Innovations in Distributed Water Systems: Residential and Commercial Case Studies

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Introduction

Kent Butler defines sustainability as the process of trying to solve as many community or environmental objectives as possible with each measure taken. Within this line of thinking, the sustainable management of water is a key component of the larger encompassing sustainability movement. Water, when managed properly, can solve many complex problems in the larger realm of sustainability. As populations increase and resources become more scarce, it is imperative that sustainable practices and resource conservation become commonplace in our communities. Pursuing an agenda that produces the most benefits with the least amount of investments in order to improve efficiency of resources should be the primary goal of designing sustainably. Systems for sustainable water management can do just that: water conservation, reclamation and reuse practices can provide multiple benefits to the environment.

While water systems are often considered on a large or city-wide scale, there is great potential in water reclamation systems that focus on much smaller communities and household units. At this level of management, planners, architects and engineers can be instrumental in providing the infrastructure required to use water sustainably while providing benefits to their clients. Sustainable water management in small-scale settings has great potential to improve environmental quality by conserving water, reducing erosion and runoff, and tempering the need for urban-scale water treatment, storage, and distribution, as well as wastewater collection and reclamation. Additionally, the provision of alternative or backup water sources provides a security to individuals and communities that has been taken for granted for many decades.

A technique in water management that has proven to be successful is the use of rooftop rainwater collection and harvesting. This method of water management benefits both the environment and the individual, and can be implemented at the household level, in commercial developments, and even at the community scale. Preceded by an explanation of how water reclamation practices work, the following case studies offer a glimpse of the potential that rainwater harvesting has at varying scales and densities.

Rainwater harvesting

“Rainwater harvesting, in its essence, is the collection, conveyance, and storage of rainwater”. This technology’s scope and complexity can vary from simple rain barrels for garden irrigation to large scale systems that use harvested water as a primary source for a variety of municipal uses. Regardless of
the size or complexity of a rainwater collection system, there are six main components of a typical system: (see Figure 4)

1. Catchment surface
2. Gutters and downspouts
3. Debris filter
4. Storage tank
5. Delivery system
6. Purification system (if the system is used for potable water use)

Most existing rainwater harvesting systems in central Texas are for non-potable uses such as irrigation, but there are already hundreds of cases of such systems providing potable water to individual residences. In most situations, rainwater harvesting is only practical when the volume of rainfall collected and stored from a catchment surface can generate enough water for the intended use. Central Texas appears to be a highly suitable region in these regards. Most rainwater harvesting systems can only compete with the cost of a central utility’s potable water supply when the system remains in use for many years.

Where a centralized water treatment system is present, potable rainwater collection systems require a larger investment of infrastructure than is usually acceptable in terms of the number of years it takes to offset the cost of such an investment. However, governmental units at all levels are beginning to provide financial incentives for the use of these systems because of the many benefits these systems have for area wide water management and conservation.

The State of Texas offers incentives for the implementation of rainwater harvesting equipment in the form of sales tax exemptions. City and county governments are offering exemptions from property taxes and even partial subsidies for the costs of installation. In rural settings rainwater collection is cost competitive with sources such as drilled wells and can be designed to be equally if not more reliable. And given a large catchment area, as is typical of commercial uses, rainwater can be used cost effectively for landscape irrigation and flushing toilets. For further information regarding the implementation of rain water systems, see the Texas Manual on Rainwater Harvesting, published by the Texas Water Development Board.3

**On-site water management**

It is increasingly important to the overall water resources of an urban region that the water flowing through each given site is managed and used effectively. In the last few decades, urban storm water management systems for new developments have been designed to move water off site and downstream as quickly as possible. This practice has caused flooding, erosion, scoured stream banks, increased pollution and sediment downstream. It has also reduced outdoor quality of life benefits such as the ecology and human enjoyment of streams and lakes. From a planner’s perspective, water should be dealt with before it becomes too distributed and much less manageable. By containing water on a localized site, many problems are abated and new opportunities arise. Water that is not collected or otherwise infiltrated into the earth is called storm drainage. Storm drainage must be controlled, not only to prevent erosion, but to protect water...
quality and quantity. Quantity refers to the volume of runoff in a rain event with the goal being prevention of flash flooding or overcharging urban drainage networks. Quality must also be considered, particularly when runoff goes to bodies of water that are used for drinking supplies.

