VOLUNTEER WATER QUALITY MONITORING IN NORTHEASTERN SOUTH CAROLINA FOR NPDES PHASE II STORMWATER COMPLIANCE

Susan Libes, Ken Hayes and Christine Ellis
Waccamaw Watershed Academy
Burroughs & Chapin Center for Marine and Wetland Studies
Coastal Carolina University, Conway, SC

ABSTRACT

Over the past five years, three volunteer water quality monitoring programs have been implemented in northeastern South Carolina to help meet regulatory requirements under the NPDES Phase II Stormwater Program. This region, which encompasses two counties and is entitled the Myrtle Beach Urbanized Area (UA), contains eight small municipal separate storm sewer systems (SMS4s), each of which is required to develop and implement their own stormwater management program. Each monitoring program focuses on a watershed that crosses jurisdictional boundaries, requiring collaboration of several SMS4's to provide funding and coordinate management responses to reports of water quality problems. The longest running of the programs is based in the Waccamaw River, with 12 sites in SC and 6 in NC.

South Carolina does not have a centralized volunteer monitoring program, so the efforts in the Myrtle Beach UA are free standing. They are implemented through a QAPP and SOPs available at: http://www.coastal.edu/wwa/vm along with the program's data which are presented in a viewer customizable format, including tables, graphs, and csv file data downloads. The SMS4's stormwater managers play a central role in these monitoring programs. They respond to rapid reports of potential illicit discharges enabled by an online data entry system used by the volunteers. They also participate in biannual public meetings to discuss findings. To facilitate management follow through, percentile-based site specific water quality "standards" have been developed.

KEYWORDS

Stormwater, monitoring, volunteer, NPDES, citizen science.

INTRODUCTION

NPDES programmatic context. The US EPA specifies volunteer water quality monitoring (VWQM) as an acceptable activity for accomplishing Minimum Control Measure 2 (Public Participation/Involvement) under its National Pollution Discharge Elimination System (NPDES) Phase II Stormwater program. The latter is a component of the federal Clean Water Act directed at reducing nonpoint sources of pollution into water bodies as carried by stormwater runoff. The program is implemented in a decentralized way, recognizing that most nonpoint source pollution arises from the cumulative activities of a large and diverse number of locally-based contributors. Thus successful stormwater management requires implementing pollution control strategies on a community scale. To direct these activities, municipalities are required to develop and implement stormwater management programs that address the six Minimum Control Measures (MCM's) listed in Table 1.

Table 1. Six Minimum Control Measures in the NPDES Phase II Stormwater Program

MCM1:	Public Education and Outreach
MCM2:	Public Participation/Involvement
MCM3:	Illicit Discharge Detection and Elimination
MCM4:	Construction Site Runoff Control
MCM5:	Post-Construction Runoff Control
MCM6:	Pollution Prevention/Good Housekeeping

Activities that address MCM's 1 and 2 tend to be closely linked. The intent of MCM 2 is to realize the benefits of the combined efforts of professional stormwater staff and members of the community. In the case of VWQM, the volunteers partner with technical staff to generate data and then assist in broadcasting this new understanding of local stormwater issues through their social and political networks. The data collected through VWQM also support MCM's 3 and 5. We describe below how three VWQM programs are helping the Myrtle Beach Urbanized Area (UA) meet their NPDES Phase II stormwater program requirements.

History of Volunteer Water Quality Monitoring in the USA. Volunteer water quality monitoring is an example of "citizen science" which is broadly defined as the collection of scientific data by trained citizen volunteers. The US EPA began formal support of VWQM in the 1980s (Lee 1994). The agency maintains a volunteer monitoring program through web-based resources located at: http://water.epa.gov/type/rsl/datait/waters/georef/epasvmp.cfm. These resources include: a newsletter, a listserv, methods manuals, periodic conferences, and a directory of VWQM groups. Another major repository of VWQM resources is maintained at: http://www.usawaterquality.org/volunteer/ by the USDA in support of their VWQM National Water Resource Project.

Multiple Benefits of Volunteer Water Quality Monitoring. VWQM provides multiple benefits and hence is a highly cost-effective stormwater management strategy. These benefits fall under two broad categories: (1) The production of data over time and space scales that would otherwise go unmonitored and (2) Increased community engagement in stormwater management with the volunteers serving as articulate advocates for their watersheds. The various activities of the program provide opportunities for publicizing water quality issues to the larger community, including press coverage of sampling events and public access to the data via the internet. The resulting heightened awareness of local issues can aid in voluntary adoption of recommended best management practices and support of stricter stormwater regulations.

