Turning Drains Into Sponges
and
Water Scarcity Into Water Abundance

by Brad Lancaster

www.HarvestingRainwater.com
www.DesertHarvesters.org
What is the story of this place?

What is the story of its water?
Tucson, Arizona, USA
304 mm average annual rainfall

1904
Watershed acting as a sponge

2007
Watershed acting as a drain
Evidence of a hydrophobic society

- dehydration infrastructure

- dysentery infrastructure
Floods that occurred every 100 years begin to occur every 10 years - after development paves the watershed and increases the rate and volume of stormwater running off site.
pollute our local waters then import ever more distant water

Distance is energy

The largest consumer of electricity (and single source producer of carbon) in Arizona is the pumping of water
This landscape is irrigated with imported water high in salt. This increases salt levels in the soil and decreases soil fertility.

Irrigating with on-site rainwater, which has almost no salt reduces salt levels in the soil and increases soil fertility.
A degenerative ruin.
Is that the story of this place?
Is that its purpose?
Its calling?
Water consumption in Amman
The average water consumption per person in Amman, Jordan is 130 liters per person per day

Free rain falling on Amman
Average annual rainfall (272 mm or 272,900,000 liters/ square km) multiplied by surface area of Amman (1680 sq km) divided by 365 (days of the year) divided by population of Amman (2,919,000 people) equals 441 liters per person per day

A different story
Path to Scarcity
DRAINS LOCAL RESOURCES

30 to 70% of the potable drinking water consumed by the average single family household in the western U.S. and Australia is used for landscape irrigation

Path to Abundance
HARVESTS LOCAL RESOURCES

- Rainwater is primary water source
- Greywater is secondary water source
- Municipal/well water only a supplementary source
Rain garden - a living sponge
Here it is a level-bottomed, mulched and vegetated infiltration basin
Before sponge of mulch and vegetation placed within water-harvesting earthworks 60 cm deep

After sponge is planted. It is irrigated only with harvested rainwater and household wastewater - no drinking water
Integrated water harvesting has 10 times the flood control capacity of a conventional system.
Harvest and utilize water as close as possible to where it falls within the oasis zone - within 10 m (30 ft) of catchment surface.
Air conditioning condensate harvesting

DRY CLIMATE/SEASON:
- A home air conditioner can generate 1 liter (0.25 gallons) of condensate per day
- A large commercial air conditioner can generate 1,900 liters (500 gallons) per day

HUMID CLIMATE/SEASON:
- A home air conditioner can generate 68 liters (18 gallons) of condensate per day
- A large commercial air conditioner can generate over 7,500 liters (2,000 gallons) per day

Condensate harvest to courtyard Jeddah, Saudi Arabia
Air conditioning condensate waterfall, City Hall, Austin, Texas
Gravity-fed greywater harvesting into rain garden doubling as a greywater garden
Split or distribute the flow

Gravity-fed, branched drain greywater system
Multi-pipe laundry greywater system

see Greywater chapter of Rainwater Harvesting for Drylands and Beyond, Volume 2 for more
Landscape in Tucson, Arizona (304 mm annual rainfall) irrigated only with passively harvested rainwater and greywater - no drinking water used in landscape
34,100 liters of water from (330 m² roof) equals:
- 5,625 toilet flushes (6 liters per flush)
- 750 loads of clothes washing (45 liters per load)
- 900 five-minute showers (37.9 liters per shower)
Australian rainwater harvesting tank (4,500 l) connected to outdoor faucets, washing machine, and toilet.
Water truck pumping water up to rooftop tanks downtown Amman, Jordan

17% of the national energy production in Jordan used for pumping water.

Water is pumped 330 km from Disi to Amman and an elevation rise of 1,300 m from Jordan Valley to Amman.
Sameeh Al-Nuimmat of Care International
Village of Bayudah Al Shrquia, Jordan
Rainwater tea
Mercy Corps - funded
Roman era cistern rehabilitation
northern Jordan
Before - the planting of rainwater, stormwater, and trees - 1996
Lancaster household, Tucson, AZ, USA (304 mm annual rainfall)
After the planting of rainwater, stormwater, and trees - 2006
Lancaster household, Tucson, AZ, USA (304 mm annual rainfall)
For every 100 mm of rainfall...

- A 3-m wide paved street will drain 300,000 liters of rainfall per 1 km
- A 6-m wide paved street will drain 600,000 liters of rainfall per 1 km
- A 9-m wide paved street will drain 900,000 liters of rainfall per 1 km

My neighborhood street receives over 3 million liters of rainwater per kilometer

That is enough rain to passively irrigate trees spaced every 8 meters on both sides of the street.
Growing local food with local rainwater
Spring created by a loose rock check dam slowing, spreading, and sinking flow of water
What is the story of this place?

What is the story of its water?

What is your role in this story?
Tucson, Arizona USA in 1904
304 mm annual rainfall. Watershed working as a sponge
Tucson, Arizona USA in 2007
304 mm annual rainfall.
Watershed working as a drain

Dropping water table
Crew of four builds 35/year.

In clay soil excavation takes 8 days, in rock it takes longer.
“Rainwater is the best, it tastes better, and it is the water that comes from Allah.”

- Ali Flahmohammad Khtatabh, Whadnehe village Imam, Jordan

JOHUD funded revolving community loans funded cisterns, greywater, composting, gardening, and small livestock.

Cisterns cost $2,500 JD
Utilizing local waters,
Ten millimeters of rain...

