Sustainable Cooling Water Treatment Through Non-Chemical Technologies

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Learning Objectives

1. Define “sustainability” in simple terms and explain its importance for the future.
2. Describe the main concerns in treating cooling tower water.
3. Identify key differences between non-chemical and chemical water treatment.
4. Explain how non-chemical devices can qualify for, and be used to generate, ***LEED*** credits/points.
5. Explain how non-chemical devices can help comply with water efficiency standards.
6. Describe why “green roofs” can have a beneficial affect for both building owners and society.

What Is Sustainability?

- "Sustainability" is a buzzword that has come to symbolize a mindset.
- There are many explanations of what sustainability means.
- The literal definition is to have the *aptitude*, *skill* or *capability* to *maintain*, *continue* or *carry on* [fill in the blank].
- In simple terms, sustainability for the environment can mean:
  - Use only what you ***need*** (don't waste)
  - ***Maximize*** the ***efficiency*** of what you do use
  - Minimize the tendency to diminish or destroy the capability to ***re-use*** that which you have consumed
  - **Bottom line: Leave this world the same or better than you found it**

Why Sustainability?

- History is a wonderful teacher, but only if its students are paying attention.
- Progress comes with a price tag.
- What is the price tag for diminishing (or destroying) our non-renewable natural resources?
- Are we wise enough to recognize the signs of trouble, and sensible enough to do the right thing about it?

Energy vs. Water

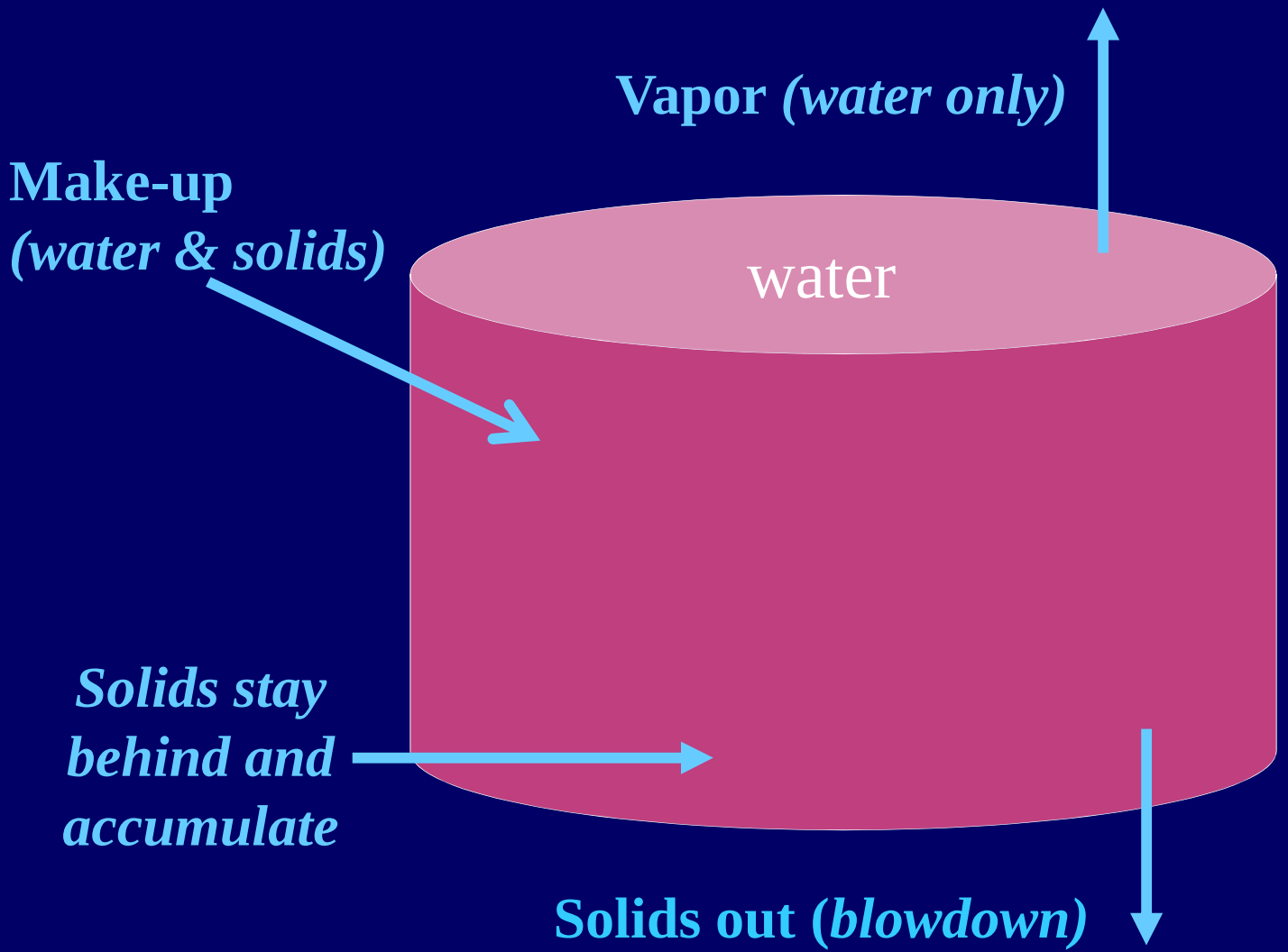
- Which is more important to conserve when determining the most efficient cooling, heating and refrigeration methods?
- Water is a ***renewable*** resource (mostly).
- Most forms of energy (fossil fuels) are not renewable.
- Water-cooled condensing systems are **20-40%** more energy efficient than air-cooled condensing systems.
- The Big Picture: more water can be consumed in the production of the extra electricity required for air-cooled condensing systems, than is consumed by the water-cooled condensing system.

