

# Water Reuse to Support Net Zero Water for Installations

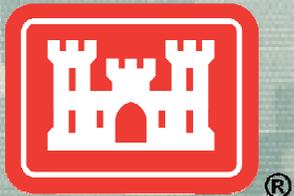
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US Army ERDC-CERL, Champaign, IL

Net Zero Installations

Chicago, IL

18-20 January 2012



US Army Corps of Engineers  
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# Water Thoughts

- **The ultimate source of all of our fresh water is precipitation**
- **“When the well is dry, we know the worth of water.” Benjamin Franklin, 1746**
- **8% of all energy use in the USA is directly related to pumping, treating or heating water – Clark Reed, USEPA**
- **Equivalent of green energy**
  - ▶ **Utility costs - \$2.00 to \$5.00 per gallon day of capacity to build water or wastewater treatment plant**
  - ▶ **New supplies costly and rising**
  - ▶ **Consumer costs – water and sewer combined between 0.5 and 1.0 cent per gallon**
- **The cheapest water you will ever have is the water you already have**



# Overview

- **Background**
- **Water issues**
- **Water reuse**
- **Rainwater harvesting**
- **Graywater use**
- **Contingency base reuse**
- **Summary**



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# Army Installations

- Cantonments are like small cities, up to 50,000 population
- Directorate of Public Works – responsible for all real estate, easier to implement changes
- Have all the amenities – schools, housing (barracks and family), hospitals, restaurants, commissaries, service stations, heating plants, hotels, industry
- Large amounts of green space – parade grounds, athletic fields, parks, cemeteries
- Thousands of acres of undeveloped area
- Self-contained, but dependent on surrounding region for support
- Usually senior water rights, but follow a good neighbor policy and take stewardship of natural resources seriously



# Concerns

- **Future water shortages**
- **Global climate change**
- **Reduced levels of surface streams or aquifers**
- **Competing regional requirements with other sectors especially in arid and semiarid lands**
- **Installation footprint may play major role**
- **Water is essential for: industrial processes, military operations and installation quality of life**
- **What can be done? Two options: encourage less use, find alternative sources and supplies**
- **Efficiency, conservation, reuse and recycling will play bigger roles.**



# Background

- **Water - Historically, Low Rates**
  - ▶ **Costs, value increasing**
  - ▶ **Military costs cheaper than private sector**
  - ▶ **Shortages, unsustainable withdrawals**
  - ▶ **Competition for water**
  - ▶ **Many uses could use lower quality water**



# Background

- Drivers
  - ▶ Executive Orders 13423, 13514 **require reductions in water use**
  - ▶ Incorporate water efficiency/conservation measures
  - ▶ EISA Section 438
  - ▶ LEED (Leadership in Energy and Environmental Design) USGBC
  - ▶ Green Building Initiative
  - ▶ Army sustainable design and development policy
  - ▶ ASHRAE 189.1-2009
  - ▶ Net Zero Water Installations Initiative



# Other Water Use/Alternate Water Sources Options

*What can be done to increase available supply?*

- ▶ Rainwater /stormwater runoff harvesting
- ▶ Graywater reuse
- ▶ Water reuse
- ▶ Water from pump and treat activities
- ▶ Sewer mining
- ▶ Desalination
- ▶ Produced water
- ▶ Ground water recharge

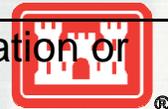


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# Definitions

Term	Definition
Blackwater	Water captured from toilets and urinals along with kitchen waste.
Direct potable reuse	The introduction of highly treated reclaimed water either directly into the potable water supply distribution system downstream of a water treatment plant, or into the raw water supply immediately upstream of a water treatment plant.
Graywater	Water captured from sinks, baths, showers, and residential laundries that can be treated and reused. It does not include water from kitchen sinks or dishwashers.
Indirect potable reuse	The planned incorporation of reclaimed water into a raw water supply such as in potable water storage reservoirs or groundwater aquifer, resulting in mixing and assimilation, thus providing an environmental buffer.
Rainwater harvesting	Runoff captured from rooftops or other hard surfaces that can then be used for beneficial use after minimal treatment.
Reclaimed water	Municipal wastewater that has gone through various treatment processes to meet specific water quality criteria with the intent of being used in a beneficial manner such as irrigation. The term recycled water is often used synonymously with reclaimed water.
Wastewater	Used water discharged from homes, businesses, and industry.
Water reuse	The use of treated wastewater for a beneficial use, such as irrigation or industrial cooling.