Citizen science is also recognized as a way to leverage the skills and experience of volunteers. These folks tend to be highly knowledgeable of their local watersheds and hence can provide novel insights as to the causes and best solutions to water quality problems. In some cases, they have expertise that greatly augments the professional resources. In our case, a volunteer did much of the initial PHP software code development for our web-based data entry and control charting systems.

VWQM can also be an intergenerational activity that promotes development of stewardship through all age levels. Finally, it supports public outreach education efforts. In our case, we have facilitated this synergy by administering our local VWQM programs through the Coastal Waccamaw Stormwater Education Consortium (Libes 2011). This group of educators and stormwater managers work collaboratively to help cover the MCM's 1 and 2 requirements for the Myrtle Beach UA. To read more about CWSEC, see: http://cwsec-sc.org.

PROGRAM DESCRIPTION

Program Objectives. The Myrtle Beach UA lies in the northeastern corner of South Carolina within Horry and Georgetown Counties. It is one of the fastest growing regions in the United States, prompting concern for the potential effects of coastal development on local waterways. This UA encompasses eight municipalities which are regulated as small separate storm sewer systems (SMS4's) in the NPDES Phase II stormwater program. Four of these SMS4's are engaged in VWQM. The oldest program was initiated in 2006 and covered 10 sampling sites in the Waccamaw River. This was expanded in 2007 to 12 sites. In 2012, an additional 6 sites were added to cover the river's headwaters which lie in Brunswick and Columbus counties in North Carolina. The program now totals 18 sites across 140 river miles. A VWQM program was initiated in 2008 in Murrells Inlet, a mesotidal estuary that lies in Georgetown and Horry Counties. The newest program, which commenced in 2010, is based in the town of Surfside Beach. It covers a set of networked ponds that receive drainage waters from Horry County and discharge into the Atlantic Ocean and Murrells Inlet.

The overall goals of each program are to: (1) address NPDES Phase II program MCM's for public education and involvement; (2) document long-term water quality trends with a focus on identifying sites of poor water quality; (3) assist with illicit discharge detection; and (4) demonstrate improvements arising from implementation of stormwater BMPs, such as retrofits designed to remediate water quality problems.

Program Design. Sampling site selection in each program was designed to address site specific concerns using a watershed approach whose goal is to identify sources of pollutants. In the case of Murrells Inlet, the focus is on implementation of a fecal coliform shellfish Total Maximum Daily Load (TMDL) approved in 2005 that requires an 80% reduction in pathogens, but does not identify the source of the pollutogens (SC DHEC 2005). In this program, the VWQM sites were selected to test the hypothesis that flows from tidal creeks can carry significant amounts of fecal bacteria into Murrells Inlet.

In the Surfside program, the coastal waters that lie near the mouth of several small tidal creeks, called swashes, are on the state's 303(d) list of impaired waters for recreational impairments caused by chronic contraventions of *Enterococcus* water quality standards (WQS). These pollutogens are hypothesized to originate from land-based sources and are carried by stormwater runoff into the networked ponds that discharge through the swashes into the ocean.

Other issues of concern in these programs are hypoxia, eutrophication, and sediment pollution. In the Waccamaw River, a TMDL for dissolved oxygen (DO) was approved for the southern half of the river in 1999 (SC DHEC 1999). Many of the TMDL sites are still not meeting the DO WQS. Sampling sites were selected to provide insight into land-based sources of Biochemical Oxygen Demand (BOD).

Organizational Structure. Technical support for this program is provided by staff from Coastal Carolina University's EQL, which is part of the Waccamaw Watershed Academy within the Burroughs and Chapin Center for Marine and Wetland Studies. This staff includes a VWQM coordinator and program director, with the latter serving as the QA officer. The EQL is certified by SC Department of Health and Environmental Control (SC DHEC) for regulatory measurement of water quality parameters including those covered by the VWQM programs. Support includes maintenance of kits, provisioning of supplies, data archiving, visualization, and analysis and production of technical reports and presentations, including illicit discharge reporting. Each of the programs has a field leader: the Waccamaw Riverkeeper™ serves the Waccamaw River program, staff from the community group Murrells Inlet 2020 serves the Murrells Inlet program, and the chair of Surfside Beach's Stormwater Committee serves the Surfside program. The field leaders are responsible for recruiting volunteers, keeping them organized, and executing public outreach events including annual data conferences.

