Green Trends 2013

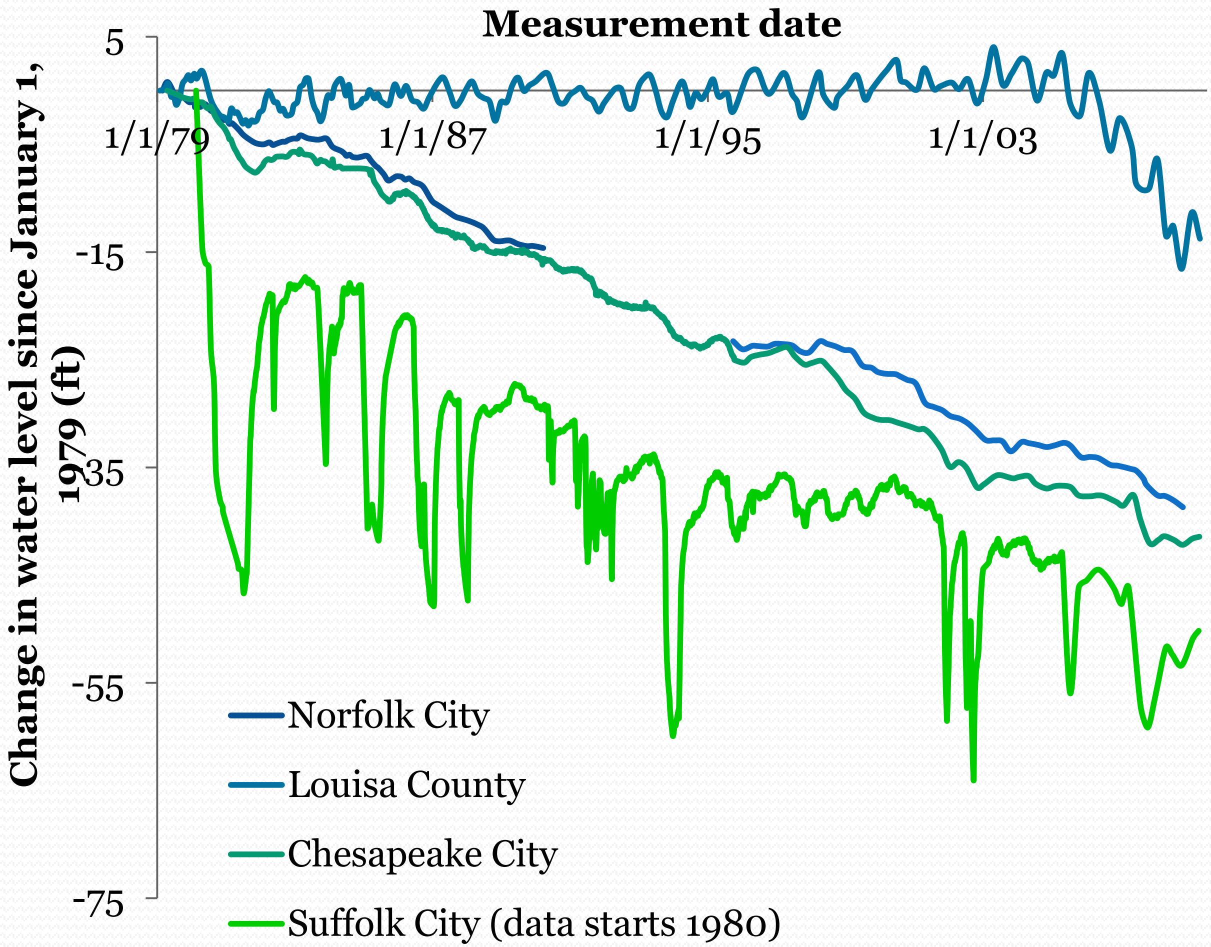
Rainwater harvesting

System design

Benjamin Sojka

“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 well all show declining water levels. Data are courtesy of the USGS and available through (http://www.epa.gov/WaterSense/pubs/supply.htm).

Possible uses of rainwater

Outdoor uses

Indoor non-potable uses

- Toilet flushing
- Laundry
- Cooling

Indoor potable uses

- Drinking
- Bathing
- Cooking, etc.

System design:
From roof to use

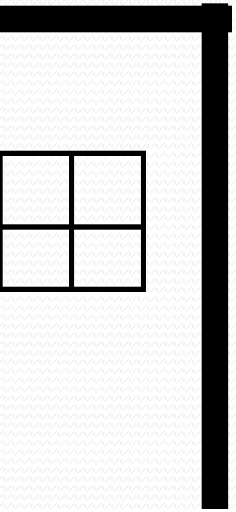
No matter how big the job is, the concepts are the same

You just have to choose the right tools

Water treatment philosophy

It is better to protect the quality of the water from the beginning, than spend a lot of money, energy, and possibly chemicals on cleaning it up later.

Rooftop



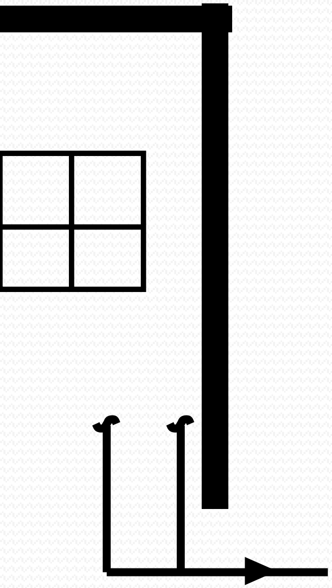
- Why only roofs?

- Does roof material matter?

Roof recommendations

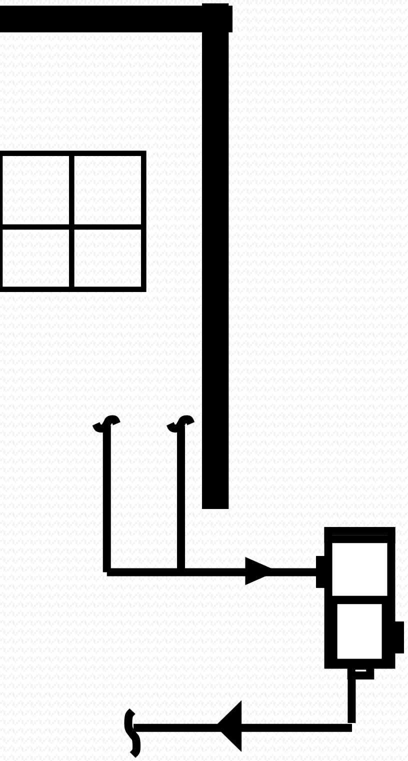
- For potable systems --- NSF certified roofing materials, or water quality testing before design
- For non-potable indoor systems – copper can cause staining of porcelain fixtures, green roofs should be used with caution
- For outdoor use – be cautious of metals if used for swimming or edible gardens

Conveyance from roof to cistern



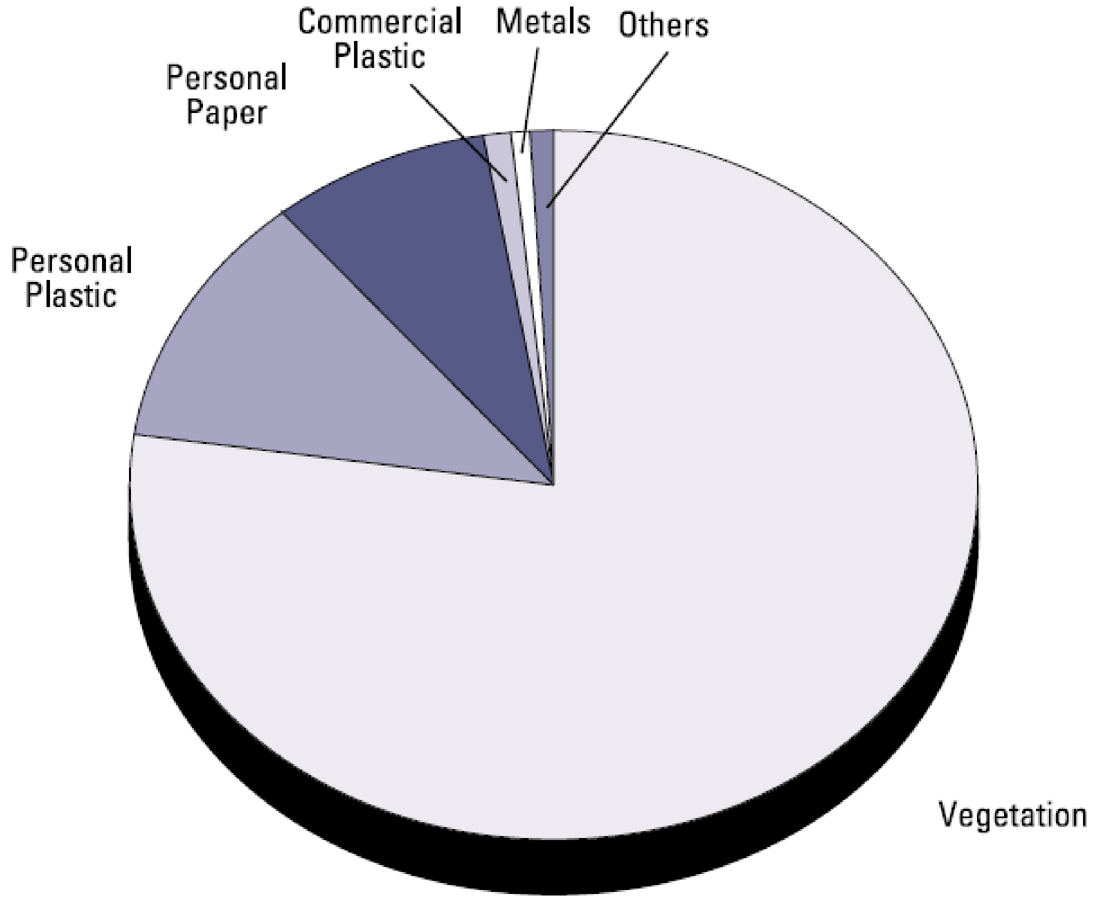
- Should be separate from site drainage
- Gutters, downspouts and roof drains should be sized for the design storm
- Consider tank location, roof slope and shape, and downspout/roof drain locations