- falling on a 100 m² catchment surface = 1,000 liters of water
- falling on a 1 hectare catchment surface = 100,000 liters of water
- falling on a 1 square kilometer surface = 100,000,000 liters of water

304 mm/year of rainfall on Tucson = 228,934,000,000 liters
Water consumed annually by residents of Tucson = 181,321,000,000 liters
Public urban water harvesting, Vine Street, Seattle, WA
Greywater stub out and 3-way valve
Tucson, Arizona, USA

1904
Watershed as a sponge

2007
Watershed as a drain
One-rock check dams - more appropriate where there is no bedrock

free publication on Education and Outreach/ publications page at:
www.QuiviraCoalition.org
Greywater compatible soaps - no salt/sodium, no boron, no chlorine

Dr Murad Bino, Executive Director for the Islamic Network on Water Resources Development & Management developed a sodium-free soap in Jordan.
Eight Principles of Successful Water Harvesting

1. Long and thoughtful observation
2. Start at the top of the watershed and work your way down
3. Start small and simple
4. Slow spread and infiltrate
5. Always have an overflow and use it as a resource
6. Maximize living and organic groundcover - the sponge
7. Maximize beneficial relationships and efficiency by “stacking functions”
8. The feedback loop: long and thoughtful observation
Late Afternoon

Noon

Early Morning

Summer Solstice 32° N Latitude

WEST

EAST

Late Afternoon

Noon

Winter Solstice 32° N Latitude

Early Morning
Leaf Eater Advanced
rain head from
RainHarvesting.com
Fig. 130. Plan of negarin microcatchment plots; the largest are 1000 m$^2$ and the smallest 15.6 m$^2$ in area.

Fig. 131. Plan and cross section of a negarin plot. The arrows indicate the direction of runoff flow.

Fig. 132. Pomegranate tree in a 500-m$^2$ plot (1967).
Urban drool harvesting, Los Angeles
Tujunga Wash Flood Control Channel between Vanowen Street and Oxnard Avenue, Los Angeles, CA
Rainwater irrigated greenhouse
Paul Cross, Charybda Farms, Arroyo Hondo, NM
Watergy - The Water / Energy Connection

42% of the energy consumed by the City of Tucson is used to pump and distribute water

(does not include additional energy consumed to get water from Colorado River to Tucson through CAP canal)


How to Estimate the Energy Embedded in Your Water Supplies

www.rivernetwork.org
Roman era cisterns of 10,500-gallon (40-m$^3$) capacity in northern Jordan
### Patterns of Climate, Water Per Capita, Watery & Sun: Amman, Jordan

#### Average High & Low Temperatures: 1976 - 2005

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
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<th>Sep</th>
<th>Oct</th>
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<tbody>
<tr>
<td>High</td>
<td>12.2</td>
<td>13.5</td>
<td>17.0</td>
<td>22.7</td>
<td>27.6</td>
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<td>30.5</td>
<td>26.5</td>
<td>19.7</td>
<td>14.2</td>
<td>23.2° C</td>
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<tr>
<td>Low</td>
<td>3.9</td>
<td>4.5</td>
<td>6.6</td>
<td>10.2</td>
<td>14.2</td>
<td>17.5</td>
<td>19.7</td>
<td>19.4</td>
<td>17.6</td>
<td>14.5</td>
<td>9.3</td>
<td>5.5</td>
<td>11.9° F</td>
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<tr>
<td>Highest on Record</td>
<td>44°C</td>
<td>111°F</td>
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<tr>
<td>Lowest on Record</td>
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<td>20°F</td>
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Source: [met.jometeo.gov.jo](http://met.jometeo.gov.jo) (note #1)

#### Average Rainfall: 1923 - 1990

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<th>Month</th>
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<th>Jul</th>
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<tr>
<td>Rainfall</td>
<td>63.3</td>
<td>62.6</td>
<td>43.6</td>
<td>17.3</td>
<td>3.5</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>6.1</td>
<td>28.2</td>
<td>48.0</td>
<td>272.9 mm</td>
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<tr>
<td>Inches</td>
<td>2.49</td>
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<td>1.72</td>
<td>0.68</td>
<td>0.14</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.24</td>
<td>1.11</td>
<td>1.89</td>
<td>10.74</td>
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Source: [www.worldclimate.com](http://www.worldclimate.com)

#### Wettest Year's Rainfall: 450.34 mm

#### Driest Year's Rainfall: 98.0 mm

Source: [met.jometeo.gov.jo](http://met.jometeo.gov.jo) (note #2)

#### Longest Period with No Measurable Precipitation


#### Area: 1,680 km²

#### Population: 2,919,000

#### Rainfall Income: 430 lpcd

#### Municipal Use: 130 lpcd

Percentage of Jordan's total electricity consumption used to pump water in 2001: 15.3%

Daily shortage in liters of city of Amman's water supply: 90 million

# of avg Jordanian citizens whose kWh usage would be needed to desalinate that water: 48,291


#### Latitude: 32°

#### Winter-Solstice Shadow Ratio: 1:1.45

Source: [Google Earth](https://www.google.com/maps)

#### Elevation: 790 m

#### # of Degrees Sun is Above the Southern Horizon At Noon

<table>
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<th>Month</th>
<th>Mar 21</th>
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<th>Sep 21</th>
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<tr>
<td>Degrees</td>
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<td>81</td>
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**Notes:**
