Cistern Maintenance in the USVI:
Technical Guidance and Resources

Who We Are - The Team

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Cistern Workshop Learning Outcomes

- Hear your cistern issues in the Virgin Islands
- Introduce **Clean, Protect, and Maintain** concepts
- Discuss how pollutants in water can affect health
- Define different ways to treat cistern water
- Review local case studies- “What to look for”

Let's Hear From You...

Tell us the challenges that affect your cistern

Voyage of a Water Drop… Rain to Use

Locally, there are many ways that we use cistern water

System Features provide protection to water collected for local use

Pollutants enter water from many sources: some local, others from around the world

Treating your cistern water is important for staying healthy

Testing treated water regularly ensures that your treatment system works correctly

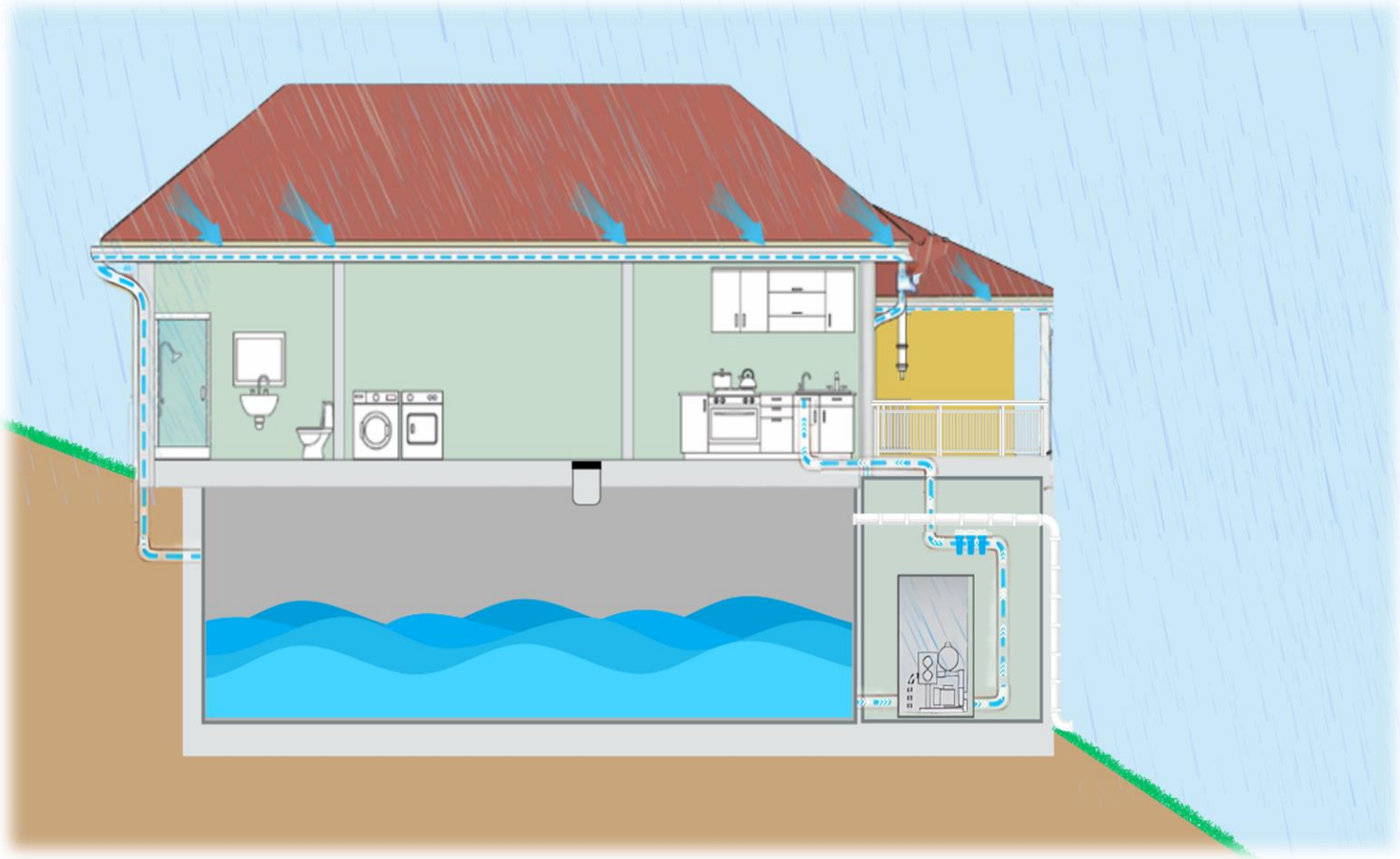
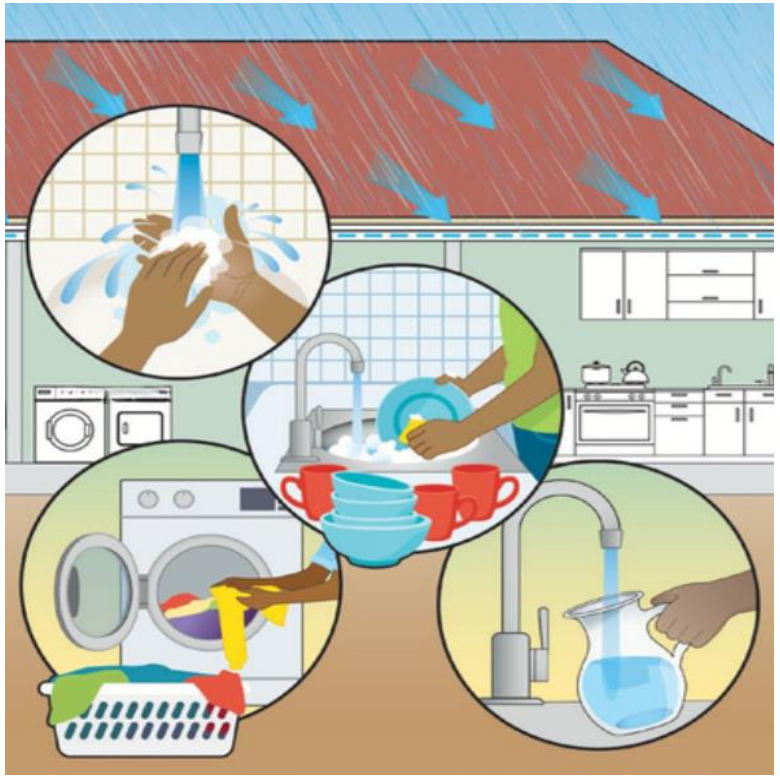


Image: *Avanti*

Department of Health
Cistern Study in the Virgin Islands (2019)

Water enters your body in many ways

- 90% of homes use cistern water everyday
- 18% drank from their cistern directly
- 89% used cistern water for bathing
- Survey found most households did NOT treat water before use
- 64% had *E. coli* present



Clean, Protect, Maintain

Source: VI DOH (2019, October 4) DOH Completes the 2019 Cistern Study
Image: *Avanti*

