Dense and Beautiful Stormwater Management

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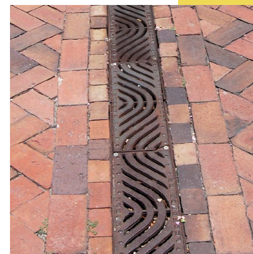
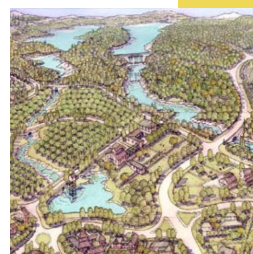
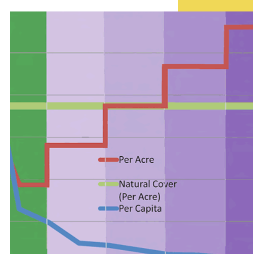
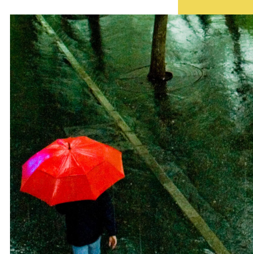




SUMMARY

The practice of stormwater engineering and design possesses the technical capacity to both manage stormwater well and encourage smart growth development. However, stormwater standards and regulations frequently put compact urban development at a competitive disadvantage, which may unintentionally promote sprawl development patterns and unnecessarily damage watersheds. Four guidelines for stormwater management are proposed to encourage compact neighborhood development: (1) recognize density as a best management practice; (2) allow off-site mitigation, preferably in the neighborhood; (3) plan according to the Transect (neighborhood context); and (4) design according to the Transect (neighborhood context).

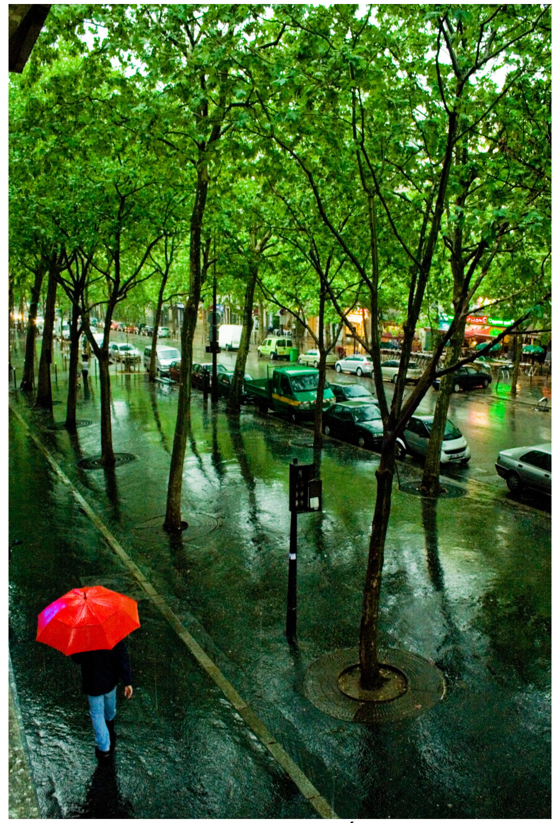




Consider two views about sustainable cities. Call one the Green City, and the other the Compact City.

Green City: *A sustainable city is a green city. It has lots of plants and trees that make the city more beautiful, provide habitat for wildlife, and help clean the air and water. It even has community gardens where people grow food and flowers.*

Compact City: *A sustainable city is a compact city. It has lots of buildings and activities conveniently close together so people can walk, bike, and take transit. It even has paved squares and plazas where people gather and participate in markets, performances, free speech, and recreation.*



Rain forest in Paris. Photo credit: Éole

The Green City is popular as never before. Everyone wants more trees, more landscaping, more living green in their neighborhoods. Stormwater standards are shaping up to be the major vector by which the Green City is delivered—even mandated, in many cases. What does this mean for the Compact City? Is there a conflict between the two views?

In fact, both views are necessary. We have the technical know-how to create neighborhoods that are both compact and green. But sometimes standards and regulations don't recognize this, particularly stormwater standards. Well-intentioned stormwater standards and regulations can put compact urban development at a disadvantage. They may have the unintended consequence of promoting sprawl, which hurts watersheds more than compact development.

Unlike many barriers to compact development, this is not a technical, social, financial, or even political problem. It is largely an administrative problem. Doing the right thing is simply more difficult for administrators.

This essay suggests four guidelines for stormwater management that support and encourage compact neighborhood development. These guidelines can help put regulations back on the right track, and may also help to make the job of administering stormwater more manageable:

1. Recognize density as a best management practice
2. Allow off-site mitigation, preferably in the neighborhood
3. Plan according to the Transect (neighborhood context)
4. Design according to the Transect (neighborhood context)

BACKGROUND: STORMWATER AND THE EXISTING REGULATORY REGIME

On natural land, the soil and vegetation soak up rainwater and stormwater. Plants and trees grow, and the soil gradually releases the water. But on developed land, water behaves differently. On developed land with paved and built surfaces (known as "impervious surfaces"), the water doesn't soak into the ground as much. Instead, it flows over the surface. Flowing water from precipitation (known as "runoff") must be handled properly; otherwise it will cause flooding and erosion, and will pollute and damage streams, lakes, and rivers.

In the midst of the post-World War II building boom, researchers and government agencies started noticing the stormwater impacts of rapid, sprawling development (Rome, 2001). Surveys in the late 1950s found that suburban development practices and patterns led to more frequent and severe flooding than regulations had anticipated. Impacts like erosion, landslides, and septic tank failure were also troubling. Agencies and engineers soon developed stormwater mitigation guidelines, and by the early 1970s subdivisions began incorporating the recommendations. The guidelines called for slowing and storing stormwater (for example, with buffers, swales, and impoundment ponds) and preservation of open space (for example, natural stream beds and floodplains).

These features have become ubiquitous in present-day development regulations. They have become mainstream.

The legacy is a strong bias against urban density. The mainstream of stormwater engineering and administration sees urbanization as the culprit: a condition to be penalized and barely tolerated.

BMP AND LID

In 1999, the EPA issued regulations for stormwater management for all municipally owned sewer systems in the U.S., an event described as "the most influential planning phenomenon over the past decade" by former EPA analyst Lisa Nisenson. While the conventional approach to stormwater management emphasized water collection, piping, storage, and discharge, the EPA regulations advocated a more holistic and proactive set of techniques, known as best management practices (BMPs). These combine some or all of the following:

1. Local and regional planning to manage growth and protect ecologically sensitive areas
2. Site design to minimize land disturbance and paved surfaces, and to buffer water bodies with strips of vegetated land
3. Retention of stormwater with facilities such as detention ponds and dry basins
4. Allowing stormwater to percolate into the soil with infiltration facilities such as trenches and permeable or porous pavement
5. Vegetation that absorbs pollutants and assists percolation, used in facilities such as swales, constructed wetlands, and rain gardens

A subset of BMPs is low-impact design (LID) or environmentally sensitive design (ESD). The goal of LID is to emulate the stormwater function that a site had in its natural state, before it was touched by humans. LID techniques can include green roofs, cisterns, rain gardens, permeable pavement, and swales.

