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PROJECT SPOTLIGHT

NC State University Permeable Pavement Research: Water Quality, Water Quantity, and Clogging

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Introduction

Runoff from impervious areas carries pollutants, such as sediments, nutrients and heavy metals, into our surface waters. These pollutants adversely impact water quality resulting in reduced dissolved oxygen levels, and increased turbidity and metal toxicity levels. Permeable pavements are an alternative to traditional impermeable surfaces and have the potential to reduce the quantity and improve the quality of stormwater runoff. Permeable pavement allows stormwater to either infiltrate into an underground storage basin or exfiltrate to the soil, providing for groundwater recharge. Despite the potential water quality benefits, prior to 2005, permeable pavements were not assigned stormwater credit by the state of North Carolina due to potential problems with clogging. Installations of permeable pavement were considered 100% impermeable. This article presents results of recent research on permeable pavements that evaluated hydrologic and pollutant removal performance.

Figures 1a, 1b, and 1c show three of the most common permeable pavements: concrete grid pavers (CGP), permeable interlocking concrete pavers (PICP), and permeable concrete (PC). CGP have both internal voids and voids between individual pavers. PICP are

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Figure 1a. Concrete Grid Pavers (CGP)

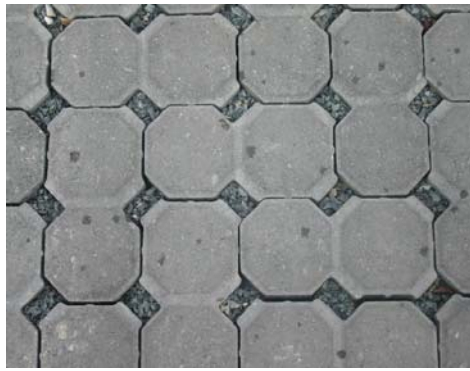


Figure 1b. Permeable Interlocking Concrete Pavers (PICP)



Figure 1c. Permeable Concrete (PC)

EDITOR'S NOTE

This issue of *NWQEP NOTES* highlights results of recent research conducted by NC State University in the southeastern and mid-Atlantic U.S. on permeable pavements. Three of the most common types were evaluated for their ability to reduce stormwater runoff volumes and pollutants. The effect of clogging on surface infiltration rate was also investigated. Findings indicated that the permeable pavements tested reduced stormwater runoff and pollutant loadings, as compared to traditional impervious pavements. Based on the impressive performance results, the authors suggested an equivalent grassed percentage to be applied to permeable pavements in sandy soils that meet certain criteria, and also stressed the importance of siting the pavement in a location free from sediment accumulation and the need for frequent maintenance. Based on the authors' recommendations, the state of North Carolina is now considering granting stormwater runoff reduction credit for sandy soil applications of permeable pavement. Results of future research planned at NCSU may dictate whether permeable pavements are also given credit for pollutant reductions. Communities, particularly coastal, should be excited by these new findings, which support the addition of permeable pavements to the list of practices potentially allowed for meeting Phase II stormwater requirements.

As always, please feel free to contact me regarding your ideas, suggestions, and possible contributions to this newsletter.

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concrete pavers that when installed form voids located at the corners and midpoints of pavers. PC is different from standard concrete in that fine aggregate has been removed from the mix, allowing interconnected void spaces to form during curing. Permeable pavements allow drainage through the existence or formation of these void spaces.

Recent research conducted at North Carolina State University has focused on several topics relating to permeable pavement function, including: (1) water quality impacts of permeable pavement; (2) longer term runoff reduction; and (3) preventing and mitigating clogging of permeable pavements. The first and second studies examined three permeable pavement sites in North Carolina where water samples were collected for pollutant analysis. Two of these sites in eastern North Carolina were instrumented to measure rainfall and runoff rates. The third study monitored surface infiltration rates at 40 permeable pavement sites in North Carolina, Virginia, Delaware, and Maryland.

