Reclaiming the Infrastructure: the Potential of Green Infrastructure for Urban Renewal around Stormwater Management

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3TEP Meeting
May 20-22, 2010
University of North Texas

Somehow Plato's account of the acclaimed first philosopher, Thales of Miletus (c. 624 BC-545 BC), has become a popular caricature of philosophy (*Theaetetus* (174 A). In a new column in the New York Times, Simon Critchley adds to the refrain (New York Times, May 16, 2010)

> Socrates tells the story of Thales, who was by some accounts the first philosopher. He was looking so intently at the stars that he fell into a well. Some witty Thracian servant girl is said to have made a joke at Thales' expense — that in his eagerness to know what went on in the sky he was unaware of the things in front of him and at his feet. Socrates adds, in Seth Benardete's translation, "The same jest suffices for all those who engage in philosophy." http://opinionator.blogs.nytimes.com/2010/05/16/what-is-a-philosopher/

There is a lot to say in favor of the image of the philosopher as the laughing stock, the one who dares to stumble and question, the one who takes the time to approach things slightly otherworldly. But something is lost in this image. Thales made major contributions to mathematics, astronomy, navigation, and investigated the basic principles of matter, theoretically moving towards a scientific treatment of natural phenomena. No longer following the traditional beliefs that the gods organized, shaped, and controlled the cosmos, he was, for Aristotle, no longer a theologian like the old poets, but the founder of natural philosophy. In short, Thales was not only the first philosopher, but he actually combined environmental philosophy, philosophy of technology, metaphysics, and field philosophy in a most natural way. For Thales, water had the potentiality to transform into the myriad things of which the universe is made, the physiological, meteorological, botanical, and geological states. Being from Miletus, which was a harbor town in his time, he was interested in navigation, studied indeed the stars, and traveled to Egypt, the origin of geometry and a haven for mathematics, all based upon the inundation patterns of the Nile. In short, water pervaded his every day life, and it is his careful analysis based upon careful observations of the movements of water in relation to the skies and the land, which led him to his scientific conclusions. It was the primary principle of the universe for him (Aristotle, *Metaphysics* 983 b20). And, yes, he did fall into the well too… and made people laugh. What more can one wish for? How can we as philosophers relate to the everyday world, take our cues from it, and connect to the people in a way that they get a laugh out of us? How can his example be followed? As a variation on "What Would Jesus Drive?" we can ask, "What Would Thales Think?" That what is beneath our feet and deals with water might be a good candidate. Given his interest in engineering, water and nature I think Thales would have been fascinated by green infrastructure.

What is Green Infrastructure?

When a storm rolls through town, rain batters futilely upon rooftops, parking lots and streets, hammering impervious surfaces, which it cannot infiltrate. The stormwater washes over these surfaces, picking up chemical and microbial pollutants—like oil, fertilizers, paint--before draining into the stormwater collection system, a public drainage system with publicly maintained pipes, culverts, gutters, catch basin, ditches, channels, ponds, wetlands and the like. In some cities this contaminated water merges with wastewater and goes through the wastewater treatment plant, but given the danger of system overflow after a heavy storm event, most stormwater and wastewater systems are separated. Where wastewater—water from sink, toilet, shower, dishwasher, washing machine etc—is treated by the wastewater treatment plant before it is released in any water body, stormwater flows directly and untreated into streams, rivers and lakes. This not only impacts the ecosystems places we use for drinking water and recreation. – causing not only overflows, flood risk, abetting erosion but seriously degrading water quality. Indeed, according to a 2008 report from the National Research Council, "stormwater runoff from the built environment remains one of the great challenges of modern water pollution control" (p. vii).

In the last decade, a growing number of cities have begun transforming the impervious surfaces of their "gray infrastructure" – roads, buildings, and utilities – into a "green infrastructure" of trees, soil and open spaces ("Gray and Green Infrastructure," 2003). Spurred in part by changes to the Clean Water Act, urban planners and municipal officials have sought out more sustainable ways of managing stormwater and wastewater. These efforts have been underwritten by a growing body of literature on the advantages of green infrastructure. Here I present different definitions of green infrastructure, consider green infrastructure's role in stormwater/wastewater control, a variety of cases studies and conclude with a specific case study of how environmental philosophy can enhance this innovative trend.

Defining Green Infrastructure

The term "green infrastructure" gained currency in the late 1990s as concerns about climate change and scarce resources heightened interest in sustainable urban development. In 1999, the President's Council on Sustainable Development identified green infrastructure as one of five opportunity areas for sustainable community development, defining it as "the network of open space, airsheds, watersheds, woodlands, wildlife habitat, parks, and other natural areas that provides many vital services that sustain life and enrich the quality of life" (p. 64). The Council stressed the need for "Smart Growth," urging communities to "conserve, protect and restore" their natural resources, thus effecting more "efficient land use and development practices."