LID techniques are extremely popular in the field of landscape design today, and for good reason. They are usually less costly than conventional practices and often perform better. Regulators are moving to require these techniques in all land development regulations. For many practitioners, LID represents the essence of sustainable urbanism—the melding of biophilia, aesthetics, ecological performance, and habitat protection.

But the universal and inflexible application of BMPs and LID can have significantly negative consequences on the quality of urban places and the health of watersheds. LID purports to encourage smart growth and urban redevelopment, but as a rule this support is nominal, little more than lip service. In general practice, LID puts urban density at a competitive disadvantage.

The best way to reduce stormwater impacts is well-designed urban density in conjunction with regional planning that preserves natural land. Compact, walkable urbanism is by far the best performer on a per-capita basis, and can be a superior performer on a per-neighborhood and per-watershed basis. But most stormwater standards and regulations pursue the Green City and disfavor the Compact City. They promote green-yet-low-density development—green sprawl, so to speak.

Low-impact subdivision: LID in sprawl. Image credit: Lisa Nisenson

At the larger regional scale, this has the opposite effect than intended, and results in greater damage to the watershed. Thus the stormwater regulatory regime in the U.S. can be self-contradictory and even self-defeating.

Four principles can help correct this unfortunate and unnecessary situation.

RECOGNIZE DENSITY AS A BEST MANAGEMENT PRACTICE

Many experts and organizations have confirmed that dense development reduces per-capita stormwater impacts, and thus can dramatically reduce the total impact on watersheds. A great introduction to this idea is the EPA's Smart Growth page on water.

Two EPA reports are highly relevant and have been widely cited. *Protecting Water Resources with Higher-Density Development* makes the case for planning a variety of densities to better manage stormwater. A simple mathematical model compares development at 1 dwelling per acre with development at 8 dwellings per acre. The model shows that higher density reduces the runoff per dwelling by 73 percent. Building the same number of houses at the higher density reduces impervious surfaces by 60 percent.

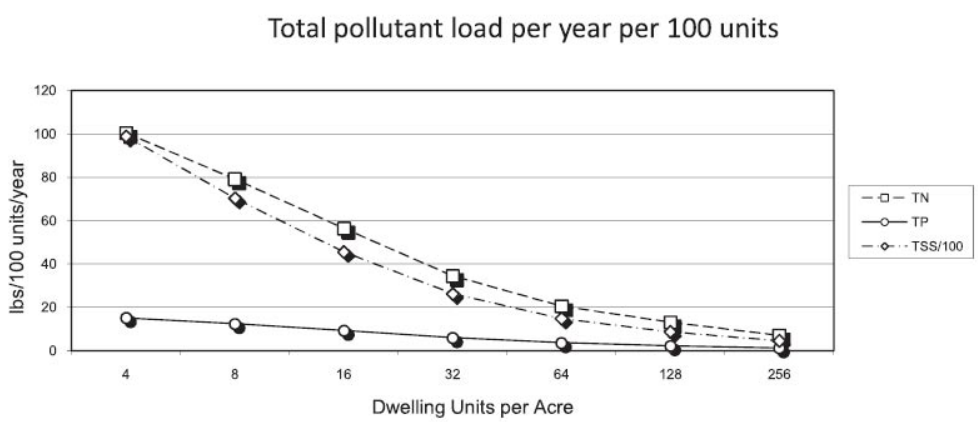
The EPA report *Using Smart Growth Techniques as Stormwater Best Management Practices* reviews a variety of smart growth practices and their relationship to stormwater management. The report describes how land preservation should be paired with compact development:

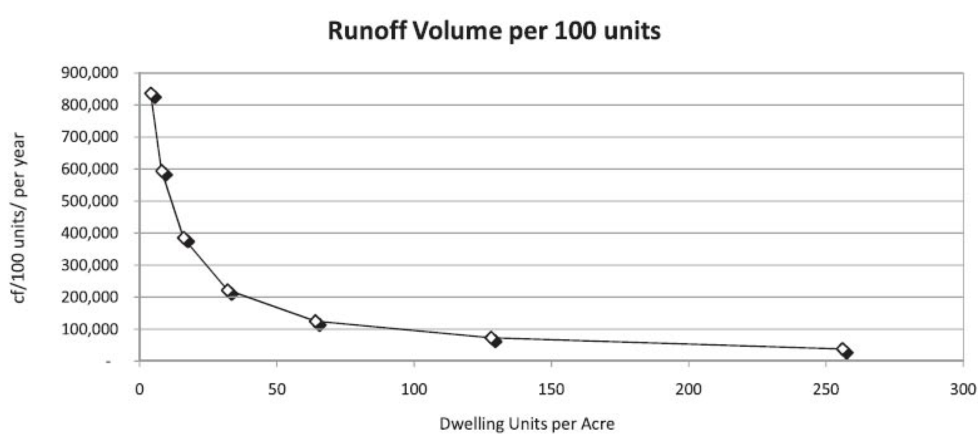
> A first step is to plan for strategic preservation of continuous tracts of open space. Second, preservation of critical ecological areas such as riparian corridors, stream buffers, flood plains, and wetlands is needed. These parcels are of critical importance in developed areas to absorb and filter stormwater. Third, for land that is to be developed, smart growth strategies such as higher density and more compact development serve to disturb less land and accommodate more development.
>
> – *Using Smart Growth Techniques as Stormwater Best Management Practices*, p. 59

One major reason that smart growth is so important to watershed protection is the fact that stormwater problems are largely an automobile problem. As Tom Schueler of the Center for Watershed Protection notes, “Two-thirds of all impervious coverage today is to provide habitat for cars—parking lots, driveways, roads and highways.”

A 2009 study by Jacob and Lopez takes the modeling a step further. “Is Denser Greener? An evaluation of higher density development as an urban stormwater-quality best management practice” uses more sophisticated stormwater runoff models and applies them to a range of urban densities. These graphs show the relationship of density to runoff volume and runoff water quality.

The models show that improvements in per-dwelling pollutant load start at 4-12 dwellings per acre. Dramatic improvements in per-dwelling runoff volume start at 4 dwellings per acre and begin to level out at around 20-30 dwellings per acre. The increase in benefits is less dramatic above





Above: Total pollutant load per year per 100 units. Below: Runoff volume, per 100 units per year, as a function of dwelling units per acre, model scenario. Image credits: John S. Jacob and Ricardo Lopez.

those densities.

