NWQEP NOTES

The NCSU Water Quality Group Newsletter

Number 102 August 2001 ISSN 1062-9149

NC STATE UNIVERSITY
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IN THIS ISSUE

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PROJECT SPOTLIGHT

Urban Stream Restoration Using a Natural Channel Design Approach

Excerpt from ASCE Wetlands Engineering and River Restoration Conference Proceedings, Aug. 27-31, 2001, Reno, Nevada

Barbara A. Doll[1], James W. Jenkins, Jr.[2], Jan M. Patterson[2], N. Jill Coleman[3], Gregory D. Jennings[4], Carolyn M. Buckner[5], David B. Mayes[6]

Background

As little as ten-percent impervious cover has been linked to stream degradation, with degradation becoming more severe as impervious cover increases (Schueler, 1995). Hammer found that the average annual flood, which equaled the 1.78-year storm, was doubled by an increase in population density of 5,500-6,000 persons per square mile from a rural condition (Hammer, 1973). In addition, large contiguous impervious areas can significantly increase the size of a stream channel (Hammer, 1972). A common sequence of physical adjustments has been observed in many streams following disturbance. This adjustment process is often referred to as channel evolution. Disturbance can result from channelization, increase in runoff, removal of streamside vegetation, as well as other changes that negatively affect stream stability. All of these disturbances are common in the urban environment.

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Several models have been used to describe this process of physical adjustment for a stream. Two models (Schumm et al., 1984; Simon, 1989 and 1995) are the most widely accepted among many channel evolution models. Simon characterizes evolution in six steps, including 1) sinuous, premodified, 2) channelized, 3) degradation, 4) degradation and widening, 5) aggradation and widening, and 6) quasi equilibrium.

The channel evolution process is initiated once a stable, well-vegetated stream that frequently interacts with its floodplain is disturbed (See Figure 1). Disturbance commonly results in an increase in stream power that causes degradation, often referred to as channel incision. Incision eventually leads to over-steepening of banks followed by streambank failure. When the banks fail, soil and rock move downstream causing the channel to widen and degrade habitat. Incision and widening continue moving upstream, a process commonly referred to as a head-cut. Eventually, the mass wasting slows and the stream begins to aggrade. A new low-flow channel begins to form in the sediment deposits. By the end of the evolutionary process, a stable stream, with dimension, pattern, and profile similar to those of undisturbed channels, forms in the deposited alluvium. The new channel is at a lower elevation than its original form with a new floodplain constructed of alluvial material. The old floodplain remains a dry terrace (FISRWG, 1998). Most urban streams are at some stage of this evolutionary process. The time period required to reach a state of quasi equilibrium is highly variable and has not yet been determined.

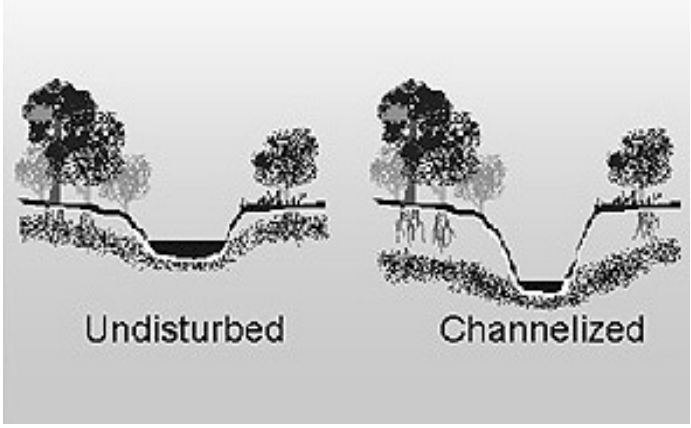

Figure 1. Profiles for undisturbed and disturbed channels.

