

Appendix C

WATER QUALITY MONITORING IN THE MB UA: SUPPORT FOR MCMS #1 AND #2

The SMS4s of the Myrtle Beach Urbanized Area continue to partner in water quality monitoring programs that help fulfill MCMs #1 and #2 for public outreach and engagement and MCM 3 for IDDE. A brief summary of ongoing activities and highlights from 2013 are summarized below. These collaborative efforts were featured during oral presentations delivered at StormCon 2013 and the 3rd quarter meeting of the SC Association of Stormwater Managers.

To address MCM #1, all monitoring data are accessible through public websites. The URLs are advertised via business cards that are program specific. These URLs are presented in collated form at: <http://www.coastal.edu/www/datasets.html>. Web counters are used to document traffic at these sites. Data are also being uploaded to the national STORET Data warehouse using the US EPA's Water Quality Exchange (WQX) portal. The programs and their data have been described in the proceedings of the SC Water Resource Conference and will be part of the forthcoming first volume of the new SC Water Resources Journal.

The monitoring data have been used in presentations to municipal councils and committees. In 2013, these included two workshops hosted by the North Inlet-Winyah Bay NOAA NERRS Coastal Training Program, one hosted by the Green Building and Sustainable Living Committee for the City of Myrtle Beach's planning commission, and continuing meetings of the stormwater advisory committees/boards of Conway, Horry County, and Surfside Beach. Data collected in Murrells Inlet were used to inform development of a watershed-based plan.

Use of the data for IDDE is facilitated through production of provisional reports. These reports highlight findings of regulatory exceedances of water quality criteria and site-specific norms. The latter are based on percentile rankings developed from each sampling site's historical dataset. In most of the programs, data sets are now long enough to conduct statistical tests for long-term trends. These have been performed using the same tests that SC DHEC uses for its watershed water quality assessment reports, i.e. the seasonal Mann-Kendall test for monotonic trends.

Another collaborative effort that reached closure this year was development of local capacity for microbial source tracking (MST). This was a priority effort as pathogens are the most common POC in the MB UA. This joint effort was undertaken by Horry and Georgetown Counties, and the cities of Myrtle Beach and North Myrtle Beach. Additional funding was provided by the USACoE via a Planning Assistance to States grant. An MST protocol document was developed that outlines the roles and procedures to be followed by an SMS4 to conduct a watershed-based investigation in partnership with CCU's Environmental Quality Lab (EQL). The latter collects and analyzes samples using tracers, such as genotypic qPCR assays that are specific for host animal sources. The protocol and final report are available at: <http://www.coastal.edu/eql/projects/pollution/documents.html>. An extensive set of web pages explaining the protocol, MST tools, and the results from their implementation at

Withers Swash in Myrtle Beach are posted at:

<http://www.coastal.edu/eql/projects/pollution/sources.html> . The results of this work have been presented at the 22nd biennial conference of the Coastal & Estuarine Research Federation in Nov 2013, 2013 StormCon, 2013 SC Environmental Conference, 2013 Southeast Tidal Creek Summit, and the 2014 Aquatic Microbiology Conference.

Volunteer Water Quality Monitoring

Three volunteer monitoring water quality monitoring programs are being supported in the MB UA. They include programs in: (1) the Waccamaw River whose field leader is the Waccamaw Riverkeeper (Christine Ellis and Paula Reidhaar), (2) Murrells Inlet whose field leader is Murrells Inlet 2020 (James Wilkie and Sue Sledz) and (3) Surfside Beach whose field leader is a member of the Surfside Beach stormwater committee (Ken Harth). Sampling is conducted biweekly year round and data are posted within one month of collection at: <http://bccmws.coastal.edu/volunteermonitoring/>. Management meetings are held with the field leaders. Each program hosts an annual data conference and a luncheon for their volunteers. Presentations from these events are posted at the program websites (<http://www.coastal.edu/wva/vm/>) maintained by CCU's Waccamaw Watershed Academy who provides technical support. These websites include rain data from NOAA's CoCoRaHS (Community Collaborative Rain, Hail and Snow Network) volunteer monitoring program. NOAA's NERRS Central Data Management Office is also providing areal estimates of daily rainfall by subwatershed.

These programs are listed online at: (1) the Volunteer Water Quality Monitoring National Water Resource Project's listing of Volunteer Water Quality Monitoring and Master Naturalist Programs in the US (<http://www.usawaterquality.org/volunteer/VolunteerMonPrograms/index.html>); (2) the US EPA's National Directory of Volunteer Monitoring Programs: <http://yosemite.epa.gov/water/volmon.nsf/Home?OpenForm>; and (3) the National Water Quality Monitoring Council's Volunteer Water Quality Monitoring Program Directory: http://acwi.gov/monitoring/vm/programs/vm_map.html.

More details on each program and highlights from 2013 are provided below.

