Training Module- Rain Water Harvesting & Grey Water Recycling Systems

THE WATER PROJECT JAMAICA

JN Bank FOUNDATION

OMIN IDB CIF CLIMATE INVESTMENT FUNDS

Presented by: Robert Stephens
On behalf of: Heart Trust

Basic Information

- **Course-** Design & Installation of Rain Water Harvesting & Grey Water Recycling Systems
- **Delivery-** one lecture for 1-2 hours
- **Schedule-** 25/7/2021
- **Lecturer-** Robert Stephens
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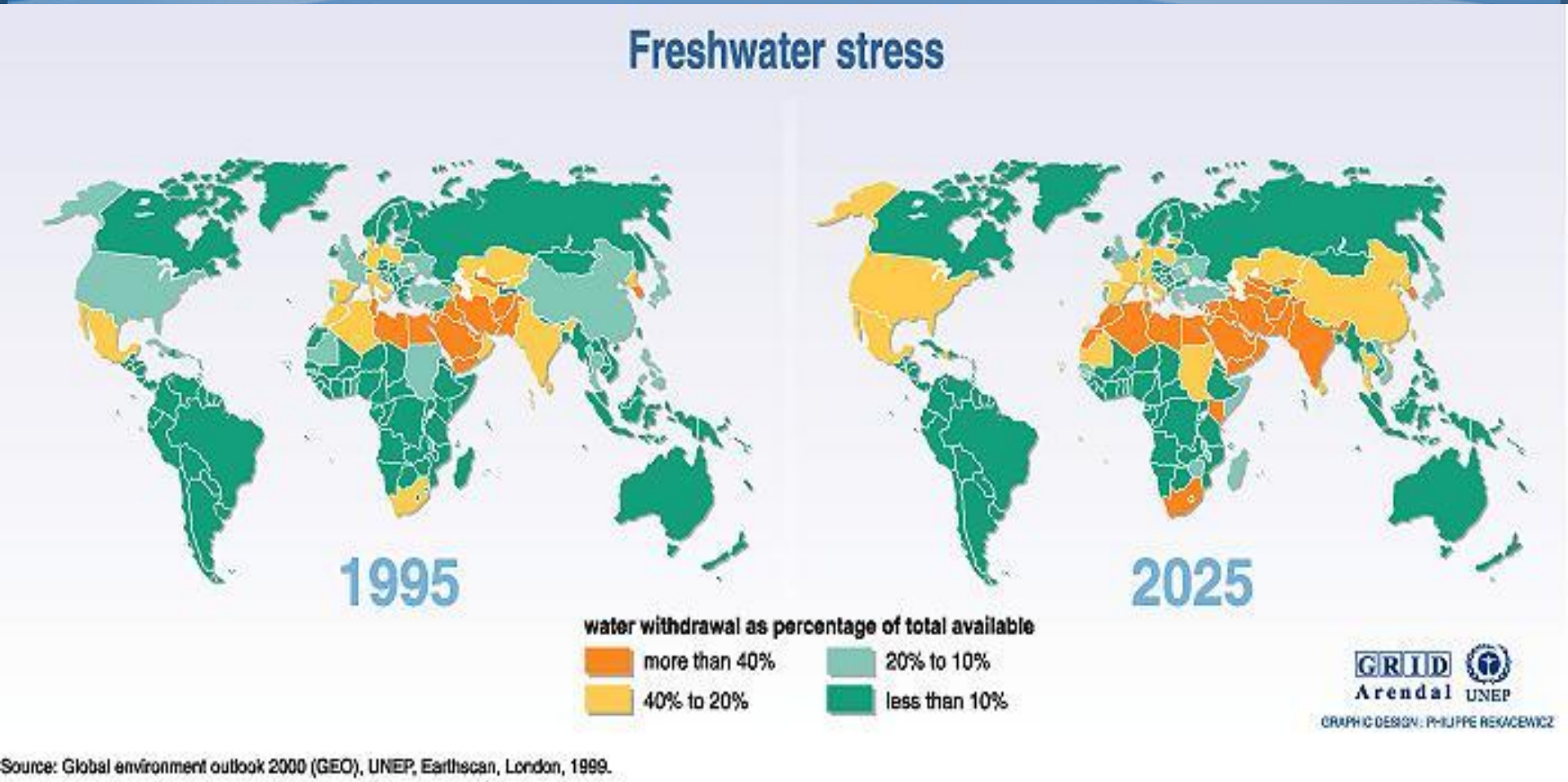
Learning Objectives

- Appreciate what is Rainwater Harvesting & Grey Water Recycling
- Discuss and understand some of their characteristics
- To provide a basic Overview of Rainwater Harvesting and Grey Water Recycling Systems

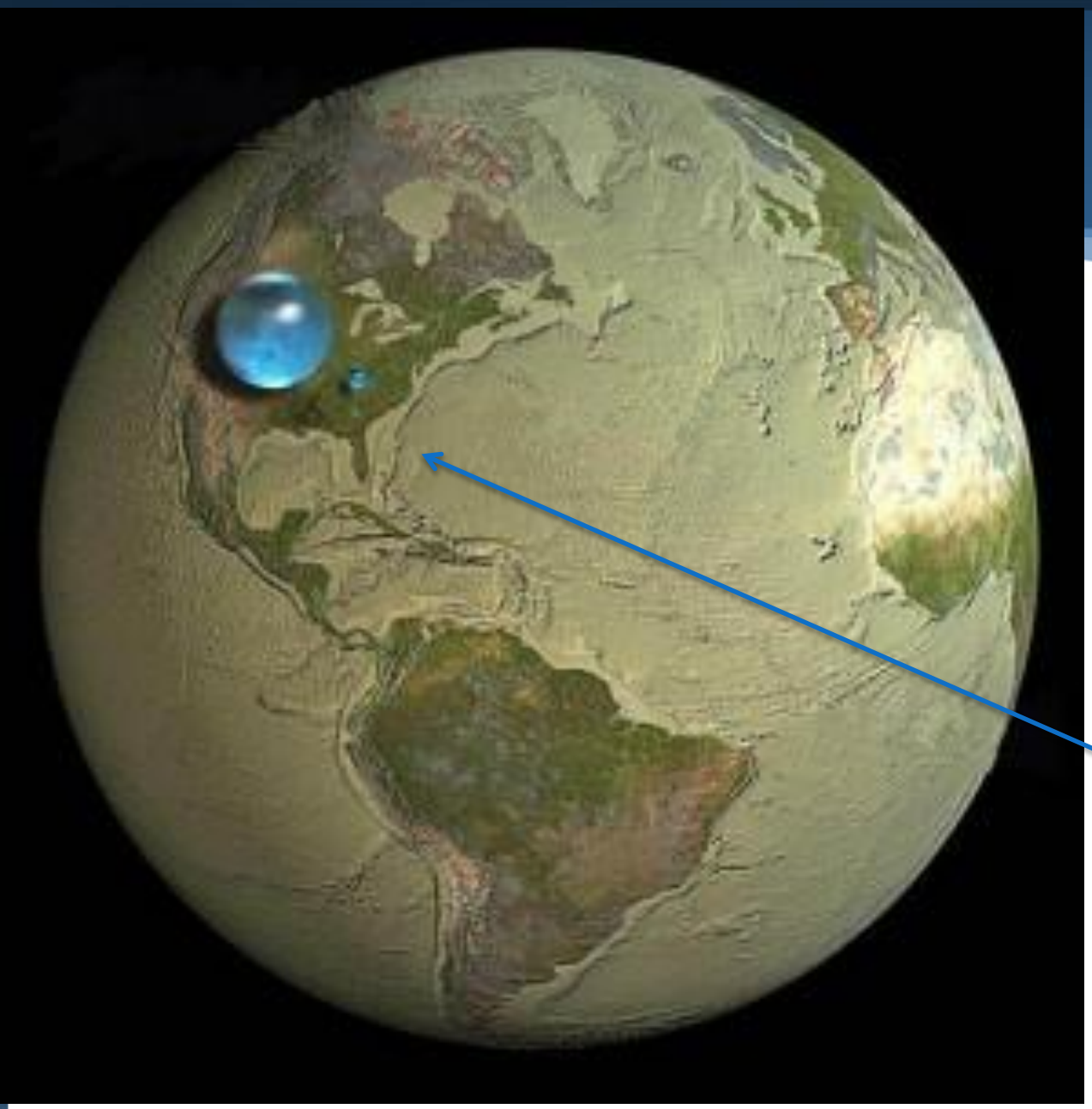
Key Reference Materials & Sources

- https://www.arcsa.org/page/EducationalVideos American Rainwater Catchment Systems Association (ARCSA)
- https://www.watercache.com/education/rainwater-harvesting-101
- https://rainwatermanagement.com/blogs/news/rainwater-harvesting-101-overview
- https://m.wikihow.com/Build-a-Rainwater-Collection-System
- https://www.youtube.com/watch?v=pNXooT2FVXM
- https://www.youtube.com/watch?v=P-e6oOyrQ04
- https://morningchores.com/rainwater-harvesting/
- https://www.thespruce.com/residential-rainwater-harvesting-1822548
- http://www.caribbeanrainwaterharvestingtoolbox.com/handbook.htm
- chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://cdn2.hubspot.net/hubfs/3779244/Website%20Downloads/Handbooks/Rain_Harvesting_Handbook.pdf
- https://thetinylife.com/how-to-setup-rainwater-catchment-system/
- http://www.oas.org/usde/publications/unit/oea59e/ch10.htm

Worldwide Water Shortage



Source: Global environment outlook 2000 (GEO), UNEP, Earthscan, London, 1999.



