Rainwater Harvesting and Recharge Techniques for Flood Control and Improved Stormwater Quality

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Vaikko is the Stormwater Regulatory Manager for CONTECH Construction Products Inc., where he assists regulators, engineers and environmental organizations in the development of regulations that are clear, implementable, and protective of our public waters. Throughout his 14 years of stormwater management experience, he has managed BMP testing programs, new product development initiatives, and been involved in numerous work groups providing technical guidance on TMDL implementation, hydromodification planning, and low impact development. Formerly, Vaikko served as Technical Manager of Vortechnics, Inc., a rapidly growing stormwater BMP provider that was acquired by CONTECH in 2004. He holds a BS degree in environmental science and policy from the University of Southern Maine with a concentration in water resources. He also holds patents for several stormwater BMPs.

The following is a transcript of an oral presentation given by Vaikko Allen.

Good morning. I'm glad to be here today and I've enjoyed meeting a few of you here as I spend some time in New Mexico. What I want to spend most of the time talking about is rainwater harvesting and infiltration and capturing water that might otherwise be lost to the atmosphere and perhaps using it for something useful, thereby reducing potable water demand. That water is needed for all kinds of things here, farming for example, and it is also over-allocated if you are look at the Rio Grande or other water systems.

I want to zoom down to the micro level, the site level. What do you actually do on specific projects and what are some of the techniques? But before we look at that, I thought it would be wise to take a macro view and ask ourselves what is our goal and what are we trying to do here. I think as you back up further and further, you eventually reach a point where nobody can disagree, which is to say, sustainability is really the important strategy or endpoint that we are all trying to reach. It is where you have some kind of a balance between extraction of resources and the natural replenishment of the resources so that you can provide for the needs of the present without compromising the ability of future generations to satisfy their needs.

Back in 1987, the World Commission on Environment and Development came up with a definition that is one of the first widely referenced definitions of sustainability. People usually quote the beginning part, but the more interesting parts **follow in bold**. The commission recognizes that it does imply that there are some limits, particularly to resources and how much of them you can use, but they also point out an important point, which is that those limits are a function of the technology and social organization that exists at the time. To the extent that we can improve on those two things, we can actually increase our ability to use our resources, and we can use more of them some of them perhaps.

> Humanity has the ability to make development sustainable to ensure that it **meets the needs of the present without compromising the ability of future generations to meet their own needs**. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of **technology** and **social organization** on environmental resources and by the **ability of the biosphere to absorb the effects** of human activities. (WECD, 1987)

The report included some simplistic math and maybe it applies to water resources; the more we extract that isn't replaced or the more we degrade what is remaining there, the less we have to use.

- Water Resource Impact = Resource Depletion + Resource Degradation
- Resource Depletion = Resource Use – Regeneration Rate
- Resource Degradation = Pollution Inputs – Assimilative Capacity

For those of you who are visual learners, about the most macroview that you can have puts this in perspective (Fig 1). What we see is obviously the earth in two views, but you are seeing a representation of the total amount of water on earth as compared to the earth itself and the total amount of air in the atmosphere. That is a pretty small drop in the bucket so to speak, about 1.4 billion cubic kilometers of water we have on earth. As you all probably know, of that water, 97 percent is in the oceans. What we are left to manage is really a very small amount. We need to be exceeding careful and deliberate about how we use it.

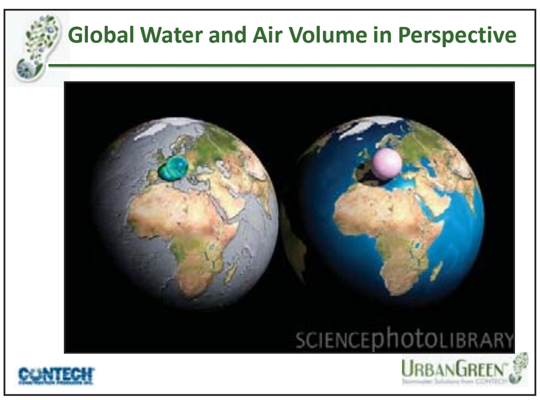


Figure 1. Total volume of water on earth (left) and total volume of air in atmosphere (right) [Credit Adam Nieman/ Science Photo Library]

Getting a little bit closer to where we are now, and looking at what the future holds for us, we can talk about the next ten years perhaps and water policy decisions and management decisions that need to be made (Fig. 2). If you look at New Mexico specifically, in the next ten years between 2010 and 2020, we are expected to have a little more that 100,000 additional people move here. It may be a less dramatic increase than some of the surrounding states, but it is still pretty important when you do the math as far as water demand. A 150 gallon per day (gpd) per capita target is not something that we are at right now but it is set as a realistic goal for us in the next few years. We are at about 155 or 160 gpd. When you do the math, there is 17,500 acre-feet per year in additional demand that has to be coming from somewhere. Where does it come from? I don't know the answer to that question, but I think as we go through the rest of the presentation, we'll see some places where we may be able to salvage a bit of water that otherwise may be a loss.