Water Quality Study

Three PICP sites, located in Cary, Goldsboro, and Swansboro, NC, were outfitted with monitoring and automatic sampling equipment. The Cary site was constructed using PICP laid over a 2 in. layer of No. 78 stone over 10 in. of washed No. 57 stone. The voids between the pavers were backfilled with No. 78 stone. The permeable pavement cell included a geotextile impermeable liner and underdrains, due to in-situ clay loam soils and potential for pavement instability due to expansion from soil saturation. Rainfall and PICP outflow samples were collected from the Cary site for pollutant analysis and comparison. The Goldsboro and Swansboro sites each had an 8 in. storage basin of washed No. 57 stone with a thin layer of No. 78 stone over top. Pavers were laid over the No. 78 stone and No. 78 stone was backfilled into the voids. Asphalt runoff from the surface adjoining the permeable pavement, and PICP outflow, were collected from the Goldsboro site, while the Swansboro site was designed for the collection of PICP runoff and outflow.

Cary Monitoring Site

For research purposes, the Cary site (Figure 2) was constructed to prevent off-site runoff from entering the site. Samples of rainfall and PICP outflow from 15 events were collected between February and December 2004. Table 1 displays mean pollutant concentrations of the collected samples.



Figure 2. Cary PICP water quality monitoring site.

Table 1. Statistical mean pollutant concentrations and factors of significance for Cary site for samples collected from February 2004 through December 2004.

Pollutant Analysis	Rainfall (mg/l)	Exfiltrate (mg/l)	p-value
Total Nitrogen Calculation mg/l (TN)	1.62	2.13	0.4036 [LT]
Nitrate-Nitrite in Water mg/l as N (NO ₂₊₃ -N)	0.39	1.66	0.3018 [SN]
Total Kjeldahl Nitrogen/Water mg/l (TKN)	1.26	1.04	0.5107 [LT]
Ammonia mg N/l (NH ₄ -N)	0.64	0.06	0.0005 [SN]
Organic Nitrogen mg/l (ON)	0.85	0.98	0.6673 [LT]
Total Phosphorus/Water mg/l (TP)	0.255	0.404	0.1185 [SN]
Orthophosphate mg P/l (PO ₄)	0.083	0.341	0.0352 [SN]
Bound Phosphorus (BP)	0.098	0.041	0.0142 [LT]

Bold p-value indicates a significant difference ($p \leq 0.05$) was determined. [LT] log-transformed student t-test; [SN] sign test.

Table 2. Statistical mean pollutant concentrations and p-values from the Goldsboro site.

Pollutant Analysis	Asphalt Runoff (mg/l)	PICP Exfiltrate (mg/l)	p-value [Test]
Total Nitrogen Calculation mg/l (TN)	1.33	0.77	0.0511 [LN]
Nitrate-Nitrite/Water mg/l as N (NO ₂₊₃ -N)	0.30	0.44	0.1668 [N]
Total Kjeldahl Nitrogen/Water mg/l (TKN)	1.03	0.41	0.0074 [LN]
Ammonia mg N/l (NH ₄)	0.31	0.05**	0.0003 [LN]
Organic Nitrogen mg/l (ON)	0.88	0.54	0.6875 [SN]
Total Phosphorus/Water mg/l (TP)	0.134	0.049	0.0017 [LN]
Orthophosphate mg P/l (PO ₄)	0.038	0.022	0.2730 [LN]
Bound Phosphorus (BP)	0.077	0.057	0.2752 [SN]
Total Suspended Solids mg/l (TSS)	43.8	12.4	0.5811 [SN]
Copper by ICP/MS-Water mg/l (Cu)	0.016	0.006	0.2188 [SN]
Zinc by ICP/MS-Water mg/l (Zn)	0.067	0.008	0.0001 [N]

* Bold values are significant ($p \leq 0.05$) differences. N: normal student t-test; LN: log transformed normal student t-test; SN: sign test.