Building on the Council's insights, Benedict and McMahon (2003) have offered the most commonly cited definition of green infrastructure: "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (p. 6). This definition developed from the work of the Green Infrastructure Work Group, led by the Conservation Fund and the USDA Forest Service, and it was later elaborated in a book-length work (Benedict, 2000; Benedict and McMahon, 2006). Green infrastructure, according to Benedict and McMahon, encompasses both natural and restored ecosystems and features, which together form a system of “hubs,” “sites,” and “links.” Hubs include anything from managed preserves to publicly owned lands to community parks, and they serve as anchors to green infrastructure networks. Sites are smaller than hubs and include local areas intended for nature-based recreation or enjoyment. Links – such as floodplains and greenbelts - tie the system together and are “critical to maintaining vital ecological processes” (Benedict and McMahon, 2006, p. 13). Such connectivity, say Benedict and McMahon, is the key to green infrastructure.

By stressing the interconnectivity of green infrastructure, Benedict and McMahon hope to craft a principled, integrated, long-term approach to sustainable community development. They argue that green infrastructure can be implemented at any scale, from the household to the regional level. They stress the need for a comprehensive framework for sustainable development grounded in careful planning and wise public investment. Implemented properly, green infrastructure benefits both nature and people, respecting the needs and desires of landowners and stakeholders while protecting vital natural resources (Benedict and McMahon, 2006). This approach has been broadly influential, and their definition has been adopted by Randolph (2004), Erickson (2006), Walmsley (2006), the American Planning Association (2006), the Conservation Fund 2009), the U.S. Environmental Protection Agency (2009b), and Wickham, Riitters, et.al. (2010).

However, as Benedict and McMahon concede (2003), “green infrastructure means different things to different people depending on the context in which it is used” (p. 5). To some, green infrastructure refers simply to “natural features” in urban areas, including trees, wetlands, streams and open (or green) spaces (Beatley, 2000; Weber, Sloan and Wolf, 2006; Olsenius, “Gray and Green Infrastructure,” 2003). Others think of green infrastructure in terms of planning, practices and policies. They emphasize the conservation of natural resources combined with the re-engineering of the urban environment to promote natural hydrological cycles (Colorado Department of Public Health; Tzoulas, Korpela, et.al., 2007). Such definitions are compatible with the arguments of Benedict and McMahon, but they are less grand in scope, less ambitious in their claims.

Green Infrastructure, BMPs, SCMs and LID

However it is defined, green infrastructure has moved closer to the center of both public and intellectual discourse on stormwater and wastewater management. Traditional measures of stormwater control have become too damaging, inefficient and costly to persist. Green infrastructure offers alternatives that are more sustainable, more efficient and less costly. As Wise puts it (2007), "the future of stormwater has arrived, and that future is green. Green infrastructure, that is" (p. 15).

In the United States, the transition from the gray infrastructure of sewage and drainage systems to a green infrastructure has been driven in part by the U.S. Environmental Protection Agency (EPA). In 1987, Congress revised the Clean Water Act to bring stormwater runoff under federal regulation. As part of the National Pollutant Discharge Elimination System (NPDES), the EPA has called for the incorporation of Best Management Practices (BMPs) into urban drainage systems – "techniques used to control stormwater runoff, sediment control, and soil stabilization, as well as management decisions to prevent or reduce nonpoint source pollution" (Stormwater Authority). The EPA maintains a National Menu of Stormwater Best Management Practices, providing information for six categories of BMPs: public education, public involvement, illicit discharge detection and elimination, construction, post-construction, pollution prevent/good housekeeping (U.S. EPA, 2008). The EPA has also teamed up with the American Society of Civil Engineers and other organizations to create the International Stormwater BMP database, which includes more than 300 BMP case studies (http://www.bmpdatabase.org/).

Green infrastructure comprises the foundation of BMPs because it helps to "conserve, protect and mimic natural hydrological functions within the built environment" (Wise, 2007, p. 16). According to Richards (2009), green infrastructure manages stormwater "through infiltration (water soaking into the ground), capture and reuse (water being stored in a rain barrel or cistern for later use in watering plants or flushing toilets), and evapotranspiration (water being used by trees and plants)." These three processes –

infiltration, reuse and evapotranspiration – constitute the basis of green infrastructure BMPs.

