

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 MCM #1 for outreach, MCM #2 for public engagement and MCM #3 for illicit discharge detection and elimination. The monitoring data can also provide insight into long-term water quality trends and hence help evaluate progress in MCM #5 for post construction discharges. Some of these programs are staffed by volunteers and others are conducted by CCU's Environmental Quality Laboratory (EQL) that is certified by SC DHEC.

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>. An upgrade has been completed to enable co-plotting of sites on time trend graphs and coplotting of parameters on time trend graphs. Web counters are used to document traffic at these sites and these quantitative results are included in the CWSEC (bi)annual reports to the SMS4. Data are also being uploaded to the national STORET Data warehouse using the US EPA's Water Quality Exchange (WQX) portal. The uploaded data are available to the public via US EPA's My Waters Mapper (<http://www.epa.gov/waterdata/my-waters-mapper>) and the National Water Quality Monitoring Council's Water Quality Portal (<http://www.waterqualitydata.us/index.jsp>). The latter also houses data from the United States Geological Survey's National Water Information System (NWIS) and the United States Department of Agriculture, Agricultural Research Service's (USDA ARS) Sustaining the Earth's Watersheds - Agricultural Research Database System (STEWARDS). The monitoring programs in the Myrtle Beach UA and their data have been described in the proceedings of the SC Water Resource Conference, StormCon, the SC Environmental Conference, SCASM, and the SC Water Resources Journal as well as the

National Water Quality Monitoring Council's National Monitoring Conference.

The monitoring data continue to be used in presentations to municipal councils and committees. Use of the data for IDDE is facilitated through production of biweekly provisional reports. These reports highlight findings of regulatory exceedances of water quality criteria and site-specific norms. The latter are based on annually updated 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.

To address MCM #2, Horry and Georgetown Counties, the City of Conway, and the Town of Surfside Beach support volunteer water quality monitoring programs that are run collaboratively with CCU's Waccamaw Watershed Academy (WWA) and field leaders as shown in Table 1.

To address MCM #3, CCU's WWA produces provisional reports and potential IDDE reports that are sent to the relevant stormwater managers. These reports compare measurements to state water quality standards, site-specific norms established by the program data, and US EPA recommended water quality thresholds. In the case of findings that suggest a new acute illicit discharge has been detected, the volunteers and EQL staff alert the program coordinator immediately so that this information can be transmitted as quickly as possible to the stormwater managers. Several such cases occurred in 2015 and resulted in site reconnaissance efforts on the part of the stormwater managers.

More details on each of the monitoring programs along with highlights from 2015, such as the IDDE investigations, are provided below.

Volunteer Water Quality Monitoring

Three volunteer monitoring water quality monitoring programs are being supported in the MB UA. Details are provided in Table 1.

Table 1 - Volunteer Water Quality Monitoring Programs in the Myrtle Beach Urbanized Area

| Monitoring Program | Field Leader | Sampling Sites | Number of Volunteers | Start Date | Funding Partners |
|--------------------|----------------------|---------------------|----------------------|------------|-------------------------------------|
| Waccamaw River | Waccamaw Riverkeeper | 6 in NC 12 in SC | 54 | 2006 | Georgetown & Horry Counties, Conway |
| Murrells Inlet | Murrells Inlet 2020 | 8 | 18 | 2008 | Georgetown & Horry Counties |
| Surfside Beach | Ken Harth | 2 | 6 | 2010 | Surfside Beach |
| CCU Campus | Waccamaw Riverkeeper | 3 | 5 | 2011 | CCU's WWA & QEP Program |

Sampling is conducted biweekly year round and data are posted within two weeks of collection at <http://bccmws.coastal.edu/volunteermonitoring/>. Management meetings are held with the field leaders. With some exceptions, each program hosts an annual data conference for the public and a luncheon for its volunteers. Presentations from these events are posted at the program websites (<http://www.coastal.edu/wwa/vm/>) maintained by the WWA. 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 sub-watershed.

