Rainwater Harvesting

Billy Kniffen
The ability to effectively manage our water resources is essential for personal and global sustainability.
World Population

The water present on the planet millions of years ago is the same water present today.
If all the world's water were fit into a gallon jug, the fresh water available for us to use would equal only about one tablespoon. [http://www.lenntech.com/water-trivia-facts](http://www.lenntech.com/water-trivia-facts)
U.S. Drought Monitor

July 16, 2013
Valid 7 a.m. EDT

Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:
- S = Short-Term, typically <6 months (e.g., agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g., hydrology, ecology)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

Released Thursday, July 18, 2013
Author: Richard Heim, NOAA/NESDIS/NCDC
Estimated World Water Use

![Estimated world water use 1900 – 2000](Image)

- **Reservoir losses**
- **Industrial***
- **Municipal***
- **Agriculture***

**km³ per year**

**Years:** 1900, 1920, 1940, 1960, 1980, 2000

SOURCE: FAO
“We never know the worth of water, till the well is dry.”

Thomas Fuller, Gnomologia

Changes in groundwater levels at monitoring wells at four sites in Virginia. These wells all show declining water levels. Data are courtesy of the USGS and available through [http://www.epa.gov/WaterSense/pubs/supply.htm](http://www.epa.gov/WaterSense/pubs/supply.htm).
“Water is the oil of the 21st century.”
Andrew Liveris, chief executive, Dow, August 2008.
All Rainfall Is Valuable
Water is life

• Two methods to sustain water supply:
  – Increase Supply
  – Reduce Demand
Rising Rainwater Interest

- Increased Demand for a Decreasing Supply
- Escalating Environmental and Economic Costs
- Health Concerns
- Drought - Flooding
- Providing Water to Areas Without Water
- Reducing Storm Water Runoff and Pollution
- Rainwater’s Purity
- Right Thing to Do
Passive vs. Complex /Active Rainwater Harvesting

Complex water harvesting system with roof catchment, gutter, downspout, storage and drip distribution system.
How to Collect Rainwater

0.6 gallons per square foot roof per 1” rainfall
2,000 sq. foot roof X 1” rain = 1,200 gal. water
1,200 gal. X 20” rainfall per year = 24,000 gal/yr
Supply

- Footprint of the building
My Home and Barn

5000 sq. foot of roof
5000 x .6 gallons/foot =
3,000 gallons of water per 1” rain
First flush and wet system
Volume per first flush 30 gallons total
Rain Barn and Greenhouse 2500 Square Foot Roof
Rain barn – 16,500 gallons storage inside and 9,000 gallons out back. Total 25,500 gallons
2” ball valve on each tank and faucet. All tanks tied together with 1 ½” pvc. One feeder line to pump room. Tanks setting on river gravel. Mainline below ground.
Overflow from tank-to tank 4” pvc
Pump room
4’x8’ by 8’high
Pipes coming out of pump room
One line potable one not potable
(for outside drip irrigation)
1 horse pump and
40 gallon pressure tank
3 filters – 80 micron, 20 micron and 5 micron charcoal filter
Ultraviolet light
Disinfection system
Water Usage – Inside The Home

• 19 gallons per person inside the home
• 2 people – 38 gallons per day
• 1,140 gallons per month
• 38 x 365 days = 13,870
• 13,870 / 3,000 = 4.62” per year
Landscaping for Rainwater Capture
Water Usage – Outside The Home

• September – 82 gallons per day
• Use for May – September (5 months)
• 82 x 30 x 5 = 12,300 gallons
• 12,300 + 13,870 = 26,170
• 26,170 / 3,000 = 8.72 inches per year
• Drought of Record – 1951 = 7.64”
  1953 = 9.22”

Nov. 2010 – Nov. 2011 – 5.5”
Menard, TX Margie Russell Memorial Garden
Rain Garden Bringing Water in off Street
Low Impact Development (LID)

- Low impact development (LID) is increasingly being adopted as an alternative to traditional water management systems.
- LID includes practices such as bioretention, green roofs, rainwater harvesting, and permeable pavements.
Pre Development

40% evapotranspiration

25% shallow infiltration

25% deep infiltration

10% runoff
Post Development

30% evapotranspiration

55% runoff

10% shallow infiltration

5% deep infiltration
Urban Water Budget - Pavement and Rooftop Scenario

- Rooftop Runoff!!
- Groundwater??
- Evaporated Water
- Infiltration??
- Surface Runoff!!

