NWQEP NOTES

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IN THIS ISSUE

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PROJECT SPOTLIGHT

The Effect of Urban Stormwater BMPs on Runoff Temperature in Trout Sensitive Waters

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North Carolina State University, Raleigh, NC

Introduction

It has been long understood that the introduction of pollutants such as metals and nutrients into natural water bodies can be detrimental to the aquatic environment. During the 1950s, as advances in aquatic ecology coincided with increased industrialization and urbanization, it became evident that warm water discharges could also impair aquatic ecosystems (Langford, 1990). Thermal pollution was especially a concern in cold water environments inhabited by fish such as trout and salmon. While most industrial cooling processes have since been modified to limit their thermal discharges to surrounding water bodies, non-point sources of thermal pollution continue to potentially affect aquatic environments.

Suitable water temperatures are crucial to a number of important physiological and behavioral functions in fish and other aquatic organisms. Elevated water temperatures – especially sudden spikes in temperature above 32º C – can be lethal to resident organisms that cannot move to avoid them. Sublethal effects of elevated water temperature can influence feeding behavior, metabolic rates, reproductive behavior, and resistance to disease. Warm water can hold less dissolved oxygen, adding another stress on aquatic life. Although lethal water temperatures can vary based upon a number of factors, there is evidence that trout and salmon avoid water temperatures above 21º C, likely due to the onset of stress or damage caused by higher temperatures (Coutant, 1977). The full effect of thermal pollution on an aquatic environment is difficult to predict due to the complex interactions within the aquatic ecosystem, where some organisms flourish under warm temperatures while others perish. These interactions illustrate the importance of maintaining a natural thermal regime in cold water environments to preserve the integrity of the ecosystem.

EDITOR'S NOTE

As land is cleared for development, vegetation and soil are largely replaced by asphalt and other impervious surfaces capable of absorbing large amounts of solar radiation. This transformation not only increases the amount of stormwater runoff, but also the temperature of the runoff, threatening temperature-sensitive aquatic life and local economies that rely on recreational fishing. Stormwater best management practices (BMPs) are commonly used to mitigate the impacts of excess runoff, but their effects on runoff temperatures are not well known.

This issue of *NWQEP NOTES* features research on three types of BMPs in western North Carolina—home to several species of trout—to evaluate their impact on runoff temperatures. The results indicate that while each BMP is capable of contributing to thermally-polluted runoff, such impacts may be reduced through modification of standard BMP design practices. The authors discuss BMP design considerations and suggest modifications for reducing BMP outflow temperatures.

It is important to note that thermal pollution might be further mitigated, as suggested by the authors, by increasing the amount of shade provided by broad leaf vegetation. Shade trees and shrubs may reduce the temperature of pavement, surface runoff, and soil and ponded waters of stormwater BMPs. Policymakers should encourage the development community to minimize the removal of tree cover while promoting replanting of mature trees as common-sense solutions to the urban heat island effect.

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North Carolina is home to Brown Trout (*Salmo trutta*), Brook Trout (*Salvelinus fontinalis*), and Rainbow Trout (*Oncorhychus mykiss*) and contains more streams capable of supporting these species than any other state in the Southeastern United States. In North Carolina, trout are found primarily in the western part of the state (Figure 1). In addition to their ecological role, fish serve as an important part of the economy. In North Carolina, more than $1 billion is spent on fishing related activities each year, with an estimated 173,000 anglers fishing for trout (U.S. Dept. of Int., 2001).

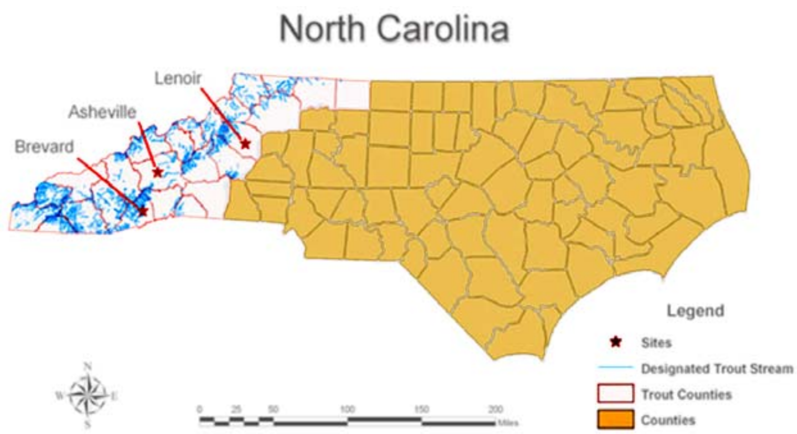

Figure 1: Location of research sites and areas where trout are found in North Carolina.

