Stormwater Outfall Study in North Carolina Assesses Impacts of Discharge to Coastal Ecosystem

In-Situ® Level TROLL® 500 and TROLL® 9500 Instruments help identify sources and patterns of pollution loading to the coast

Application

Stormwater outfalls that flow into coastal waters can affect human and environmental health. Fecal contamination is a potential concern in areas adjacent to stormwater outfalls. Elevated levels of pathogenic organisms have been found in waters near coastal stormwater outfalls around the world. This contamination leads to closures of recreational beaches and shellfish harvesting areas, to human illnesses, and to negative economic impacts. The U.S. Environmental Protection Agency (USEPA) has identified ocean outfall research as a high priority.

The USEPA reported that of the 3,771 coastal beaches monitored in 2006, 1,201 (32 percent) had at least one advisory or closure during the 2006 season (USEPA 2006). Beach closures have a significant impact on tourism—the nation's largest employer and second largest contributor to the GDP, generating over $700 billion annually. For example, the cost of closing a Lake Michigan beach could be as high as $37,000 per day (Durham County 2007). Beaches are the leading tourist destination, with coastal states earning 85 percent of all U.S. tourism revenues. Approximately 89.3 million people vacation and recreate along U.S. coasts every year (Leeworthy 2000).

Like tourism, the shellfish industry has been harmed by stormwater outfall. The most recent comprehensive survey of shellfish waters in the United States, completed in 1995, found that 3.5 billion acres (1.4 billion hectares), or nearly one in every seven acres (2.8 hectares) of classified shellfish beds, were not approved for harvest due to poor water quality. For 14 of the 21 coastal states included in the 1995 National Shellfish Register, more than 95 percent of the areas closed to

Mike Piehler collects water samples at an outfall monitoring site.

shellfishing were impaired by non-point sources (NOAA 1996). In 1997, the USEPA estimated that impacts from stormwater runoff cost the United States shellfish and commercial fish industries nationwide between $17 to $31 million (Durham County 2007).

Water quality impacts are just part of the stormwater picture. The quantity of stormwater runoff poses its

Figure 2: Beach closures in North Carolina impact local economies. Collecting accurate water level and water quality data help scientists understand patterns of pollution delivery. Photo courtesy of UNC Coastal Studies Institute.

own problems. Increased development brings more paved surfaces and roofs that shed water instead of absorbing it. One inch of rain falling on a one-acre parking lot produces 16 times more runoff than the same inch of rain falling on a one-acre meadow (NC Department of Environment and Natural Resources, Environmental Health).

Researching ocean outfalls

The University of North Carolina (UNC) Chapel Hill Institute of Marine Science (IMS) and the UNC Coastal Studies Institute are currently studying ocean outfall in Dare County, North Carolina at nine sites on North Carolina's Outer Banks. The research is being funded by the North Carolina Department of Environment and Natural Resources (NCDENR). The project aims to:

- Identify key microbial constituents.
- Assess water quality.
- Determine concentrations and likely sources of indicator and tracer microorganisms.
- Provide measures of patterns of indicator and pathogen loading in storm and ambient conditions.

Stormwater drainage networks bypass natural filtration pathways provided by soil and vegetation and are believed to be conduits for pollution from residential areas (sewage and septic systems, pet waste), industry (toxins and hydrocarbons), and agriculture (livestock waste, bio-solids, and antibiotics). Coastal stormwater outfalls in North Carolina are cause for concern given the volume of precipitation that is typically received during annual and episodic events (e.g., hurricanes, Nor'easters), and warrant further study.

Identifying patterns of pollution delivery

The study is divided into two phases. Phase I is currently underway and includes pilot scale monitoring at nine stormwater outfalls. The nine sites are within miles of each other, and the watersheds are small—some only three blocks from the beach. Data are being collected to determine the amount of pollution entering coastal receiving waters from stormwater discharge. The outfalls are prioritized in terms of likely impact on recreational waters. Water samples are being collected from multiple stations within the watershed of each outfall.