Clemson Public Service
Urban Water Budget - Rainwater Harvesting Scenario

ROOFTOP RUNOFF!!
We are entering into a new era of water management. Consider this:

• We pay to bring water in.
• We pay to get rid of it.
• We pay to get rid of the free water (rain) via stormwater fees and infrastructure.
Current Water Supply Paradigm

Municipal Potable Supply Line represents an unlimited supply of Potable water for all end uses. Building/Site all end uses treated equally
New Water Supply Paradigm.

- **Non-Potable (Rainwater) Supply line for non-potable uses, represents a finite amount.**
- Municipal Potable supply line for specific uses.
- Building/Site Requiring Water Supply
Three approaches to rainwater/stormwater management

- Cistern managed for water supply
- Cistern managed for stormwater control

AND
Cistern managed for BOTH water supply and managed for stormwater control or fire protection.
Definitions
Rainwater Harvesting

Rainwater harvesting is the accumulating and storing, of rainwater collected from the roofs of houses, tents, local institutions and other above ground impervious surfaces. It may be used for potable and non-potable in-home use, livestock, irrigation, wildlife, firefighting or to refill aquifers in a process called groundwater recharge. Water runoff from the ground, roads, parking lots impervious areas is called Stormwater harvesting.
Residential Wastewater

Graywater or Greywater or Gray Water is untreated household wastewater that has not come into contact with toilet waste meat preparation sinks including water from:

– Showers
– Bathtubs
– Hand washing lavatories
– Sinks (not used for disposal of hazardous or toxic materials)
– Sinks (not used for food preparation or disposal)
– Clothes-washing machines (excludes diapers and other human excreta)
Reused, Recycled or Reclaimed Water

Reused, recycled or reclaimed water is water that is used more than one time before it passes back into the natural water cycle. Thus, water recycling is the reuse of treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, or replenishing a groundwater basin (referred to as groundwater recharge).
Rainwater is not:

- Recycled water.
- Reclaimed water.
- Reused water.

Rainwater is:

- Primary source water.
- Water that has never been used.
# Annual Rainfall – Denver

15.8” Annual Rainfall

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<th>Month</th>
<th>Rainfall</th>
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<tr>
<td>June</td>
<td>1.6</td>
</tr>
<tr>
<td>July</td>
<td>2.2</td>
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<tr>
<td>August</td>
<td>1.8</td>
</tr>
<tr>
<td>September</td>
<td>1.1</td>
</tr>
<tr>
<td>October</td>
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</tr>
<tr>
<td>November</td>
<td>1.0</td>
</tr>
<tr>
<td>December</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Annual Rainfall – Atlanta, GA
50.2” Annual Rainfall

January – 5.0
February – 4.7
**March** – 5.4
April – 3.6
May – 4.0
June – 3.6
July – 5.1
August – 3.7
**September** - 4.1
**October** – 3.1
November – 4.1
December – 3.8
<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
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<tr>
<td>February</td>
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<tr>
<td>March</td>
<td>2.4</td>
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<tr>
<td>April</td>
<td>0.6</td>
</tr>
<tr>
<td>May</td>
<td>0.2</td>
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<td>August</td>
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<td>September</td>
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</tr>
<tr>
<td>October</td>
<td>0.4</td>
</tr>
<tr>
<td>November</td>
<td>1.1</td>
</tr>
<tr>
<td>December</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Percent of Annual Normal Precipitation, July to September

Based on monthly temperature and precipitation data from the U.S.A., Mexico, and Canada gridded by NCDC/NOAA

Percent of 1971–2000 Annual Normal Precipitation
Calculate Supply and Demand

- Rainfall Amount
- Size of Roof
- Use and/or Need
- Rain intensity
- Rain Frequency (or length between rains)
- Storage Size
- Is there a back-up supply
## TWDB Calculator

