Rainwater Harvesting: Embedding Storage in Home Structure

Sustaining public water supplies is a complex task that can only be achieved by initiating changes in our consumptive behavior. One way of constraining water use is to develop the built world according to conservational and regenerative designs. From a water management perspective, this explicitly dictates the tapping of new potable sources and the protection of traditional ground and surface water supplies from excess runoff and overdraw. Methods of doing both exist, and have been manipulated to the point that some public infrastructure systems and building designs now incorporate new, generally neglected water sources in altering the inputs and outputs of prior water use and distribution systems.

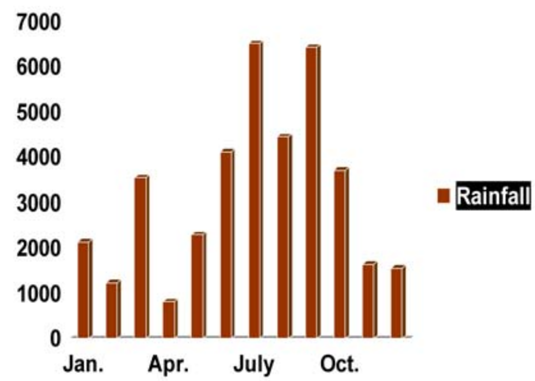
Three promising innovations in this new vein are reclaimed water systems, greywater reuse mechanisms, and rain harvesting apparatus. Reclaimed water systems, which offer connections to treated municipal effluent at a lower cost than potable water provision, are effective tools for large volume users like agricultural operations, food production outfits, and golf courses to reduce their potable water consumption. To date however, these systems have made little progress in reworking conventions of residential water delivery, mainly because of infrastructure costs and public perceptions that treated effluent, which is actually filtered more vigorously than faucet water,[1] is unsuitable for supplying home needs like clean bathing and drinking water. Greywater reuse systems remain uncommon and with a few exceptions are still more of an academic, experimental exercise in recycling drain water than an infrastructural reality.[2] Concerns similar to those impeding wider reclaimed water use also hinder broader greywater implementation, questioning the suitability of greywater for even the most simple irrigational uses.[3]

Rainwater systems are by no means a new invention, having existed for centuries in places like Australia, Bermuda, Indonesia, Japan, Thailand, and Hawaii, but have more recently been put to innovative new applications in the continental United States. Utilizing native landscaping, roof catchment surfaces, and external storage cisterns, citizens of rain-parched areas like Austin, Texas and Tucson, Arizona are enjoying impressive residential water conservation results attributable to these home design elements. Rain harvesting achievements like those made at Tucson's Civano development, which is touted as America's first sustainable community, prove that over 50% of a home's potable water consumption can be eliminated by way of these techniques.[4] Nearly 250,000 other Americans harness similar home designs to realize substantive potable savings.

With the exception of downfall in some polluted urban areas, rainwater is generally clean, can be purified with minimal filtration, and is at least suitable for eliminating potable water use for irrigation and toilet purposes. The achievements made at places like Civano and the general suitability of rainwater as a potable water substitute merit the consideration of applying rain harvesting both large home tract development and municipal water supply problems are civic norms. Given these constraints, warm, humid climates like Florida are the ideal settings for siting new design proposals that further integrate rainwater harvesting systems into current in-home water use and distribution regimes. Conducting such a design exercise is to experiment with making the home a more sustainable entity, and such an experiment is submitted below.

Prior to advancing a new and integrative sustainable home design, we would be wise to constrain, and thus legitimatize our design practices according to current building conventions. First and foremost, it is necessary to understand rainfall dynamics and the storage volume achievable given a designated rain catchment surface. Second, daily and monthly user requirements must be taken into consideration to envision the substantiality of attainable results. And last, building conventions and financial considerations must shape any rethinking of in home water regimes, in order to avoid excessive project costs and construction difficulties.

Florida receives about 55 inches of rainfall each year,[5] which, considering that 1500 square feet of catchment surface can accumulate 825 gallons per inch,[6] permits average catchment volumes on the order of thousands of gallons of water each month. As the figure below illustrates, the areas in consideration could collect 2000 gallons of water at least eight months of the year.