The Basics Of Water Chemistry

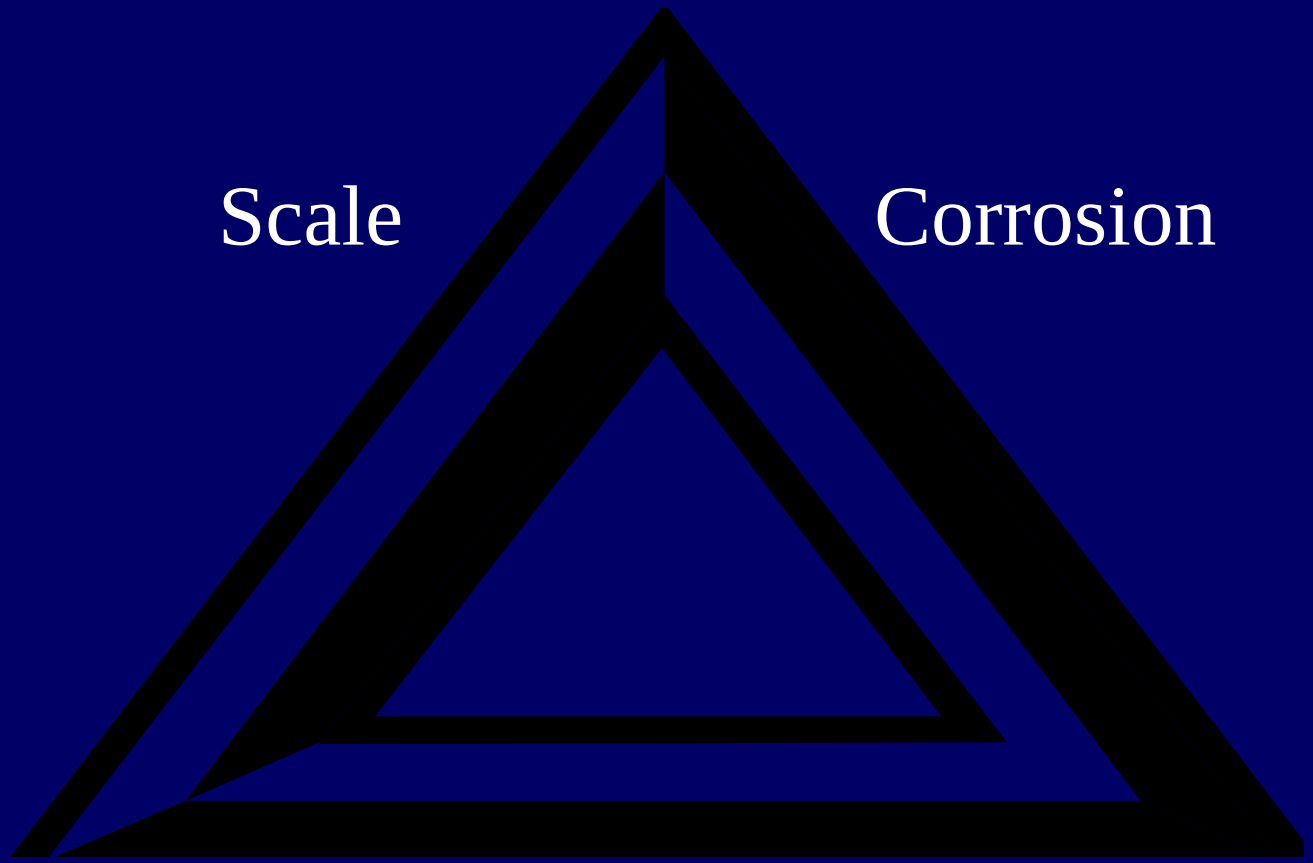
What Is In Water?

- Not just H_2O.
- Water is called the universal solvent.
- All natural waters contain various kinds of impurities:
  - Dissolved solids
  - Suspended solids
  - Dissolved gases
  - Bacteria
- These impurities cause problems.

The Basics Of Water Chemistry
What Happens With Evaporation



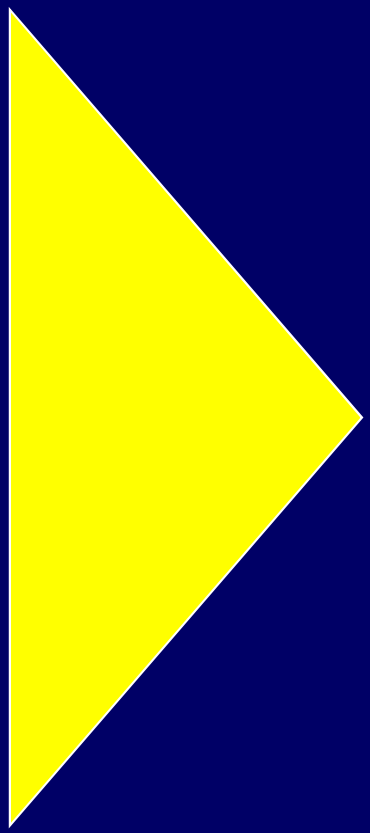
What Are The Problems With Cooling Water?



What Are The Affects Of These Cooling Water Problems?

PROBLEMS

- Scale
- Corrosion
- Bacteria



AFFECTS

- Increased maintenance costs
- Reduced heat transfer efficiency
- Increased energy costs
- Increased water costs
- Increased sewage costs
- Increased safety and training issues
- Reduced plant efficiency
- Reduced equipment life
- Growth of hazardous micro-organisms

What Is Scale?

- Calcium Carbonate ($CaCO_{3)}$ – inversely soluble with increase in temperature.
- As cycles of concentration increase solubility limit is reached, $CaCO_3$ precipitates on heat transfer surfaces as very hard scale known as calcite.
- Chemical control uses dispersants to try to keep $CaCO_3$ from precipitating.