** 0.05 is one-half of the minimum detection limit (MDL) of 0.1 mg/l. All NH₄ samples were less than the MDL.

Ammonia (NH₄-N) and Bound Phosphorus (BP) were the only pollutants with significantly lower concentrations in outflow than in rainfall. Orthophosphate (PO₄) concentrations were significantly greater in outflow than in rainfall. On average, Total Phosphorus (TP) and Total Nitrogen (TN) concentrations were greater in outflow than in rainfall. The probable cause for the increase in TP and TN is that this site was at a model home with a finely manicured lawn. The additional TP and TN loads likely originated from over spreading of fertilizer onto the pavers.

Lined permeable pavement cells such as the driveway tested in Cary reduce peak flows; however, they do not reduce the volume of stormwater runoff. Since stormwater is designed *not* to infiltrate into soil under the pavement, underdrains or other drainage systems must be installed for the permeable pavement to function structurally. Permeable pavement applications in clay soils can be designed as detention basins, holding runoff for several hours while releasing outflow at a rate much less than the contributing rainfall.

Goldsboro Monitoring Results

Water quality samples were collected at the Goldsboro site (Figure 3) from asphalt runoff and PICP outflow (exfiltrate) from June 2003 until December 2004 from 14 storm events. As with the Cary site, off-site runoff was directed away from the permeable areas. Concentrations of Zinc (Zn), NH₄-N, TP, and Total Kjeldahl Nitrogen (TKN) in PICP outflow were significantly lower than in asphalt runoff based on means (Table 2).

The Goldsboro PICP cell was designed to drain quickly to facilitate aerobic conditions. Under aerobic conditions, NH₄-N can be converted to NO₂₊₃-N by nitrification, while denitrification – the conversion of NO₂₊₃-N to N₂ gas – typically only occurs under anaerobic conditions. This permeable pavement application was designed to freely drain and therefore be only aerobic. Due to this environment, it was anticipated that NH₄-N levels would decrease, while NO₃-N would increase. For the six outflow samples analyzed for NH₄-N, concentrations were less than the minimum detectable level (0.1 mg/l) and were significantly less than in asphalt runoff (Table 2). NO₂₊₃-N concentrations were not significantly different, but on average were higher in PICP outflow than asphalt runoff.



Figure 3. Goldsboro PICP water quality monitoring site.

TP outflow concentrations were significantly lower than in asphalt runoff (Table 2). TP concentrations may have been lower due to filtering of Bound Phosphorus and binding of PO_4 with available cations within the drainage cell. TSS concentrations were not significantly different between PICP outflow and asphalt runoff.

Swansboro Monitoring Site

No runoff was produced at the Swansboro PICP parking lot (Figure 4) during monitoring from March to December 2004. Thus, no runoff samples were collected for pollutant analysis. However, exfiltrated samples were collected and analyzed for pollutant concentrations. Over 10 months, for a 0.24 ac site, 0.68 lb of TN and 0.10 lb of TP exfiltrated the site. By extrapolation, over the course of a year, the Swansboro parking lot may have eliminated 2.8 lbs or 3.4 lbs/ac/yr of TN and 0.40 lb or 0.48 lbs/ac/yr of TP from runoff.



Figure 4. Swansboro PICP water quality and hydrologic monitoring site.

Hydrologic Monitoring Study

Three permeable pavement sites across eastern North Carolina (located in Kinston, Wilmington, and Swansboro) were instrumented to determine runoff reduction performance. For each site, rainfall was measured onsite and runoff was routed over a weir for flow-rate measurement. The Kinston site was constructed of CGP filled with sand (Figure 5). The pavers were laid on 2 in. of bedding sand over a permeable geo-textile to prevent clogging of the storage basin (8 in. of washed No. 57 stone) below. The Wilmington site (Figure 6) was constructed with 4 in. of permeable concrete (enough to store 1 in. of runoff) laid over top of a sandy base soil, with no gravel storage layer. The Swansboro water quality monitoring site, detailed previously, was also utilized for runoff reduction monitoring (Figure 4).