Disturbance and subsequent evolutionary adjustment of urban streams result in significant streambank erosion. The NC Division of Water Quality has determined that sediment is the primary cause of water quality impairment in North Carolina. Thousands of miles of streams in North Carolina are unstable and eroding. Based on monitoring and quantification of bank erosion by NC State University researchers, streambank erosion can contribute a large portion of the total sediment load in many stream systems. Traditionally, culvert pipe, concrete and riprap have been used to armor eroding urban streams. However, these methods can accelerate flow, often transferring erosion problems downstream. In addition, these approaches are costly and can destroy aquatic habitats along with the natural beauty of the stream (Rosgen, 1996). In contrast, natural channel design techniques can offer long-term stability for degraded streams through the incorporation of natural stream features.

EDITOR'S NOTE

In a previous issue of NWQEP NOTES, we featured a stream restoration project using natural channel design that was located in a state park in North Carolina. In this issue, we highlight a different type of stream restoration project - one that is located in an urban setting, which presents a very different set of challenges to the restoration design team. The project is being conducted on the campus of North Carolina State University, and once again, natural channel design concepts are employed. Currently, the majority of the creek is incised with eroded banks, or is piped and paved over to allow for parking lots. The goal of the project is to integrate the creek into the campus community and cultivate a sense of stewardship and pride for the creek for its aesthetic and ecological values such as habitat and flood control. The riparian buffer will be enhanced with native vegetation, a greenway will be constructed adjacent to the creek, and innovative stormwater controls will be installed. The project will serve as a demonstration site for raising the awareness and educating the public, water quality professionals, and the 34,000 students, faculty and staff at NC State University on urban stream protection and restoration.

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

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Methods

Restoration and stabilization of urban streams is a priority focus for many federal, state and local government agencies and nonprofit groups. Many restoration practitioners strive to restore stability to disturbed streams by using a natural channel design approach. Stability is achieved when the stream has developed a stable dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades (Rosgen, 1996). Natural channel design involves rebuilding natural stream characteristics, including a properly sized bankfull channel, adequate floodplain width, meanders, riffles, and pools. The area and discharge of the bankfull channel are based on the existing condition survey and validated using regional curves (Doll et al., 2000). The width and depth of the bankfull channel, floodplain width, meander pattern, and the riffle and pool spacing and slope are based on dimensionless ratios taken from a stable reference reach (Rosgen, 1998). Rosgen has developed a natural channel design priority-based approach for repairing incised stream channels (Rosgen, 1997). Four priorities are considered based on available land, flooding, cost, and project goals and objectives (see Figs. 2 and 3 for Priorities 1-3). The four priorities, in order of preference, include: 1) re-establish the channel on its previous floodplain, 2) re-establish the channel and floodplain at the stream's existing elevation, 3) convert stream types without creating an active floodplain, and 4) stabilize the channel in place. Urban streams present a variety of situations as a result of utility, land availability and flooding restrictions. Rosgen's geomorphical approach to restoring incised rivers was tested on the Rocky Branch urban stream restoration project.

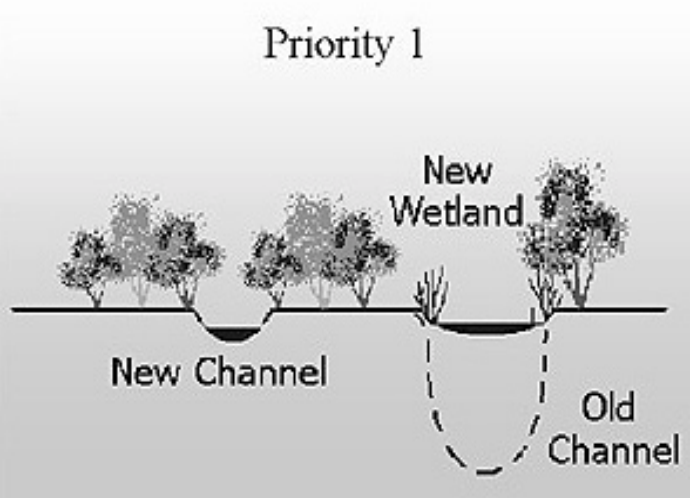

Figure 2. Stream Restoration Priority 1: Re-establish the channel on its previous floodplain.