# Water Reuse

- **Match use to desired quality**
- **Regulations vary with type of use**
- **States determine quality for use of treated wastewater effluent**
- **Other uses more leeway**
- **Water rights variable and must be checked**



# Water Reuse Categories and Typical Applications

Category	Typical Application
Irrigation	<ul style="list-style-type: none"> <li>Parks</li> <li>School yards</li> <li>Highway medians</li> <li>Golf courses</li> <li>Cemeteries</li> <li>Parade grounds</li> <li>Athletic fields</li> <li>Building landscapes</li> <li>Crops or vegetable gardens</li> </ul>
Industrial recycling and reuse	<ul style="list-style-type: none"> <li>Cooling water</li> <li>Boiler feed</li> <li>Process water</li> <li>Construction</li> </ul>
Groundwater recharge	<ul style="list-style-type: none"> <li>Groundwater recharge</li> <li>Saltwater intrusion control</li> <li>Subsidence control</li> </ul>
Recreational/environmental uses	<ul style="list-style-type: none"> <li>Lakes and ponds</li> <li>Marsh enhancement</li> <li>Streamflow augmentation</li> <li>Fisheries</li> </ul>
Nonpotable urban uses	<ul style="list-style-type: none"> <li>Fire protection</li> <li>Air conditioning</li> <li>Toilet flushing</li> <li>Water features</li> </ul>



# Army Examples

- Irrigation
- Vehicle washing
- Aquifer recharge
- Cooling towers
- Environmental enhancement



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# Central Vehicle Wash Facility



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# Rainwater Harvesting



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**Long history**

**Catchment structures date back 5000 years**

**Negev Desert,  
Greece, Italy,  
Egypt, Turkey,  
Mexico**



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# Why Rainwater Harvesting?

**Climate change**

**Water shortages – Augment supply**

**Save resources**

**Maintain local control**

**Insure reliability of supply**

**Mitigate flooding**

**Reduce erosion**

**Reduce hydraulic loading**

**Requires little energy input**

**Excellent water quality**

**LEED points – percent water savings, storm water reduction,  
reduction of sewage from potable water**

**Most water used on installations does not have to be of drinking  
water quality.**

**Beneficially use water which would normally be discarded as  
stormwater**



# Rainwater Harvesting

**Ideal for large barracks, industrial or commercial/institutional buildings**

**Also applicable to expansive parking lots**

**Water stored in tanks or ponds – reducing runoff**

**Stored water can be used indoors – filtered and treated – fixture flushing, laundry, cooling tower, boiler makeup**

**Outdoors – irrigation, water features**

**Some areas use for potable purposes**

**Result – reduces overall demand for municipal water**



# Standards

- **No national standards**
- **Plumbing Codes Changing - Currently UPC and IPC do not directly address rainwater harvesting in potable or stormwater sections causing confusion**
- **Definitions – UPC**
- **Harvested rainwater – Conveyed from a building roof, stored in a cistern and disinfected and filtered before being used for toilet flushing, can also be used for landscape irrigation**
- **States and local jurisdictions have developed standards or guidelines**
- **Ex. Texas – State promotes for any use including potable provided appropriate treatment**
- **Portland, OR – Use for nonpotable applications**
- **Draft guidelines suggested by American Rainwater Catchment Systems Association**
- **Many states and municipalities established or establishing rules – OH, KY, HI, AZ, NM, WA, WV, TX and others**
- **Rules, ordinances, building codes etc. run gamut from requiring RWH systems in new construction to prohibiting tanks as an eyesore**



# Components of a Rainwater Harvesting System

Catchment Surface/Collection Area

Conveyance

Roof Washer (Prefiltration)

Primary Settling Tank

Storage

Distribution

Purification

Screens, Debris Excluders, Etc



Siphonic filter



Downspout filter

Disinfection array with pump, filters and UV lamp





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# Candidate Buildings and Locations

## Best candidates

Simplest Collection Point – Roof

Ex. Low to Mid-rise Buildings Best Ratio: Roof Area to Toilets

However, Nearly Any Building Can be Used

## Development of An Active Rainwater Harvesting System

System size - L,M,S?