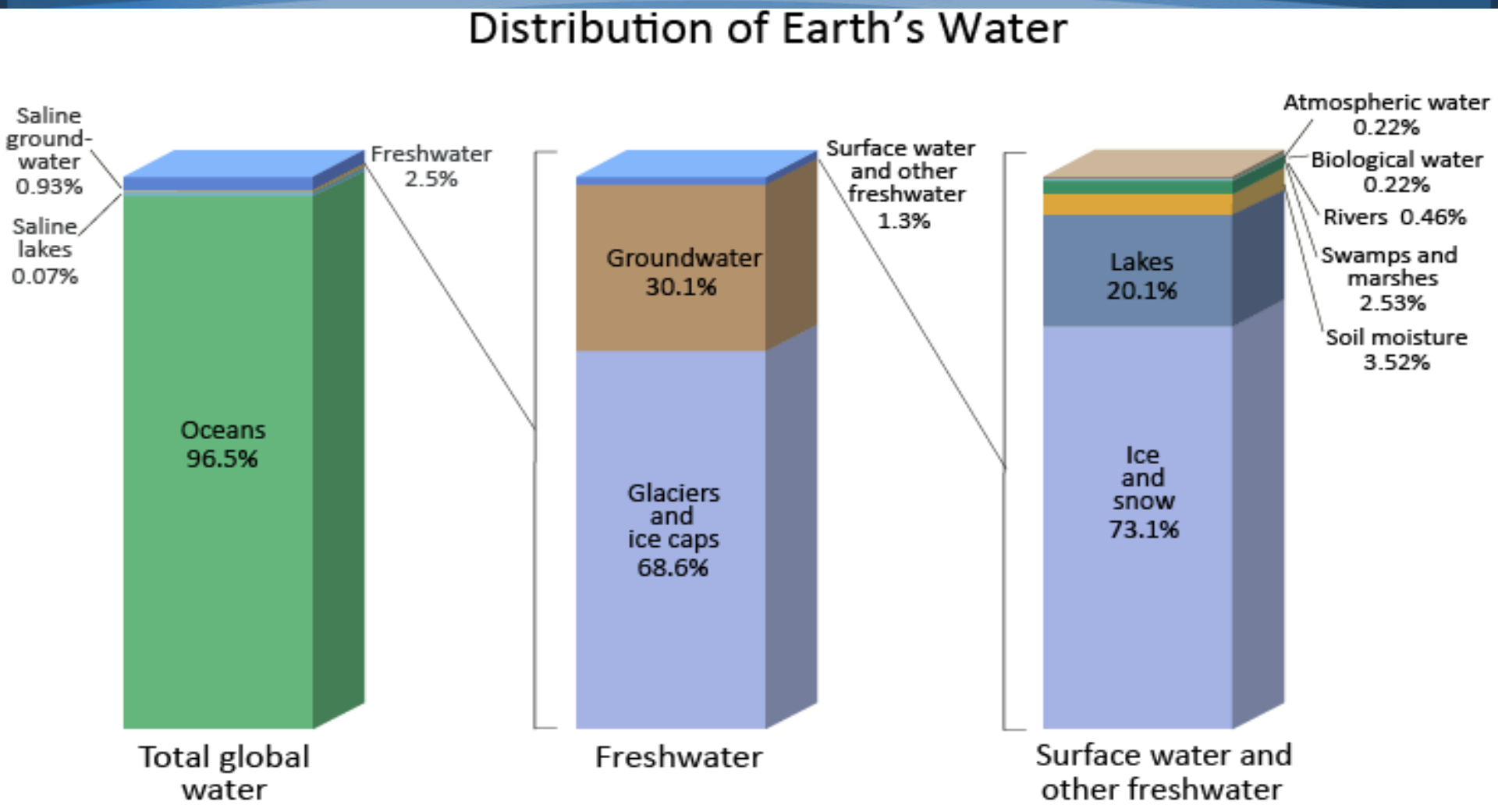
aquaven.com

Why Rainwater?

- Largest sphere = All Earth's water.
- Smaller sphere = world's liquid freshwater
- 99% is groundwater, much of which is not accessible to humans.
- Tiny bubble over Atlanta = all fresh water in lakes and rivers on planet.

(www.aquaven.com)

HUMAN RELATIONSHIP TO THE WATER CYCLE



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

Current realities

- Climate change is affecting water supplies worldwide.
- Water is becoming a commodity that is more in demand but is getting scarce worldwide
- Frequent water restrictions and lock offs are becoming the norm rather than the exception
- Demand for Water conservation including rainwater harvesting and Grey water recycling

What is a Rainwater Harvesting System?

- Rainwater harvesting (RH) is collecting the run-off from a structure or other impervious surface in order to store it for later use.
- Rain from a roof will collect in gutters that channel the water into downspouts and then into some sort of storage tank.
- RH systems can be as simple as collecting rain in a barrel or as elaborate as harvesting rainwater into large tanks to supply a development
- RH systems can be configured to supply all your house and/or your landscape needs.

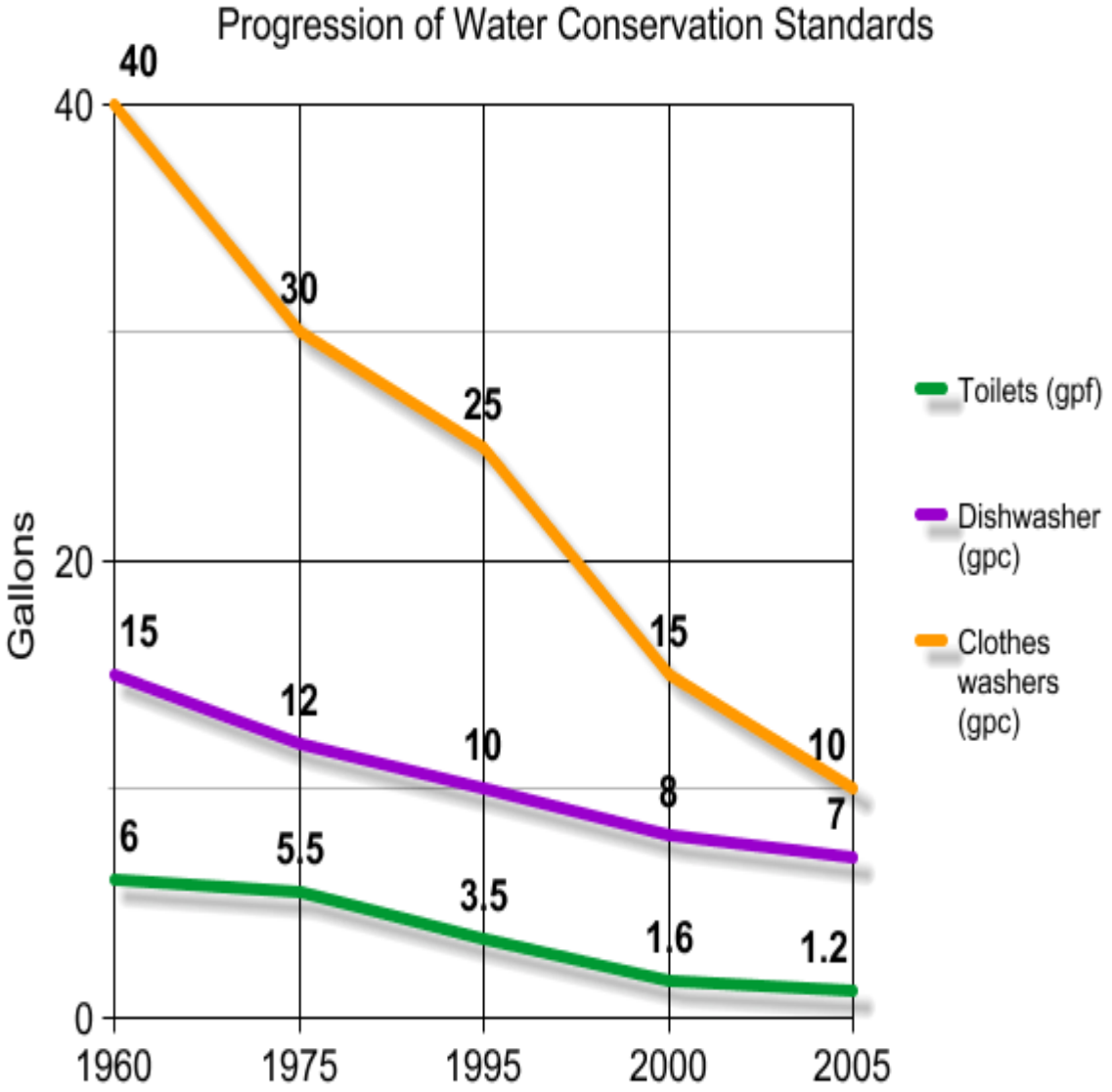
Benefits of Rainwater Harvesting

- Rainwater is relatively clean and absolutely free
- You have total control over your water supply
- Socially acceptable & environmentally responsible
- Promotes self-sufficiency and helps conserve water
- Rainwater is better for landscape plants and gardens because it is not chlorinated
- Reduces stormwater runoff & drainage problems
- Simple inexpensive and easy to maintain
- Can be main source of water or back up source
- Flexible, modular & can be fitted to an existing structure or built during new home construction

Benefits of Rainwater Harvesting

- End use close to the source, eliminating the need for complex and costly distribution systems.
- Rainwater provides a water source when groundwater is unacceptable or unavailable
- Zero hardness of rainwater helps prevent scale on appliances, extending their use
- RH eliminates the need for a water softener and the salts added during the softening process
- Rainwater is sodium-free, important for persons on low-sodium diets
- Rainwater is superior for landscape irrigation
- Rainwater harvesting reduces utility bills

Why Is Rainwater Harvesting Important?