Water quality is one of the most difficult factors to control due to the diffuse nature of urban sources of pollution and the high expense required to filter urban storm runoff stemming from impervious surfaces. Rooftop rainwater collection systems are a form of source control for pollution, as well as a way to reduce other potential problems caused by storm drainage.

Among the many methods of managing urban storm runoff, maintaining the quality and quantity of urban area water resources, and enabling the efficient reuse of water, there is perhaps no better single method than rooftop rainwater harvesting. The water is controlled and retained during storms and then made available in off-peak times for irrigation and other nonpotable water demands; and the problems of downstream erosion and pollution are directly reduced. Effectively, harvested rainwater also becomes a new water supply for on site water demands. Notwithstanding the capital costs of installation, it represents a very economical long-term supplement to conventional municipal water supplies.

Rainwater collection may very well be the most powerful new tool for water management due to its many sustainable benefits. Compared to utility-scale water infrastructure that is financed and paid for over the course of tens of years, the pay-back time for the capital investment cost of a rainwater system is relatively short. While urban residents and commercial interests are for the most part accustomed to large-scale infrastructure involving a pay-as-you-go utility that addresses virtually all operating, maintenance, and institutional costs for the price of a monthly user charge, a more distributed system is much lower in cost of operation, simpler in management, and self-accountable.

If cities and utilities take into consideration the full array of community-wide benefits afforded by rainwater collection systems, they will provide increasing amounts and types of support for their construction and use. Public support could come in the manner of facility financing, subsidies or rebates for private investment, and reductions in user charges for drainage and related utility operations that are enhanced directly by rainwater systems.
Approximately one thousand homes in the Austin area have rain water collection systems. They are principally located on rural home sites where central water utilities are not providing potable water supplies. Many others are in urban and suburban locations, using the collected rainwater to meet most or all of the nonpotable water demands on the site. Elsewhere in the world, other cities, states and provinces are proving that rainwater collection can be used on a much larger scale. In Australia, over 400,000 homes have rainwater collection systems. In west Germany it is presumed that each new home will have an interconnected rainwater-utility service system, using rainwater for as long as it is available for all nonpotable demands, and shifting to water mains, provided by the utility, as a backup supply. In urban environments in the US, while it is not yet common and in many cases not expressly permitted, rainwater collection systems should be coupled with main water and then used for non-potable purposes. The following case studies in the central Texas area are indicative of the various ways that rainwater collection systems can be used on small and large scales.

**Case Study: Western Travis County residential rain water collection system**

Depending on density, the way water is managed in residential areas will vary. Rural developments with lots of one acre or more can be self-containing with a well, a septic system and plentiful pervious land for a drain field and no infrastructure for storm water runoff control. Urban settings by necessity have a much more engineered approach to cope with the reduced lot area, such as using large amounts of piping to get water and sewage to and from a home. Finally, low impact developments or clustered developments try to be more distributed and self-contained like other rural schemes, but also strive to function in higher density settings.

Low impact development is a term used to describe an approach to managing urban stormwater through the use of technology and small, cost effective landscape features located on an individual site (see Figures 5 and 6). Clustered development, similarly, is a concept involving the clustering of home sites into a small footprint while setting aside a correspondingly large area as permanent open space. The desired outcome of these measures is increased on site infiltration of stormwater (and groundwater recharge), lower volume of discharges leaving the site, and more open space for habitat and passive recreation.