In 2015, all programs completed their transition from Hach Sension to Orion Star Multimeters. This makes the third generation of equipment to be used in the longest running program (Waccamaw River) and the second generation in the others. The CCU campus monitoring program was awarded a grant in 2015 to purchase a Hanna multimeter with an onboard turbidity sensor. This provides an opportunity to field test another meter option to succeed the Orion Star multimeters once they need to be replaced. The project budgets assumed a 4 year lifespan for equipment, which appears to be realistic and is a tribute to the care that the volunteers use in working with the meters. The transition to another meter OEM necessitated a reconfiguration of the database used to maintain training records, generation of a new SOP and changes to the calibration and field datasheets. The former lead to a reconfiguration of how training records are created, reviewed and archived. The new process is modelled after the one in use in the EQL in which a personnel qualification record is maintained for each volunteer as a folder that contains the paper records and an inventory of these records.

All datasheets and QA/QC paperwork is now being bound annually using a uniform format. The binders are maintained in an archive in the EQL that requires users to sign out the binders. This procedure is modelled after the one in use in the EQL.

The new program coordinator (Kelly Hall) who took over in November 2014 has facilitated several QA/QC improvements such as: (1) control charting of turbidity secondary standards; (2) upgraded equipment inventory tracking, and (3) improved forms. Another personnel shift has been the hire of an EQL technician (recent CCU MSCI undergraduate) who assists Kelly with kit maintenance. An inventory of the water quality measurements made to date in each of the programs is provided in Table 2. These collectively represent about 83,000 measurements.

Table 2 - Water quality measurements made to date in the volunteer monitoring programs of the Myrtle Beach UA

| <i>Program</i> | <i>Site</i> | <i>Samplings</i> | <i>Measurements per sampling event</i> | <i>Total independent measurements</i> |
|--|----------------------|------------------|--|---------------------------------------|
| Waccamaw River since June 2006 | Maple Street | 93 | 11 | 1,023 |
| | Canal Cove | 93 | 11 | 1,023 |
| | Big Creek | 93 | 11 | 1,023 |
| | LAWA Dam | 93 | 11 | 1,023 |
| | Babson's Lndg | 60 | 11 | 660 |
| | Pireway | 60 | 11 | 660 |
| | Hwy 9 | 226 | 11 | 2,486 |
| | Reaves Ferry | 217 | 11 | 2,387 |
| | Murrells Lndg | 1670 | 17 | 28,390 |
| | Sterritt Swamp | 206 | 11 | 2,266 |
| | Conway | 226 | 11 | 2,486 |
| | Pitch Landing | 226 | 11 | 2,486 |
| | Peachtree | 189 | 11 | 2,079 |
| | Enterprise | 224 | 11 | 2,464 |
| | Bucksport | 227 | 11 | 2,497 |
| Wachesaw | 228 | 11 | 2,508 | |
| Hagley | 224 | 11 | 2,464 | |
| Sampit | 220 | 11 | 2,420 | |
| Total = | | | | 60,345 |
| Murrells Inlet since May 2008 | Woodland Drive Pond | 180 | 11 | 1980 |
| | Point Drive Canal | 179 | 11 | 1969 |
| | Rum Gully Creek | 179 | 11 | 1969 |
| | Marina Colony Pond | 179 | 11 | 1969 |
| | HS | 181 | 11 | 1991 |
| | BHR | 180 | 11 | 1980 |
| | Bike Bridge | 181 | 11 | 1991 |
| | Oyster Landing Beach | 180 | 11 | 1980 |
| Total = | | | | 15,829 |
| Surfside Beach since May 2010 | 11th Ave N | 128 | 11 | 1408 |
| | 4th Ave N | 128 | 11 | 1408 |
| Total = | | | | 2,816 |
| Campus Volunteer Monitoring since Oct 2011 | 501 West | 119 | 11 | 1309 |
| | 544 East | 17 | 11 | 187 |
| | 544 West | 115 | 11 | 1265 |
| | Wall Pond Bridge | 103 | 11 | 1133 |
| | Wall Pond East | 2 | 11 | 22 |
| | Wall Pond West | 2 | 11 | 22 |
| Total = | | | | 3,938 |

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

In 2015, the Murrells Inlet and Waccamaw River volunteer monitoring programs continued to collect water samples to support a research project conducted by a CCU student, Joe Cannon, who is investigating the use of coliphages as a fecal indicator. He uses the volunteer's E. coli data to compare with his coliphage concentration measurements. His results received a student research award.