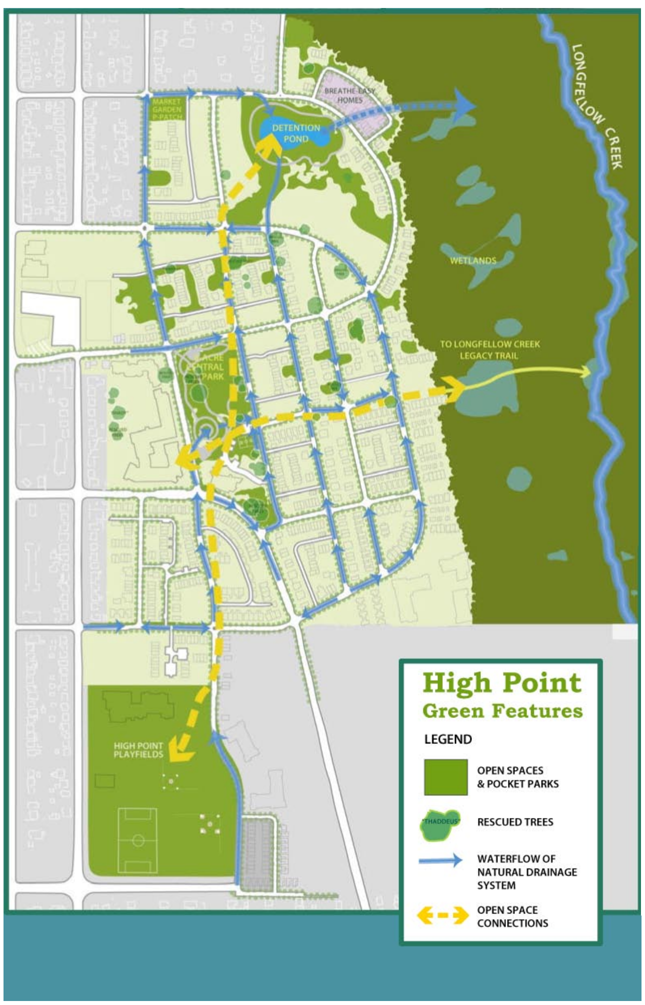
Many historic, 2-4 story city neighborhoods exist at those densities, like Alexandria, VA, or Oak Park, IL, or the French Quarter in New Orleans. Housing types in those places may be a mix of single-family, rowhouse, and low-rise multifamily buildings.

The study concludes with a remarkably strong endorsement of urban density:

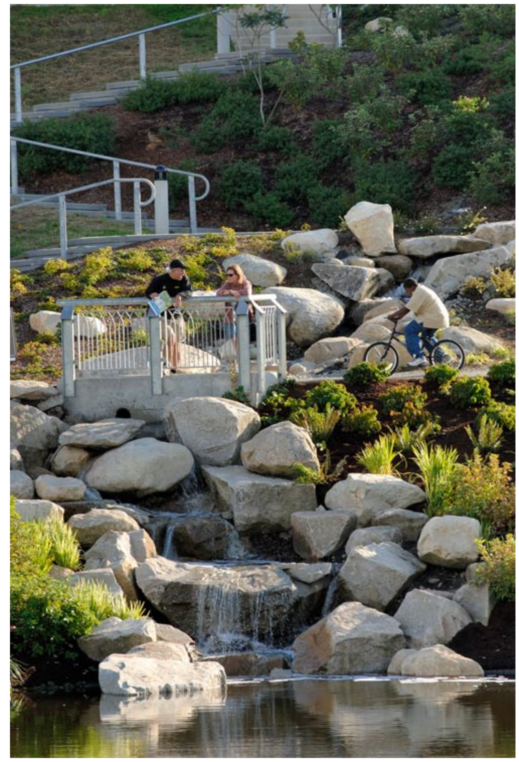
> … building a denser city is not only not contrary to improving runoff water quality from urban areas, **it may be the single most important practice any city can undertake to improve the surrounding environment.** *(emphasis added)*
>
> – Is Denser Greener?

ALLOW OFF-SITE MITIGATION, PREFERABLY IN THE NEIGHBORHOOD

Developments are usually required to manage their stormwater on-site, which means that site boundaries are all-important to the administration of stormwater regulations. The boundary of a site may delineate a single lot with a single building. Or the boundary of a site may encompass an entire neighborhood with hundreds of lots and buildings. This has huge implications for the design and applica-



High Point: Left, green features map. Image credit: Seattle Housing Authority. Above right, swale and pocket park. Below right, rain garden under construction. Photo credits: Mithun



High Point: Left, detention pond and park. Right, waterfall flowing into detention pond. Photo credits: Mithun

tion of stormwater BMPs.

Large, neighborhood-scale projects inherently have more options. They can use *shared solutions*—BMPs within their public spaces, streets, and parks—to receive and absorb runoff.

