Urban Rainwater:

From Pollution Source to Resource via Value-Added Design

Terrence Miller
Yale School of Forestry and Environmental Studies
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* "Stormwater" is used interchangebly with "rainwater" in this report to refer to any water resulting from a rain event. Others may use stormwater to refer to the volume of rainwater resulting from a particular storm event. ie: A 2 year 24-hour storm.

Traditional Stormwater Management

The design of stormwater infrastructure and management systems in the United States has been largely reactionary and motivated by avoiding negative storm-related events in urbanized areas. More specifically, as densely developing areas pave roads and erect structures the otherwise pervious ground becomes virtually sealed. During rain events this results in the accumulation of significant volumes of rainwater in an environment occupied principally by humans. To resolve this problem, infrastructure has been developed and implemented to quickly remove this water from the streets and either discharge it into a designated outfall water body or treat it at a chosen wastewater treatment plant.

As stormwater flows through the built environment it accumulates various constituents (auto fluids, sediments, metals, temperature) that are foreign and detrimental to the ecological viability of its outfall water body. A separate storm/sewer system is designed to directly discharge this runoff into a designated outfall water body. A combined system is designed to combine sewer and rainwater in the same pipe and treat the combined volume at a wastewater treatment plant. During significant storm events, however, treatment facilities are unable to accommodate the significant volume of rainwater and the system is designed to direct the combined waste to a selected outfall water body ("Combined Sewer Overflow" or "CSO"). As cities grow, so do the ratio of impervious to pervious surfaces and subsequently the frequency of CSOs.

In reaction to this problem, municipalities have allocated significant sums of money towards the removal of stormwater from the combined system. In addition to several natural management strategies such as tree planting and downspout disconnection, the City of Portland, Oregon is installing new underground pipes to intercept CSOs from existing combined systems and divert them to upgraded treatment facilities as part of its 20 year, $1 billion CSO reduction program. New Haven, Connecticut currently plans to separate the currently combined system in Fair Haven at the cost of around $15 million (Piscotelli, personal communication). Underground structural management strategies are effective in reducing runoff pollution yet are extremely expensive and add no value to rainwater as a resource. The design of this type of system merely directs the water elsewhere to insure that the polluted water will undergo an energy intensive treatment process prior to discharge.

Further contributing the shortcomings of this design is that the infrastructure is located underground rendering the rainwater virtually invisible to the city or building occupant. As a result, perceptions of rainwater are limited to the rain falling in the air and the runoff flowing to the nearest storm drain. This promotes the discernment that rain has no place in cities and that the best thing to do is remove it from the human experience as soon as possible. As a result, little creativity or effort beyond simplified, underground mega-infrastructure is given to rainwater management design.

This paper seeks to reveal the potential to add value to rainwater as a viable resource in urban areas via design that positively engages both humans and nature in the built environment. It examines rainwater design in the context of the LEED Green Building Rating System, biophilia, three commercial rainwater projects, and three residential applications in an effort to show what may result from properly designed, awareness-promoting demonstration projects.

Green Building

Green Building can generally be defined as building efforts that reduce their impact on the natural environment (in contrast to traditional building practices) by focusing on energy, materials, water, and indoor air quality in site and building design. The United States Green Building Council (USGBC) has published a green building rating system entitled Leadership in Energy and Environmental Design (LEED) that serves as checklist for projects aspiring to earn a LEED rating. The USGBC awards certification, bronze, silver, gold, and platinum awards for buildings that earn a determined number of points from the checklist. Points are earned by meeting the criteria of a particular credit such as Stormwater Management (Credits 6.1 & 6.2, LEED v. 2.1). The LEED rating system has made it relatively easy to build green and has quickly been adopted by designers all around the country. As of 8-2002 there are more than 515 LEED registered projects in 45 states and 6 countries (USGBC website, 11-2002).

The USGBC defines “green design” as “design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas: sustainable site planning, safeguarding water and water efficiency, energy efficiency and renewable energy, conservation of materials and resources, and indoor environmental quality" (USGBC website, 11-2002). Interestingly, the USGBC states that one of the benefits of green design is that "the local and global environment benefits from protecting air quality, water quality, and overall biodiversity and ecosystem health" (USGBC website, 11-2002). Merging these two statements regarding the USGBC's definition of "green design" one can say that the natural environment benefits from green design because it eliminates or reduces the negative impact of buildings. The USGBC also says that part of the motivation for LEED was to "facilitate positive results for the environment" (USGBC website, 11-2002).

Eliminating negative impacts is a positive action, however, it does not necessarily mean that it is facilitating positive results for the environment. For example, a building that uses less energy, but obtains that energy from the same fossil fuel burning source, is merely doing less bad. This is a step in the right direction but should not be described as "facilitating positive results". If it is labeled as such, a false perception of reality and achievement will persist and potentially limit the degree of design exploration and creativity.

Additionally, it is true that the local and global environment benefits from protecting air quality, water quality, and overall biodiversity and ecosystem health. But are LEED-inspired building designs truly "protecting" these elements of nature or are they merely reducing their impact upon them?

LEED & Stormwater Management

In LEED v 2.1, Stormwater Management Credit 6.1 for rate & quantity requires the following: prevent post-development runoff rate from exceeding pre-development runoff rate OR if imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff.

