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Session 1C

Kentucky Water Resources Research Institute, University of Kentucky

ENGAGING PARTNERS IN THE CANE RUN WATERSHED

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The Cane Run Watershed (CRW) project management team, composed of the University of Kentucky, College of Agriculture, Environmental and Natural Resources Initiative, and the Department of Biosystems and Agricultural Engineering staff, is involved in an innovative, comprehensive program that engages K-12 students and teachers and citizens within the watershed and is designed to increase understanding of water quality issues and promote urban stream restoration. The two goals of the project, one for each major audience, include the following:

Goal 1: Engage K-12 and community partners in an urban watershed, the Cane Run Watershed, in an innovative education project to improve water quality in the watershed

Goal 2: Engage all citizens within the watershed in the urban-stream restoration project.

The K-12 portion of the program involves the formation of partnerships between community groups and three schools to develop a geographic education tool – a map of Cane Run Environment & Watershed. The map uses a GIS platform and is accessible from an Internet portal at UK. When completed, the map will include water quality data, demographics, geographic information, photos and video intended to illustrate the environmental health of the watershed. In the process of making the map, students will interact with environmental science professionals to learn about career opportunities and the technical knowledge required for these professions. In addition to creating the map, students will make presentations at community and local government events to demonstrate their learning.

A second component of the program involves an upcoming urban stream restoration project. The restoration project involves a section of the Cane Run Creek located in a city-owned park adjacent to a newly built 12-mile streamside walking/biking path; the project location presents a unique opportunity for citizens to become involved in watershed issues. The UK management team will not only educate citizens regarding this restoration project but will also create opportunities for community input (including students, teachers, and their newly-developed map) into the planning process.

Participants who attend this session will learn about the planned education and community activities and progress to date. Students involved in the program will be invited to the Symposium to present their findings and talk about their maps.

NOTES

WATER QUALITY MONITORING RESULTS FROM THE MCCONNELL SPRINGS STORMWATER QUALITY WETLAND POND AND GAINESWAY POND RETROFIT PROJECT

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In December 2009 the Lexington-Fayette Urban County Government (LFUCG) completed construction of the McConnell Springs Stormwater Quality Wetland Pond. The facility is composed of a pre-treatment gross debris trap, three-cell settling forebays, 0.2 acre deep-pool pond, and 0.5 acre shallow marsh/littoral shelf area. The purposes of this facility were to reduce non-point source pollution entering McConnell Springs and neighboring impaired streams Wolf Run, Town Branch, and South Elkhorn Creek; and as a public demonstration of the benefits that natural environments provide to water quality and quantity control. In Spring 2009, LFUCG remediated Gainesway Pond at Centre Parkway. The renovations were part of the Gainesway Retention Basin Water Quality and Environmental Education Project. The goal of this project was to retrofit the existing Gainesway Pond to increase pollutant removal through addition of constructed wetlands, aquatic plantings, an aerator, and upstream biofiltration and gross debris traps. The Gainesway project also provides the community with environmental educational opportunities. Both of these projects were funded in part through a §319(h) grant provided by the U.S. Environmental Protection Agency and administered by the Kentucky Division of Water.

To determine the on-going effectiveness of pollutant reduction by the two stormwater projects, LFUCG Division of Water Quality collected water samples in 2010-2012, with emphasis on runoff samples during storm events. At McConnell Springs, the Friends of Wolf Run Inc. provided training to community volunteers who assisted with some sample collections. Five sampling sites were identified at McConnell Springs, sites M1-M3 were located in the pre-treatment and forebay cells and sites M4-M5 were located in the main pond. Five sampling sites were also identified for Gainesway Pond: upstream, mid-stream, wetland area, Pond A, and Pond B (i.e., GP1-GP5). A total of 18 sampling events were conducted at McConnell Springs and 12 sampling events at Gainesway Pond in 2010-2012. On-site measurements included: temperature, pH, ORP, dissolved oxygen (DO), conductivity, and total dissolved solids (TDS). Additional analysis included: alkalinity, hardness, carbonaceous biological oxygen demand ($CBOD_5$), total suspended solids (TSS), total ammonia, nitrate, nitrite, total phosphorus, orthophosphates, and bacterial enumeration (fecal coliforms, *E. coli*, and total coliforms). Analysis of metals in water samples from McConnell Springs were performed in 2010 by the Kentucky Geological Survey (KGS) Laboratory. Additional metal sampling is scheduled for February 2013.