<table>
<thead>
<tr>
<th></th>
<th>Water Demand</th>
<th>Total Demand</th>
<th>Average rainfall</th>
<th>Collection surface size</th>
<th>Gallons/ft² coefficient</th>
<th>Efficiency factor</th>
<th>Rainfall collected</th>
<th>End of month storage</th>
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<td>28,000</td>
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<td>15,000</td>
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<td>0.9</td>
<td>21,762</td>
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<td>3.18</td>
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<td>0.62</td>
<td>0.9</td>
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<td>0.62</td>
<td>0.9</td>
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<td>28,000</td>
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<td>0.9</td>
<td>22,683</td>
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</table>
Texas AgriLife Extension Service Rainwater Harvesting Calculator

To use the calculator fill in all highlighted input values.

**Input Values**

- Catchment area (ft²): 150
- Collection efficiency (%): 95
- Initial tank volume (gal): 0
- Tank size (gal): 300
- Plant water use coeff: 1
- Irrigated area (ft²): 100
- Monthly indoor demand (gal): 0

**Monthly indoor demand (gal)**

<table>
<thead>
<tr>
<th></th>
<th>Avg. rainfall (in)</th>
<th>Avg. PET (in)</th>
<th>AC Condensate (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>3.3</td>
<td>2.78</td>
<td>0</td>
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<tr>
<td>February</td>
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<td>2.89</td>
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<tr>
<td>March</td>
<td>2.4</td>
<td>3.2</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>0.8</td>
<td>4.45</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>0.2</td>
<td>5.7</td>
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</tr>
<tr>
<td>June</td>
<td>0.1</td>
<td>5.05</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>0.0</td>
<td>5.4</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>0.1</td>
<td>5.18</td>
<td>0</td>
</tr>
<tr>
<td>September</td>
<td>0.3</td>
<td>3.64</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>0.4</td>
<td>3.2</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>1.3</td>
<td>2.46</td>
<td>0</td>
</tr>
<tr>
<td>December</td>
<td>1.8</td>
<td>2.22</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13.1</strong></td>
<td><strong>44.22</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Yearly Percent Average Rainfall (%)**

- Year 1: 100%
- Year 2: 100%
- Year 3: 100%

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**Tank Volume and Supplemental Water Needs for 3 years**

![Graph showing tank volume and supplemental water needs for 3 years](image-url)
Rain Intensity

- El Paso – 2.0 inches per hour
  - 0.021 gallons per square foot per minute
- Tucson – 3.0”/hr
  - 0.031 g/sq’/min
- San Antonio – 4.4”/hr
  - 0.036 g/sq’/min
<table>
<thead>
<tr>
<th>City</th>
<th>Inches/ Hour</th>
<th>GPM/Square Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytona Beach</td>
<td>4.0</td>
<td>0.042</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>5.0</td>
<td>0.052</td>
</tr>
<tr>
<td>El Paso</td>
<td>2.0</td>
<td>0.021</td>
</tr>
<tr>
<td>Houston</td>
<td>4.6</td>
<td>0.048</td>
</tr>
<tr>
<td>Banger, Maine</td>
<td>2.2</td>
<td>0.023</td>
</tr>
<tr>
<td>San Diego</td>
<td>1.5</td>
<td>0.016</td>
</tr>
</tbody>
</table>
Rain Intensity - Denver

• 2.2” per hour
• 0.023 Gallons per minute per square foot

• 1000 sq’ x 0.023 = 23 gallons/minute
Sizing Gutters

1/16” slope/ft. and 2” per hour
3 gutter – 680 sq’
4” gutter – 720 sq’
5” gutter – 1,250 sq’
(For each downspout)
Vertical Piping/Downspouts

- 3” – 67 gpm 3220 sq’ roof
- 4” – 144 gpm 6,920 sq’ roof
From Rain Barrels
Rain Saucers
First - Roof
• Preventing debris from going into a tank is cheaper and easier than removing it from the tank
• Prune Trees
Graf Quattro Twist
Downspout Filter and Diverter
3P Technik VF1 Volume Filter
Dry Line vs. Wet Line
El Paso’s Kay Bailey Hutchinson Desalinization Facility And TECH2O Educational Center
How Many Drops Are There in 1 Gallon of Water?
How Many Drops Are There in 1 Gallon of Water?