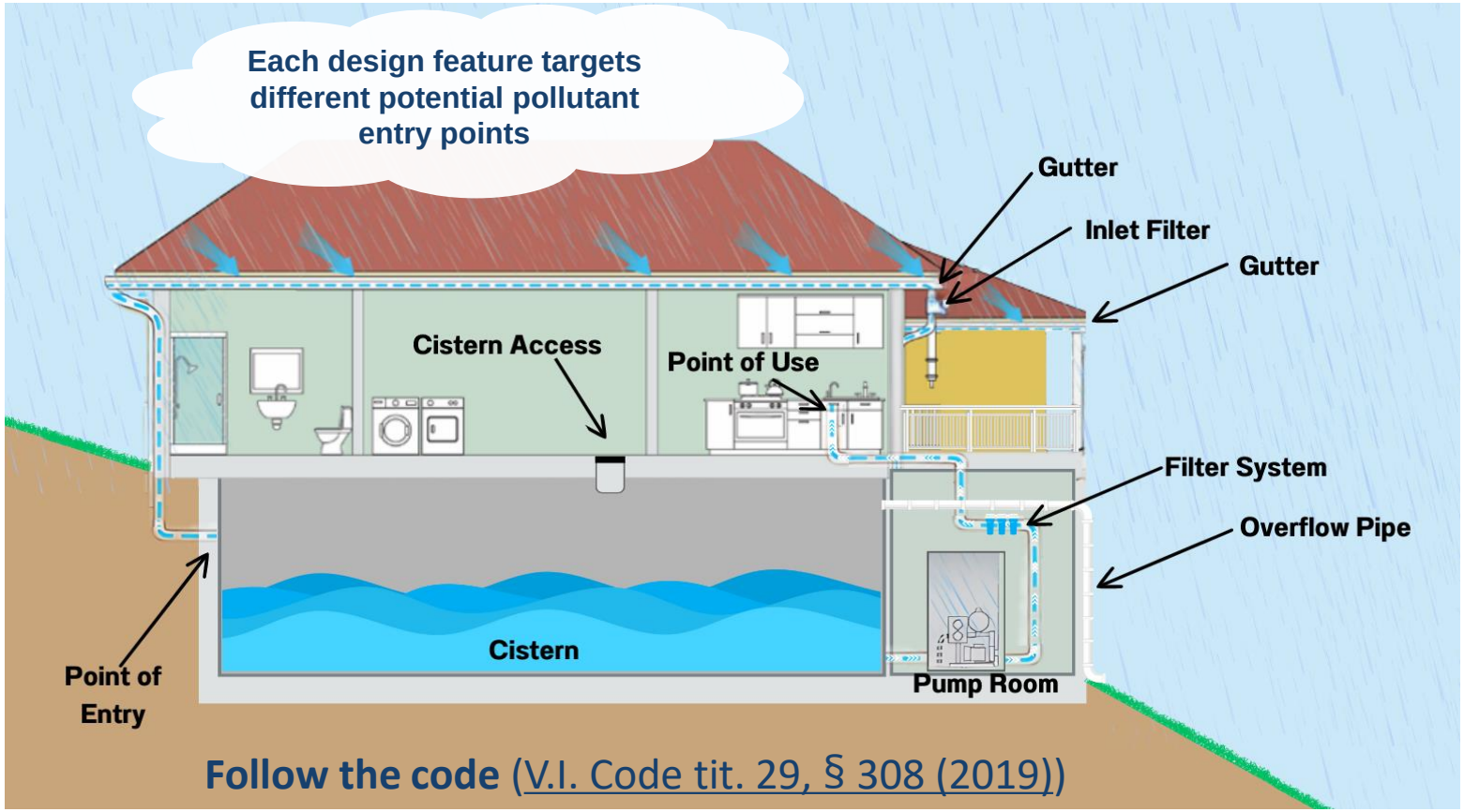
Typical VI Cistern System

Function and Design

The roof collects the water

A cistern stores the water

Store enough for dry periods



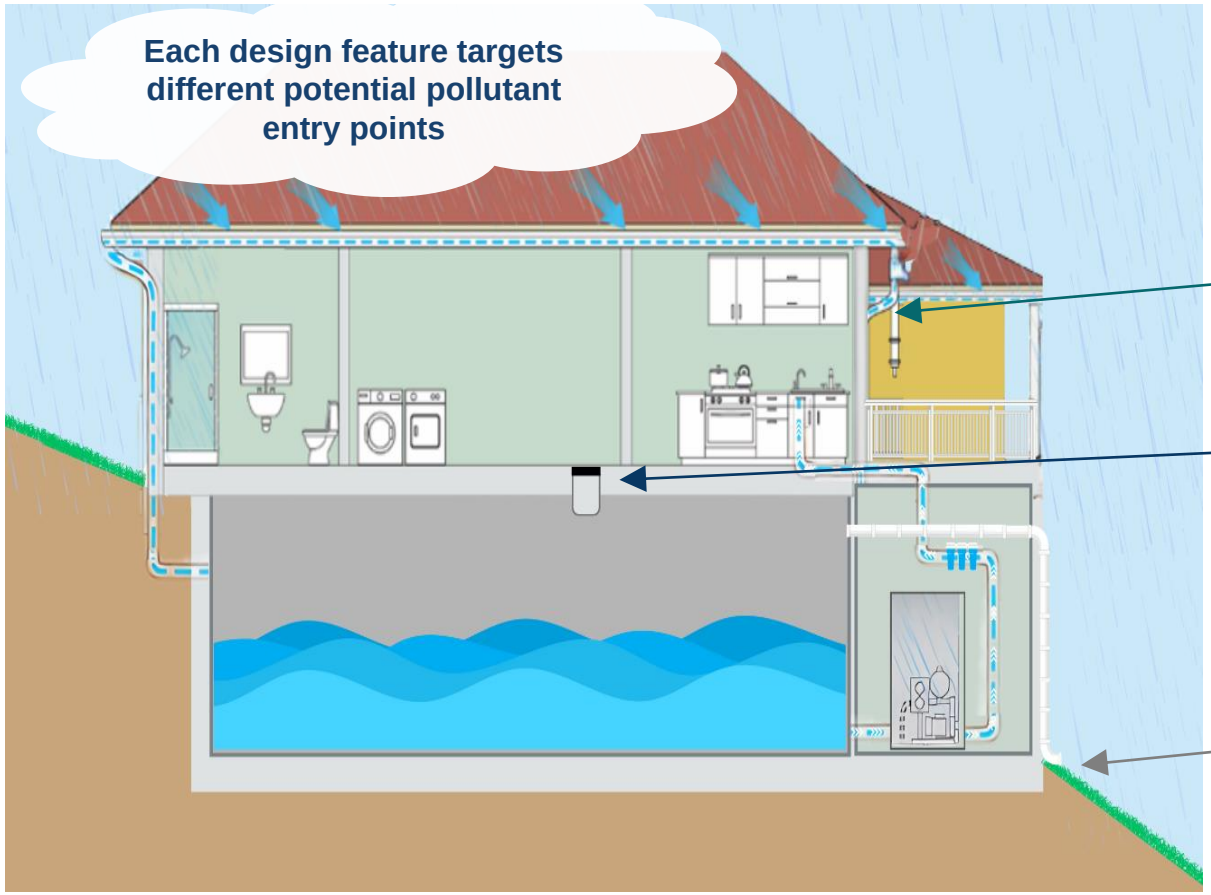
Downspouts and pipes carry the water

A pump moves the water to final use

Store 3-month supply per person

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf
Image: *Avanti*

Other System Design Features



First Flush Diverters:
Helps move the debris from initial rainfall away from the cistern intake

Access Point: An entry into the cistern to monitor, inspect, clean, and maintain, which should be air-tight when closed, and ideally in a low traffic area

Overflow: All cisterns must have an overflow outlet with a screen on the end. The screen should be inspected often for damage and repaired quickly to avoid critters from getting inside

Follow the code (V.I. Code tit. 29, § 308 (2019))

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf
Image: *Avanti*

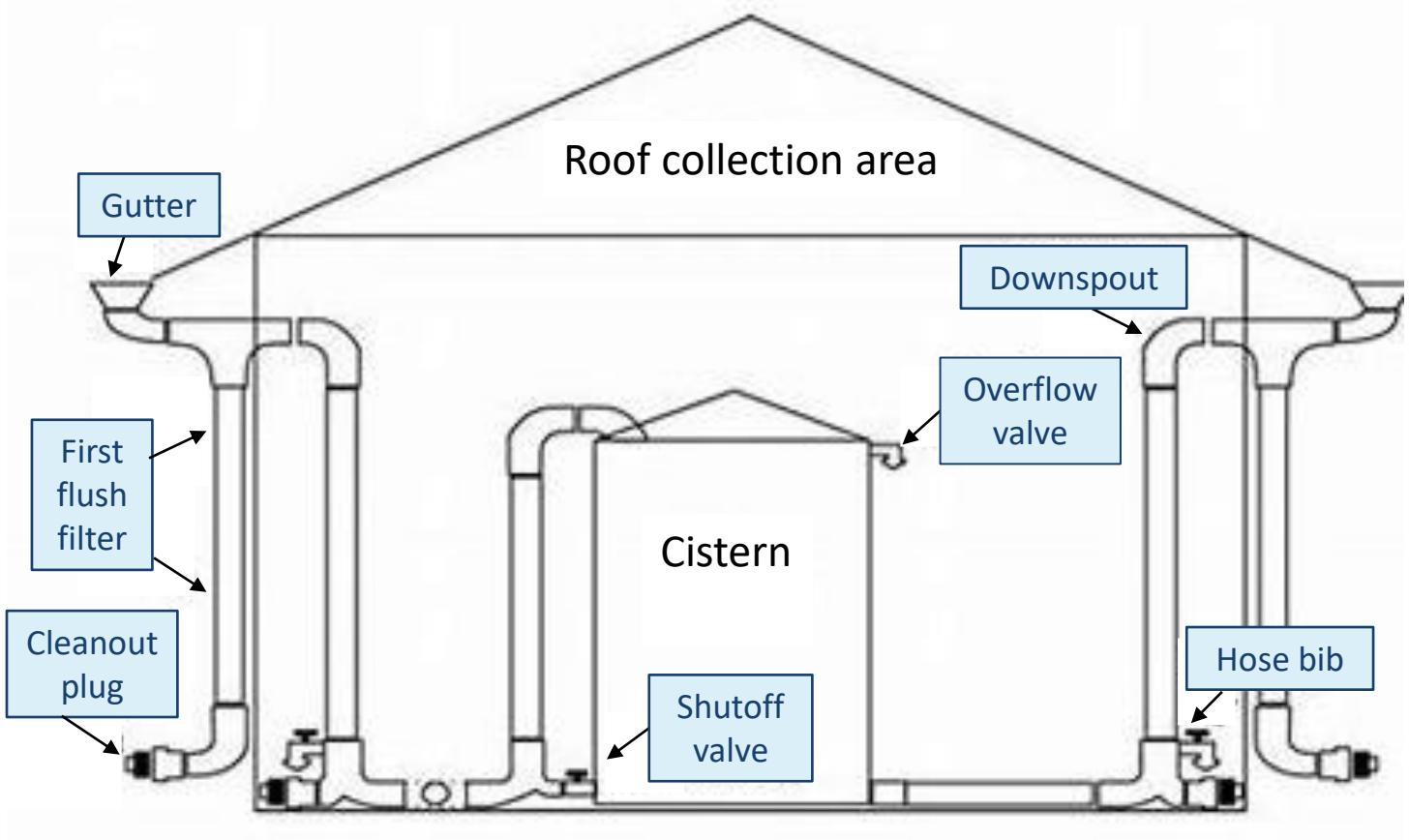
OVERALL DESIGN
Maintenance Features and Connections

Shutoff valves before and after filtration and treatment systems ease maintenance and create bypasses

Use electrical and shut off valves as a safety precaution

Drain points and cleanout plugs help to empty the line of liquid and debris

A **split cistern or cistern divider** allows you to have stored water while the other side is being serviced



Source: Schematic of a rainwater harvesting system. | Download Scientific Diagram (researchgate.net)

KNOW THE CODE: DESIGN

An Optimized System

Water Supply § 308. Water supply, cisterns, gutters, downspouts, wells

Universal Citation: V.I. Code tit. 29, § 308 (2019) - self sustaining water systems

DESIGN SPECIFICATION

(1) Cisterns shall be constructed of metal, masonry, concrete or other materials approved by the Commissioner and be **maintained in a watertight and mosquito and rodent proof condition at all times**. Metal cisterns shall be placed above ground level unless approved for underground installation in the building permit.

(2) Cisterns shall be located at a point free from **flooding**.

(3) An **overflow** of cross-section area at least equal to the combined cross-section areas of all inlets shall be provided on each cistern.

Source: V.I. Code tit. 29, § 308 (2019)

KNOW THE CODE: CAPACITY

An Optimized System

Water Supply § 308. Water supply, cisterns, gutters, downspouts, wells

Universal Citation: V.I. Code tit. 29, § 308 (2019) - self sustaining water systems

CAPACITY

(1) Cisterns for dwellings, apartments and hotels shall have a **minimum usable capacity of 10 gallons for each square foot of roof area for buildings of one story and 15 gallons for each square foot of roof area** for buildings of two or more stories. If a dwelling shall have access to the potable water system and is verified by appropriate WAPA officials and service is installed, no cistern will be required.

(2) **All other buildings shall have cisterns with a minimum usable capacity of 4 ½ gallons for each square foot** of roof area except that churches and warehouses shall not be required to conform to this standard. If at any time buildings formerly used for churches and warehouses are converted to other uses compliance shall be required.

Source: V.I. Code tit. 29, § 308 (2019)

HOW TO PLAN FOR HOUSEHOLD NEEDS

Needed storage capacity: the right **volume** needed for your system depends on the **number of people** serviced multiplied by expected **daily use** per person, household **animals**, and any water use features.

CALCULATE

Required catchment area: determined by measuring area of the roof that can enter the pipe system during a 1" rain event.

MEASURE

Research design features to find the best options for YOUR needs

Example Features: construction materials available for roof, pipes, gutters and gutter guards; needed line size; quantity of downspouts; roof washer options; screens and filters for intakes; overflow location; cistern access; force breaker; fill pipe; shutoff valves; and diverter.

RESEARCH

DESIGN

Source: PennState Extension

ACTIVITY: CALCULATE CATCHMENT

Calculate Rain Harvest Volume

Calculate Volume – Catchment Area/Roof Footprint

What Information you need to know:

- Catchment **area** in feet squared
- Rainfall **depth** in inches

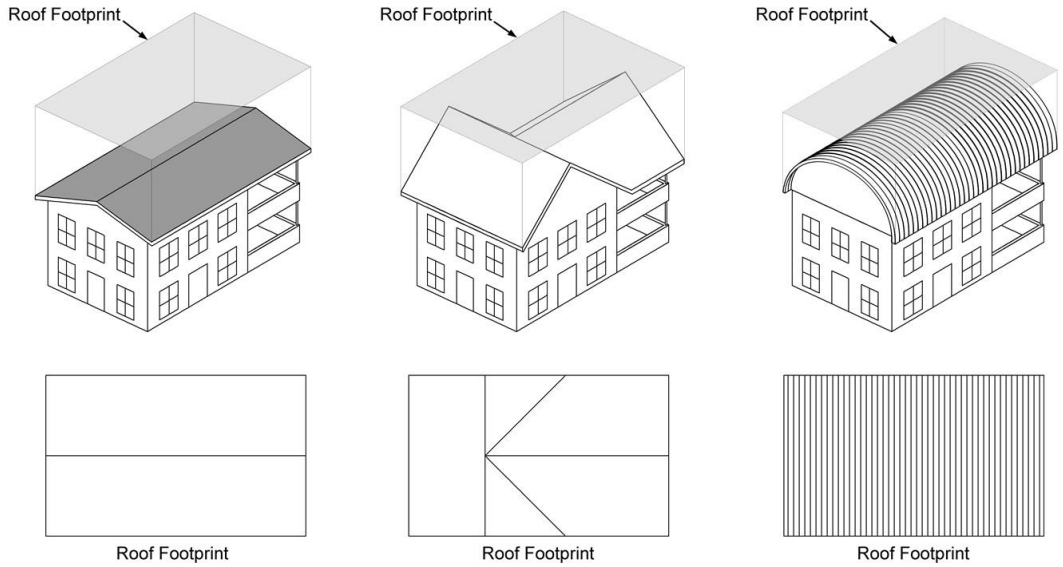


Image: Catchment Area | Rainwater Harvesting (tamu.edu)