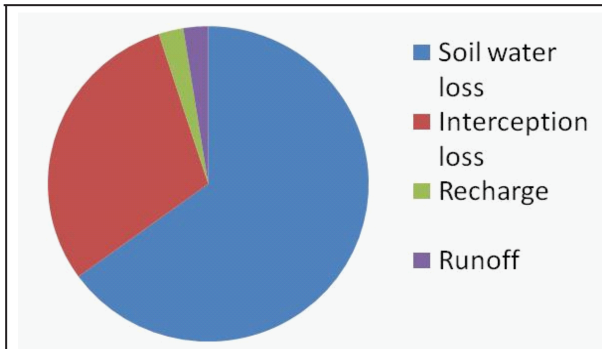
The biggest thing to focus on when talking about water or energy or many other utilities is efficiency improvements. That's kind of like a free additional source or supply. To the extent that you can be careful with what you are using, there is more of it to go around. Desalination projects around here use pretty deep groundwater but sure enough, people are extracting it, and of course you look to the extent to which you can bring water in from outside, although I think around here it is usually the case that more people are trying to take the water from here and export it outside the state than the other way around. A lot of those avenues are either expensive, as with desalination, or they are often tapped out at this point.

Region, division, and state	Numerical change 2000 to 2010	Numerical change 2010 to 2020	Numerical change 2020 to 2030	Numerical change 2000 to 2030	Percent change 2000 to 2010	Percent change 2010 to 2020	Percent change 2020 to 2030	Percent change 2000 to 2030
United States	27,513,675	26,868,965	27,779,889	82,162,529	9.8	8.7	8.3	29.2
Colorado	530,293	447,313	513,490	1,491,096	12.3	9.3	9.7	34.7
New Mexico	161,179	104,116	15,367	280,662	8.9	5.3	0.7	15.4
Arizona	1,506,749	1,819,067	2,255,949	5,581,765	29.4	27.4	26.7	108.8
Utah	361,844	395,081	495,273	1,252,198	16.2	15.2	16.6	56.1
Texas	3,797,068	3,986,008	4,682,848	12,465,924	18.2	16.2	16.4	59.8

U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.
Internet Release Date: April 21, 2005

Figure 2. Project population growth for western states

I thought it was interesting to look at the dryland range water balance (Fig. 3). I know you are a sophisticated audience and we don't have to look at the whole water balance graphic, of which there are many pretty pictures: the rain falls, some of it evaporates, some of it infiltrates, some of it runs off, and so on. If you look at this on dryland range, similar to what you would have in places in New Mexico, you see that the actual run-off percent and the recharge percent are very small and in most cases will be substantially less that 10 percent of the total rainfall. In a lot of these cases, the water falls and is absorbed in the top layer of soil and then it evaporates over time, some of it is directly intercepted by vegetation just falling on leaves and such and evaporating directly. That water doesn't go anywhere in terms of improving your water supply; it isn't available to you. It falls, goes back up into the atmosphere and is lost; thus the water is unavailable.



- 30-80% Soil water loss
- 20-40% Interception loss
- <5% Runoff
- <5% Deep Recharge

Figure 3. Dryland range water balance. Wilcox, B.P., D.D. Breshears, and M.S. Seyfried. 2003. Water balance on rangelands. In *Encyclopedia of Water Science*, Marcel Dekker, New York, 791-794

Think about the way urban development works: you come in and build houses, you pave areas, and you turn the landscape runoff, which has a natural sponge that may be taking up 80+ percent of your precipitation. The runoff piece of the pie dramatically increases in these cases, especially as imperviousness increases. What can we do with that water? How can we use that? That leads me to the rest of the presentation on is rainwater harvesting; getting water into the ground in such a way that it could potentially be useable or recoverable later on.

Conservation has been outlined a bit today, but who has heard of green infrastructure and low-impact development as a terms being thrown around, especially as terms in the stormwater world? It is kind of a buzz word this year. I know U.S. EPA has been through this region conducting green infrastructure workshops. I'm going to trace through a couple of developments that are happening at a national level and you can see a direction where things are headed from a stormwater management perspective.