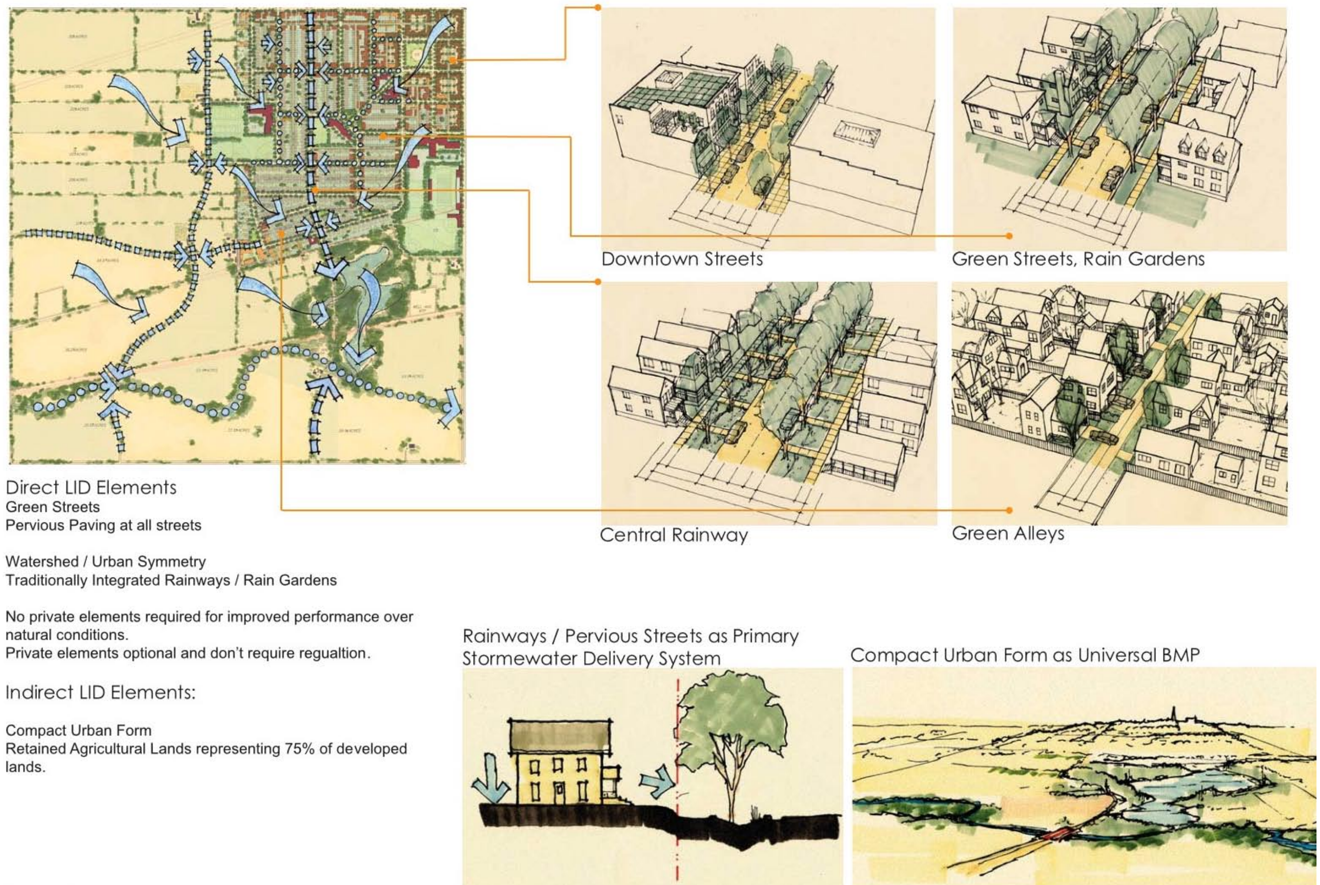
The High Point development in Seattle, WA, has won numerous awards as a exemplary model of smart growth, receiving special praise for its stormwater management. High Point also provides affordable housing, mixed use, walkability, brownfield redevelopment, and new parks and gardens.

High Point features an elaborate three-part stormwater system: (1) lot-level BMPs include furrows, dispersion trenches, rain gardens, and pervious pavements; (2) block-level BMPs include swales and berms which also serve as pedestrian crossing points; and (3) a community-level stormwater pond and parks. The system removes 80 percent of total suspended solids, reduces runoff from 2-year storm events to predevelopment volumes, and controls the peak flow from 100-year storm events.

Another model example is the "Salon des Refuses" proposal for Katy, TX, submitted to the Houston Land/Water Sustainability Forum's LID Design 2010 Competition. The project maintains the predevelopment runoff characteristics of the site using 100 percent shared, community-level infrastructure; no lot-level BMPs are needed. The project description states that "… privately owned and operated measures were not needed to achieve the hydrology goals of this neighborhood. Compact development, green streets, and constructed wetlands BMPs alone more than exceeded the goals."

High Point and the Katy competition entry work because they are large sites that can employ shared solutions. But when mainstream stormwater standards and regulations are applied to individual lots within larger areas, even moderately dense neighborhoods like High Point and Katy become impossible.

The National Research Council's comprehensive review of stormwater management observes that:



Stormwater infrastructure incorporated into street types calibrated to the Transect. The project did not win the Houston Land/Water Sustainability Forum competition, but it did win a CNU Charter Award in 2010. Image credit: Dreiling Terrones Architecture and Crabtree Group Inc.

> … on-site stormwater management controls are often recommended as the preferred means of stormwater management, although they tend to encourage lower-density development patterns. And while they are easily implemented and regulated given the incremental, site-by-site development that is typical of most urban growth, monitoring and maintenance can be expensive and difficult for both the individual property owner and the regulating authority.
>
> – *Urban Stormwater Management in the United States*, p. 372

A small urban project, such as a single building that occupies all of its lot, doesn't have the option of shared solutions. It is forced to use more expensive or intrusive BMPs such as green roofs, cisterns, or above-ground tanks. Thus, it is put at a cost disadvantage or functional/operational disadvantage despite its superior per-capita performance. Larger sites with more vegetated ground and open space have cheaper stormwater options available, such as swales, rain gardens, and ponds.

It is easy to understand why regulators want land parcels to retain most of their stormwater on the premises. Seven hundred and seventy-two cities in the United States have antiquated storm sewer systems, so that during heavy rains, raw sewage overflows into nearby rivers and lakes. Cleaning up this mess is an excellent goal, but required on-site retention for urban sites discourages dense, walkable urbanism. The policy is detrimental to the watershed because it promotes sprawl (albeit nicely landscaped sprawl):

Setting overly ambitious or costly goals for urban streams may result in the perverse consequence of causing more waters to fail to meet [standards]. For example, consider efforts to secure ambitious [standards] in highly developed areas or in an area slated for future high-density development. Regulatory requirements and investments to limit stormwater quantity and quality through open-space requirements, areas set aside for infiltration and water detention, and strict application of maximum extent practicable controls have the effect of both increasing development costs and diminishing land available for residential and commercial properties. Policies designed to achieve exceedingly costly or infeasible [standards] in urban or urbanizing areas could have the net consequence of shifting development (and associated impervious surface) out into neighboring areas and watersheds.

… In such a case, it might be sound water quality policy to accept higher levels of impervious surface in targeted locations, more stormwater-related impacts, and less ambitious [standards] in urban watersheds in order to preserve and protect designated uses in other watersheds.

– *Urban Stormwater Management in the United States*, pp. 289-290

The Chicago Center for Green Technology has four 3,000 gallon cisterns, plus a green roof, vegetated swales, and a constructed wetland area. On smaller urban sites, stormwater elements such as these may be intrusive and interfere with visibility and pedestrian access. Image credit: Burke Group Events

Analyst Lisa Nisenson put it more succinctly:

… if local governments are having a hard time attracting development to these vacant sites now, how are strict rules that make redevelopment even more expensive and difficult going to help? … For redevelopment, there is a regulatory sweet spot: pushing for as much on-site stormwater management as possible without tripping decisions that result in no improvement at all.

– A Browner Shade of Green

Furthermore, stormwater regulations only apply to new construction and redevelopment, not to existing development. In other words, new and redeveloped sites are supposed to bear the entire burden of solving existing stormwater problems. This hits urban redevelopment projects especially hard. The net result of these well-intentioned but misguided policies is a watershed with more habitat lost to development, more impervious surface, and more impaired streams.

Site-by-site review is the easiest and most common way to address stormwater because that is how the entire real estate industry is set up. Building permits, zoning changes and variances, traffic impact studies, building inspections, bank loans, investments, and property taxes—with few exceptions, these activities are administered on a site-by-site basis. Most local governments have a building permit department, but far fewer have a planning department. Planning for the health of an entire watershed is more complicated and less familiar.