Example:

Roof Area (square feet) x Rainfall depth (inches) x 0.623 (conversion factor) = Rain Volume Harvested

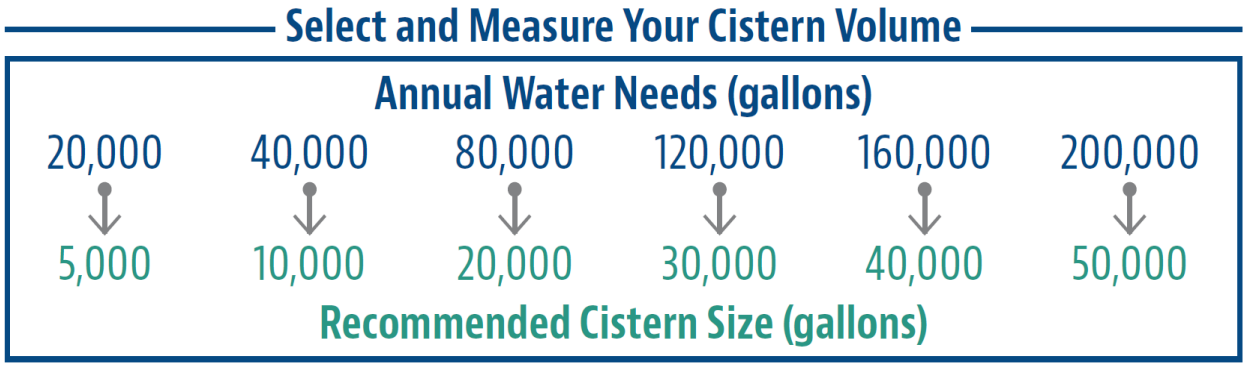
Source: Rainwater Cisterns: Design, Construction, and Treatment

ACTIVITY: CALCULATE STORAGE

Calculate Water Volumes

Calculate Volume – Cistern Sizing

- How many people live in the house/use the building.
- Amount of water expected to be used is calculated on a per day basis (typically 50-70 gallons) and a 90-day storage minimum.



Example:

 # Household/building occupants x 50 gallons x 90 days = Volume Needed

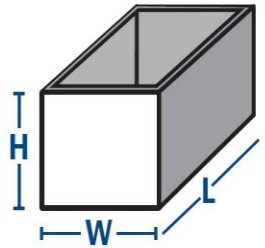
Source: Rainwater Cisterns: Design, Construction, and Treatment

ACTIVITY: CALCULATE STORAGE
Calculate Water Volume

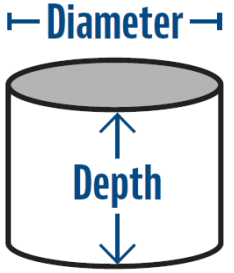
Calculate Volume – Existing Cistern

- Calculate by shape (square or cylindrical)
- Measure the sides and height (feet)
- If there are more than cistern. Calculate for the shape and then add the total volumes together.

Does your existing system match your need?



Square or rectangular shapes:
Volume (gallons) = Length (ft) x Width (ft) x Height (ft) x 7.5 (gal/ft^3)



Cylindrical or round shapes:
Volume (gallons) = 0.785 x (diameter)^2 x depth (ft) x 7.5 (gal/ft^3)

Source: Rainwater Cisterns: Design, Construction, and Treatment

Pollutant Sources

- Animals & Birds
- Roof & Sealants
- Industry & Traffic
- Vegetation & Debris
- Local landfill fires
- Pollen
- Sahara sands
- Salt
- Storms

Image: Avanti

Pollutants Can Affect Health

Pollutant Source	Pollutant	Associated Health Effects
Animals and Animal Waste	Parasites Bacteria	Ear and skin infections, diarrhea, digestive issues, dysentery, fever, influenza, and respiratory flu Chronic fatigue, cause mental health imbalance, and digestive issues
Insect Breeding Grounds	Overpopulation of disease carrying insects	*Examples*: Malaria, Dengue, and Chikungunya Viruses
Materials and Sealants	Toxic metals	Short- and long-term harm to different body systems. Can affect the eyes, digestive issues, cause mental health imbalance, reproductive issues, and allergies
Pollen and Sahara Sands	Chemicals Pesticides	Same as ***Materials and Sealants***
Vegetative Debris and Organic Material	Parasites Bacteria Nutrients Secondary Pollutant: Disinfectant Byproduct (DBP)	Same as ***Animals and Animal Waste*** DBPs associated health risks: Prolonged exposure could lead to cancer, reproductive issues, and developmental issues

Table: Avanti

Bacterial Pollutants

Why does that matter?

- Most bacteria are beneficial, some may be harmful
- Over time, harmful populations can multiply
- These tiny organisms may produce toxins
- They can't be seen with the naked eye
- Examples: Legionnaire's, E.coli, and fecal coliforms

Remember that **2019 Study**?

Where does it come from?

- Bird and rodent waste
- Dead animals
- Leaves / debris

Water was collected directly from local cisterns and kitchen taps! They tested **POSITIVE** for a harmful type of bacteria!

When not controlled or removed, **harmful bacteria can affect your health!**

How to treat?

- Circulate water often
- Screen your inlets
- Treat your water

Sources: VI DOH (2019, October 4) DOH Completes the 2019 Cistern Study
Twenty years of waterborne and related disease reports in Florida, USA – ScienceDirect
Bacteria: the Good, the Bad, and the Ugly | National Center for Health Research (center4research.org)

Roof Materials & Pollutants

The **materials** and **sealants** that are part of the roof can be a source of **pollutants**

Roof Material	Check Before Use
Plywood	• Verify roofing materials and sealants are safe for potable water systems • Avoid tar-based, petroleum products • Use tested and certified products when making repairs or building new structures
Cement	
Galvanized Aluminum or Metal/Galvalume	

Source: ARCSA International

Image: Avanti

Feature Selection - Reduces Pollutants

Screens and filters keep out leaves, twigs, and pests from the collection system

Image: SK Roofing

Image: Marathon Drains

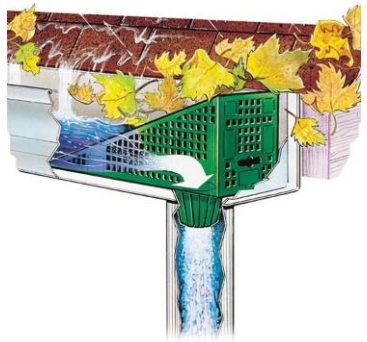


Image: Home Depot

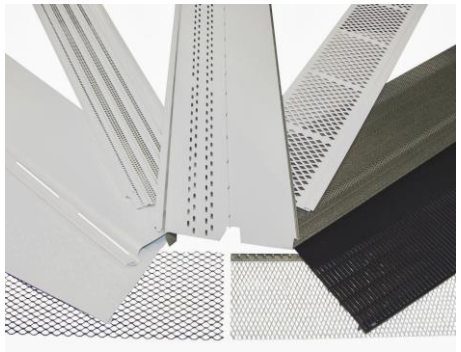


Image: Gutter Supply

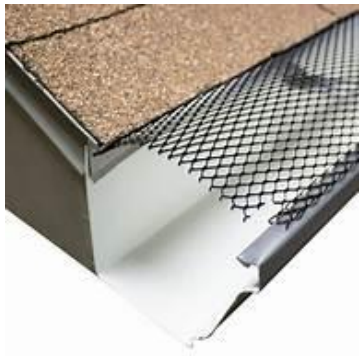


Image: Lynch Aluminum

Image: Newport Gutter Cleaning

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf

Roof Best Management Practices

- Make permanent anchors when you can and use a harness
- Extend ladder 3 feet past the surface
- Have a spotter
- Keep the ladder and roof free and clear of slippery materials like soap and algae

- Use soft cleaning techniques like low-pressure washing or a leaf blower to save water and limit damage to seals
- Use biodegradable detergents and avoid bleach on metal roofs
- Hire a contractor if you can't do it yourself

Source: www.purewaterroofing.co.uk/blog/how-to-clean-your-roof-without-stepping-on-roof-tiles/
Image: How To Lean Ladder Against Gutter | Storables; How to clean your roof without stepping on roof tiles - Purewater Roof Cleaning

Example
Interactive Discussion

Are there any issues?

The roof and gutters need cleaning, and trees need to be trimmed back

Describe the best management practices

Trim trees, remove overhanging vegetation, and clean gutters regularly

Use gutter and downspout screens

Source: DPNR 2024

Scenario
Interactive Discussion

A large landfill fire happened nearby. It was big and the neighborhood was enveloped in smoke. The smoke continued for several days.

What part of cistern systems are easily affected?

The collection system - roof and gutters

What steps should you take to protect your cistern?

Isolate your cistern intake as soon as possible with a diverter or disconnect valve

Clean your roof and gutters of debris and sediment before collecting water again

Source: St. Thomas Source, September 2023

Example
Interactive Discussion

Are there any issues?

Inlet filter is clogged and needs maintenance

Describe the best management practices

Regular visual inspection, cleanout, and repair of filters and gutters

Source: DPNR 2024

Example
Interactive Discussion

Are there any issues?

No issues noted. It is an example of a first flush diverter

Describe the best management practices

Use to prevent water intake of pollutant rich first flush and to isolate your cistern during emergencies

Source: DPNR 2024

Example
Interactive Discussion

Are there any issues?

Gutter inlet is missing a screen

Describe the best management practices.

Make sure to install a screen to keep outside debris and critters out

Source: DPNR 2024

Example
Interactive Discussion

Are there any issues?

Screen has a hole and needs to be repaired

Describe the best management practices

Do regular inspections of openings to keep critters and insects out! Make repairs as soon as an issue is found

Source: DPNR 2024

Example
Interactive Discussion

Are there any issues?