Green infrastructure and low-impact development action plans have been developed. These plans make it very clear what they are trying to do. They are trying to build in such a way that they preserve that sponge, that evapotranspiration, and that natural functionality of our landscapes even though you are putting in buildings, parking lots, and roads.

An interesting piece of legislation is the Energy Independence and Security Act. This applies to federal facilities and from a stormwater perspective, it contains an important short paragraph, Section 438, and a guidance manual published in 2009. It basically says that for a federal facility, to the maximum extent technically feasible, you can't have any increase in the post-development run-off duration, magnitude, temperature, or volume. That is a pretty difficult thing to calculate and to prove what you've done, but they said that instead of doing all those complicated calculations, you can just retain the 95th percentile store on site by design. In most cases that works out to one or two inches. You must take the rainfall and not let it leave your site. That applies to federal facilities, so those working on military bases and would have to follow this, too. In 2010, EPA published the MS4 Permit Guidance that applies to municipal and separate storm sewer systems. It is expecting that as permits get renewed, they will basically do the same thing, retain the 95th percentile design storm on site to the maximum extent technically feasible. So you can see the direction EPA is pushing things as stormwater permits are updated.

I live in California, and it has been a pretty interesting and tumultuous couple of years as we have had eight or nine municipal permits being renewed in places like Orange County, San Diego, San Francisco Bay, and other places. Figure 4 is my attempt to summarize and homogenize all relevant requirements into a handy table. Basically what it says is that you have a hierarchy of management techniques that you are expected to use when it comes to managing stormwater. If you start at the top, source control and design techniques are things to preserve that natural sponge that exists or to just use less impervious materials. If you can't do that, then you need to infiltrate that water at the surface via retention. If you can't do it at the surface, then dry wells or something similar is used. If you can't get that done, you can use rainwater harvest to keep that water from running offsite. If you can't get the job done through any of those techniques, which actually retain the water onsite, you need to go to the next step, which is to do some sort of flow-through treatment. Before you get there, you must do a feasibility test, basically to prove that it is technically infeasible, not financially infeasible to hold that water onsite. As you can imagine, the development community thinks it will be difficult if not impossible as well as extremely expensive and all the details are settling out. I think this framework is what we are moving toward everywhere in the U.S. Right now the EPA is engaged in a rulemaking process and they expect that in 2012 they will have a new stormwater requirement that will apply universally and which will be patterned after this kind of approach.

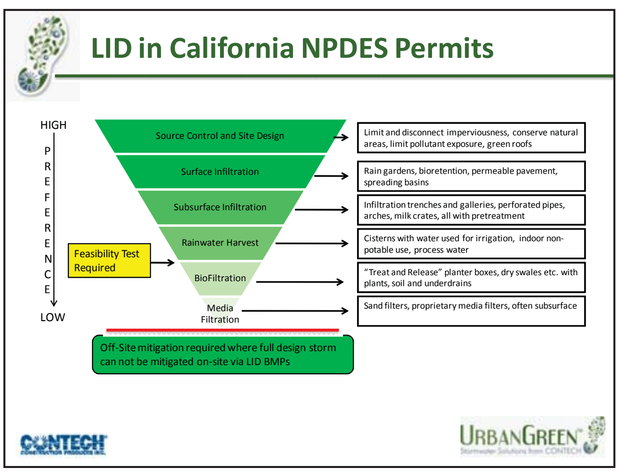


Figure 4. Hierarchy of management techniques used when it comes to managing stormwater

For the rest of the presentation, I want to talk about these controls: what they look like physically, how they are designed, and what we need to think about. First, for the infiltration part, there are some very obvious things like if water goes in the ground you need to think about where it is going. You don't want to put it in the vicinity of contaminated soils, contaminated groundwater plumes, or building foundations. If you are going to be doing infiltration, you need soils that are permeable; obviously you can't permeate if you have bedrock or clay or anything else impermeable. And, wherever the water goes, things that are soluble are going to go with it, so you must pay attention to what is located in the area like gas stations. You don't want to be doing infiltration and later end up with problems created as a result.

