for the tests completed in the laboratory was milligrams per liter (mg/L). This information was converted into a unit of “percent saturation” (%sat) in order to use the readings in the Water Quality Index calculations.

## Turbidity

Turbidity refers to the optical property that causes light to be scattered and absorbed by particles and molecules. [3] Higher turbidity increases water temperatures because suspended particles, [4] which can promote regrowth of microorganisms in the distribution system, absorb the light converting it into heat. It is measured in inches and converted into [5] Streams with high turbidity absorb more heat, and also reduce the amount of light penetrating the water, which reduces photosynthesis and the production of Dissolved Oxygen (DO). [4]

## Clarity

Water clarity is a measure of the amount of sunlight that can penetrate through the water. [8] Water clarity is affected by water color. [7] Two types of color of water are apparent color and true color. Apparent color is water sample that has not had substances filtered out of the water, and true color is water sample that has had all the substances filtered out of the water. [8]

## Total Dissolved Solids (TDS)

Total Dissolved Solids are the total amount of mobile charged ions. These mobile charged ions include minerals, salts, and metals that are dissolved in a given volume of water. TDS is related to the purity of water. A high level of TDS is an indicator that the water has toxic ions which is often caused by the presence of potassium. [9]

## Salinity

Salinity is the amount of dissolved salt in a body of water. Salinity determines what types of living things live in that specific environment. The unit of measurement for salinity is parts per millions (ppm). The higher the salinity reading, the lower the dissolved oxygen reading will be. [10]. Salinity can also be an indicator of sea level rise as ocean waters encroach on brackish and coastal watersheds. The sun can affect salinity more in the summer than the winter because higher temperatures increase levels of evaporation.

## Conductivity

Conductivity is the measure of water’s capability to pass electrical flow. It is affected by negative charged ions such as chloride and nitrates or positive charged ions like calcium and sodium. Conductivity is also affected by water temperature as both factors will either increase together or decrease simultaneously. Conductivity is measured in Siemens (mho) which is a reciprocal of resistance (ohm). [10].

## pH

The pH measurement is used to determine if a solution is acidic or basic. The pH readings range from 0 to 14 with acidic levels between 0 and 6.9 units and basic levels between 7.1 and 14. A reading of 7 is considered to be neutral. If either substance is very acidic or very basic, then the substance is reactive as it can cause a serious chemical burn. [11].

# Methodology

## Pre-Field Work

Preparing for the fieldwork, the Global Positioning Systems (GPS) devices were loaded with points and routes by using the Garmin BaseCamp software for each waterway. Before each waterway was tested, the Dissolved Oxygen (DO) meter was calibrated using zero solution and distilled water. Duplicate test equipment was taken on each trip to ensure that data would be captured.

## Field Work

At each test point, several pieces of data were recorded. The time was noted as a reference for samples being taken as several test results could vary during the day. Wind speed, wind direction, and air temperature were then obtained. The water temperature and water sample were acquired at a consistent depth of three feet. The clarity and turbidity were acquired using the Secchi disk and the amount of dissolved oxygen in the water was obtained by using the DO meter.

## Post-Field Work

Once all the data was collected, in-house tests were performed to obtain the pH, conductivity, salinity and the total dissolved solids information. The pH meter was calibrated using distilled water and a pH tablet. The water samples that were taken from the field work were poured into small styrofoam cups for testing. The pH meter was placed into the sample and the pH readings were recorded. This was also done for the Pocket Tester which was used to test salinity, conductivity, and total dissolved solids.

# ANALYSIS

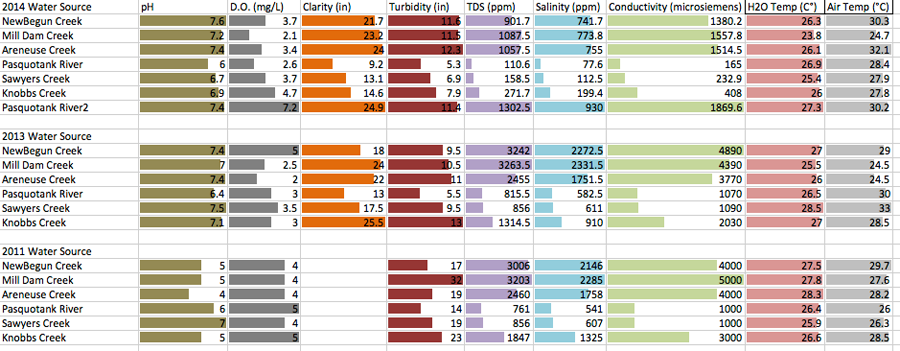
## Water Quality Index

The overall water quality index (WQI) for all of the waterways that were tested remained constant. Newbegun Creek’s water quality fell between the two water qualities recorded by the 2011 team and the 2013 team with a medium WQI. Mill Dam Creek’s water quality has risen higher than both teams' readings but still has a bad WQI. Areneuse Creek’s water quality is greater than the previous years and advanced to have a medium WQI. The Pasquotank River’s water quality is lower than the 2013 and 2011 teams' readings and has the lowest reading for the 2014

Watershed Research Project. Sawyers Creek’s water quality fell between the two previous teams' WQIs with a medium water quality index. Knobbs Creek’s water quality recorded a higher WQI than the two preceding teams and the highest for 2014. This year is the first year the lower Pasquotank has been tested. The lower Pasquotank had a good WQI due to it width.