Additional details on each of the volunteer monitoring programs and highlights from 2015 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 September 2013. The data can be accessed at: <http://www.wunderground.com/personal-weather-station/dashboard?ID=KSCMURRE10>. The link for this URL is included in the MI2020 newsletters and on their website. A new computer and weather stations were purchased by MI2020 to replace the original. The installation work was done by the WWA. The console is located inside the Crazy Sister Marina's offices. The field leader received training such that he is able to restart the equipment at this location.

Data presentations were given as requested at two meetings of the Murrells Inlet watershed committee meetings on April 29th and December 11th. A new outreach poster was developed and used at the Murrells Inlet Chowder Talk held on May 20th. These presentations were done in lieu of the more traditional data conferences that have been done in past years to deliver information to another audience. The data conferences are typically attended by the volunteers, CWSEC and stormwater staff. Instead of attending the usual meeting, the volunteers instead participated in two training sessions in July so they could transition to the new Orion meters.

Following the passing of the Jim Wilkie, the founding field leader, Robert Steffens agreed to become the new field leader. Renee Williamson (MI2020) has continued to serve the program by providing outreach through her organization that includes posting information in the printed newsletters and the emailed updates. This has been used as a venue for recruiting new volunteers. She has asked Stephen Williams to represent MI2020 as a review of the biweekly provisional reports.

The watershed-based plan for Murrells Inlet approved by SC DHEC in August 2014 is being implemented by a steering committee that includes CCU's WWA, Murrells Inlet 2020, and the stormwater managers of Horry and Georgetown Counties. Two peer-reviewed articles about the plan were published in the SC Water Resources Journal. The citations are:

Libes, S., H. Young, D. Newquist and S. Sledz (2015) Watershed-based planning for Murrells Inlet: source assessment of fecal bacteria using volunteer and shellfish sanitation program data, *Journal of South Carolina Water Resources*, 2, 26-31.

Fuss, D., D. Newquist, S. Sledz, T. Jones and D. Hitchcock (2015) Watershed Plan Implementation:

Challenges for SMS4s in Murrells Inlet. *Journal of South Carolina Water Resources*, 2, 55-62.

In October 2014, SC DHEC awarded a US EPA 319 grant to the Waccamaw COG to fund implementation work. The volunteer monitoring data will be used to assess the degree to which the BMP's are reducing fecal bacteria. A microbial source tracking effort at three sites on the south end of Murrells Inlet was conducted during the summer and fall at the request of Georgetown County. The final project report will be available in March 2016.

Waccamaw River

Twelve sites in SC have been monitored since 2006 and 6 sites in NC since 2011. This bi-state effort engages 54 volunteers and over the life of the program has generated over 60,000 measurements, providing the basis for spatial and temporal trend analyses.

The annual volunteer appreciation luncheon was held on April 1, 2015. The purpose of the luncheon is to recognize and provide an update to our volunteers. The upgrade of the website was discussed as were the issues with the use of the conductivity probe during the cold snap experienced that winter (the temperature limit of the probe, <5° C, was reached and resulted in some equipment performance issues). Unusually cold weather in the winter of 2015 and icy conditions resulted in implementation of the Inclement Weather Policy; however, volunteers persisted in safely obtaining water quality data despite the conditions.