There are lots of ways to do surface infiltration. Figure 5 addresses permeable pavement. A lot of options are out there; this is basically used exactly the same as regular asphalt or concrete would be, they just remove the fines from the mix and you have a relatively porous top surface. Below that, there is a bed of washed stone that has a 30-40 percent void ratio and usually a fabric liner underneath that, which acts as a reservoir. So when it rains, it acts like a permeable surface, the water goes into the ground and is able to percolate into the native soil. This is not accomplishing much as far as water supply, but it will satisfy stormwater requirements. There are also plastic grids that are sometimes used with turf on them. However, around here let's avoid turf if at all possible in light of our conservation goals. You can use gravel with the idea that essentially you are reinforcing the driving surface so that it can support much more load; it is like a snowshoe, it supports a load over a wider area so you don't destroy the driving surface. Also, if it rains, it is a much more durable surface because the water can flow through and you don't end up with ruts.

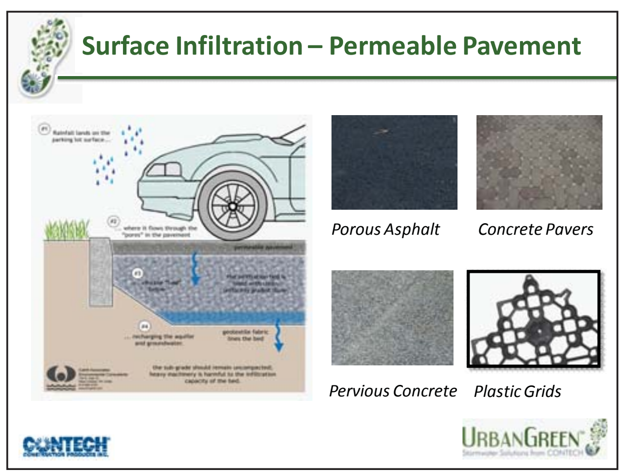


Figure 5. Examples of permeable pavements

The other way to get water in at the surface is by retention and Figure 6 is an example of a typical one in San Diego. Essentially what you are doing is taking sheet flow from an impermeable area and running it to a pervious area with some kind of surficial depression; sometimes they are much more recessed than the one in this photo and the water just does what it would do naturally, infiltrate into the ground. Typically there is a rock layer or something below that has some kind of reservoir volume so that you can accommodate the volume of water that comes off impermeable surfaces. What we find, especially in California and in urban areas, is that you start to have development densities that drive up the cost of land and also decrease the amount of land with which you have to work. Often people don't want to give 10, 12, or 15 percent of their site area over to a bio-retention system because it represents lost parking spaces or other useable space.

Figure 6. Bio-retention of parking lot runoff in San Diego

A way to get around that problem is to do subsurface infiltration. Figure 7 provides an example with before and after photos of an Ohio college dorm. Instead of having a pond for retention, a below grade pond was built essentially out of corrugated pipe with the land surface on top. There are lots of ways to do this. In this case there was a detention system, but those pipes could be perforated and it could be infiltration as well.

Figure 7. Subsurface infiltration: Construction (left) and after (right)

It should be pointed out that especially when we are talking about subsurface infiltration, pretreatment is critical; basically, infiltrating surfaces are going to be below some landscaped or paved area. You do not want to have to go back in there during the life of the project, 20 or 30 years, and rehabilitate that infiltrating surface. To the extent that you can keep solids out by using advanced pretreatment, it is a very good idea. Figure 8 is a cartoonish version of what that might look like: we have a catch basin taking runoff from the parking lot, running it through a separator, and running into long barrels, in this case perforated corrugated metal pipe. From the perspective of someone parking their car there, they would have no idea that this system exists, but it is performing the recharge function and doing it in a way that is really unobtrusive.

Figure 8. Subsurface infiltration where pretreatment of runoff would be required

A lot of different materials are available for infiltration and detention, including concrete, metal, and plastic (Fig. 9). Some systems are extremely large. The CON/SPAN units are precast, delivered, and usually set up with strip footings, at least in an infiltration application, and it is essentially an underground spreading basin. Crushed rock lies between the strip footings and water would be able to infiltrate. We have placed these at airports; they drive planes right over the top because it can be reinforced. Essentially we are taking an infiltration basin and putting it underground to recover some of that useable land. Corrugated metal pipe tends to be one of the cheaper ways to go about this, in many cases $.50 to $1.00 per gallon of storage volume. And these systems can look like just about anything and are very versatile. When we are doing stormwater work in most cases, we use aluminized pipe as opposed to galvanized pipe because the zinc content of galvanized pipe can sometimes cause problems downstream so it is avoided.