But site-level administration is an inferior and harmful method if the ultimate goal is good watershed health. Stormwater policy should not only *allow* off-site mitigation, in addition it should not penalize or disfavor off-site mitigation. A level playing field is the minimum requirement for smart growth objectives.

SHARED SOLUTIONS IN CLOSE PROXIMITY

When planning shared stormwater solutions, consider that *BMPs are more effective the closer they are to the source of runoff*. Close proximity allows the linkage between source and solution to be clearly visible. In the case of BMP failure or poor maintenance, a BMP can be traced back to its source. The evidence to date suggests that managing stormwater within the boundaries of a neighborhood can work well.

The farther that runoff is shipped, the less environmentally effective the system overall. More distant receiving areas require more pipes and underground infrastructure, and may require more energy-intensive water pumping. For instance, Southern California imports most of its water. Water conveyance for Southern California requires more than 50 times the energy than it does for Northern California. In some areas like San Diego County, water conveyance constitutes several percent of the total electricity demand (Cohen et al., 2004).

In some cases, off-site mitigation can perform adequately at distances that are farther than the immediate neighborhood. Cities with separated stormwater systems may have the capacity to pipe stormwater longer distances to receiving areas that can absorb runoff and its pollutants in sustainable ways. But as distances grow, the ability to monitor specific sources and link them to BMPs far downstream becomes more difficult.

The extreme of off-site mitigation is when the physical link is broken entirely. Urban sites may have the option of paying into a fund instead of meeting strict on-site stormwater requirements. The fund is used to upgrade storm sewers or install BMPs elsewhere in the watershed. This approach requires careful tuning to avoid placing density and urban redevelopment at a cost disadvantage. Any fees should reflect the fact that dense urban sites have the lowest per-capita stormwater impact.

Another popular idea is tradeable stormwater credits. Urban sites are given the option to purchase credits that in theory offset their stormwater impacts. The impacts of runoff in one location are traded for the absorbing capacity of another location, which may be in an entirely different region or watershed.

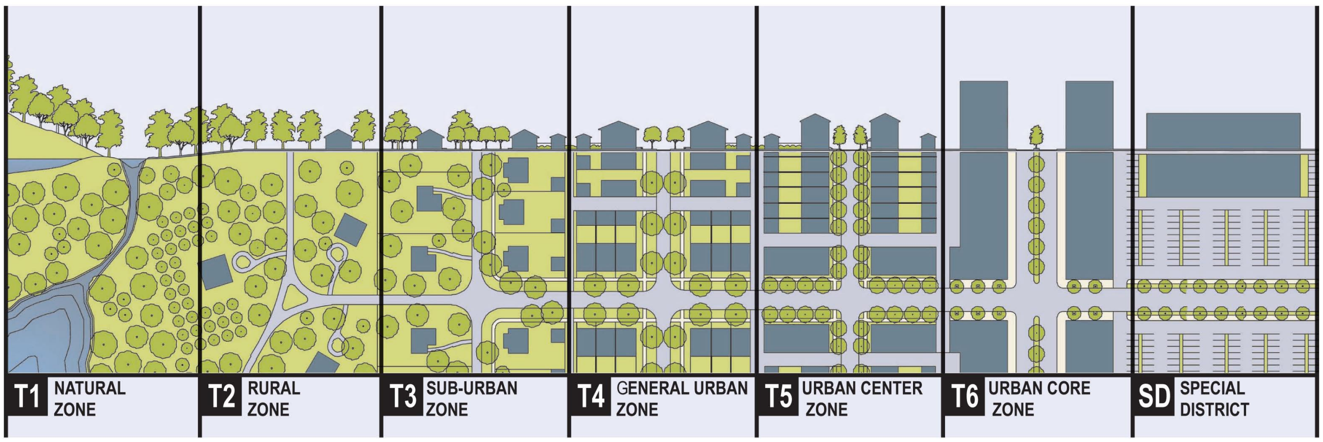
This raises a lot of issues. Urban/high-density sites generally will pay, and suburban/low-density sites will get paid—setting up yet another bias in favor of sprawl. Who will verify that credit-producing buffers are preserved and that rain gardens, green roofs, and so on, are maintained over the long term? Without preservation and maintenance, the BMPs won't perform as advertised. Will tradeable credits require a department of on-site inspectors making annual visits?

When shared solutions are nearby to a site, BMP failure is easy to observe and trace back to individual sites. When credits are traded statewide, everything gets very abstract and hard to enforce. Tradeable credits have similar problems as carbon offsets—lots of optimistic talk, but sometimes subpar performance that just doesn't get the job done. The intricacies and loopholes of credit trading are a bonanza for lawyers, though.

PLAN ACCORDING TO THE TRANSECT (NEIGHBORHOOD CONTEXT)

Great neighborhoods have a variety of streets and blocks with different kinds of character, serving a broad range of real estate market desires. Some people like homes with generous yards and gardens, set on quiet streets with no retail businesses. Some people prefer houses with only a small patio or terrace to maintain, set in main street environments with a range of shops and services nearby. And some like apartment living with downtown intensity, in neighborhoods with nightlife or major cultural venues and institutions nearby.

This way of understanding urban environments is based on the *rural-to-urban Transect* concept. The Transect is a system of classifying urban environments from rural to urban, according to intensity and character. This diagram by Duany Plater-Zyberk is the classic representation of the concept:



Transect zones on a spectrum from rural to urban. The diagram is generic and does not represent an actual place or specific recommendation. Image credit: Duany Plater-Zyberk & Company and Center for Applied Transect Studies

The goal of Transect-based planning is to serve a variety of preferences for urban environments, delivered in neighborhoods that are compact and complete. Each environment has an identifiable character that results from the coordination of urban design elements in an internally consistent manner. These environments are called Transect zones, and they range in size from a few acres to tens of acres. Good neighborhoods are composed of three or more Transect zones.

The illustration (right) of a generic traditional town shows that denser, more intensive Transect zones (T5 and T6) occupy a relatively small percentage of land within a neighborhood or town. The majority of land in a traditional neighborhood or town is occupied by T1 through T4 zones.