What Does Scale Look Like?

What Is The Affect Of Scale On Energy ?

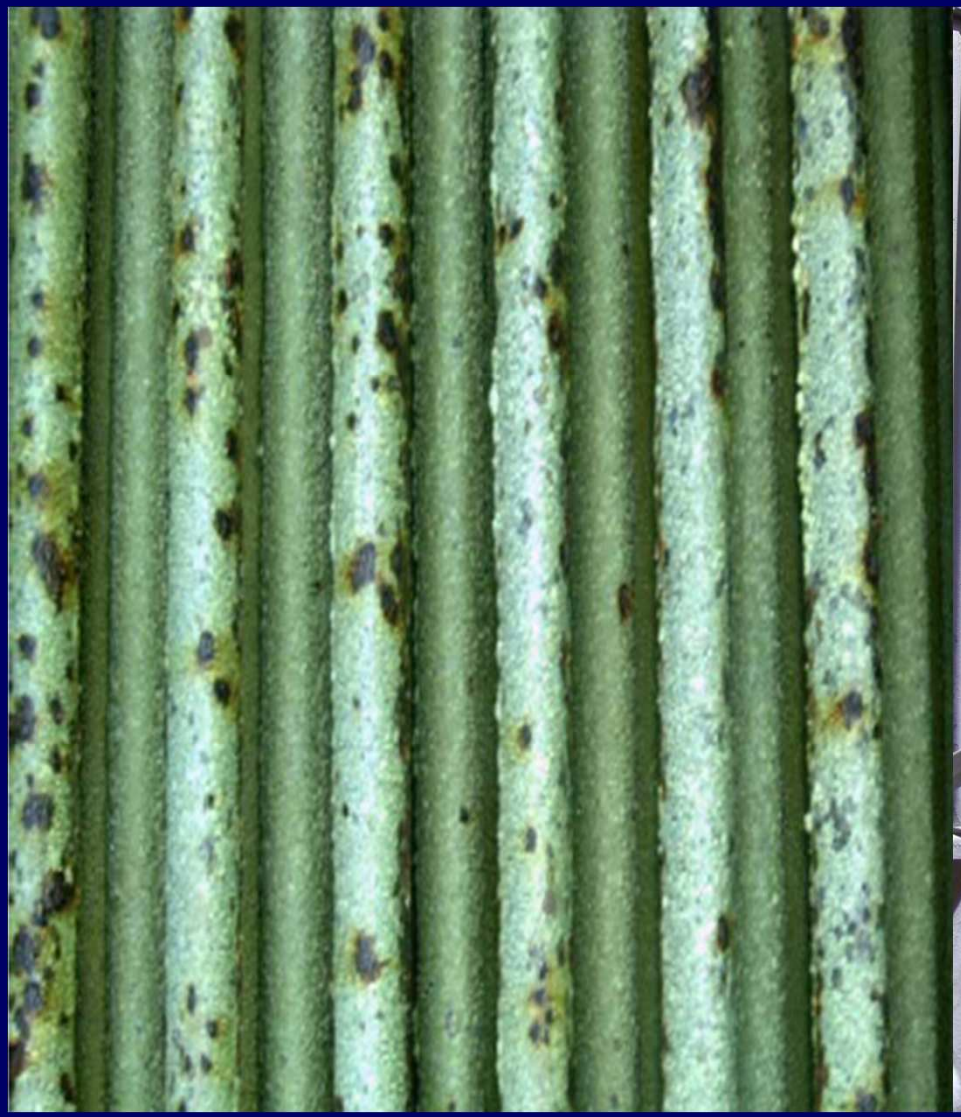
A/C	.001 Fouling	.002 Fouling	.003 Fouling
	= 10.8% Increase	= 21.5% Increase	= 32.2% Increase
Tonnage	Factor (1/84")	Factor (1/42")	Factor (1/32")
200	$804	1,770	2,410
500	2,010	5,745	8,620
1000	4,020	8,045	12,010
2500	10,050	20,100	30,160
5000	20010	57,450	86,200

Conditions: 1. Unit operating at 95% load
2. Unit operating 24 hrs/day; 360 days/year = 8640 hrs.
3. Electricity costs $0.07/KWH

What Is Corrosion

- ***Dissolved gases*** drive pH lower causing metal loss.
- Biological activity (***biofilm***) can also set up local corrosion sites.
- ***Suspended solids*** also tend to set up local corrosion sites.
- Chemical control uses buffering agents and film forming corrosion inhibitors.

What Is Corrosion?



Biological Contamination

Biological Contamination

- Planktonic bacteria (free floating)
- Sessile bacteria (attached): slime layer
- Higher life forms (Amoeba): pathogens

Biofilm insulates heat transfer surfaces, which leads to reduced efficiency and creates a corrosive environment!

Question/Answer

- Q: What are the main issues with cooling water treatment?
- A: Scale, corrosion and bacteria control.

- Q: Why are these problems?
- A: They can:
  - Reduce efficiency of the chilled water/refrigeration system.
  - Reduce the life expectancy of system components.
  - Pose potential health risks.

The Solution To Water Problems? Good Water Treatment

- Historically, ***chemicals*** have been used to provide cooling water treatment.
- Do they work? Most of the time.
- Are there drawbacks?

Issues With Chemical Water Treatment

- Requires careful oversight.
- Most chemicals are petroleum based.
- Chemicals interact with each other.
- Concentrated chemicals are often toxic.
- Chemicals are eventually released to the environment.
- Environmental regulations.

Is There A Viable Alternative?