BMPs have the most relevance at the municipal or regional level, where managing stormwater through green infrastructure necessitates changes in land use – i.e., a transition away from gray infrastructure. BMPs demand not only the restoration and preservation of natural landscapes such as forests, floodplains and grasslands but also a reduction in the "overall imperviousness" of a watershed (Colorado Department of Public Health). Such efforts might include the establishment of pocket wetlands and riparian buffers, the restoration of forested areas, the replacement of paved shoulders with drainage swales, the use of permeable pavement in streets and parking lots, and the clustering of new development to avoid urban sprawl (Wise, 2007; US EPA, 2008). According to Wise (2007), these practices can reduce stormwater runoff pollution by 30 to 90 percent.

There is some disagreement concerning which stormwater BMP offers the greatest benefit. Day and Dickinson suggest that infiltration techniques can concentrate stormwater and increase the likelihood of contamination. They advocate the use of trees in stormwater management, because trees intercept and store water in their canopies, guide water into the soil and transpire water into the air. Smith (2009), on the other hand, posits a decentralized system of stormwater and wastewater treatment that "consists of a detention basin, vegetated and open free water surface wetlands, and ultraviolet disinfection" (p. 1465). Constructed wetlands, Smith argues, allow designers and engineers to "integrate wastewater treatment into the urban landscape in more attractive and multi-functional ways" (p. 1473). Wadzuk, Rea, et.al. (2010) have also shown that a constructed stormwater wetland "improves urban stormwater runoff quality, mitigating downstream impacts" (p. 385). And a German research team – not interested in BMPs per se, but certainly interested in green infrastructure – has advocated moving away from dykes and other coastal defenses and toward constructed estuaries to control storm surges in Hamburg (von Storch, Gonnert and Meine, 2008).

The National Research Council (2008) has sidestepped such debates altogether, instead emphasizing the need for multiple local solutions. The NRC has in fact rejected the term Best Management Practice in favor of the more specific term Stormwater Control Measure (SCM). According to the Council, SCMs can be evaluated using five basic categories: erosion and sedimentation control, recharge/base flow, water quality, channel protection and flooding events. SCM design must therefore be based on a region's rainfall and runoff conditions, and it must include a range of solutions at a variety of scales (p. 294).   The Council lists some twenty different SCMs, ranging from watershed and land-use planning to reforestation and soil conservation to stormwater education (p. 296).

On a smaller scale, the green infrastructure approach to stormwater control is based on Low Impact Development (LID) techniques. LID is a "site-design strategy" focused on micro-scale methods that "mimic natural hydrologic functions and decrease the amount of impervious area and stormwater runoff from individual sites" (U.S. EPA, 2010c). Practices include bioretention facilities, mulching and composting, green rooftops, rain gardens, vegetated swales, downspout disconnection and permeable pavement (U.S. EPA, 2010a). According to Wise (2007), these practices do more than reduce stormwater runoff: they "also foster community cohesiveness by engaging residents in planning, planting, and maintaining highly visible stormwater infrastructure that beautifies and adds value to neighborhoods" (p. 16).

LID techniques have been in use for decades – becoming especially popular in the 1990s as part of Smart Growth initiatives – and there is a considerable body of literature on the subject. In 2000, the U.S. EPA published its own literature review of LID, which examined studies of various practices as well as case studies of particular locales. A pioneering case study of Prince George's County, Maryland, helped to define the methodology for conducting hydrological analysis using LID (Prince George's County, 1999).   The EPA also hosts dozens of publications and a number of webcasts at its Web site to promote the use of LID to manage stormwater runoff (U.S. EPA, 2010 and 2010b). It even offers a municipal handbook "to help local officials implement green infrastructure in their communities," offering advice on funding, incentive mechanisms and retrofitting (U.S. EPA, 2010c).

As the literature suggests, transitioning away from gray infrastructure toward green infrastructure to manage stormwater and wastewater runoff involves a welter of practices at multiple scales. No single BMP, SCM or LID technique can restore the natural hydrological cycle at a given location. Rather, each city must craft a comprehensive plan of stormwater and wastewater management that applies green infrastructure theory from the household to the regional level. An expansive body of literature exists to support such efforts, and a growing number of case studies have amply demonstrated the advantages of moving toward green infrastructure.

Case Studies

There are myriad case studies of the transition to green infrastructure, including dozens on the uses of green infrastructure in stormwater and wastewater management. A complete survey exceeds the scope of this essay. However, a few key case studies – some long-term and some in their preliminary stage - may be highlighted to show the range of the literature.