Runoff from urban and other developed areas can raise temperatures in adjacent surface waters. Especially during the summer months, pavement absorbs large amounts of solar radiation and can be heated to temperatures in excess of 60° C (Asaeda, et al. 1996). Other aspects of the urban environment, including removal of shade and decreased evapotranspiration due to elimination of vegetation, contribute substantially towards elevated surface temperatures. During a storm event, runoff flowing over heated pavement can absorb this heat and transfer this thermal energy to other parts of the watershed, including rivers and creeks. Due to the thermal properties of asphalt, much of the absorbed heat is concentrated near the surface. During a storm, this surface heat is rapidly transferred to runoff, leading to initial runoff temperature spikes and subsequent cooling. Because runoff flows are increased with urbanization and total thermal energy is dependent on both temperature and flow, the impact of heated stormwater runoff to creeks and other receiving water bodies can be substantial.

Although an understanding of temperature gradients in stormwater BMPs is still emerging, thermal stratification within natural ponds and soils has been studied for many years. Air temperatures, wind speed, vegetation, and interactions between the water and surrounding soil have all been shown to affect thermal stratification within ponds (Dale and Gillespie, 1976; Moss, 1969). In a study into the effects of warm irrigation water on temperatures within the soil column of an agricultural field, it was found that warm water had little impact on soils at greater depths because the infiltrating water quickly cooled to the temperature of the surrounding soil, providing some insight into the potential effect of bioretention areas (Wierenga et al., 1970).

With the proliferation of stormwater BMPs across the country, it is important to understand their effects on all aspects of water quality. One contaminant that has not been historically considered in BMP design is thermally polluted stormwater runoff. Due to the function of stormwater BMPs to capture, treat, and release stormwater runoff into natural water bodies, the potential to affect runoff temperatures is evident. However, few studies have examined the effect that stormwater wetlands and wet ponds have on the temperature of runoff. It has been shown, for example, that the effluent temperature from a wet pond can be warmer than that of the incoming runoff due to solar radiation captured by the pond (Kieser et al., 2004). It has also been observed that water at the surface of a wet pond is warmer than water at a depth of 1 m, but moderate winds and inflows reduce this temperature difference (Van Buren et al., 2000). Research on the effects of bioretention practices on water temperature is quite limited.

The goals of this study were to determine the influence of several popular stormwater BMPs on runoff temperature, identify which stormwater BMPs can effectively reduce runoff temperature, and propose design criteria that support water temperature reduction.

Methods

A study conducted by the Biological and Agricultural Engineering Department at North Carolina State University during the summers of 2005 and 2006 examined the effect of urban stormwater BMPs on runoff temperature in Western North Carolina. The monitoring sites consisted of a stormwater wetland, a wet pond, and four bioretention areas. Bioretention areas were a particular focus because little was known about their effects on runoff temperature. Remote monitoring equipment was installed at each site and used to measure temperatures at all major inlets and outlets, the ambient air, receiving creek, and various locations within the BMPs on a 5 minute interval. A combination of HOBO® 4-channel loggers with attached thermistor temperature sensors, as well as HOBO® Water Temp Pro submersible temperature loggers were installed within inlet and outlet pipes and shielded from direct solar radiation. At the stormwater wetland, wet pond, and one bioretention area, thermistor temperature sensors were installed at evenly spaced intervals within the water and soil columns to observe temperature gradients within the BMP. Identification of such gradients was expected to be useful in identifying potential modifications to the BMP outlet structures to improve thermal performance.

Results and Discussion

Pavement Runoff

Mean runoff temperatures leaving the pavement surfaces at all monitoring sites were significantly ($p<0.05$) warmer than 21° C during the summer months of June, July, and August. With these water temperatures elevated above acceptable levels for trout, there was potential for the direct discharge of this runoff into a cold water creek environment to negatively impact trout populations. Runoff temperatures were normally highest at the beginning of a storm and subsequently cooled in conjunction with the cooling pavement (Figure 2). For most of the analyzed storms, rainfall in excess of 2.5 cm did not result in additional cooling.

