Landscape Design and GIS in Campus Stormwater Planning

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The University of Tennessee – Knoxville (UTK) is an urban campus comprised of roughly 27,000 students along with an additional 10,000 in faculty and staff. The University of Tennessee has developed a master plan with a new vision for the Knoxville campus landscape. According the master plan, a guiding principle in the new design is to “promote energy and environmental responsibility”. In an effort to promote environmental stewardship, the Office of Sustainability was established in 2007 to promote sustainability across campus in many areas, strategically bridging the gap between campus operations, teaching, research, and outreach. With these new goals in mind, Facilities Services identified the need to improve stormwater management on campus. The UTK campus properties (Figure 1) reside on approximately 767 acres with stormwater runoff directed through drainage infrastructure to the Tennessee River, Second Creek, or Third Creek (Schwartz and Simmons, 2013).

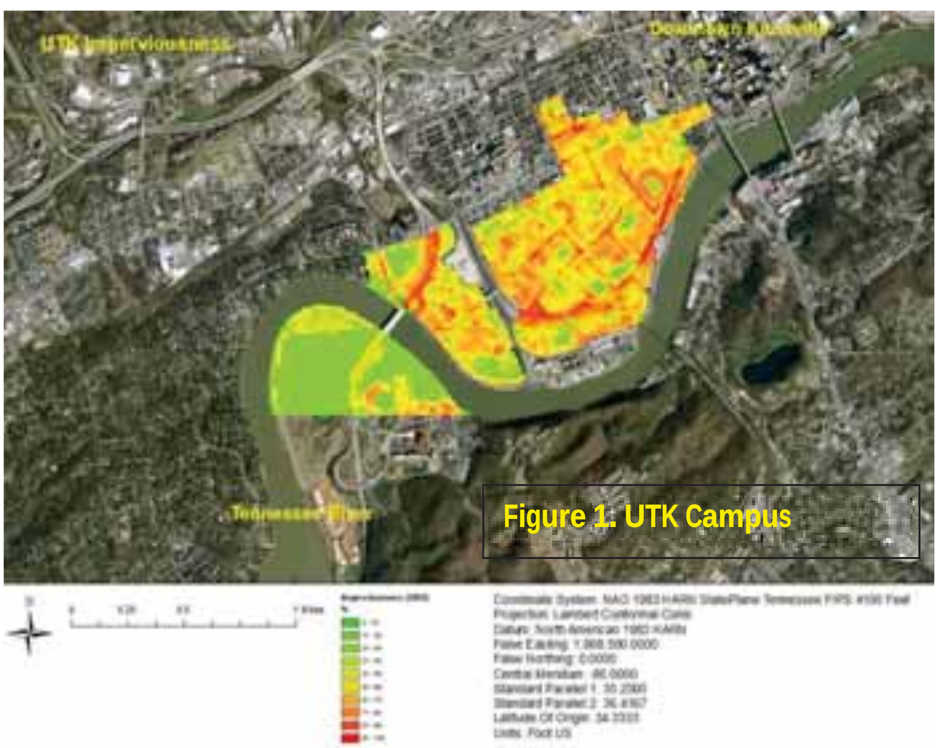


Figure 1. UTK Campus

The importance of developing a UTK Stormwater Master Plan became evident when UTK was identified by the Tennessee Department of Environment and Conservation (TDEC) as a municipal separate storm sewer system (MS4), which required UTK to submit a Notice of Intent (NOI) to apply for a Phase II stormwater permit. Prior to this past year, UTK's stormwater system was part of the City of Knoxville's Phase I MS4 permit. Each Phase II entity, including our campus, is required to implement the following six minimum measures: public education and outreach; public participation and involvement; illicit discharge detection and elimination; construction site runoff control; post-construction runoff control; and pollution prevention/good housekeeping. Stormwater management on our campus is especially important because much of the property is essentially a riparian corridor for the Tennessee River.

In monitoring and assessment, over one-half of the MS4s in Tennessee employ GIS mapping and conduct visual assessments to monitor water quality in their local watersheds (Gangaware and Farnsworth, 2009). Currently, Facilities Services at UTK does not have a GIS technician, and most of the existing data related to stormwater planning is in CAD format. The existing drainage system at UTK (street catch basins, manholes, pipes, drainage outlets, grassy swales, and trench drain) has been converted into GIS format by Knoxville GIS. Although the potential for a comprehensive understanding of the system is possible through these files, the database is vastly incomplete and outdated (Schwartz and Simmons, 2013).