Wadzuk, Rea, et.al. (2010) have conducted an impressive multi-year study of a constructed stormwater wetlands on the Villanova University campus. Employing discrete analysis to measure the effects of both storm events and base flow periods on water quality, the authors investigated the wetlands' performance in removing suspended and dissolved solids, nitrogen, phosphorous, lead, copper and chlorides. They found that the wetlands significantly improved water quality in all conditions, though it was most effective in removing phosphorous, nitrogen, lead, copper and suspended solids. They suggest that design might be used to retain water for an even longer period, thus allowing more time for the removal of harmful pollutants. Most significantly, the study showed that a constructed wetlands "maintains its water quality benefit over a decade of operation" (p. 393). Such longitudinal scientific assessments of green infrastructure approaches are rare, making the study even more valuable.

In contrast, Pires (2004) focuses on the political process of green infrastructure implementation, describing New York City's metamorphosis "from a centralized, technocratic waterworks operation to a complex institutional apparatus for integrated watershed management" (p. 161). New York's water supply system serves more than 9 million people, but throughout much of the 1990s, city officials skirted federal regulations concerning water filtration. After 1997, however, New York began adopting measures that were compatible with a green infrastructure approach, purchasing hydrologically sensitive areas, protecting its native watersheds, creating riparian buffer zones, and implementing new stormwater pollution controls. Although the changes came with much political wrangling and intrigue, Pires concludes that using buffer zones to protect water quality is a "cost-effective 'win-win; situation" – especially "where buffer zones are used in conjunction with other land-use BMPs that help to control nonpoint (i.e., diffuse) sources of pollution" (p. 173). Pires has shown that green infrastructure approaches can be effective even at large scales and in the face of entrenched opposition.

Another policy-centered approach comes from Weber, Sloan and Wolf (2006), who have studied Maryland's use of Green Infrastructure Assessment to prioritize land use and development. In 1997, the Maryland Department of Planning project that urban land use would increase 20% by 2020, while forest cover would decrease by 9% - a trend that might have had devastating effects on stormwater control. In consequence, researchers developed the Green Infrastructure Development tool using a study of the entire state. They identified Maryland's hubs and links, ranking them according to ecological importance and development risk. This comprehensive assessment of the state's green infrastructure has become the basis of Maryland's development policy, although the authors consider it a "work in progress" (p. 108). In sum, the study suggests how green infrastructure theory might be used to craft a long-term land-use and watershed planning policy. In doing so, it offers a roadmap for other states and communities who wish to follow suit.

Building Green Infrastructure (2000) suggests the potential benefits of using green infrastructure theory to ground public policy. It includes brief case studies of four imperiled watersheds: Edward Aquifer in Austin, Barneget Bay in New Jersey, Mountain Island Lake in Charlotte, North Carolina, and Indian River Lagoon in Florida. Although each watershed stands within a strikingly different ecosystem, they were all saved and revitalized by common methods of land acquisition, conservation, and comprehensive development planning. Once again, these studies show that public policy based on green infrastructure can reverse potentially catastrophic trends, helping to return urban areas to a more natural hydrological cycle.

Other case studies speculate on the future benefits of shifting from gray to green infrastructure. Kessel (2010), an engineer, has provided a detailed plan for using green infrastructure to save Shoal Creek, an embattled urban stream in Austin, Texas. Heavy use has damaged Shoal Creek's riparian zones, causing erosion, soil compaction and loss of vegetation. To revitalize the area, a project team has designed 11 green infrastructure projects, including a rain garden, filtration ponds and flow spreaders. One of the major goals of the project is to better manage stormwater at the site, reducing runoff and generating new plant growth. Once complete, Kessel notes, "the restoration of Shoal Creek where it passes through Pease Park will provide a notable example of integrated stormwater management" (p. 31). The plan will also restore some 75 acres of green space to Pease Park. The Shoal Creek project suggests that controlling stormwater through green infrastructure has cascading benefits, not only improving water quality but also restoring degraded ecological zones and expanding recreational areas.

On its Web site, the EPA (2009a) has published an intriguing proposal to use green infrastructure to manage stormwater in Northern Kentucky. The study advocates an integrated stormwater control program that spans all scales, in the process utterly transforming the urban spaces of Northern Kentucky. At the regional level, it suggests the preservation of open spaces and the encouragement of development in already built areas. At the neighborhood level, it advocates compact mixed-use development along revised street design to reduce impervious surface areas. And at the site level, it proposes a range of LID solutions, such as pervious pavement, green roofs, rain gardens, vegetated swales, downspout disconnection, and stormwater curb extensions. The study, with its meticulous attention to detail, demonstrates the feasibility of a multi-scale green infrastructure approach to managing stormwater and wastewater. Potential obstacles to implementation, however – including political opposition, funding and public apathy – remain somewhat neglected.