Data generated from this program is presented at the Annual Data Conference that is usually scheduled to coincide with the World Water Monitoring Challenge from September 18th – October 18th. In 2015, the scheduled conference was pre-empted by the historic flooding on the Waccamaw and deferred until January 20th 2016.

The historic flooding on the Waccamaw that occurred in early October 2015 presented a number of obstacles to volunteer monitoring and caused implementation of the Inclement Weather Policy. Despite access issues at many of the monitoring sites, the volunteers safely accessed most of the sites and gathered data subsequent to the flooding. Of special note, Team #4 sampled its sites (Wachesaw, Enterprise and Peachtree) by boat (*see image below*). In all cases, we are grateful to our volunteers for their determination and commitment to maintaining our biweekly sampling schedule and the data generated.



Figure 1 – Water sampling from pontoon boat during October 2015 historic flooding on the Waccamaw River

As a result of this historic flooding, water quality results initially showed the effects of dilution caused by flooding but by the 3rd sampling event (1st week of November) higher than normal turbidity and bacteria levels were recorded. These were corroborated by the EQL's River Gaging Program providing a valuable demonstration of comparability in quality of the volunteer data with a SC DHEC certified lab. Water quality results returned to more normal levels for the 4th sampling event after flooding.

Several local news articles provided information on water quality issues of interest to the public during the flood event.

Also in 2015, an IDDE investigation was launched at Sterritt Swamp as a result of high conductivity results over several samplings in the summer-fall and observed turbidity later that year. The Riverkeeper and Horry County Stormwater staff investigated and identified potential sources but a conclusive determination has not yet been made. An IDDE investigation was also launched by the Riverkeeper and Georgetown County Stormwater at Hagley Landing for higher than normal turbidity levels, believed to have resulted from upstream dock construction.

In June 2015 the program entered its 10th year of volunteer monitoring and this fact was celebrated at the January 20th 2016 Annual Data Conference. Included were presentations from: the USGS (USGS National Water Census, Coastal Carolinas Water Availability Study); SC DHEC (SC Surface Water Quality Monitoring – Waccamaw Basin); CCU's WWA (Using the Online Database to Visualize Spatial and Temporal Water Quality Trends); Horry County Stormwater (Freshwater Mussels in the Waccamaw and Pee Dee Rivers); as well as updates from Georgetown County Stormwater, and the Waccamaw Riverkeeper, including an update on the benthic macroinvertebrate monitoring program that commenced in 2013 as a citizen science project with support from SC DHEC, Clemson University and grant funding from International Paper.

Presentations from both the volunteer appreciation luncheon and the annual data conference are archived at <http://www.coastal.edu/wwa/vm/wr/publications.html>. The Waccamaw RIVERKEEPER® Program oversees the volunteer monitoring effort in North Carolina in partnership with Lake Waccamaw State Park and financially supported through grants from International Paper, Columbus County and Z Smith Reynolds Foundation. CCU's WWA provides pro bono support

for this effort and presented on the NC data set specifically at a volunteer luncheon hosted by Lake Waccamaw State Park on March 9th 2015. Efforts continue to secure a sustainable funding source for continued operational needs.

The program continues to rely on data generated by the USGS gages (water quality, discharge, gage height) and corroborate the VM generated data. In 2015 the USGS gage at Babson's Landing (Waccamaw River at Freeland) was put back into operation (it went offline as a result of the government shutdown in 2013) and includes over 74 years of data on discharge and gage height.

Information from the Waccamaw River Volunteer Monitoring Program is also presented at the Waccamaw Conference, an annual public education event hosted by the Waccamaw Riverkeeper. The 2015 Waccamaw Conference was held on Saturday, January 31st.

Surfside Beach

Two sites have been monitored since 2010 by 6 volunteers. Data updates are being provided by the field leader, Ken Harth to Surfside's Stormwater Committee during their quarterly business meetings, which is also attended by CCU's WWA to help address any water quality questions.