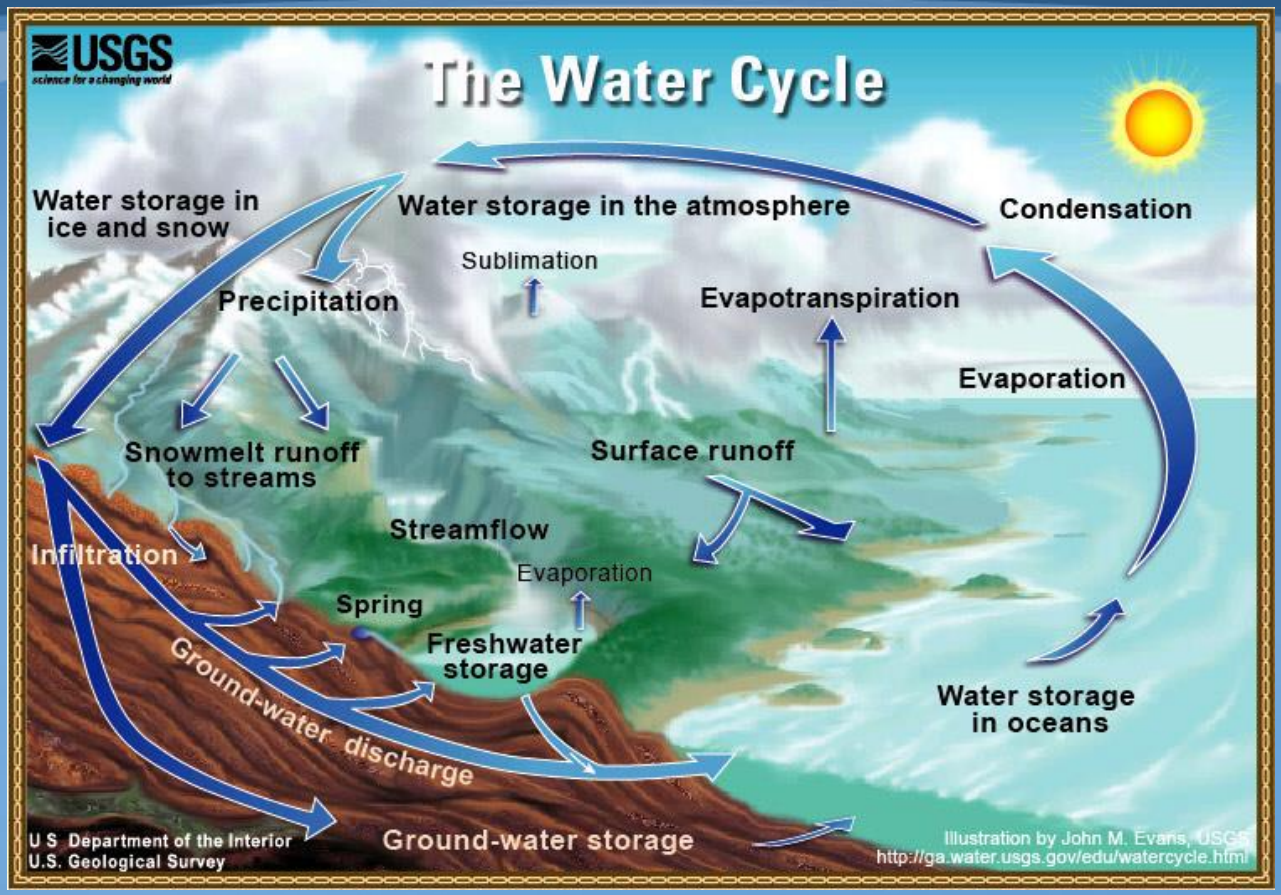


Graph shows gains achieved with indoor water fixtures governmental standards and innovation by fixture companies

Why Is Rainwater Harvesting Important?

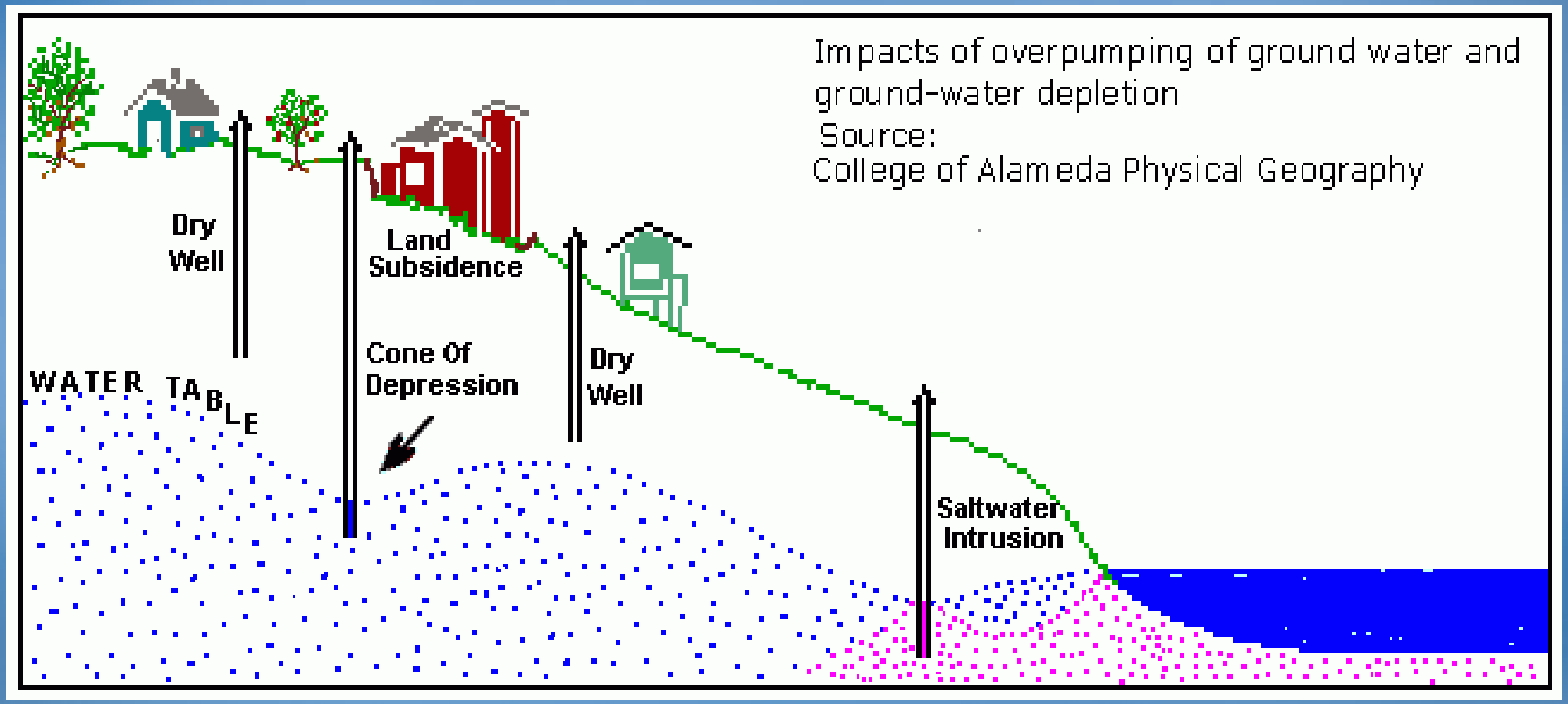
- Water is becoming a scarce necessary commodity
- Water Conservation is critical
- Water Efficiency in Homes can still be improved
- Water for showers, toilets, dishwashers etc can be further reduced
- We don’t have much more room to go in terms of achieving more efficiency gains with our indoor fixtures.
- Rainwater Harvesting & Grey Water Recycling will be the areas for greatest impact on water conservation

WHAT IS THE WATER CYCLE?



The water cycle describes the existence and movement of water on, in, and above the Earth. Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it continuing to work.

Effects of Groundwater Depletion



What are our Choices ?

- Grid supplied Water
  - Generally available year round
  - Cheap in Short Term
  - Long term reliance uncertain in some areas
  - Recent & likely future disruptions
- Rainwater Harvesting
  - Can replace or compliment grid supply
  - Requires careful installation & treatment
  - Must ensure safeguards from Potable Water System
- Greywater
  - Available On site
  - Expensive first cost but usually has a decent payback
  - Serves to buffer combined sewer overflows

Definitions

ARCSA Rainwater Catchment Design and Installation Standard

Rainwater: Water from natural precipitation that was not contaminated by use

Stormwater: Any rain that touches the ground and flows across the surface of the ground (roadway, parking surface, gully, creeks, streams etc.) .Also termed surface water

Per IAPMO Green Plumbing Supplement

Rainwater: Natural precipitation that has contacted a rooftop or other man-made above ground surface and has not been put to beneficial use.