Sampling and Analysis. The parameters monitored in the VWQM programs provide information on the related issues of bacterial pollution, hypoxia, eutrophication and sediment pollution. Sampling is conducted bimonthly year round and includes in-situ measurements of dissolved oxygen, temperature, conductivity/salinity/total dissolved solids, and pH. Grab samples are collected and analyzed by the volunteers for turbidity, nitrate, nitrite, ammonia, *E. coli*, and total coliforms.

The standard operating procedures for sampling and analysis are available at: http://www.coastal.edu/wwa/vm/sops.html. The volunteers work in teams, each covering one to three sites. Team members tend to specialize in particular tasks, such as field data recording, meter usage, bacteria counting, or online data entry. Each team has a master sampler who is responsible for calibrating equipment and performing field calibration checks. Hach Sension™ meters are used for the in-situ measurements and turbidity is measured with a Hach 2100P turbidity meter. *E. coli* and total coliforms are measured with Micrology Lab's Coliscan Easygel™ plus media which provides confirmation based on UV fluorescence. Dissolved inorganic nutrients (nitrate, nitrite and ammonia) are measured using Hach test strips. The master samplers keep the equipment, including an incubator, and supplies at their homes between sampling events. The equipment is returned to Coastal Carolina University's Environmental Quality Laboratory (EQL) every 6 samplings (3 months) for maintenance and restocking of supplies. At a single site on the Waccamaw River (Murrells Landing), sampling is conducted every other day, including measurements of true color, chlorophyll, phaeopigment, and alkalinity. This data set extends back to 1998.

For each program, sampling is conducted synoptically within a three-hour window. In the event of foul weather, the master samplers are empowered to decide to cancel sampling, however, the volunteers have generally elected to sample and have contrived systems for keeping dry. If not; volunteers are encouraged to make up a missed sampling at the earliest possible date. All measurements are performed on surface water sampled with a 2-L, wide-mouth plastic thermos attached to a sampling pole. Extensive testing has demonstrated that this volume is large enough to minimize bottle effects.

Funding. Funding is provided on a continuing basis from each of the SMS4s via allocations from their municipal stormwater utility fees. The budget includes an equipment amortization plan that supports replacement of all equipment on a four-year cycle. Over the VWQM programs' lifetimes, this has enabled upgrades to newer models and technologies.

Quality Control & Training. The quality assurance and quality control (QAQC) activities for the VWQM programs are documented in a Quality Assurance Project Plan (QAPP) (http://www.coastal.edu/wwa/vm/qapp.html). This plan is modeled after US EPA guidelines for VWQM programs (US EPA 1996). All volunteers receive training by EQL staff that culminates in their successful performance of an initial demonstration of capability (IDC). Training records are maintained in a web-accessible database that includes a tool for producing the documentation needed by the SMS4s to meet their annual NPDES reporting requirements for MCM 2. Additional formal training is provided for master samplers who calibrate sampling equipment, undertake measurement of turbidity and/or prepare and read bacteria samples. The volunteer monitoring coordinator visits each sampling team on site at least once a year. A group meeting is held once a year for each VWQM program to obtain feedback from volunteers and to resolve methods issues.

For in-situ measurements of DO, conductivity/salinity/TDS, and pH, meters are calibrated within 24 hours of use and then checked in the field with laboratory check standards. Temperature is checked against a NIST thermometer during equipment maintenance performed at the EQL every 3 months. The in-situ field measurements are made in triplicate after meter values have stabilized. At least once a month, these values are control charted to evaluate the precision of the data. The control charts are constructed from the standard deviation of the triplicate values. The control limits are monitored to ensure compliance with the programmatic data quality objectives as specified in the QAPP. Production of the control charts is handled by PHP code that accesses data archived in a MySQL database. The control charting results are likewise archived into the database and include commenting. This enables tracking of trends in meter noise and signal drift. Accuracy issues are tracked by comparing results to those of nearby USGS water quality monitoring stations, where available. This has led to refinements in the use of the meters, such as extending sensor stabilization times, especially when measuring pH in cold waters of low conductivity. This also helps target retraining efforts.