Murrells Inlet

Eight sites have been monitored since 2008 by 18 volunteers. CCU and Murrells Inlet 2020 have partnered on a weather station with observations accessible through a Weather Underground site that went online in Sept 2013 (<http://www.wunderground.com/cgi-bin/findweather/getForecast?query=33.55529785,-79.03279877&sp=KSCMURRE10>).

In response to volunteer activism, Murrells Inlet 2020 and the Waccamaw COG led an effort this year to develop a watershed-based plan for Murrells Inlet whose goal is to address load reductions specified in a fecal coliform TMDL issued by SC DHEC in 2005. Many of the participants in the volunteer monitoring program participated in this effort which was funded via a US EPA 319 grant awarded by SC DHEC. The effort was immediately preceded by a natural resource economic valuation study conducted by

CCU's Center for Economic and Community Development with funding provided by the Donnelly foundation.

To provide additional data on fecal bacteria sources, Georgetown County supported a microbial source tracking effort designed and conducted by the volunteer water quality monitors and CCU's WWA in four subwatersheds located on the south end of Murrells Inlet. Horry County conducted a microbial source tracking effort on the north end of Murrells Inlet using technical assistance from CCU's EQL that featured qPCR assays specific for host animal sources. The results of these efforts were presented at the 2014 National Water Quality Monitoring Conference.

Waccamaw River

Twelve sites in SC have been monitored since 2006 and 6 sites in NC since 2011. This bi-state effort engages 49 volunteers. A new benthic macroinvertebrate monitoring program was started in 2013 by the Waccamaw Riverkeeper with support from SC DHEC and Clemson University. Grant funding was provided by International Paper. It is staffed by Winyah Master Naturalists. The South Carolina volunteers were nominated in 2013 for recognition by the SC Association for Volunteer Administration. The North Carolina volunteers won the NC Governor's Award for Volunteerism in Columbus County. This program also partnered with Clemson University researcher, Dr. A. Chow, on an NSF proposal to study salinity intrusions on the river.

Surfside Beach

Two sites have been monitored since 2010 by 6 volunteers. In October 2013, the volunteer monitoring program results were presented to town council as part of a workshop conducted by the North Inlet-Winyah Bay NOAA NERRS Coastal Training Program regarding water quality in stormwater ponds. This workshop was requested by town council to help them explore options for revising ordinances. Also notable was installation in Jan 2014 of a water quality BMP (Fabco Industries, Inc. StormBasin) to reduce loading of bacteria upstream of the volunteer monitoring sampling site located at Myrtle Lake.

Long Bay Hypoxia Monitoring Consortium

Horry County and the cities of Myrtle and North Myrtle Beach are collaborators in the Long Bay Hypoxia Monitoring Consortium (LBHMC). The goal of the LBHMC is to monitor water quality and meteorology at three fishing piers. The monitoring data are to be used to characterize normal conditions for oxygen, pH, turbidity and chlorophyll in the coastal waters of Long Bay and to detect occurrence of hypoxia and eutrophication. Data are collected every 15 minutes from the surface and bottom waters and via a weather station.

The data are now accessible through a new web portal, called the Long Bay Observing System: <http://bccmws.coastal.edu/lbos/>. Data are displayed on monitors at the 2nd Ave and Apache Piers and feature a newly redesigned format. Examples can be viewed at: <http://bccmws.coastal.edu/lbos/ccu-apac-ws/latest.html> and <http://bccmws.coastal.edu/lbos/ccu-chgrv-ws/latest.html>. The pro bono computers have also been upgraded. Educational signage is posted at the piers, and CCU's EQL continues to conduct outreach activities biannually at Apache Pier.

The data are being harvested for deposit into regional and national databases, such as the Integrated Ocean Observing System's Southeast Coastal Ocean Observing Regional Association (SECOORA) and the National Weather Service's Meteorological Assimilation Data Ingest System (MADIS) via /Mesonet, and made available to the public through web portals maintained by these entities.

The innovative deployment strategy developed by the EQL who is providing technical support was presented at the 2013 ASLO Conference. The innovative collaboration represented by the LBHMC is the subject of a peer-reviewed article soon-to-be published in the first volume of the new SC Water Resources Journal. The data being collected are notable as they represent the only continuous water quality information on pH, turbidity and chlorophyll being collected in the coastal waters of South Carolina. The pH data are of particular interest to national initiatives directed at studying impacts of ocean acidification in coastal waters.

The data are being leveraged to support assessment required as a special condition of a SC DHEC OCRM permit issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach. Information on this program was presented at a workshop in Jan 2013 conducted by the NOAA NERRS North Inlet-Winyah Bay Coastal Training Program and at the 2014 SC Environmental Conference.