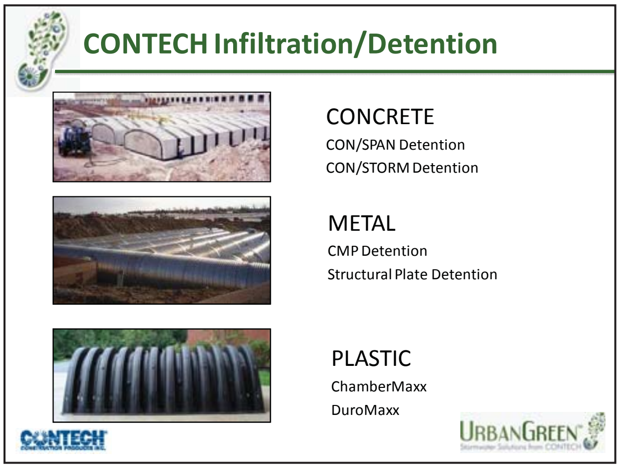


Figure 9. Example of concrete, metal, or plastic for infiltration

Lots of plastic systems are out there; for example, there are milk-crate type systems (their generic term), that are square boxes that you can stack. They have a 90 percent void space; there are lots of different containers for the water and you can think of them as gravel replacements. You basically fill the trench with gravel and sometimes put an under-drain on the bottom. All these systems are a way to avoid using a lot of gravel, thereby shrinking the size of your system pretty dramatically and improving the loading capabilities.

Depending on what your constraints are, if you have a very wide or shallow application, you might use plastic. If you are looking to save a lot of money and have room for an 8- or 12-foot diameter pipe to be buried under-site, then corrugated pipe is typically the most cost-effective option. There are lots of ways to install it, but the idea is to get the water below the surface and to infiltrate it into the ground.

An example I thought was interesting was a recent job I worked on in downtown Los Angeles (Fig. 10). It was located in an old industrial area with a bunch of buildings, some housing, but mostly old dilapidated commercial buildings that they tore down and are building a massive new development on the city block. No landscaping is required because it is in the downtown commercial zone; there aren't even setbacks, you can literally do a lot-line to lot-line development. As you can imagine, as they develop and add a lot of paving, either for the driveways and parking lot or for the building rooftops, there is a whole lot of stormwater runoff that is going to be generated. A big concrete system with drywells punched in the bottom was installed. The system will hold the runoff volume and over the space of a couple days, it will infiltrate the drywells, three of them underneath manholes that go down about 40 feet below the bottom of the system. Eventually there will be a fire lane over the top in the middle of the site so there is access to maintain or inspect it as needed. This is an extreme example of a very dense site, but that is how it can look.

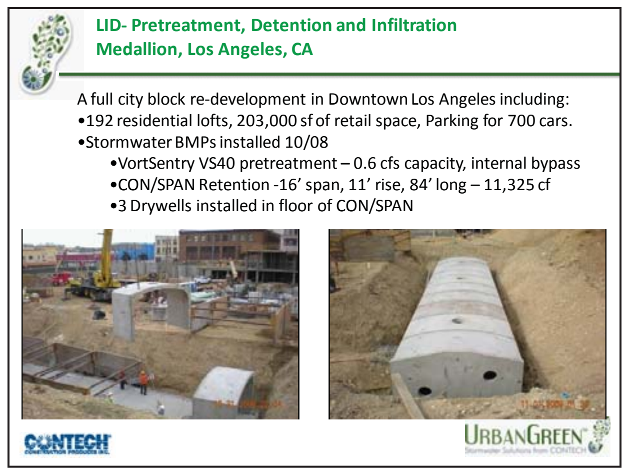


Figure 10. Los Angeles concrete infiltration and drywell system

Let's switch gears a bit and talk about rainwater harvesting, the other way to capture and hold onto water. Two philosophical design approaches exist when you are talk about stormwater or rainwater harvesting. Traditional water harvesting is the collection and reuse of stormwater, grey water, and other sources to reduce or eliminate the consumption of municipal potable water. Typically, the way we've been doing things for thousands and thousands of years is essentially an attempt to conserve water; you try to offset demand for water that you might have to bring in from some other source by increasing your catchment area. Rainwater harvesting for low impact development is the collection and reuse of stormwater for beneficial purposes to reduce or eliminate post-construction runoff.

Figure 11 contrasts the two approaches. If you are trying to conserve water to offset municipal water demand, you want to have a big catchment area to increase your supply. If you are doing it for stormwater purposes, you want to make your catchment as small as possible so that there is less runoff to try to eliminate. If you are trying to minimize and conserve the water usage, it is a conservation approach. With a stormwater focus, you must search for water reuse applications to get rid of that water somewhere onsite so that you can recover the cistern storage space for the next time it rains. Taking that further, it is good in a conservation paradigm if your tank is full because that means you have water available for your next irrigation. In a stormwater application, if you have a full cistern and its going to rain, you aren't going to be able to retain that water, so you want to empty the tank as soon as possible. There are some competing design ethics that are interesting in the way that they determine what the systems actually look like. As it turns out, usually if you are designing for conservation, you probably are going to be meeting your stormwater requirements as well, but it doesn't necessarily work in the other direction.