Overall pH values at the McConnell Springs stormwater structure remained constant from 2010 to 2012. No distinct trends in DO concentrations were observed in

2010, with DO levels ranging from 3.03 to 8.4 mg/L. In 2011-2012, DO levels increased through the system, with sites M4-M5 having the highest DO. Total alkalinity remained constant with average values of 72, 69, and 78 mg/L for 2010, 2011, and 2012, respectively. Hardness was elevated in 2010 (343 mg/L), but average concentrations decreased in 2011 (77 mg/L) and 2012 (74 mg/L) as the system became established. For 2010 collections, TSS concentrations at sites M1-M3 averaged 29 mg/L, whereas sites M4-M5 averaged 12 mg/L, indicating an initial settling of suspended solids. Reductions of TSS in the system were more evident in 2011-2012. Overall ammonia levels in 2010 decreased at sites M4-M5, except for an increase in 8/27/10, attributed to low-flow conditions. As with TSS, ammonia reductions were more evident in 2011-2012. Similar reductions were found for nitrate and nitrite. Concentrations of total phosphorous and orthophosphate decreased through the system from 2010 to 2012. Average total phosphorous concentrations were lower with time, however, elevated orthophosphate levels were observed in October and December 2012. Overall reduction in bacterial counts were observed from 2010 to 2012. Fecal coliform geometric means for 2010, 2011 and 2012 were 34330, 4911, and 350 MPN/100 mL, respectively. Whereas, geometric means for *E. coli* were 1014, 755, and 590 MPN/100 mL. Of the 30 metals tested in 2010, only the concentrations of aluminum, copper, iron, nickel, sulfur and zinc decreased through the stormwater facility.

At the Gainesway Pond stormwater structure the overall pH levels remained fairly constant. DO levels in 2010 were elevated during high-flow conditions (4/2/10 and 12/2/10), but decreased in the summer. In 2011 and 2012, lowest DO levels were observed at the wetland site (GP3), but increased in the downstream ponds (GP4-5) in part due to a new aeration fountain installed in the pond. Total alkalinity and hardness concentrations were fairly constant in 2010 through 2012. Average alkalinity values were 191, 207, and 150 mg/L and average hardness values were 265, 237, and 239 mg/L for 2010, 2011, and 2012, respectively. TSS values from 2010 were initially lower in the ponds, but the levels increased in subsequent collections (12/2/10; GP1= 2 mg/L, GP4= 8 mg/L). This trend was more evident in 2011 and 2012, with highest TSS values at the ponds (GP4-5). Average ammonia concentrations did not vary in 2010-2012. However, decreasing levels of nitrate and nitrite were observed from 2010 through 2012. Total phosphorous and orthophosphates increased in spring-summer 2011, but remained somewhat constant during fall-winter. There were slight decreases in total phosphorous and orthophosphate concentrations from 2010 to 2012. In general, bacterial counts were generally highest at upstream sites and decreasing in the ponds. A reduction in fecal coliform counts was observed with time. *E. coli* geometric means were 763, 589, and 500 MPN/100 mL for 2010, 2011 and 2012, respectively.

Based on three year monitoring data, the structures are performing as expected. More consistent results are being obtained as the systems become established. Reductions of several pollutants were observed at both systems. Of interest were the reductions in bacterial counts over time. These reductions aid in decreasing urban stormwater impacts on neighboring streams. As part of their management, LFUCG will continue to monitor water quality regularly. In particular, close monitoring of ammonia, total phosphorous and bacterial counts which can have detrimental impacts to the facilities and receiving waters.