Stormwater. Natural precipitation that has contacted a surface at grade or below grade and has not been put to beneficial use.

Stormwater Catchment System. A system that collects and stores stormwater for a beneficial use.

RHS Design Considerations

- Simplest rainwater harvesting systems (RHS) are “dry systems” nonpressurized systems, such as rain barrels, where the pipes run from rain gutters into a tank.
- “Dry systems,” do not hold any water in the pipes after it stops raining and do not create breeding grounds for mosquitoes and other insects.
- “Wet systems” are necessary when the pipes cannot be configured to run directly into the tanks and are usually pressurized so that the long runs of pipes do not retain stagnant water.

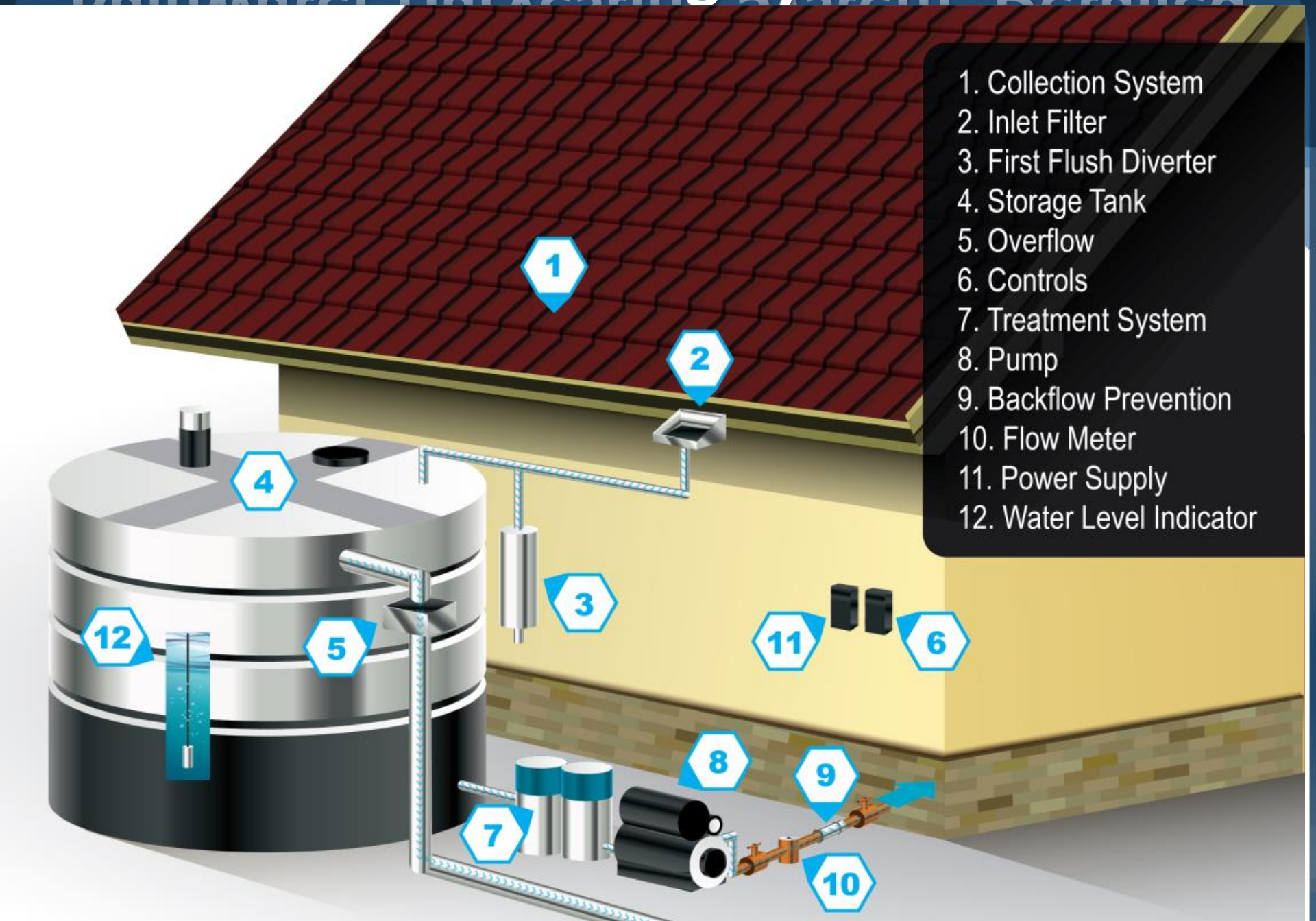
Four Pillars of RH Design

1. **Understand your needs-** Clearly understand volume and quality of rainwater you need
2. **Understand your environment-** Vegetation; Fine particles; Intruders; Hidden activity; Seasonality
3. **Apply the 8 Rain Harvesting Steps-** Limit sources of contamination; Plan for volume; Filter leaves and debris; Divert the first flush; Secure the system; Manage standing water; Consider a safety net; Monitor & Maintain
4. **Design and install your system Based on Pillars 1, 2 and 3** and you will have the right system

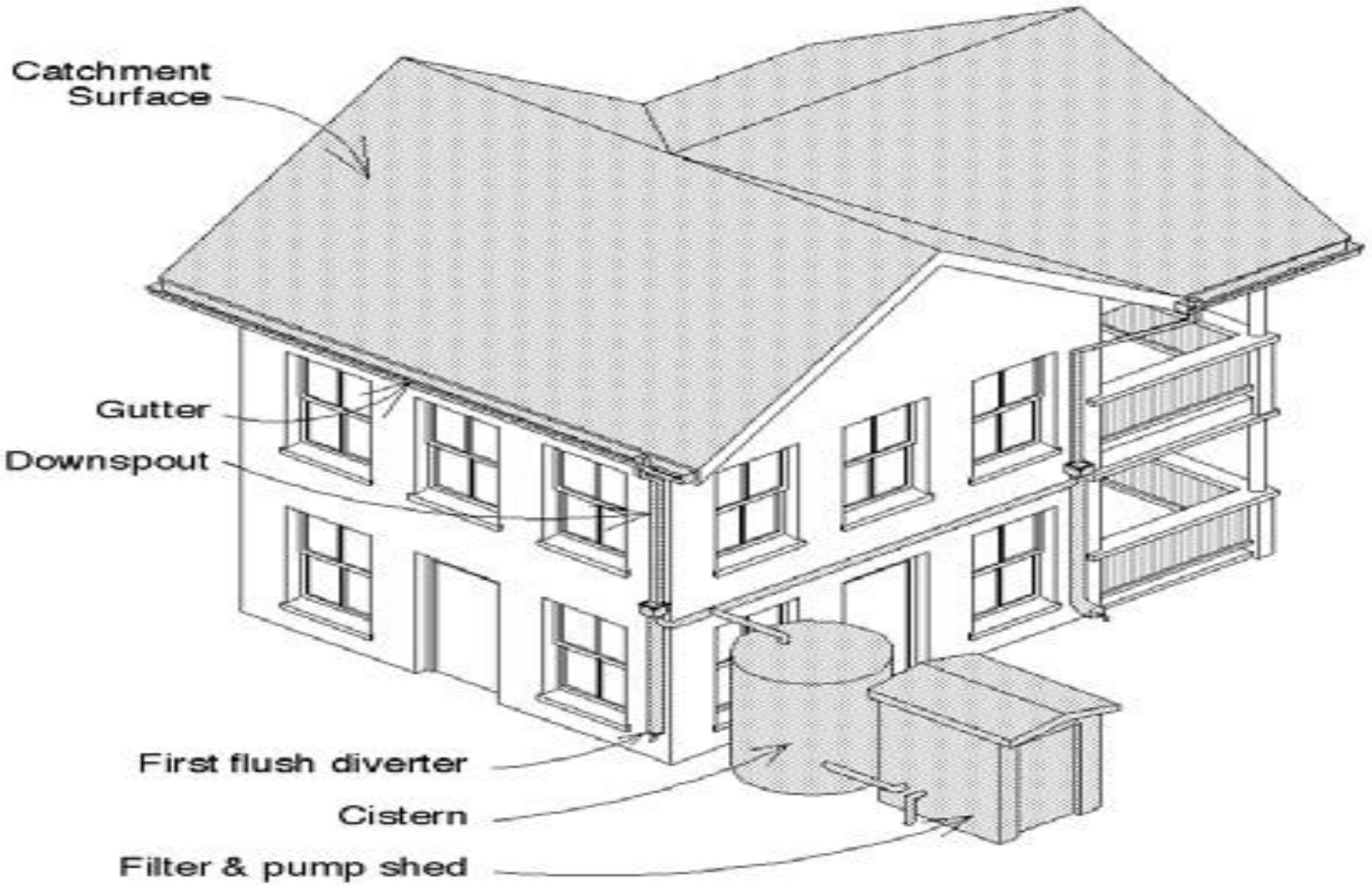
Basic Components of Rainwater Harvesting System

- Catchment surface
- Gutters & Downspouts
- Leaf screens
- First-flush diverters & roof washers
- Storage tanks
- Cistern Design, Construction, and Capacity
- Water Balance and System Sizing
- Quality and Treatment