Pre-tank filtration



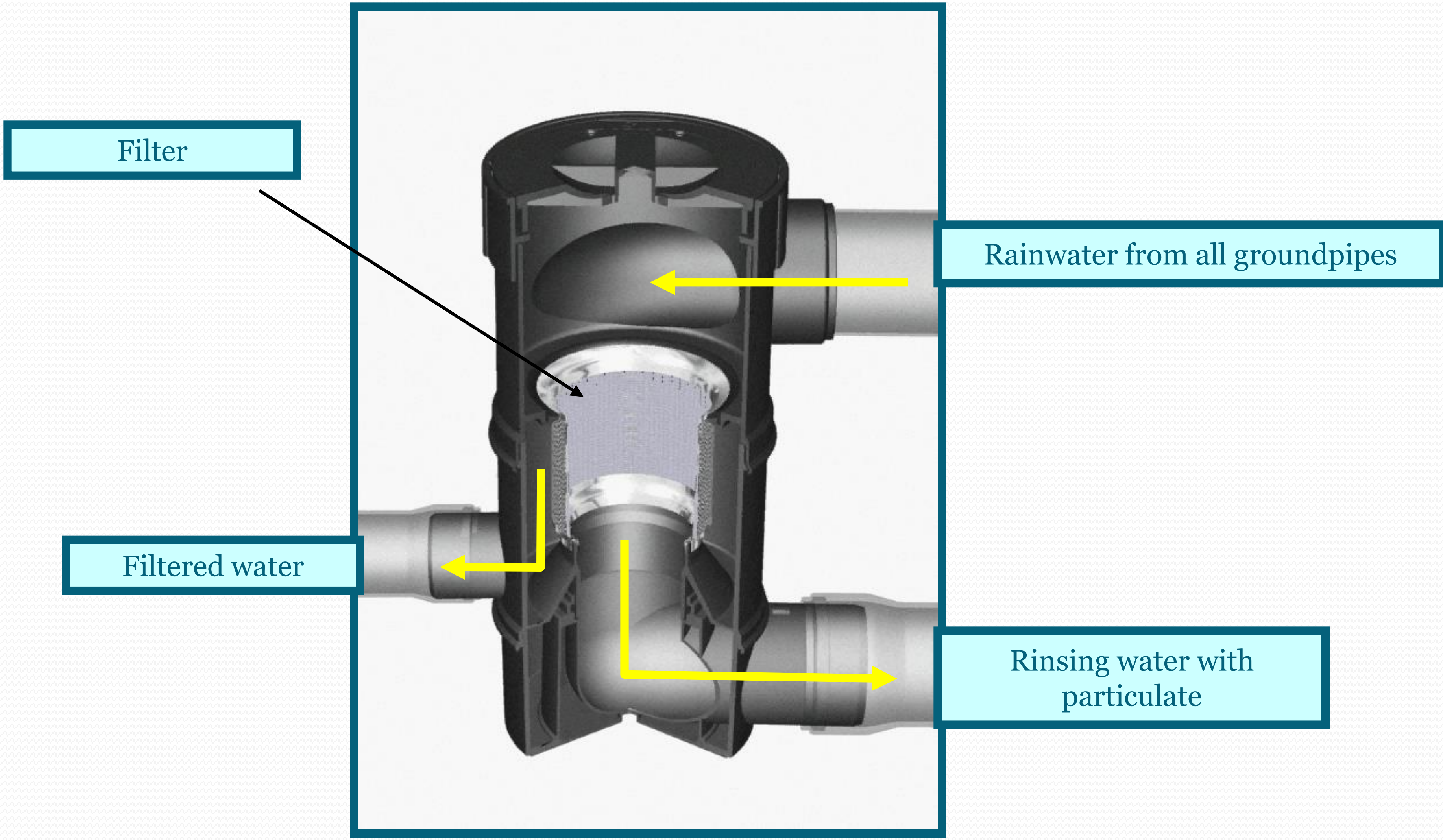
- Divert the “first flush” away from the tank
- Prevent debris from entering the tank
- This is a frequently ignored, but VERY important step

Pre-tank filtration



Composition of gross pollutants by mass

Sample pre-tank filter
section and function view



Different size filters for different roof areas

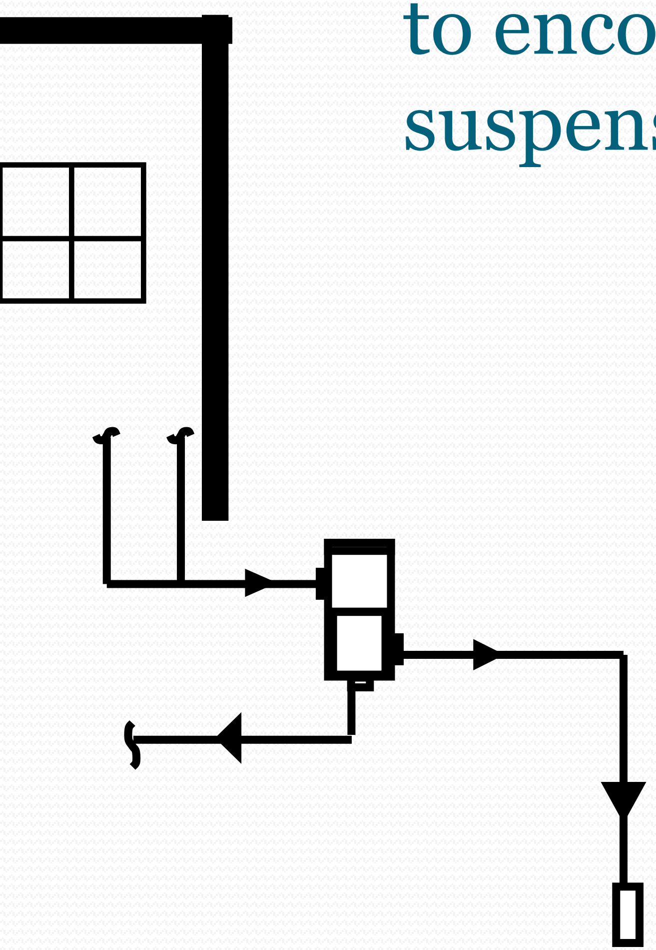
1,000 sq ft

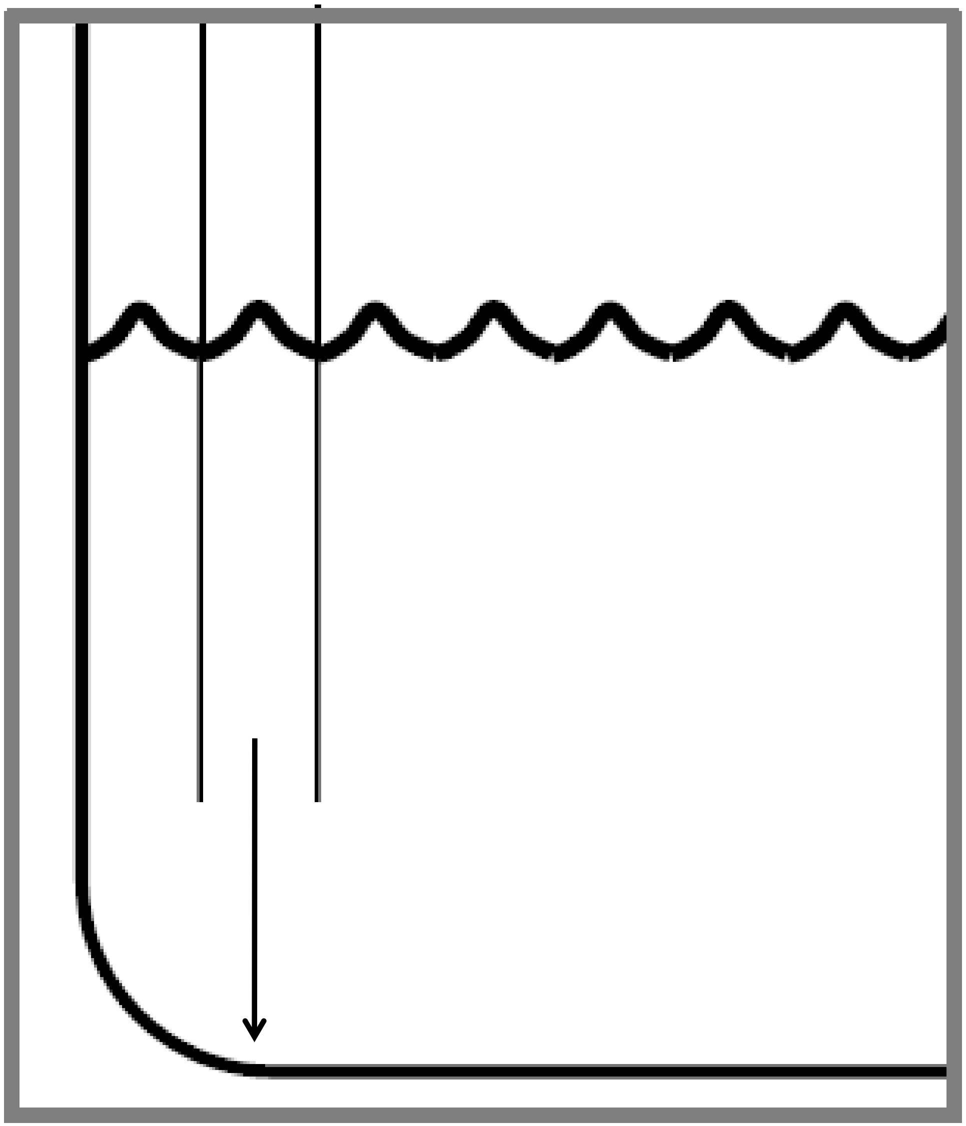
5,500 sq ft

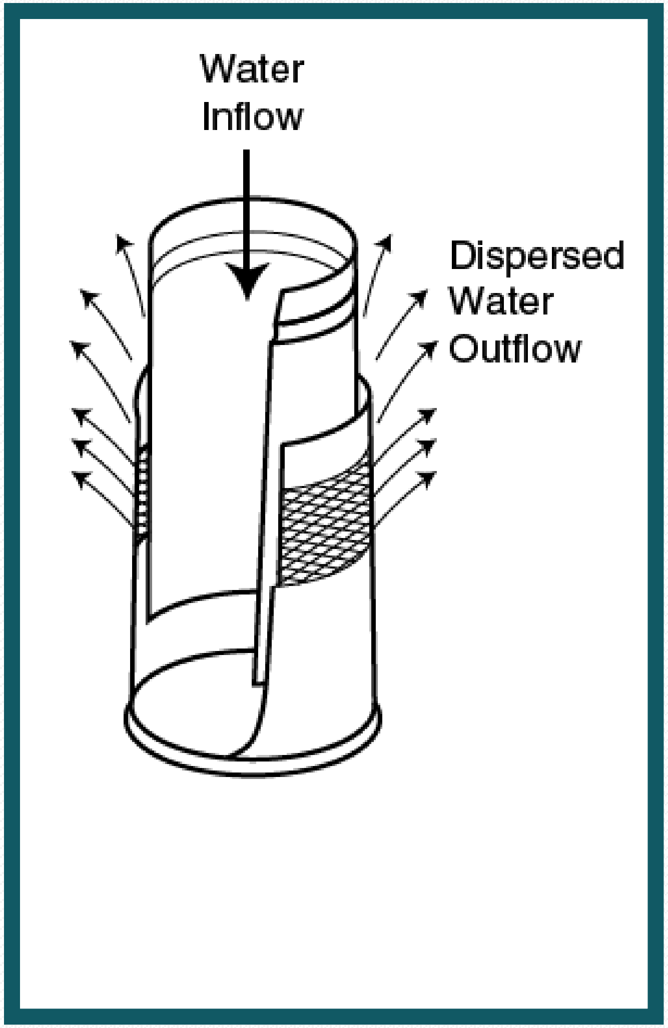
32,292 sq ft

Inlet to tank

Inlet to the tank should be designed to encourage settling and decrease re-suspension