An IDDE event involving turbidity issuing from construction sites upstream of Surfside was detected by the volunteers in Lake Dogwood in February 2015. Through engagement of the stormwater managers, the source was identified and eliminated. The turbidity in Lake Dogwood returned to site-specific normal values in June. The Lake levels were lowered in the Spring of 2015. Volunteer monitoring was used to assess whether this impacted ammonia or oxygen concentrations.

A microbial source tracking effort that was conducted by CCU's EQL at the request of Surfside's stormwater manager in Myrtle Lake revealed E. coli concentrations substantially higher than has

been reported from the volunteer monitoring program. The cause of this discrepancy is being investigated and started with a collaborative effort between the field leader, Ken Harth and the EQL. Based on the data collected, an extensive study is being undertaken by a master's student working in the EQL as part of her thesis research.

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 being used to characterize normal conditions for oxygen, salinity, temperature, 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 every 5 minutes via a weather station. CCU's EQL is responsible for technical support and data management.

In 2015, the data relay was transitioned from YSI Econet to SutronWin with funding provided by the Burroughs and Chapin Center for Marine and Wetland Studies. Data from July 2015 are made available to the public at SutronWin website: http://sutronwin.com/sutron/logincontroller?action=login&user_name=user&password=user. A new series of real-time displays were also implemented for the large screen monitors deployed at the piers (<http://www.coastal.edu/pierdata>). A new website was developed to direct users to the multiple ways the data can be viewed and to the data collected prior to July 2015 (<http://scmss.coastal.edu/project/lbhmc>), including CCU's Long Bay Observing System: <http://bccmws.coastal.edu/lbos>. Real-time data are streaming to monitors at each of the piers. The EQL continues to conduct outreach activities biannually at Apache Pier; Local's Appreciation Day and Kid's Appreciation Day.

All of the data have been ingested into CCU's Long Bay Observing System. In 2016, the goal is to expand the web app to provide public access to the entire data set, both raw and corrected versions. In the meantime, static versions of the historical data have been posted at <http://scmss.coastal.edu/project/lbhmcc>.

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 US Mesonet.

The data 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. In 2015, the effects of an historic flood associated with Hurricane Joaquin initiated a period of anomalously low salinity in the nearshore of the Grand Strand that was detected by the pier sensors and has continued to date.

The data are also being used to support assessment required as a special condition of a SC DHEC OCRM permits issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach and the 4th Ave N Ocean Outfall in Myrtle Beach. Two peer-review papers were generated in 2015:

Peterson, R.N., W.S. Moore, S.L. Chappel, R.F. Viso, S.M. Libes and L.E. Peterson (2016) A new perspective on coastal hypoxia: The role of saline groundwater, *Marine Chemistry*, 179(1), 1-11.

Troup, M.L., D.B. Fribance, S. Libes, R. Gurka and E.E. Hackett (2016) Physical conditions of coastal hypoxia in

Long Bay, South Carolina: 2006-2014, *Estuaries and Coasts*, submitted.

Low oxygen continues to be episodically observed during summer months. From analysis of the data collected at all three piers since spring 2012, conditions of low oxygen have been documented at all three piers, occurring concurrently along with low pH, high turbidity and chlorophyll. Spectral analysis performed by Troup et al. (submitted) suggests that these ep

Following the October flood associated with Hurricane Joaquin, the pier sensors have documented an extended period of low salinity along with oxygen deficits that persisted at least through the end of the year. The latter were likely supported by unusually high temperatures that were present through the end of December 2015. Based on aerial imagery, water color, and USGS discharge measurements, at least some of the low salinity water is suspected to have originated from Little River and/or the Cape Fear River.

Several of these researchers are currently preparing a proposal to NOAA's Coastal Hypoxia Research Program to investigate the offshore spatial extent of low oxygen in Long Bay using continuous sensors deployed in a grid about 1 km from the coast. These data would be used to validate models that will seek to test the sensitivity of oxygen levels in Long Bay to increased terrestrial nutrient and organic matter loading and to climate change, i.e. intensification of the hydrological cycle and warming waters.