Damaged cistern cover

Describe the best management practices

Cistern cover should be sealed and watertight

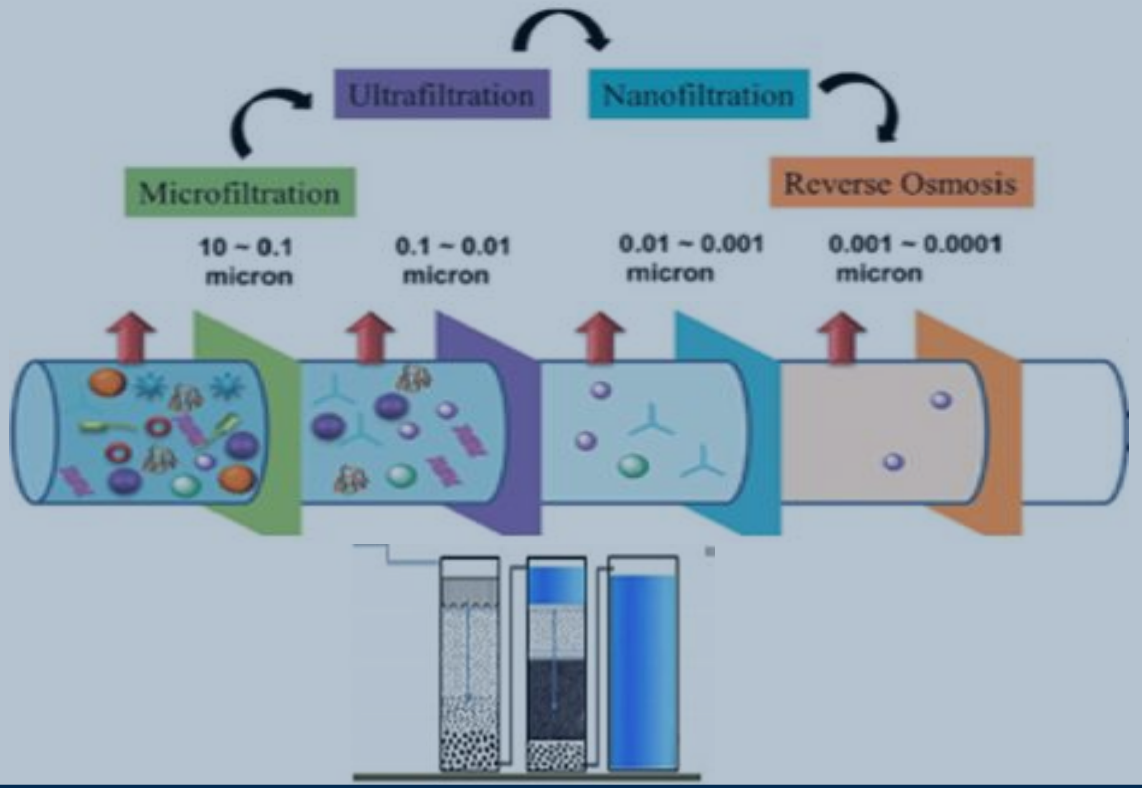
Source: DPNR 2024

Daily Cistern Water Treatment

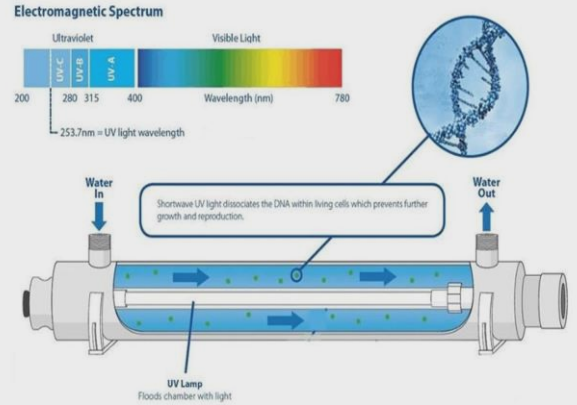
Each type of treatment is effective against different pollutants

Bleach removes bacteria **AND** viruses (no metals or chemicals); harmful disinfectant by-products (**DBPs**) are formed when organic material mixes with residual chlorine

Filtration removes metals and most chemicals



Ultraviolet (UV) kills bacteria and viruses. Used with filtration it is very effective



Each treatment can be used separate or in combination

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf

Image: Progress in electrospun polymeric nanofibrous membranes for water treatment: Fabrication, modification and applications – ScienceDirect
UV Water Purification Pros and Cons - S3DA Design, Structure &MEP (s3da-design.com)

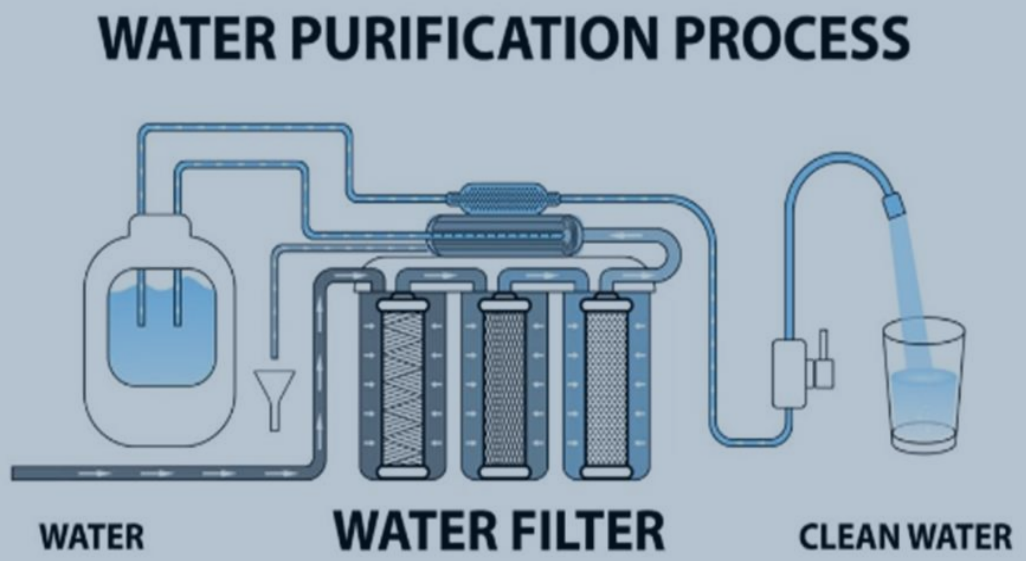
Less Common Treatment

Each type of treatment is effective against different pollutants

Boiling removes bacteria AND viruses (**NOT** sediment, metals, chemicals)

SHORT-TERM EMERGENCY USE ONLY

Reverse Osmosis is a type of filtration using a semi-permeable membrane. Use for high purity water



Spin Down Filter use when filter cartridge is getting clogged too quickly. Easily cleaned

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf
Image: AguaLite. US

Chlorination
Common Chlorine Bleach Types

Liquid

Tablet

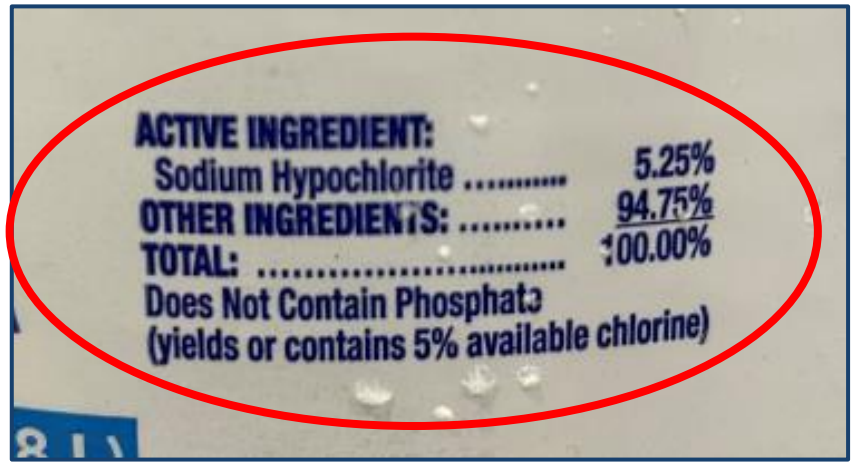
Chlorine concentrations can be between 3% - 9%. The amount you use depends on the chlorine **concentration** and the **volume** of water

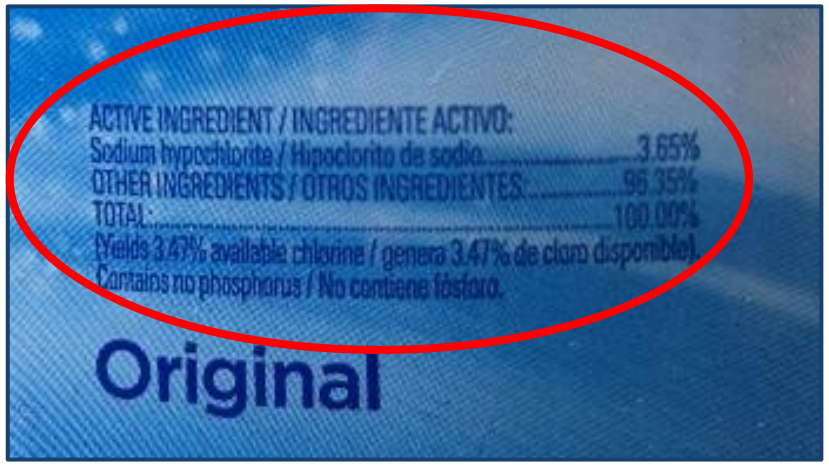
- Chlorine effectively **kills** bacteria and viruses
- Most **common** form of disinfection
- It is **economical, easily available,** and **simple** to use

Source: EPA: Emergency Disinfection of Drinking Water; About Water Disinfection with Chlorine and Chloramine | Drinking Water | CDC

Chlorination Treatment
Chlorine Bleach - What The Labels Mean

BUYER BEWARE – Use a product that is certified or regulated!!
USE REGULAR Chlorine Bleach and DO NOT USE OUTDOOR Bleach





Chlorine Scenario

Which chlorine bleach can be used safely to disinfect your water supply?

A

B

C

Chlorination
Free vs. Total: Why it Matters

90% of free chlorine is lost by the time it reaches the tap

REASONS FOR CHLORINE LOSS

- **Treating pollutants on way to tap** (excess organic matter)
- **Sunlight and heat** (it is volatile)
- **pH and chemical imbalances** (over or under treatment)

Measure the **FREE** chlorine to make sure it is greater than the **COMBINED** chlorine

Presence of **FREE** chlorine means it is available to disinfect

+

COMBINED chlorine has done its job and can no longer disinfect

=

TOTAL chlorine is the sum of **free** and **combined** chlorine

Source: Water Disinfection with Chlorine and Chloramine | Public Water Systems | Drinking Water | Healthy Water | CDC

Chlorine Dosing
Begin with Water Volume

Dosing is based on water height (volume)

- For manual chlorine disinfection, use a **Reference Chart** to determine the amount of liquid bleach (% sodium hypochlorite) to add per gallon of water
- The residual chlorine should be measured weekly, to determine when to add more chlorine

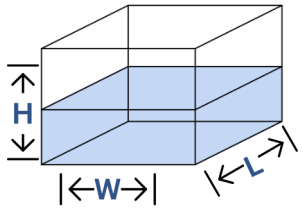
Measure ACTUAL water DEPTH in cistern

Source: Rainwater Cisterns: Design, Construction, and Treatment
Image: Coral Bay Community Council

How to Measure Water Volume
Based on Shape

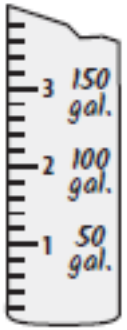
Calculate Total Cistern Capacity vs. Water Volume

- Calculate capacity (potential) by shape (square or cylindrical)
- Measure the sides and height (feet)



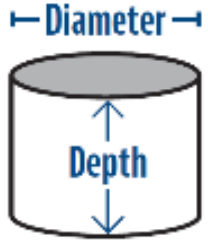
Square or rectangular shapes:
Volume (gallons) = Length (ft) x Width (ft) x Height (ft) x 7.5 (gal/ft³)

Measure Actual Water Volume



Make a Measuring Stick or Mark Your Tank

1. A measuring stick can be made or purchased
2. Mark the tank or install a measuring tape when empty in an easy-to-read place with feet and inches. **The goal is to read how much water is in the tank**



Cylindrical or round shapes:
Volume (gallons) = 0.785 x (diameter)² x depth (ft) x 7.5 (gal/ft³)

Source: Rainwater Cisterns: Design, Construction, and Treatment

Disinfecting with Chlorine
Large Volume Reference Chart

For manual chlorination, use the **Reference Charts** to determine the amount of liquid bleach (% sodium hypochlorite) to add per gallon of water to disinfect the water supply

- Measure free chlorine weekly, to determine when to add more chlorine

Storage Tank Gallons	Storage in Quarts	Ounces		Teaspoon		Drops
		chlorine bleach (unscented) or % sodium hypochlorite				
		5.25%	8.25%	5.25%	8.25%	Estimated 5%–9%
10,000	40,000	25.5	16			
5,000	20,000	12.5	8			
1,500	6,000	3.8	2.4			
250	1,000			4	2.5	
100	400			1.5	1	
5	20					40
1	4					8
0.25	1					2