These case studies represent a mere sampling of the literature on green infrastructure and stormwater/wastewater management. Whether they are intended to evaluate the performance of green infrastructure techniques or propose programmatic changes for a particular locale, they all agree that moving from gray to green is more than desirable: it is necessary. Green infrastructure practices not only halt the degradation of water quality due to stormwater and wastewater runoff. They actually reverse the damage wrought by traditional gray infrastructure, revitalizing the ecosystem, creating new opportunities for growth and forging new community bonds.

Social and Cultural Infrastructure

While these studies make abundantly clear the advantages of green infrastructure, they too often ignore the political, social and economic realities that make the shift difficult to achieve. As Olsenius (2010) points out, moving from gray to green infrastructure also requires "a social infrastructure that supported the process of land use change" (p. 18). How to achieve such an infrastructure remains unclear.

Despite the abundance of resources on green infrastructure and stormwater/wastewater management, the literature – like the theory and the practices – is still in its infancy, engaged in speculation and advocacy as much as in scientific investigation. However, as more cities make the transition from gray to green infrastructure, the raw data for new studies will become available, and we will gain a greater understanding of both the advantages and the complications of moving from gray to green.

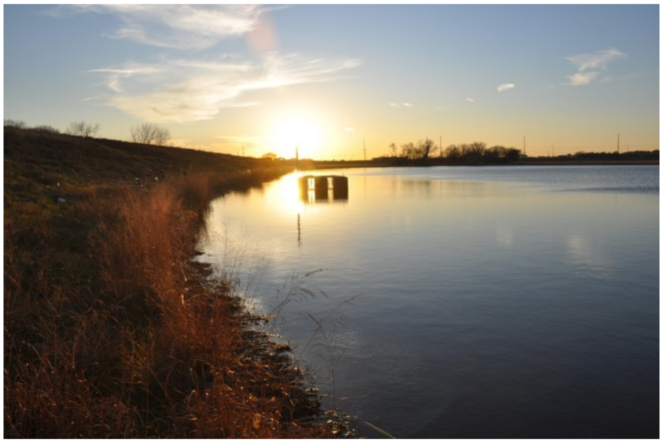
Infrastructure refers to technical structures and physical networks that support society. Usually these structures are conceived and designed in terms of their functional operational tasks--in the context of water, for example, storm runoff, drinking supply, waste water treatment, and irrigation. Infrastructural water projects could form a powerful medium for reconciling conservation of bio-cultural diversity with social economic development and cultural well-being. In an era of rapid urbanization, infrastructural entities such as storm water detention ponds could provide ecosystem services as well as public space; thus fostering a cultural nexus around water bodies.

A vexing aspect of a portion of the water infrastructure is its invisibility. An underground network of pipes connects each home to large treatment plants. Only when there are problems--burst or clogged pipes, etc—are the arteries unearthed and made visible. Other portions of the contemporary water infrastructure are highly visible: major dams block the flow of mighty rivers, and thousands of miles of irrigation ditches are engraved upon the landscape. Visibility and invisibility function both on various levels. For example, at the beginning of the twenty-first century, one in ten of the world's major rivers no longer reach the sea for part of the year because of upstream use of their waters. Charismatic rivers such as the Nile, the Yellow, the Indus, the Rio Grande, and the Colorado, along with many others, end in sand, sometimes hundreds of kilometers before their mouths. The absent river (invisible water) makes visible how the river is over-exploited. "Thinking with Water" would entail thinking through this dynamic of visibility and invisibility.

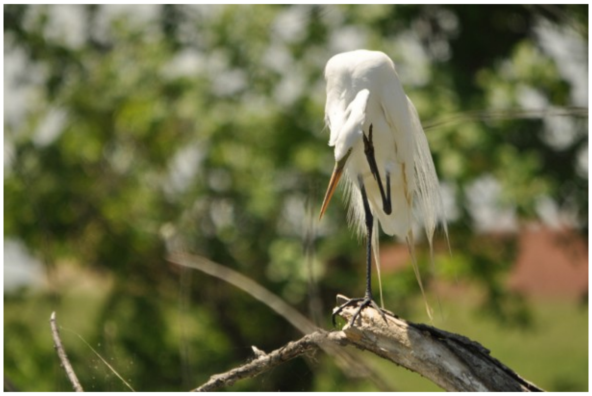
What are the effects of the invisibility of our everyday water infrastructure? A re-connection to our water bodies in and through the infrastructural developments might facilitate an understanding and appreciation of the hydrological and ecosystem function of water in the larger landscape. There are different ways to accomplish a renewed connection to water; River Festivals foreground rivers on special occasions while low-key experiences such as walking one's dog along a detention pond that functions as a 'lake' can weave water and its surrounding ground into daily life The experiential boundary between hydrological infrastructure and natural landscape feature becomes blurred in such everyday activities. Thinking with water becomes in this case a question of how one can translate these low-key experiences into a public understanding of the importance of healthy watersheds in order to keep water running from one's tap.