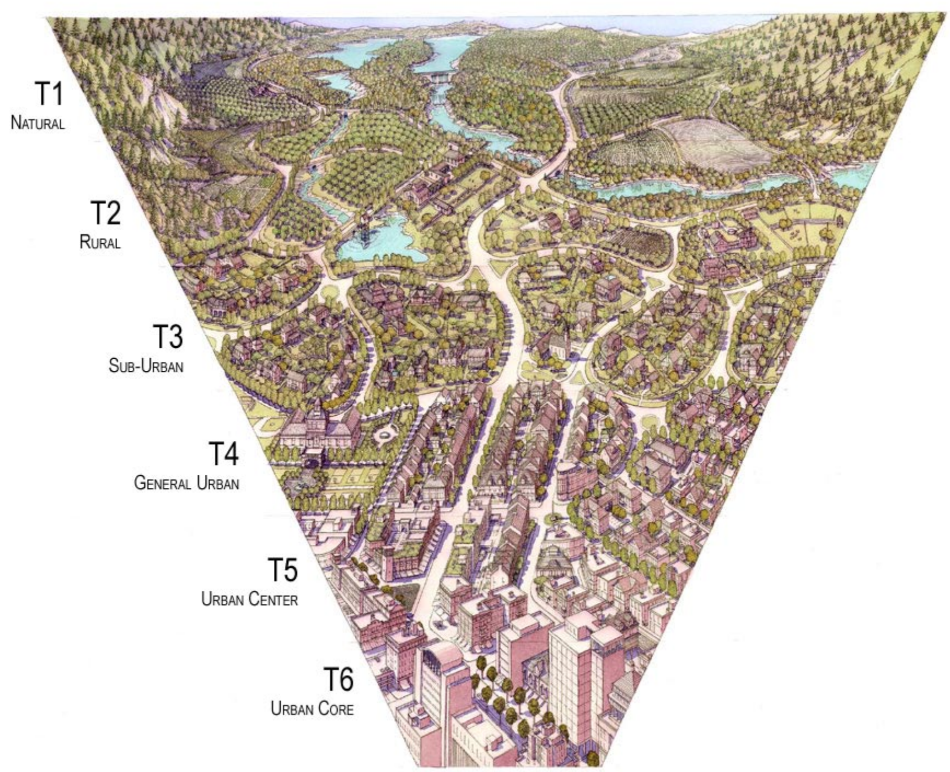


Image credit: Duany Plater-Zyberk & Company and Center for Applied Transect Studies

Paul Crabtree of Crabtree Group has developed an innovative and promising approach to Transect-based stormwater planning. The key is that lower-intensity zones can easily retain and absorb stormwater, while in higher-intensity zones the difficulty and cost of retaining stormwater is much greater. Lower-intensity zones can retain extra stormwater, thereby balancing the runoff generated by higher-intensity zones.

Crabtree has implemented this approach in plans such as Wharton Town Center in South Fork, CO (adopted in June 2009) and the Regional Watershed Management Plan for the towns of Westcliffe and Silver Cliff, CO. For the aforementioned Houston Land/Water Sustainability Forum competition entry, Crabtree used this approach to plan stormwater infrastructure and model its impacts.

The table below illustrates the conceptual basis of this method. To understand the table, a word needs to be introduced. Engineers describe stormwater using characteristics such as runoff volume, time of concentration, and peak flow. The alteration of these characteristics is called *hydromodification*.

	T1: Natural	T2: Rural	T3: Sub-Urban	T4: General Urban	T5: Urban Center	T6: Urban Core
Difficulty of stormwater retention	N/A	Very easy	Easy	Average	Onerous	Very onerous
Hydromodification allowed or required	N/A	50% reduction required	25% reduction required	0	25% addition allowed	50% addition allowed

The difficulty of stormwater retention in various Transect zones (top row) corresponds to the hydromodification that is required to be reduced, or that is allowed to be added (bottom row).

The T2 and T3 zones are required to retain more runoff than the "natural land" condition would. The T5 and T6 zones are allowed to have greater stormwater impacts than the "natural land" condition. The T4 zone represents the balance point where runoff characteristics must be equal to the "natural land" condition.

Runoff Volume
SmartCode Greenfield TND

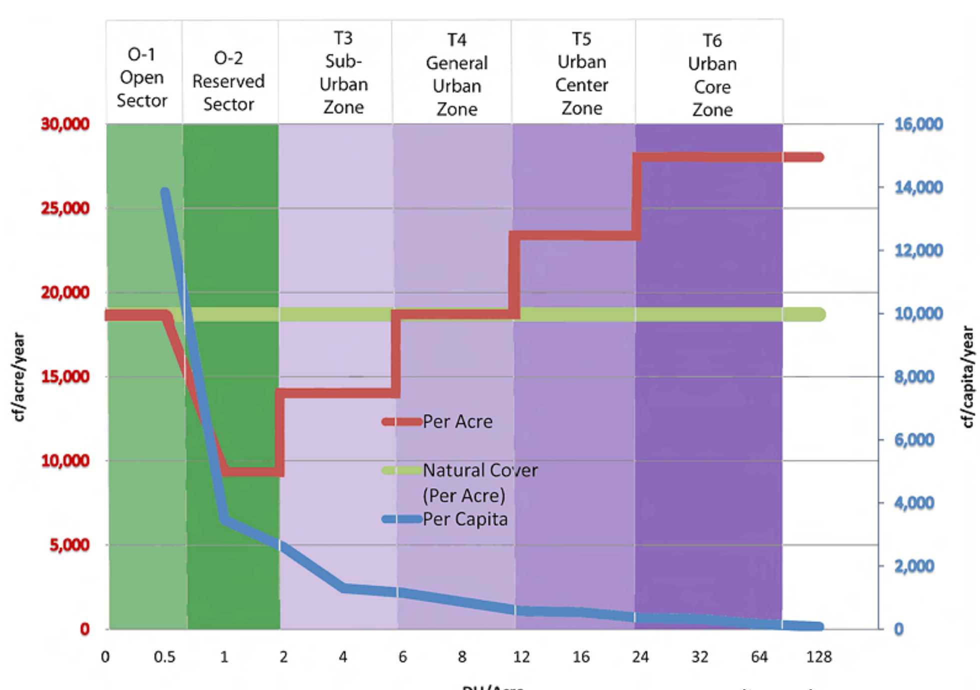


Image credit: Crabtree Group, Inc.

The graph to the right illustrates the same idea; the light green horizontal line represents the "natural land" condition.

To put the idea into practice, the stormwater engineer calculates multiplication factors for each Transect zone. The followng table shows generic multiplication factors for a greenfield new urbanism development:

	T1: Natural	T2: Rural	T3: Sub-Urban	T4: General Urban	T5: Urban Center	T6: Urban Core
Multiplication factor	N/A	1/3	1/6	1/12	N/A	N/A

Table of generic multiplication factors. No development is allowed in T1; no storage is required in T5 and T6.

The designer, developer, or builder uses the multiplication factors to determine the actual storage requirements. One would multiply the area of impervious surface added (in square feet) by the multiplication factor to determine cubic feet of stormwater storage required.