For each hydrologic monitoring site, SCS Curve Numbers were determined for each event that was greater than 2.0 in. Equivalent CN's were determined by back calculating through the SCS Curve Number equation. In addition, an equivalent



Figure 5. Kinston CGP hydrologic monitoring site.



Figure 6. Wilmington PC hydrologic monitoring site.

ratio of grassed area (CN: 61) to pavement area (CN: 98) based on runoff depth for each event (> 2.0 in.) was calculated (Figure 7).



Figure 7. Ratio of grassed area and pavement area hydrologically equivalent to permeable pavement.

Hydrologic Monitoring Summaries

The CGP site in Kinston was monitored from June 1999 through July 2001. During this period, six storms were greater than 2.0 in., including Hurricane Floyd, which produced 14.5 in. of rainfall. For these storms, the median CN was 79 and the median equivalent percent grassed area was 62 (Table 3).

Rainfall and runoff were recorded at the Wilmington PC site from May 2002 through July 2003. Three storms produced at least 2.0 in. of rainfall; the largest was 3.8 in. The median equivalent CN was 89 for these events, while the median equivalent grassed percentage was 42 (Table 4).

The Swansboro PICP site produced no runoff during monitoring from March to December 2004. Five storms were greater than 2.0 in; the largest was 3.5 in. For the same rainfall depths, based on the SCS Curve Number (CN) method, a

Table 3. Calculated CN's for events greater than 2 in. from the Kinston CGP site.

Rainfall (in.)	Runoff Depth (in.)	Site CN	Grassed %
14.5	14.2	97	2
4.8	1.5	64	92
4.3	4.1	98	0
2.8	0.0	42	100
2.7	0.5	69	89
2.6	1.6	90	36
Median		79	62

Table 4. Calculated CN's for events 2 in. or greater from the Wilmington PC site.

Rainfall (in.)	Runoff (in.)	Calculated CN	Grassed %
3.8	2.8	91	26
2.3	1.3	89	42
2.1	0.1	61	101
Median		89	42

grassed sandy soil (CN: 61) would produce runoff. For the storms monitored, the pavement reduced more runoff than a standard grass lawn. Therefore, the equivalent grass percentage was 100% for each event. The median SCS CN was 45 (Table 5).

Table 5. Calculated CN's for events greater than 2 in. from the Swansboro PICP site.

Precipitation Depth (in.)	Runoff Depth (in.)	Site CN	Grassed %
3.5	0	37	100
3.0	0	40	100
2.5	0	45	100
2.2	0	48	100
2.0	0	50	100
Median		45	100

Surface Infiltration Rate Results

Surface infiltration tests were performed at 40 sites located in the mid-Atlantic and southeastern U.S. to determine whether maintenance significantly improved surface infiltration rates of CGP and whether surface infiltration rates of PICP and PC sites located near disturbed landscapes were significantly less than sites in stable watersheds. Double-ring infiltrometers were primarily used to measure surface infiltration rates. However, single-ring infiltrometers were used instead for locations with rates too high (> 60 in/h) for water to fill a double-ring infiltrometer. The double ring test requires the outer ring to maintain a constant hydraulic head. At high infiltration rates, water could not be poured into the outer ring quickly enough. The single ring infiltrometer was neither as precise nor as accurate as the double ring test. Three locations were tested at each pavement application. Each site's surface infiltration rate was the average of three test locations, which in turn, was the average of three individual tests at each location.

Concrete Grid Pavers

Of the 40 permeable pavement sites tested, surface infiltration tests were conducted at 15 CGP sites in North Carolina to evaluate the effect of maintenance on infiltration rates. Prior to the tests, the CGP voids were filled with sand and appeared to be mixed with additional coagulated material, indicating the potential for clogging or a reduced permeable condition. For each site, tests were run in three locations where the CGP surface remained unaltered. In three additional locations at the same permeable pavement application, accumulated materials in void spaces were removed to a depth between 0.5 and 0.75 in. to simulate maintenance by a vacuum truck. Surface infiltration tests were then run on the maintained locations and compared to the tests conducted on pavers with the non-altered voids.