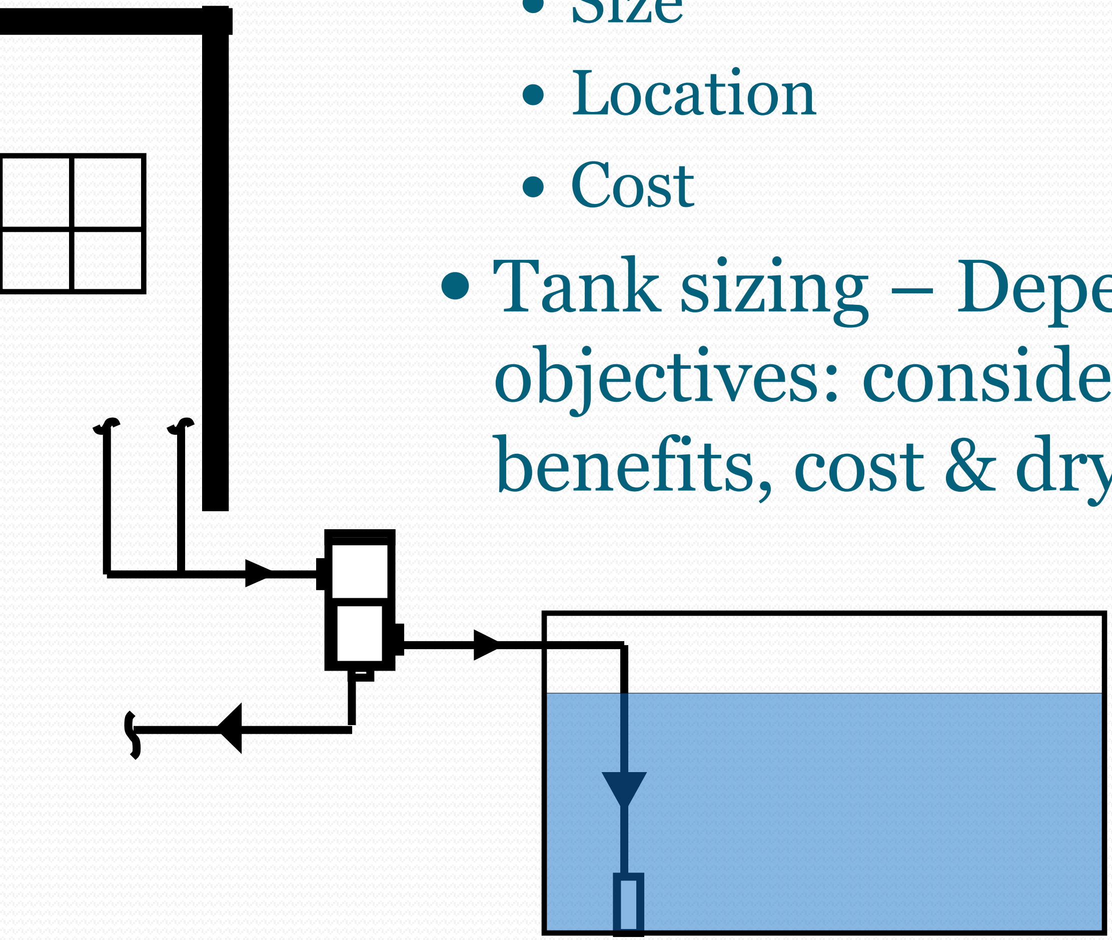





Water
Inflow
Dispersed
Water
Outflow

Cistern

- Choosing the type of tank
  - Size
  - Location
  - Cost
- Tank sizing – Depends on design objectives: consider supply, stormwater benefits, cost & dry frequency



Tank Materials

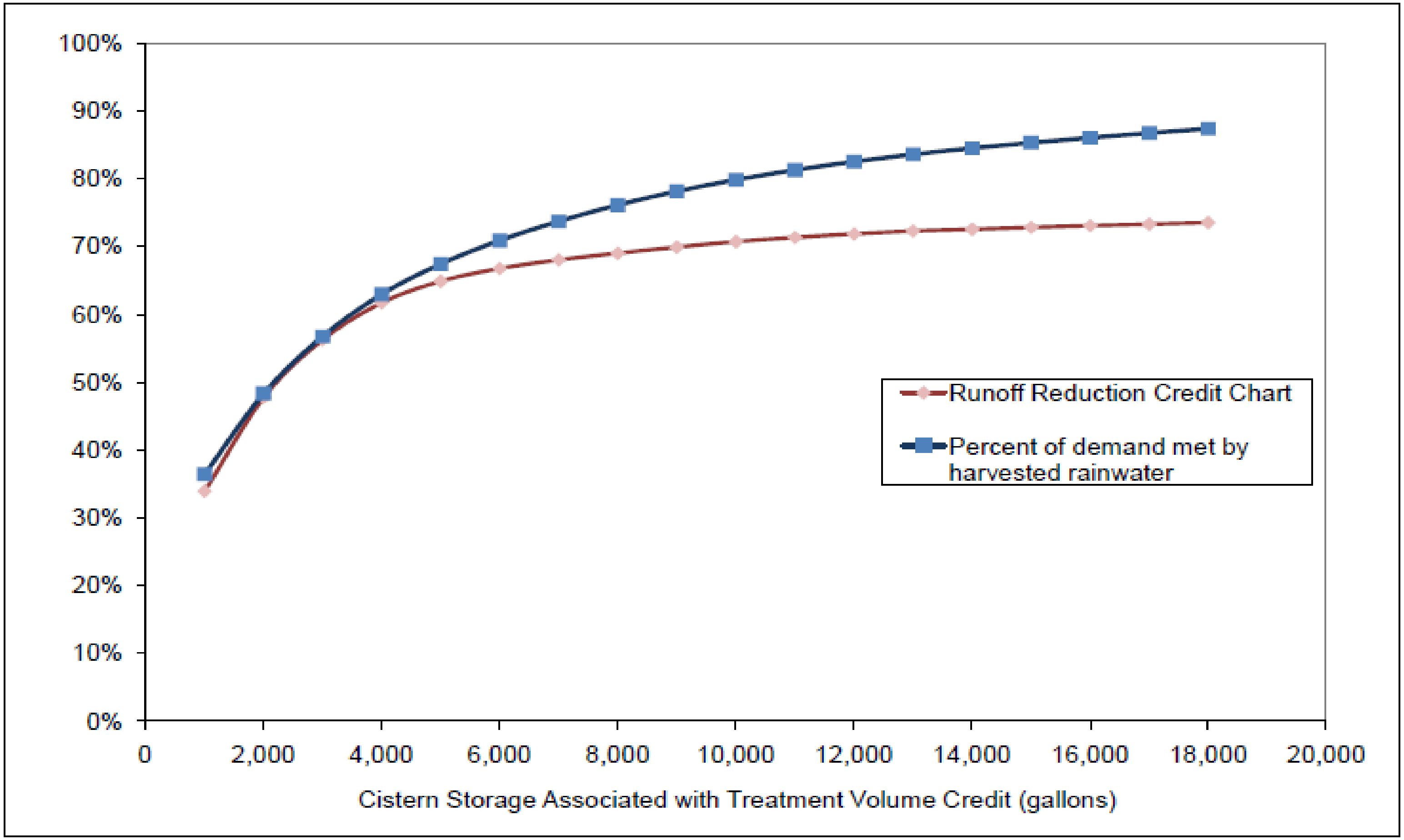
Fiberglass

Metal

Modular

Polyethylene

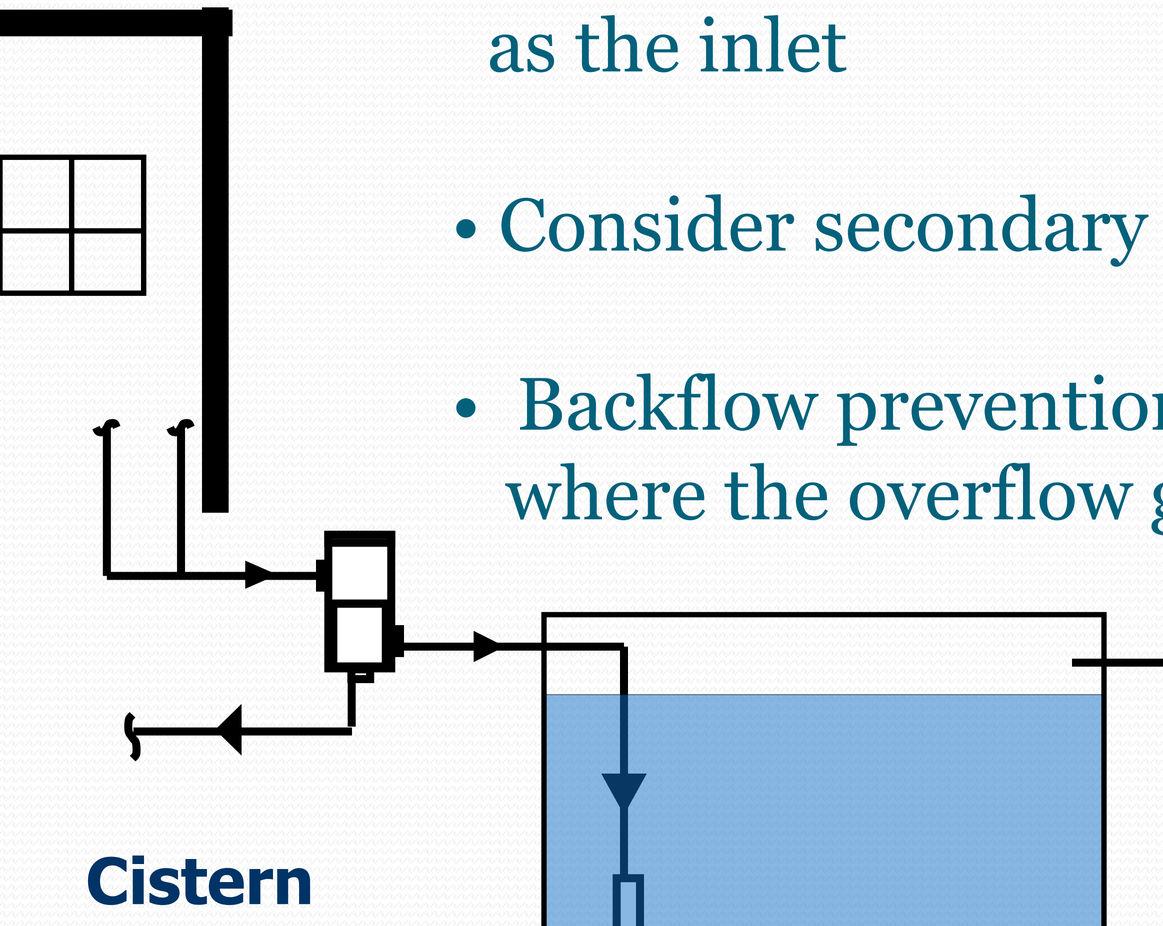
Tank sizing



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
Cistern Storage Associated with Treatment Volume Credit (gallons)
Runoff Reduction Credit Chart
Percent of demand met by harvested rainwater

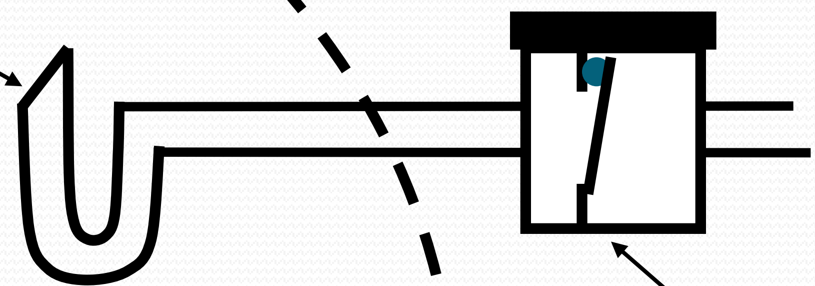
Overflow

- Must be sized to handle same flow rate as the inlet
- Consider secondary BMP treatment
- Backflow prevention is dependent on where the overflow goes