HYDROLOGIC CHARACTERIZATION OF A TREE- AND SHRUB-VEGETATED RAIN GARDEN IN CENTRAL KENTUCKY

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Urbanization increases the volume of stormwater generated through the addition of impervious surfaces such as parking lots, rooftops, and paved surfaces. Such increases in imperviousness have led to reduced levels of infiltration, and subsequently increases in peak flows coupled with reductions in groundwater recharge, as runoff is quickly directed to the storm sewer system. Traditional stormwater management practices have focused on capturing, detaining, and releasing stormwater flows through structures such as detention ponds. While these traditional stormwater management structures help reduce peak flows, they have little impact on runoff volumes and often cause increased streambank erosion problems downstream. Under the new U.S. Environmental Protection Agency (USEPA) performance guidance, the focus is shifting to management strategies that utilize infiltration and evapotranspiration. Low impact development (LID) is one such stormwater management method. LID structural controls seek to imitate pre-development hydrologic conditions, as much as possible, by focusing on stormwater containment near the source.

Rain gardens, which are structures that use a conditioned planting bed and landscaping in a shallow depression, are one type of LID structural control that promotes stormwater runoff infiltration and evapotranspiration. However, minimal research has been done to characterize the hydrologic performance of rain gardens. Of the few studies done, results indicate that rain gardens are an effective way of infiltrating runoff. However, these studies are not truly representative of real-world conditions as water from the rain gardens was not allowed to infiltrate into the groundwater but was captured by an underground impermeable layer for purposes of volumetric water-mass balance computations. Furthermore, these rain gardens were planted largely with flowers and/or grasses and trees and shrubs. It is expected that the deep and extensive rooting systems of trees and shrub will further promote infiltration even as rain gardens age and the potential for clogging increases.

What is lacking in rain garden design, and LID design in general, is a feedback mechanism whereby implemented rain gardens are monitored to help assess whether or not the design guidelines used are the most appropriate or if modifications are needed. Such a feedback mechanism is particularly important as the USEPA and more and more municipalities encourage commercial and residential entities to embrace rain gardens. The Lexington-Fayette Urban County Government (LFUCG), for example, has funded a number of rain garden projects as part of their Stormwater Quality Projects Incentive Grant Program.

The primary objective of this study is to evaluate the effectiveness of a tree- and shrub-vegetated rain garden at infiltrating stormwater. The secondary objectives are to measure the vertical flux of infiltrated stormwater, calculate the potential evapotranspiration, and compare the results from this study to other types of rain gardens.

Methods

In September 2011, Coca-Cola Enterprises constructed a tree- and shrub-vegetated rain garden at their Leestown Road bottling facility in Fayette County, Kentucky. The rain garden has a surface area of approximately 9,500 ft^2. Runoff from the facility's roof and parking lot is routed into the rain garden through two inlet pipes. A 1,000 gallon infiltration chamber is installed at the down-gradient edge of the rain garden because the hydrologic performance of rain gardens in Fayette County is not well known. A 12 inch overflow pipe carries water, when it reaches a defined elevation in the rain garden, into the infiltration chamber. If the infiltration chamber fills, the rain garden can continue to fill before overtopping. As designed, it is expected that water in the rain garden will completely infiltrate within 48 hours (i.e. no surface water will be present).

Data collection commenced in March 2012 and is expected to continue through March 2013. These data will be used to construct a water budget for the rain garden. Rainfall data are collected using a tipping bucket rain gauge. Data loggers continuously record stormwater inflow and outflow, if outflow occurs, as well as water depth in the rain garden. Soil moisture is continually measured at depths from 0 to 4 ft below the soil surface. Weather data from the University of Kentucky Agricultural Weather Center is being used to compute reference evapotranspiration rates using the Penman-Monteith equation. Infiltration rates are being modeled using the Green-Ampt equation.

This project is the first of its kind to evaluate the hydrologic performance of a rain garden constructed in central Kentucky. The results from this project will aide in the development of design recommendations for rain gardens in central Kentucky.