Although UTK is a state land grant institution long involved in water issues—from applying on-the-ground Best Management Practices (BMP) to conducting research and formulating policy to ensure abundant clean water for the future of Tennessee citizens - it has done a poor job of managing its own stormwater. For example, in June, 2011, a watch dog agency measured 32,500 Nephelomteric Turbidity Units (turbidity is a measure of the light

Figure 2. Construction at Sorority Village

penetration in water) in stormwater from the construction site of Sorority Village (Figure 2) - the highest ever recorded by this agency from a construction site - forcing the state to review all reports from their construction projects.

In 2012, UTK partnered with a Landscape Architecture firm to propose a landscape design for campus. Among the accomplishments to date is the redesign of Gate 21 of Neyland Stadium (Figure 3), including the construction of a semi-pervious brick courtyard, a grassy amphitheater, and a large number of tree wells. In addition to improving the aesthetic appeal of the area surrounding the stadium, this new design provides needed space for rainwater to infiltrate the ground. Gate 21 stands in stark contrast with

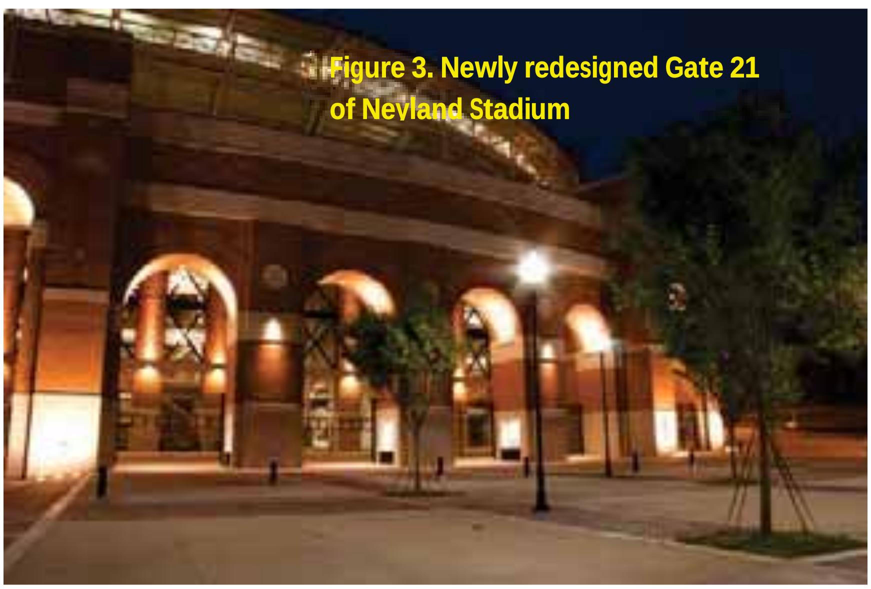


Figure 3. Newly redesigned Gate 21 of Neyland Stadium

most of the area around Neyland Stadium, which is mostly hardscape and therefore, impermeable.

With the lack of GIS and stormwater planning experience in the Facilities Services department, the situation begs the involvement of many faculty from Landscape Architecture, Plant Sciences, Soils Sciences, Environmental Sciences, Engineering, Information Sciences, Planning, and Geography as well as stormwater-related programs and organizations on campus – the Office of Sustainability, Service Learning Office, Water Resources Research Center, Tennessee Stormwater Management Assistance Research and Training Center, Municipal Technical Advisory Service, UT Extension, Library Map Services, Campus Committee or the Environment, various student clubs, and the Watershed Minor Subcommittee – just to name a few. The UTK Stormwater Management Master Plan was compiled by UTK Faculty and students. UTK students with an interest in stormwater management and planning would be a great source of labor and enthusiasm as they complete research and service projects related to the Master Plan. The recommended BMPS – bioretention (rain gardens), stormwater wetlands, detention basins, sand filters, filter strips, grassed swales, restored riparian buffer, infiltration devices, permeable pavement, cisterns, and rooftop runoff management – would provide a real-world and diverse suite of topics for research and design projects. Not only would they contribute to the pollution control aspects of the discharge permit, they would also be integral to public outreach and involvement.