The treatment credit (Credit 6.2) requires the construction of a stormwater treatment system designed to remove 80% of the average post-development total suspended solids and 40% of the average post-development total phosphorus based on the average annual loadings from all storms less than or equal to the 2-year/24-hour storm. It also requires the usage of EPA or local government best management practices to guide the design of the system; whichever is the stricter of the two. The underlying motivation for the stormwater management system design is achieving these functional standards. For this reason, it is important that LEED is not used as the sole resource for green design if green design is to truly facilitate positive results for the environment. The design of the system is just as important as the performance if it is to have effects beyond the site itself (ie: the "environment").

Biophilia and Contextually Appropriate Design

The Biophilia Hypothesis states that human's have a weak, innate biological affinity for the natural environment that cannot be purged but can atrophy or be manifest in artificial forms. Furthermore, this weak affinity must be cultivated via experience and education in order to assure the health and general well being of the individual. This reinforcement is most effectively provided on a daily basis and can be articulated in the urban environment by the mere suggestion of nature in design. Through the multi-scale use of shapes, textures, and materials in a design program that enables a sensory experience associated with the natural environment, this innate affinity can be fostered on a daily basis in so-designed built environments. Such design has been termed "biophilic design" (Kellert, personal communication).

Towards Biophilic Design…

In biophilic design, the form is determined by optimizing the relationship between the built and the natural so that all natural processes simultaneously benefit the building and its occupants. This effectively debunks the traditionally negative relationship of the built to the natural.

A successfully biophilic design should evoke the aforementioned sensory experience while concurrently affirming the contextual integrity of the built environment. Failure to do so further promotes the existing polarization of the natural and built environments. Doug Farr, of the architecture and urban design firm Farr Associates, eluded to this point in a recent presentation at the 2002 International Green Building Conference, “Doing the right thing doesn’t mean creating a natural looking environment”. A “too natural” looking application in an urban area may be inappropriate, disrespect the integrity of what is built, and threaten the most predominant species in an urban ecosystem, humans. The urban dweller must be able to define their environment. If they cannot identify with their surroundings a negative experience may result. Founder of Deep Ecology Arne Naess iterates, “A lack of identification leads to indifference” (Naess, 174). Proper design results in an experience with which urban dwellers can identify and consequently creates the desire to foster that environment insuring future experiences. In a recent stormwater ecocharrette for a new waterfront development in Portland, Oregon, landscape architect Gerhard Hauber of the distinctive multi-disciplinary firm Atelier Dreiseitl reinforced this point.

“In urban areas, it is often ‘too urban’ to incorporate natural or naturalistic areas into the design. It simply will not fit and will be confusing to the pedestrian.” However, he also noted that natural areas closely approximated to developed areas could actually be protected by creating naturalistic spaces *within* or along the periphery of the developed area (Hauber). Gerhard’s comments touch upon the project specificity and complexity involved in determining a contextually appropriate design that will communicate a consistent and proper message regarding the value of nature in urban areas.

Universally, though, Roger Ulrich notes that one of the most straightforward findings in his review of the research literature is that “people prefer natural scenes over built views, especially when the built views lack vegetation or water features” (Kellert, 15). Indeed, Kellert states that “Various studies have documented the many rewards of the naturalistic experience, among them relaxation, calm, and peace of mind” (Kellert, 12). To further add value to these applications the creation of a “naturalistic” environment in an urban context should not merely be representative of nature but an ecologically affirmative one as well.

When the proper considerations have been made the resulting design should cultivate existing biophilic affinities, enhance or restore ecologic viability, empower the pedestrian, and instill the sense of security necessary for one to willingly participate in their surroundings. Without participation, valuation and subsequent fostering of one's environment is impossible.

Biophilia in action- a fussy toddler is calmed by the experience of an undulating pool of water at the Lady Bird Johnson Wildflower Center in Austin, Texas.

In a study by Tesitel et al that looked at the failure of urban planning to recognize aesthetic and symbolical relations of humans to nature during the 1970s and 1980s in a housing estate in the town of Tabor, South Bohemia they concluded that, "Though they are able to create an environment that is almost artificial, humans themselves remain biologically determined beings. Therefore, their position is somehow paradoxical — unsatisfied biophilia needs may depreciate the "livability" of the environment they have created. It could be possible to paraphrase the well-known Liebig's law of minimum and to state that the absence of nature, at least in its symbolical form, can become a limiting factor of the "pleasant existence" of the people living within housing estates" (Tesitel et al, 2001).

Rainwater is an excellent opportunity for cultivating biophilic needs in the built environment due to its subtlety. The continuous flow of water can be very relaxing to see and hear without overpowering a given situation. Furthermore this continuity is very comprehensible and takes away the potential of a particular design being too natural or complex to be understood. In addition to its subtlety, rain events occur at a temporal scale to which humans can relate. It rains, the water travels, arrives, and is gone. The relatively short period of time over which this occurs provides a design opportunity to communicate the importance of this window of time in adding value to the rain. Rainwater-activated design features that enhance the character of a city or building may have the potential to result in the valuation of the element itself (rain) that animates the prized design feature. A group of Harvard students whose proposal recently won the EPA/MIT Charles-River Stormwater design competition touched upon the value of this experience, "The rock filters and stone stream bed will glisten during storms and be dry at other times, drawing attention to the ephemeral nature of rain" (Neuman, 1). In this way the design can draw attention to the fact that it is raining in an interesting, biophilic manner that subsequently promotes an affirmative perception of this resource.