All QC activities are documented on field data sheets and calibration logs. The hard copies are returned to the EQL where they are reviewed and archived. Within one week of collection, the data are collated into a provisional report and submitted to the QA officer for review. As discussed below, this report is used to facilitate a rapid response to potential illicit discharges.

Data Management. After sampling, volunteers post their results online at a password protected website. The entries are checked by the VWQM coordinator against hard copies of the field data sheets mailed to the EQL by the volunteers. These data are compiled into a provisional report that is reviewed by the QA officer, and then submitted with a narrative summary to the field leader. The field leader reviews the report and e-mails it on to the stormwater managers with comments highlighting issues, as necessary. This process, from data collection to data entry to data review and reporting to the stormwater managers, takes approximately 14 days. Volunteers are also encouraged to call as soon as they observe an unusual measurement. To facilitate this, they have been provided with site-specific norms for each parameter for each of their sampling sites. These values were developed from the first three-to-five years of data. When the volunteers call in unusual findings, the VWQM coordinator can suggest additional activities to verify and support the data. This information can then be rapidly relayed to the stormwater managers, thereby enabling a rapid response to potential illicit discharges.

Data Visualization and Internet Resources. The VWQM data are housed in a MySQL database on one of CCU's computer servers. The database is accessible to the public through a web interface located at: http://bccmws.coastal.edu/volunteermonitoring/index.php that allows the user to select sites, parameters and date ranges over which to generate summary statistics, graphs, and downloadable csv files. The graphs allow users to zoom in and scroll across both the x and y axes. A ©Google map API is used to provide an interactive map view of the data. The user can also generate graphs that co-plot rain and water quality data to investigate the role of stormwater runoff on water quality. Rain data are obtained from sources including the US Geological Survey, National Climate Data Center, and Nexrad satellite imagery. We have also established sampling sites in the National Oceanic and Atmospheric Administration's Community Collaborative Rain, Hail and Snow Network (CoCoRaHS), a volunteer rain monitoring program, to enhance spatial coverage (http://www.cocorahs.org/).

Each of the volunteers has a password protected account that permits them access to a data entry portal. The staff has accounts that provide access to program management tools including: contact and training information for the volunteers, control charting, data review and commenting, an automated email sampling reminder system, and control settings for the interactive graphs. The latter permits display and editing of WQS's shown on the graphing applications, along with an explication of these standards.

For programs with at least three years of data, box plotting has been used to set percentile-based site-specific norms that are functionally water quality "standards". Comparisons to these norms and the regulatory WQS are included in each provisional report sent to the stormwater managers. The 75th and 90th percentiles are used to identify unusual and highly unusual results, respectively. This is particularly useful for sites that have chronic water quality problems, such as *E. coli* in some of the tidal creeks in Murrells Inlet where samples almost always exceed the US EPA's recommended thresholds. In such cases, the percentile rankings help identify results that are unusually high and hence merit an immediate effort to track down pollution sources.

FINDINGS TO DATE AND MANAGEMENT RESPONSES

Murrells Inlet. Bimonthly sampling conducted since June 2008 has identified two tidal creeks and one stormwater retention pond as having chronic *E. coli* impairments. As shown in Figure 1, the median concentrations at these sites are equal to or higher than the US EPA health criteria for even occasional contact. A map view of these data is presented in Figure 2 as generated on the program's website. Values increase after significant rainfall. This has stimulated source tracking efforts that have detected contamination within the tidal creek sediments and has led to a joint effort amongst the SMS4s, EQL and US Army Corps of Engineers to develop genotypic markers to identify human-sourced bacteria (Trapp et al. 2012).