Two programs at UTK - The Master of Landscape Architecture (MLA) Program in the College of Architecture and Design and the Biosystems Engineering and Soil Science (BESS) department in the College of Agricultural Sciences and Natural Resources have created an informal partnership to foster incorporation of design and GIS in stormwater planning. Having a design aspect in the recommended BMPs lends an aesthetically appealing and visual component that advances public education and outreach, and the GIS provides tools to answer spatial questions about reductions in stormwater runoff. The MLA program, established at UTK in 2009, fosters community partnerships while providing educational, technical, and cultural support to increase the livability of communities. The BESS masters programs in Environmental and Soil Sciences (ESS) and Biosystems Engineering Technology (BsET) have a long track record in completing studies related to environmental stewardship, especially water quality research. MLA students with projects in stormwater planning and design have BESS faculty on their graduate committees, and several joint projects have been completed, as well.

One option for supporting student projects related to stormwater is to have them participate in competitions. As part of a senior design class, future MLA students were required to complete a proposal for the Rainworks Challenge. Launched in May 2012, the EPA Campus RainWorks Challenge is a student competition designed to inspire the next generation of landscape architects, planners, and engineers to develop innovative green infrastructure

systems that mitigate the impacts of urban stormwater while supporting sustainable communities (EPA, 2013). Our challenge was to build green infrastructure on campus not by construction of a single project, but rather through influence on campus planning. We started with design of a planned infrastructure project from the Campus Master Plan short-term priority list – 'Parking Improvements on Lot S9'. Lot S9 is located in highly significant central location on campus, and is unfortunately the only available location for parking to support several major auditoriums and event facilities in the center of campus. Our intent was to demonstrate how a watershed-based approach to design; restoration of natural features, native associations, soils and ecosystem services; and creative 24/7/365 programming of activities could bring life and energy to an undesirable but required campus infrastructure project. Our ambition was to substantially influence the RFP issued for this 'parking project' so it would include greening and programming of the roof, walls, and surrounding site areas the site became more than a concrete rack to park vehicles for the buildings that surround it. As an increasing number of surface parking lots are closed in favor of peripheral parking garages, the ideas and plans developed for Lot S9 could be easily transferred to other garages. Most of the student designs involved a conversion of the paved parking lot to a greener parking garage surrounded by a greenscape that would serve as a stormwater drainage and filtration feature (Figure 5).