Storms yielding the highest runoff temperatures typically occurred in the late afternoon, because pavement surfaces had accumulated heat throughout the day; however, runoff temperatures above 21° C were encountered at all times of day. While not the focus of this research, increases in stream temperature were often observed during times of rainfall, likely due to the effect of thermally polluted runoff throughout the watershed (Figure 3).

In response to research into the urban heat island effect, many management practices have been identified to reduce ground surface temperatures, such as shade provided by mature trees and light-colored paving surfaces. Preliminary results

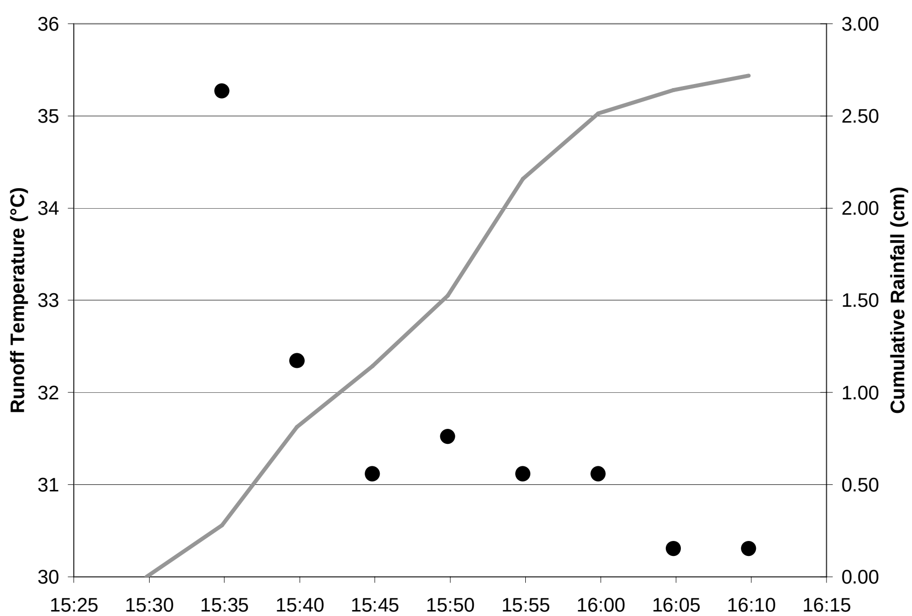

Figure 2: Runoff (from pavement) temperatures over the course of a storm on 8/20/06 in Brevard, NC.

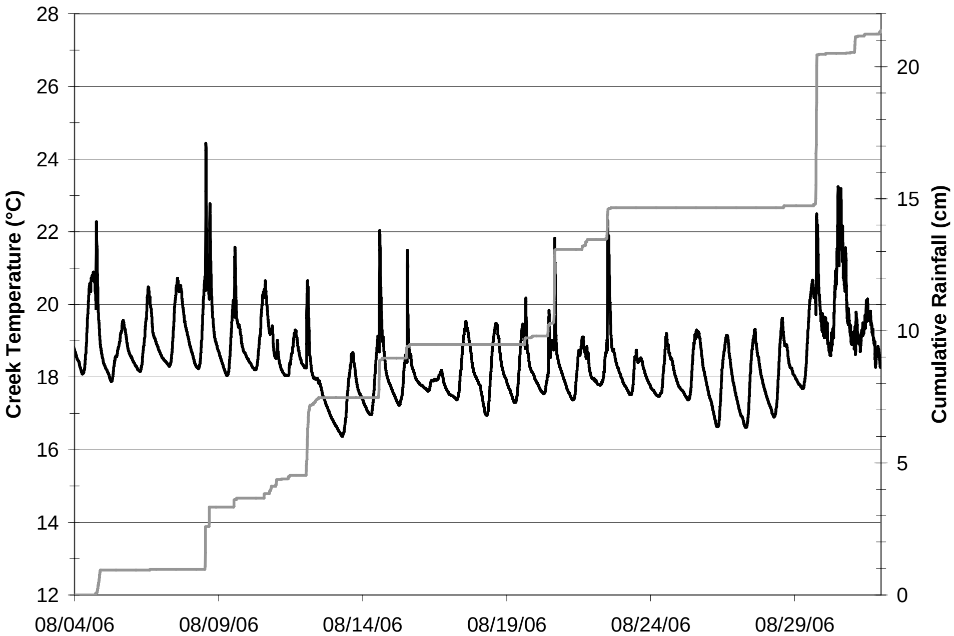

Figure 3: Plot showing the effect of rainfall events on King's Creek temperature in Brevard, NC. Note spikes in water temperature associated with each increment of precipitation.