Rainwater Harvesting – Two Perspectives

	Conservation Focus	Stormwater Focus
Primary Goal	Reduced municipal demand	Eliminate runoff (pollution prevention)
Secondary Benefits	Reduce SW Runoff, Energy, CO_2	Conservation, Energy, CO_2
Catchment Area	Maximize, to Increase Supply	Minimize, to Reduce Supply
Water Usage	Minimize and Conserve	Find Reuse Applications
Seasonal Challenge	Dry Season – not enough rain	Wet Season – too much rain
Cistern Goal	Keep it full	Empty it quickly
Economic ROI	Negative – "external costs" not included in market price of water	Positive – best LID solution in many cases

Designing for conservation usually meets stormwater requirements but not vice versa.

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Figure 11. Stormwater approach vs conservation approach in rainwater management

Where is this used? It is used primarily for irrigation, toilet flushing, clothes washing, vehicle washing, process water cooling, and fire suppression. Plumbing codes and public health issues are concerns when you start to bring water inside a building. It turns out that when you do rainwater harvesting for stormwater runoff production purposes, it is very important to find those reuse applications for inside, because typically when it rains you need to get rid of water quickly to recover the volume in your cistern. However, you usually don't need the water right then for your landscaping, so you can use it to flush toilets, do laundry, or something similar.

We generally have two types of systems; although an oversimplification, you have passive and active systems. First, let's look at passive systems briefly. These are typically intercepting roof runoff just because of the head or grade differential; you need the gravity from the roof to be able to fill your cistern and the cistern should be located above where you need to use it. Figure 12 is an example. The conservation design of the tanks corresponds to the annual rain volume and can get very large. For a low-impact development design, we usually see tanks designed to hold the average storm, 1 to 1.5 inches, and which empties relatively quickly over the space of a couple of days. This kind of system does not do anything to offset potable demand, but it does solve the stormwater runoff issue. Typically, you have some connection to the roof, a screened opening, sometimes a screen in the downspout, an overflow pipe in case it gets full, a spigot connected to a hose or some other water distribution system, and a drain to clear the system out periodically (Fig 13).

Figure 12. Passive rainwater harvesting design [Credit Sherwood Design Engineers]

Figure 13. Components of a passive rainwater harvesting system

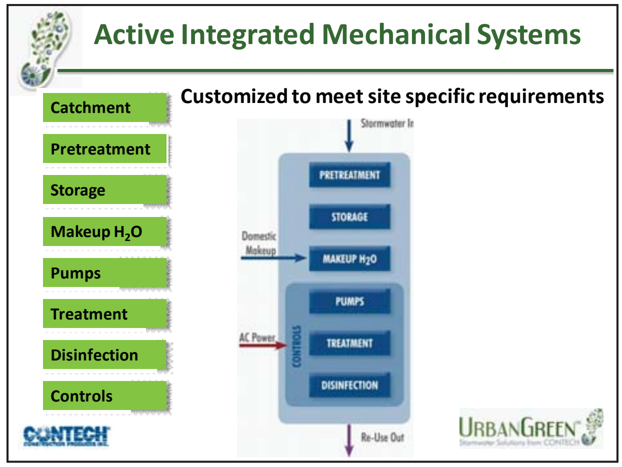

Figure 14. Active mechanical rainwater harvesting diagram

Active systems are a bit more complex; essentially water comes in and goes out and you need a way to model what happens over the course of a year or multiple years to determine the system's design. A notable difference with the passive system is that power is required for the active system because you have controls, like pumps, treatment, or disinfection oftentimes, and depending on the system's design, you may have municipal makeup water pumped directly into the system. Figure 14 shows the components of an active integrated mechanical system. The catchment is very important depending from where your water is coming. If it is from your rooftop, it's going to be relatively clean, probably just a couple millimeter screen will suffice to catch the leaves and other large debris. If you are draining from a parking lot or roadway, there will be a whole lot more stuff in it and you probably want to go down to a 20-micron screen just to get the pavement abrasion, the organics that may be accumulating, tire and brake pad disintegration, and so on. Obviously you want to avoid any industrial areas where you have potential for spills. Once you get that water off your impervious surface, pretreatment is important. Again, if you are at a rooftop, you want to use a screen; if it is coming from the surface, you want to use a filter or at least some kind of gravity separator. We want to keep the BOD level down; we don't want to have organics going into a cistern and sitting there for a long time making the water anoxic or septic, which can be an issue.