How complex – “Active” or “Passive”?

Permissible costs?

System requirements - Intensity of use, level of commitment, water security?

Intended use of the system? Irrigation, potable, other?

What water quality is required?

## Water Balance Analysis

Allows designer to determine how much rainwater can be collected.

Provides a supply and demand analysis on a monthly or quarterly basis

Examine variables of rainfall and water demand

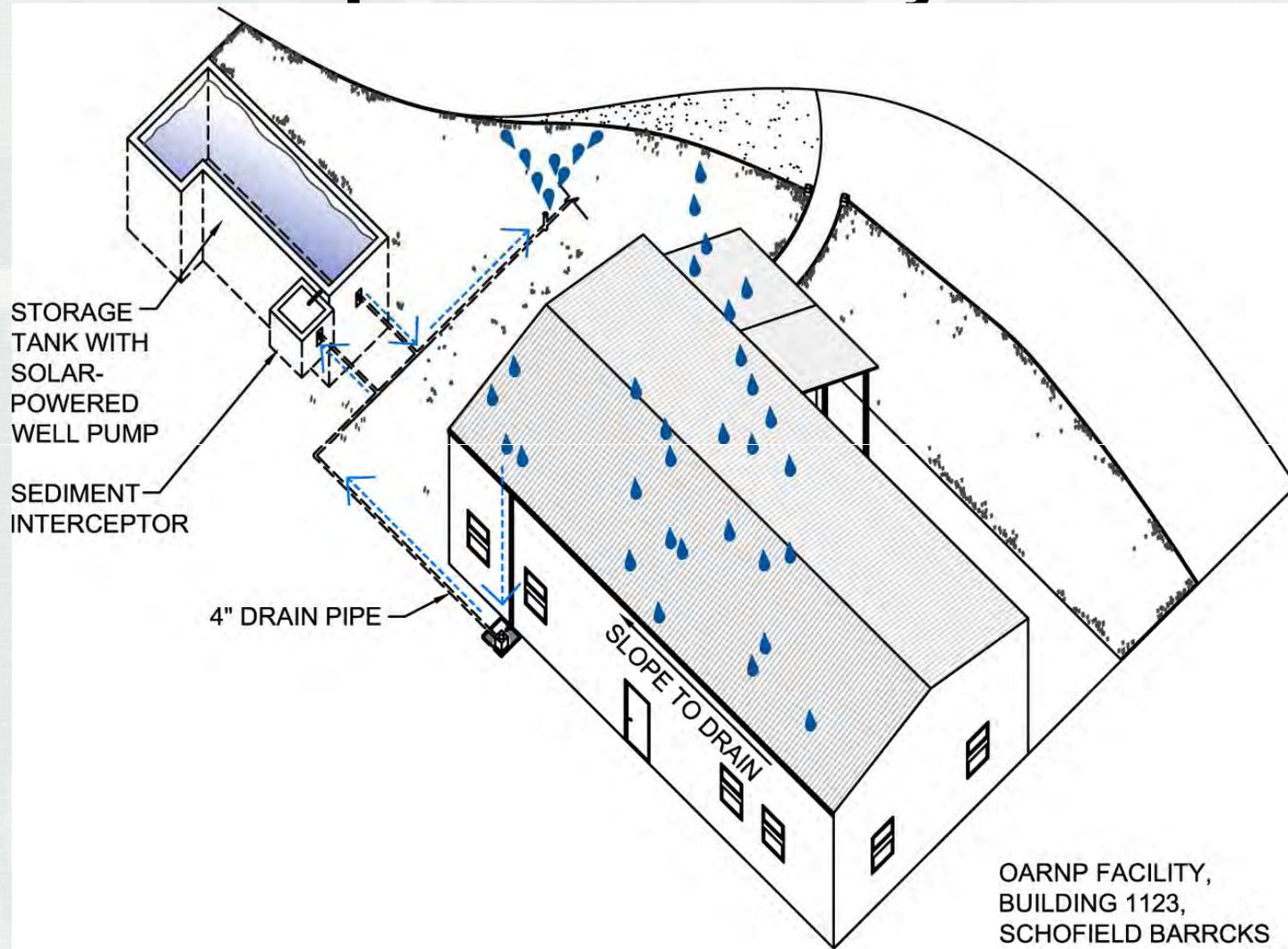
Determine cistern capacity – Is backup potable available or not?