Use Test Strips or Meter

1 milligrams per liter (mg/L) = 1 part per million (ppm)

Don't forget to pick up a QUICK REFERENCE PACKET

Source: Rainwater Cisterns: Design, Construction, and Treatment
Image: How to Test for Chlorine in Water | waterfilterguru.com

Disinfecting with Chlorine
Small Volume Reference Chart

Volume of Water	Amount of 6% Bleach to Add*	Amount of 8.25% Bleach to Add*
1 quart/liter	2 drops	2 drops
1 gallon	8 drops	6 drops
2 gallons	16 drops (1/4 tsp)	12 drops (1/8 teaspoon)
4 gallons	1/3 teaspoon	1/4 teaspoon
8 gallons	2/3 teaspoon	1/2 teaspoon

Test free chlorine often to know when to add more

Free chlorine goal is 0.2 – 2 ppm

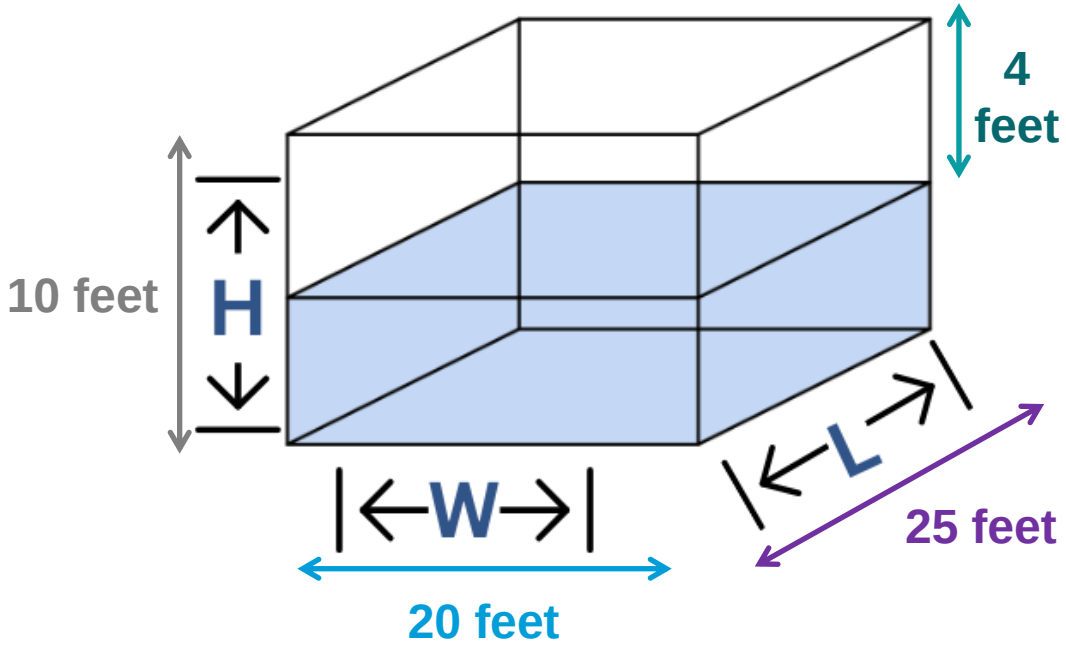
Source: Rainwater Cisterns: Design, Construction, and Treatment

Scenario
Measure to Calculate Volume
Dolly and George's Existing Cistern

Dolly and George's cistern is 25 feet long, 20 feet wide and 10 feet deep. The waterline is at 8 feet.

What is the capacity of their cistern? **37,500 gallons**

What is the amount of water in their cistern?
22,500 gallons



REMINDER

***Capacity* is the *potential volume* (outside measurements) while water in a cistern is *"actual" volume* (inside measurements)**

Volume = Length x Width x Depth x 7.5 (gal/ft³)

Source: Rainwater Cisterns: Design, Construction, and Treatment

Scenario
Using Chlorine Dosing

Use these chlorine dosing charts to answer the following questions

1. The stored 30,000 gallons needs how many ounces of 8.25% chlorine bleach added to the tank? **48 oz.**

2. 30,000 gallons using 5.25% chlorine? **76.5 oz.**

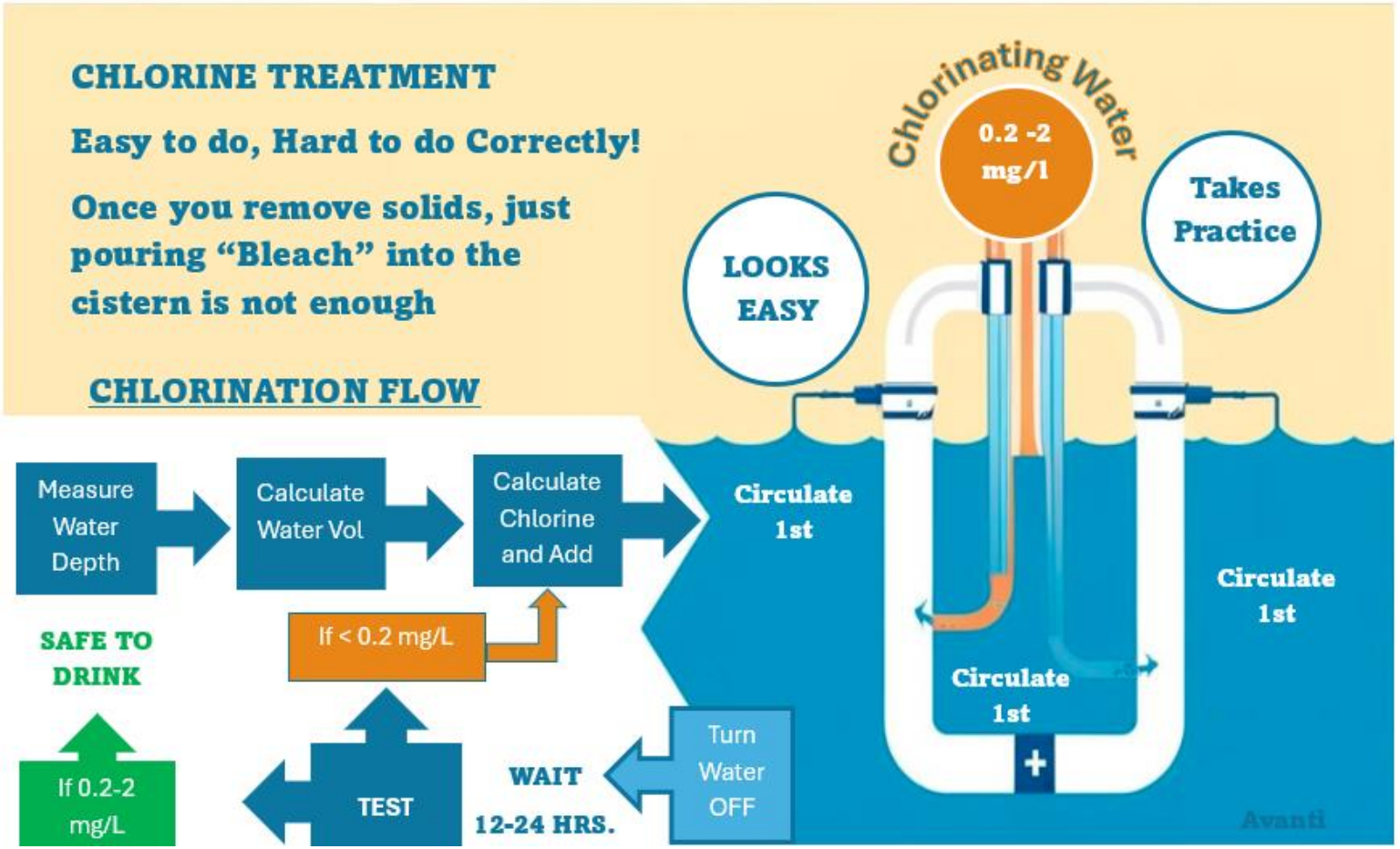
Volume of Water	Amount of 6% Bleach to Add*	Amount of 8.25% Bleach to Add*
1 quart/liter	2 drops	2 drops
1 gallon	8 drops	6 drops
2 gallons	16 drops (1/4 tsp)	12 drops (1/8 teaspoon)
4 gallons	1/3 teaspoon	1/4 teaspoon
8 gallons	2/3 teaspoon	1/2 teaspoon

Storage Tank Gallons	Storage in Quarts	Ounces		Teaspoon		Drops
		chlorine bleach (unscented) or % sodium hypochlorite				
		5.25%	8.25%	5.25%	8.25%	Estimated 5%–9%
10,000	40,000	25.5	16			
5,000	20,000	12.5	8			
1,500	6,000	3.8	2.4			
250	1,000			4	2.5	
100	400			1.5	1	
5	20					40
1	4					8
0.25	1					2

3. A 5-gallon bucket filled up halfway with 8.25% chlorine? **15 drops**

Chlorine as a Disinfectant
Process

Remember Safety First!
Don't forget to ventilate!
Do not store or mix chemicals together!



Perform mechanical cleaning first

During disinfecting process - wait at least **12 hours before testing**

During treatment, run the tap to circulate disinfectant, then turn **OFF and DO NOT USE until levels are tested**

NOTE: more water needs more treatment time AND biofilm removal takes longer

Source: Cistern Safety and Disasters: Before, During, and After | Water, Sanitation, and Hygiene (WASH)-related Emergencies and Outbreaks | CDC
Image: *Avanti*