Figure 15 is a mechanical system that looks more complicated than that rain barrel we saw in Figure 12. Typical component options include treatment with screen, filters, manual or auto back flush; makeup water with day-tank with air-gap; back-flow preventer; disinfection of UV with chlorination, instant or recirculation; pressurization with suction pumps or submersible pumps; controls for operation, monitoring with tie to building management; power supply of 120/240/480 v in 1-phase or 3-phase, and enclosure indoor, outdoor, or underground. CONTECH has been supplying these types of skid mounted or palletized systems. We heard again and again from engineers, developers, and designers that these systems were just too complicated: to get the parts sourced and working together, and to get the control panel built and able to talk to the pumps and flow meters. We thought this was an opportunity for innovation and we started working with a couple companies who do this work. We now are providing systems that look somewhat like the system in Figure 16.

What you can't see in Figure 16 is the back where there is the feed-in from the cistern; it goes through the back of the panel and through a filter and drops into the tank, which is an empty day tank. The filter backwashes and this backwash travels from the filter through a pipe and discharges. It is not ultimately part of the water use, so some water is lost. We have a municipal makeup waterline in this system with a little air gap so the water comes in from the municipal source and tops off the tank in times when you don't have enough water available in your cistern to fill the tank. This system has a UV disinfection loop. We aren't disinfecting the whole cistern; we disinfect the water that gets used on a daily basis. It's best to disinfect water as close to the time it's needed and disinfecting a smaller volume is less expensive. The pump at the bottom of the figure takes water from the day tank and delivers it to the use application. In this case the water will be used for irrigation. A control panel on the left side keeps track of different valves, flow-meters, and so on, and makes sure the system is operating as intended. The water from this system goes outside to an enclosure (although it could go to an indoor basement); sometimes we use a vault, so there are lots of different ways to go.

Figure 15. Traditional active mechanical rainwater harvesting components

Figure 16. New active mechanical rainwater harvesting

Cisterns oftentimes are the biggest cost. Lots of types exist and some of the types we provide are described in Figure 17.

Cistern options

Type	Product	Options	Water Tight Rating		Pricing (per gallon)	Best Use
Below Ground	**Wrapped** (pond liner)	Perforated CMP ChamberMaxx	Non Pressurized	10-25 yrs (longer life liner options possible)	$0.50 - $1.0	Infiltration Inlet Large Storage (100k gal and up) Non-critical storage
	BGM Below Ground Metal	Single Tanks (up to 48' Long) Multiple Tanks (no joints, daisy chain)	Up to 8 psi	25-75 yrs (depends on soil)	$0.65 to $2.0	Small/Medium Size (3k to 100k gal) General Use
	SRPE Steel Reinforced Polyethylene	Tanks (14' or 22') Barrels (No Headers)	15 psi	50-100 yrs (depends diameter and pressure)	$1.70 to $4.0 $0.60 to $1.40 *(+ shipping)*	Medium/Large Systems Water Critical (near building, slope, potable)
Above Ground	**AGM** Above Ground Metal	72" to 15' tall 96" to 20' tall 120" TBD	Up to 8 psi (20ft head)	25-100 yrs (Metal life 100 yrs, replaceable liner)	$0.75 to $3.0 *(+ foundation)*	Above Ground Up to 10k gal

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Figure 17. Cistern options

Figure 18 shows the standard components of the system. In Figure 19, you can see the pond liner, which is an impermeable geotechnical membrane that gets wrapped around the entire system. Figure 20 shows corrugated metal pipe that is perforated and will be backfilled with gravel and wrapped over the top, similar to the chamber system. We also install metal pipe tanks below grade, which is a technology we've adapted that is similar to a rhino liner for the back of a pickup truck bed, it is basically a rubberized sealant (Figs. 21 and 22).