The following is an examination of three commercial projects in Portland, Oregon that implemented alternative rainwater management systems into their buildings. Each project is examined for how well it enables water as an operational resource and the degree to which it incorporates contextually appropriate, biophilic design to promote a positive perception of urban rainwater.

The Brewery Blocks

A 5-block project in downtown Portland known as the "Brewery Blocks" is currently being developed and all five buildings will earn a LEED rating. One building in particular is earning both stormwater credits from LEED v 2.1. To earn the volume credit an intensive/extensive ecoroof was designed for the lower rooftop that covers 17,800 ft^2 of the 40,000 ft^2 building footprint. The ecoroof will attenuate stormwater from the upper and lower roof and then be directed to the nearby buried Tanner Creek via underground pipe.

The stormwater will enter the buried creek downstream of a sanitary diversion pipe after it goes through a manhole filtration system know as a "downstream defender". The "defender" will earn the project the stormwater treatment credit and has removal rates of 90% for sediments and 30% for phosphates. The developer was responsible for developing all utilities in the district and the additional cost to carry the water to this spot was $200,000.

Brewery Smokestack *Site of future ecoroof*

The City approved this system but not before rejecting other stormwater management proposals. Dennis Wilde, project manager, says that one idea that did not survive was to harvest all stormwater for gray water purposes (primarily toilets). The idea did not last because "It's really tough to do in the city" due to the required storage capacity to meet the building's gray water needs and the difficulty in obtaining permits for such a system in a commercial buildings. Interestingly, one of the buildings has two 45,000-gallon grain towers, one of which will be used for firewater, on an eighth floor setback that may have served this purpose well in addition to affirming the industrial character of the building.

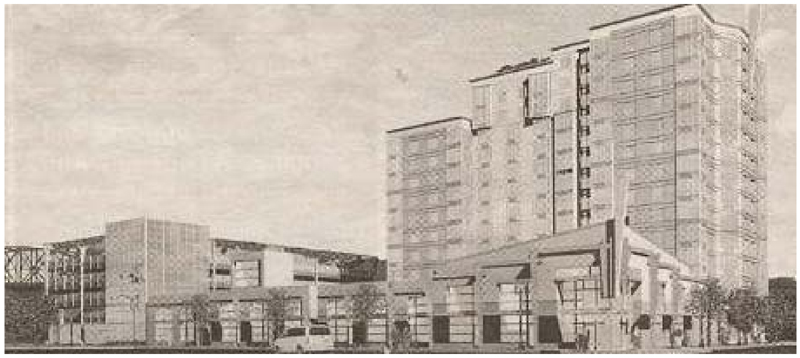
Grain Towers

Another idea was to install depressed planting areas at grade to serve as stormwater detention facilities in the sidewalk at the base of the building. These applications were designed to retain and phytoremediate all runoff from the building envelope and perimeter sidewalks. The proposal was rejected three years ago but Dennis thinks that, today, it would pass given increased awareness and commitment to CSO elimination by the City.

The Brewery Blocks project touches upon the shortcomings of the LEED rating system. Beyond the ecoroof accessible only to building occupants, the stormwater management system that will earn the project both LEED stormwater credits functions underground and adds no use or value to the water. In fact, the water is costing the Brewery Blocks money thus rendering the water a liability, not a valued resource. The LEED rating system fails to acknowledge this thus encouraging little creativity vis a vis *how* stormwater systems are designed and credits are earned. Most importantly, the Brewery Blocks missed the opportunity to demonstrate the different way in which this building handles its rainwater to the people working, shopping, driving, and walking around this vibrant section of downtown. Fortunately, the progressive aspirations of the City of Portland are enabling achievements beyond LEED.

Station Place

Station Place is currently being developed by REACH, a nonprofit community development corporation, and will include the gray water system that Dennis Wilde hoped to obtain permits for three years earlier. The roof of the 14-story residential high rise will serve as a "mini-watershed" and all of the rainwater from the roof will cascade into a 20,000-gallon tank located in the basement. There, the water will be treated and pumped to the first six floors in a separate plumbing system that supplies the toilets (Tevlin, 17). REACH's construction manager Kevin Kraus estimates that the harvesting system will reduce the building's annual demand on Portland's drinking water by 250,000 gallons. Moreover, Kevin notes, "Instead of sending 250,000 gallons of stormwater to the Willamette River every year, I'm using it one more time before I send it to the sanitary system" (Tevlin, 17).



Station Place (Portland Business Journal)

This points to perhaps the most important element of this building's design. The REACH building, *by design*, adds value to all of the rainwater that falls on it. A system will be set in place (rainwater harvesting) that allows natural processes (rain events) to actually enable one aspect of the building's operations (toilet flushing). Toilet flushing in homes accounts for roughly 40% of potable water consumption and this number is presumably larger in commercial buildings (Daniels, 27). Furthermore, this design shifts the paradigm of traditional building design. The shape and form enable the building to act more like nature in its management of rainwater rendering the building an active component of the greater natural system in which it is located. Contextually, the building design equally respects the urban nature of its immediate surroundings in downtown Portland as a 176-unit, mixed-use high rise.

The REACH building offers a glimpse into the potential value of design that acknowledges not only the local urban context but also the greater natural system in which the building can participate. While this building could feasibly further acknowledge the ecological potential of the project, it is moving in a truly sustainable direction because its green measures are value-added measures that benefit both humans and the natural environment. The City of Portland recognized this value in the REACH building design and awarded the rainwater-harvesting system component a $70,000 grant from the City's Green Investment Fund to offset the capital costs.