Theory – 1 inch of rain on 1000 square feet of nonpermeable surface provides 620 gallons

Estimate demand



# Simplified RWH System



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# RWH Systems for Livestock and Wildlife

From: Texas Cooperative Extension TAMU

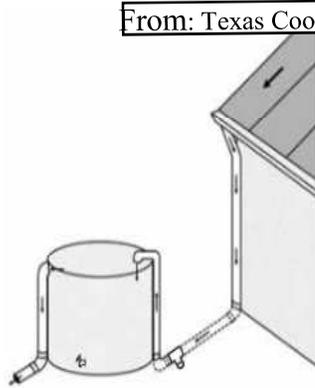


Figure 1. A typical rainwater harvesting system uses a roof, gutters, downspout and pipes underground, and backup into the top of the collection tank. This prevents livestock from damaging the pipes and allows the tank to be much further away from the shed. Unless there is a drain along the lower pipe, the standing pipes will contain water that is susceptible to freezing.

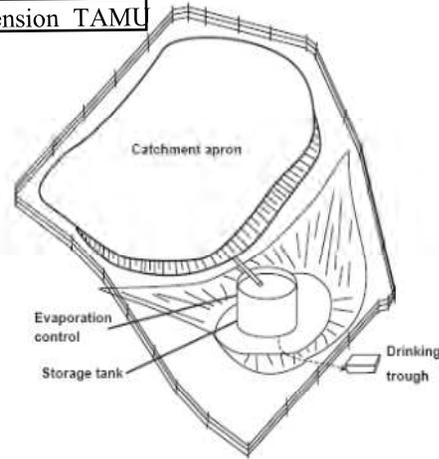


Figure 2. This rainwater harvesting system uses a prepared surface of concrete, rock or a sealing material to shed the rainfall. The rainwater is then diverted into the top of the collection tank.



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# Military Experience

- **Army Experience**

- ▶ Limited in CONUS, HI and Guam have potable collection facilities
- ▶ Buildings have been designed with focus on nonpotable applications

- **Lessons learned**

- ▶ During design phases increase coordination between all engineering disciplines and improve technical drawings.
- ▶ Essential for design team to have familiarity with rainwater detention technologies.
- ▶ O&M staff need thorough training
- ▶ Buy-in is essential between designers and construction and O&M staff to be aware of water reduction goals of the project and be committed.
- ▶ Thoroughly review early construction documents to avoid change orders
- ▶ Require rainwater harvesting at the Request for Proposal level and emphasize life cycle costs over first costs