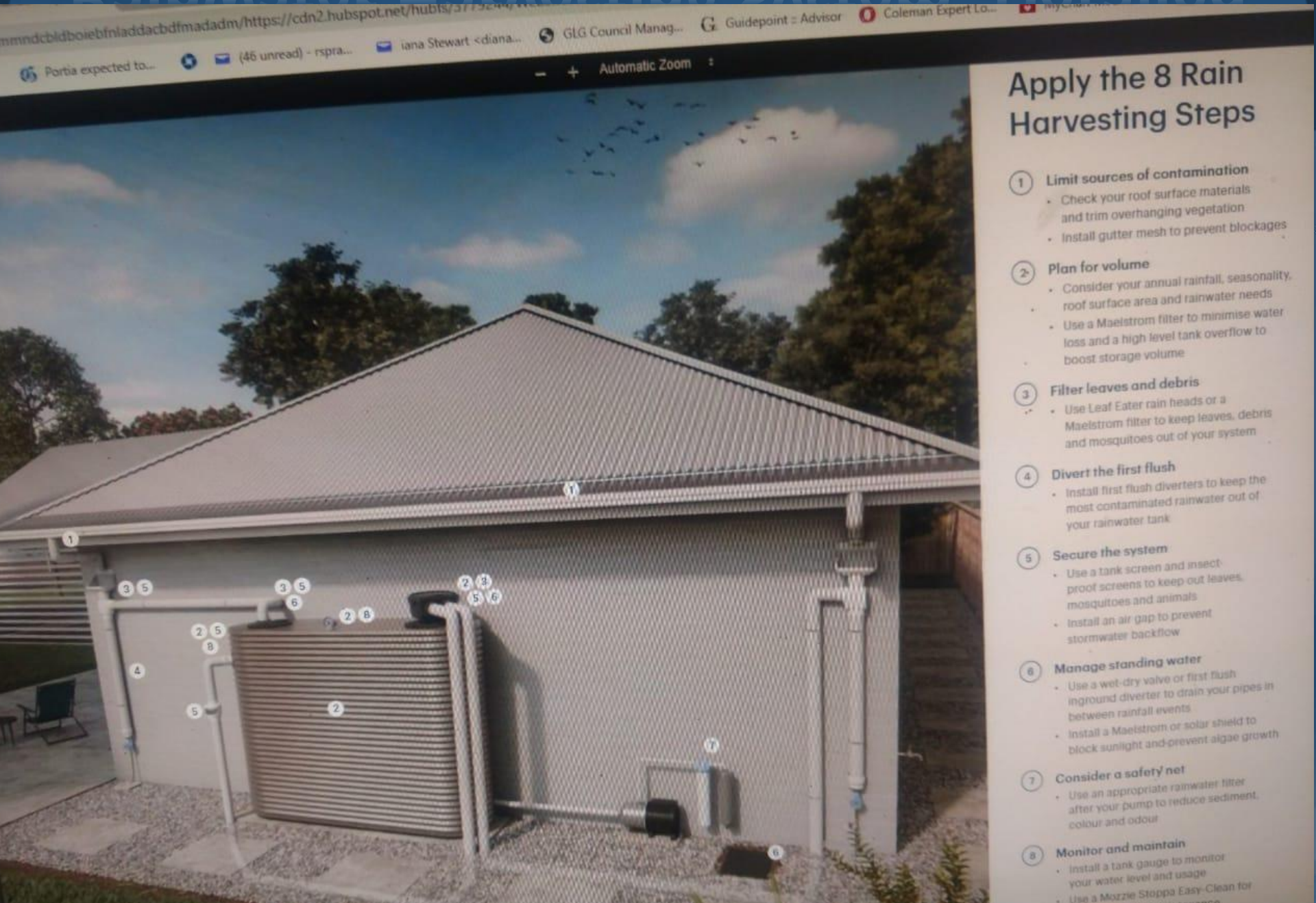
Rainwater Harvesting System- Detailed



Basic Rainwater Harvesting System

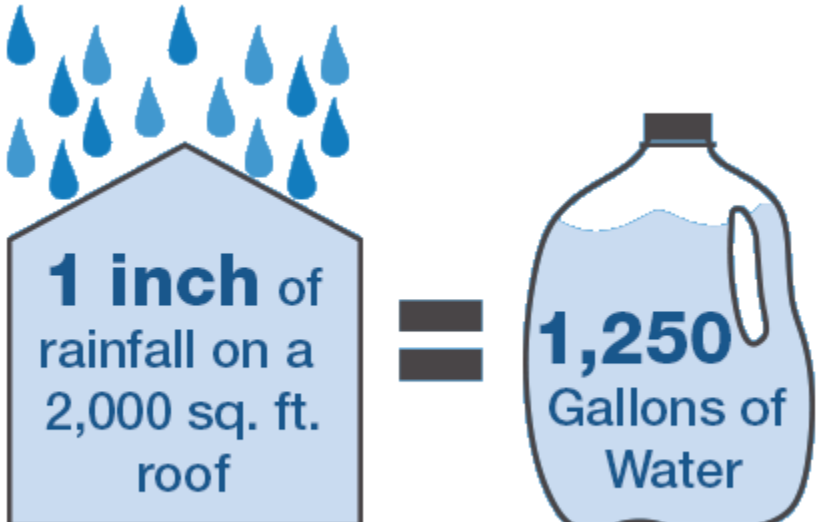


Rainwater Harvesting System- Detailed



Calculating Demand & Supply

- One inch of rainfall on 2000 sf roof=1250 gals of H2O
- 30” annual rainfall generates 41,000 gallons of reusable water.
- Average 10,000 square foot lot uses up to 3K gals/week
- Running a sprinkler for 2 hours can use up to 500 gallons of water.
- Seventy percent of water used at home is used outdoors.
- 66,175 gallons of water are used outdoors per household, per year.



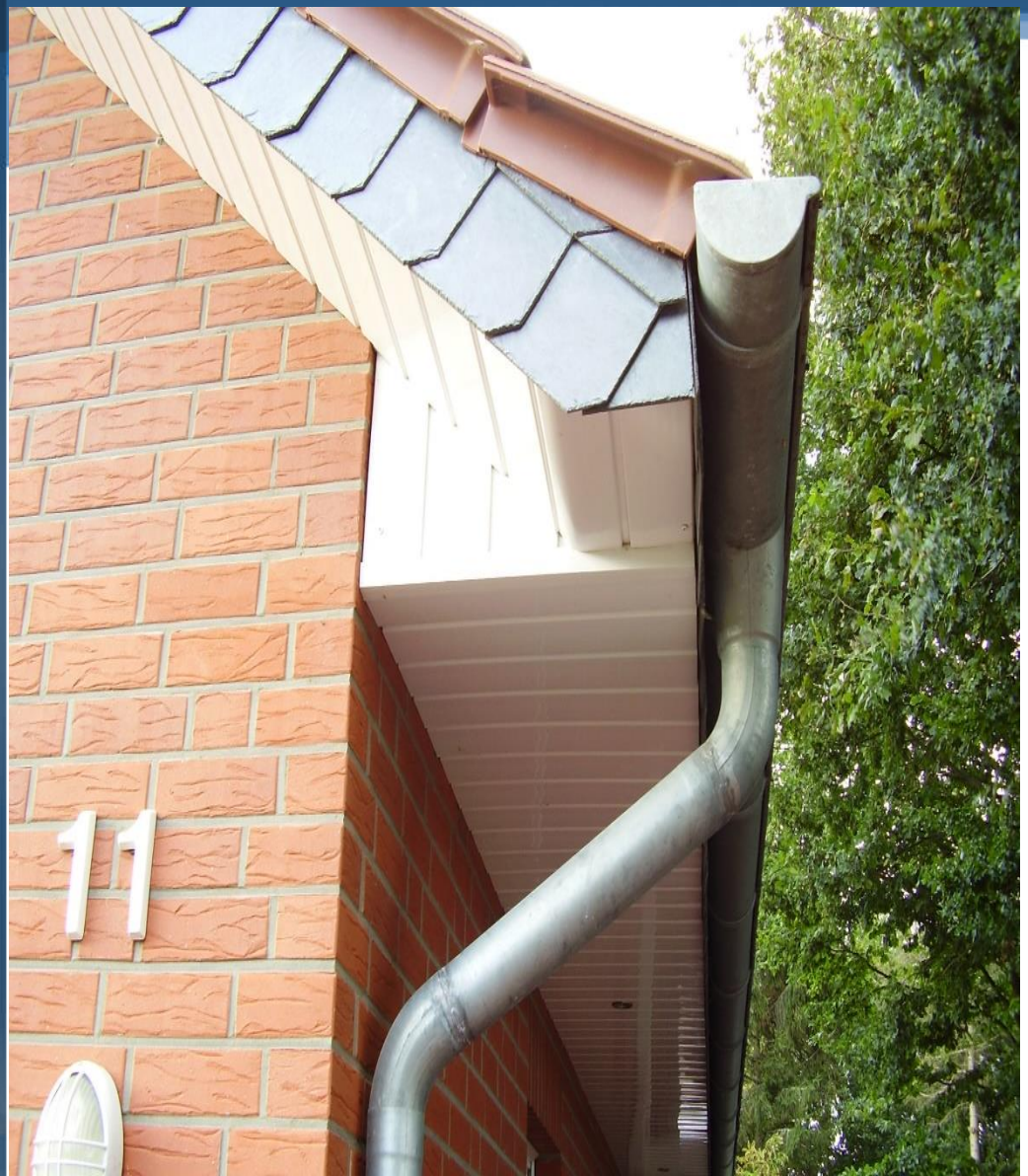
RH Components- Collection Surface

- Can be any flat surface
- Mainly roofs because it's a large surface
- Could be Chicken coop, Barn, Parking area roof- be creative
- Surface materials vary
- Careful of contaminants