WQI 2014.tiff

Figure 1. Water Quality Comparison between the 2014, 2013 and 2011 Projects

Figure 2. Averaged Water Source Readings for 2014, 2013, and 2011 Projects

## Dissolved Oxygen

The dissolved oxygen measurements for 2014 corresponded to the 2013 and 2011 projects. The measurements differed between the head of the each waterway and their intersection with the Pasquotank River. The leading factor for calculating dissolved oxygen was wind and the width of the waterway. Knobbs Creek had the best water quality this year, mainly due to its high dissolved oxygen readings. The lower Pasquotank River had a better reading than any other waterway this year, possibly due to its width and the winds effects.

## TDS/Salinity/Conductivity

The 2014 readings for total dissolved solids (TDS), salinity, and conductivity have all decreased from the 2013 readings. The air temperature was lower in 2014 possibly illustrating a lower amount of evaporation which would yield a lower salinity reading.

Knobbs Creek had a high reading of salinity, TDS, and conductivity. Newbegun Creek, Areneuse Creek, and the Pasquotank River had a high salinity reading as these brackish (high levels of salt) waterways are located nearer to the ocean. The TDS, salinity, and conductivity readings for the lower Pasquotank River were higher than any other waterway for this year’s project.

Salinity in freshwater streams is a major indicator in sea level rise. This year’s readings were much lower than previous years, which may have been due to more moderate temperatures during this year’s research.

## pH

The pH levels remained similar to the previous years’ readings. Newbegun Creek, Mill Dam Creek, and Areneuse Creek had a base pH this year (7.1-14). The Pasquotank River, Sawyers Creek, and Knobbs Creeks had a reading of either 6.9 or lower which made them acidic. The lower Pasquotank River’s pH readings were close to the other waterways this year.

## Clarity/Turbidity

The clarity and turbidity readings have kept a constant standard from previous years. The clarity was always ten inches or higher than turbidity because turbidity determines the amount of suspended particles in the water and clarity determines how clear the water is. No variations were recognized. The lower Pasquotank River’s readings were close to Mill Dam Creek, Areneuse Creek, and Newbegun Creek as these three waterways empty into the lower Pasquotank.

# Conclusion

## Overall

In this year’s project, the data and graphs present the continued healthiness of the Pasquotank Watershed. Determined by the Water Quality Index Calculator, this year’s water quality has not greatly differed from 2013 and 2011 water quality tests.

## Variations

There were minor variations found in the WQI, but the overall quality of the waterways this year was within the medium range or close to it. The most noticeable variation was the comparison between the 2014, 2013, and 2011 TDS, salinity, and conductivity readings. The readings for 2014 decreased greatly from the 2013 and 2011 readings. This may have been due to the lower temperatures during this year’s research period.

## The Lower Pasquotank River

This is the first year of testing the lower Pasquotank River. The water quality of this water was good compared to the other waterways. The lower Pasquotank River is connected with Mill Dam Creek, Areneuse Creek, and Newbegun Creek. These waterways have similar pH, clarity, turbidity, dissolved oxygen, salinity, conductivity, and TDS readings.

## Areneuse; Mill Dam; and Newbegun Creek

This year’s readings continued to follow the pattern of last year’s readings in that the salinity, TDS, and conductivity were much higher in the waterways below Elizabeth City where the Pasquotank River widens. With the addition of the four new waypoints in the lower Pasquotank, the team was able to gather data confirming this correlation. Continued testing of these new points will add to the further monitoring of this section of the watershed.

# Future Works

## Digital Thermometer

For a more accurate reading, a digital thermometer is suggested to be used in the field work. The Water-Proof Thermometer by Hoskin Scientific [28] has a probe cord of five feet and has retail price of $32. This meter will provide a more accurate reading of the water temperature as compared to the current mercury thermometer being used.

## Database Development

An online database that gives access to any set of data from any project year should be developed for future analysis. Developing a PHP Hypertext Preprocessor (PHP) interface with the data needed would allow for better comparison and contrasting of multiple sets of data.

## Inclement Weather Data Recording

During this year’s trip, the inclement weather inhibited us to record data due to wet data sheets. This occurred on three trips. The “Rite in the Rain” company provides all-weather paper and writing utensils.

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