Kilauea Military Camp, Hawaii



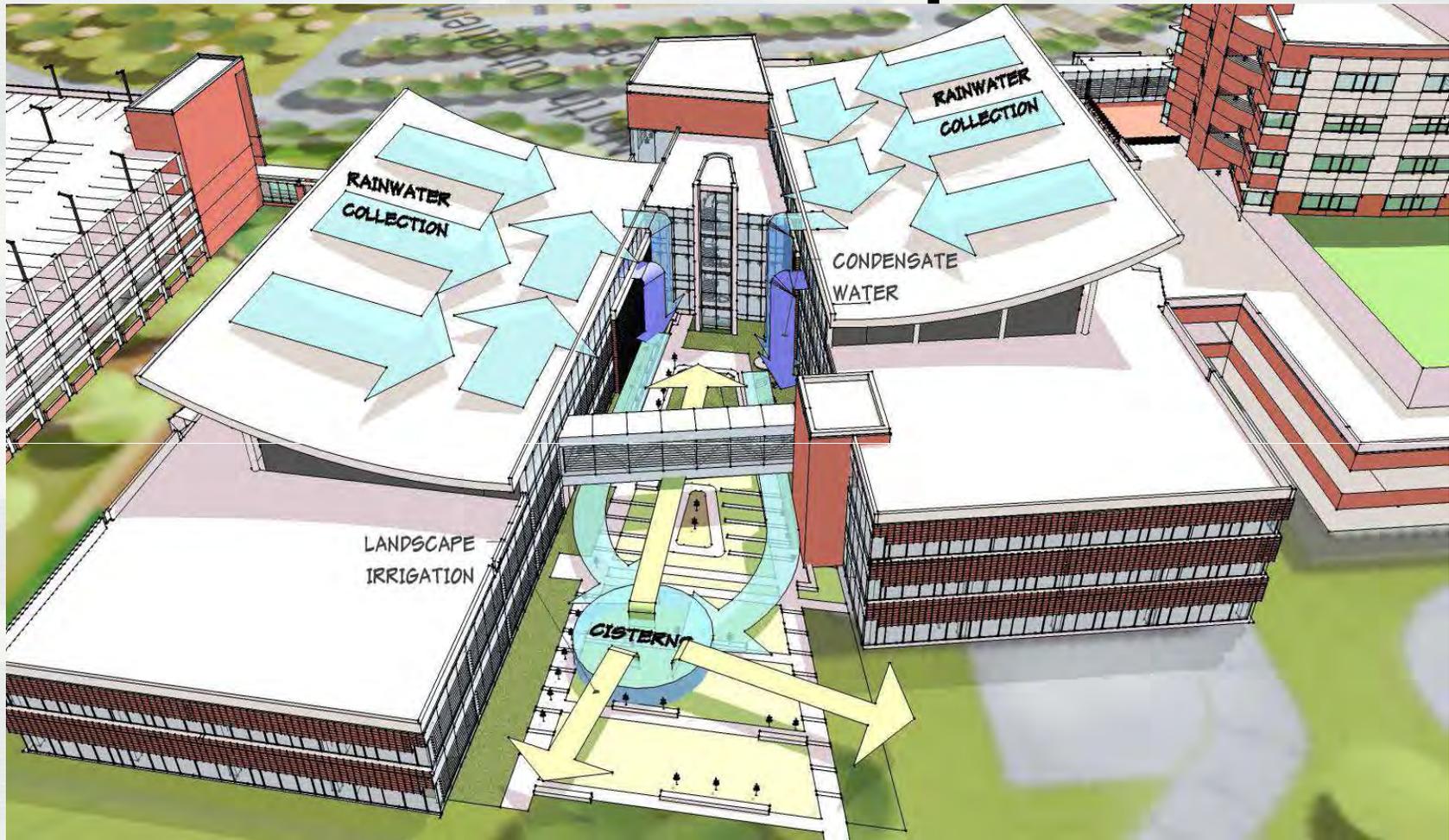
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# Army Example -Rainwater Retention Vaults

- **22,000 gallon precast concrete vault**
- **Roof runoff directed to vault**
- **Non-potable water pumped into buildings and used to flush toilets**