Interestingly, the City code does not allow gray water usage for toilets because toilet water (normally pretreated to potable standards) is named as an emergency source of drinking water in buildings. However, the City remained committed to the demonstrative capacity of the project and agreed to permit gray water usage under two conditions: all toilets in the building must be bolted shut and have a sign that says "do not drink the water" placed on them (Tevlin, 18).

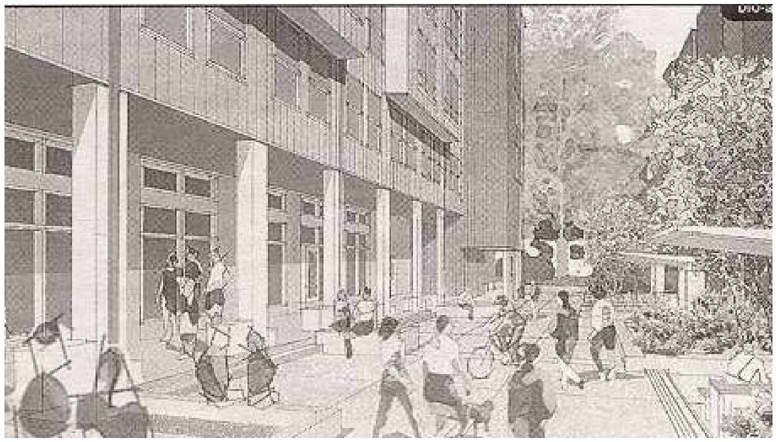
Of note, the measures taken to harvest rainwater were not inspired by LEED credits and the building is not aspiring for certification. Besides being the first commercial application of rainwater harvesting in a residential high rise in Portland, Kevin Kraus' comments regarding the positive impact the system will have on the Willamette River (a six mile stretch of which is a Superfund site) suggest a motivation fueled by a connection to Portland's ecological heritage. This, in turn, brings about a noteworthy degree of proud stewardship of that environment.

While the rainwater harvested by the REACH facility will add operational value to the building, it still missed the opportunity to implement the rain as a design feature in and around the building. The communicative capacity of the system is limited to a sign reminding those who use the toilets on the first six floors not to drink the water. The rest of those in and around the building will be told nothing of this application. A Portland State University project, however, acknowledged the value of designing with rainwater and included it in a progression of value-added rainwater measures for a new dormitory.

Portland State University

Portland State University's new Birmingham Hall located in downtown Portland fittingly includes a multipurpose rainwater management system that functions as both a source of water, vegetation, aesthetic, and education. It will serve as one of its many sustainable features that aided it in achieving a silver LEED rating. Markedly, the system is designed to do far more than simply meet the LEED criteria for the stormwater management credits.

The system has been described as a "sort of public plumbing system" (Business Journal, 16). Rain that falls on the building's roof is funneled via downspout into several open-air, river-rock "splash boxes" located at the foot of the building in a plaza. The water then travels via exposed runnels through the plaza to vegetated planter areas. Some of the water will feed the vegetation and the rest will be cleansed as it filters down through the root masses. At the base of the planter box perforated pipes will collect the filtered water and deliver it to a large storage tank. The water from the storage tank will then be used to flush five public toilets on the first floor of the dorm.



Downspouts, splash boxes, runnels, and vegetated areas (Portland Business Journal)

PSU's sustainability coordinator Michelle Crim notes that the real benefit of this system is education, "our goal was to make the rainwater visible and interactive…we want to make it noticeable so we can do a lot of community education and awareness around the issue of how we deal with stormwater" (Tevlin, 16). In addition to this educational benefit, the system is estimated to save approximately 111,000 gallons of drinking water a year. The vegetation will use roughly 10,000 gallons and the remaining 100,000 gallons will be used for toilet flushing.

This design is an articulation of environmental principles in a contextually appropriate built form. An urban system has been put in place whose function will be driven by a free natural process. This is a delicate balance to strike and the message it communicates is equally difficult to communicate in urban areas: even in a built environment, humans are participants in the natural environment. As David Suzuki of The David Suzuki Foundation noted in a presentation to attendees of the 2002 International Green Building Conference, "In a human created environment, it's easy to think that we don't need nature." By communicating that humans are indeed always in need of nature via an aesthetically pleasing, ecologically affirmative design, the system is sure to withstand the test of time and truly be sustainable.

The rainwater falling on the new dormitory can certainly be perceived as a valuable asset. Quite simply, it activates an animated design feature (splash box and runnel), flushes five public toilets, and feeds native vegetation that will, in turn, purify the air, cleanse the water, provide shade, create habitat, and act as an aesthetic amenity. This type of design can virtually eliminate the need for antiquated underground infrastructure, associated water pollution, using treated water to transport feces, and spending millions of taxpayer dollars to do so. In this regard, the design of the system will greatly increase the value of the rainwater falling on the dorm. An additional value is that the naturalistic design of the system creates the potential for its effect to go beyond the physical site.

By communicating the function of the process that adds value to the rainwater in an aesthetically pleasing and naturalistic manner, there exists the potential to promote private demand for these values in one's own built environment. The fashioning of this "demand" can partially be explained by the creation of an aesthetically pleasing environment but the attraction may be suggestive of a deeper (biophilic), innate connection that humans have to the natural environment.