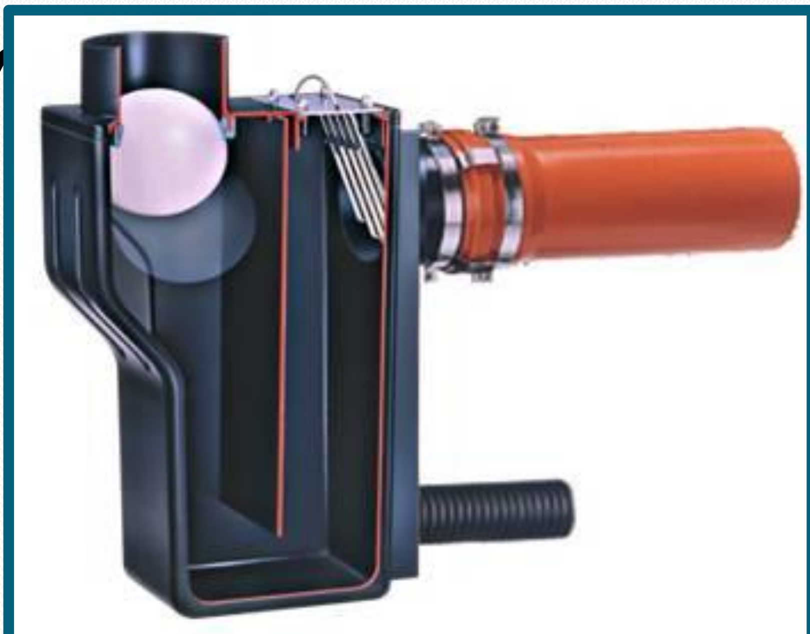


12.25 to 22.5 degree angle cut in pipe provides skimming of the water

Storage tank



Flapper valve allows water to overflow, but prevents entry into the tank



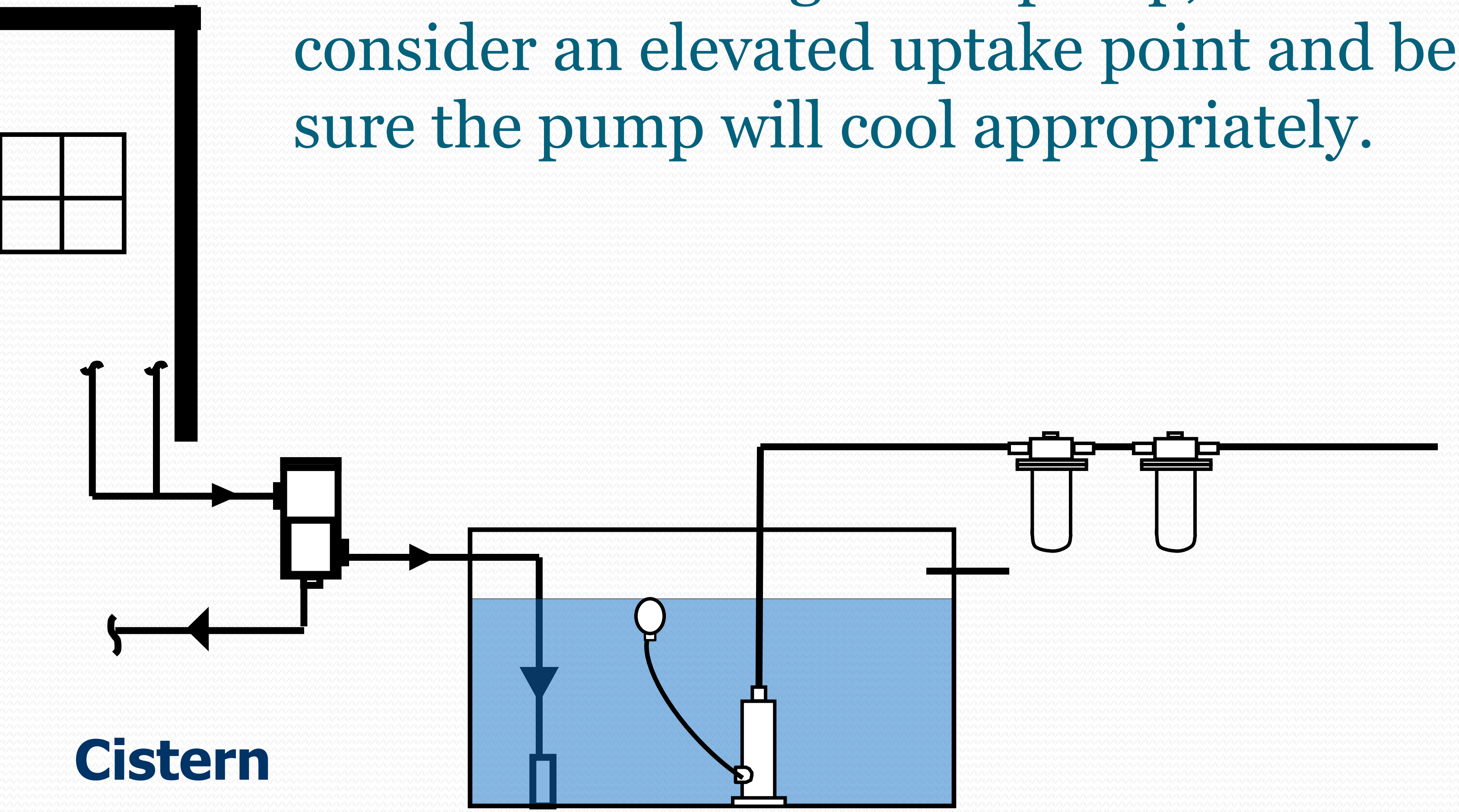
Secondary BMP

- Grass Filter Strip
- Grass Channel
- Biorentention (micro, small)
- Dry Swale
- Infiltration

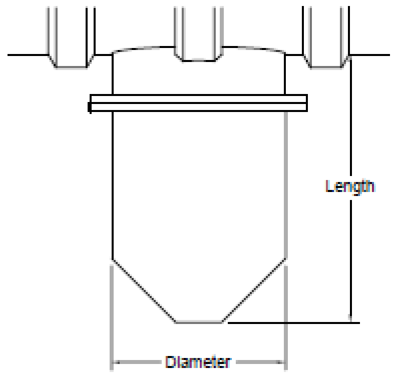
BMP Clearinghouse http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Pump

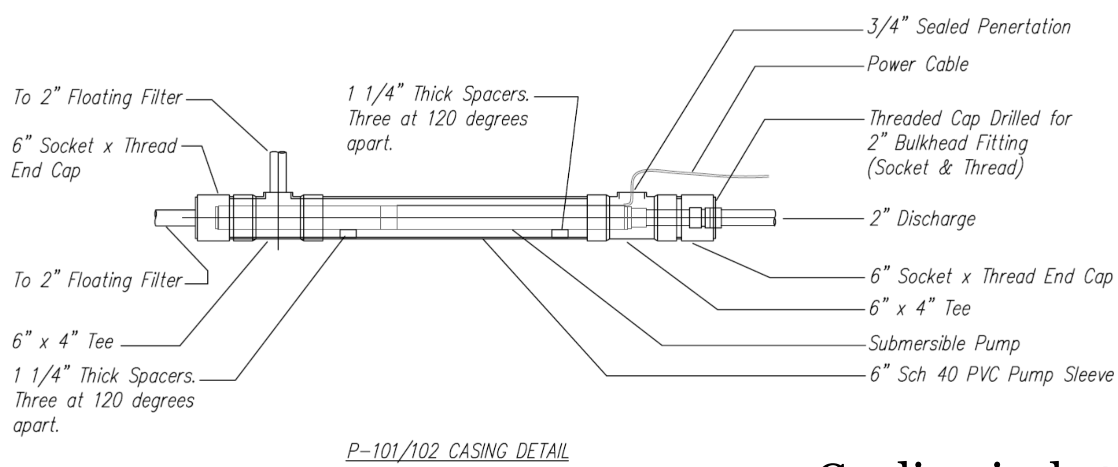
The same as sizing a well pump, but consider an elevated uptake point and be sure the pump will cool appropriately.



Pump tricks



Bottom sump



Cooling jacket

VFD

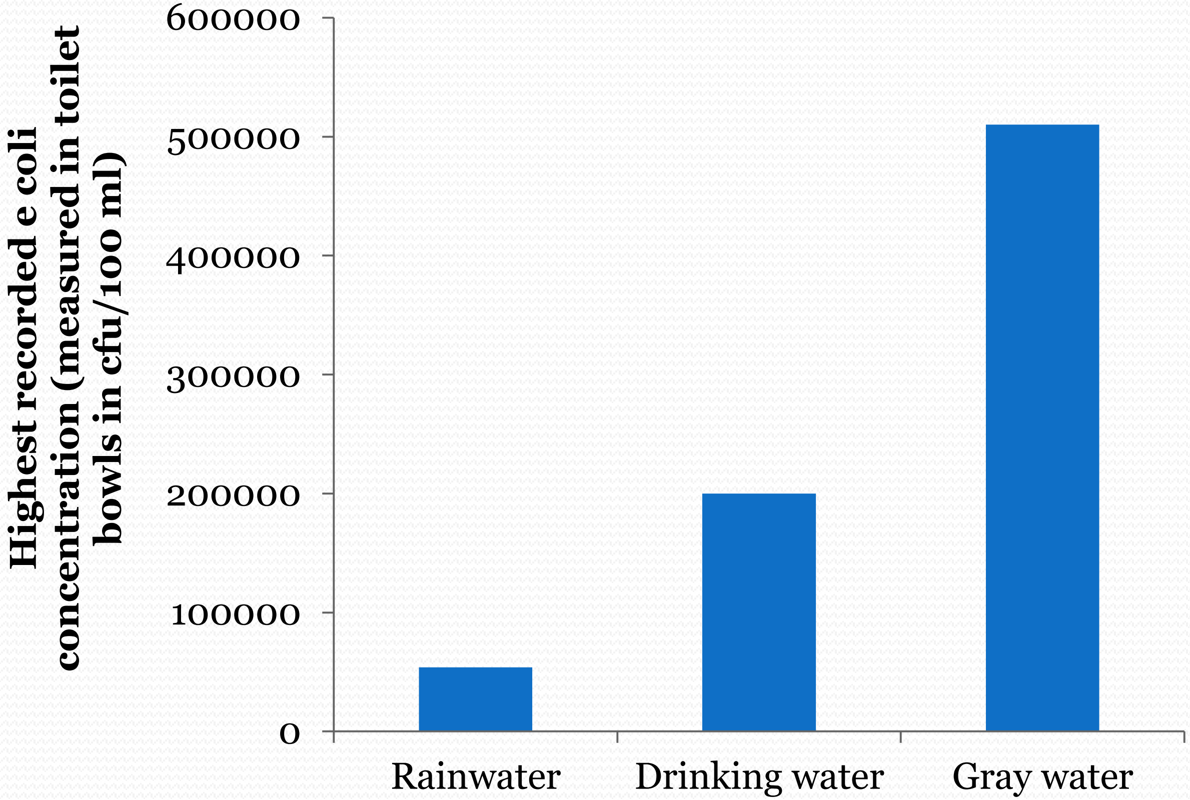
Booster pump in a vault

Sediment filtration

- Sediment filtration can prevent damage to fixtures and irrigation equipment.
- Sediment filtration can increase the efficacy of disinfection.