# Fort Belvoir Hospital



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# UT School of Nursing



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# Graywater Reuse

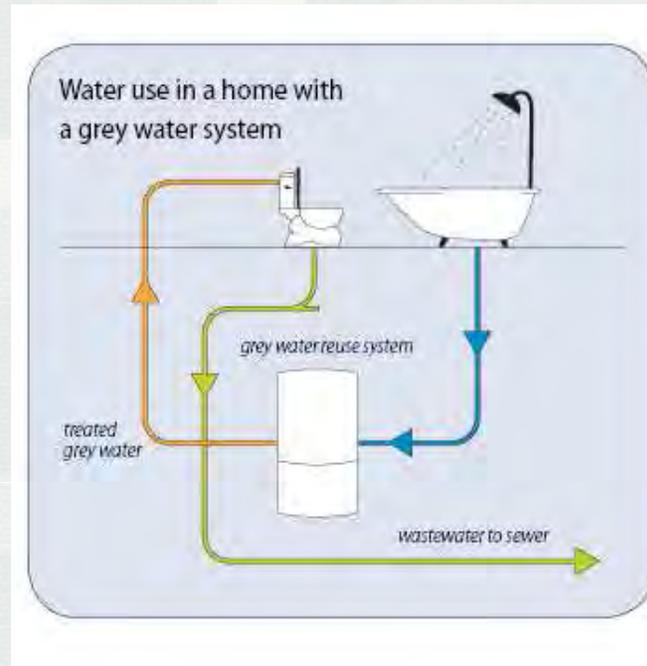
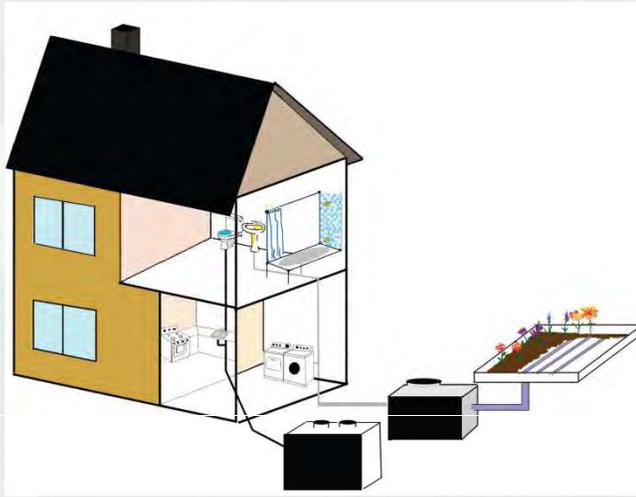


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# Definitions

**Graywater = Greywater = Gray Water = Grey Water**



**Graywater is used water from bathroom sinks, showers, and laundry**

**Blackwater**

**Toilet, kitchen wastewater**



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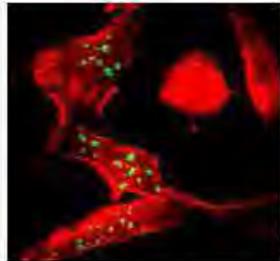
# History of Graywater Use

- **Long history in arid parts of the U.S.**
  - ▶ **Common in rural areas**
  - ▶ **Technically still illegal in many places, approval spreading**
  - ▶ **May get 40 gallons per day per person**
  - ▶ **States vary in acceptance, regulations**
  - ▶ **Technology to use – highly variable**
    - **Rinse water from washer for next load**
    - **Direct discharge to irrigation**
    - **Or complex treatment**
    - **Living systems – water plants and sand filtration**
    - **Often minimal treatment then underground irrigation system**
- **Many commercial package plants**
  - ▶ **Filtered, disinfected product – fairly expensive**

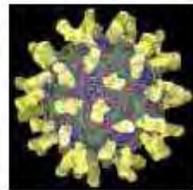


# Human and Ecological Hazards in Graywater Pathogens

(Water-based) Pathogens (Fecal)



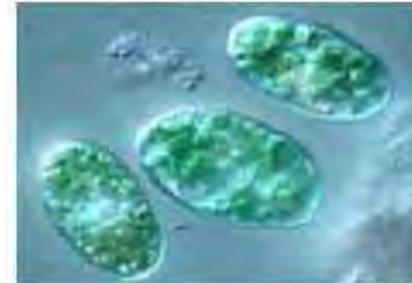
Lung  
macrophages



Viruses



Bacteria



Parasitic protozoa

## Chemicals



Cleaning agents



Pharmaceuticals  
Antibiotic resistance

20

From: Ashbolt 2010

# Attributes of Graywater

- **Biological**
  - ▶ **Microorganisms**
- **Chemical**
  - ▶ **Dissolved Salts – sodium, nitrogen, phosphates, chloride**
  - ▶ **Others – oils, fats, soap, detergents**
- **Physical**
  - ▶ **Soil, lint**
- **Compared to conventional wastewater**
  - ▶ **Lower in BOD**
  - ▶ **Lower in Suspended Solids**
  - ▶ **Lower in nitrogen**
  - ▶ **Lower in phosphorous**
  - ▶ **More alkaline**
  - ▶ **Higher in salts**