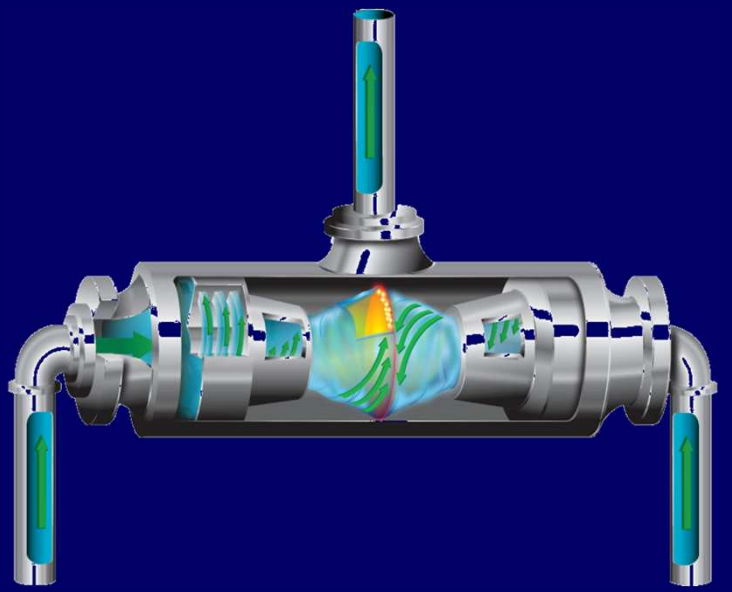
- Non-Chemical water treatment devices (NCDs) have been in the market place for many years.
- Many of these devices have not been effective:
  - History of aggressive promotion.
  - Can you spell “snake oil salesman”?
- Disparaged by chemical suppliers.
- And yet…research, long-term effective field use, and peer reviewed papers have found some NCDs to be as effective, or more, as chemical water treatment.

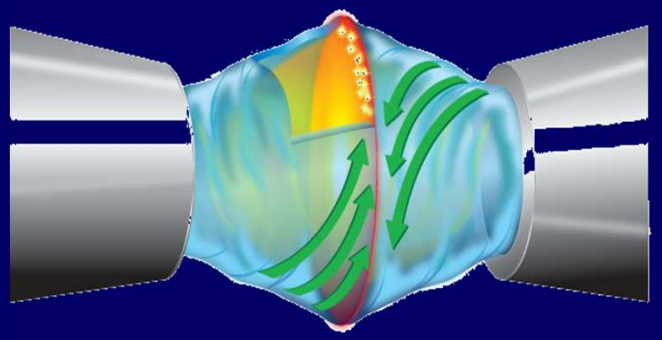
What Are These Non-Chemical Technologies?

- Hydrodynamic cavitation.
- AC induction coils.
- Magnetic.
- Ultrasonic.

Hydrodynamic Cavitation (HDC)

- The HDC device consists of a pressure equalizing chamber and a cavitation chamber.
- Water is pumped into the pressure equalizing chamber, then the water is channeled into the cavitation chamber where it is forced to rotate at high velocity through truncated nozzles.
- Rotating water streams create strong vacuum.
- Micro bubbles form and grow in the vacuum zone.
- The opposing streams collide at the mid-point of the chamber.
- The bubbles collapse catastrophically when streams collide.





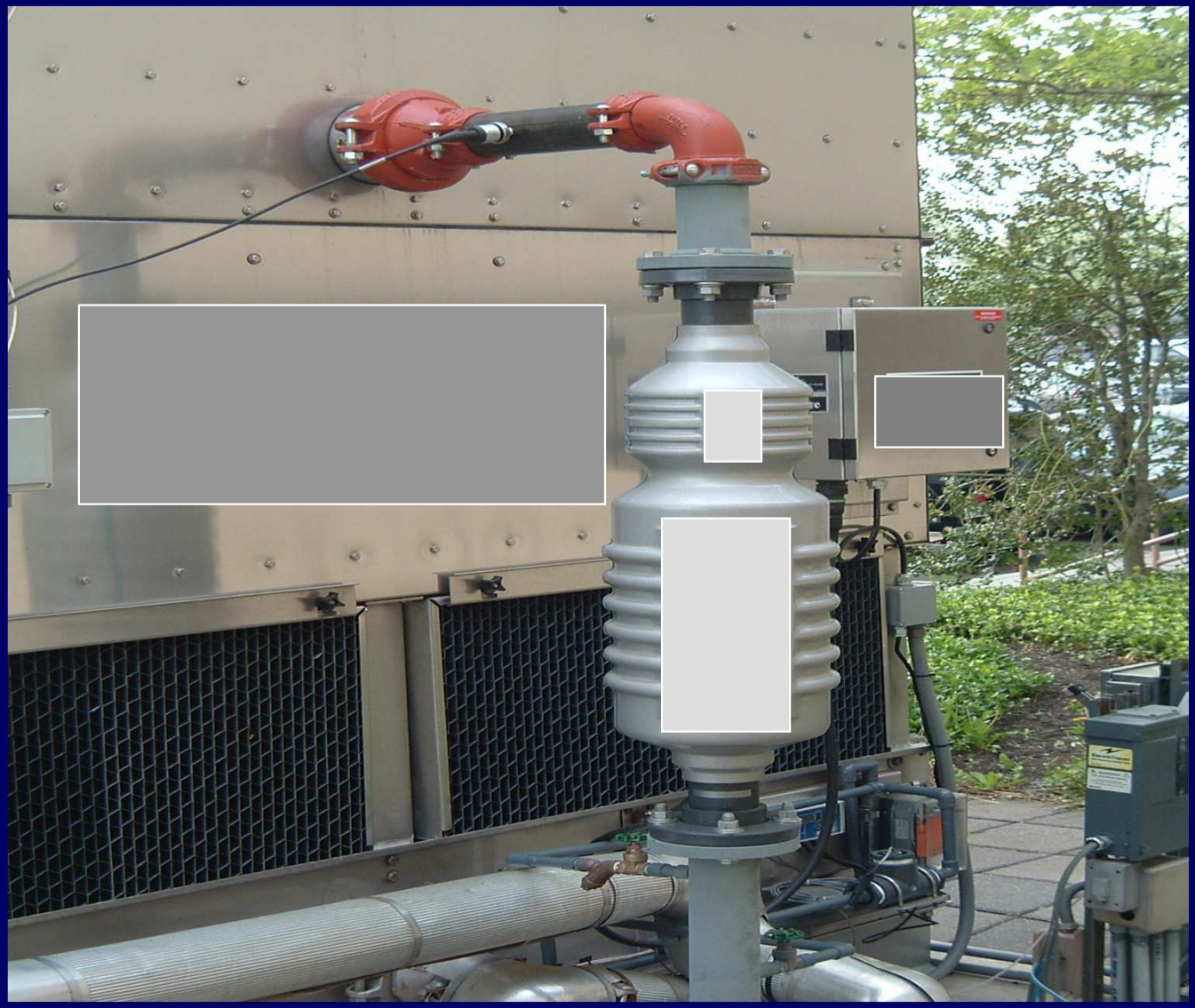
Hydrodynamic Cavitation (HDC)