Surface infiltration rates from sites with simulated maintenance were significantly ($p = 0.007$) higher than rates from existing surface conditions. Of the 15 sites tested, 14 had higher surface infiltration rates for the maintained locations. The median existing surface infiltration rate was 1.9 in/h (ranging from 0.39 to 7.4); the median maintained surface infiltration rate was 3.4 in/h (ranging from 0.64 to 13); an increase of 60%.

Permeable Interlocking Concrete Pavers

Surface infiltration tests were conducted at 14 PICP sites in Maryland (7), North Carolina (4), Virginia (2), and Delaware (1) to compare infiltration rates in stable versus disturbed, sediment transporting landscapes. At the time of construction, the gaps between each of the permeable interlocking concrete pavers were filled with pea gravel. However, it was observed that the five lowest infiltration rates at PICP sites were those with partially clogged surfaces due to sediment accumulation in the gaps initially filled with pea gravel. These five sites were all located adjacent to disturbed soils. The median surface infiltration rate for sites affected by sediments was 3.2 in/h (ranging from 0.64 to 92), while the median rate for sites without sediment accumulation was 900 in/h (ranging from 40 to 1600); an increase in infiltration of over 99%. Sites without fines had significantly ($p = 0.002$) greater surface infiltration rates. Of note, the surface infiltration rates of sites with sediment accumulation were comparable to rates of CGP filled with sand. This is not surprising, due to the fact that sand was the primary soil type filling the gaps of the PICP.

Permeable Concrete

Surface infiltration tests were conducted at 11 PC sites located in the Piedmont and Coastal Plain of North Carolina to compare infiltration rates in stable versus disturbed landscapes. The seven highest rates were from sites relatively free of fines, while the remaining four sites had sediment deposition on the surface. The median surface infiltration rate for sites free of fines was 1500 in/h (ranging from 250 to 2600); while the median surface infiltration rate for sites with evidence of fines was 5.3 in/h (ranging from 4.5 to 11). Surface infiltration rates of the four sites with fines were significantly lower ($p = 0.008$) than the seven sites free of fines.

Surface Infiltration Rate Summary and Recommendations

The study showed that removal of the top 0.5 to 0.75 in. of material accumulated from within CGP void spaces significantly improved surface infiltration rates. To maintain higher surface infiltration rates for concrete grid pavers filled with sand, maintenance, such as using a vacuum sweeper, should be performed on regular (quarterly to annual) intervals. Sand should then be backfilled into the void spaces to prevent clogging at greater depths.

PICP and PC sites installed for runoff reduction should not be sited in areas prone to substantial sediment accumulation. Sources of sediments include vehicular traffic, wind blown sediments, and runoff from adjacent areas. Permeable pavements should be maintained regularly by use of a vacuum sweeper to mitigate sediment accumulation on the surface. Sediment removal should be addressed before fines are compacted into void spaces and possibly migrate to lower, harder to maintain depths within the pavement drainage profile. External sources of sediment should be closely monitored during construction of the permeable pavement to attain high surface infiltration rates.

Of note, 37 of 40 sites had surface infiltration rates greater than 1.0 in/h, which is comparable to rates expected for some hydrologic group A and B soils (loamy sands, sandy loams) covered with grass. Clogging at the permeable pavement surface in predominantly coarse grain (sandy) soil environments, therefore, does not cause a reduction in surface infiltration rates below some naturally grassed areas.

Equivalent Grassed Percentage

Table 6 summarizes surface infiltration data from sites in the Sandhills, Coastal Plain, and Coastal regions of North Carolina. Ranked percentages refer to the percent of sites with higher surface infiltration rates. Thus, for the River Bend PICP site, 49% of the permeable pavement sites tested, located in the selected regions had surface infiltration rates at least 9.1 in/h.