RH Components- Collection Surface

- **Composite Shingle**- Not usually good for potable or garden use but can be used for general use
- **Built up flat roof-** roof decking plus membrane and can have tar. Used for garden and landscape areas but not usually for potable water due to tar and other contaminants
- **Corrugated Asphalt Panel-** usually good for all uses except potable
- **Tile roof**- good for every water use except if toxic material embedded
- **Corrugated metal**- All uses including potable
- **Poly carbonate or Vinyl-** multiple uses including potable.
- **Wood Shingle-** mainly for gardens and landscaping as wood can have chemicals embedded for treatment.
- **Concrete Catchment –** Often used for community water supply
- **Water quality-** function of the type of roof material, climatic conditions & the surrounding environment
- https://www.youtube.com/watch?v=jbwDsWnBpWs

RH Components- Gutters & Downspouts



- **Gutters-** usually plastic or corrugated metal & can be continuous or seamless
- **Downspouts-** can also be metal or plastic
- **Lead cannot be used** as gutter solder as this will contaminate the water supply.
- The most common materials for gutters and downspouts are half-round PVC, vinyl, pipe, seamless aluminum, and galvanized steel.

RH Components- Leaf Gutter Filter

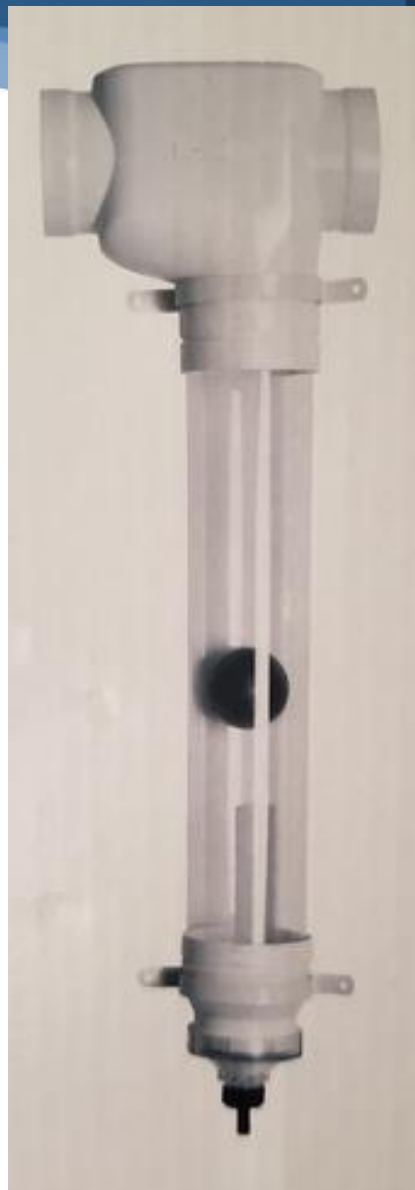
- **Leaf Filter** prevents gutters from blocking and eliminates a fire hazard.
- Makes rainwater catchment even more efficient.
- Filter usually mounted directly under the roof gutter.

RH Components- First Flush Diverter

- **First-Flush Diverters** allow leaves, debris, and fecal matter to wash away, keeping tank water cleaner.
- The cleaner the water going in to your system improves quality
- **First-flush diverters** typically require no power, so they are a low-cost, low-tech way to improve water quality significantly

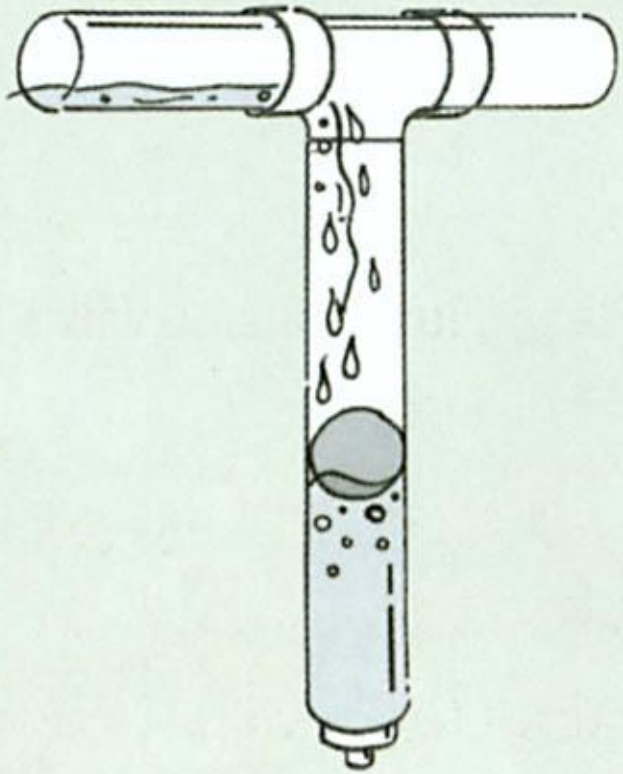
https://www.youtube.com/watch?time_continue=11&v=fUuGvpRlKwY

https://www.youtube.com/watch?v=ucumJOIPYzs



First flush of contaminated water is diverted into chamber

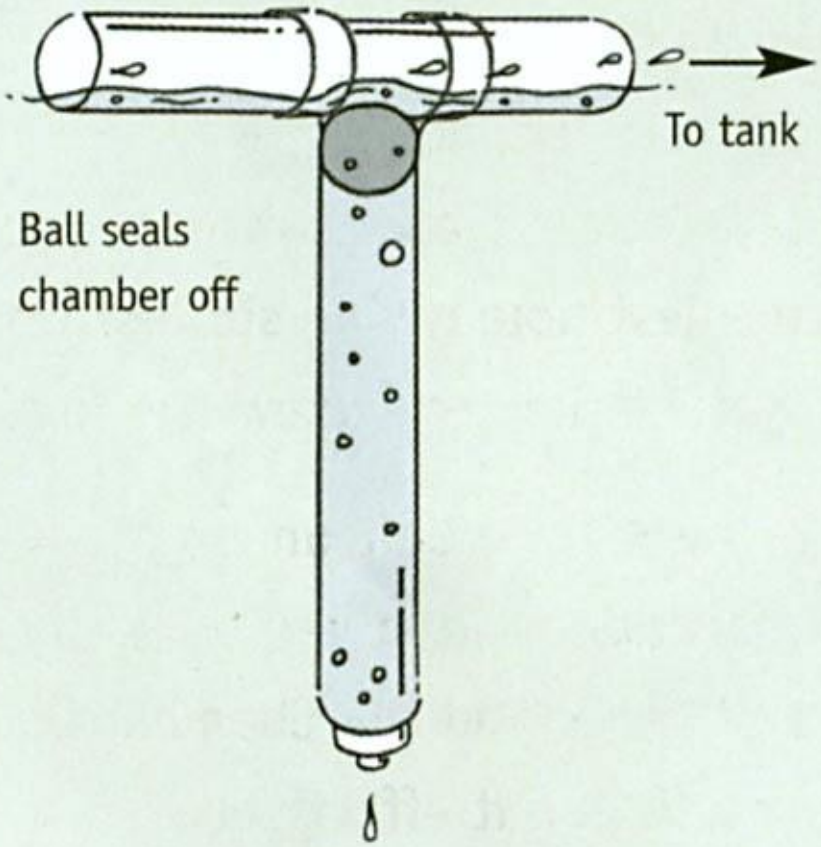
Water flow from roof



Once chamber is full fresh water flows to tank

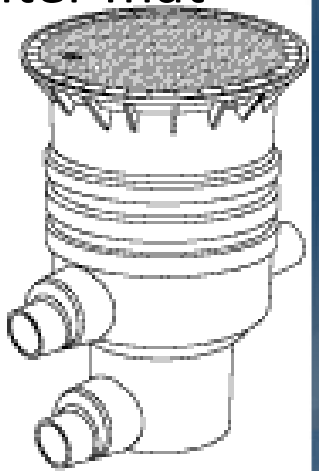
To tank

Ball seals chamber off



RH Components- Roof Washer

- **The roof washer-** placed just ahead of the storage tank, usually consists of a tank with leaf strainers and a filter. A commercially available model has a series of baffles and a 30-micron filter.
- **POT FILTERS:** simplest rainwater pre-filters, simply a flanged plastic tray with a perforated bottom that covers the top of a large basin with a side outlet. A filter pad is placed over the perforations, the pad is covered with gravel, and the outlet is piped to a rainwater tank. Water from a downspout dumps onto the gravel which strains out leaves and coarse debris and then flows through the filter mat which retains solid particles as small as 1/64".