# Using Graywater

- **Advantages**
  - ▶ **Saves water**
  - ▶ **Less discharge**
  - ▶ **Less energy and chemical use**
  - ▶ **Recovery of nutrients**
  - ▶ **Reduction of hydraulic load to existing systems**
  - ▶ **On-site reuse, water already available, no delivery cost**
  - ▶ **Indoor or outdoor options**
- **Disadvantages**
  - ▶ **More costly**
  - ▶ **May decrease flow to sewage plant**
  - ▶ **Potential for spreading disease through human contact if not properly handled or treated**
  - ▶ **Damage to soil long-term?**
  - ▶ **Potential odors in surge or storage tanks**



# Concerns

- **Regulations – constantly evolving**
- **States vary**
- **Plumbing codes vary**
- **Usually use for sub-surface or drip irrigation**



# Concerns for Indoor Use

- **Collection system**
- **Prefilter**
- **Storage**
- **Makeup water**
- **Filtration**
- **Disinfection**
- **Identification (labeling and dyeing)**
- **Distribution**
- **Permit to construct**



# What are the Barriers to Graywater Reuse?

- **Consumer perception with use of lower quality water.**
- **Inexpensive cost of potable water for many regions.**
- **Lack of plumbing infrastructure to accommodate partially treated water.**
- **Lack of enabling regulatory codes.**
- **Lack of product evaluation standards.**
  - ▶ **NSF standard now available**



# Controversy?

- **Why? Potential health threat**
  - ▶ No cases reported
- **No national guidelines**
- **More states becoming proactive in encouraging use**
- **Lobbying at federal level for recognition for use**
- **Guidelines vary internationally**



# Towards Broader Acceptance

- **Federal demonstration interest**
- **Research interest by USEPA, CDC, DoD, WaterReuse Research Foundation, Water Environment Research Foundation (WERF), other**
  - ▶ **Ex. Research needs symposia with focus on health aspects**
  - ▶ **Ex. Drainline research**
- **Academia promotion and use**
- **Code development**



# Towards Standardization and Wider Use

- **NSF standard 350**
  - ▶ **For onsite water/wastewater treatment reuse products**
  - ▶ **Includes protocols for graywater systems and wastewater systems**
- **Incorporation into plumbing codes**
- **Addressing manufacturers' concerns**
- **Acceptance in federal and DoD guidelines**



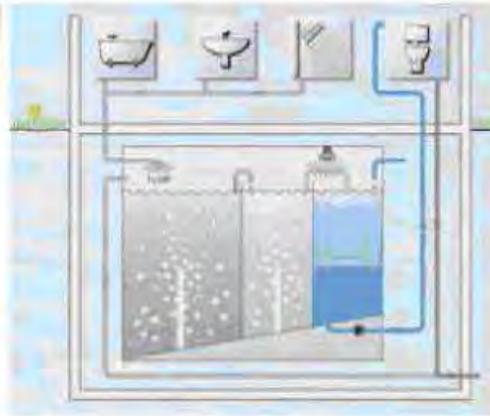
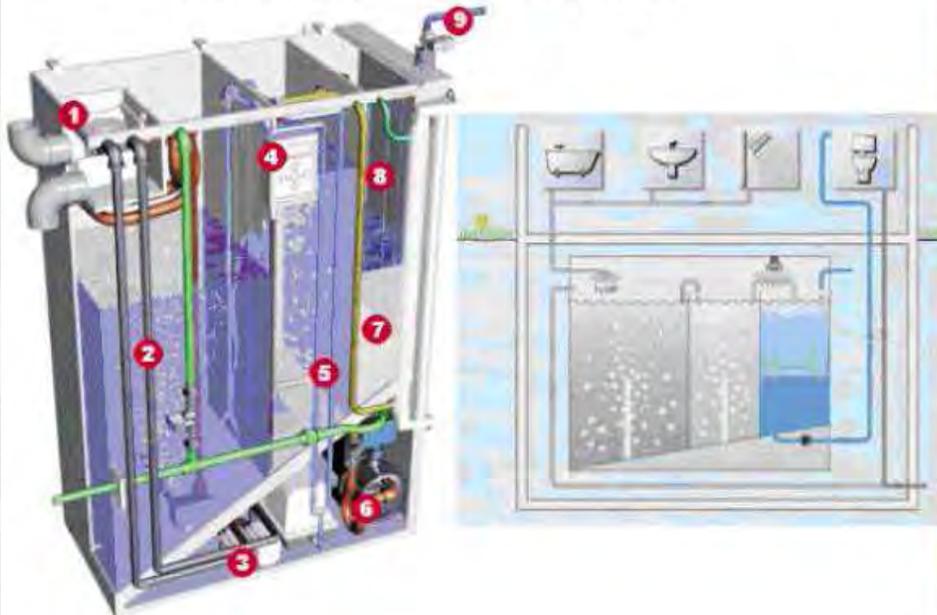
# Demonstration at UGA