For instance, a builder would:

1. Look at the Transect-based regulating plan to see which Transect zone he is building in
2. Measure the amount of impervious surface he is adding
3. Multiply that square footage by the factor given in the table
4. Provide that amount of storage volume using the appropriate Light Imprint methods (discussed in the next section)

The factors shown here are generic; the actual engineering involves a more complex process of modeling, customization, and testing. Crabtree describes his firm's approach:

> The transect multipliers are derived both theoretically and empirically through an iterative process. … we run the hydrology model to test the performance of the watershed so that there is either no overall watershed impact due to community development, or that the hydrology of the watershed is actually improved by the development … We also test the multipliers on a few actual sites in different Transect zones to make sure they can be accomplished without denigrating the urbanism realm of the Transect for the site. This tuning process is iterative until we obtain a set of multipliers that perform well both theoretically and empirically both for the watershed and the pedshed. The net result is a watershed hydrology regulation that improves the hydrology of the watershed and supports existing *and* improved urbanism.
>
> – Rainwater in Context listserv communication, 28 May 2009

Crabtree has also written a Regional Watershed module for the SmartCode (a Transect-based, open-source model zoning code) that enables this scheme for the community and regional scales.

DESIGN ACCORDING TO THE TRANSECT (NEIGHBORHOOD CONTEXT)

When discussing the minutiae of environmental policies and practices, it's all too easy to overlook the elements that makes urbanism pleasurable to live in—especially beauty and delight. Throughout history, the greatest towns and cities were designed with beautiful vistas and spaces intended to delight their inhabitants. The treatment of water was no exception, and craftsmen and landscapers often created parks, canals, and fountains that were works of art in their own right.

Today, the role of beauty in place making is denigrated. Some philosophies even propose that beauty is in the eye of the beholder, a purely individual response. But beauty is not so hard to identify. People enjoy urban environments of high aesthetic quality, and show their preference by popularizing those places. Beautiful, walkable streets and neighborhoods are in greater demand, visited more often, and valued more highly. Beauty and delight are important contributors to a good quality of life, and more so when combined with functional purposes such as stormwater management.

A system that marries traditional neighborhood design with environmentally sensitive stormwater management is Light Imprint, developed by Tom Low of the Duany Plater-Zyberk & Company Charlotte office.

Left: photo credit, *Light Imprint Handbook*. Right: French drain, Savannah, GA. Photo credit: *Light Imprint Handbook*

Light Imprint draws upon the global heritage of urban water management solutions that have proven their worth over long spans of time. These include small park areas, street trees, pools, drains, masonry troughs, paving treatments, and so forth. LID techniques such as green roofs and rain gardens are included but not overemphasized or universally promoted. French drains and underground pipes in higher-intensity Transect zones are also included. Light Imprint promotes "trains of treatment"—linking BMPs in a functional series that applies water treatments sequentially. Compared to the standard suite of BMPs, Light Imprint aims to:

- Utilize more natural, more durable, less costly solutions
- Reduce intrusive and overengineered solutions
- Draw upon the vast history of town and city building for beautiful and proven solutions
- Allocate each solution to appropriate Transect zones
- Maintain compact urban form and walkable streets and public spaces
- Draw upon the latest engineering advances when consistent with the above goals

The Light Imprint Toolbox Matrix presents a wide range of stormwater solutions, and allocates each one to the Transect zones it is best suited for. For instance, a wide, grassy swale is suitable for a T3 street frontage, but not for a T6 downtown setting. Masonry water channels and elaborately artistic fountains can be wonderful in a T5 town or village center, but are less suitable for T2 rural roadway frontages.

Why is it so important to design stormwater solutions according to the Transect? The *Light Imprint Handbook* offers one perspective:

Spread from the *Light Imprint Handbook* compares LID vs. Light Imprint treatments of commercial and residential frontages (pp. 124-125).

Suburban retail with Low Impact (LID) standards has green space, but compromises walkability and connectivity between businesses.

A Light Imprint urban design, along with being green, readily conforms to community walkability and connectivity between businesses.

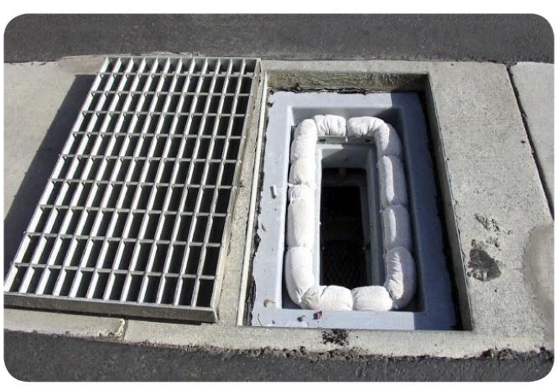
Low Impact Development (LID) tools intended for suburban development apply rain gardens on sprawling front lawns.

In walkable communities with compact yards, a Light Imprint communal rain garden is applied to serve a group of homes.

Spread from the *Light Imprint Handbook* compares LID vs. Light Imprint treatments of parking and drainage (pp. 126-127).

This conventionally engineered suburban parking lot has excessive and costly infrastructure to support its rain gardens.

This Light Imprint parking lot provides a low tech solution using pervious stone. It is beautiful with or without vehicles.



This grate inlet skimmer box is an expensive and high maintenance method of filtering stormwater. These tools are generally categorized as high-tech green solutions.

This vegetative and stone swale leading to a filtration pond is both a beautiful and more economical method of channeling and filtering stormwater. Light Imprint tools are generally categorized as intrinsically green tools.

> Finally, without intensive calibration, LID may actually prevent sustainable development. Many of its standards and practices involve lot-based, rather than block- or neighborhood-based, solutions; that increases the need for large lots. For instance, despite their environmental benefits, putting rain gardens in front of houses increases the front setback significantly. To foster walkable urbanism, the houses need to be close to the sidewalk.
>
> … compact development suffers when the BMP techniques result in stormwater detention areas in front of or beside buildings. This approach prevents social connectivity. In addition, shop owners find that detention areas in front of their buildings interfere with the customers' access to goods and services.
>
> – *Light Imprint Handbook*, pp. 121, 128

The zealous and unidimensional insertion of green space in all contexts and in all situations degrades the pedestrian functionality of heavily trafficked spaces. It disperses buildings into more scattered patterns, creating awkward obstacles to the flow of foot traffic, and preventing the continuous, spatially defining frontages needed for successful pedestrian-oriented retail. Inserting green space into the most intensively urban places regardless of design or context makes walking more inconvenient—precisely where it is most desirable.

Furthermore, some types of BMPs are more prone to wear and tear when placed in intensively urban environments. Downtown streets are a tough environment for plants, as they face challenges like high foot traffic, mechanical damage, deposits of grit, salt and particulates, and litter accumulation. Porous pavement requires more frequent cleaning in high-traffic urban areas; otherwise it will clog up and stop functioning as designed.

Green stormwater solutions must be allocated by context in order to meet the functional requirements of good urbanism: pedestrian-oriented frontages, walkability, viable retail, active civic spaces (such as squares and plazas), close proximity to mixed use and daily activities, and so on.