UrbanGreen Cisterns

Standard Components

- Inlet
- Overflow
- Transfer Pipe (not shown)
- Calming Inlet
- Floating Outlet
- Access and Vent

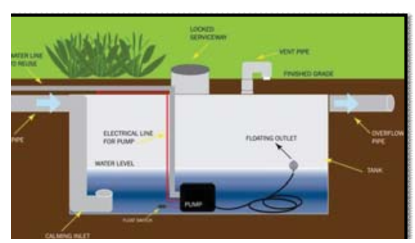

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Figure 18. Standard cistern components

Figure 19. Impermeable pond liner in the background and perforated metal pipe that will be filled will gravel and wrapped over the top, similar to the chamber system

Figure 20. Wrapped corrugated metal pipe that has been filled with gravel

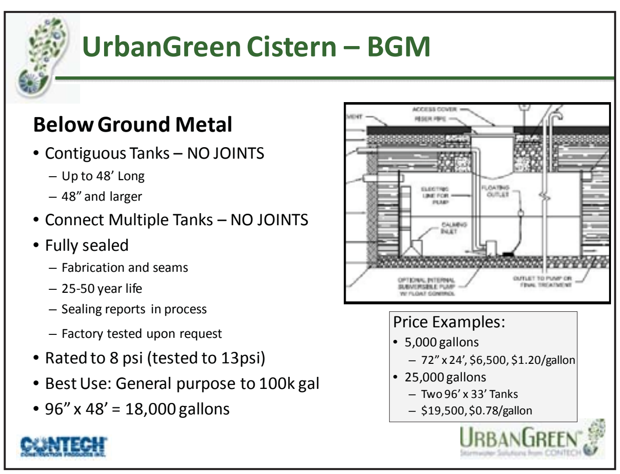

Figure 21. Diagram for below ground metal cistern with rubberized sealant

Figure 22. Rubberized sealant was adapted from industrial tank lining and is rated to 8psi

We did a project in Tucson recently, a big plastic pipe system (Fig. 23). Another project was done on a ranch where the farmer was withdrawing water year-round to irrigate his crops using too much water in the summertime (Fig. 24). The downstream users actually paid for the system for him. They were able to take water captured during the rainier parts of the year when they had higher flows in the stream and store it for use later in the dry season.

Figure 23. Tucson plastic pipe cistern system

Figure 24. California ranch cistern system

Figure 25 shows an above ground metal tank. Your tank size and catchment area involve very site-specific design parameters. Typically you need to know what the water supply will be, like rainfall, or perhaps air conditioner condensation, or whatever you are using for water supply. You also need to know what the demand is in terms of your irrigation, or number of toilets and rate of flushing, or similar. You can use actual rainfall data and daily rainfall totals over a period of years to model how your cistern fills and how it depletes. We have a model that does exactly that and can also calculate potential monetary savings by using rainwater instead of potable water, based on local water rates.

Figure 25. Above ground metal cistern

Parting thoughts: Rainwater harvest generally does not make sense from a purely economic perspective because water rates are usually very low. I don't know what they are here, but in most cases it is somewhere less than $5 per hundred cubic feet so you have to fill your cistern and overturn it many, many times, usually thousands of times, before it pays for itself in terms of municipal water savings. But there are other opportunities here, particularly with tax incentives where you can get 8 or 10 LEED points if you have a rainwater harvesting system, depending on its uses. Some areas allow development density bonuses if you are doing rainwater harvesting; some places allow you to move to the head of the line as far as plan reviews, plan checks, and building safety; sometimes fees are reduced for plan checks. Other incentives must be put in place if we are going to encourage rainwater harvesting to happen on a more widespread basis.

Figure 26 lists other things I haven't had a chance to talk about, like 4 percent of our energy nationally is used to treat or move water around, in California it is closer to 40 percent. So to the extent that we can do this on a local level, we are building in some redundancy to the system. We are building in some additional water security, reducing our carbon footprint, as well as meeting energy demands. And potentially, we create habitat and recreational opportunities. So there is a lot beyond rainwater. Thank you.

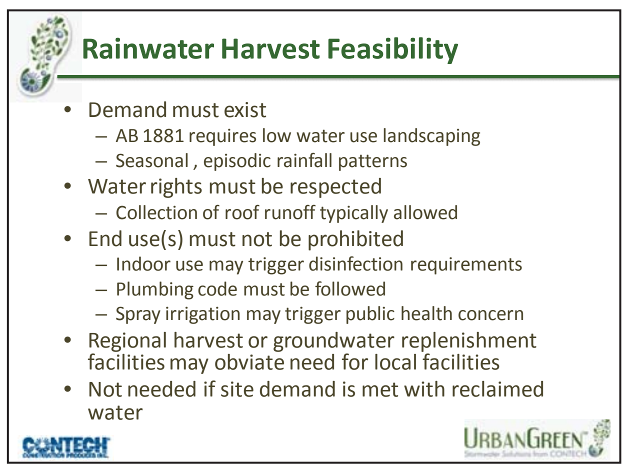

Figure 26. Rainwater harvest feasibility concerns