Due to a reconfiguration of the cabana at the end of Apache Pier, the EQL had to fabricate a new deployment for all the gear at this pier. The prior configuration was circa 2006. This work was completed early in 2015. As a result, all three piers now have similar deployments with the bottom sonde suspended from a stainless steel cable attached to a large anchor (800 lb.) and the surface sonde is deployed on a counterweighted sled so it bobs around 1 meter below the sea surface. The larval recruitment tiles

and radon pump are deployed from cables that are also attached to the anchor. The old standpipes at Apache Pier were removed.

In June 2015, lightning struck the ocean near 2nd Ave N and caused about \$30,000 of damage to the equipment. CCU's inland coastal marine insurance policy provided funds to replace both sondes and all the sensors.

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 (<http://bccmws.coastal.edu/enteroview/>) constructed and maintained by CCU's EQL. This is a pro bono effort designed to support development of TMDL's, microbial source tracking projects and to meet other needs for temporal and spatial trend analysis.

The Enterococcus data trends are used as a component of the water quality assessment required by SC DHEC as part of the special conditions for the permits issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach and the 4th Ave N Ocean Outfall in Myrtle Beach.

The EQL continues to coordinate sampling with SC DHEC during beach season to minimize the number of additional samples needed to cover required follow up activities following reports of contraventions. In 2014, the EQL began issuing weekly potential IDDE reports for samples that contravened the Enterococcus water quality standards. The reports compare the weekly results to site-specific norms for Enterococcus and salinity using data collected from 2008 when the current monitoring protocol was initiated. Samples with unusually low salinity suggest that elevated bacterial levels could be due to stormwater runoff. Samples with normal salinity suggest that an illicit discharge could be the cause of the elevated bacteria levels.

In 2015, several microbial source tracking efforts was undertaken by the EQL at the request of the stormwater managers to investigate the sources of impairments. These include: 16th Ave S in North Myrtle Beach, White Point Swash, and Briarcliffe Swash. A trend in increasing impairments at 77th N in Myrtle Beach has been identified and is being investigated by the stormwater staff.

River Gauge Monitoring

Since January 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 at eight sites in the Waccamaw River and one site in Pee Dee River. The work is being performed under a SC DHEC approved Quality Assurance Project Plan.

Grab sampling is conducted at sites where the USGS is maintaining real-time water quality sensors for parameters that cannot be measured in-situ. The EQL also performs in-situ measurements to provide a back-up source of data for interpreting the grab samples. These data are being collated to provide a statistical comparison with the USGS real time data. The former have been certified by the SC DHEC, but not the latter so this comparison provides confirmation of the USGS data. When a lack of agreement is observed, the EQL notifies the USGS who then follows up to investigate a possible sensor failure.

The USGS real-time data are made available to the public at <http://waterwatch.usgs.gov/wqwatch/map?state=sc&pcode=00010>. The EQL's results are posted within one month of sampling at: http://bccmws.coastal.edu/river_gauge/.

The results are transmitted to the stormwater managers in provisional reports. A first report is sent within one to day days following sampling. The rest of the results can take as much as a month to generate, so a follow-up report is sent. As with the volunteer monitoring reports, these provisional reports compare the observations to regulatory standards, recommended levels and

site-specific norms. The latter have been established from the entire dataset. Sampling is conducted on alternating weeks from the volunteer monitoring program to increase the temporal resolution of the monitoring data. Thus data analysis includes a comparison with the results from the volunteer water quality monitoring program.

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.

In June 2015, the EQL completed a one-year comparison of fecal coliform to E. coli. This was recommended by SC DHEC to facilitate transition to the new fecal indicator for freshwater, i.e. E. coli. Data analysis was presented to the stormwater managers at the CWSEC biannual meeting held in June 2015. These results suggested that the frequency of contraventions should not be significantly impacted by the transition to the new fecal indicator.