from this study indicate that parking lot shading from a tree canopy resulted in lower runoff temperatures; however, further analysis is needed to quantify this reduction. Also, no substantial differences in runoff temperatures were observed between a parking lot covered with a light colored chip seal, installed to minimize heating by solar radiation, and a nearby standard asphalt parking lot.

Stormwater Wetland

The stormwater wetland under study was located in Asheville, NC and covered an area of 724 m². An estimated 70% of the wetland surface area was shaded by vegetation, such as Woolgrass (*Scirpus cyperinus*), Pickerelweed (*Pontederia cordata*), and Soft-stem Bulrush (*Schoenoplectus taberaemontani*) (Figure 4).

Mean outflow temperatures from the stormwater wetland were significantly ($p<0.05$) warmer than inflow temperatures over the entire monitoring period; effluent temperatures were significantly ($p<0.05$) above 21°C during the peak summer months. As the wetland drained after a storm, effluent temperatures for the months of June, July, and August were 22.8°C, 24.6°C, and 23.1°C, respectively. Even though the majority of the stormwater wetland was shaded by vegetation, the BMP apparently served as a source of thermal pollution.

With the current outlet drawing water from the surface of the wetland, the possibility of drawing cooler water from depths below the surface was examined. During the summer, water temperatures were coolest at the bottom waters of the stormwater wetland and were also least affected by fluctuations in weather near the surface (Figure 5). During large storm events exceeding 2.5 cm, water at all depths within the wetland cooled and sometimes would not return to antecedent temperatures for several days.

Not only was the water at the base of the wetland typically coolest but during the months of May, June, September, and October, this water was significantly ($p<0.05$) cooler than 21°C. Because these temperatures were below the upper avoidance temperature for trout, there is evidence that implementation of a modified outlet structure that draws water near the bottom waters of the wetland could reduce or eliminate thermal pollution impacts during these time periods. The difference in temperature between the wetland bottom waters and all other depths can likely be attributed to not only thermal stratification within the water column but also the proximity to the soil below the wetland. The soils surrounding the wetland are not easily subjected to changes in temperature, making thermal exchanges between the water at the bottom waters of the wetland and soil below likely responsible for both the limited fluctuations and cooler temperatures at that depth. Although specific flow reductions could not be quantified, several small storms (< 0.5 cm precipitation) during the monitoring period were completely captured without discharging water from the outlet structure, effectively eliminating any downstream thermal pollution impact.

Figure 4: Site photo of the Asheville stormwater wetland.

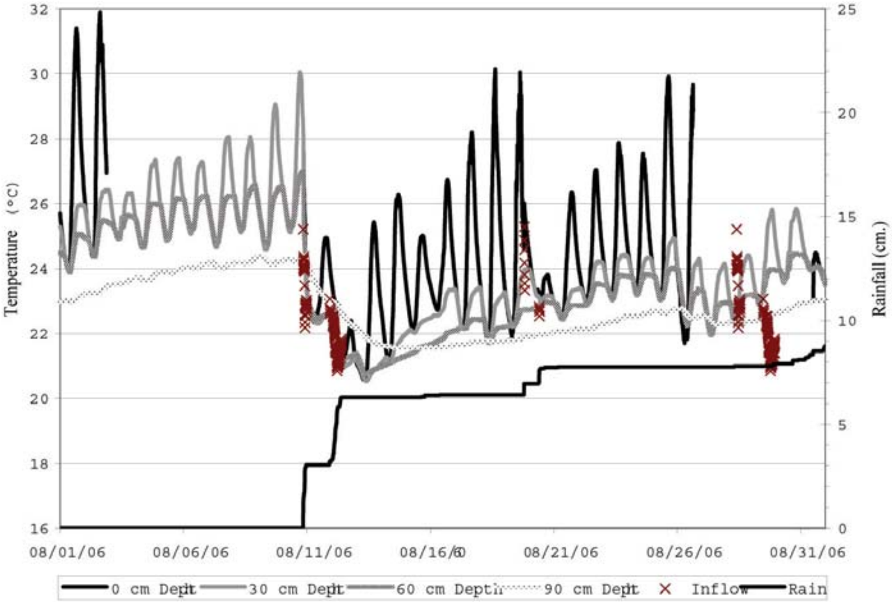

Figure 5: Plot showing effect of daily fluctuations and rainfall on water temperature distribution near the stormwater wetland outlet. Water temperatures were consistently cooler with depth and deeper waters were less affected by surface temperature fluctuations. Water at all depths in the wetland cooled in response to storm events exceeding 2.5 cm.