RH Components- Cisterns/Tanks

- All rainwater tank designs should include:
  - A solid secure cover
  - A coarse inlet filter
  - An overflow pipe
  - A manhole, sump, and drain to facilitate cleaning
  - An extraction system that does not contaminate the water; e.g., a tap or pump
  - A soakaway to prevent spilled water from forming puddles near the tank
- Additional features might include:
  - A device to indicate the amount of water in the tank
  - A sediment trap, tipping bucket, or other "foul flush" mechanism
  - A lock on the tap
  - A second sub-surface tank to provide water for livestock, etc.

Above Ground Polyethylene Tanks

Galvanized Metal Tanks

Underground Polyethylene Tanks

Underground Concrete Tanks

Factors Affecting Rainwater Quality

- Water quality is determined by the composition of water as affected by natural processes and human activities.
- WQ depends on the constituents dissolved or contained within the water.
- Pure rainwater not possible due to dissolved gases, dust, salt etc.
- 3 types of contamination can be distinguished:
  - **(Micro)biological contamination** especially enteric pathogens. Enteric pathogens are micro-organisms (bacteria, viruses, and protozoa) that cause gastrointestinal illness. These organisms are introduced into drinking water supplies by contamination with faecal material (from human or animal origin) or dead animals and insects. The most important indicator is E-Coli.
  - **Chemical contamination** mainly from air pollution (industrial and traffic emissions), runoff and leaching of chemical substances (agricultural and human activities) and toxic material use.
  - **Physical contamination** includes inorganic and organic sediments like sand, silt, clay, or plant material and affects the colour, odour or taste of the water, but it poses no direct health risk.
- RW can also pose a health risk due to mosquitoes in or near RWH systems
- RW storage containers need secure covers or screens to avoid mosquitoes

Common Contaminants in Rainwater

- Rainwater can absorb gases such as carbon dioxide, oxygen, nitrogen dioxide, and sulphur dioxide from the atmosphere.
- It can also capture soot and other microscopic particulates as it falls through the sky.
- **Debris-** any contaminant that you can see includes leaves and twigs, dust and dirt, bird and animal droppings, insects, and other visible material reduces the aesthetic quality of the water
- “Debris” can also have herbicides and pesticides
- Bird and animal droppings can contain microscopic parasites, bacteria, and viruses.
- Chemical Contaminants- Mostly introduced during collection, treatment, and distribution.
- Volatile organic chemicals (VOCs) include plastics, glues, and solvents, as well as gasoline, greases, and oils.
- Most VOC contamination due to use of non spec materials not manufactured specifically for drinking water applications

Water Quality Standards

- Jamaica National Ambient Water Quality Standard
  - Calcium (Ca) 40.0-101.0 mg/L
  - Chloride (Cl-) 5.0- 20.0 mg/L
  - Magnesium (Mg2+) 3.6- 27.0 mg/L
  - Nitrate (NO3-) 0.1- 7.5 mg/L
  - Phosphate (PO43-) 0.01 - 0.8 mg/L
  - Potassium (K+) 0.74- 5.0 mg/L
  - Silica (SiO2) 5.0- 39.0 mg/L
  - Sodium (Na+) 4.5- 12.0 mg/L
  - Sulfate (SO42-) 3.0- 10.0 mg/L
  - Hardness (CaCO3) 127.0-381.0 mg/L (as CaCO3
  - Biochemical Oxygen Demand (O) 0.8- 1.7 mg/L
  - Total Dissolved Solids 120.0-300 mg/L
  - pH 7.00- 8.40
  - Conductivity 150.0-600 µS/cm

Water Quality- NWC Monitoring

NWC monitors potable water island wide and this includes checking for the following possible contaminants.

NITRATES	CALCIUM	TOTAL COLIFORM	NITRITES	SODIUM
TOTAL FAECAL COLIFORM	SILICA	MAGNESIUM	TOTAL SOLIDS	TOTAL DISSOLVED SOLIDS
IRON	MANGANESE	TOTAL SUSPENDED SOLIDS	PHOSPHATES	SULPHATE
FLUORIDE	CHLORIDE	TOTAL PLATE COUNT	SPECIFIC CONDUCTIVITY	ALUMINIUM
ALKALINITY	TURBIDITY	COLOUR	CHEMICAL OXYGEN DEMAND	BIOCHEMICAL OXYGEN DEMAND

Filtration & Purification

- **Filtration** is designed to remove waterborne protozoa and bacteria, but not viruses.
- **Purification** is designed to combat all three classes of microbes, including viruses.
- **Potable water systems** require treatment beyond the leaf screen and roof washer to remove sediment and disease-causing pathogens from stored water.
- **Treatment** generally consists of filtration and disinfection processes in series before distribution to ensure health and safety.
- **Filtration & UV** disinfection is popular with two in-line sediment filters 5-micron fiber cartridge filter & 3-micron activated charcoal filter followed by UV light.
- **Ozone (O3):** acts as a powerful oxidizing agent to reduce colour, eliminate foul odours, and to reduce total organic carbon in water.
- **Chlorination** is popular to kill bacteria but contact time is critical and is usually from 2 minutes to 5 minutes
- **Reference-** www.rainharvesting.com.au

Summary Treatment Techniques

Method	Location	Result
Screening • Leaf screens & strainers	• Gutters & downspouts	• Prevents leaves & other debris from entering tank
Settling • sedimentation • activated charcoal	• Within tank • Before tap	• Settles particulate matter • Removes chlorine • Improves taste
Filtering • Roof washer • in-line/ multi-cartridge • activated charcoal • slow sand	• Before tank • after pump • after sedimentation filter • separate tank	• Cuts suspended material • sieves sediment • removes chlorine/taste • traps particulate matter

Summary Treatment Techniques (Contd)

Method	Location	Result
Microbiological Treatment/Disinfection		
• Boiling/Distilling	• Before use	• Kills Microorganisms
• Chemical treatments-Chlorine or Iodine	• Within tank or at pump (liquid, tablet, granular) & before activated charcoal	• Kills Microorganisms
• Ultraviolet light	• After Activated charcoal	• Kills Microorganisms
• Ozonation	• After Activated Charcoal	• Kills Microorganisms
• Nanofiltration	• Before use polymer membrane	• Removes molecules
• Reverse Osmosis	• Before use	• Removes ions (contaminants and microorganisms)

Adapted from Texas Guide to Rainwater Harvesting, Second Edition, Texas Water Development Board, 1997.

Maintaining Rainwater Harvesting System

- **Gutters-** Monthly, check for rusting or leaks and use sandpaper and aluminium gloss paint to fix the rusting areas, and use silicon glue to repair leaks
- Make sure gutters secured to wooden flashings and wood not rotting
- **Gutter Screens-** Monthly, check if damaged or clogged with leaves or dirt and clean or repair/replace
- **First Flush-** After every rainstorm clean by unscrewing end cap slowly, draining and remove debris collected. Screw end cap back on, but not all the way so as to allow for the pipes to drain slowly
- **Gravel Pits-** monthly, check and clear debris or garbage and if necessary add a fresh layer of sand to ensure that drainage can still occur.
- **Tank-** Annually, clean and disinfect tank to prevent slime, algae, bacterial growth, and the build-up of sediments. To clean the tank, first drain all the water from the tank and close the tap. It is preferable to wait until the tank is almost empty (at the end of the dry season), to clean the tank. Wash and remove dirt from inside surfaces of the tank with water. Drain the wash water and sediment from the bottom of the tank by opening the spigot. Use chlorination to disinfect the inside surfaces of the tank. Chlorine tablets can be added to the tank, or add bleach (5ml of bleach per L of water added) and mix it very well. Once the water inside the tank is chlorinated, let the chlorine solution sit in the tank for 3-5 hours, and then drain the tank completely. Fresh water can then be added to the tank. Run the water from the spigot until there is no smell of chlorine, and then continue normal usage of the tank.

National Standards & Best Practices

- No Jamaica national standards for RWH systems
- Manchester & St. Elizabeth- Rainwater harvesting is recommended by the Municipal Council
- In other areas such as Kingston the regularity of water lockoffs suggests it should be required
- The voluntary approach has been the hallmark of water conservation efforts, and Water Conservation
- Best Management Practices Guide has been developed in some states in the USA such as Texas.
- American Rainwater Catchment Systems Asscn. Good source of information https://www.arcsa.org/

Key Components of Greywater Recycling Systems

- Greywater Definition
- Basic Greywater Systems
- Basic Greywater guidelines
- Types of Systems
  - From Washing Machine & Laundry
  - From the Shower
  - From Kitchen Sinks
  - Storage & Pumped Systems
  - Indoor Greywater use
- Plants & Greywater

Greywater Definition

- **Greywater** or **sullage** is all wastewater generated in households or office buildings from streams without fecal contamination, i.e. all streams except for the wastewater from toilets.
- Sources of greywater include, sinks, showers, baths, clothes washing machines or dish washers.
- As greywater contains fewer pathogens than domestic wastewater, it is generally safer to handle and easier to treat and reuse onsite for toilet flushing, landscape or crop irrigation, and other non-potable uses.

Basic Greywater Overview

Quality

- Greywater contains traces of excreta and is not pathogen free
- Excreta comes from washing a person's anal area in the bath and shower, or from the laundry (washing underwear).
- Greywater quality can deteriorate rapidly during storage because it often is warm and contains some nutrients and organic matter (e.g. dead skin cells), as well as pathogens.