Demonstration and Communicating a Message

The goal of a demonstration project is to communicate a convincing message at a scale so large that it cannot be missed. The project itself may have little physical impact on the urban scale, but it seeks to convince enough people to do the same to create some desired outcome. While the Brewery Blocks, REACH, and Portland State University projects all demonstrate that rainwater can be a resource in city buildings; only the PSU project communicates this message in an engaging manner. The opportunity for these few high profile projects to have an effect on a scale greater than the building lies not in their ability to be plumbed to flush toilets with rainwater, but in their ability to reveal the fact that they do so in an engaging manner transparent to all who pass by and occupy the building. Such design that communicates via experience is apt to reach a greater volume and mix of people because the lack of literal explanation leaves some room for personal definition and valuation of the experience.

For any significant impact to be realized it is necessary that a critical mass of citizens adopt the values communicated by these projects and implement their own rainwater designs and measures in their homes and neighborhoods. As green building specialist Mike O'Brien notes, "You can't have one or two people doing this. You've got to have a whole community doing it or it won't work" (O'Brien, personal communication).

This points to why the design of high-profile demonstration projects is so crucial. If the form reveals the function in a contextually appropriate, beneficial (biophilic), and pleasing manner the likelihood that a large population of people will value such design and want to adopt the functional measures is greater. The Portland State University project has the potential to have this impact because of the appealing educational dimension of its rainwater management system. If a demonstration project is purely functional and one has to be told verbally that the building harvests rainwater, for example, then the goal of demonstration has not been met. This revisits why the LEED rating system alone is insufficient as a guiding design tool.

A revealing study performed in Mexico by Victor Corral-Verdugo et al looked at the motives for people to conserve water. The study found that perceiving that others do not save water decreases motivation for conservation. Furthermore, perceiving that others waste water actually increases individual water consumption (Verdugo et al). This begs the question, "What kind of perception of rainwater does traditionally designed infrastructure promote? Or, more optimistically, "What are the opportunities to communicate the value and preciousness of rainwater as a resource via the design of its management infrastructure?" The message of the design is crucial if the goal is widespread adoption of value-added rainwater design measures.

The Lady Bird Johnson Wildflower Center in Austin, Texas is an excellent example of how design can reveal the inherent value of rainwater. In a brochure advertising membership to the Center, one of the goals listed is, "Encouraging responsible site development and management that combines native plants with regional architecture, rainwater harvesting, and other environmentally sound principles". To the visitor, however, no words are needed because this is exactly what the experience of the Center communicates. The rainwater management system contributes significantly to the form of the built environment as exposed runnels, downspouts, and Spanish-style aqueducts transport water from all of the roofs to Spanish-style stone and steel cisterns and to vegetated areas throughout the site. At every location on the grounds one is reminded of water by these built features, trickling streams, and wetlands that support lush native vegetation and wildlife. One feature in particular provides a rich, biophilic experience as it harvests rainwater for operational uses.

Perhaps the most prominent feature at the Center is the observation tower. The tower is best explained through a progression of photos:

The Observation Tower

The top floor is graded to drain all rain through this grate.

View through top floor grate to first floor.

Rainwater falls through the top floor grate (view from inside bottom floor) through the grate on the bottom floor located directly below it, and into the underground, yet visible, storage tank. The rain is experienced from the refuge of the protected interior.

The observation tower is a demonstration of how both operational and experiential needs can be met simultaneously in the built environment. The experience of the structure alone communicates the inherent value of rain by the way rain reacts to the design. When it rains, a ring of dripping water falls into a larger body of water creating sounds that echo throughout the space and an interesting reflection of light. The terminus of the animation is a visible pool of water that will be used in lieu of potable water for operational uses.

Arguably this experience is a very powerful educational tool in communicating the viability of rain. Although one sign is located along the stairwell that tells how much water is harvested annually, none are needed to explain how this system works as it is very comprehensible via experience. The system is simple, contextually appropriate, biophilically rich, educational, and practical. In this manner, the observation tower at the Lady Bird Johnson Wildflower Center is a very valuable asset. Achieving this magnitude of effect in cities holds the potential to have a significant impact on its population's perception of rainwater and resulting practices.

In Portland, some residents have implemented rainwater-harvesting measures in their homes with the financial assistance of the City's G/Rated Program. These few residential projects reveal what might result in cities from high-profile demonstration projects that properly communicate the value of rainwater via the design of their systems.

Kristin and Matthew Bacon-Brenes

Perhaps the most integrated rainwater management/harvesting system at the residential scale in Portland is at the home of Kristin and Matthew Bacon-Brenes. The Bacon-Brenes' purchased a fire-stricken condemned home with the intention of building a new "green" home from scratch. As part of this effort they installed two 1,700 gallon cisterns underground to harvest all of the rainwater running off of the steeply pitched 1,144 ft^2 steel roof of their new home. The rainwater is directed, via gutter, to a 20 gallon galvanized steel container called a "rain washer" that holds a mix of sand and gravel for primary treatment purposes. The rain washer is mostly buried but protrudes about 2-3 feet above ground at the base of the house. From there the water is gravity fed to the underground cisterns. One cistern is located slightly lower than the other and serves as the feed to the house. The water is mechanically pumped from the cistern under the house where it undergoes micron filtration, UV radiation, and charcoal filtration. The house is plumbed to draw from this source for all water uses in the house, even drinking water. Kristin suspects that the water will be of higher quality because it is "less experienced" (Bacon-Brenes, personal communication). Total cost for the system was $7,000 and the City issued the couple a grant from the Green Investment Fund to offset these, and other, capital costs.