Wet Pond

The monitored wet pond was located in Lenoir, NC, and collected runoff from a large commercial asphalt parking lot. The wet pond received essentially no shading from surrounding trees or vegetation, but was covered by substantial amounts of algae for much of the monitoring period (Figure 6).

Leaks in the outlet structure caused this wet pond to constantly discharge water from the outlet and lowered the normal pool elevation below what was intended in the design. Effluent temperatures from the wet pond never dropped below the 21° C threshold during the summer months, indicating that this system was constantly discharging water that could be hazardous to trout populations. The maximum effluent temperature of 29.2°C was recorded in July, and was warmer than 86% of the recorded runoff temperatures during that month. From May through September, the mean temperature of the wet pond effluent was significantly ($p<0.05$) warmer than water entering the system. Also, despite cooler inflow temperatures, the temperature of effluent from the wet pond was significantly ($p<0.05$) warmer than effluent from the stormwater wetland. Although the pond was able to reduce peak flows and likely reduced concentrations of other pollutants, it served as a substantial source of thermal pollution. As storms progressed, effluent temperatures from the wet pond decreased, as cooler water entered the system. Similarly, water temperature within the wet pond cooled during the course of a storm and approached the temperature of the coolest water near the bottom.

Figure 6: Site photo of the Lenoir wet pond.

Water temperatures varied significantly ($p<0.05$) with depth over the entire monitoring period, with the warmest water during the summer near the surface, similar to the stormwater wetland water column. Even at the bottom of the wet pond, mean water temperatures were significantly ($p<0.05$) warmer than the 21° C threshold during June, July, and August. While a modified outlet structure that draws water from the bottom of the water column could yield lower effluent temperatures than the present structure, the effluent would still be warm enough to potentially impact trout populations.

Bioretention Areas

Four bioretention areas were monitored during the study. Two of the cells were immediately adjacent to each other in a shopping center parking lot in Brevard, NC. One of the bioretention areas was located in Lenoir, NC, near the monitored wet pond. The most intensely monitored bioretention area was located in Asheville, NC, near the monitored stormwater wetland. Monitoring began at this 45 m^2 bioretention area immediately following construction in 2005.

During the summer, soil temperatures were coolest at the bottom of the Asheville bioretention area (Figure 7). The soil temperature 120 cm below the surface did not fluctuate substantially in response to weather changes near the surface. However, the temperature of soil 30 cm below the surface did exhibit substantial diurnal fluctuations and was sometimes warmer than the temperature of incoming runoff. As stormwater infiltrates through a bioretention area, it equilibrates with the temperature of the surrounding soil. Consequently,

