Decentralized Urban Water Infrastructure

By Franco Montalto, PhD and Eric Rothstein

Nationally, urban water infrastructure is aging and in need of repair, while construction of new facilities is required to meet the challenges posed by urbanization, population growth, climate change, and increasingly stringent environmental regulations. As municipalities begin to contemplate how to address these challenges, increased attention is being directed to how engineers, architects, and landscape architects engineer the movement of both drinking and sewer water through developed landscapes.

Specifically, the load that buildings and landscapes exert on urban water infrastructure systems is determined by the rates of drinking water inflow and wastewater outflow, and by how these sites interact with the local hydrologic cycle. Drinking water inflow includes the rate of drinking water consumption, but also the usage of potable water for landscape irrigation, commercial and industrial washing, toilet flushing, air conditioning chiller supplies, and similar non-potable uses. On the downstream side, outflows include the rate of generation of "black water," itself contributing about 50% of dry weather flow in the sewer, as well as the rate at which other flows of water are discharged to the sewer system. These "other flows" include stormwater runoff, water extracted from dewatering efforts and basement sump pumps, as well as air conditioning condensate, chiller flows, and other industrial flows.

Conventionally and historically, when urbanization or population growth increased the demand for urban water infrastructure, large and costly interventions were undertaken to augment the capacity of centralized infrastructure systems to provide drinking water and sewer services. These efforts included the designation of huge tracts of originally rural land for municipal water supplies, construction of complex networks of water tunnels to extract and distribute the water where it was needed, all of which was typically followed by the required construction of filtration plants to ensure reliable quality of water piped out of these areas as development encroaches on them. Downstream of the city, storm drains, ditches, and canals, catch basins, sanitary sewer lines and pump stations have all been designed in an effort to collect, convey, treat, and dispose of "waste" waters (runoff and domestic sewage), an approach not too different from the way sanitation departments manage garbage.

Decentralized water management approaches that reduce drinking water consumption and wastewater and stormwater generation at the individual building scale are increasingly being considered as an important means of lessening the burden that development exerts on urban water infrastructure systems. This is akin to how a switch to fluorescent light bulbs can reduce overall energy demand.

The integration of water conservation measures and systems that capture, treat, and utilize stormwater, greywater, and groundwater for toilet flushing, landscape irrigation, air conditioning top-off, and other non-potable uses can significantly reduce both the quantity of drinking water buildings consume, and the quantity of wastewater and stormwater they discharge to municipal sewer systems. In one recent residential building project, we estimated that such measures could reduce the "waste" water stream by up to 65% over the conventional approach. However, the relatively low cost of water and wastewater services and the fact that building owners are rarely rewarded for reducing stormwater discharge from a site can pose a challenge in justifying additional consulting and construction costs associated with design of water re-use systems. Landowners typically pay for water and sewer services as a function of metered potable water usage and these prices are on the order of one dollar for every 1.4 cubic meters (375 gallons) of drinking water supplied or for every 0.9 cubic meters (235 gallons) of wastewater discharged. These relatively low water rates give little incentive to landowners and developers to install water conserving devices, let alone systems that treat and reuse greywater and require storage tanks, disinfection units, and dual plumbing lines. Until water rates increase significantly and / or policy makers make some difficult decisions, owner's of existing buildings will have little incentive to retrofit their buildings systems and developers will remain unincentivized to spend additional capital for reducing wastewater flows.

Nonetheless, an increasing number of developers are choosing to incorporate innovate water conservation and recycling technologies into the design of buildings and landscapes. Recent projects undertaken by our firm have included the harvesting, filtration, disinfection, and pressurization of roof runoff for use in flushing toilets, green roof irrigation, sprinkler systems, and pressure hoses for patio wash off for clients as diverse as restaurant owners, private and nonprofit developers, architecture firms, and individual land owners. While some of these clients are motivated by a deep environmental ethic and are fortunate to have extra resources to invest in water-efficient infrastructure, others have leveraged water conservation and recycling for eligibility for a variety of green building grants. A third set of clients are motivated by projected financial savings and expedited building permitting. Zoning boards concerned with the growing municipal water infrastructure liability are becoming increasingly reluctant to permit larger than as-of-right buildings, due to the increased load they will exert on already heavily burdened urban water infrastructure. Water conservation and recycling technologies that are shown to produce less wastewater than typical as-of-right buildings can help to convince local planners to permit these buildings, raising the bar for developers. We have been engaged by a developer to present to a NJ zoning board a model demonstrating how water saving devices and the use of all greywater and stormwater runoff onsite by our client could reduce the quantity of wastewater generated from his proposed 32 unit residential to the quantity typically generated by a standard 10 unit building. If this building is granted a zoning variance, the client will see higher revenues, the load on the sewer infrastructure will remain unchanged, the City's tax base will be increased, and energy savings will be increased due to the larger building size (surface to volume ratios).

To be sure, there is much ground still to be covered. Many zoning, building, drainage, and health codes make implementation of innovative water management schemes difficult. Municipal incentives and policies that do promote innovative lot-level water management often apply only to new development, while the integration of dual plumbing systems into existing buildings can be cost-prohibitive. In most cases discharge of stormwater to the sewer system is "free", and small-scale water filtration and disinfection technologies are still relatively costly. Further, little is known about the effect of stormwater infiltration on building foundations and other buried structures. Perhaps more formidable a challenge is the pervasiveness of a design philosophy on the part of some engineers, architects, and landscape architects that treats potable water as an infinitely available resource, and still allows good water to become waste. Urban watersheds consist of a mosaic of publicly and privately owned land, and both new and existing development. If the scale of drinking water, sanitary sewer and stormwater infrastructure serving these landscapes is to be reduced, a more enlightened approach to water management needs to be integrated into all aspects of urban design.

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