The Bacon-Brenes' estimate that they will be able to draw solely from the harvested rainwater for about nine months out of the year based on precipitation frequency and volume in Portland. The system is still connected to the city water supply for the drier months and an automated sensor switches the system over to the city supply when the cisterns run empty.

A patio will be built above the cisterns and the only evidence of the cisterns will be two 2-3 foot tall manholes exposed for maintenance purposes. Interestingly, the City of Portland required the homebuilders to build a driveway and it cost the Bacon-Brenes' $1,500 just to request a variance from this ordinance. The request failed and they plan to tear out the driveway post-inspection and plant a vegetable garden that will serve as the overflow area for the cisterns.

The Bacon-Brenes house serves as a good residential demonstration project. The green measures taken do not preclude the home's vernacular and the materials (salvaged and sustainably harvested wood and rastra block) arguably enhance the attractiveness of the home. The couple have two young children and Kristin notes, "I am not passionate about water or anything but I am conscious about basic water issues and how much water we typically use in a day. I care about water issues but not enough for them to greatly impinge on my daily life" (Bacon-Brenes, personal communication).

Site of future patio: ***1*** *= Cistern heads* ***2*** *= Site of rain washer*

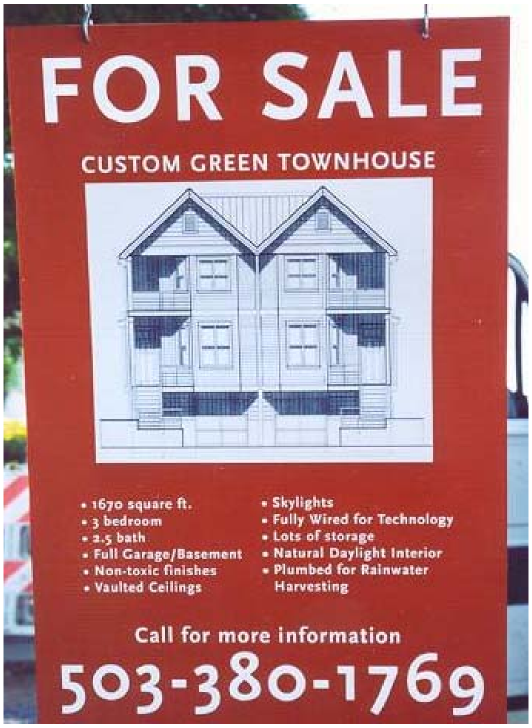
Kristin's frank comments reiterate the idea that basic consciousness about water issues may be enough to get people to consider designing for rainwater. The more people that can adopt this mentality, the greater the effect will be on the water resources upon which the built environment depends. Creating this awareness, however, may be more difficult today than ever.

Ralph Patterson, CEO and President of CH2MHill, noted in a recent speech at the Yale School of Engineering that today's environmental issues are much less apparent and much more complex than those of thirty years ago that led to such rules as the Clean Water Act. The direct pollutant discharges into water bodies of thirty years ago, now regulated by the Clean Water Act, were unattractive and had quite prominent effects such as dead fish and unsuitable waters for swimming. Such impacts were nearly impossible not to notice and the resulting awareness led to change. Today, urban runoff contributes both macro and microscopic pollutants to outfall water bodies that have detrimental impacts on spatial and temporal scales not always readily apparent to the passerby. Moreover, the transport of this pollution source to a remote water body retains the invisibility of the problem.

Further contributing to general unawareness about water is the invisibility of its supply. The following justification of an award-winning garden designed to promote awareness about the nature of water touches upon the disconnect between the user and the source. "Twentieth century genius has long been the technology of supply, so much so that it has become accessible, common and unseen without a hint of the advanced knowledge that enables it. One of the major challenges of the twenty-first century will be to uncover this knowledge and use it to conserve supply - notably that of water" (Harvard website, 11-2002). Herein lies the opportunity for design to reveal the potential for the use of rainwater in urban areas and help create the awareness necessary to result in applications such as the Bacon-Brenes' rainwater harvesting system.

Aaron Blake

Just a few blocks from the Bacon-Brenes residence Aaron Blake constructed a speculative "green townhouse" that includes a rainwater harvesting system similar to that owned by Kristin and Matthew. Aaron earned an undergraduate degree in architecture and recently started a small development company called "Reworks". His motivation to build is to show that conscious, high quality and resource responsible building and site development can occur and be even more appealing and enjoyable to live in than what's typical of "today's cookie cutter houses" (Blake, personal communication).



Aaron's original goal was to use rainwater to meet the water demands of the entire building. However, calculations revealed that this would only be feasible for about four months of the year and he decided to provide water for toilets and exterior hoses instead. The house is plumbed so that rainwater could be used for all needs in the future if occupants choose to increase storage volume. The steeply pitched roof is made up of asphalt shingles instead of steel for financial reasons and it delivers rainwater to a conventional gutter system. The downspouts convey the water to the garage where two 1,500-gallon PVC cisterns store the harvested rainwater. He notes the above ground application as beneficial for maintenance purposes. The system requires no backflow regulation because a floating cockball will trip the city system when water levels are low enough and the cistern will automatically be filled with city water. The only water quality treatment will be a rain washer similar to the Bacon-Brenes system.