Disinfection

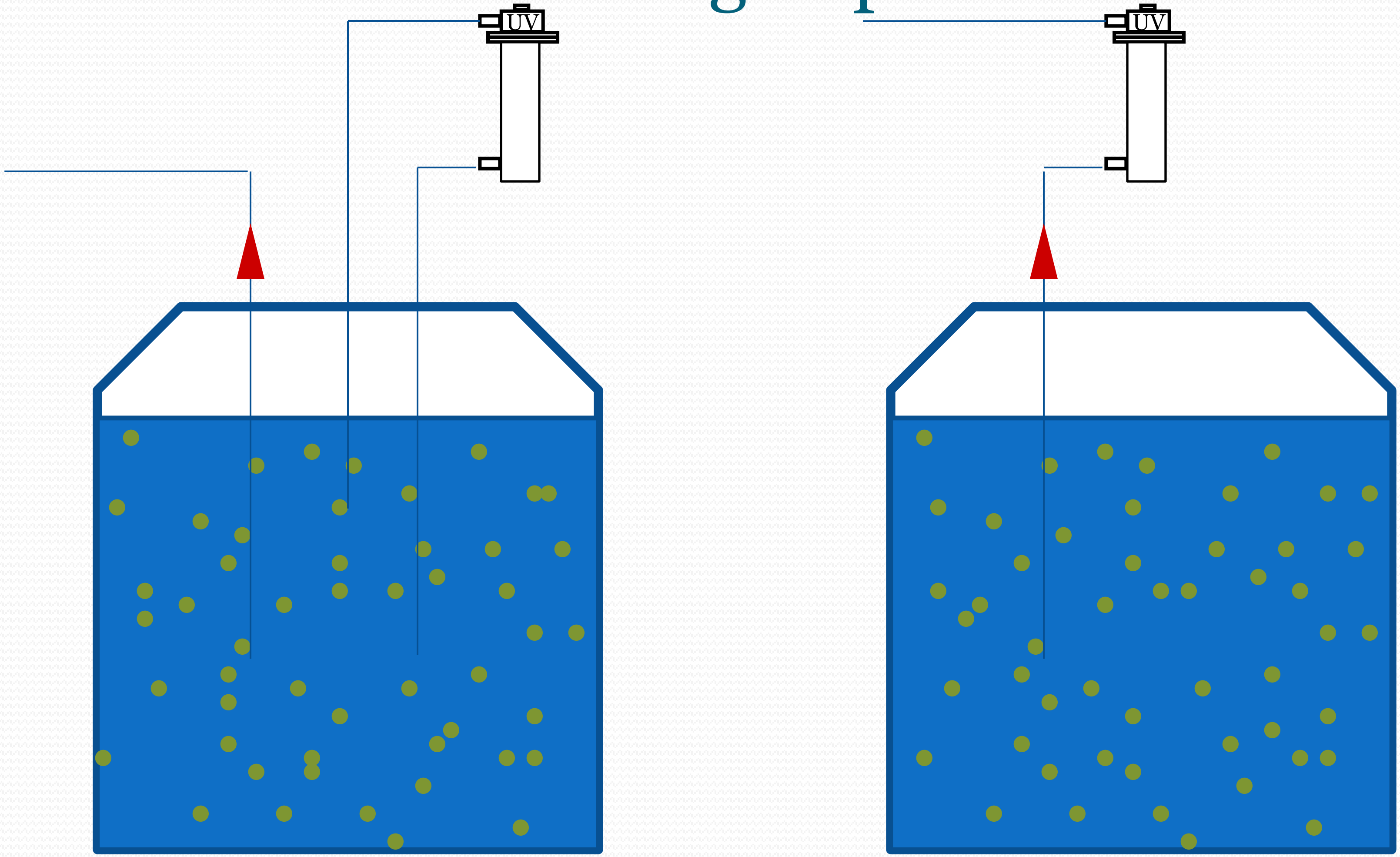
- The effectiveness of disinfection depends on the quality of the water before disinfection
- Disinfection is recommended if water is brought indoors
- Disinfection options include ozone, chlorine, and ultraviolet



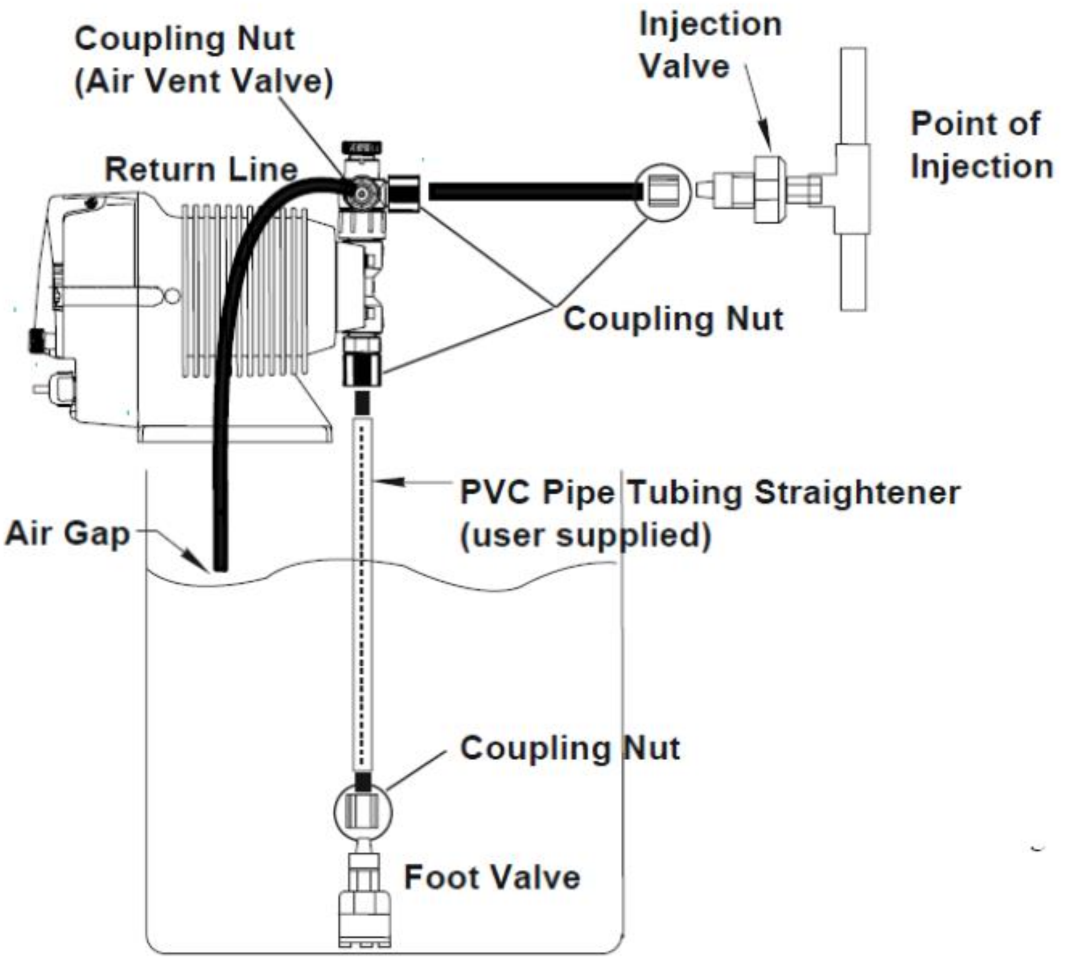
Albrechtsen 2002

Disinfection options

Re-circulating or point of use?