When a storm occurs, TROLL® 9500 Water Quality Instruments, located at each outfall, measure and log water level, temperature, conductivity, and turbidity. In addition, doppler flow modules at each site trigger ISCO 6712 samplers to collect approximately 100 water samples per storm event. After an event, the CSI laboratory analyzes the samples for *Enterococcus* sp., *E. coli*, total coliforms, chlorophyll a, and salinity. Along with rainfall data, water quality information will help researchers understand storm duration and site conditions during a storm.

"The TROLL 9500 units are easy to calibrate, and we don't have to recalibrate as often as some of our other instruments," says Mike Piehler, researcher at the University of North Carolina. "So far the TROLL 9500s have been really reliable, and they were easy to integrate with the ISCO 6712 samplers. We have been very satisfied with the performance of the TROLL 9500s."

Upstream of each outfall, researchers are collecting water level data using Level TROLL® 500 Instruments. Information collected at these sites helps researchers understand the most likely source of the flow for a particular stormwater event. Doppler flow meters measure the amount and velocity of water that passes through the system. Combining bacterial concentrations with flow measurements will provide the total amount of pathogenic bacteria passing through the system.

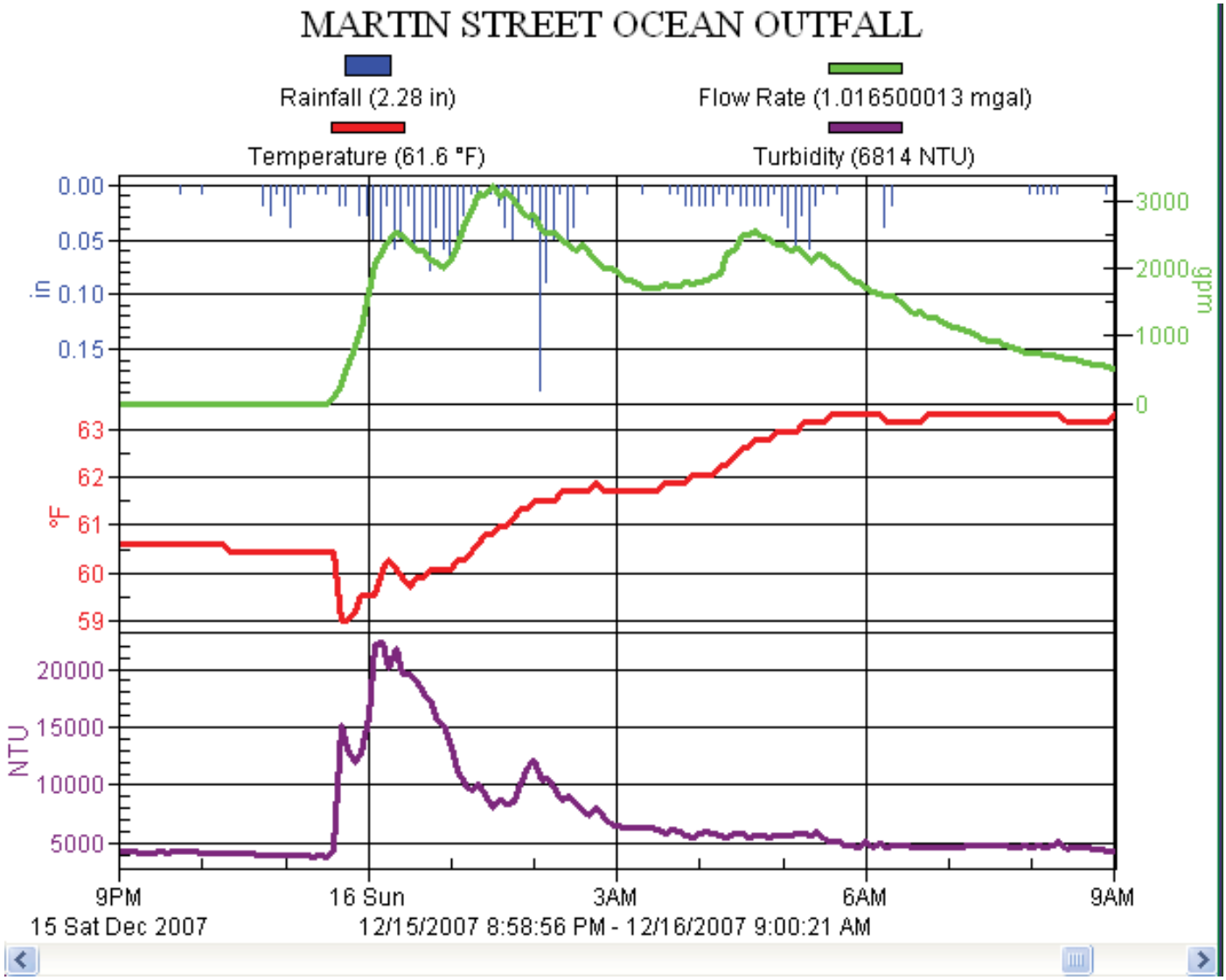

Figure 3: Patterns of rainfall, stormwater flow, water temperature, and turbidity throughout a winter rain storm.

"Some of the In-Situ sensors are monitoring corrosive, saline environments," Piehler noted. "They are holding up well, and we haven't had any problems."

Challenging conditions for researchers

The study began in the midst of the worst drought in North Carolina's recorded history.

"We had nine months without rain in 2007," says Piehler. "We had to change tactics with our data collection strategy."

Originally, scientists planned to collect data from storms generating at least one inch of rain, with sampling to be conducted within four hours of each rain event. Ambient samples were scheduled to be taken if more than five days passed without measurable precipitation in the entire region. Scientists had to adapt their monitoring protocols for the drought conditions.