In this last part I present a local study, which forms a hybrid between green and gray infrastructure in relation to social and cultural infrastructures exploring environmental cultural connections. It is a case study of mediated examination/presentation of socio-cultural impact of a specific infrastructural water body. Imaging by and of multiple actors will serve as data sets, as a means of presentation of results, and as recursive stimuli to deeper examination.

"Little Lake" and/or SCS 16

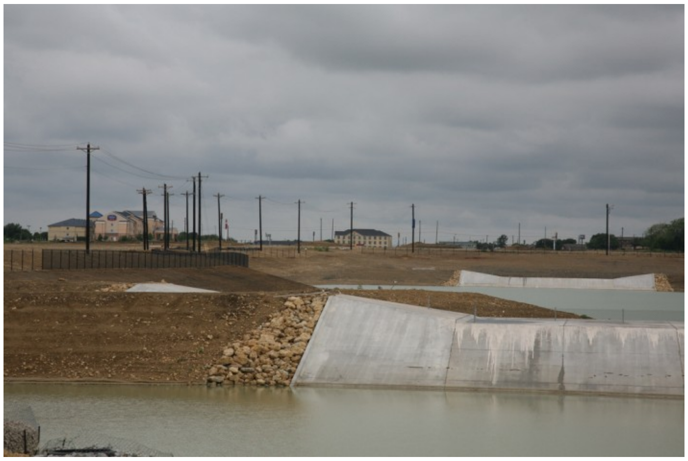


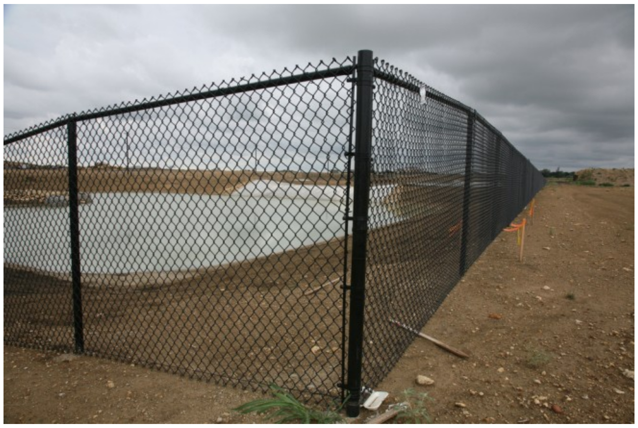
In 1957 and 1962 massive flooding occurred in Denton. In response Soil Conservation Service's Hickory Creek Basin Retarding Ponds #16 and #17 were constructed as high hazard flood control structures. The two hydraulic structures became the main hubs of North Lakes Park. They are autonomous retention structures, operating with relatively little maintenance and/or intervention. A valve allows rising water to enter into Pecan Creek when needed during peak flows; otherwise the water level remains fairly static day to day.



A thriving community of citizens and wildlife visits SCS16 regularly. SCS 16 provides opportunities for people to fish, boat, walk, and play;