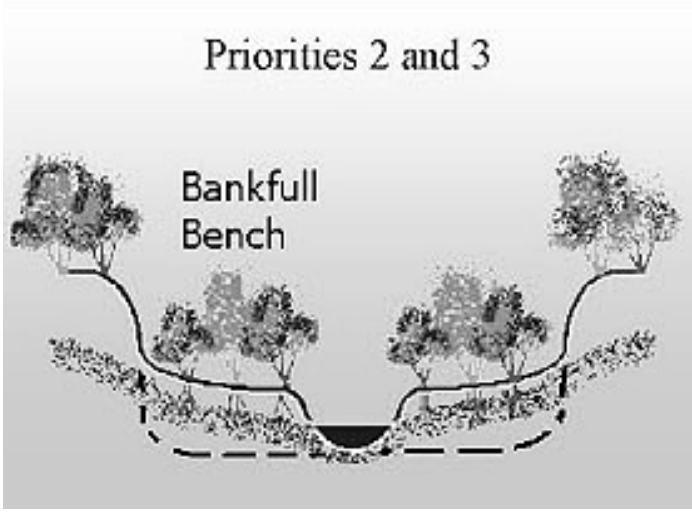

Figure 3. Stream Restoration Priorities 2 and 3: Re-establish the channel and floodplain at the stream's existing elevation. Priority 2 requires greater floodplain width than Priority 3. Dashed line represents old channel.

Rocky Branch

Rocky Branch is a severely degraded creek that cuts through the heart of NC State University located in Raleigh, North Carolina (Fig. 4).

Figure 4. Rocky Branch Creek is a severely incised channel with eroding streambanks.

Campus development over the last 100 years has encroached upon the 6100 feet of creek that runs through the university's property. Floodplains have been filled in and large sections of the creek have been channelized and culverted to accommodate the construction of tennis courts, athletic fields, parking lots and other development. The stream has a one-square-mile watershed, at the point at which it exits

university property. The university campus constitutes a large portion of the watershed and includes curb and gutter streets, asphalt parking lots, buildings, and athletic facilities. These features of the urban environment have tremendously increased the impervious surface area, thus increasing stormwater runoff, stormwater velocity and non-point source pollution. The creek is severely incised as a result of the increased stormwater runoff, floodplain filling, channel armoring (Figs. 5 and 6), and alterations in the stream's dimension, pattern and profile. Streambanks are undercut, trees have toppled into the creek and algal blooms occur seasonally. Streambank erosion from Rocky Branch contributes large volumes of sediment to downstream waterways each year.

Figure 5. Previous channel armoring of Rocky Branch with gabions. This represents a traditional engineering approach that does not enhance stream aesthetics or habitat, and prevents natural channel restabilization.

In 1978, the NC Division of Water Quality classified Rocky Branch as the state's most polluted urban stream based on the lack of total number and diversity of aquatic fauna. However, NC State Univer-sity is currently implem- enting a three-phase stream restoration plan designed to reverse the degradation of Rocky Branch. Phase I is currently nearing completion and involves restoring 3000 linear feet of stream channel. The repair of the creek is based on morphologic stream analysis rather than traditional engineering design. Morphologic features, including riffle-pool sequence, bankfull channel dimensions, flood-plain width, meander geometry, sinuosity and slope have been re-introduced to the creek based on surveys of stable reference stream reaches. The design in this first phase of construction has applied Rosgen Priorities 1 through 3.

Figure 6. Riprap placed in Rocky Branch during previous attempts to stabilize the banks. This is another example of traditional stream armoring.