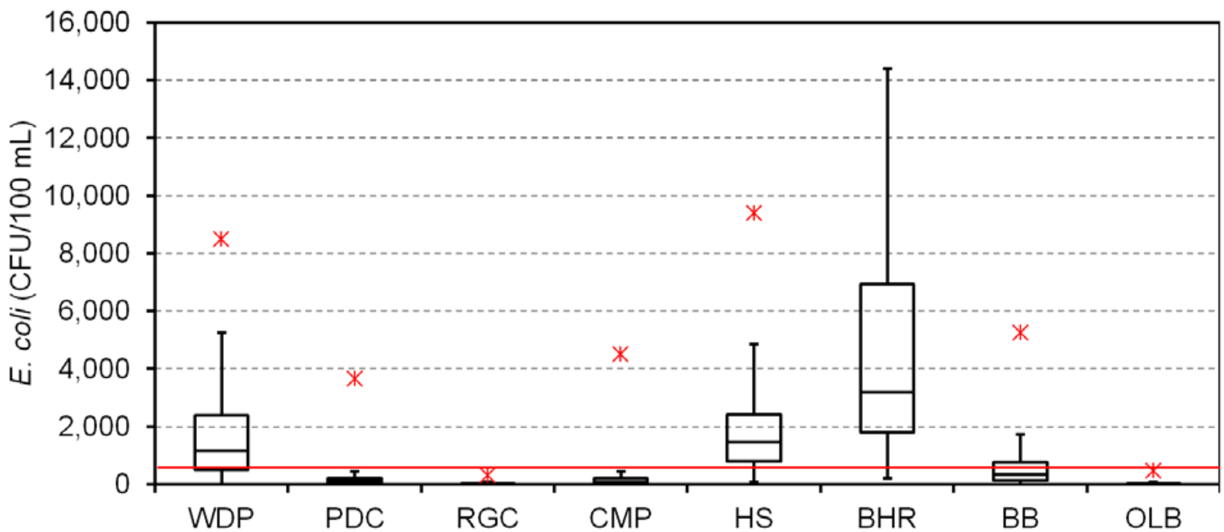

Figure 1. Boxplot of *E. coli* data (CFU/100 mL) from Murrells Inlet from Jul 2009 to Jan 2012. Red line marks US EPA single sample recreational WQS for infrequently used full body contact (575 CFU/100 mL). Single sample WQS for designated beach areas is 235 CFU/100 mL. Samples per site average 62.

Waccamaw River. – Because of the blackwater nature of the Waccamaw River, it is prone to low concentrations of DO. In response, SC DHEC has set a special WQS of 4 mg/L DO for this water body. As shown in Figure 3, the median summertime DO concentrations, measured since 2006, equal to or below this WQS at 7 of the 12 sites in South Carolina. The 25th percentile lies below the WQS at all 12 sites. The sites on the downstream end of the river have been covered by a DO TMDL since 1999 (SC DHEC 1999). Due to lack of attainment of the 4 mg/L DO WQS, the ultimate BOD (UBOD) loads permitted to the river's NPDES dischargers have since been cut several times. These dischargers are sewage treatment plants. This TMDL assumed that nonpoint sources of BOD would not increase over time.