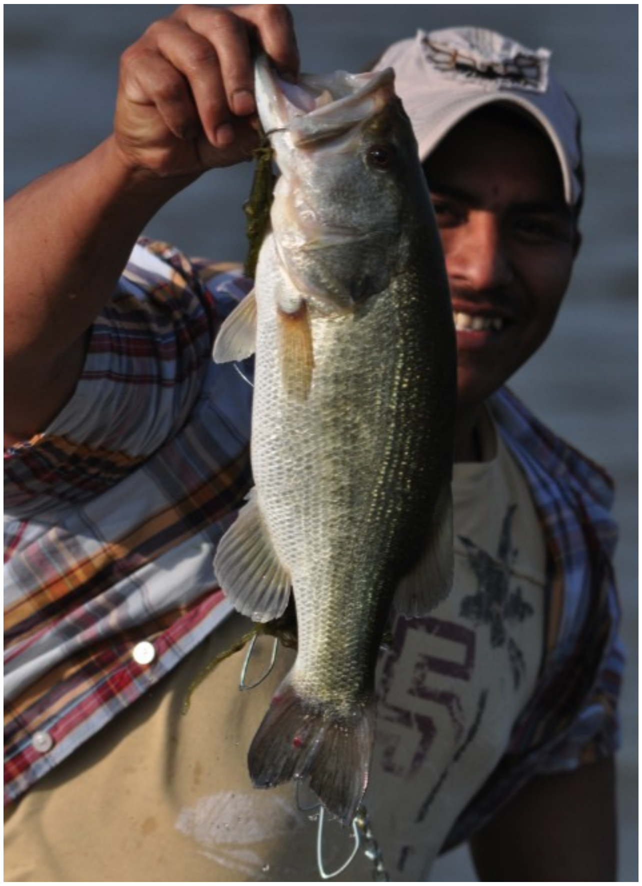
for beavers, herons, turtles, snakes, fish, ducks, coots and gulls to make a living. In short, it has become an environment, open, accessible, inviting and within city limits. SCS16, as part of North Lakes Park, is a little lake, that presents a ‘wildness’ that is not ‘foreign’ or ‘external’, but open, intimate and near by.





Where most infrastructural elements are buried physically, conceptually and experientially, in a model of reclaiming the infrastructure as socio-cultural nexus, the identity of these elements and structures are transformed by community involvement and made visible again. Thus, infrastructural elements, specifically urbanized retardation structures, can regain multiple identities. A retention pond, for example, can be planned as simply an hydraulic concrete structure or a little lake that is at once a walking path, fishing hole, disc golf course, beaver habitat, and picnic area. The undifferentiated character of the place invites these co-existent possibilities. This model of reclaiming the infrastructure provides city planners and private developers an urban development model, which allows for the creation of unexpected public space with educational and recreational opportunities.

This ongoing research explores environmental cultural connections in urban hydraulic infrastructures. It is a mediated examination/presentation of socio-cultural impact using multiple personal observations and photographs as the primary data sets. Images of multiple actors – birds, people fishing, beaver, children playing, fish, ducks, for example - serve as data sets, as a means of presentation of results, and as recursive stimuli to deeper examination. Observation and image making have been underway for several seasons and are continuing now.



Examination of changes over time in the actors and events (families fishing and scissor-tail fly catchers in the spring; boaters and beavers in the summer; disc golfers and fairie rings later in the year) are compared between photographs. The number and character of interactions are noted over time. Photographs serve as memory aids and, at the same time become their own sign of interactions between photographers and sunsets or damsel flies. Photographs provide means for determining the nature of the boundaries of the SCS #16 area – water at the shore and Peterbilt trucks parked. These data are compared with a new model of reclaiming the infrastructure as socio-cultural nexus.

Works Consulted

American Planning Association. (2006). *Planning and urban design standards*. Hoboken, NJ: John Wily & Sons.

Beatley, T. (2000). *Green urbanism: Learning from European cities*. Washington, DC: Island Press.

Benedict, M.A. (2000). Green infrastructure: A strategic approach to land conservation. Retrieved from http://www.treelink.org/docs/GreenInf.PDF.

Benedict, M.A. and McMahon, E.T. (2003). Green infrastructure: smart conservation for the 21st century. Sprawl Watch Clearinghouse Monograph Series. Retrieved from http://www.sprawlwatch.org/greeninfrastructure.pdf.

Benedict, M.A. and McMahon, E.T. (2006). *Green infrastructure: linking landscapes and communities.* Arlington, VA: Conservation Fund.

Building Green Infrastructure. (2000). Retrieved from the Trust for Public Land Web site: http://www.tpl.org/tier3_cdl.cfm?content_item_id=915&folder_id=745.

Colorado Department of Public Health and the Environment. (n.d). WPCRF green infrastructure definition. Retrieved from http://www.cdphe.state.co.us/wq/financialsolutions/pdf/WPCRFGreenInfraDef.pdf.

Conservation Fund. (2009). *What is green infrastructure?* Retrieved from http://www.greeninfrastructure.net/content/definition-green-infrastructure.

Day, S.D., and S.B. Dickinson (Eds.) 2008. Managing stormwater for urban sustainability using trees and structural soils. Blacksburg, VA: Virginia Polytechnic Institute and State. Retrieved from http://www.cnr.vt.edu/urbanforestry/stormwater/Resources/TreesAndStructuralSoilsManual.pdf.

Erickson, D. (2006). *Metro Green: Connecting open space in North American cities*. Washington, DC: Island Press.

(2003). Gray and Green Infrastructure. *Public Management*, *85*(5), 28. Retrieved from Social Sciences Abstracts (H.W. Wilson) database.