Beach Monitoring

Enterococcus data collected at 61 sites along the Grand Strand since 1997 by SC DHEC and the cities of Myrtle Beach and North Myrtle Beach have been made available to the public at a website constructed and maintained by CCU's Waccamaw Water Academy (<http://bccmws.coastal.edu/enteroview/>). This is a pro bono effort designed to support development of TMDL's, MST projects, and meet other needs for temporal and spatial trend analysis.

The *Enterococcus* data trends will be used as a component of the water quality assessment required by SC DHEC as part of the special conditions for the permit issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach.

River Gauge Monitoring

Since Jan 2008, Horry and Georgetown Counties and the city of Conway have been partnering with CCU's EQL and the USGS to maintain a monitoring program in the Waccamaw and Pee Dee Rivers. The USGS is maintaining real-time water quality sensors at one site in the Pee Dee and eight sites in the Waccamaw River. Data are available at: <http://waterwatch.usgs.gov/wqwatch/map?state=sc&pcode=00010>. Since 2008, CCU's EQL has been performing bimonthly grab sampling at 8 of these sites under a SC DHEC approved QAPP. The water quality data from these samples are posted within one month of sampling at: http://bccmws.coastal.edu/river_gauge/.

In June 2013, a new USGS gaging station and CCU sampling site was established at Reaves Ferry in the Waccamaw River. Based on information obtained from the first year of samples, the river exhibits semidaily tidal behavior at this site, approximately 60 miles upstream of Winyah Bay. The tidal behavior is being characterized by a CCU masters student who is performing a local internship with the USGS. In July 2013, the USGS

also added water quality instrumentation to their gaging station at Gallivants Ferry in the Pee Dee River. This has enabled tracking of highly turbid water from the Pee Dee into the Waccamaw River. CCU sampling at this and the Reaves Ferry sites commenced in Feb 2012 in anticipation of the USGS data additions. These enhancements were all supported by Horry County's stormwater department.

In 2013, a first effort at trend analysis was conducted using the Mann–Kendall test for trend using five years of data. The monitoring information has also been enhanced by pro bono analysis of samples for dissolved organic carbon, True Color and colored dissolved organic matter. This information coupled with DO and BOD measurements is being statistically analyzed to try to distinguish natural from anthropogenic sources of oxygen-demanding substances that contribute to continuing contraventions of the DO water quality criteria throughout the Waccamaw River, especially during warm weather.

CCU Student Monitoring

Briarcliffe Acres Groundwater

Horry County and the town of Briarcliffe Acres are partnering on a monitoring program to characterize lake and groundwater levels. The goals of this program are to provide insight into: (1) how to manage limited water resources during times of drought and (2) the frequency and timing of high water tables that have the potential to intercept septic tank flow fields. These data are to be used to engage the local community in water stewardship efforts. The data are collected from three groundwater wells and two lakes. They are downloaded monthly and posted at a public website: <http://bccmws.coastal.edu/bagw/>. Project presentations and reports are also posted at this site.

Crabtree Canal Floodplain Restoration

Restoration of a channelized swamp, Crabtree Canal, was initiated in 2009 by the City of Conway and Horry County following identification of this work as a top priority action in the Kingston Lake Watershed Management Plan. Assessment work is being performed to demonstrate restoration of floodplain structure and function. A related peer-reviewed journal article was published by Clemson University and CCU researchers in the Journal of the American Waterworks Association in 2013. The US FWS has provided funding for the restoration and assessment work. The latter is currently being conducted by CCU students who are performing annual tree counts to track survival rates and downloading waterlevel logger data for use by Clemson University to infer floodplain inundation activity. Clemson University is also monitoring channel and floodplain bathymetry and topography. The Waccamaw Riverkeeper has been working with Horry County to engage Conway High School students in outreach efforts. Also notable in 2013 have been: (1) continued efforts of the NRCS to remediate septic tanks using US EPA 319 funding awarded by SC DHEC, (2) installation of bank stabilization BMP's by Horry County, and (3) invasive plant control conducted by Horry County.

CCU Campus Monitoring

The goal of CCU's Campus Monitoring Program is to provide an assessment of water quality conditions in the stormwater ditches and retention ponds on campus, all of which

eventually send waters off campus towards the Waccamaw River. Sampling is conducted every other week during the academic semesters by CCU undergraduate students. The Waccamaw Riverkeeper serves as the field leader. CCU's Waccamaw Watershed Academy provides technical support. Both organizations are providing pro bono assistance in this effort.

In 2013/2014, CCU's QEP program awarded funding to the Campus Monitoring Program to support development of a website to house the water quality results (<http://bccmws.coastal.edu/quaye/ccum/>) and to purchase a water-quality multimeter. The website work was done by a computer science major.

The data are being used to evaluate whether water quality is improving or degrading over time at some or all of the sites using a watershed approach. As field leader, the Waccamaw Riverkeeper ensures that the data are relayed to CCU's Building and Grounds staff for follow up on potential illicit discharges.