Monthly rainfall (gallons) collectible from a 1500 ft^2 catchment surface.

These catchment volumes are substantial considering daily and monthly user requirements, which tally to 224 gallons daily and about 6700 gallons per month.[7] A cistern system capable of storing excesses of 3500 gallons a month could, if used in conjunction with conservational appliances and xeriscape landscaping techniques,[8] reproduce residential potable savings comparable to Civano results.

$2000-$3000 dollars dependent on cistern materials used.[9]

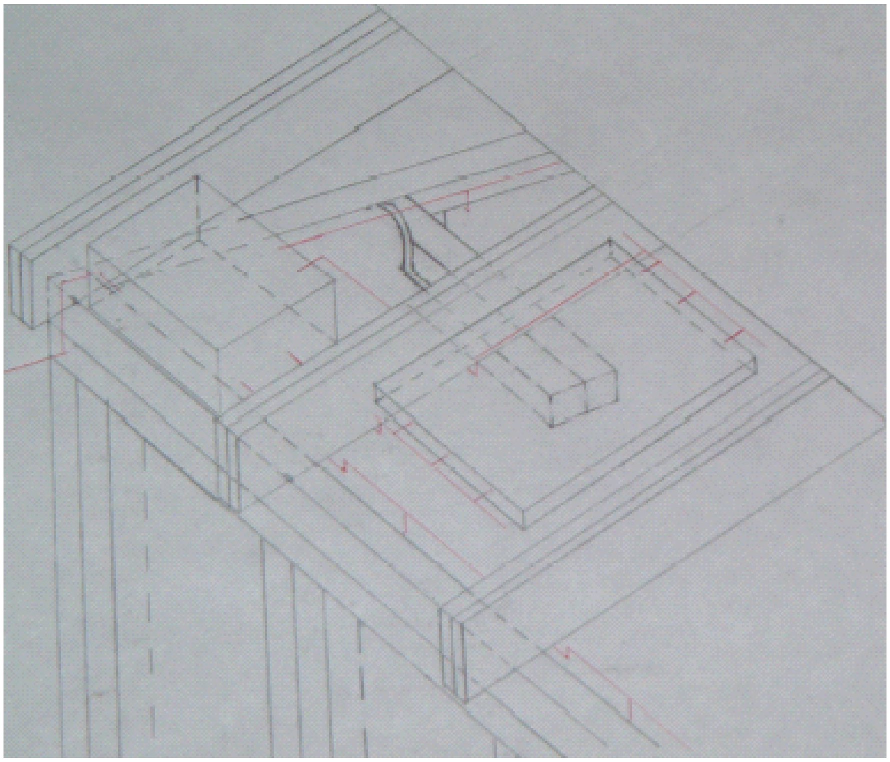
Another helpful way of rationalizing potential home water savings is to specify water uses that might easily be eliminated as draws on potable municipal supplies. Essentially, this means deciding the water uses for which rainwater may constitute an acceptable substitute. Upon preliminary examination, toilet and irrigation uses seem to be the most promising candidates for substitution, and with minimal filtration commercially available to cistern users laundry uses might also be curtailed.

Eliminating these water uses, which require approximately 80 gallons, between 30-60 gallons, and 10-30 gallons daily for a four person home, could reduce home potable water consumption by up to 70% provided 4700 of gallons storage space.

Relevant financial realities, however, dictate that for an appropriate storage system to appeal to likely clientele (large home tract developers), the entirety of added project costs must not exceed conventional home building costs by more than $5000-$6000. In all likelihood these cost constraints would limit system capacity to a maximum of 4000 gallons, which could provide for 60% of monthly home water needs. Spatial and building constraints further assert that this 8 foot high, 9 foot diameter cistern must be embedded in a concrete slab foundation.

Taken together, these figures and constraints reiterate that designing more integrative rain harvesting systems is a complex but promising exercise in mining considerable in-home water savings potential.