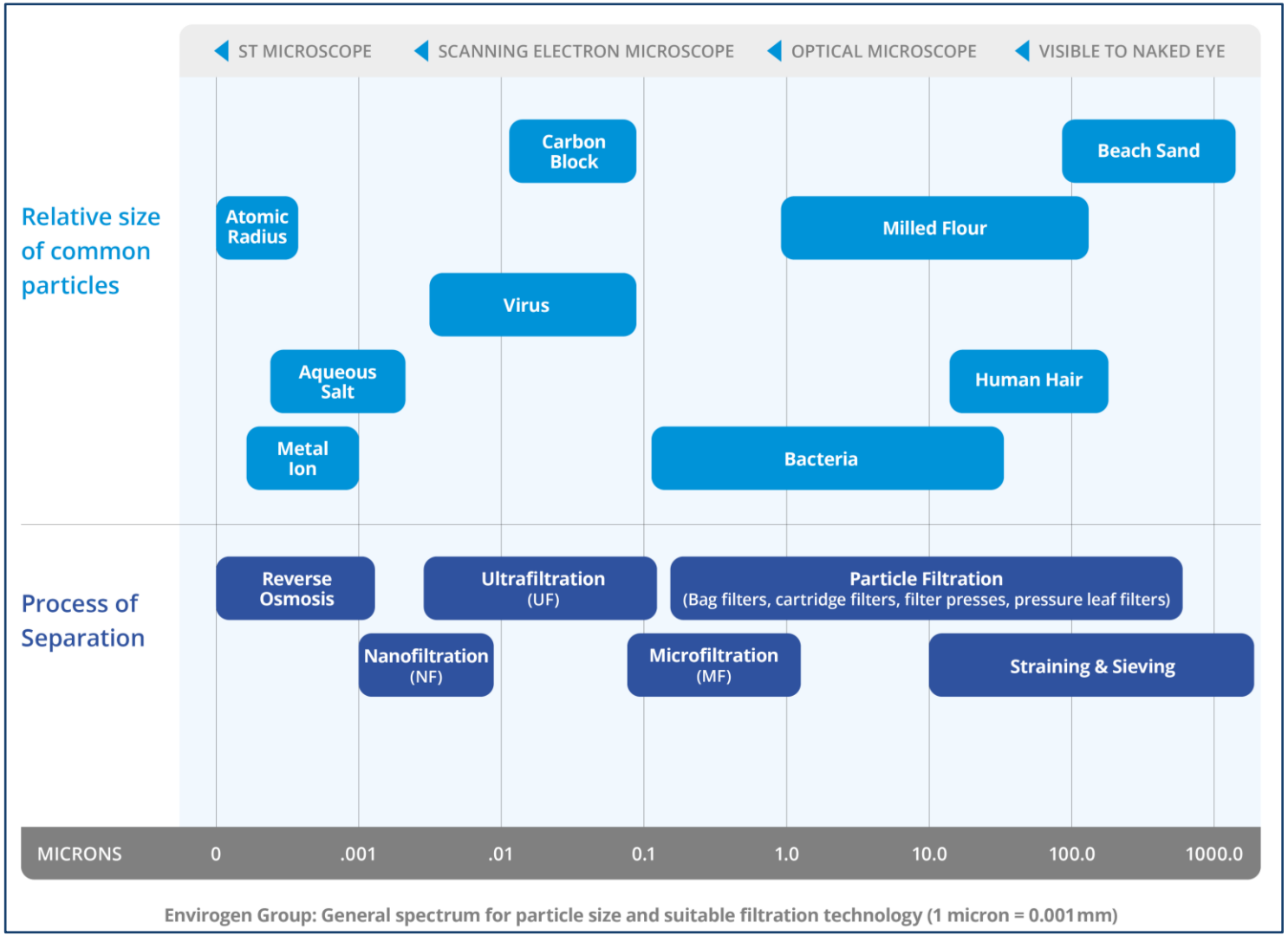
Multi-Stage Filtration
Filter Micron Size Meaning

Micron Rating

The smaller the micron the more contaminants are targeted to be removed

Impact to Water Quality

- Different filters target different contaminants
- Contaminates removed depends on the absolute or mean micron size ratings
- Can affect flow rate



Envirogen Group: General spectrum for particle size and suitable filtration technology (1 micron = 0.001 mm)

Multi-Stage Filtration
Micron - Size Selection

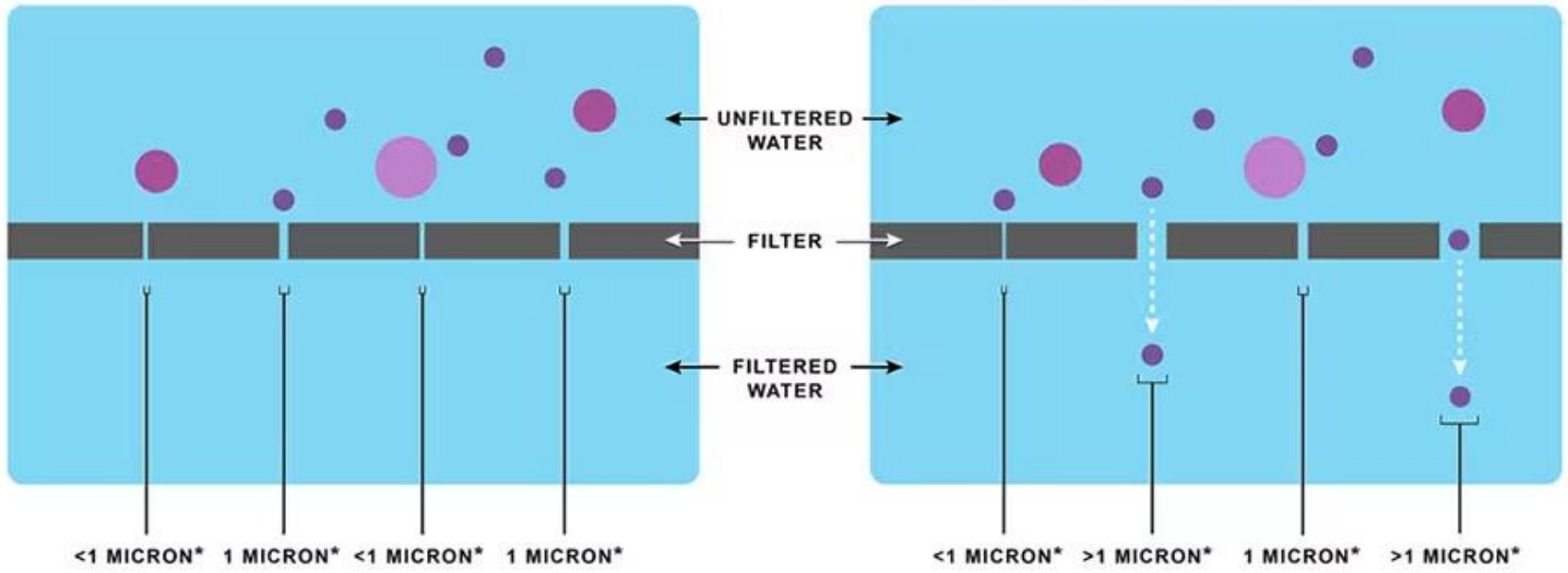
Pore size is the size of the tiny holes in a filter, that let in water

ABSOLUTE PORE SIZE

MEAN PORE SIZE

Some pores are 1 micron and some are smaller

Filters can improve both taste and safety of water. Test your water for pollutant to select the right filter for your system



Filters are usually 0.5-50 microns - the smaller the size the more contaminants removed

A micron is a very small unit of length. The average strand of human hair is 100 microns wide

A filter with an absolute pore size of 1 micron will catch a 1 –micron sized germ, but a filter with a mean pore size of 1 micron may not

*This image is not to scale

Source: Research Gate-Pore sizes associated with different membranes

Image: About Choosing Home Water Filters | Drinking Water | CDC

Shopping for a Filter
Specifications

What are Your Needs

- What is your **household size** and use needs?
  - Does the **application type** match your setup?
- What **contaminants** do you want to filter?
- Does it fit in **available space** and match your **flow rate**?
- Initial **cost and replacement** availability and schedule?
- Does it offer **additional benefits** that you want?

Product Details | Specifications | Questions & Answers | Customer Reviews

Fitting size (in.)	1 in	**Product Depth (in.)**	8.5 in
Product Height (in.)	29 in	**Product Width (in.)**	24 in

Details

Application Type	Residential, Well Water	**Bacteria Reduction (%)**	0
Chlorine reduction (%)	97	**Color**	Black
Contaminants Filtered	Chlorine	**Copper Reduction (%)**	0
Features	No additional features	**Filtration Method**	Activated Carbon, CTO, Carbon Block, Coconut Shell Carbon, GAC, Polypropylene, Sediment
Fitting style	Quick connect	**Fluoride Reduction (%)**	0
House Hold Size	8+ people	**Includes**	Filter
Indoor/Outdoor	Indoor	**Iron Reduction (%)**	0
Lead reduction (%)	0	**Maximum feed water pressure (psi)**	80
Maximum feed water temperature (F)	100	**Maximum filtered water flow (gallons per min.)**	15
Minimum feed water pressure (psi)	40	**Minimum feed water temperature (F)**	40
Number of filters included	3	**Number of Stages**	3 Stage
Pack Size	1	**Product Weight (lb.)**	63 lb
Reduces	Chlorine	**Returnable**	90-Day

Image Source: Home Depot

Scenario
Interactive Discussion

- What part of cistern system? **Treatment**
- What kind of filtration method is used?
- Does this filtration remove bacteria?
- How many people does this service?

Pro Aqua ELITE Whole House Water Filter – Available from Home Depot

Details

Application Type	Commercial, RV, Residential, Well Water	**Bacteria Reduction (%)**	0
Chlorine reduction (%)	99	**Color**	Black
Contaminants Filtered	Lead, Chlorine, Copper, Iron	**Copper Reduction (%)**	98
Features	No additional features	**Filtration Method**	Activated Carbon, CTO, Carbon Block, Coconut Shell Carbon, GAC, Ion Exchange, KDF, Polypropylene, Sand, Sediment
Fitting style	Threaded	**Fluoride Reduction (%)**	0
House Hold Size	3-4 people	**Includes**	Filter, Hardware, Installation kit
Indoor/Outdoor	Indoor	**Iron Reduction (%)**	98
Lead reduction (%)	98	**Maximum feed water pressure (psi)**	90
Maximum feed water temperature (F)	100	**Maximum filtered water flow (gallons per min.)**	15
Minimum feed water pressure (psi)	40	**Minimum feed water temperature (F)**	40
Number of filters included	3	**Number of Stages**	3 Stage
Pack Size	1	**Product Weight (lb.)**	50 lb
Reduces	Chlorine, Copper, Iron, Lead	**Returnable**	90-Day

Treatment Comparisons: Pre-filters

Types	Spin-down Sediment	Sediment Trap/Filter	Activated Carbon
Description	Clear cartridge that traps sediment in filter mesh	Different types available in a range of micron ratings. Uses filter media to trap sediment	Loose carbon granules Commonly used in whole house systems
Cost	*Does not include installation cost*		
Upfront	$24 to $230*	$50 to $125*	$25 to $100
Maintenance	$8 to $50* for mesh or filter replacement	$6 to $65* for cartridge replacement	$6 to $10 for cartridge replacement
Maintenance	Flush weekly; Replace mesh: 12 to 24 months	Replace every 3 to 24 months	Every 6 to 12 months
Consideration	The best filter for you depends on water use, flow rate, and sediment amount Some are specifically designed for well, municipal and/or rainwater		Often requires prefiltration to remove particles that can clog the filter Must be connected to a cold-water line Does **NOT** remove bacteria or viruses
	Best for large particles like sand & rust chunks	Holds more sediment	
Benefits	Low replacement need & easy to flush	Commonly available & easy to install Can remove fine particles like Sahara Sands	Removes a large variety of contaminants

* Amazon

Carbon Filter Options
The Wide Range Filter

- **Effectively removes** a select range of contaminants like chlorine, DBP, and VOCs
- **Does NOT** remove heavy metals
- **Improves** the taste and odor of water
- Does not use chemicals or require electricity
- Must be used with **cold water**

Granular Activated Carbon (GAC)
- Most common
- Allows for higher water pressure. Good for gravity fed systems
- Does NOT remove heavy metals

Activated Carbon Block
- Compressed carbon fiber powder
- Small pore size removes more impurity than GAC

Catalytic Carbon
- Most expensive
- Can in be in block, cartridge or granules form
- Removes the most contaminants

Source: Types of Whole House Water Filters (waterfilterguru.com)

Treatment Comparisons: 3-Stage Filter

Systems	Tank-Based	Cartridge-Based
Description	Uses 1 or more tanks filled with filtration media	Usually has 3 filter cartridges Prefilter, carbon and a polisher (cation and/or anion resin)
Cost	*Does not include installation cost*	
Upfront	$850 to $5,400	$170 to $580
Maintenance	$300 to $800	$20 to $180
Maintenance	Every 3 to 5 years	Every 3 to 12 months
Household Size	Best for households greater than 4	For smaller households
Considerations	More space needed to install Tank units can target a range of pollutants	Can provide a wider range of filtration
Best for	Households that use lots of water	Small spaces like under the sink

Source: Types of Whole House Water Filters (waterfilterguru.com)