WATERSHED BASED PLANNING IN THE URBAN WOLF RUN WATERSHED

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The objective of this presentation is to present a case study of the development of a watershed based plan in an urban environment. In August 2010, the Lexington-Fayette Urban County Government (LFUCG) contracted with Third Rock Consultants and Friends of Wolf Run, to complete a watershed plan for Wolf Run Creek. The project was funded through a U.S. Environmental Protection Agency 319(h) grant awarded by the Kentucky Division of Water (KDOW) to LFUCG.

The Wolf Run Watershed is Lexington's most highly urbanized watershed with about 40% of the surface covered with impervious material. The 13.5 miles of perennial streams and tributaries in the watershed drain an area of 10.18 square miles. The watershed has significant karst development including Preston's Cave, McConnell Springs, and Kenton Blue Hole among other features which complicates the hydrology by redirecting groundwater from the adjacent basins. Wolf Run Creek is listed as impaired on the 303(d) list for nonsupport of primary and secondary contact recreation and partial support of warmwater aquatic habitat with cause including fecal coliform, nutrient / eutrophication biological indicators, and specific conductance from a number of suspected sources. The goal of the watershed plan was to identify the sources of pollution and the remediation efforts necessary to return the stream to its designated uses.

The Wolf Run Watershed Council was formed in December 2010 to receive input from the community on citizen desired goals and objectives for the watershed, to provide local knowledge on specific issues within the watershed, and to provide review and feedback on the plan progress.

All available data was compiled and reviewed to evaluate the additional data necessary to complete the plan. A plan was developed in April 2011 and executed from May 2011 to May 2012. Tasks included gathering data on the macroinvertebrate community, stream habitat, hydrogeomorphology, hydrology, and chemical water quality. The data was collected through a successful cooperative effort between of Friends of Wolf Run volunteers and Third Rock biologists and engineers.

The monitoring indicated that the aquatic macroinvertebrate community ranged from "poor" to "very poor" according to macroinvertebrate biotic index scores assessed at seven sites due to extremely low numbers of absence of mayflies, stoneflies, and caddisflies. The habitat, assessed at 33 reaches according to the Rapid Bioassessment, ranged from 50 to 153, but with only 2 of the 33 reaches achieving a "fair" narrative criteria and all others "poor." Contributing factors to the poor scores included narrow riparian zone width, lack of pools and available cobble habitat, embeddedness, and poor base flow levels. Hydrogeomorphic assessments, conducted at nine sites, indicated the streams are generally over-widened and entrenched with significant channel alteration, bank armoring and bedrock substrate on many reaches. Sedimentation deposition and aggradation was noted downstream of Preston's Cave. Stage-discharge curves, developed for five locations in the watershed, indicate that streams were extremely flashy during storm events, but also sustain frequent and prolonged periods of dry or low flows.

Water quality monitoring results, sampled at 12 locations over 10 months, indicate nitrogen, phosphorus, dissolved oxygen, ammonia, specific conductance, suspended solids, and *E. coli* each exceed benchmarks for one or more events. Annual pollutant loads and reduction goals are calculated for nitrogen, phosphorus, suspended solids, and *E. coli*. Wet weather contributions to the annual loading are the most significant for *E. coli*, phosphorus, and suspended solids but less significant for nitrogen. Load reductions of over 90% are required to reach the regulatory levels for recreational use. Significant load reductions in suspended solids and phosphorus are necessary in some subwatersheds and only slight load reductions in nitrogen are needed. A watershed-wide specific conductance survey (373 measurements in 8 days) indicates the highest concentrations were in the headwaters of Wolf Run, Vaughn's Branch, and the Big Elm Tributary.

Based on these results, the Wolf Run Watershed Council devised general goals and objectives for the watershed, and recommended the types of Best Management Practices (BMPs) and locations for implementation. An Outreach Campaign Subcommittee was organized to develop an education and outreach plan for the watershed and a Water Quality BMP Technical Subcommittee was organized to review the Council recommendations and develop an implementation strategy with prioritized projects.