Practically, these ideas might work their way into conventional home designs by connecting a rooftop and gutter catchment assembly to a solar and sand and gravel filtration apparatus that then feeds a 4000 gallon cistern embedded in the home’s foundation. Attaching the extra system components necessary for construction, which consist of piping infrastructure, solar panel and distillation assemblies, and filtration mechanisms, would admittedly add to project costs. However, as Civano investment returns suggest, the private and municipal utility savings possible from potable water use reductions may very well justify these added costs.[10] The system might manifest itself to resemble the roof assembly



A roof assembly sketch. Red lines indicate the path of water flow from gutters into a filter, from the filter to a solar distillation panel, and then from the filter-panel assembly to a foundational cistern and, ultimately, home appliances.

The logic underlying the above design is derived from conservational ideals. The filter, solar panel, and cistern assembly is designed to minimize piping distances and limit the work that pumps must perform against gravity, improving upon traditional external cistern systems by increasing pumping proximity and utilizing rainwater to feed appliances. The only non-foundational spatial allowances that must be made are for battery storage, structural supports, and maintenance access ways, all of which might be relegated to occupy attic space instead of living areas below.

As a further exercise in approaching sustainability through residential and municipal resource efficiency, the idea of integrating water storage into conventional wall stud and insulation assemblies was assessed. The premise of this concept was that if homes could also store rainwater in prefabricated “tank-panels” situated between wall studs, then energy costs for home temperature control could be replaced by a green-powered system that regulated temperature by recycling wall panel water through solar heating and convection cooling mechanisms. This idea was dashed however, because of concerns that water does not provide a sufficient thermal mass. It seems that the appliance-oriented approach is a more viable way of reducing home consumption and making the home a more sustainable entity.

Before realizing potential water savings, further research is needed to examine rainfall dynamics and design a functional, cost-effective water system that balances supply draw down and storm replenishment flow regimes. Clearly, that research is justified, for if such a retooling of in-home water flows can save on over half of home use, then figures on savings per developed community will be equally substantial. Were each home in a 1000 home residential development to save 60% of its water consumption, then the responsible municipality entity could cut 4,000,000 gallons from its monthly delivery load. A county with 20 such developments could realize potable savings on the order of billions of gallons each year.

Sources:

1 - For more information on reclaimed water quality, see the Tucson website at www.ci.tucson.az.us/water/water_resources/reclaimed_water/reclaimed_water.htm [Accessed 3/23/04]
2 - St. Petersburg, Florida, distributes reclaimed water to 7000+ residents. See www.stpete.org/wwwrecla.htm [5/4/04]
3 - To examine greywater quality, see www.ag.arizona.edu/pubs/garden/mg/vegetable/rooti ng.html [3/23/04]
4 - See figures at http://www.civanoneighbors.com/docs/environment/Civano Water2003FNL.PDF [2/27/04]
5 - For Florida rainfall figures, see www.worldclimate.com/cgi-bin/data.pl?ref=N27W08 2+2200+088021C [4/3/04]
6 - For calculations, see the report at www.civanoneighbors.com/docs/environment/revised 2civwaterfinal.pdf [2/25/04]
7 - For home water usage figures, consult www.ga.water.usgs.gov/edu/qahome.html. Estimates range but confirm that usage is 60-80 gallons per person per day. [4/3/04]
8 - For information on xeriscape landscaping, see http://www.xeriscape.org/. To see Floridian xeriscape in practice, go to www.sfwmd.gov/newsr/2_photo.html [3/23/04]
9 - See the Texas Rain Harvesting Guide at www.twdb.state.tx.us/assistance/conservation/Cons-image/Downloads/RainHarv.pdf [3/23/04]
10 - Civano achievements repaid an added $4000 initial investment in 2 years. Potential municipal savings from initiating rain harvesting cistern rebates instead of extending reclaimed water systems could also be substantial. See www.sustainable.doe.gov/success/civano.shtml and www.rmi.org/images/other/Businesses/NC99-19k_AqueousSltns.pdf [3/23/04]

Pictures from:

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