Treatment Comparison: UV Light

UV light is **NOT** a filter

Systems	Ultraviolet(UV) Light
Description	UV light kill harmful microorganisms in water Typically installed as a final stage or standalone
Cost	*Does not include installation cost*
Upfront	$350 to $1500. *Larger systems may require a plumber*
Maintenance	$25 to $140
Maintenance	Every 9-12 months the bulb needs to be replaced. Film can build-up on lamp
Household Size	For smaller households
Considerations	Requires constant electricity May require pre-filtration Low maintenance No chemicals
Best for	Use at end of other treatment (finisher)

Source: Types of Whole House Water Filters (waterfilterguru.com)

Typical UV Installation

Shutoff valves seen here are a great example of how to **isolate** the system without losing stored water

This approach can be used for any of the treatment types

Source: DPNR 2024

Treatment Comparison: Reverse Osmosis

Systems	Reverse Osmosis (RO)
Description	Water purification using a semi-permeable membrane to separate molecules by applying pressure Installed as a point of use or whole house
Cost	*Does not include installation cost*
Upfront	Smaller under-sink units: $150 to $600 Whole-house systems: $1,000 to $4,800
Maintenance	Approximately 35-55% of regular cost for replacements
Maintenance	Every 1 to 2 years
Household Size	Industrial and high purity needs
Considerations	Uses more water As part of the backwash process, RO discards wastewater Frequent filter maintenance
Best for	Removal of chemicals, metals and bacteria

Source: Types of Whole House Water Filters (waterfilterguru.com)

Water Treatment Systems
Additional Considerations

Filter Replacement Indicators:
- If used in combination with chlorine, sample at the faucet for presence of chlorine. This means that needs to replaced filters
- Place a flow meter before the filtration unit to log volume used
- Note seasonal variations as filters may need to be replaced at different intervals because of Sahara sands or pollen

Associated Maintenance:
- Filters can build up biofilm that could contain bacteria or viruses. They should be monitored for biofilm and consider distribution system disinfection
- Clogs from slime and bacterial buildup increases replacement frequency

Considerations:
- A single stage filtration system will not remove all contaminants. The broadest range single filter is an activated carbon based
- Supply costs and accessibility

Source: Types of Whole House Water Filters (waterfilterguru.com)
Image: ecoteam.ca

Boiling For Drinking Water
Treatment - Short-term

Water must boil for 1-3 minutes to kill bacteria

How To

Before boiling- allow water to sit to settle out large particles

Gently pour out water leaving the particles behind **or** filter out the particles to remove as many solids as possible

Can be used as a last step in treatment after chlorine dosing to reduce volatile **disinfectant byproduct (DBP)**

Caution – it's HOT!

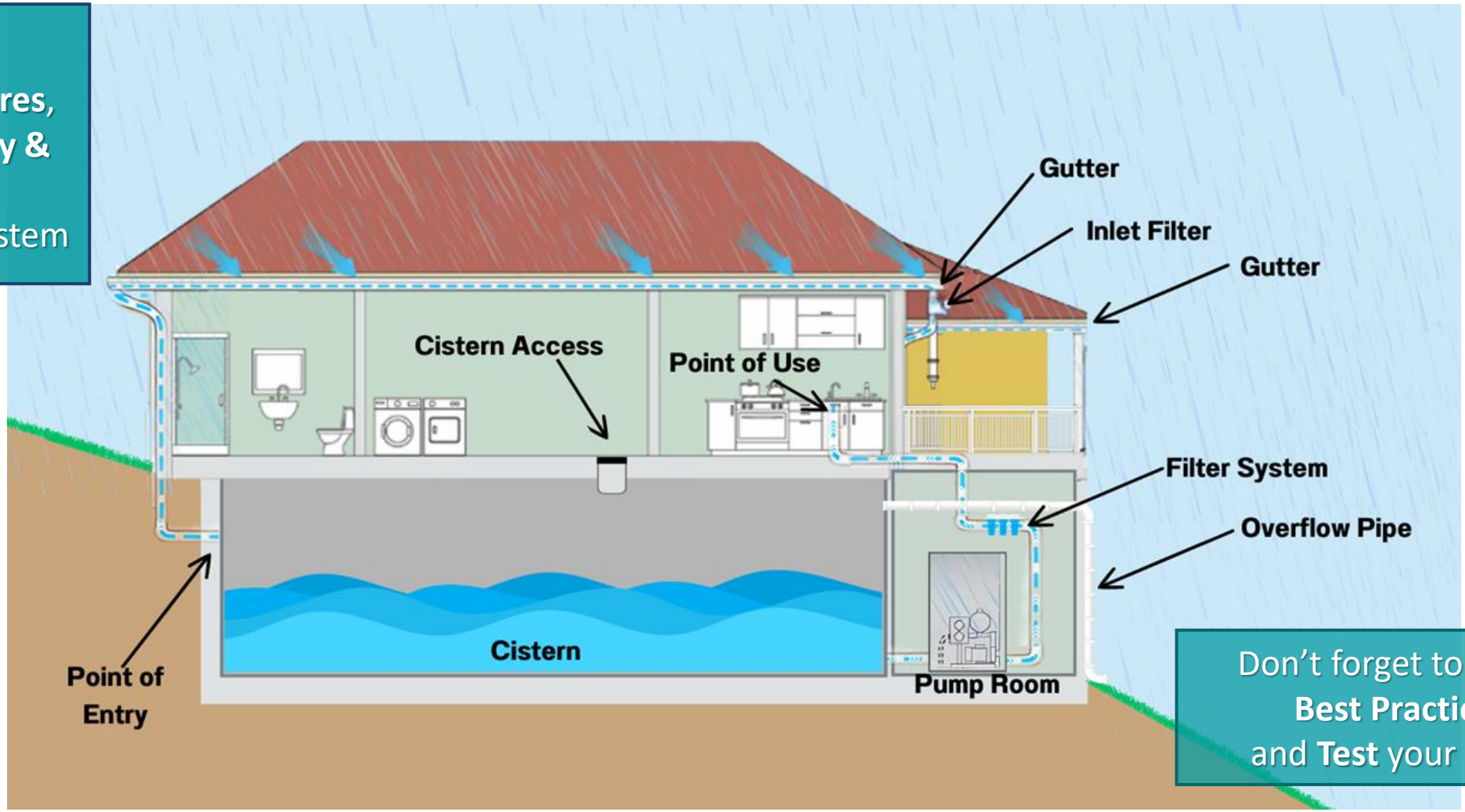
Limitations

- Fuel costs and safety may be limiting factors. Consider boiling for **emergencies only**
- Boiling does **NOT** remove metals and some types of chemical contamination

Source: USVI-YourHealthandCisterns_-FinalTechGuide_Feb-22.pdf

Clean, Protect, and Maintain
Routine Maintenance and Deep Cleaning

We've learned to-
- **Use design features**,
- **calculate capacity & volume**, and
- **treat** a cistern system



Don't forget to follow **Best Practices** and **Test** your water

Image: *Avanti*

Protect - STAR
Routine Maintenance - Pipes and Point of Use

★	Water Consideration	Control Measure	Recommendations
S	**S**ediment and biofilm	Flushing, cleaning, and maintenance	• Clean UV lights of film • Clean and maintain water system parts such as water heaters, mixing valves, aerators, showerheads, hoses, and filters
T	**T**emperature	Control temperature limits	• Keep circulating hot water above 120°F • Keep circulating cold water below range of 77 to 113°F
A	Water **A**ge	Flushing	• When water line has not been used in more than a few days
R	Disinfectant **R**esidual*	Keep it between 0.2 to 2 mg/L	• Chlorine: Test free chlorine often and maintain minimum concentration of 0.2 mg/L

* Disinfectant residual recommendations apply to disinfectant delivered by the municipal water authority. Supplemental disinfection system control limits are not prescribed here and must be dictated by the water treatment professional and water management program.

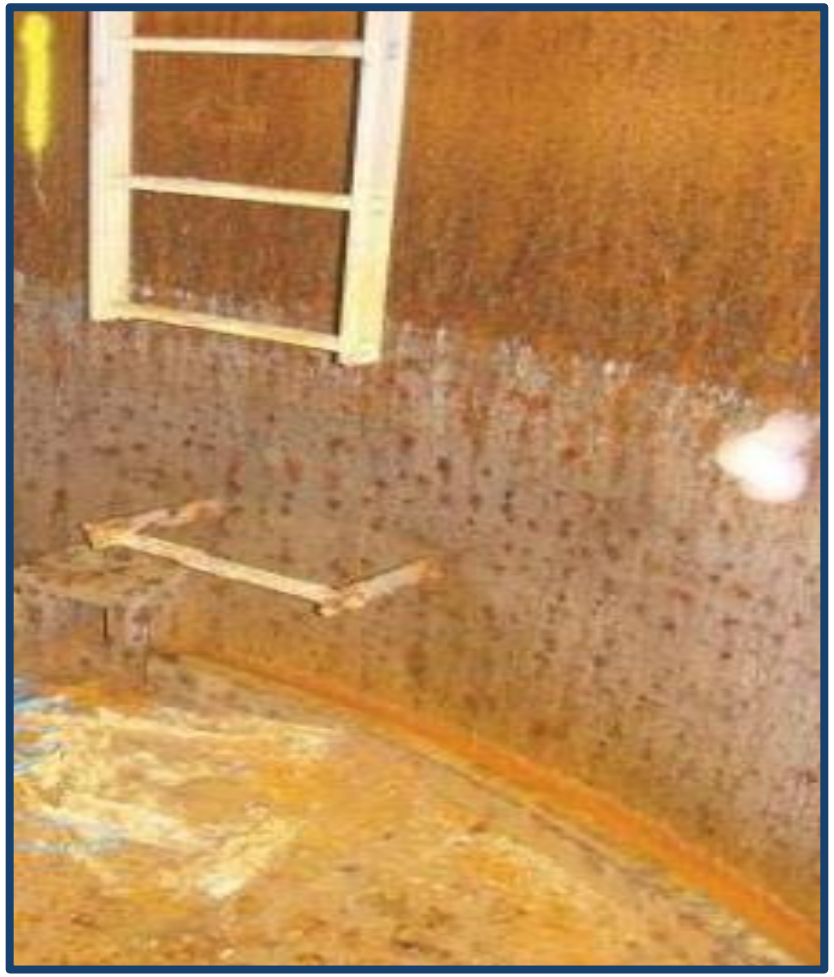
Source: Toolkit for Controlling Legionella in Common Sources of Exposure (Legionella Control Toolkit) (cdc.gov

Routine Cleaning
Yearly or As Needed

Customize intense cleaning needs based on system characteristics, water use, water quality, and location

Examples:

- ❑ If you have a "spin-down" sediment filter:
  - ❑ Flush cartridge **daily or weekly**
  - ❑ Clean internal mesh on your own or by a professional **yearly or as-needed**
- ❑ Remove mineral, scum, and scale build-up from the inside of the cistern that comes from intense use and evaporation **yearly, or as-needed**



Source: DPNR 2024

Deep Clean Maintenance

DO NOT use your cistern water during disinfection!