- The result is a change in the chemistry of the water:
  - $CaCO_3$ (calcium carbonate or scale) is precipitated out.
    - This “seed” crystal agglomerates with similar crystals, and becomes a nucleation site for calcium and bi-carbonate ions.
    - Filtration is used to remove the scale particle from the water.
  - The vacuum degasses some CO_2 from the water.
    - This buffers the pH of the water to a non-corrosive level (8.2-9.2).
  - The rapid change in pressure ruptures the cell walls of bacteria, and the shear forces further breaks them apart.
    - No ability of bacteria to form resistance to cell disruption.

Hydrodynamic Cavitation (HDC)

- The HDC device is combined with filtration to remove suspended solids from the water:
  - Calcium carbonate.
  - Dead bacteria.
  - Dirt and debris sucked into the cooling tower.

AC Induction – Pulsed Power (PP)



AC Induction – Pulsed Power (PP)

- These devices use induction coils.
- An alternating current is sent through the coils, causing variable magnetic and induced electric fields in the water.
- Suspended particles are activated which strips them of their natural static charge.
- These seed crystals become the preferred precipitation site for calcium carbonate rather than other surfaces in the system.

AC Induction – Pulsed Power (PP)

- These seed crystals also become the nucleus for agglomeration of other suspended solids in the water, including bacteria.
- Bacteria encapsulated into these crystals are unable to reproduce.
- The rapidly changing electric field will expand and contract bacteria cell walls, eventually leading to perforation of the walls

Are There Differences Between NCDs?

- Some devices are able to remove more calcium carbonate than others.
  - More calcium carbonate removal can result in higher cycles of concentration (i.e. water savings).
- Some devices require the use of some biocides in order to achieve good bacteria control.
- Some devices have a greater affect on corrosion control than others.

Question/Answer

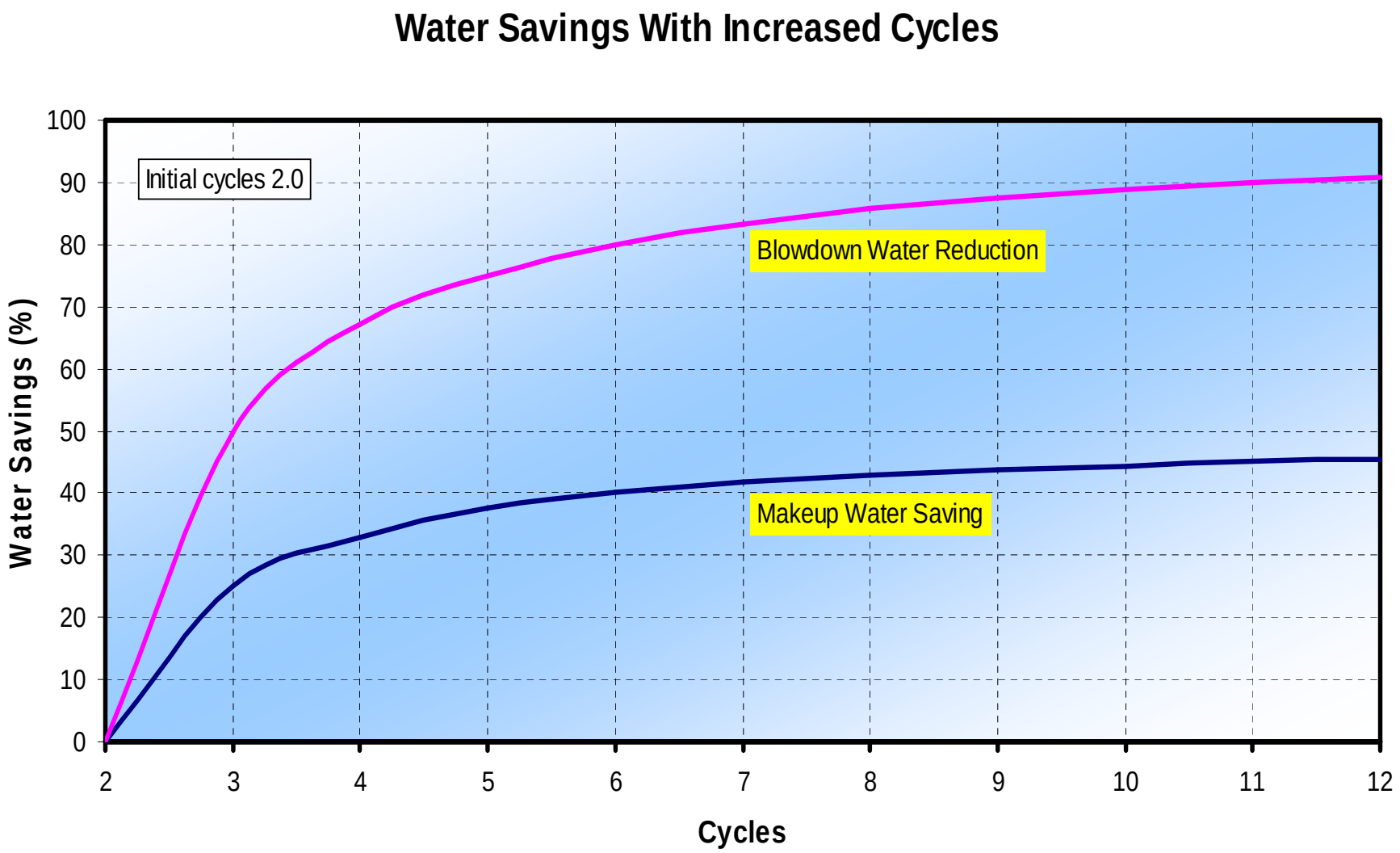
- Q: What are some of the major differences between chemical and non-chemical (NCD) water treatment?
- A:
  - NCDs use a physical device to treat water.
  - Chemicals try to keep scale causing minerals in suspension; NCDs precipitate these minerals to lower the scaling potential of the water.
  - Chemicals reduce corrosion by coating metal surfaces; some NCDs reduce the corrosion potential of the water by increasing pH.
  - Chemicals use biocides to poison bacteria; some NCDs use physical forces to rupture bacteria cell walls