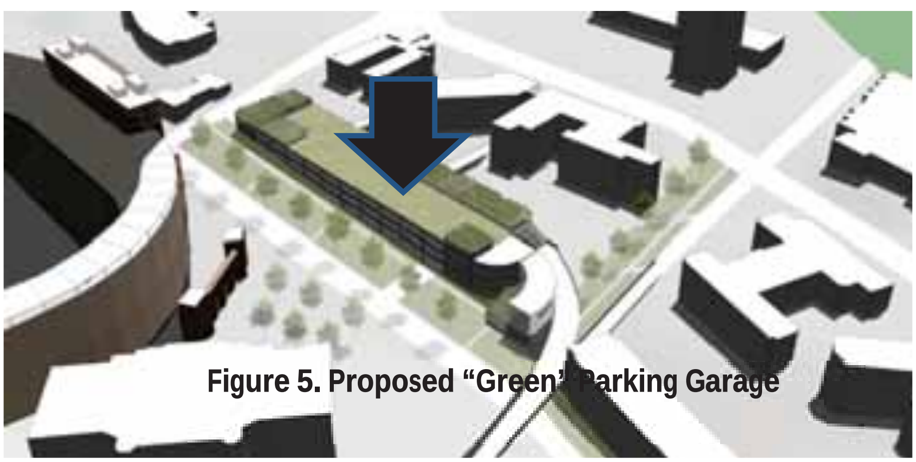
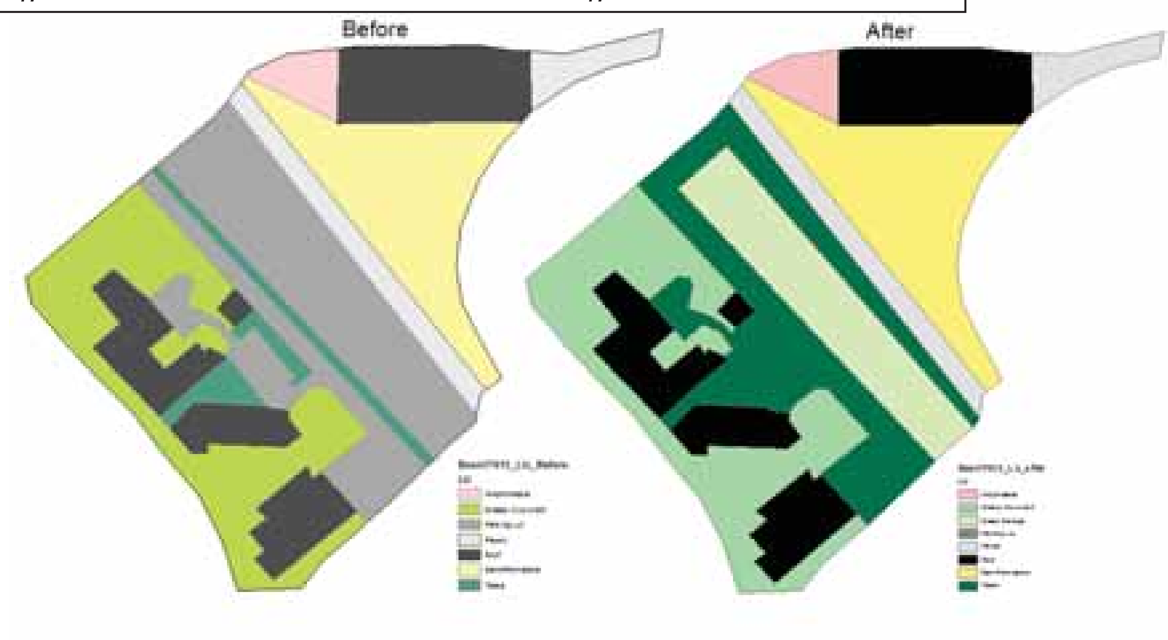


Figure 5. Proposed "Green" Parking Garage

One of the tasks of the GIS student was to calculate the impact of the proposed design on the peak rate of runoff by creating a landuse feature class for Sub-Watershed Management Area TN13 – grassy courtyard, trees, parking lot, other paved, roof, semi-pervious paving, amphitheater (Figure 6). The Rational Method was used to estimate the peak rate of runoff as a function of the drainage area, runoff coefficient, and mean rainfall intensity for a duration equal to the time of concentration, t_c. The t_c is the time required for water to flow from the most remote point of the basin to the location being analyzed. The Rational Method is expressed as Q = CIA where Q = peak rate of runoff in ft^3s^{-1}, C = runoff coefficient representing a ratio of runoff to rainfall, I = average rainfall intensity for a duration equal to the t_c (in/hr), and A = drainage area contributing to the design location (acres). The peak rate of runoff was calculated as 8.02 ft^3s^{-1} before the green design was implemented and 5.45 ft^3s^{-1} (a reduction of 32%) after the "green" garage was included and the rest of the parking area was replaced with trees. If the new green infrastructure could serve as detention/filter area for the roofs in this sub-watershed, the peak rate of runoff could be reduced to 3.88 ft^3s^{-1} (a reduction of 52%).

Figure 6. Landuse in the TN13 sub-watershed management area - before and after.



Conclusion

As part of the stormwater MS4 Phase II requirements, public outreach and education are integral components. An innovative approach to foster the cooperation of faculty, staff, and students at UTK will integrally involve them in stormwater inventory, mapping, modeling, research, planning, and management, as well as the design, construction, and monitoring of BMPs. Now that the 50 sub-watershed management areas have been delineated (Figure 7), BMPS can be prioritized. Centralized campus planning at UTK in combination with its location in impaired urban reaches of the Upper Tennessee River watershed places UTK Research Centers, academic programs, and faculty in a unique position to use our campus as a laboratory for innovative planning, conservation, restoration and applied-research projects within a managed watershed context.