"Since rainstorms were producing significantly less rain, we traveled to the monitoring sites one hour before a projected storm and collected data for storms producing less than one inch of rain," Piehler says. "We didn't want to miss any data because of storm anomalies, and we wanted to make sure that minimal amounts of precipitation were triggering ISCO 6712 samplers, TROLL 9500, and Level TROLL devices to collect data."

Phase I of the study has continued past the scheduled June 2008 completion. Researchers would like to collect more data from significant storm events to better understand watershed-specific trends and patterns of pollution delivery.

Providing baseline data to BMPs

Phase I data will be used to set up Phase II. In Phase II, after application of best management practices (BMPs), a comprehensive monitoring project will occur for all

nine outfalls. Researches will continue to use TROLL 9500 Instruments, Level TROLL 500 devices, and ISCO 6712 samplers in Phase II of the study.

A stormwater BMP refers to a practice or method that effectively reduces sources of pollution. The engineering firm Moffatt and Nichol will explore the use of BMPs such as bioretention areas, marshland buffers, filters installed into outfall catch basins, UV disinfection, and hydrodynamic separators. These BMPs can provide wildlife habitat and increased evapotranspiration and infiltration rates while decreasing the amount of sediment and nutrients in stormwater runoff. In addition, dye studies will be conducted at outfalls determined to be a significant public health risk. During periods of flow, Rhodamine dye will be released into catch basins and tracked along the beach with fluorometers. Data gathered will give an idea of how far and how fast stormwater plumes travel from outfalls.

The research should provide scientists with a better understanding of the levels and possible sources of bacteria and viruses in stormwater. Dye studies will show how far along a beach the health risk to the public extends during times when outfalls are flowing. The data will aid in developing predictive models to better foresee potential public health risks in the presence of stormwater.

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Figure 4: Mike Piehler calibrates the TROLL® 9500 Water Quality Instrument in the laboratory before deploying it to an outfall monitoring site.

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