What Increasing Cycles Of Concentration Can Do For You

- Depending on a number of variables, such as:
  - The tonnage of the tower/condenser
  - The load factor
  - The hours of operation
  - The climate
  - The chemistry of the source water
  - The type of NCD utilized

increasing the cycles of concentration can result in water savings of **thousands** or **millions** of gallons of water annually!

What Increasing Cycles Of Concentration Can Do For You



"Green" Benefits From NCDs

- "Green" Technology
  - *Eliminate* (or reduce) *Chemicals* in system.
  - May be able to re-use blow-down water for landscape irrigation or other non-potable purposes.
  - May be able to avoid draining to the sanitary sewer.
  - Lower life cycle costs.

- Many NCDs are eligible for utility water efficiency rebates in some areas (California, Arizona, Nevada, etc.)

- NCDs can qualify and help score ***LEED*** points in multiple categories (Water Efficiency, Energy & Atmosphere, Innovation & Design).

Question/Answer

- Q: What are cycles of concentration, and how are they important for water conservation?
- A:
  - Cycles of concentration measure the mineral concentration of the cooling tower water compared to the make-up water.
  - Increasing the cycles of concentration will reduce the amount of blow-down water, which, in turn, decreases the amount of make-up water.

How Do You Evaluate NCDs

- **DO YOUR HOMEWORK!!!!**
- Review the technical materials available.
- Does it sound like science or pseudo-science?
- Deal with a reputable manufacturer.
- Check out the references.
- What warranties are provided?
  - Is it a real warranty or a “trust me” warranty?
- Listen for tell tale catchphrases:
  - “This is a zero blow-down system”
  - “Eliminates all corrosion”
  - “Never needs monitoring or maintenance”

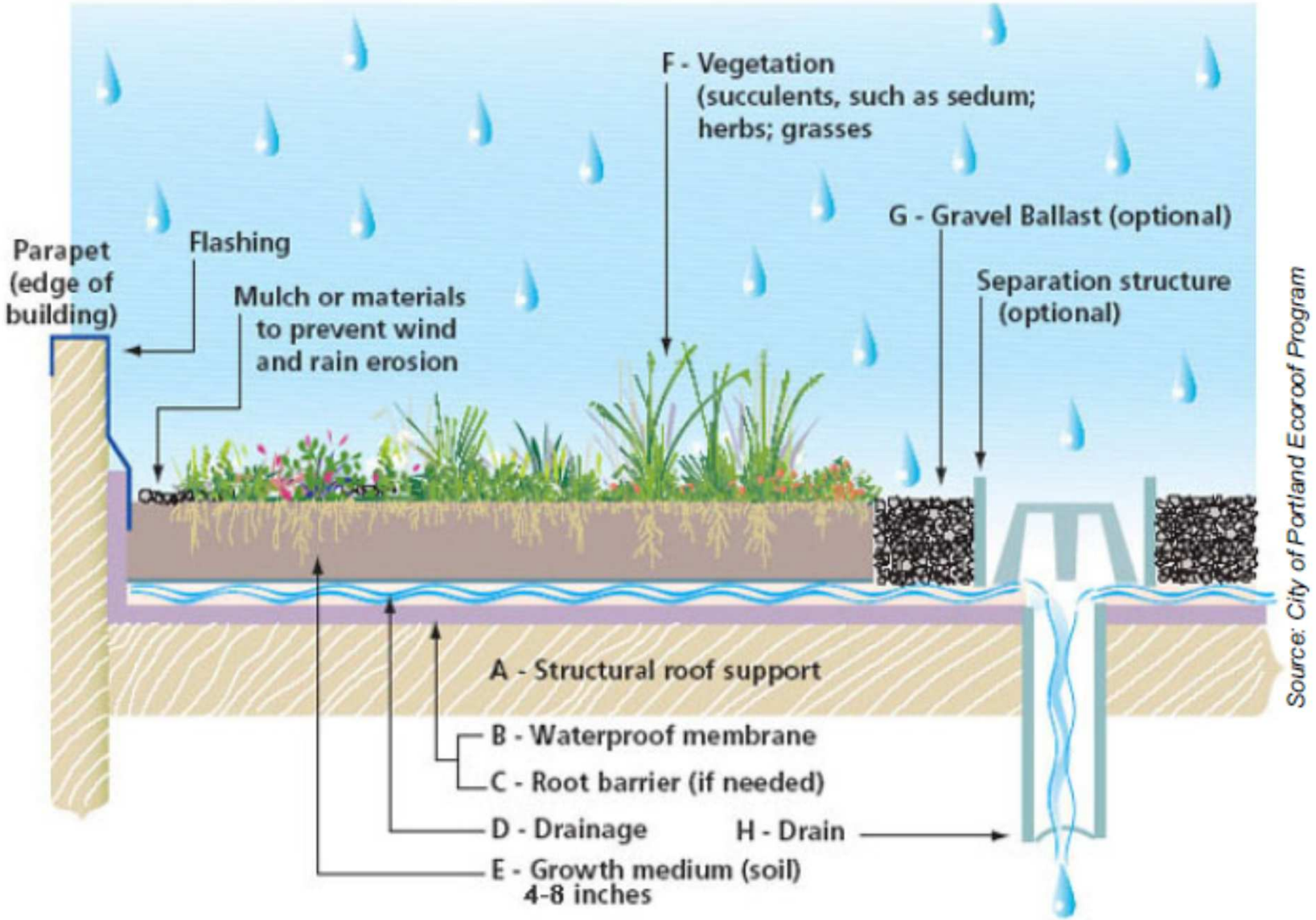
What Does All This Mean For Landscape Irrigation?