References

Environmental Protection Agency, 2013. Campus RainWorks Challenge. http://water.epa.gov/infrastructure/greeninfrastructure/crw_challenge.cfm

Gangaware, T. and M. Farnsworth. 2009. Understanding Priorities, Activities, and Needs of MS4 Stormwater Programs in Tennessee. Center for Watershed Solutions. http://isse.utk.edu/wrrc/cws/MS4Needs_09.pdf

Schwartz, J. S., and P. Simmons. 2013. Stormwater Management Master Plan. University of Tennessee, Knoxville, TN.

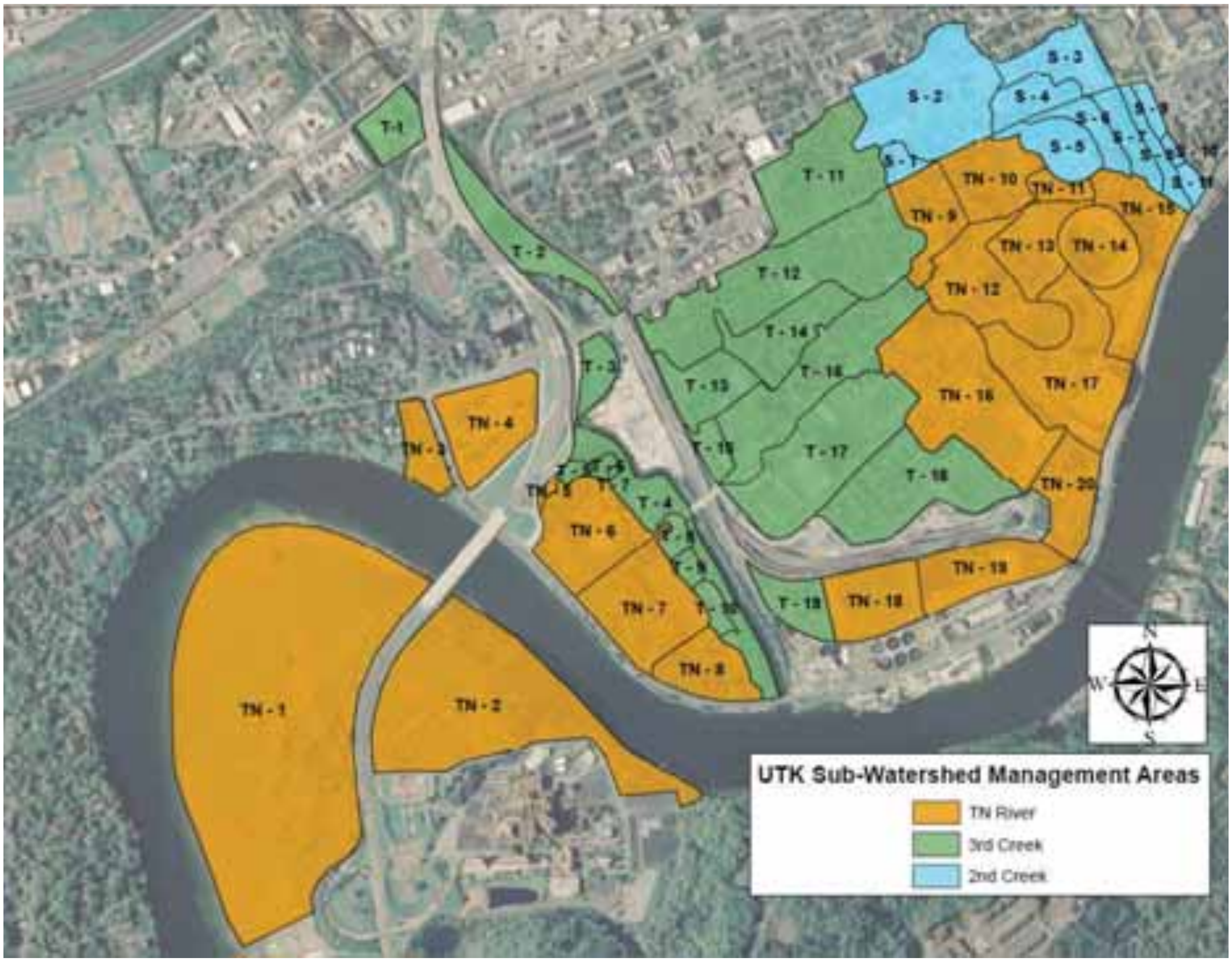


Figure 7. UTK Sub-Watershed Management areas (Schwartz and Simmons, 2013)