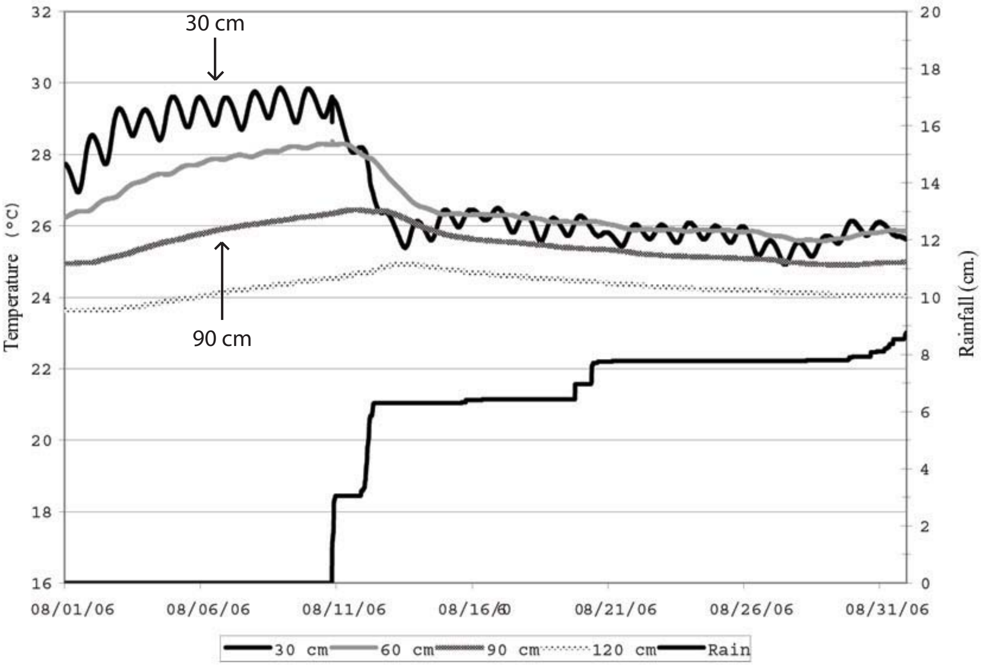

Figure 7: Plot showing effect of daily fluctuations and rainfall on soil temperature distribution within the Asheville bioretention area. During the summer, soil temperatures were coolest at the bottom of the bioretention area; soil temperatures 30 cm below the surface exhibited significant diurnal fluctuations. Soil temperatures decreased substantially with the storm event of 8/11 - 8/12, but remained above 24°C.

these warm soil temperatures near the surface indicate that a bioretention area without adequate soil depth could serve as a source of thermal pollution as infiltrating runoff water could pick up heat from the warmer upper soils. In a deep bioretention area, although water may be heated initially, it will cool as it infiltrates through the remainder of the soil profile and is collected by the underdrain network. Similar problems arise if a bioretention unit is not properly sized to capture the first flush. If stormwater is able to bypass the bioretention area early in a storm, it will not only convey heat from the parking lot surface, but also from the warm bioretention surface soil to a receiving water body. If the bioretention area is designed to accept the first flush, any subsequent runoff bypassing the bioretention area through an overflow structure will not be as heated because the parking lot and soil surfaces will have given up much of their heat to previous runoff. Although underdrain effluent from the bioretention areas was typically cooled below the temperature of the incoming runoff, it still often exceeded temperatures of 21° C, indicating that although the BMP did not serve as a source of thermal pollution, neither did it eliminate thermal pollution concerns.

Effect of Conveyance in Buried Pipes

During the peak summer months of June, July, and August, water temperatures were significantly ($p<0.05$) cooler than surface runoff after traveling through a buried metal pipe to the stormwater wetland and a buried concrete pipe to the wet pond. At times differences in maximum temperatures between the inlet and outlet of the buried metal pipe exceeded 6° C. Because water within the stormwater wetland and wet pond was typically warmer than the inlet water that had been cooled by these pipes, temperature reductions due to conveyance in the buried pipes did not have an immediate impact on effluent temperatures. A decrease in effluent temperatures as storms progressed can likely be attributed in part to this cooler water mixing throughout the water column during the course of a storm. In order for the thermal benefits of conveyance in buried pipes to have a direct impact on effluent temperatures, conveyance should be incorporated after water has been treated by the wetland or wet pond. While it may not always be practical or economical to install buried pipes solely for the purpose of runoff temperature reduction, the value of such a conveyance should be recognized when it exists.

Conclusions and Recommendations

Monitoring results have indicated that thermal impacts from stormwater runoff may be reduced when consideration for thermal pollution is incorporated into BMP design. Employing standard design practices, bioretention areas appear to be the only type of BMP capable of reducing runoff temperatures, given a soil depth of at least 4 feet; however, effluent temperatures may still be elevated above temperatures suitable for trout. The effluent temperatures of wetlands and wet ponds are governed in great part by ambient air termperatures. It is therefore difficult using standard design guidance to reduce effluent temperatures below those of average air. For stormwater wetlands and wet ponds, some type of modified outlet structure that draws water from the cooler bottom waters appears to be necessary to prevent runoff temperature increases and possibly reduce temperatures. These modified outlet structures could consist of perforated pipe along the bottom of a wetland or wet pond, surrounded by a gravel envelope, and connected to the outlet structure at the normal pool elevation with non-perforated pipe (Figure 8). While this type of outlet structure should reduce effluent temperatures during the summer months, it raises maintenance concerns with the potential for clogging and water quality concerns with the potential for higher TSS and other pollutant concentrations at the base of the water column.