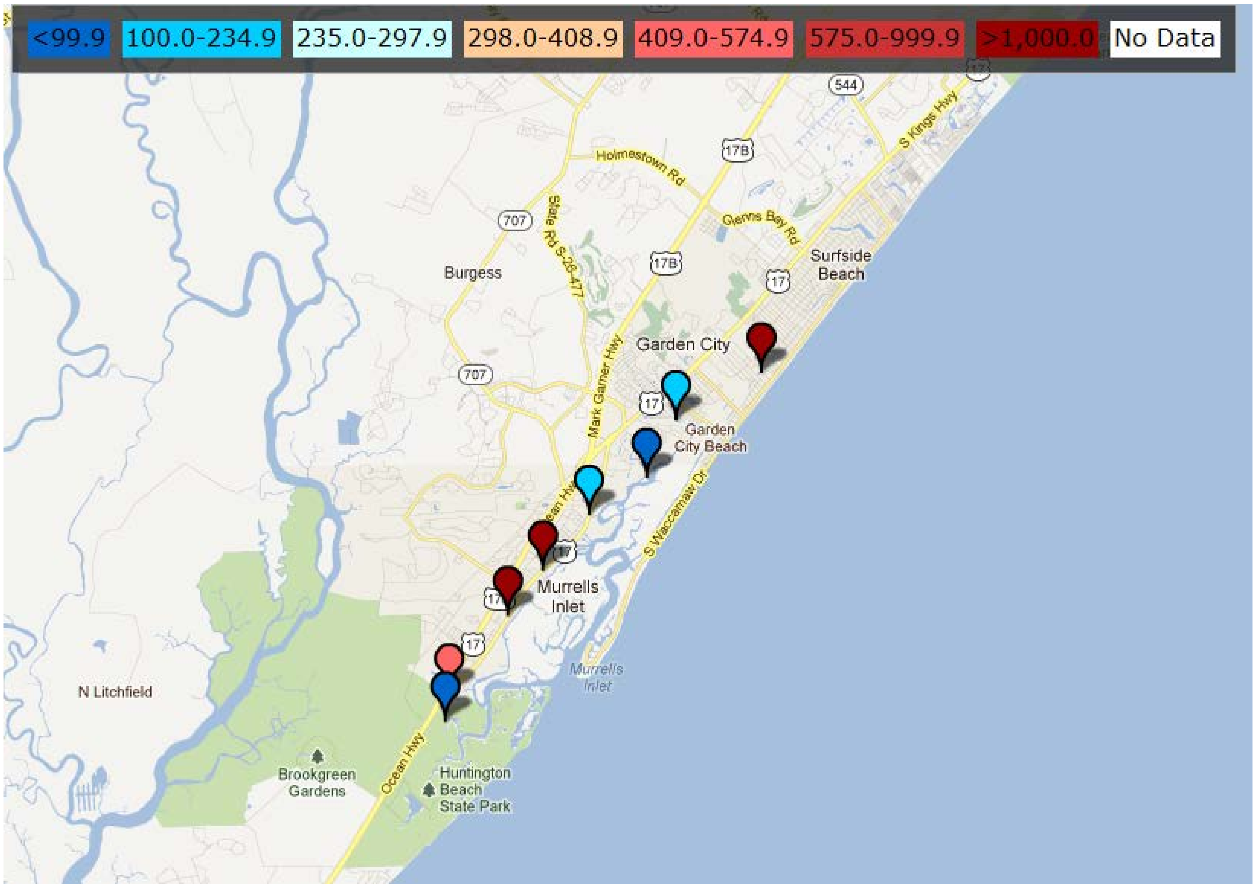

Figure 2. Geographic trends in mean *E. coli* (CFU/100 mL) in Murrells Inlet from Jul 2009 to Jan 2012. USEPA recreational WQS for infrequently used full body contact is 575 CFU/100 mL. Samples per site average 62.

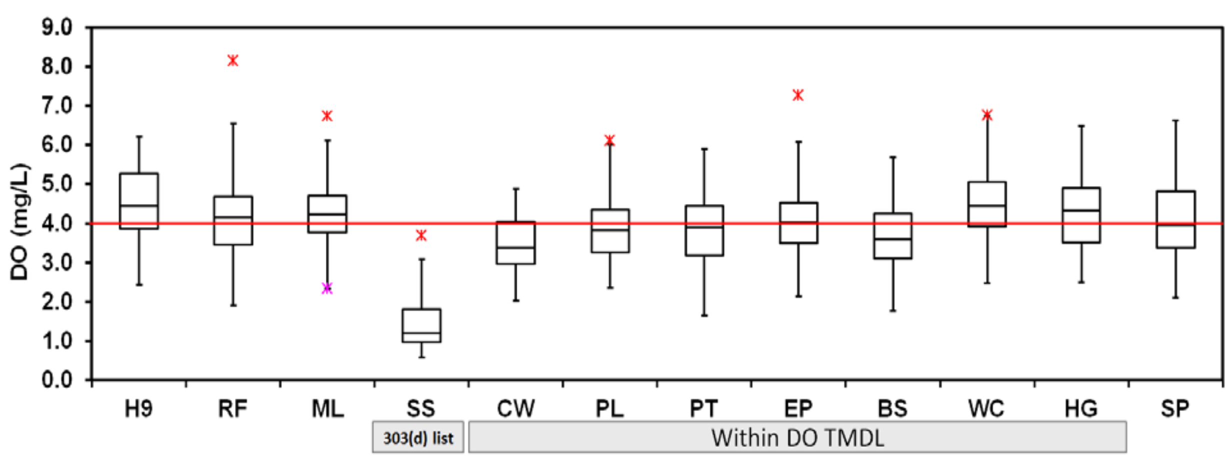

Figure 3. Boxplot of dissolved oxygen (mg/L) in the Waccamaw River when water temperatures exceed 20 C. Data are from Jun 2006 to Jan 2012. Samples per site average 62. Outliers are marked with asterisks. The red line marks the state WQS. The x axis is laid out with sites progressing from upstream on the left to downstream on the right.