By comparison, a study by Dr. Robert Pitt and his colleagues in Alabama and Washington State found that the average infiltration rate of grassed urban sandy lawns in Birmingham, Alabama was 2.5 in/h. This value was used as a benchmark for converting surface infiltration rates of permeable pavements tested to equivalent grassed percentages. For surface infiltration rates of at least 2.5 in/h, the equivalent grassed percentage would be 100% grass.

Table 6. Surface infiltration rates and ranked percentage for sites in the Sandhills, Coastal Plain and Coastal regions of North Carolina.

Site	Surface Infiltration Rate	Ranked Percentage
Goldsboro PICP	1600	3
Dough Rollers PICP	1000	11
Harve de' Grace PICP	40	24
River Bend PICP	9.1	49
Atlantic Beach PC	5.5	51
Carrabba's CGP	2.9	76
FTCC I PA	2.1	89
Somerset Dr. PICP	0.6	100

Sites fell approximately at 10, 25, 50, 75, and 90% of surface infiltration rates for sites in the Sandhills, Coastal Plain, and Coastal regions.

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- Understanding the Role of Agricultural Landscape Feature Function and Position in Achieving Environmental Endpoints: Final Project Report (to the U.S. Environmental Protection Agency) (1996) (118p) (*abstract and instructions for downloading the report available at: ftp://ftp.epa.gov/epa_ceam/wwwhtml/software.htm*)

Production of *NWQEP NOTES* is funded through U.S. Environmental Protection Agency (EPA) Grant No. X825012. Project Officer: Tom Davenport, Office of Wetlands, Oceans, and Watersheds, EPA, 77 W. Jackson St., Chicago, IL 60604. Website: <http://www.epa.gov/OWOW/NPS>

From Table 6, 76% of the permeable pavement sites tested had surface infiltration rates (2.9 in/h) at least as good as grass (2.5 in/h). Therefore, 76% of sites tested had an equivalent grassed percentage of 100% grass, meaning they behaved as if they were 100% grass.

Equivalent grassed percentages were calculated for representative permeable pavement sites in Table 6. The median equivalent grassed percentage value (used in Table 7) for surface infiltration rates was based on the 89th percentile, rather than the 50th percentile, to be conservative. From Table 6, 89% of sites tested were at least as permeable as 2.1 in/h. Since 2.1 in/h is 84% of the benchmark infiltration rate for grass of 2.5 in/h, the equivalent grassed percentage for such sites would be 84% grass and 16% impermeable surface. In other words, a permeable pavement with surface infiltration rate of 2.1 in/h behaves as if it were 84% grass and 16% impermeable surface. Approximately 90% of the permeable pavement sites tested behaved this way or were more permeable.

Results of the equivalent percentages were presented to NC DWQ for consideration in giving stormwater credit for permeable pavement applications.

Stormwater Credit

Table 7 summarizes results from the three hydrologic monitoring sites and surface infiltration test comparisons. For each monitoring site, the permeable pavement sites produced substantially less runoff volumes than what would be expected from impermeable pavements. The hydrologic performance of these permeable pavement sites corresponded with lower CNs than traditional impervious surfaces (98). Therefore, correctly using permeable pavements may reduce runoff volumes and thus reduce pollutant loadings.

Based on the surface infiltration and hydrologic monitoring studies performed in this project, as well as results from additional research, the authors suggested a credit system for permeable pavements in North Carolina. Permeable pavement sites that are constructed without a gravel storage basin, located in areas with in-situ sandy soils, and maintained regularly (such as the Wilmington PC site) should be considered 60% impervious and 40% grassed area. Conversely, permeable pave-

ment sites that meet the above requirements, but also have an unlined gravel storage basin of at least 6 inches washed stone (such as the Kinston CPG site) should be considered 40% impervious and 60% grassed area. As permeable pavement hydrologic performance is researched further and monitored, these ratios may be adjusted.