International Stormwater BMP Database. (n.d.) Retrieved from http://www.bmpdatabase.org/.

Kessel, J. (2010). Shoring up Shoal Creek. *Stormwater*, *11*(1), 24-31. Retrieved from Environment Complete database.

National Research Council. (2008, October 15). Urban stormwater management in the United States. Washington, DC: National Academies Press.

Olsenius, C. (2010, May-June). Institutional barriers to wetlands protection at the local level. *National Wetlands Newsletter*, *32* (3), 16-19. Retrieved from the Environment Complete database.

Pires, M. (2004). Watershed protection for a world city: the case of New York. *Land Use Policy*, (21), 161-175. Retrieved from the ScienceDirect database.

President's Council on Sustainable Development. (1999, May). *Towards a sustainable America*. Retrieved from http://clinton2.nara.gov/PCSD/Publications/tsa.pdf.

Prince George's County (Md.). Department of Environmental Resources. (1999). *Low-Impact Development Hydrological Analysis*. Retrieved from http://www.lowimpactdevelopment.org/pubs/LID_Hydrology_National_Manual.pdf.

Randolph, J. (2004). *Environmental land use planning and management.* Washington, DC: Island Press.

Richards, L. (2009, Winter). Managing stormwater runoff: a green infrastructure approach. *Planning Commissioner's Journal* , (73).

Smith, B.R. (2009). Re-thinking wastewater landscapes: combining innovative strategies to address tomorrow's urban wastewater treatment challenges. *Water and Science Technology, 60* (6), 1465-1473. Retrieved from the Environment Complete database.

Stormwater Authority. (n.d.) *Best Management Practices*. Retrieved from http://www.stormwaterauthority.org/bmp/.

Tzoulas, K., Korpela, K, et. al. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning*, (81), 167-178. Retrieved from the Science Direct database.

U.S. Environmental Protection Agency. (2000, October 15). Low impact development (LID): A literature review. Retrieved from http://www.epa.gov/owow/nps/lid/lid.pdf.

U.S. Environmental Protection Agency. (2008, January 9). *National menu of stormwater best management practices.* Retrieved from http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm.

U.S. Environmental Protection Agency. (2009a, May). *Stormwater management handbook: Implementing green infrastructure in Northern Kentucky communities.* Retrieved from http://www.epa.gov/smartgrowth/pdf/northern_kentucky_ch1-4.pdf.

U.S. Environmental Protection Agency. (2009b, October 16). *Green infrastructure and green communities: Linking landscapes and communities*. Retrieved from http://www.epa.gov/greenkit/green_infrastructure.htm.

U.S. Environmental Protection Agency. (2010a, February 10). *Low Impact Development (LID)*. Retrieved from http://www.epa.gov/nps/lid/.

U.S. Environmental Protection Agency. (2010b, May 6). *Municipal handbook*. Retrieved from http://cfpub.epa.gov/npdes/greeninfrastructure/munichandbook.cfm.

U.S. Environmental Protection Agency. (2010c, May 11). *Types, applications and design approaches to manage wet weather.* Retrieved from http://cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm#greendev.

Von Storch, H., Gonnert, G, and Meine, M. (2008, December). Storm surges – an option for Hamburg, Germany, to mitigate expected future aggravation of risk. *Environmental Science & Policy, 11* (8), 735-742.

Wadzuk, B., Rea, M., Woodruff, G., Flynn, K., & Traver, R. (2010). Water-Quality Performance of a Constructed Stormwater Wetland for All Flow Conditions. *Journal of the American Water Resources Association*, *46*(2), 385-394. doi:10.1111/j.1752-1688.2009.00408.x. Retrieved from the Environment Complete database.

Walmsley, A. (2006). Greenways: Multiplying and diversifying in the 21st century. *Landscape and Urban Planning*, (76), 252-290. Retrieved from the ScienceDirect database.

Weber, T., Sloan, A. and Wolf, J. (2006). Maryland's green infrastructure assessment: development of a comprehensive approach to land conservation. *Landscape and Urban Planning, 77*, 94-110. Retrieved from the ScienceDirect database.

Wickham, J.D., Riitters, K.H., Wade, T.G., and Vogt, P. (2010). A national assessment of green infrastructure and change for the conterminous United States using morphological image processing. *Landscape and Urban Planning*, (94), 186-195. Retrieved from the ScienceDirect database.

Wise, S. (2008). Green Infrastructure Rising. *Planning*, *74*(8), 14-19. Retrieved from Academic Search Complete database.