CONCLUSION

This essay proposes four principles for stormwater management policy that support attractive, compact, and walkable urban development. In regards to density and urban redevelopment, the mainstream of the stormwater industry frequently pursues policies that have contradictory and self-defeating results. Policies should counter the pervasive trend that Lisa Nisenson describes:

> It seems like no matter the regulation or rule, sprawl gets easier and redevelopment gets harder, whether it's finance, stimulus, or stormwater. Urban areas face standards to re-create natural areas, while new development gets to deface nature as long as the spreadsheet works out.
>
> – Rainwater in Context listserv communication, July 15, 2009

A few innovative regulations point the way towards common sense and relief. The West Virginia statewide stormwater permit reduces requirements for projects that are redevelopment, high-density development, or transit-oriented development. In Ventura County, CA, projects may be exempted from on-site requirements if they discharge to a storm drain, or if they are redevelopment in the urban core and do not alter preproject site runoff characteristics. Policies like these are promising starts; they should be monitored and tested to find out if they are encouraging smart growth and development density.

The EPA's *Water Quality Scorecard* evaluates municipal stormwater management policy. It includes green infrastructure policies as well as a wide range of smart growth policies that reduce stormwater impacts. The *Scorecard* looks at policy at the site, neighborhood, and regional scales, and it also gives credit to policies that support off-site and shared stormwater solutions.

With respect to design in accordance with the Transect, the innovations that have been described in this essay are are fledgling efforts that need to grow. And while scores of Transect-based codes have been adopted, that is still a small percentage of all zoning codes nationwide. Policies, codes, and regulations need to be developed that will:

- Encourage density and recognize the per-capita benefits of density
- Support stormwater solutions that are shared between different sites and landowners
- Develop public-private partnerships to retrofit existing urban areas with shared stormwater solutions
- Better understand the best strategies for various urban patterns and Transect zones
- Help administrators adopt the larger view of what is best for the watershed

Finally and not least, research and policies should emphasize design quality. Many of the great models from history, both large and small, are still relevant today; designers can draw upon the global heritage of urban water infrastructure made for delight and aesthetic refreshment. Stormwater should not be a green chore, but a celebration of the natural and manmade in combination: the dual ingredients of the uniquely human habitat of towns and cities.

RESOURCES

Center for Applied Transect Studies and SmartCode Central (Transect-based planning)

Center for Neighborhood Technology: Green Values Stormwater Management Calculator

High Point, Seattle, WA stormwater design information:

- Project web site
- City of Seattle web site
- Web site of Mithun, the lead design firm
- Profile by Global Green USA
- Profile by Stormwater Journal
- Profile by Sustainable Sites Initiative

Light Imprint Handbook web site

Rainwater in Context listserv

US EPA web pages:

- Low Impact Development (LID)
- Post Construction Controls
- Smart Growth Publications: Water
- Stormwater Discharges From Municipal Separate Storm Sewer Systems (MS4s)

- Stormwater Phase II Final Rule: Post-Construction Runoff Control Minimum Control Measures (Fact Sheet)
- Water Quality Trading

BIBLIOGRAPHY

Cohen, Ronnie, Barry Nelson and Gary Wolff, Energy Down the Drain: The Hidden Costs of California's Water Supply. Natural Resources Defense Council and Pacific Institute, August 2004.

Crabtree, Paul, Principles of Smart Growth and Their Corresponding Rainwater Dos and Dont's. *Stormwater*, March/April 2010.

Goonetillekea, Ashantha, et al., Understanding the role of land use in urban stormwater quality management. *Journal of Environmental Management*, Volume 74, Issue 1, January 2005, pages 31-42. See also an archived copy.

Harbor, J., et al., A Comparison of the Long-Term Hydrological Impacts of Urban Renewal versus Urban Sprawl. US EPA, *Proceedings*, National Conference on Tools for Urban Water Resource Management & Protection, February 7-10, 2000, pp. 192-197.

Hirschman, David J. and John Kosco, *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program*. Ellicot, MD: Center for Watershed Protection, July 2008.

Jacob, John S. and Ricardo Lopez, Is Denser Greener? An Evaluation of Higher Density Development as an Urban Stormwater-Quality Best Management Practice. *Journal of the American Water Resources Association*, Vol. 45, No. 3, 2009, pp. 687-701. See also an archived version.

Kloss, Christopher and Crystal Calarusse, *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Washington, DC: Natural Resources Defense Council, June 2006.

Langdon, Philip, Natural drainage systems can cut NU's development costs. *New Urban News*, January/February 2007.

Lehner, Peter H. et al., *Stormwater Strategies: Community Responses to Runoff Pollution*. Natural Resources Defense Council, May 1999; revised October 2001.

Low, Thomas E., *Light Imprint Handbook: Integrating Sustainability and Urban Design*. Version 1.3. New Urban Press, 2008.

Low, Thomas E., Light Imprint Urbanism—A Framework for Urban and Environmental Sustainability. Paper presented at Congress for the New Urbanism XVI, Austin, TX, April 3-6, 2008.

National Research Council, *Urban Stormwater Management in the United States*. Washington, DC: National Academies Press, 2008. Read online and order the hard copy at the National Academies web site.

Nairn, Daniel, Stormwater Management should work with, not against, Smart Growth. *Discovering Urbanism*, July 7, 2009.

Nisenson, Lisa, A Browner Shade of Green: The New Water Rules and the Next Chapter of Sprawl. *Planetizen*, June 11, 2007.

Nisenson, Lisa, Sustainable Development or Green Sprawl? New Barriers to Infill. Presentation given at New Partners for Smart Growth Conference, Los Angeles, CA, February 8-10, 2007.

Nisenson, Lisa, Thou Shalt Review Ordinances…And Then What? *Stormwater*, October 2009.

Rome, Adam, *The Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism*. Cambridge University Press, 2001.

Schueler, Tom, The Reformulated Impervious Cover Model: Implications for Stream Classification. Technical Bulletin No. 3. Center for Watershed Protection, 2008. See also the summary article, The Reformulated Impervious Cover Model.

Sorlien, Sandy, "All Green is Not Good: Sustainability by the Transect." *CNU Council Report VII: On Green Architecture and Urbanism*. Gaithersburg, MD: The Town Paper, 2008, pp. 26-27.

US EPA, *Protecting Water Resources with Higher-Density Development*. Lynn Richards, principal author. Washington DC: US EPA, January 2006.

US EPA, *Using Smart Growth Techniques as Stormwater Best Management Practices*. Lisa Nisenson, principal author. Washington DC: US EPA, December 2005.

US EPA, *Water Quality Scorecard: Incorporating Green Infrastructure Practices at the Municipal, Neighborhood, and Site Scale*. Abby Hall and Lynn Richards, principal authors. Washington DC: US EPA, October 2009.