Numerous lateral restrictions were encountered in the design of phase I, including underground utilities, overhead power lines, parking lots, and tennis courts. In addition, three road crossing culverts and 16 stormwater outfalls had to be addressed in the design. In order to achieve the design goals for stream sinuosity, bankfull channel width, floodplain width and embankment stability, it was necessary to relocate 1100 feet of sewer line, remove 7100 square feet of parking lot and replace two culverts (Figs. 7 and 8). The culverts were replaced in order to raise the bed elevation of the stream by several feet and were configured to allow for both bankfull channel and floodplain flow. Rock vanes and log vanes were installed to provide grade control and take pressure off streambanks during storm events, thus reducing bank erosion. After the stable morphologic pattern was reconstructed, bioengineering was used to stabilize streambanks. Natural materials including rootwads, logs and willow branches were installed for streambank stabilization rather than riprap and other traditionally used man-made materials. Stormwater outfalls have been equipped with several different energy dissipaters that reduce the erosiveness of storm flows entering the stream.

Figure 7. Culvert replacement at Rocky Branch.

A greenway path was installed adjacent to the restored creek to provide the public with an alternate transportation path, recreational opportunities and to increase the public's awareness of the creek and it's environs. Located in one of the most densely populated areas of Raleigh, this greenway

Figure 8. Culvert replacement and installation. Floodplain culvert also added to drain water at bankfull elevation.

will serve as a valuable recreational and social function and will alleviate traffic congestion and parking shortages. The new greenway path will connect to the existing City of Raleigh greenway system, helping to create a network of public green space throughout the city. In addition, access points have been incorporated into the streambanks so that the stream can be accessed for outdoor recreation, maintenance and field laboratory exercises. Interpretative signs will be installed along the greenway to explain the concepts of natural channel design and to identify the flora and fauna.

The landscape adjacent to the greenway path was designed to create scenic views of the creek, and to signal entrances to the creek at major intersections. The stream and associated greenway path passes through areas of campus that vary from urban to more rural in character. The plantings were designed to reflect those changes in character and to also provide a more graceful transition between the natural and urban environment. Existing plantings along the stream were intended to hide the creek, contributing to its neglect. The new vegetation has been designed to increase the view and thus the awareness of the creek. Narrow buffers (10 feet or less) exist along much of the creek's riparian shoreline through the university campus. The existing buffer is composed primarily of exotic vegetation and manicured lawn. In contrast, the new landscape includes native trees, shrubs and grasses, increasing the width of the forested buffer zone. Once established, a canopy will be maintained in perpetuity throughout the corridor to provide shade over the creek. Landscape improvements will also improve, and in many cases create, a wildlife corridor. Clusters of understory vegetation have been connected throughout the corridor to provide food and cover. The landscape design strives to find a balance between providing views of the creek while maintaining vegetative cover for wildlife. The increased likelihood of viewing wildlife will add to the scenic beauty of the greenway.

In addition to restoring the creek, enhancing the riparian buffer and installing the greenway path, the project features innovative stormwater controls to improve water quality. A stormwater pond and three bioretention areas were installed with the first phase of the project. The stormwater pond has a12-foot wide aquatic wetland bench at the permanent pool elevation. The pond is also equipped with an outfall structure to dissipate energy prior to discharging the water into the stream channel. The bioretention areas, also known as rain gardens, were designed to filter and detain stormwater runoff from campus roads and parking lots. Curb cuts were installed along the campus road that parallels the stream in order to divert the runoff through two rain gardens located adjacent to the greenway.

Phases II and III of the project will include the upgrade of two stream culverts to allow safe passage for pedestrians and wildlife beneath major thoroughfares. The upgraded culverts will also be designed to increase floodplain area, thus improving stability of the stream itself. The culvert improvements are intended to not only protect pedestrians, but also embrace the opportunity to bring people closer to the stream and improve wildlife connectivity along the stream corridor. Phase III currently proposes to "day-light" a minimum of 250 feet of stream. The stream will be removed from culvert pipes and recreated to have a bankfull channel and a small floodplain. This unearthing of the channel will further increase both visibility and access to the stream.