Quantity

- In households with conventional flush toilets, greywater makes up about 65% of the total wastewater produced by that household.

Practical aspects

- The small traces of feces that enter the greywater stream via effluent from the shower, sink, or washing machine do not pose practical hazards under normal conditions, as long as the greywater is used correctly (eg farming or landscape irrigation).

Basic Greywater Guidelines

- Greywater is different from fresh water and requires different guidelines for it to be reused.
- **Don't store greywater** (more than 24 hours). If you store greywater the nutrients in it will start to break down, creating bad odors.
- **Minimize contact with greywater.** Greywater could potentially contain a pathogen if an infected person's feces got into the water, so your system should be designed for the water to soak into the ground and not be available for people or animals to drink.
- **Infiltrate greywater into the ground, don't allow it to pool up or run off**-Knowing how well water drains into your soil (or the soil percolation rate of your soil) will help with proper design. Pooling greywater can provide mosquito breeding grounds, as well as a place for human contact with greywater.
- **Keep your system as simple as possible, avoid pumps, avoid filters that need upkeep**. Simple systems last longer, require less maintenance, require less energy and cost less money.
- Install a 3-way valve for easy switching between the greywater system and the sewer/septic.
- **Match** the amount of greywater your plants will receive with their needs.

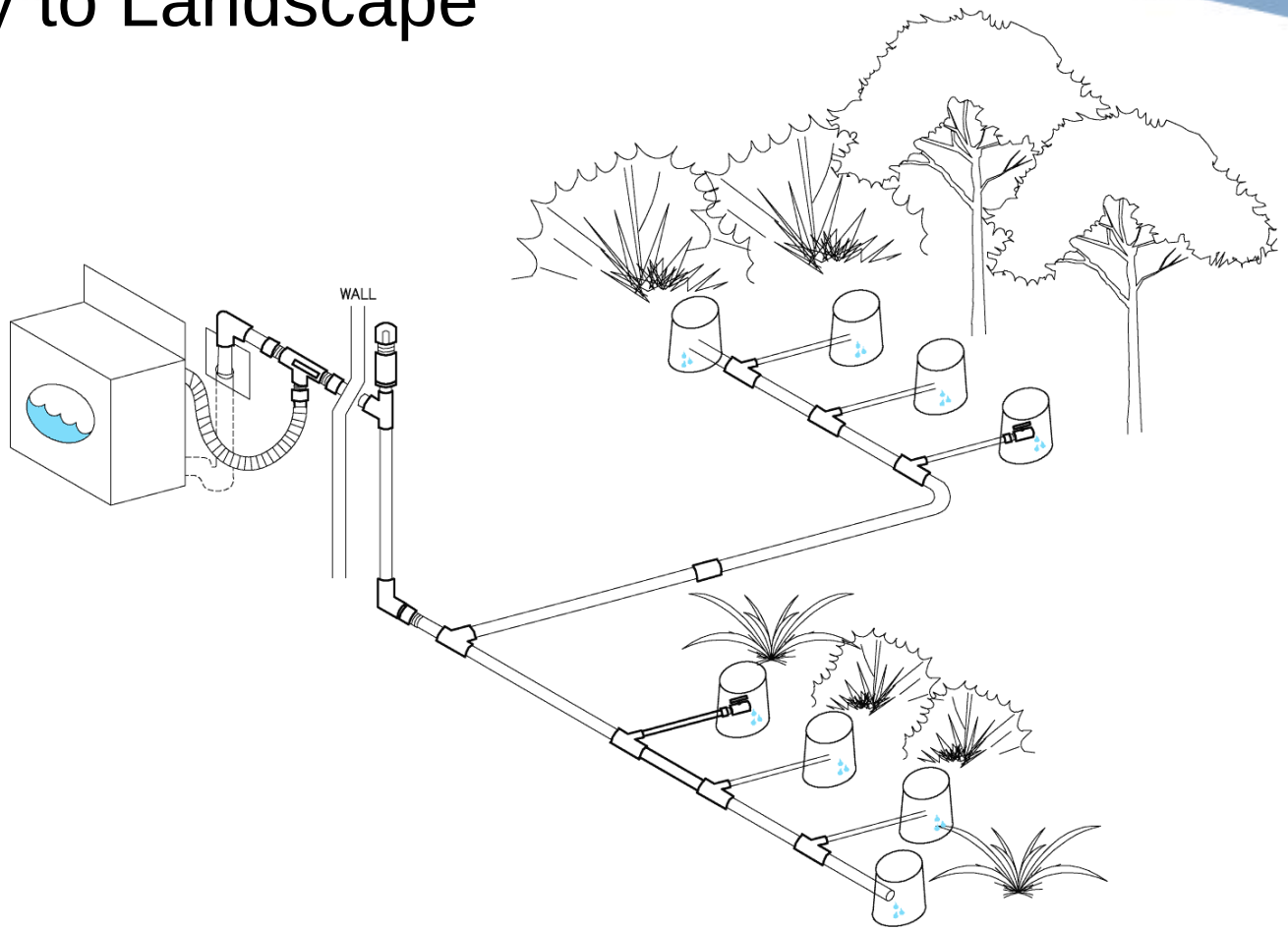
Basic Greywater Systems

From Washing Machine

- Typically the easiest source of greywater to reuse because it can be diverted without cutting into existing plumbing.
- Each machine has an internal pump that automatically pumps out the water and that can be directed to plants
- A drum or surge tank can be used to store laundry machine wastewater for irrigation
- At the bottom of the drum the water drains out into a hose that is moved around the yard to irrigate.
- This is the cheapest and easiest system to install, but requires constant moving of the hose for it to be effective at irrigating

Basic Greywater Systems

Laundry to Landscape system



Basic Greywater Systems

From the Shower

- Showers usually produce a lot of relatively clean water
- A simple shower system is gravity-based (no pump)
- Pump required If yard is located uphill from the house
- Branched Drain: Greywater in this system flows through standard (1 1/2" size) drainage pipe, by gravity, always sloping downward at 2% slope, or 1/4 inch drop for every foot traveled horizontally
- Branched drain systems are time consuming to install, but once finished require very little maintenance and work well for the long term.

Basic Greywater Systems

From the Kitchen Sink

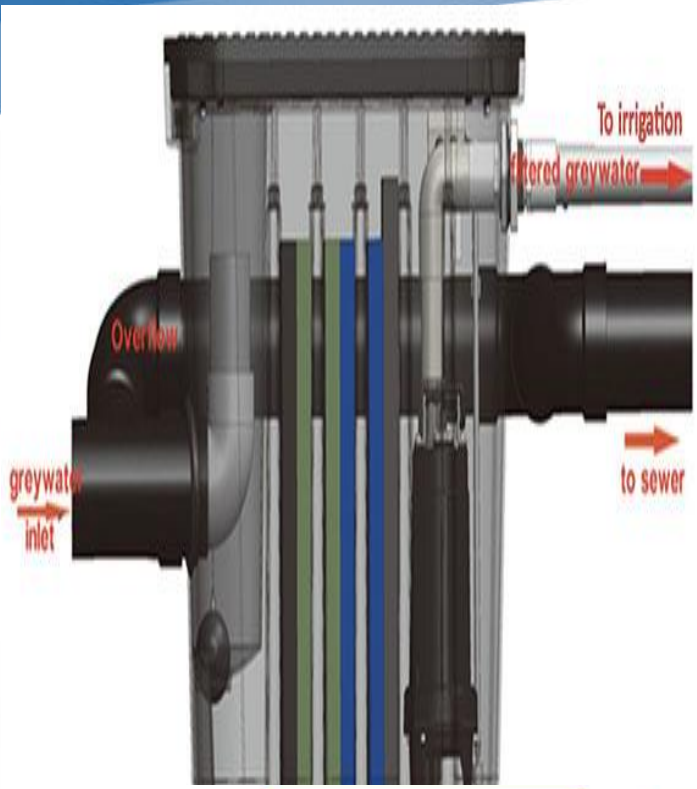
- Kitchen sinks are the source of a fair amount of water, usually very high in organic matter (food, grease, etc.).
- Kitchen sinks are not allowed under many greywater codes
- This water will clog many kinds of systems
- To avoid clogging, a branched drain system with mulch basins, organic matter collects in the woodchips and decomposes.
- Another option is to filter the water or install a grinder
- Since bathroom sinks don't typically generate much water, they can often combine flows with the shower water, or the sink water can be drained to a single large plant, or divided to irrigate two or three plants.

Pumped Greywater Systems

Pumped System

- If you can't use gravity to transport the greywater (ie the yard is sloped uphill, or it's flat and the plants are far away) you will need to pump greywater uphill.
- In a basic pumped system greywater flows into a large (usually 50 gallon) plastic barrel that is either buried or located at ground level.
- Inside the barrel an effluent pump pushes the water out through irrigation lines to the landscape.
- Pumps add cost, use electricity, and will break, so avoid this if you can.

Filtered Greywater Systems



Mainly used for irrigation

- AES of New Zealand uses Greywater from showers, hand basins and washing machines and filters out particles from the liquid
- Filtered water is pumped to garden irrigation system
- The filters are designed to be cleaned occasionally over and over so you don't need to replace them
- Filtered Greywater Systems Sample- https://www.et.nz/greywater-recycling/

Ladies & Gentlemen

Thank You!

For your attention & participation