Continued on p. 9

Figure 8: Illustration of a possible modified outlet structure for temperature reduction.

Vegetative shading should be employed within stormwater BMPs whenever possible. The lack of vegetative shading over the wet pond is likely the primary reason why water temperatures were warmer at that location than the stormwater wetland. Incorporating plants with leaves that are not in contact with the water or soil surface are expected to result in lower surface temperatures, and therefore effluent temperatures, since the space between the leaves and water or soil surface serves as additional insulation from the solar radiation effects.

It should be emphasized that flow reduction, a key design function of these stormwater BMPs, would serve as an important mitigating factor for thermal pollution. By reducing stormwater flow, even elevated effluent temperature would have a lower impact on receiving waters as the total amount of thermal energy discharged would be lower than without the BMP. Although several of the BMPs studied were identified as thermal pollution sources based on increases in water temperature, it is possible that thermal impacts to receiving creeks were reduced due to a reduction in flow.

Because runoff temperatures cool during the course of a storm, limiting effluent flowrates during the beginning of a storm, which is a main component of first flush designs, should assist in mitigating the thermal impacts from stormwater runoff. Unlike some conventional pollutants, which typically require a substantial amount of time after a storm to build up within a watershed, pavement temperatures are very dynamic and capable of contributing to thermal pollution shortly after rainfall has ceased.

With trout and other coldwater creek inhabitants serving as important components of the ecosystem and economy, it is important to consider the thermal effects of urbanization and stormwater BMPs. While able to reduce flows and concentrations of many nutrients and other pollutants, it is important to recognize that stormwater BMPs have the potential to increase runoff temperatures. Modifications to some stormwater BMPs, such as drawing bottom waters into a stormwater wetland or wet pond outlet or specifying a greater soil depth for bioretention, may help reduce the thermal impacts of BMPs on cold water environments, but additional research is needed to determine if design changes can reduce outflow temperatures below critical thresholds for cold water fish. Evaluation of proposed design modifications in the field, assessment of the net effects of flow reductions achieved by BMPs on thermal pollution, and measurement of the cumulative effect of BMPs across a watershed on receiving water temperature regimes are all topics in need of study. Ongoing research at North Carolina State University involves the development of a computer model to simulate the effect that urban stormwater BMPs have on runoff temperature and quantify the thermal impacts associated with urbanization in an effort to address some of these issues.

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 (note, pages 7 and 8 have been deleted intentionally)

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SPECIAL ANNOUNCEMENT

Due to funding limitations, *NWQEP NOTES* will no longer be available in printed version after this issue. The newsletters will continue to be posted to the NCSU Water Quality Group's website and will be in pdf format, which can be downloaded for printing. If you would like to be notified when future issues of *NWQEP NOTES* are posted on-line, please send an email to **wq_puborder@ncsu.edu.**

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INFORMATION

Free Social Marketing Guide for Watershed Outreach

A free guide for using social marketing to further watershed program goals is now available, courtesy of the Utah Dept. of Agriculture and Food. The book is titled *Getting Your Feet Wet with Social Marketing: A Social Marketing Guide for Watershed Programs*, and is available online as a 7.3 MB PDF at **http://www.ag.utah.gov/conservation/GettingYourFeetWet1.pdf**

New Stormwater Guide for Evaluating MS4 Programs

The EPA Office of Water published a new MS4 Evaluation Guide on EPA's stormwater website at **http://cfpub.epa.gov/npdes/stormwater/munic.cfm**. Available only on the web, the Guide is designed for use by NPDES authorities to evaluate the quality of Phase I and Phase II MS4 programs for permit compliance, technical assistance and other purposes. It can be used for comprehensive program evaluations or for certain components of an MS4 program. MS4 program managers may also find it helpful as they evaluate their own programs. The document is being provided in Microsoft Word format so NPDES programs can modify it to meet the unique components of their programs such as those required by state regulations.