- Increasingly green designers and owners are seeking to use non-potable water sources for landscape irrigation:
  - Rainwater
  - Municipal reclaim water
  - Greywater
  - Non-chemically treated cooling tower blow down water
- Why? Because common sense AND Standards and Codes will/do require it!
  - ASHRAE Standards 189.1 and 191

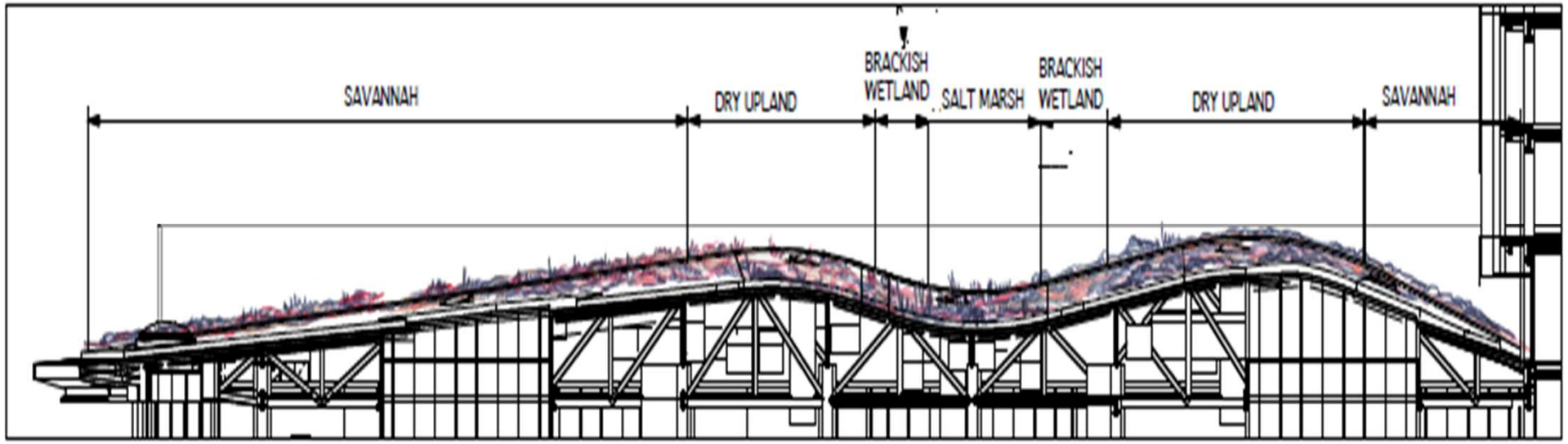
What Is A Green (Living) Roof?

- An ecological Green Roof is comprised of a layer of lightweight soil and plants that replaces traditional roofing materials

What Comprises A Green Roof?