For More Information

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ANNOUNCEMENTS

NCSU Water Quality Group Staff Changes

Greg Jennings

We would like to extend our farewell to Dr. Greg Jennings, who has worked as Professor and Water Quality Specialist with the NCSU Water Quality Group, Department of Biological and Agricultural Engineering, since 1990. Greg served as NCSU's College of Agriculture and Life Sciences Water Quality Coordinator since 1996, and recently spent a year as Associate Program Leader for Agriculture and Natural Resources with North Carolina Cooperative Extension Service. He was also director of NCSU's Soil and Water Environmental Technology Center, a state-wide training facility.

Dr. Jennings has been a tremendous asset to NCSU and to the state of North Carolina in the field of water quality. He was extremely active in NC Cooperative Extension county-based water quality programs. Most noteworthy was his instrumental role in coordinating relief efforts in eastern North Carolina following the devastating flooding of Hurricane Floyd in September 1999. In addition, Greg was a founding member of the NC Stream Restoration Institute and made significant contributions to advancing the knowledge of stream restoration in North Carolina. He also provided technical support to the Section 319 National Monitoring Program, in particular, for the Long Creek project in North Carolina.

Effective July 2001, Greg joined a new consulting firm in Raleigh, NC specializing in stream restoration. We wish Greg the best of luck.

Jon Calabria

Welcome to Jon Calabria, who joined the NCSU Water Quality Group in March 2001 as an Extension Assistant in Stream and Watershed Management. Jon serves as the French Broad River Training Center coordinator, and is working with research and extension faculty to demonstrate and evaluate watershed management and stream restoration systems for protecting water quality. He is housed at the NC Arboretum in Asheville, in western North Carolina. Jon received his Bachelor of Landscape Architecture degree from the University of Georgia in 1992 and is a registered Landscape Architect in North Carolina and Georgia. Welcome, Jon!

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INFORMATION

National Management Measures to Control Nonpoint Source Pollution from Forestry released by EPA

This draft guidance is intended to provide technical assistance to State, local, and tribal program managers and others on the best available, economically achievable means of reducing nonpoint source pollution of surface and ground water from forestry activities. The comment period ends on September 27, 2001. Comments on the draft guidance may be sent to Christopher Solloway of EPA's Nonpoint Source Control Branch at: solloway.chris@epa.gov .

The draft guidance is available in PDF (for both the whole document and chapter-by-chapter) at: **http://www.epa.gov/owow/nps/forestrymgmt/**

CD-ROMs of the document are also available upon request from Chris Solloway.

GAO Reports on NPDES Stormwater Program

The General Accounting Office has released its report on the NPDES storm water program. Titled, "Better Data and Evaluation of Urban Runoff Programs Needed to Assess Effectiveness," the June 29, 2001 report is available on the GAO website at www.gao.gov. A summary of the report GAO-01-679 and recommendations is available under the Fiscal Year 2001 Archives section. The entire report in pdf format is also available from GAO in the reports section under the Environmental Protection heading. Orders for the written report can be submitted online with GAO at www.info@www.gao.gov. You can also order by phone at 202-512-6000.

The report was carried out by GAO at the request of Senator Olympia Snowe (R-ME) and Reps. Sherrod Brown (D-OH), Martin Meehan (D-MA), James Oberstar (D-MN) and Jack Quinn (R-NY). GAO was asked by the members of Congress listed above to address: 1) the amount of runoff from urban areas, particularly from roads, highways and other impervious surfaces, and its effects on water quality; and 2) the programs that federal regulations require local governments to develop to address urban runoff, and the costs and effectiveness of these programs.

Call Susan Gilson at 202-218-4133 if you have difficulty obtaining a copy of the report.