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MEETINGS

Call for Abstracts

3rd Mid-Atlantic Stream Restoration Conference: Science, Engineering, and Policy: November 7-8, 2007, Cumberland, MD. Sponsored by Canaan Valley Institute. Abstracts are due May 31, 2007. Visit website: http://www.canaanvi.org/canaanvi_web/events_ed.aspx?collection=cvi_workshops&id=140

Meeting Announcements — 2007

April

National Mitigation & Conservation Banking Conference: The Next Decade of Banking: April 10-13, 2007, St. Louis, MO. Contact Carlene Bahler at 703-837-9763, or visit website at: http://www.mitigationbankingconference.com/

2nd National Conference on Ecosystem Restoration (NCER): April 22-27, 2007, Kansas City, MO. Visit conference website at: http://conference.ifas.ufl.edu/NCER2007

May

18th Annual Nonpoint Source Pollution Conference: Seeking New Solutions to Old Problems: The Nonpoint Source Program at 20 Years: May 21-23, 2007, Newport, RI. Sponsored by the New England Interstate Water Pollution Control Commission and the Rhode Island Department of Environmental Management. Visit conference website at http://www.neiwpcc.org/npsconference.

June

2007 ASABE Annual International Meeting: June 17-20, 2007, Minneapolis, MN. Website: www.asabe.org/meetings/aim2007/index.htm

August

StormCon '07: August 20 - 23, 2007, Phoenix, AZ. Visit website at http://www.stormcon.com

15th National Nonpoint Source Monitoring Workshop: August 26-30, 2007, Austin, TX. See full announcement and call for abstracts on page 11.

October

WEFTEC.07: 80th Annual Technical Exhibition and Conference: October 13-17, 2007, San Diego, California. Visit website: http://www.weftec.org

November

43rd AWRA Annual Water Resources Conference: November 12-15, 2007, Albuquerque, NM. Website: http://www.awra.org/

Meeting Announcements — 2008

November

2008 Southeast Regional Stream Restoration Conference, November 3-6, 2008, Asheville, NC. Website: http://www.ncsu.edu/sri

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15th National Nonpoint Source Monitoring Workshop

Monitoring for Decision Making
August 26-30, 2007
Austin, Texas
The Driskill Hotel
http://www.rivers.txstate.edu/NPS07

Call for Papers and Posters: You are invited to submit proposals for oral and poster presentations. Presentations will be 20 minutes, followed by 10 minutes for discussion. Poster presentations are also encouraged.

Presentations should focus on one of the following session topics: Monitoring for Decision making • NPS pollution and karst aquifers • Detecting change in water quality from BMP implementation • Modeling applications for NPS pollution and control strategies • Integrating social indicators monitoring with environmental monitoring • Innovative management strategies in agriculture and urban landscapes • Nonpoint source pollution TMDLs • River restoration projects • Presenting monitoring data to the Public • Monitoring the impacts of agricultural drainage management • Monitoring the long term impact of 319 projects • Innovative monitoring in agricultural and urban landscapes • Riparian area and stream protection/restoration • Programs and approaches for animal operations and nutrient management

Instructions for Submitting Proposals: Download proposal submittal form at http://www.rivers.txstate.edu/NPS07. Proposals can be submitted three ways. Pick one of the following:

1) Mail to:
Nonpoint Source Workshop
River System Institute
601 University Drive
San Marcos, Texas 78666

2) Fax: (512) 245-7371, Attn: Annette Paulin

3) Email to: NPS07@grandecom.net

All proposals must include the following information: *(MS Word or Text file)*

a) Author name, affiliation, session topic the presentation will address, and preferred presentation format (oral or poster). Also include mailing address, phone, fax and email.

b) The circumstances creating the need for the project and relationship to the State/Tribal Nonpoint Source Management Program.

c) The measurable objectives of the project.

d) The project design and methods employed in: developing the project, enlisting cooperators, developing implementation programs or approaches, measuring implementation, monitoring the effectiveness of the implementation, and developing TMDLs.

e) Partnerships (public and private) supported and/or created by this project, including partner role and contribution to the project.

f) A description of how the project integrated monitoring, decision making, and implementation.

g) A discussion of results (e.g.):
- How was monitoring data used for decision making?
- What were the specific results?
- Did the monitoring indicate the project goals were accomplished?
- What management action was taken?
- How did these changes relate to water quality monitoring results?
- How was the model used in conjunction with the implementation?
- How was the TMDL implemented?

Deadline for submission of abstracts is **April 22, 2007.**

Review and Notification:
The workshop program committee will review abstracts. Authors will be notified by May 15, 2007 regarding the status of their abstract. Accepted abstracts will be published in the conference proceedings.

For Further Information:
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