Most of these benefits are realized due to significant reductions in the amount of impervious surfaces relative to conventional, more uniformly sized and distributed lot patterns. The underlying strategy in designing a low impact development is to mimic natural pre-existing site hydrology. Rainwater harvesting technologies help considerably to realize these goals by retaining rain water in a storm event for reuse on the site, thereby also reducing demands for further withdrawal of groundwater from centralized potable water sources.¹

Even though many hundreds of individual household systems exist in rural areas, they are virtually unregulated. In order to deploy this marvelously simple technology for all household water demand Construction and maintenance standards and enforcement provisions will be needed to allow interconnec-
This study was undertaken to determine the true costs of rainwater harvesting and allied systems to meet potable demands in higher density settings.

A research and feasibility study was conducted at The University of Texas at Austin on a with the developer of the Rocky Creek Ranch and the Lower Colorado River Authority, to determine the benefits and costs of low impact development designs and community-wide use of rooftop rainwater harvesting. The Rocky Creek Ranch, comprising 469 acres of rolling grassland and sparse woodland and incised intermittent stream channels, is located in western Travis County in the contributing drainage areas of the Edwards Aquifer.

The study developed three scenarios of differing degrees of clustering and on site impact, and determined detailed cost estimates for each scheme. The conventional rural development has 230 lots, the suburban, clustered community has 430 lots, and the low impact development has 230 lots divided into clusters, each with their own water reclamation and reuse systems (see Figures 2, 3, and 4). The study focuses on the benefits that the low impact development has for the environment and its would-be occupants.

Figure 10: US Drought Monitor for the state of Texas, October 21, 2008. Travis county, highlighted, is experiencing a drought.

Each house in the low impact development would have a rooftop collection and cistern storage system (see Figures 2, 3, and 4). The cisterns would be located inside the garage so that they are hidden from view and so the enlarged garage serves to supplement the amount of rainwater capture. Each household unit would have its own rainwater filtration and disinfection system. However, each house would also remain connected to a community well supply line. This backup of water systems provides an appealing benefit for those concerned with water security. Surprisingly, almost all cities have only a single water source, despite the vulnerability it poses.

Effluent leaving each house would be collected by a gravity sewer and then treated in a small packaged water reclamation system serving all the houses within each cluster, using advanced treatment technology and managed by a community-wide utility with professionally trained and certified operators. The reclaimed effluent would be returned to the housing cluster and applied through underground pressure drip irrigation lines to the turf plots on each residential lot, thereby providing for ample outdoor irrigation but requiring essentially no supplemental water supplies. Additionally, low impact landscape methods would be used to deal with storm drainage on streets and drives and induce as much as possible to infiltrate into the soil. Most importantly, the end results of the low impact development would see a dramatic reduction in net household water use and a tremendously reduced environmental impact (see Figure 11).

This scenario and feasibility analysis offers a model of centralized management and decentralized infrastructure to meet the water-related needs of new communities. The net differences in costs to the homeowner of the innovative low-impact scheme is not considerably different from the conventional layout or the moderated version of low-impact development.

Two final major constraints are likely to limit the deployment of the technologies and configurations illustrated in the Rocky Creek Ranch study, at least in the short term. One is the market readiness for shared ownership and maintenance of the water reclamation system and backup water supplies. And the other is, will the State and local governmental entities adopt standards and regulations that permit these schemes and make it economically feasible to receive the needed approvals. The government can be hesitant and cautious in fostering experimentation when public health impacts are in play. And it can be difficult to find a “guinea pig” to take on this type of endeavor.

Despite these significant barriers there are examples of successful water reclamation systems on a large scale in other parts of the country. For example, in the Tampa-St. Petersburg area of Florida there is a program in place for using reclaimed municipal effluent to water several thousands of residential lawns.

This case study, which highlights the benefits of rainwater collection systems in low impact developments as compared to traditional rural
and suburban developments, outlines the numerous benefits that rainwater collection offers. It also suggests a realistic method for protecting the precious water resources of the central Texas region.