One sampling site in the Waccamaw River VWQM program is located in a tributary, Sterritt Swamp, which is 303(d) listed for fecal coliform and DO based on sampling conducted from Sept 2008 to Sept 2009. No further sampling has been done by SC DHEC due to funding limitations. VWQM sampling has confirmed continuing conditions of high levels of fecal bacteria and low concentrations of DO. Land uses upstream of this sampling site include the county landfill and several large golf course/residential communities.

The Pee Dee River converges with the Waccamaw River near the Horry-Georgetown county line. The influence of the Pee Dee River on elevating the turbidity of the lower end of the Waccamaw River is illustrated in Figure 4. The state WQS for turbidity is 50 NTU. Observations rarely exceed this and the US EPA (2000) has suggested a more suitable threshold would be around 4 NTU. The data from the VWQM program document that upstream of the confluence with the Pee Dee River, the 75th percentile for turbidity is about 6 NTU.

Figure 4. Mean turbidity (NTU) in the Waccamaw River from Jun 2006 to Jan 2012. Samples per site average 140.

Surfside Beach. This VWQM program commenced in June 2010, so long-term trend information is not yet available. Results to date suggest that waterfowl at one of the sampling sites could be a significant contributor to observations of high *E. coli* concentrations. To address this issue, this SMS4 has engaged in some animal relocation work and volunteers have started an upstream source-tracking effort.

DATA USAGE AND PUBLIC OUTREACH

As described above, the SMS4's have been using the VWQM data to meet their NPDES Phase II stormwater requirements under MCM's 2, 3 and 5. The data have been used for illicit discharge detection and to define long-term trends. They have also been used to develop site-specific "standards" that provide additional insight not afforded by the regulatory WQS. The findings have stimulated ancillary research projects by the EQL, such as development of microbial source tracking tools customized for the watersheds of concern (Trapp et al. 2012). And they have led to intensive reconnaissance efforts to trace pollutant discharges to their upstream and land-based sources.

Because the program's data are available online, it is accessible to the general public and has been used by researchers. The data are also presented annually at conferences open to the public that are attended by the volunteers, field leaders and stormwater managers along with SC DHEC's Pee Dee watershed manager and other staff. Other frequent attendees include the US Geological Survey staff and local elected and appointed officials. The latter have helped facilitate management interventions.

Other resources supporting MCM 1 are housed at the home page of the VWQM programs at: http://www.coastal.edu/wwa/vm/ . These include detailed descriptions of each program and customized public outreach materials such as brochures and presentations. The Waccamaw River program also contributes its data to the World Water Monitoring Challenge™ , an international education and outreach program that builds awareness and involvement in protecting water resources around the world by engaging citizens to conduct basic monitoring of their local water bodies (http://www.worldwatermonitoringday.org/).

LESSONS LEARNED & FUTURE EFFORTS

One of the keys to sustainability of the VWQM programs has been the organization of volunteers into teams of 4 to 6 people per team. This redundancy ensures coverage in the event of team member illness or vacation and provides for flexibility of involvement during each event. Team participation has provided a social outlet for individuals within the community to enjoy volunteering their time and skills for a common purpose. Another key has been committing to a continued effort to recruit and train volunteers to accommodate attrition and thereby ensure long-term sustainability. The high quality of the data is attributable in significant measure to Hach's durable, easy-to-use sampling equipment and to our ongoing effort to optimize sampling techniques in response to QC results. We have also come to appreciate that it takes years to develop a data management and visualization system and this will continue to evolve to take advantage of new internet technologies. Finally, it has proven essential to keeping the volunteers interested and committed that we demonstrate their data are being used and are leading to water quality improvements.

Plans for the future include: (1) integrating the VWQM data with US Geological Survey's discharge measurements as this is a strong influence on water chemistry trends, (2) better engaging young people – most of our volunteers are retired. One opportunity to engage younger people is to develop a companion biological indicator monitoring program using K-12 students. Macrobenthic invertebrates are the conventional bioindicator for streams but are not readily amenable to use in blackwater systems due to naturally low species diversity typical when DO and pH are low, (3) long-term trend analysis using the seasonal Mann-Kendall test which requires a minimum of 5 years of data, and (4) usage of the VWQM data by SC DHEC for their 303(d) and 305(b) reporting requirements. The latter will require obtaining certification; a major hurdle may be acceptance of master samplers who calibrate their equipment at their homes rather than at a certified lab.