The system also includes an overflow pipe that delivers excess water to a landscaped swale. The swale is to be constructed according to the City of Portland Stormwater Management Manual and will serve as both an ecological and aesthetic amenity in the backyard.

Another ingredient of Aaron's goal as a developer is to provide homes with sustainable measures integrated into them for people who cannot afford to hire an architect to design their home. His design and amenities are quite different than what is typically available in the range of new speculative homes. During construction three different interested parties contacted Aaron based solely on the aesthetic of the house and property. Once he told them about the rainwater system and other applications they became even more interested (Blake, personal communication).

One key, Aaron notes, is that the design incorporates the vernacular of that neighborhood. The roof, for example, has significant roof pitches and eaves and these are two elements typically seen on older homes in Portland that are a response to the rainy climate. "Most older homes have extra long eaves often covering a front porch so that people can still be outside regardless of the weather. People just don't use an outdoor space unless it has a roof" (Blake, personal communication).

Aaron's townhouse design is an excellent example of contextually appropriate value-added rainwater design. The steep pitched roof and significant eaves respect the dialect of the older neighborhood while satiating the ageless biophilic demand to be outdoors yet protected, when it's raining. The rainwater harvesting system adds additional value to the climate-responsive, vernacular design of the roof by enabling it to serve as an effective conduit of rainwater to the harvesting system. The system, in turn, permits rainwater to be used in lieu of potable water as a resource inside and outside the home.

Besides a virtual elimination of any contribution of runoff to the City's storm/sewer system, the rainwater design reduces the demand for high energy-embedded potable water. Notably, only 44% of household potable water usage is used for drinking, dishwashing, or personal hygiene; uses that require treated water for health reasons. The remaining 56% of uses including laundry, flushing, watering, car washing, and cleaning could be served by gray water with no threat to human health (Daniels, 27).

As revealed by the parties attracted to Aaron's townhouse, the magnetism of Aaron's design is due to his recognition of the neighborhood's vernacular. This vernacular, in turn, is embedded in Portland's rainy climate and this is something to which all locals can relate. This identification created the initial interest that only grew when they learned of the rainwater harvesting system among other green features. Even though the rainwater harvesting system was not the feature that drew their initial attention, it is of note that the *design* resulted in further investigation by interested parties who consequently learned about rainwater harvesting. In this regard, Aaron's design is creating awareness about rainwater in this neighborhood and has value as an educational resource.

Covered porches

Under Construction (front)

Garages and Cistern Storage

Backyard

Cistern overflow pipe…

…leading to site of future landscaped swale.

Pedro Ferbel & Mark Lakeman

Pedro Ferbel and Mark Lakeman designed and installed a very simple retrofit rainwater harvesting system onto their existing house for uses outside their home. In the front of the house a structure housing six 55-gallon drums receives all the runoff from the north slope of the roof. Pedro indicates that one good rain event will fill all of the drums effectively storing 330-gallons of rainwater. The water is used to irrigate a densely planted permaculture garden that provides corn and other vegetables throughout the summer. The weight of the head of water in the drum creates enough pressure to water the garden via hose thus no mechanical pumping is necessary. Pedro points out that this significant volume of vegetation on the west side of the house also helps to cool the area due to moisture retention. When the runoff volume exceeds storage capacity the excess rain is directed to the garden. In addition to the 6 drum configuration in the front yard, every downspout around the entire house discharges to one or two drums of its own.

The most significant feature on the property is a cob sanctuary that was constructed as part of the Green Building Convergence- a community based green building effort in which the community performs the entire process from design to construction. Mark Lakeman was the architect guiding the process and when this writer recently met Mark and told him how much he liked his design he replied, “Well, the community designed it, I didn’t” (Lakeman, personal communication).

Cob Sanctuary

All of the materials used to make the structure are local and a significant volume came from the property itself. The cob used to construct the walls is a mixture of sand, clay, straw, and water and has a beneficially high R-value. The clay came from the hole they dug for the foundation, the water used in the mixture is mostly rainwater harvested from the roof, the sand was initially dredged from the Columbia River, and the straw is from Oregon but did have to be transported to the site. The foundation is made up of the broken up driveway that Pedro and Mark converted to an extension of the garden and the ecoroof is composed of native plant materials that were locally purchased. The structure cost $200 to build.

Future plans as of July include a gutter system around the ecoroof that will funnel into a pond planned for the middle of the backyard. Additionally, a river-like channel is planned that will be supplied by the roof of a shed that sits at the highest elevation of the backyard. This backyard river will be activated by rain events and will feed either the pond or an underground storage cistern. He also plans to plumb the house so that it can use rainwater for toilet flushing.

Another water saving measure taken in the home includes the collection of experienced bathroom sink water in a five-gallon bucket. This is achieved by simply removing the elbow pipe under the sink to allow the water to fall into the bucket. That water, along with all collected shower water (via a stopper), is then used to flush the toilet by simply pouring it into the toilet after using it. Pedro notes that he is much more conscious about how much water he uses at the sink and in the shower because it collects and the end volume is so visibly apparent (Ferbel, personal communication).