The 2015 year was dominated by the effects of flooding on the Waccamaw and Pee Dee Rivers. This has included periods during which widespread elevations of turbidity and fecal bacteria have been observed. Oxygen deficits have been unusually low during the winter of 2015-2016. This is interpreted as resulting from organic matter loading associated with flooding of the adjacent swamps and relatively high temperatures that persisted through December 2015. Due to concurrent flooding of the Waccamaw and Pee Dee Rivers, water levels achieved record highest downstream of the confluence of these rivers as observed by the USGS sensor at Hagley Landing.

A new real-time sensor has been deployed in Winyah Bay by NOAA's North Inlet-Winyah Bay National Estuarine Research Reserve with funding provided by the Donnelly Foundation. It is expected to become operational early in 2016. These data will improve the value of information being collected by the upstream USGS gages and the EQL. Specifically, the new data will help quantify the impact of river discharges on the coastal ocean.

CCU Student Monitoring

The following three monitoring programs are being conducted by CCU's undergraduate students to provide data for the SMS4's. As noted below, these efforts are being supported by the SMS4s and CCU. CCU's boundaries lie within the SMS4 jurisdictions of Conway and Horry County.

Briarcliffe Acres Groundwater

Since June 2012, Horry County and the town of Briarcliffe Acres have been 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. This project was designed to engage students by having them perform the data download. In 2015, two students delivered a poster presentation at CCU's Undergraduate Research Competition on April 14th entitled: "Rainfall, Lake, and Ground Water Monitoring in Briarcliffe Acres, SC."

Since the first three years of funding reached completion in 2015, CCU sought and obtained grant funding to support replacement

of all equipment. Horry County has agreed to continuing support travel and undergraduate student salary.

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 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. The US FWS has provided funding for the restoration and assessment work. The latter was conducted by CCU students who performed annual tree counts to track survival rates and downloaded water-level logger data for use by Clemson University to infer floodplain inundation activity. Clemson University was also monitoring channel and floodplain bathymetry and topography. Water monitoring ended in July 2015 due to lack of funding. The tree surveys were suspended by mutual agreement of the Crabtree Restoration working group in light of the relative stability of the restored vegetation.

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. This program was started in 2009 to help meet the requirements of a wetlands permit issued to enable construction of Wall Pond. Data collected since 2011 are made available to the public at:

<http://bccmws.coastal.edu/ccum/index.html>. A web page with a program description and portal to the data is located at: <http://www.coastal.edu/wwa/datasets/coastalcarolinauniversitycampusmonitoring/>

CCU undergraduate students can either enroll for 1 credit under MSCI 399Q or volunteer in a non-credit role. 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. CCU's Waccamaw Watershed Academy provides technical support. The Waccamaw Riverkeeper serves as the field leader and ensures that the data are relayed to CCU's Building and Grounds staff for follow-up on potential illicit discharges. Both organizations are providing pro bono assistance in this effort.

In 2015, CCU's QEP program was awarded another round of funding to support this program. A request has been submitted to continue funding into 2016. This funding has helped support acquisition of a Hanna multimeter for in-situ measurements. A new SOP was generated for use of this meter. CCU also began providing a fellowship to a graduate student who serves as the teaching assistant for the QEP course. Her role is to provide hands-on technical coordination and perform the first layer of data review.

In 2015, the students generally sampled weekly from January 27th through November 17th at three locations (501 West, Wall Pond, 544 West) and generated 303 triplicate sample measurements in 2015, resulting in a total of 1062 triplicate data points since the program commenced on October 13, 2011.

An on-campus IDDE investigation was launched in 2015 resulting from student-generated data that indicated high turbidity levels. The Riverkeeper and the Buildings and Grounds staff investigated and determined the issue to be on-site construction activities that were subsequently resolved.

At the end of each semester, the students and the Riverkeeper hold a mini data conference to review their results. In 2015, these data conferences were held on May 6th and December 8th. Biweekly sampling is conducted during the summer by EQL work-study students.