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WEB RESOURCES

EPA's Biweekly Restoration Information Updates

EPA's River Corridor and Wetland Restoration – Biweekly Restoration Information Updates can be found online at the following address:

http://www.epa.gov/owow/wetlands/restore/update/

The Biweekly Updates provide current information on wetland and river corridor restoration projects, recognizes outstanding restoration projects, and provides a forum for information sharing.

USGS Launches New Web Site for Nation's Water Data

The U.S. Geological Survey (USGS) recently launched its new, online National Water Information System (NWISWeb). The new website, found at: **http://water.usgs.gov/nwis/** allows users to access several hundred million pieces of archival and real-time data.

Data from the NWISWeb can help water managers, engineers, scientists, emergency managers, recreational water users, utilities, etc. to:

- evaluate current water supplies and plan for future supplies,
- forecast floods and droughts,
- operate reservoirs for hydropower, flood control, or water supplies,
- evaluate and control water quality,
- navigate rivers and streams,
- safely fish, canoe, kayak, or raft.

NWISWeb data comes from a vast, nationwide network of more than 1.5 million USGS water data collection stations including:

- 338,000 water-quality sites where samples are taken from rivers or aquifers,
- 21,200 past and present streamflow sites,
- 7,570 real-time sites including streams, lakes/reservoirs, ground water, and meteorological sites.
- 1.37 million wells.

For information about access to the wide array of other USGS data types (maps, satellite images, geology or biology data), visit the USGS home page at http://www.usgs.gov.

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MEETINGS

Call For Papers

Ninth International Conference on Hydraulic Information Management: HYDROSOFT 2002: May 29-31, 2002, Montreal, Canada. Organized by Wessex Institute of Technology. Web site: www.wessex.ac.uk/conferences/2002/hy02/

The conference encourages presentations on all aspects of Hydraulic Information Management. The main areas covered include groundwater, open channel and pressure flow, and presentations on water quality and decision support systems. Abstracts due **as soon as possible**.

6th International Conference on Precision Agriculture and other Precision Resources Management: July 14-17, 2002, Minneapolis, Minnesota. Conference web site: www.precision.agri.umn.edu/2002. Abstracts due by **December 14, 2001**.

6th International Conference on Diffuse Pollution: September 30-October 4, 2002, Amsterdam, Netherlands. Contact Conference Secretariat, Buerweg 51, 1861 CH Bergen, Netherlands. Tel: +31-20-4602466; Fax: +31-20-4602475; Email: r.r.kruize@inter.nl.net. Abstracts due **January 1, 2002**.

Meeting Announcements — 2001

AUGUST

Wetlands Engineering & River Restoration Conference 2001: August 27-31, 2001, Reno, Nevada. Sponsored by American Society of Civil Engineers. Contact J. Craig Fischenich, General Conference Chair, Tel: 601-634-3449, Fax: 601-634-4263; email: fischec@wes.army.mil; Website: www.asce.org/conferences/wetlands2001.

9th National Nonpoint Source Monitoring Workshop

August 27-30, 2001
Hyatt Regency, Indianapolis, IN
http://www.ctic.purdue.edu/CTIC/NPSCall.html

About the Conference: This workshop will bring together land managers and water quality specialists to share information on the effectiveness of best management practices in improving water quality, effective monitoring techniques, and statistical analysis of watershed data. The workshop will focus on the successes of Section 319 National Monitoring Program projects and other innovative projects from throughout the U.S. The agenda will include three days of workshop sessions/presentations and a one-day field trip. Two half-day workshops will focus on monitoring program evaluation and GIS.

Session Topics:

-Detecting change in water quality from agriculture BMP implementation
-Modeling application of NPS pollution
-Agricultural nonpoint source pollution TMDLs
-Volunteer monitoring in 319 projects
-Innovative monitoring in agricultural landscape
-Programs and approaches for animal operations and nutrient management

Contact Tammy Taylor at taylor@ctic.purdue.edu or call 765-494-9555.