Dye injection

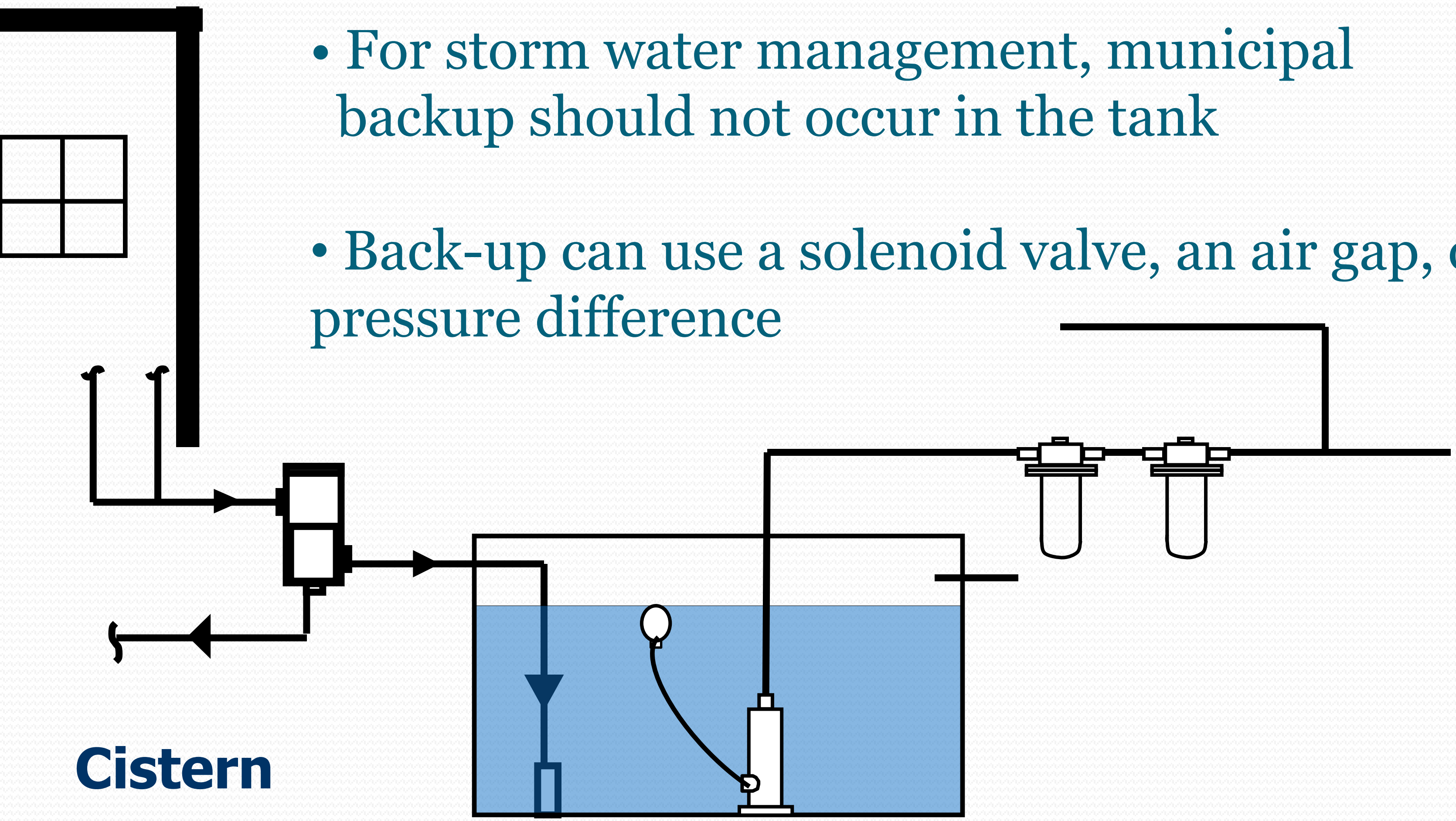


Additional treatment

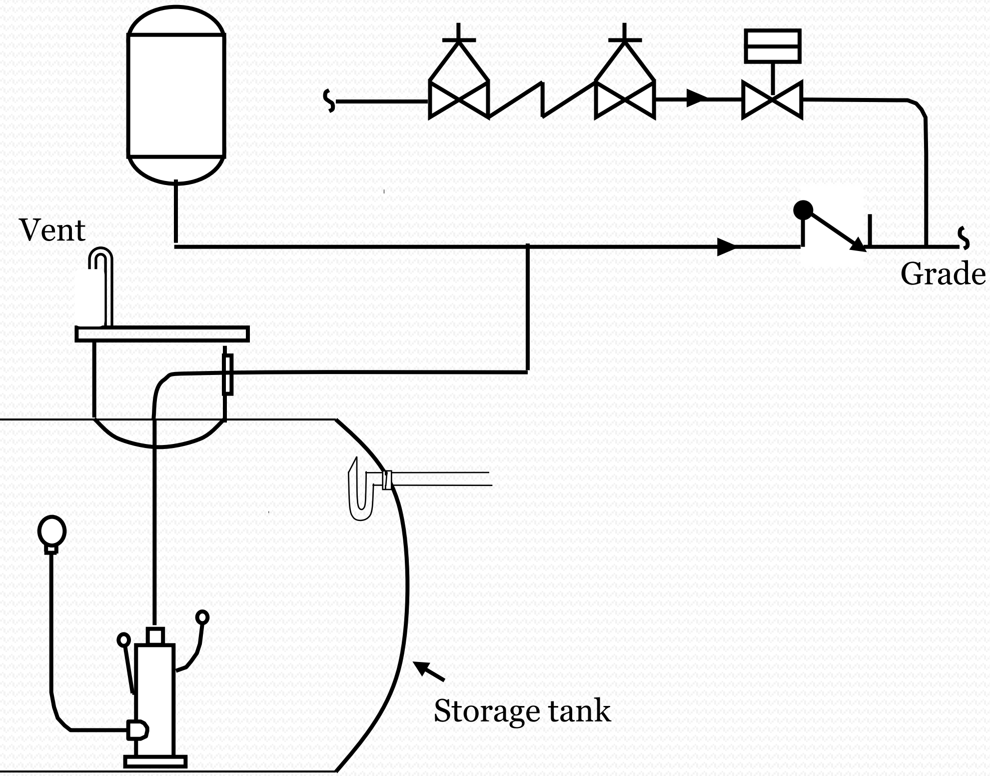
- pH injection
- Carbon filtration

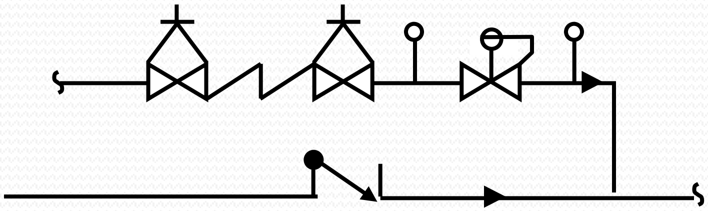
Municipal back-up

- Most systems will need seamless back-up
- For storm water management, municipal backup should not occur in the tank
- Back-up can use a solenoid valve, an air gap, or a pressure difference

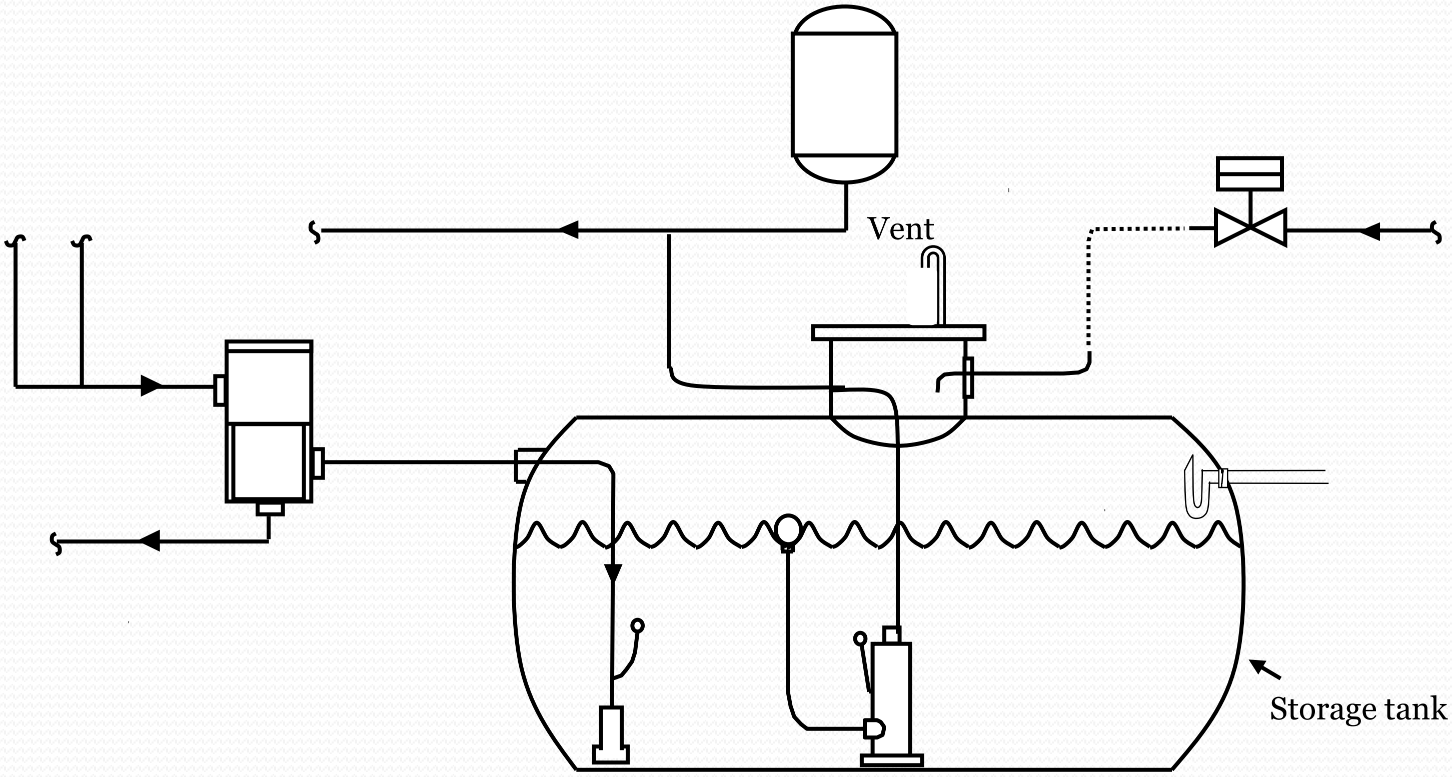


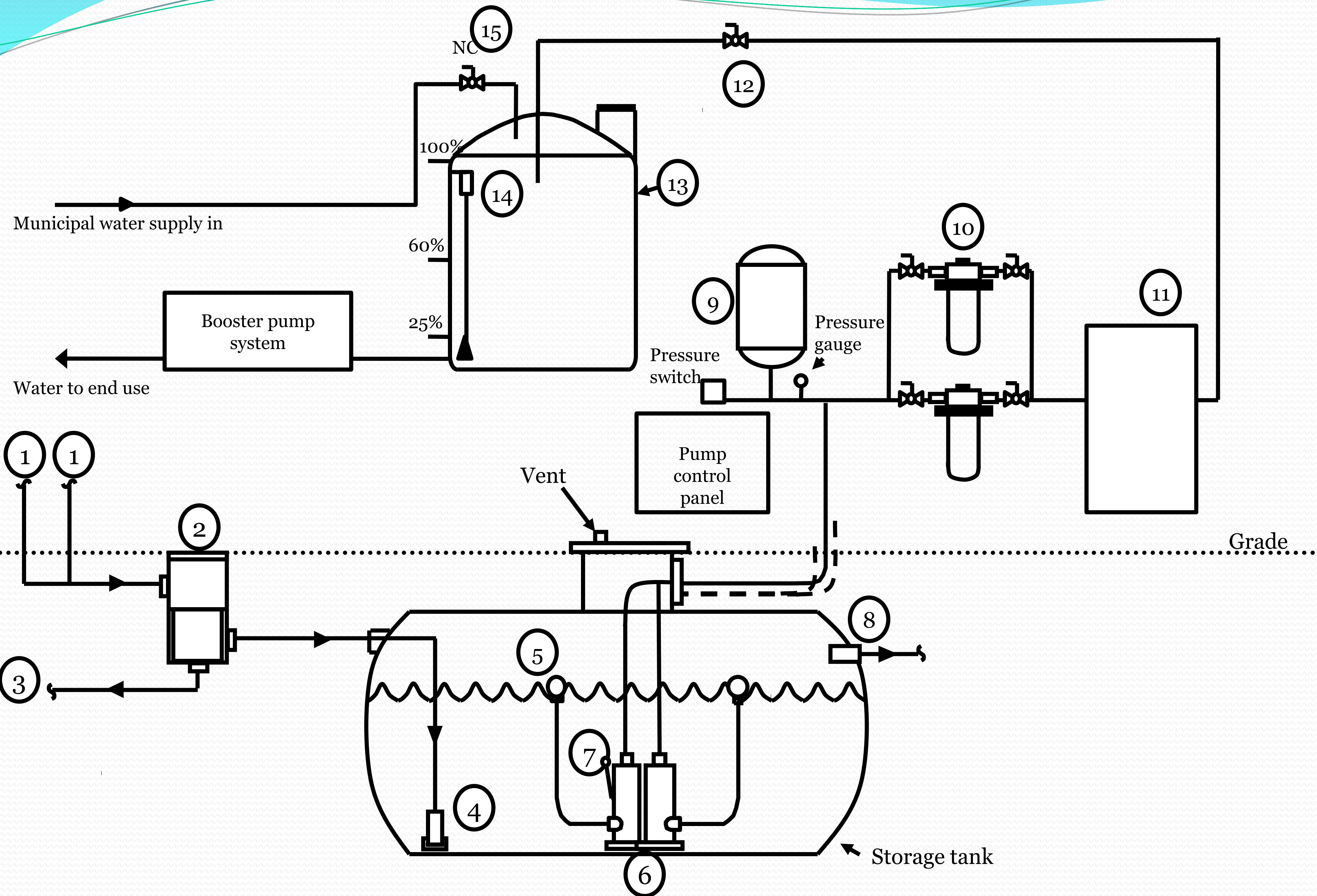
Using an RPZ





Using an air gap




NC
15
NC
12
100%
14
13
Municipal water supply in
60%
10
9
11
Booster pump system
25%
Pressure gauge
Pressure switch
Water to end use
Pump control panel
1
1
Vent
2
Grade
8
5
3
7
4
Storage tank
6

Making it simpler

4 steps for rainwater harvesting

- Pre-tank filtration
- Avoid disturbance of sediment and biofilm where water enters the tank
- Take the cleanest water from just below the surface
- Allow the tank to overflow, but protect the water quality

Case studies

Western Virginia Regional Jail

- Regional partnership between the counties of Franklin, Montgomery, Roanoke and the city of Salem
- 264,000 sq. ft. with a rated capacity for 605 inmates
- Seeking LEED certification
- Includes a siphonic roof drainage system

