NEW LIFE FOR OLD OUTFALLS

Employing regenerative storm water conveyances for nutrient & sediment load reduction

By Ward Marotti

Linear biofiltration conveyance systems, also known as regenerative storm water conveyances (RSCs), provide effective end-of-pipe treatment in an otherwise constrained linear environment. They are becoming more widely used in the Southeast and mid-Atlantic regions to reduce nutrient and sediment loads, especially from "first flush" flows. RSCs improve water quality by removing significant volumes of total suspended solids (TSS), total nitrogen and total phosphorus. They combine the features and treatment benefits of more traditional storm water best management practices (BMPs), including swales, infiltration, filtering and wetland structures. They use a series of shallow aquatic pools, riffle weir grade controls, native vegetation and underlying sand and wood chip beds to detain, treat and convey storm flows.

Successful establishment of woody and herbaceous vegetation communities is essential for both the systems' long-term stability and their efficacy. Like stream restoration projects, planting of rhizomatous, woody vegetation along RSCs' banks and at the edges of "in-line" structures should be done as soon as possible following the completion of earth work.

Beyond the Traditional

Historically, storm water conveyances were designed to transport flows through and away from areas of concern (e.g., buildings, roads and fields). They included

armored and impervious structures, both closed and open. Trapezoidal concrete channels, gabion baskets and long, buried concrete and corrugated metal pipe and box culverts are typical. Because their urban, suburban and agricultural catchments are often largely impervious, well-maintained, and/or devoid of vegetation for much of the year, incoming pollutant loadings often are significant. Over the years, growing development in catchments resulted in increased inflow volume, which many structures were not designed to convey. This, along with a lack of ongoing maintenance, has caused many to fail. More often than not, this results in large-scale erosion, which, in turn, causes additional, significant downstream pollutant loadings.

In addition to the instability of the structures, their outfalls typically were not designed to protect receiving waters. During high-flow events, additional pollutant loadings resulted from uncontrolled and significant scour effects.

For decades these traditional storm water conveyances have been primary contributors to large-scale water quality degradation. Some of the common and publicly well-known unintended consequences have included eutrophication, fish kills and sedimentation in and reduction of lakes' flood storage capacities.

Over the past two decades, designers have begun to incorporate both water quality treatment and stable and safe conveyance into both their new and retrofitted designs. Common storm water BMPs now include rain gardens, grassy swales, wet and dry detention basins, bioretention cells, level spreaders, vegetated filter strips, sand filters, permeable pavement, and storm water wetlands.

All things considered, if correctly designed and installed, these BMPs adequately address either water quality or quantity. None adequately address both. In addition to addressing only one component of storm water treatment, most typical modern storm water BMPs require ongoing and costly maintenance to remain functional.

RSCs, on the other hand, do both without significant maintenance requirements.

RSC Benefits

Depending on their depth, volume and catchment size, RSC substrates (80% sand and 20% wood chip/mulch) can temporarily store and treat two- to three-year storm events. They have been shown to remove up to 90% of TSS. By temporarily creating an anaerobic environment, they can remove up to 50% of total nitrogen and 60% of total phosphorus.

Their temporary, sequential subsurface storage provides delayed, low-energy discharge and promotes infiltration, which recharges groundwater and raises the hyporheic zone. The establishment of vernal pools and wetland areas creates local micro-habitats and refugia, which promote uplift of the system's ecological function, both on site and downstream.

In addition to the water quality and

quantity benefits provided for smaller events, RSCs are designed to not only safely convey large flows (e.g., 100-year events) over and through their step-pool sequence, but also to create a series of energy dissipaters that decrease downstream velocities and overall shear stress, which results in a reduction of the downstream erosional impacts often associated with more conventional storm water outfalls.

In order to effectively account for infiltration losses and surface flow attenuation, WK Dickson & Co. Inc. created the RSC Infiltration/Surface Flow Model, which routes an inflow hydrograph through each RSC cell. For each cell the model calculates key hydraulic parameters, including volume lost through infiltration, maximum pool water surface elevation level, pool surface storage volume, underlying sand storage volume and a complete system outflow hydrograph. This model can guide engineers and scientists through the RSC design process and help estimate overall RSC hydraulic performance.

Recent Projects

WK Dickson completed the design of the Linda Lake pilot RSC for the city of Charlotte, N.C. The site is a 20-ft-deep eroded gully with ephemeral flow that contributes significant sediment and nutrient loads to its receiving perennial stream, which flows into an impaired (303(d)-listed) receiving water. The design includes a series of baffles and monitoring devices to document the structure's efficacy and calibrate the new model.

The company is designing pilot RSCs for Richland County (Columbia), S.C., and the city of Greenville, N.C. The Columbia project will be installed within a 4,100-ft-long, 15- to 20-ft-deep storm water ditch that parallels an eroding railroad right of way and drains into the Little Jackson Creek stream and wetland restoration site (a 303(d) listed stream). The Greenville project utilizes two RSCs that are being used as end-of-pipe treatment for the highly impervious university parking lot. The proximity of these devices to a public walkway and university property allows for both general public education and graduate-level research opportunities.

By integrating low- to moderate-flow infiltration and treatment with higher flow conveyance and energy dissipation, RSCs provide a combination of storm water management offered by no other standalone device. As monitoring results are beginning to confirm, they provide a cost-effective, aesthetically pleasing and low maintenance solution to a variety of challenges, including steep, deeply incised gullies and large, mostly impervious catchments. Their continued addition to BMP manuals will expand their usage and reduce their installation costs. SWS

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