The establishment of a VWQM program in the northern coastal counties of South Carolina has proven timely for several reasons: (1) Reduced funding has forced SC DHEC to reduce their ambient water quality monitoring program by eliminating some sites and cutting their sampling frequency to every other month (SC DHEC 2012a); (2) We have been able to adopt *E. coli* as a fecal indicator years in advance of SC DHEC (SC DHEC 2012b); and (3) The VWQM program is providing data in a more timely and accessible framework than SC DHEC, which requires accessing STORET where data uploads have lag times as long as a year (http://www.scdhec.gov/environment/water/surface.htm).

ACKNOWLEDGEMENTS

The following have provided financial support over the years: US EPA (Region 4, Wetland Program Development Grant CD-96416209-0), International Paper, Horry County, Georgetown County, City of Conway, and the NC Glaxo Smith Kline Foundation. SC DHEC's Pee Dee Watershed managers, Waccamaw District staff and shellfish program managers have given generously of their time along with the US Geological Survey's SC Water Science Center, National Oceanic and Atmospheric Administration National Estuarine Research Reserve's Central Data Management Office, SC Department of Natural Resources' State Climatology Office, Murrells Inlet 2020 and the Waccamaw Riverkeeper™ Program of the Winyah Rivers Foundation. Software code was authored by Q. Trimble, C. Banks, T. Tinker and F. Meiere.

REFERENCES

Lee, V. 1994. Volunteer Monitoring: A Brief History. The Volunteer Monitor, V. 6, No. 1, http://water.epa.gov/type/rsl/monitoring/upload/2004_10_13_monitoring_volunteer_newsletter_volmon06no1.pdf.

Libes, S. 2011. The Waccamaw Watershed Academy: How A University Is Supporting Local NPDES Phase II Compliance Efforts. Proceedings of the South Carolina Environmental Conference, Myrtle Beach, SC, http://www.sc-ec.org/images/Proceedings11/39-2%20Libes.pdf

SC DHEC. 1999. Total Maximum Daily Load Determination for the Waccamaw River and the Atlantic Intracoastal Waterway near Myrtle Beach, SC. SC DHEC Technical Report Number 013-99. http://www.scdhec.gov/environment/water/tmdl/docs/tmdlwac.pdf

SC DHEC. 2005. Total Maximum Daily Loads for Fecal Coliform in Shellfish Waters of the Murrell's Inlet Estuary, South Carolina. SC DHEC Technical Report Number 025-05, http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_murrells_fc.pdf

SC DHEC. 2010. The State of South Carolina's 2010 Integrated Report, Part I: Listing of Impaired Water, http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_10-303d.pdf.

SC DHEC. 2012a. State of South Carolina Monitoring Strategy for Calendar Year 2012. http://www.scdhec.gov/environment/water/docs/strategy.pdf

SC DHEC. 2012b. Proposed Revision of S.C. Regulation 61-68, Water Classifications and Standards (R. 61-68) and S.C. Regulation 61-69, Classified Waters. http://www.scdhec.gov/environment/water/wq_bacteria.htm accessed 2/23/12.

Trapp, M., E. Burge, S. Libes and A. Sturgeon. 2012. Use of qPCR Technologies in Stormwater Regulatory Quantification and Watershed Source Tracking of Fecal Indicator Bacteria. Proceedings of the South Carolina Environmental Conference, Myrtle Beach, South Carolina, March 10-13, 2012.

US EPA. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans, Office of Wetlands and Waters, EPA841-B-96-003, http://water.epa.gov/type/rsl/monitoring/qappcovr.cfm

US EPA. 2006. NPDES: Stormwater: Menu of BMPs. URL:http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

US EPA. 2000. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion XIV. Office of Water. EPA 822-B-00-022.

US EPA. 2011. Water/Our Waters/Rivers & Streams/Monitoring and Assessing Water Quality – Volunteer Monitoring. http://water.epa.gov/type/rsl/monitoring/index.cfm

USDA. 2012. Volunteer Water Quality Monitoring National Water Resource Project. http://www.usawaterquality.org/volunteer/