90,400 Drops
How Many Seconds are in 1 Day?
How Many Seconds are in 1 Day?

86,400
Dry Line to 15,000 Gallon Tank, Denton, TX
RWH Tank Options
• 620 gallon slim line tank
• First Flush
• Dry Conveyance
• Installed November 2009 in Pacific Grove
Cisterns Come in many sizes and types of material
4 Million-Gallon, modular, NSF Annex G-certified potable tank
Fiber Technology Corporation
USA: A Range of Climates

Source: backyardgardener.com
USA: Varying Temperatures

ASHRAE Minimum Building Insulation Recommendations (per Standard 189):
- Zone 1: R-20
- Zone 2 – 5: R-25
- Zone 6: R-30
- Zone 7 – 8: R-35

Source: ASHRAE.ORG

The house insulation r value of insulating boards are:
- Expanded polystyrene: 4/inch
- Extruded polystyrene: 5/inch
- Polyisocyanurate & Polyurethane: 6-7/inch

Source: ARCSA
USA: Varying Snowfall

Annual Mean Total Snowfall

Source: mscd.edu
USA: Varying Frost Lines
Protection From Freezing

• Tank Options:
  • Locate Indoors
  • Bury below frost line
  • Insulate
  • Circulate/Aerate
  • Winterize
  • Heat with elements or resistant wire
The next series of slides come from this document. I have not asked for permission to publish or re-use.

WATER CISTERN CONSTRUCTION for SMALL HOUSES

Introduction
This publication is one of nine that has been translated from Norwegian. They are taken from a series of publications produced by the Norwegian Building Research Institute (NBI) series, “Byggdetaljer,” which literally translated means “building details.” The translations were done by Dr. Nils Johanson and Richard D. Seifert of the University of Alaska Fairbanks with the cooperation and permission of NBI, Oslo, Norway. The financial support for the translations and printing came through the Alaska Department of Community and Regional Affairs, from USDOE Grant DE-FG06-80CS6908. The publications use the original index code of the Norwegian “Byggdetaljer” series so that specific translations can be directly cited. All questions on these translations should be directed to Richard D. Seifert, Cooperative Extension Service, P.O. Box 756180, University of Alaska Fairbanks, Fairbanks, Alaska 99775-6180. Phone: 907-474-7201

http://www.uaf.edu/files/ces/publications-db/catalog/eeh/HCM-01557.pdf
Figure 22
Examples of placement of systems.
Using Rainwater
Green Houses
Water Features
Wildlife
Livestock Water
Types of Drip Irrigation
By-product
McDonald Observatory
- For Fire Protection
In-home Use
Mosquitoes & Midge
The Bugs

Getting Rid of:

Bacteria

Virus

Parasites

Protozoa
Filtration

- Coarse solids
  - Screen
  - Disk
- Sediment filter – 1, 3- to 5- micron
  - Bag filter
  - Cartridge filter
Disinfection, not Sterilization

The goal of disinfection is to rid the water stream of those organisms capable of causing infection.

Sterilization is freeing the water stream of ALL LIFE.

Possible options for disinfecting rainwater delivered by system
Distillation
Reverse Osmosis
Chlorination
Ultraviolet light – UV
Ozone
pH Rainwater naturally Acidic

4.5 to 6.3
Acidic
Affects Copper
Raise with -
Baking Soda
Individual **RAIN BARRELS** for collection of Rainwater

**General Treatment Goals**

1. Nothing grows within: Mosquitoes, Algae
2. No Debris that will promote odor
3. No Animal matter present
4. Label Non Potable Water Sources as below:

**Untreated Rainwater**

**Do Not Drink**
“The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value.” Teddy Roosevelt
Resources

• ARCSA website www.arcsa.org - FREE public domain rainwater harvesting manuals: TX, VA, GA, FL, HI, Ontario. “Resources & Documents” many free publications and hyperlinks to rainwater information around the world

• Texas A&M University http://rainwaterharvesting.tamu.edu
Thank You - Billy Kniffen