Conclusions

Currently, North Carolina stormwater officials are considering giving permeable pavements runoff reduction credit in the Sandhills and the sandy Coastal Plain. The state’s potential change of position is based upon research described in this article. Equivalent grass percentages will be employed by the state to give future permeable pavement applications runoff reduction credit. More work is continuing to evaluate how different types of permeable pavements reduce runoff and improve water quality at a side-by-side testing location in Kinston, NC. Perhaps this data, together with water quality data described herein, will allow state government officials to determine whether permeable pavements should also be given pollutant removal credit.

The studies also showed that to achieve optimal hydrologic performance, permeable pavements should be sited away from locations prone to sediment accumulation, be constructed with a storage basin of washed stone, and be maintained by a vacuum sweeper on a frequent basis. Since sites with lined storage basins do not effectively increase infiltration to soil, credit was only suggested for permeable pavement sites in sandy soil environments.

For More Information

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Other websites of interest:

- www.bae.ncsu.edu/topic/permeable-pavement
- www.bae.ncsu.edu/stormwater

Table 7. Summary table of median equivalent grassed percentages and curve numbers.

Site	Calculated CN	Median Equivalent Grassed Percentage
Wilmington PC	89	42
Kinston CGP	79	62
Surface Infiltration Rate Comparison	N/A	84
Swansboro PICP	45	100

WEB RESOURCES

New Additions to 319 Success Stores Website

EPA has added 8 new stories to the Section 319 Nonpoint Source Success Stories Web site. The Web site features projects receiving grant funds from the Clean Water Act sec-

tion 319 Nonpoint Source Program that have achieved documented water quality improvements, including the achievement of water quality standards and removal from state section 303(d) lists of impaired waters. The Web site was launched in August with 18 stories, and an additional 8 new stories are now featured from Ohio, Colorado, Wisconsin, Pyramid Lake Paiute Tribe/Nevada, Missouri, Minnesota (Minneapolis Chain of Lakes), and 2 more from Washington (Lower Yakima and Dungeness River). Visit the web site at: <http://www.epa.gov/nps/success>.

For more information, or to recommend additional stories for the website, contact Stacie Craddock by phone at 202-566-1204 or by e-mail at craddock.stacie@epa.gov.

INFORMATION

Conference Report

The 13th National Nonpoint Source Monitoring Workshop was held September 18-22, 2005 in Raleigh, NC. The theme of this year's conference was enhancing states' NPS management programs through lessons learned from NPS monitoring projects. One hundred ninety participants from various states in the US, and as far away as Hawaii and American Samoa, gathered to share information on best management practices in improving water quality, effective monitoring techniques, and statistical analysis of watershed data. Progress made and lessons learned from Section 319 National Nonpoint Source Monitoring Program projects, as well as other nonpoint source control watershed projects, were highlighted.

The workshop included two pre-conference tours, including a canoe trip on the Neuse River to learn about local water quality and land use issues; a workshop on presenting data to the public; and a choice of three all-day field trips, focusing either on urban stormwater BMPs, agricultural runoff BMPs, or aquatic insect ecology. Conference session topics included improving states' NPS programs through project monitoring results and lessons learned, modeling applications for NPS pollution, education and outreach, TMDLs, detecting change from urban BMP implementation, monitoring low impact development, and riparian and stream restoration. Presentations and abstracts have been posted at: http://www.ncsu.edu/waterquality/nmp_conf/presentations.html.

A special thanks to Dr. Jean Spooner, Director of the NCSU Soil and Water Environmental Technology Center, leader of the NCSU Water Quality Group, and Chair of the conference planning committee, and to Cathy Smith, Program Assistant with the NCSU Water Quality Group, for organizing such an informative and enjoyable conference. Thanks also to Tammy Taylor with Conservation Technology Information Center (CTIC), workshop sponsors, hosts, and the rest of the plan-

ning committee. Next year's conference will take place in Minneapolis, Minnesota on September 24-28, 2006. Please see the Call for Papers announcement on Page 11 and also on our website: <http://www.ncsu.edu/waterquality>.