In January 2013, a comprehensive implementation plan was developed based on these efforts and presented for public comment. The plan identifies 138 BMP project opportunities in the watershed, 61 high priority, 33 medium priority, and 44 low priority projects. These implementation projects include 18 BMPs targeted to address the *E. coli* load and sanitary sewer, 14 education and outreach BMPs, 39 green infrastructure BMPs, 16 trash and debris cleanup BMPs, a Neighborhood Association BMP Program, and several target locations for Streets and Roads BMPs. Additional stream and habitat improvement opportunities include 3.5 miles of stream restoration, 5.6 miles of riparian buffer restoration, and approximately 850 feet of bank stabilization. Wetland creation or expansion is proposed for approximately 20 acres and enhancements are proposed at two springs.

Implementation has been initiated or is planned for the near future on about 40 of these projects. Next steps include implementation of other identified opportunities, ongoing monitoring of the water quality improvements and implementation status, and adapting the plan to address the changing needs of the watershed.

ESTIMATING LOAD REDUCTION COSTS FOR ASSESSING STORMWATER BEST MANAGEMENT PRACTICE (BMP) FEASIBILITY: A CASE STUDY OF JAMES LANE ALLEN ELEMENTARY

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What is the most cost-effective way to improve your watershed? For many Kentuckians, this question may seem difficult to answer because of a lack of familiarity with stormwater Best Management Practices (BMPs). A challenge across our Commonwealth is how to select and implement the measures needed to restore the health and function of our watersheds. A variety of financial resources have been enacted statewide to assess stream conditions, to identify pollutants and support educational or community outreach programs. More intensive studies, such as Total Maximum Daily Loads (TMDLs), have been undertaken to establish a target for pollutant reductions. The next step is to attain our water quality goals, whether it is by fines, fees, credits or other incentives. One way or another, Kentuckians will be obligated to address the cost for clean water. Developing strategic plans with consideration for cost-effective BMPs selected to meet (or exceed) our water quality targets with limited funding can be an extraordinary endeavor, but not impossible. It can be done.

From across the nation, research is emerging on the effectiveness and pollutant reduction capacities of stormwater quality BMPs. Case studies from communities across the nation in the forefront of water quality (such as Portland, Seattle, Chesapeake Bay, etc.) offer insight and innovation in design, but do not always represent weather patterns, pollutant loads and applicability in Kentucky. Despite their growing popularity, many BMPs have not been in service long enough to develop a record of their operational lives and what long-term maintenance costs are to be anticipated. Developing installation cost estimates for of these measures may also be difficult to predict because unit rate costs will vary with the scale, size or quantities of the practice. A better understanding of BMPs operating in our region is desperately needed.

The purpose of this presentation is to demonstrate how evaluating BMP life-cycle costs and estimated treatment capability can be used to appraise and prioritize the use of different practices. This presentation is based on a stormwater BMP feasibility study of James Lane Allen elementary school in Lexington, Kentucky. This study is funded by an LFUCG Stormwater Quality Projects Incentive Grant. Information from local projects was used to support realistic cost estimates. The first step was to generate a conceptual plan to identify potential BMP locations and designate drainage surfaces. Predicted annual pollutant loads from each drainage area and anticipated BMP pollutant treatment capacities were used to calculate estimated load reductions from each drainage area. The second phase of this process was to develop a total life-cycle BMP cost based on estimated costs for design, construction/installation, maintenance and operation over a predicted service life. By coupling a prorated annual BMP cost with the estimated annual load reduction, an estimated load reduction cost was developed.

The goal of this process was to identify which stormwater BMPs would have greater cost-effective potential at James Lane Allen elementary school. By developing estimated load reduction costs for each BMP we can re-evaluate and adjust the BMP conceptual plan to favor the use of more valuable BMPs. As a result of this feasibility study, demonstrating the treatment capabilities and life-cycle costs will foster better decisions for selecting and prioritizing the use of stormwater BMPs. Having estimated load reduction costs could offer financial savings by identifying expensive practices that are assumed to be highly effective. Identifying measures with the greatest performance value will produce more efficient watershed strategies to meet water quality targets at a lower cost.