SEPTEMBER

Wetlands and Remediation: The Second International Conference: September 5-6, 2001, Burlington, VT. Contact Carol Young, Battelle Memorial Institute; Tel: (614) 424-7604; email: youngc@battelle.org; Web: www.battelle.org/environment/er/wetlandsconf/wetlandsconf.html

River Basin Management 2001: September 11 – 13, 2001, Wales, UK. Contact Susan Hanley, Conference Secretariat at shanley@wessex.ac.uk. Web site: http://www.wessex.ac.uk/conferences/2001/river01/.

Meetings continued on p. 11

Third National Small Farm Conference: September 17-20, 2001, Albuquerque, NM. Contact Denis Ebodaghe, U.S. Department of Agriculture; Tel: (202) 401-4385; Fax: (202) 410-5179; email: debodaghe@reeusda.gov; Web: www.reeusda.gov/smallfarm.

OCTOBER

Addressing Animal Production/Environmental Issues: An International Symposium: October 3-5, Research Triangle Park, NC. Contact Dr. Leonard S. Bull, Program Chairperson, Associate Director, Animal and Poultry Waste Management Center, Box 7608, N.C. State University, Raleigh, NC 27695-7608. Tel: 919515-6836; Fax: 919-513-1762; email: Leonard_bull@ncsu.edu; web site: www.cals.ncsu.edu/waste.mgt/.

WEFTEC 2001. Water Environment Federation 74th Annual Conference & Exposition: Oct. 13-17, 2001, Atlanta, GA. Call 1-800-666-0206. If outside the US and Canada, call 1-703-684-2471 or send an email to confinfo@wef.org. Web site: www.wef.org.

Fourth Annual North Carolina Stream Restoration Conference - Stream Repair and Restoration: A Focus on the Urban Environment: October 16-19, 2001, Raleigh, NC. Web site: http://www5.bae.ncsu.edu/programs/extension/wqg/sri/.

NOVEMBER

2001: A Lake Odyssey – 21st International Symposium: November 7-9, 2001, Madison, Wisconsin. Sponsored by North American Lake Management Society. Web site: www.nalms.org.

American Water Resources Association Annual Water Resources Conference: November 12-15, 2001, Albuquerque, New Mexico. Contact Michael Campana, Conference Chair, University of New Mexico, Water Resources Program, 1915 Roma NE, Albuquerque, NM 87131-1217. Tel: 505-277-5249, Fax: 505-277-5226, email: aquadoc@unm.edu.

Virginia Water Research Symposium 2001 – Protecting Our Water Resources for the Next Generation: Where Do We Go From Here?: November 14-16, 2001, Charlottesville, VA. Contact VWRRC, Virginia Tech, 10 Sandy Hall, Blacksburg, VA 24061. Fax: 540-231-6673; email: water@vt.edu.

Meeting Announcements – 2002

Watershed Management to Meet Emerging TMDL Environmental Regulations: March 11-13, 2002, Fort Worth, Texas. Sponsored by ASAE. Contact Brenda West, ASAE, 2950 Niles Road, St. Joseph, Michigan 49085. Tel: 616-428-6327; fax: 616-429-3852; email: west@asae.org.

13th International Symposium of the International Scientific Centre of Fertilizers (CIEC): Fertilizers in Context with Resource Management in Agriculture. June 10-13, 2002, Tokat, TURKEY. Contact Dr. Kadir Saltali, Secretary General of CIEC-2002 Symposium, GOP University Faculty of Agriculture, Tasl Ciftlik TOKAT-TURKEY. Tel:0 356 252 1479; Fax:0 356 252 1488; email: ciec2002@gop.edu.tr; web site: http://ozel.gop.edu.tr/ciec2002

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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. Web site: http://www.epa.gov/OWOW/NPS

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