Sanitize every 3 to 5 Years Or After Extreme Storm Events

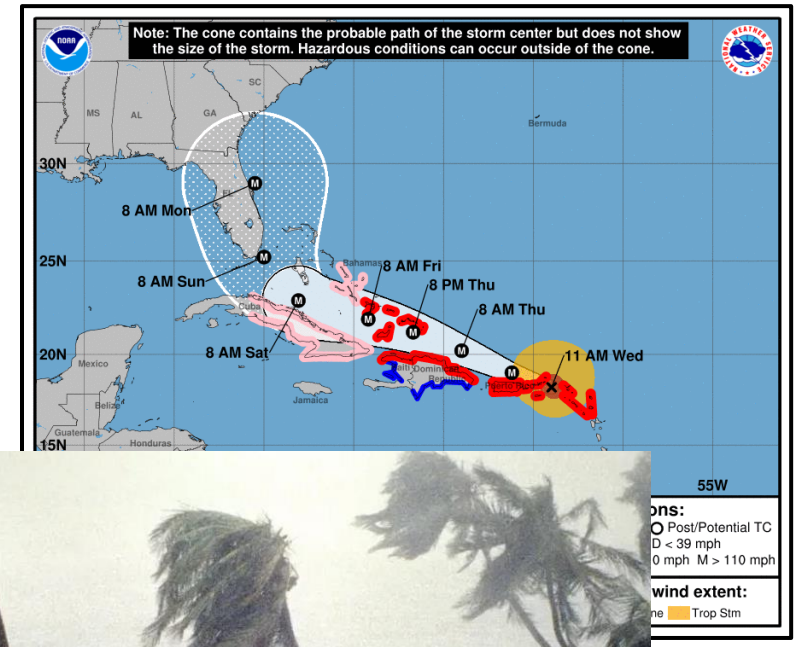
SCRUB, RINSE & FLUSH individual features and cistern Often…
To minimize the need to sanitize

Be kind to your wastewater treatment system…
stopper sinks and tubs to let the water sit in a sink or tub before letting it drain

- ❑ Set aside enough clean water to last 24 hours for household use prior to proceeding (store separately in sterile containers)
- ❑ Add bleach to your system using the cistern access
- ❑ Run each faucet continually until you smell chlorine
- ❑ Turn off all faucets and let the system sit for at least **12 hours**
- ❑ Run water until chlorine smell is gone or test before using
- ❑ If strong odor persists, pour some off and boil off residual to use for drinking until odor is gone

Protect and Maintain
Extreme Weather

- ❑ Stay current on events that could affect your drinking water or catchment area
- ❑ Have a **PLAN** to be able to **isolate** your cistern before the event arrives
- ❑ **Protect** the parts of your system that could be damaged by high winds
- ❑ **Clean** the catchment area after the event **before** collecting water from your roof again
- ❑ **Maintain replacement** collection and distribution **parts** and water treatment filters, and UV bulbs to address damages. External features, like gutters, are often damaged
- ❑ Have power backups, when possible, for the water pump and UV light to maintain access to clean, safe water
- ❑ If manually removing water from your cistern, be sure that all buckets and bailers are clean



Images: NOAA and V.I. Free Press

Checklist and Record

Develop a **CISTERN PLAN** and **SCHEDULE** that is site specific

Write It Down

Track maintenance, **record** and **save** water quality results, and note trends. **Trends** help **identify** seasonal occurrences and treatment approach

Cistern O&M Plan with Checklist

Address_____ Emergency contact_____

Cistern storage (capacity): Depth (ft) _____ Width (ft)_____ Length (ft)_____

Maximum water volume before overflow: _____

System treatment (circle): pre-filter chlorination carbon stage filter(s) UV

Roof & Gutters (downspout, shutoff, diverter)	Cistern	Inside Pipes & Treatment
Inspect collection system for blockages and buildup of sediment, cracks, rust, broken seals	Inspect inside and outside (if visible) & remove debris	If unused for more than a few days- flush the lines for 5-10 minutes
Inspect intakes & overflow screens	Make minor repairs, as needed	Rotate filters following manufacturer's instructions
Clean: remove debris, dust, droppings	Measure water volume before rain	Inspect UV filter regularly and wipe film residue
Keep downspouts clear	Measure volume after rain	Change out carbon or resin at recommended intervals based on water use
Remove critters & habitat	Treat tank with chlorine	Keep area around treatment clean and dry
Repair damage	Measure residual Chlorine (0.2-2.0 mg/L) is goal	Have system deep cleaned & serviced, as needed
	Have system professionally cleaned and repaired as needed	

Table: *Avanti*

Example
Interactive Discussion

Are there any issues?

Poorly maintained cistern. Roots and scum build-up

Describe the best management practices

Inspecting, cleaning and removing growth regularly are key for a secure water storage

Source: DPNR 2024

Water Type Matters In Analysis
What To Use When

Types	Description	Use When	NOT to Use
Distilled	Impurities removed through boiling into a vapor and condensed back into a liquid	• To clean meters after sample collection or calibration • To clean meters before storage	• Before sampling • For drinking water
Purified	Impurities removed by mechanical filtration or process		
Cistern/Tap	May contain impurities and minerals	• Consumption • Sample collection	To clean meters
Deionized / Demineralized	Ions have been removed through a chemical process	Topping off lead-acid batteries	To clean meters

BACTERIAL MONITORING OPTIONS
Water Quality Monitoring

Annual Testing Recommendation

Colilert Test

- Evaluates for Total Coliform by color
  - Pass / Fail type of test
- Evaluates for Fecal Coliform (E. Coli) by glow
  - Pass / Fail type of test

SimPlate Test / Response

- Uses Most Probable Number (MPN) estimate
- Indicates the presence of bacteria of all kinds including enterococcus
- Not necessarily indicative of bad bacteria
- Action level is 500 MPN
  - Dilution sample / actual count with multiplier

Source: IDEXX

How To Test For Chlorine In Water

Chlorine Test Strips

These affordable strips are dipped in water and change color based on the chlorine level. They can Detect free, combined, or total chlorine.

Test strips should read under 0.04 mg/L. Use test strip results to check if your water filter needs replacing

Use your results to decide if any chlorine removal is necessary or if you need to add more

Laboratory Testing

Labs send chlorine test strips for home testing due to chlorine's volatility. Consider lab testing if you want professional testing for multiple contaminants.

Source: How to Test for Chlorine in Water | waterfilterguru.com

Chlorine Color Wheel Testing
Materials and Video

- Color Wheel Kit
- Squeeze bottle - distilled water for cleaning
- Kem wipes
- Gloves - nitrile
- Paper towels
- Clean sample container
- DPD reagents

Hach Total Chlorine Color Disc Test Kit

Hach Total Chlorine Color Disc Test Kit (youtube.com)

PREPARATION FOR ACTIVITY
DR300 VIDEO

DR300 Low Range.mp4 on Vimeo

OPERATING THE DR300
Sampling Preparation

Materials

DR300

Squeeze bottle - distilled water for cleaning

Water sample

DPD Free Chlorine Reagent Powder Pillows

DPD Chlorine Standards Kit

Gloves - Nitrile

Paper towels

AAA - Batteries

Protect and Maintain
Meter Care

Inspect and Prepare	Special Notes
• Inspect the case and kit to make sure no external damage has happened since last use • Make sure measuring probe and materials are in good condition • Use buffers or solutions to calibrate before sampling	• With each use • Follow manufacturers instruction

Sample Technique and Store Clean	Special Notes
• Rinse the end of the probe with the **sample water** prior to sampling for accurate measurements • Clean the meter after each use with **distilled water** • Store meter in a safe place at room temperature. No high heat areas or direct sunlight	• With each use • Follow manufacturers instruction • Be sure to have distilled water on hand

Repair and Replace	Special Notes
• Be sure to have replacement parts and a repair plan • Check your supply of buffers and solutions. Be sure to reorder before you run out • Order replacement parts and buffers that are specific for the meter	Check supplies periodically to be sure they are not expired or damaged

Water Monitoring and Resources
Contamination and Water Quality

What to Monitor	Test Frequency
Bacteria	Annually or Interruption of treatment
Chlorine	Daily to weekly
DBP(Disinfectant Byproduct)	After treatment and annually
Metals	Initially, annually, or optional
pH	Daily to weekly

Costs for water sampling analysis at a laboratory and individual tests range from $30 - $200

Test water yourself and save $$$ - If in doubt hire a professional when you find contamination!

Laboratory Resources

Ocean Systems Laboratory

STT- 340-714-1911

STX- 340-718-3246

Environmental Quality Laboratories

PR- 787-288-6420

Cistern Suppliers
USVI - Where to Buy

This list is provided as a **courtesy** and is **NOT** an endorsement of suppliers for commercial or whole house systems

Contact information is subject to change without notice

Home Depot

1105 Barren Spot, Kingshill, St. Croix, VI 00850
- **340-719-1077**

1-2 Donoe Road 4000, St. Thomas, VI 00802
- **340-777-1077**

Poly Caribe Water Systems

6096 Estate Mariendahl, Charlotte Amalie, St. Thomas, VI
- **1-340-775-4660**

RainHarvest Systems

4475 Alicia Lane, Cumming, GA 30028
- **1-770-889-2533**

LifeSource Water Systems

11 E Colorado Blvd Suite 100, Pasadena, CA 91106
- **1-844-595-7562**

Clean Water Store

2806-A Soquel Ave, Santa Cruz, CA 95062
- **1-888-354-2219**

Ecolife Technologies, Inc.

1951 S Lynx Pl, Ontario, CA 91761
- **1-888-352-3558**

Cistern Cleaning Resources
Who to Call

Ways to Clean a Cistern-

Contractor or Do-It-Yourself

- **Robotic cleaners:** If you can limit drinking water exposure to hydraulic materials.
- **Empty:** perform every 3-5 years and schedule repairs at the same time.
  - Manual with brushes and shop vacuum.
- **Full or partially full:** as needed
  - Hyperchlorination: can be done while water is in system.
  - Manual: pool vacuum or shop vac

Cost of Cleaning-

- Ranges from $400-$1000
- Estimates per 2000-gal tank size*

Allstar Painting Service

8168 Crown Bay Marina, St. Thomas, VI 00802

- **340-626-5292**

Caribbean Pool Maintenance & Repairs, LLC

St. Thomas, VI 00801

- **340-626-3223**

Voss Pools

St. Croix & St. Thomas

- **340-625-0305**

Source: https://cleancistern.com/pricing/

*** Includes ferries**

Clean, Protect, and Maintain

Don't forget to test throughout the process

REVIEW: the goal is to design, install, and maintain a system that will minimize exposure to possible contaminants

CLEAN	**Clean your system initially, then often and thoroughly, so you are prepared to receive good clean water. This consistent care is key to a long system life**
PROTECT	**Minimize debris coming into the cistern with a shutoff. This protects already clean treated water from recontamination and minimizes wear and tear on the whole system**
MAINTAIN	**Keep up with treatments on stored water to keep it safe. Keep a separate emergency supply of clean, safe water. Ensure that your cistern is in good working order (no leaks, cracks, and treatments are operational). Perform needed repairs as quickly as possible**

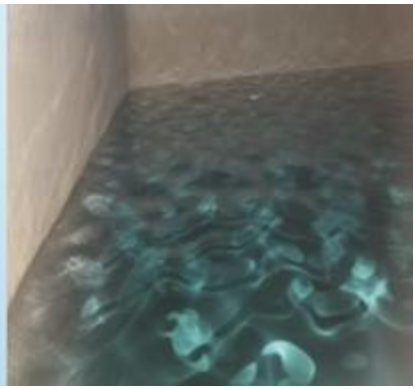
Source: Cleaning and Disinfecting Water Cisterns After Floods and Heavy Rains.

Additional Resources

1. NSF/ANSI Certifications: NSF/ANSI Certifications Explained – SimpleLab Tap Score
2. Flushing Pipes Video: Disinfecting Your Household Plumbing
3. First Flush Diverter Informational Video: https://youtu.be/L6SavoH8q-M First Flush Water Diverters
4. Gutter Cleaning Video: How to Clean Gutters & Install Gutter Guards
5. Washing Techniques Video: Soft Wash Roof Cleaning. How to wash your roof Shingles safely [Best Roof Wash Method] put water on landscaping before cleaning your roof with bleach





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