MEETINGS

Short Course

AutoCAD for Stream Monitoring and Restoration course is being offered at North Carolina State University on January 9-13 and May 1-5, 2006. The course will be taught by NCSU instructors. Space is limited to the first 20 people. For more information about the course or to register, see web site: <http://www.bae.ncsu.edu/workshops/> and scroll down the list, or contact Dave Bidelspach at dabidels@ncsu.edu.

Call for Abstracts

Virginia Water Science and Technology Symposium: October 23-25, 2006, Virginia Tech, Blacksburg, Virginia. Conference web site: <http://www.vwrrc.vt.edu/>. **Abstracts due March 31, 2006.**

2006 SRI Conference: Stream Restoration in the Southeast – Accomplishments and Opportunities: Oct 2-5, 2006, Charlotte, NC. Contact Cathy Smith, NCSU Water Quality Group, Campus Box 7637, Raleigh, NC 27695-7637, Tel: 919-515-3723, Fax: 919-515-7448, Email: cathy_smith@ncsu.edu. Conference web site: <http://www.ncsu.edu/sri/2006conference/abstracts.html>. **Abstracts due May 31, 2006.**

Sponsored by NC State University, NC Sea Grant, and NC Cooperative Extension, this biennial conference will focus on stream restoration planning, design, construction, financing, and monitoring in the Southeast. Abstracts are being sought for oral presentations and posters covering a wide range of

- Monitoring Restoration Projects
- Design Evaluation
- Urban and Rural Project Issues
- Riparian Buffers
- Project Development
- Assessment
- Watershed Scale Projects
- Regulations
- Restoration Related Research
- Funding Programs
- Case Studies of Restoration Projects

topics (see list on web site), including:

Meeting Announcements — 2006

May

5th Natl Monitoring Conf Monitoring Networks: Connecting for Clean Water: May 7-11, San José, CA. For more information, contact the Conference Coordinator at

NWQMC2006@tetrattech-ffx.com; Tel: 410-356-8993; Website: <http://www.nwqmc.org> (click on “2006 National Monitoring Conference”).

AWRA 2006 Spring Specialty Conf: GIS & Water Resources IV: May 8-10, Houston, TX. Conference Website: <http://www.awra.org/meetings/Houston2006/index.html>.

Challenges in Coastal Hydrology & Water Quality: May 21-24, Baton Rouge, LA. See website: <http://www.aihydro.org/>.



14th National Nonpoint Source Monitoring Workshop

Measuring Project and Program Effectiveness

September 24-28, 2006
 Minneapolis, Minnesota
 Courtyard Marriott at the Depot

Housed in the former Milwaukee Road Railroad Depot, the hotel is listed on the National Register of Historic Places and is within walking distance to the Mississippi River waterfront, historic museums and more!

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**:

- 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
- 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

Proposals can be submitted two ways. Pick **one** of the following:

1. Submit online at: <http://www.ctic.purdue.edu/NPSWorkshop/Abstracts.html>.
2. Email or mail a proposal with the following information included (*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 and implementation.
- g) A discussion of results:
 - What were the specific results?
 - Did the monitoring indicate the project goals were accomplished?
 - What changes in land treatment/land uses occurred?
 - 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?

MAIL TO

Nonpoint Source Workshop
 1220 Potter Drive, Suite 170
 West Lafayette, IN 47906
 Phone (765) 494-9555; Fax (765) 494-5969
 Email: taylor@ctic.purdue.edu
 Conference Website: <http://www.ctic.purdue.edu/NPSWorkshop/NPSWorkshop.html>

Deadline for submission of abstracts is **March 1, 2006**.

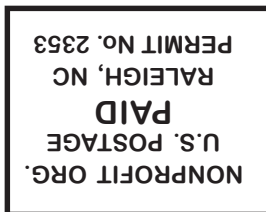
REVIEW AND NOTIFICATION

Authors will be notified of receipt of their abstract. The workshop program committee will review abstracts. Accepted abstracts will be published in the workshop program. Authors will be notified by April 15, 2006 regarding the status of their abstract.

QUESTIONS?

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