**Case Study: Seaholm Power Plant mixed-use development**

In addition to residential examples of rainwater collection systems, the City of Austin has a private-public commercial project underway that will potentially utilize a very large amount of reclaimed rainwater. The City has sold the development rights to the Seaholm Power Plant in downtown Austin. The 8-acre site, which contains an abandoned power plant and was a brownfield after the power plant was shut down some 20-plus years ago, will be adaptively reused and redeveloped to house a mixed use urban development. The former turbine building will be a retail and entertainment center and office and hotel/condominium buildings will be constructed. Altogether, some 95,000 square feet of roof area may be used to capture rainwater for nonpotable reuses on the site. However, it is the historic cooling water infrastructure of the power plant that provides a unique opportunity for potential water reuse on site and for considerable cost savings over time.

The power plant originally used water from Town Lake to cool the turbine generators in the building. This cooling system of underground pipes and storage tanks remains today, and has an enormous capacity for water volume which can be adapted into a rainwater collection cistern. There were many technical questions that had to be resolved in order to determine the feasibility of using the existing infrastructure. The table in Figure 12 shows an approximation of how much water can be captured, for example. The goal in using this system is to have zero net water brought to the site for landscape irrigation and fountain makeup water purposes. Even the potential overflow due to significant rain events will be directed to a bioswale that manages the excess water and provides an amenity feature to the site’s users. Importantly, the success of sustainable water practices on this site may provide encouragement for future developers in Austin to employ similar methods of recovery and reuse.

Similar to residential water reclamation practices, there are also barriers to commercial rainwater collection systems. The most apparent problem is cost. It is difficult to grasp the total costs associated with the rainwater collection system, especially given the unique opportunity afforded by the turbine cooling system at Seaholm. A second barrier is that the reused water...
must be considered an auxiliary supply, and this does provide redundancy to the system as was discussed with the residential system.

The advantages of reusing water are apparent, despite these barriers. Water reclamation will save water and also extend the useful life and capacity of the City's existing water infrastructure in the downtown area. As water rates increase over time, there is the potential for added cost savings. Storm water and the associated runoff pollution is managed more efficiently and effectively and with reduced polluting potential downstream. The rainwater system may also extend the useful life of water reclamation plants and stormwater drainage networks in the Austin area, by retaining and reusing this water on site.

Conclusion

Changes in climate, continuing population growth, and the increased use of natural resources all make sustainable water management practices increasingly valuable, even essential. In particular, rainwater collection and the use of water that would otherwise not be utilized efficiently, is a worthy example of a sustainable practice of distributed infrastructure that can be applied in small and large scale settings. The benefits of rainwater harvesting include reduced demand on natural water resources and municipal supplies, less pollution due to stormwater runoff, and the security of a dual water source.

The coupling of energy and water management represents the future of sustainable practices in urban planning and building design. While it is more difficult to accomplish on a large scale, individual building designs can optimize both energy and water. Hence, it is the role of architects and planners to ensure that buildings do their part to have some aspects of self-sufficiency and to leave the smallest footprint possible on their environment.

Notes


Images

Figure 1: www.aquasolutionsplus.com/images/

Figures 2-3: Courtesy of Kent Butler


Figures 7-9: Courtesy of Kent Butler

Figure 10: The Drought Monitor, National Drought Mitigation Center. http://drought.unl.edu/dm/monitor.html.

Figure 11-12: Courtesy of Kent Butler

Further Reading


Biography

Kent Butler received his B.A. from the University of Wisconsin in 1973. His M.S. and Ph.D. he received from the University of Texas at Austin in 1976 and 1977 respectively. Professor Butler is a member of the A.P.A. His current interests lie in infrastructure planning and development, metropolitan Scale planning and management of growth, water resources planning, and innovative methods to protect biodiversity in the context of urban development. In recent years, Professor Butler has ob-