When asked why these types of practices are not more commonplace Pedro makes a very interesting point. Today's older generations, he says, practiced some of these forms of conservation in the past but not by choice. It was a matter of survival and these practices are associated with poverty and hard times. They are proud that they weathered the storms of the past and even more proud that they broke out of that and into a higher level of living. As a result, toilets and virtually free running water are almost symbolic of their hard work. There is no logical reason for them to go back to that primitive lifestyle because, to them, it's almost savage. This ideal is presumably passed on to younger generations as well (Ferbel, personal communication).

Notably, Pedro and Mark's rainwater system and water conservation practices are more labor intensive and "impinging", as Kristin Bacon-Brenes would say, than most people are willing to accept. In this manner, the design of his system might not bring about the same response as other designs because it is purely functional. This is sufficient for Pedro and Mark however because they made the conscious decision to integrate the function of the system into their daily lives. Furthermore, it's high degree of visibility and requisite need for their participation to function quenches their need to know that they are doing something to lessen their personal impact on the natural environment.

Pedro and Mark's system is a good example of consciousness resulting in action. Their low-impact lifestyle and ideals led them to design an inexpensive system that effectively turns rainwater into a resource. While the 55-gallon drums are not particularly attractive or suggestive of anything beyond their function, the cob sanctuary displays rainwater's potential as an integral component of a multi-purpose, biophilically designed structure that provides a very unique and contemplative experience.

Pedro watering…

…the front yard garden…

…via the rainwater storage system.

Conclusion

This paper has sought to reveal the potential for rainwater as a value-added resource in urban areas. As cities continue to grow the strain on our water resources will only follow. It is imperative that a new paradigm for rainwater management and systems design is adopted by cities if any significant change is to take place. Traditional infrastructure and management strategies are inefficient, energy intensive, expensive, and inexperienced by the urban dweller. To facilitate this change designers must play an integral role in displaying the basic fundamentals of rainwater via the very management systems that handle and transport it in cities. These systems must be designed in a contextually appropriate, biophilic manner if their full value as instruments of management, education, and experience is to be realized. By incorporating this communicative style of design into high-profile demonstration projects there exists the potential to create private demand and valuation of rainwater in the residential sector. As Gerhard Hauber notes, "The people are the fabric of the city. What type of city do we want to have?" The more aware people are of what is around them the more likely they are to value and participate in their surroundings.

In order to meet the built environment's projected demand on water resources in a truly sustainable manner, the growing population of residents must understand the inherent value of rainwater in their homes. This understanding, coupled with incentives provided by the city, can result in the widespread application of commercial and residential rainwater projects in a city. The residential projects that benefited from the City of Portland's green building incentive program are an excellent demonstration of this theory in practice. Furthermore, once these projects penetrate city neighborhoods, they become instruments of education themselves as displayed by the interest in Aaron Blake's "green townhouse" by perspective buyers. As part of a greater education effort, design can play a substantial role in stimulating this demand. Due to this, rating systems such as LEED must not be relied upon as the guiding tool for "green design". Strict adherence to such a framework can limit the degree of design creativity and result in an unbalanced design program that leaves the potential experience and education of the pedestrian and building occupant unaccounted for. This is demonstrated by the invisibility of the underground downstream defender device that assisted the Brewery Blocks project in achieving a LEED rating.

It is evident that there exists potential to add value to rainwater via affirmative design that enables the rain to serve as an ecologic, aesthetic, biophilic, and operational resource in the built environment. When all of these dimensions are fused into a multi-purpose design the rainwater can realize its full potential. This type of value-added design must replace traditional management strategies to meet the needs of the future and truly facilitate positive results for the natural environment.

Nota Bene

The scope of this exploration of the potential of rainwater in design is limited to the projects visited by this writer. A wider analysis of other applications in various contexts may provide a broader understanding of the use of rainwater and biophilic design. The following is a very incomplete list of examples:

Theiler & Partner Project
Pilot project to demonstrate the effects of fusing rainwater managment and open space design.
Concept and Planning: Atelier Dreiseitl
http://www.dreiseitl.de/en/proj/set_proj.htm

Méry–sur–Oise
Experimental garden designed around the dynamics of water in its various states: as a gas, liquid or solid.
Landscape Architect: Pascal Cribier
http://www.france.diplomatie.fr/label_france/47/gb/15.html

Living Water Garden, China
A 5.9-acre multi-purpose public park that treats 200 cubic meters a day of the polluted Chengdu Fu and Nan Rivers.
Landscape Architect: Margie Ruddick
Artist: Betsy Damon
http://www.keepersofthewaters.org/htmls/livingwatergarden.html

DaVinci Living Water Garden
An educational stormwater management system designed as part of a one-year curriculum focused on water that includes ponds, flow forms, and cisterns.
Designers: Students at DaVinci Arts Middle School and volunteer experts
http://www.keepersofthewaters.org/htmls/davinci.html

Sparkasse Gummersbach Project
A savings bank in Germany whose multi-purpose art-glass and water are the key design elements and run the full length of the four-story facade.
Idea, Artistic Design and Planning: Atelier Dreiseitl
http://www.dreiseitl.de/en/proj/set_proj.htm

Potsdamer Platz
Multi-layered rainwater management and reuse system in the heart of downtown Berlin.
Planning: ARGE Dreiseitl/Piano/Kohlbecker
http://www.dreiseitl.de/en/proj/set_proj.htm & *Landscape Architecture* v91 (7) July 2001

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