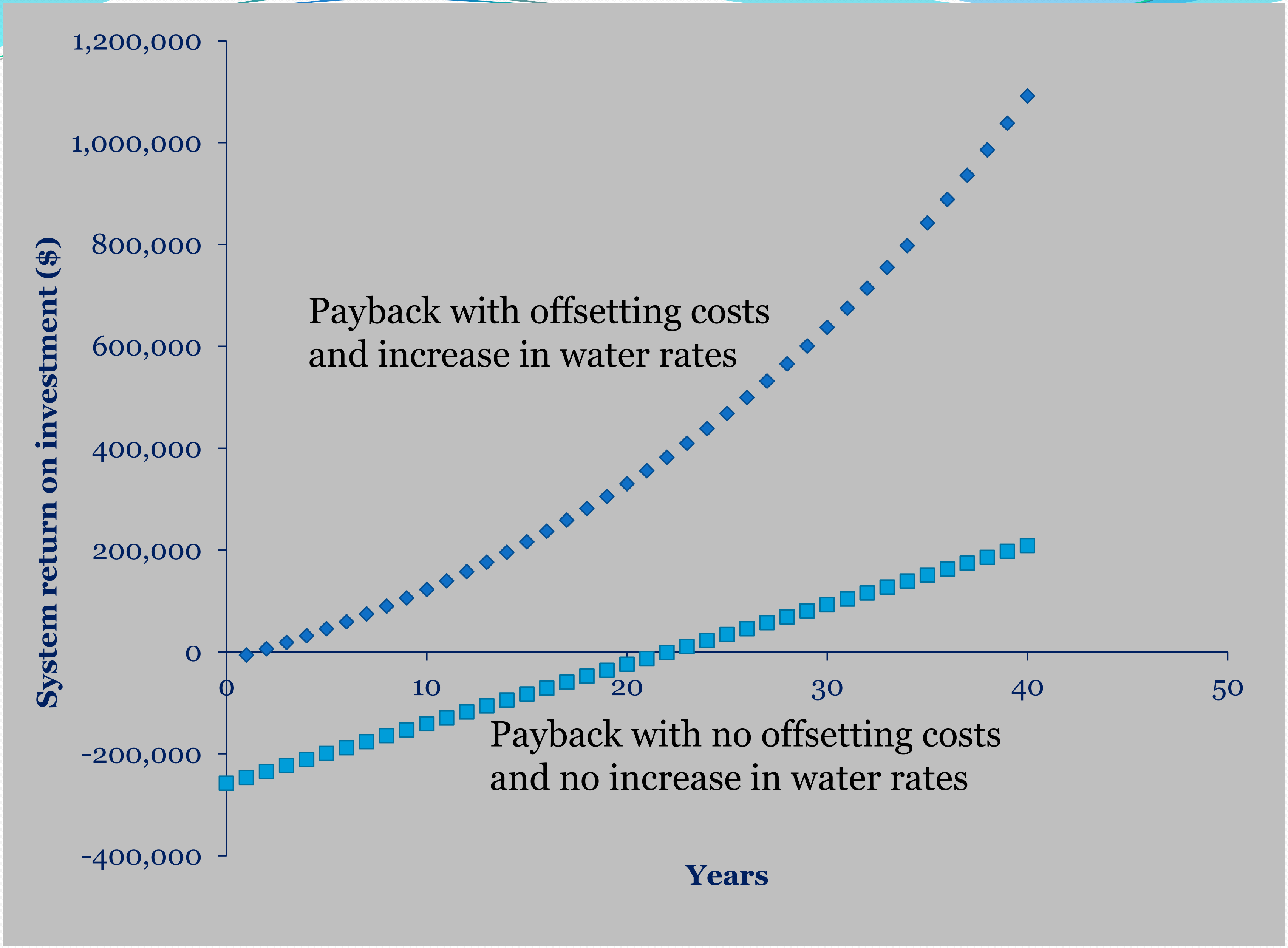
Payback analysis

- Total system cost = $258,000
- 3.9 million gallons of water saved
- Current water rate $3 per 1,000 gallons
- Annual savings from water = $11,675
- Total payback time = 22 years

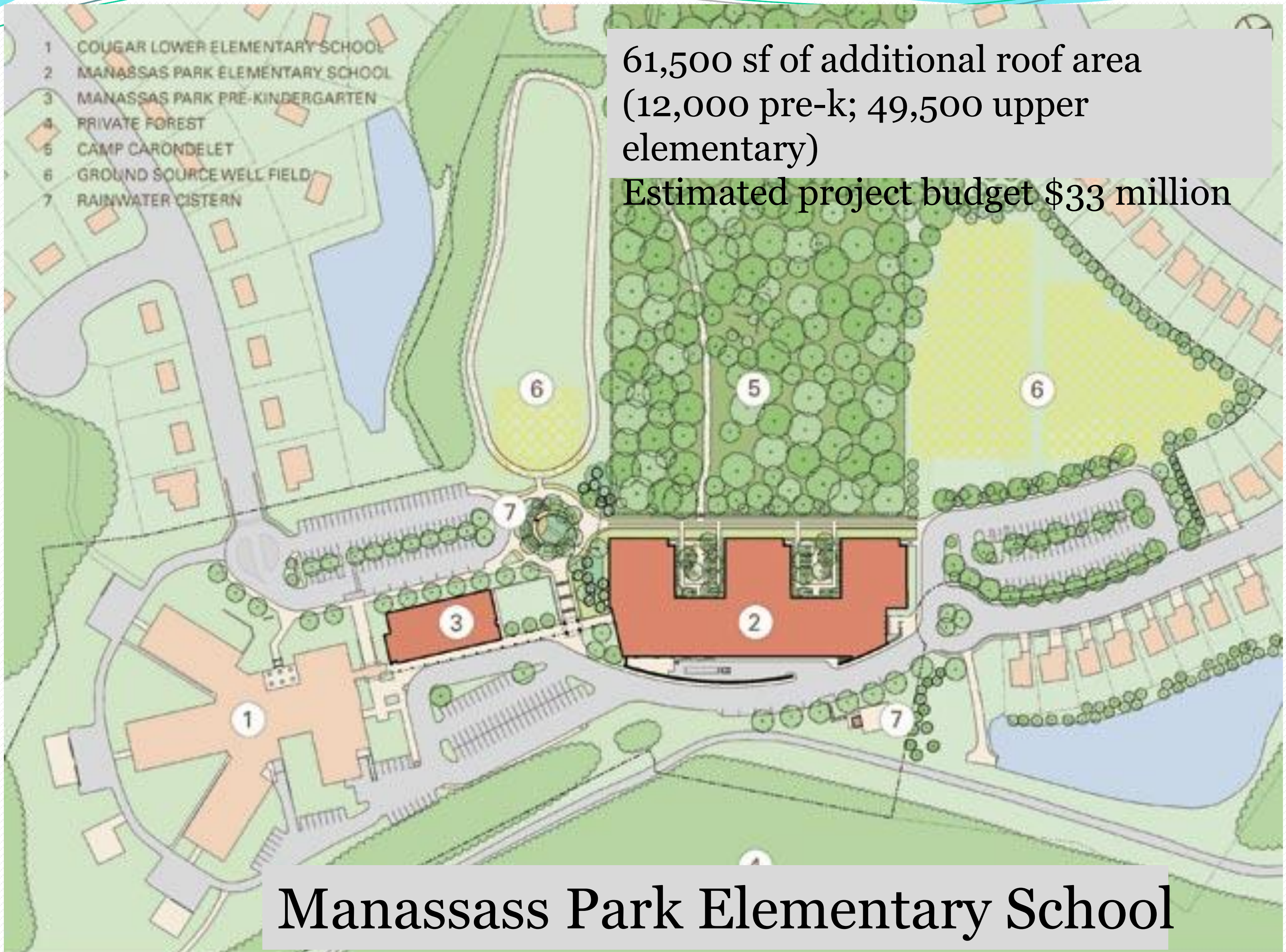
But does that really include everything?

Payback analysis

- Offsetting capital costs – the rainwater harvesting system has the same water quality benefits for storm water as a bioretention area that would cost about $240,000 plus take up space on the site
- Increasing water rates – if water rates increase 4% per year, in twenty years, the water savings will have more than doubled ($24,599 per year)


1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
-400,000
System return on investment ($)
0
10
20
30
40
50
Years
Payback with offsetting costs
and increase in water rates
Payback with no offsetting costs
and no increase in water rates

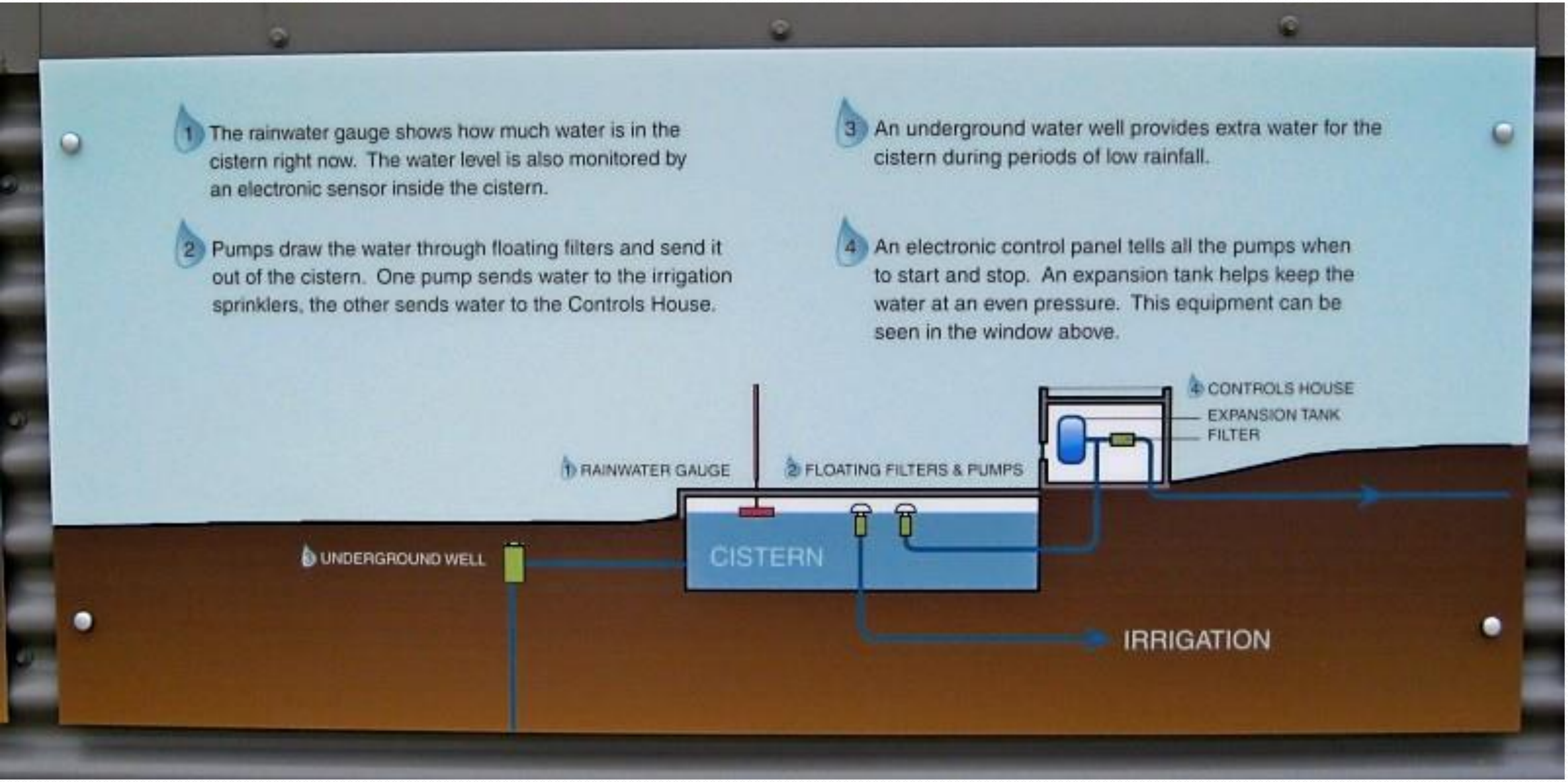
61,500 sf of additional roof area (12,000 pre-k; 49,500 upper elementary)
Estimated project budget $33 million