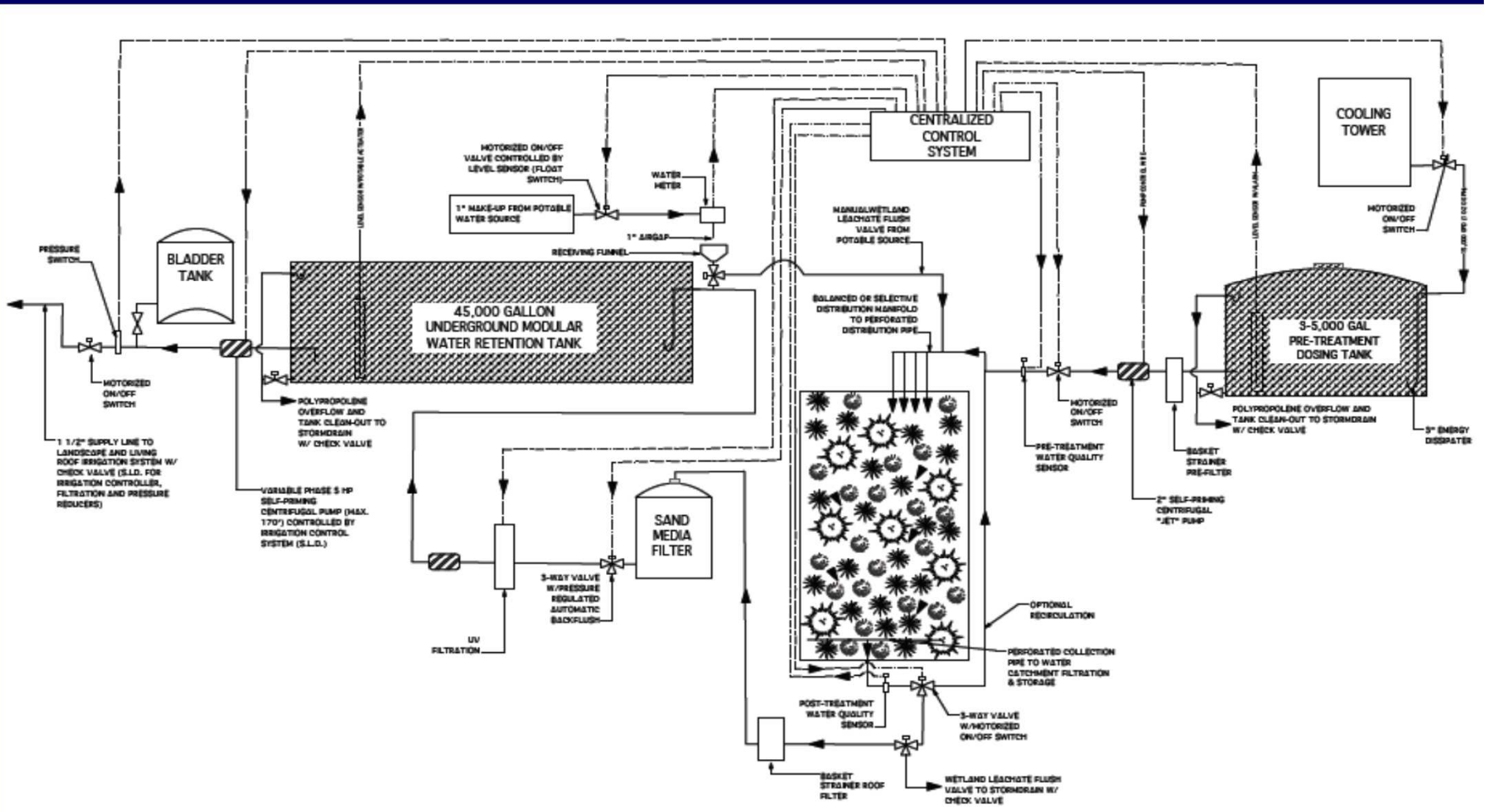


Green Roof Designs Are Based On Climatic Conditions, Water Quality, And Appropriate Plants



Hospital – Escondido CA

Use Of Cooling Tower Blow-Down For Green Roof Irrigation



Green Roofs – Can Be Bigger Than You Think!

- Millenium Park – Chicago IL
  - Covers 24.5 acres.
  - Caps a parking garage and railroad yard.

Before

After

Benefits Of Green Roofs

- Provides increased insulation to reduce heating/cooling energy costs.
- Decreases stormwater runoff.
- Sound attenuation reduces noise pollution.
- Reduces urban heat island effect.
- Increases life expectancy of roofing materials.
- Increases urban air quality.
- Encourages biodiversity and wildlife protection.
- Provides space for urban amenities.

Question/Answer

- Q: How do non-chemical water treatment systems foster sustainability?
- A:
  - They reduce the amount of water used in cooling tower and evaporative condenser operations.
  - They reduce the amount of hazardous chemicals put into the sanitary sewer system.
  - They can increase life expectancy of system components.
  - They allow building operators to re-use water.

Conclusions

Are Viable Non-Chemical Water Treatment Systems Available In The Market?

YES

Can They All Do Something?

YES

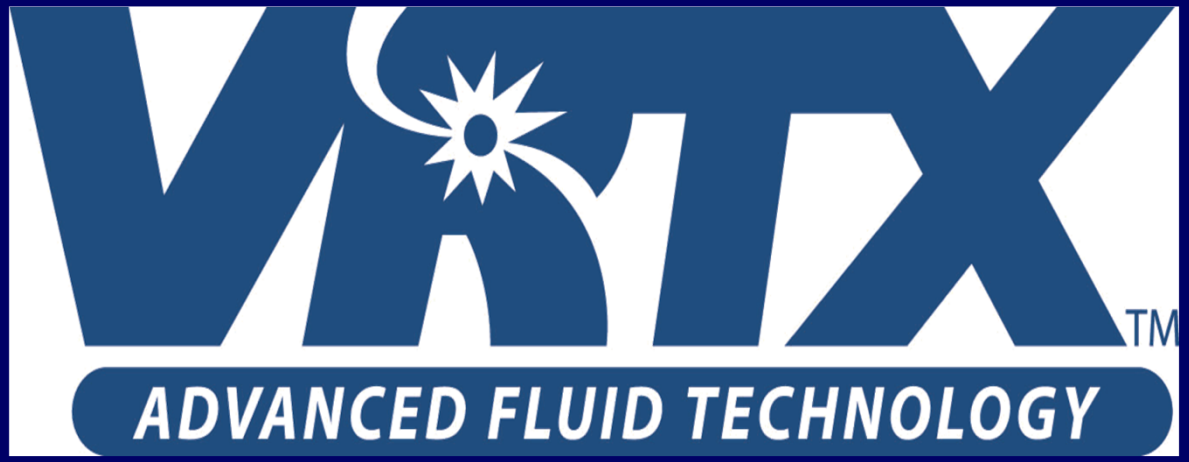
Can They Do Everything?

SOME

Do They Foster Sustainability?

ABSOLUTELY

Questions?



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