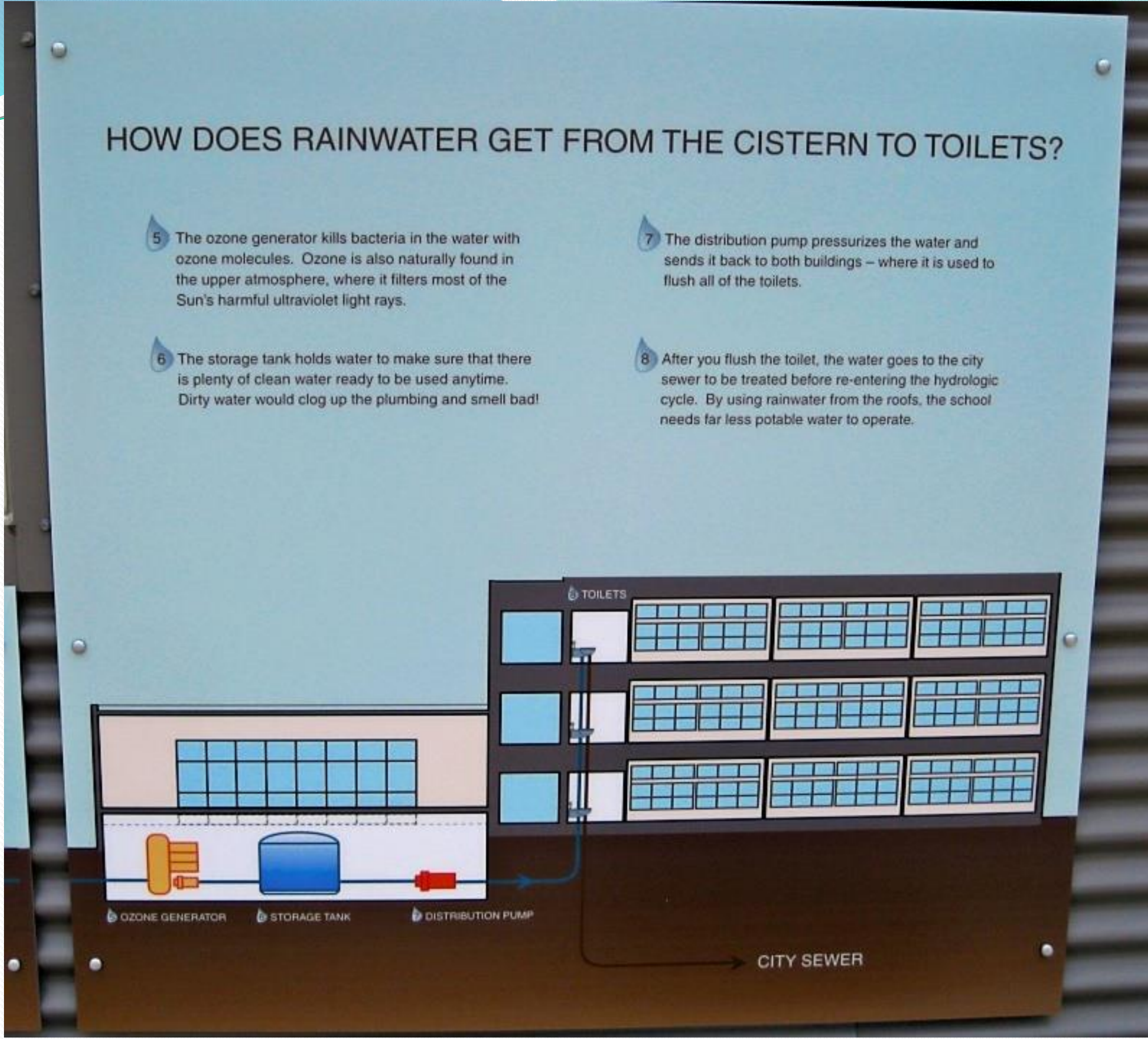


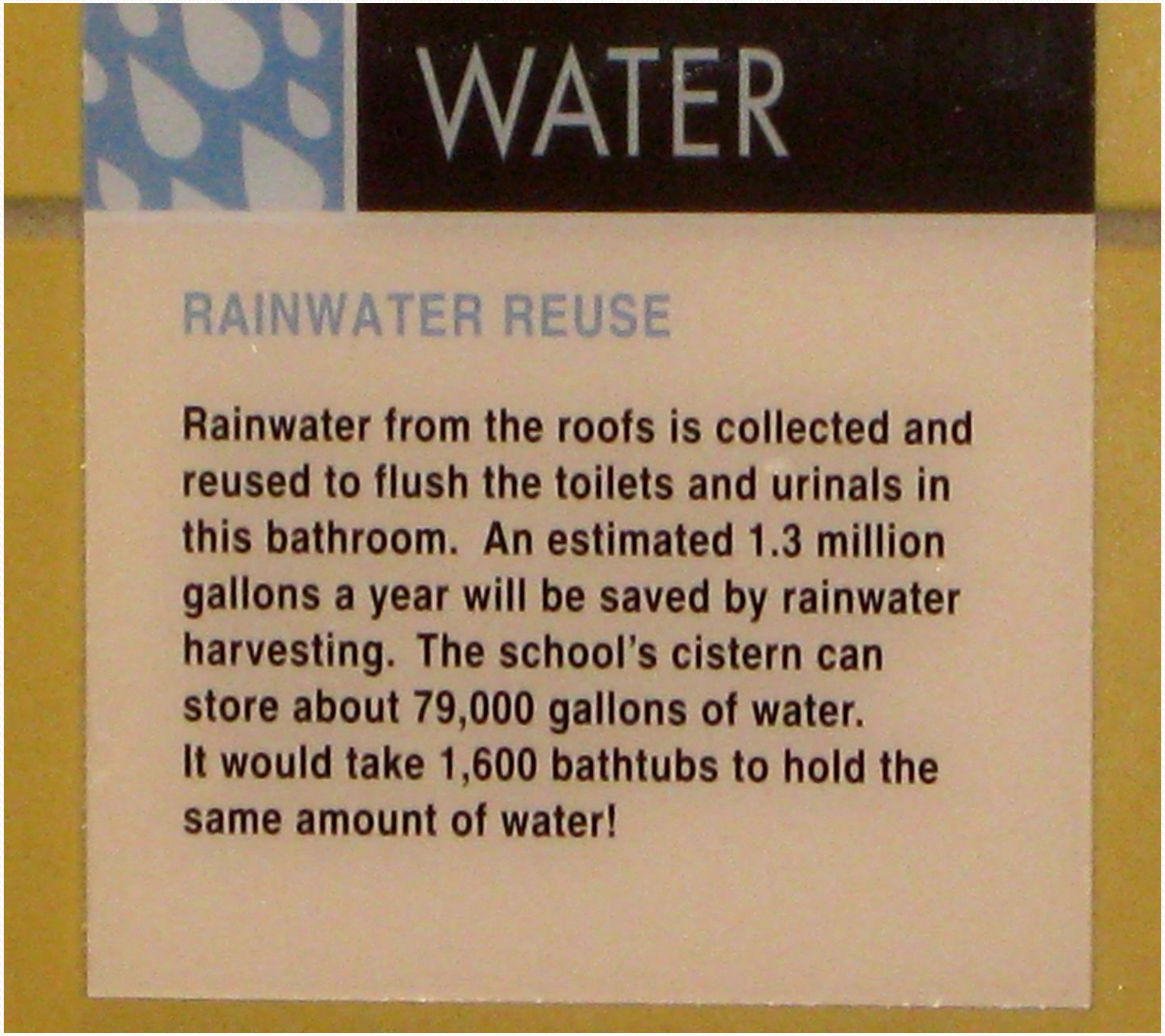
Manassas Park Elementary School

Illustration courtesy of VMDO Architects

RAINWATER HARVESTING
BULL RUN CREEK
WHEN IT RAINS, WHERE DOES THE WATER GO?
Water travels 110 miles from Manassas Park until it reaches the Chesapeake Bay.
OCCOQUAN RIVER
BELMONT BAY
YOU ARE HERE
OCCOQUAN RESERVOIR
LAKE JACKSON
BROAD RUN
CEDAR RUN
HOW DOES RAINWATER GET TO THE


1 The rainwater gauge shows how much water is in the cistern right now. The water level is also monitored by an electronic sensor inside the cistern.
2 Pumps draw the water through floating filters and send it out of the cistern. One pump sends water to the irrigation sprinklers, the other sends water to the Controls House.
3 An underground water well provides extra water for the cistern during periods of low rainfall.
4 An electronic control panel tells all the pumps when to start and stop. An expansion tank helps keep the water at an even pressure. This equipment can be seen in the window above.
4 CONTROLS HOUSE
EXPANSION TANK
FILTER
1 RAINWATER GAUGE
2 FLOATING FILTERS & PUMPS
3 UNDERGROUND WELL
CISTERN
IRRIGATION


HOW DOES RAINWATER GET FROM THE CISTERN TO TOILETS?
5 The ozone generator kills bacteria in the water with ozone molecules. Ozone is also naturally found in the upper atmosphere, where it filters most of the Sun's harmful ultraviolet light rays.
6 The storage tank holds water to make sure that there is plenty of clean water ready to be used anytime. Dirty water would clog up the plumbing and smell bad!
7 The distribution pump pressurizes the water and sends it back to both buildings – where it is used to flush all of the toilets.
8 After you flush the toilet, the water goes to the city sewer to be treated before re-entering the hydrologic cycle. By using rainwater from the roofs, the school needs far less potable water to operate.
TOILETS
OZONE GENERATOR
STORAGE TANK
DISTRIBUTION PUMP
CITY SEWER


WATER
RAINWATER REUSE
Rainwater from the roofs is collected and reused to flush the toilets and urinals in this bathroom. An estimated 1.3 million gallons a year will be saved by rainwater harvesting. The school's cistern can store about 79,000 gallons of water.
It would take 1,600 bathtubs to hold the same amount of water!

Effect of system

- Eighty-two percent of the precipitation that falls on the roof is used in the building or for irrigation (1.1 million gallons). Any additional runoff is routed to the constructed wetland for infiltration or evaporation or in extreme events, detention and release. The initial estimates used in sizing the system were based on monthly rainfall data. This difference in time interval is why the signs and other early estimates predict an annual water savings of 1.3 million gallons.
- The school uses about 356,000 gallons of water per year; the neighboring school (Cougar Elementary) uses 2.2 million gallons of water per year.
- LEED Gold certified
- Numerous awards including
  - K-12 Project of the Year, Mid-Atlantic Construction magazine
  - Platinum Design Award and People's Choice Award, 2009 Virginia School Board Association
  - Exhibition of School Architecture; 1st place in the 2007 Go Green Competition, USGBC James River Chapter
  - AIA/COTE Top Ten Green Projects

Manassas Park Elementary School- Education component

Charlottesville Public Works


Questions?

- Benjamin Sojka

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RMS

RAINWATER MANAGEMENT SOLUTIONS

434-293-4485