- **UGA dormitory with 300 tank style toilets –+550 Students**
  - ▶ **Testing protocol**
  - ▶ **Water samples for a one year period**
  - ▶ **Influent**
  - ▶ **Effluent**
  - ▶ **Holding tank water**
  - ▶ **Toilet tank water**
- **Determine via auditing the maximum duration of toilet tank water dwell time**
- **UGA will use campus lab to test water samples**
- **Controlled study of a shower influent graywater system**



# Many European Manufacturers

- Twin-Flow, a trade mark of the German Soltech company.
- AquaSave Project - Italian
- Hansgrohe Pontos - German
- Eco Play - European

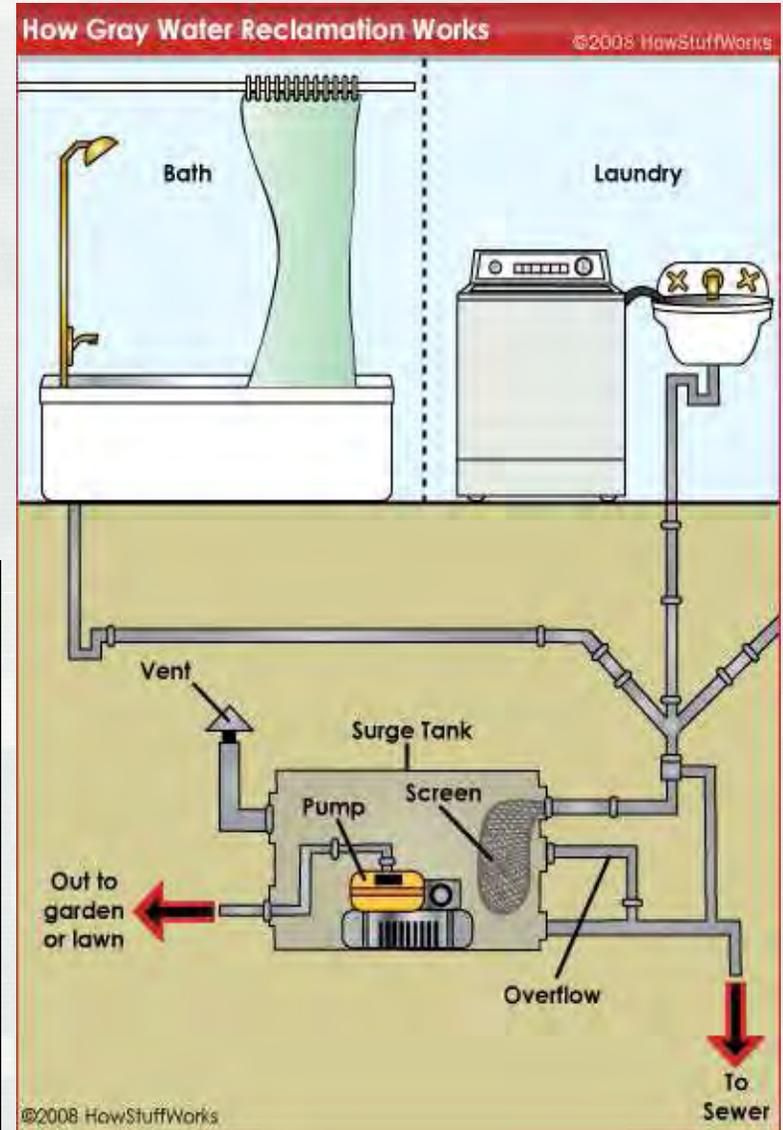


# When to Use

- **Best in new construction**
- **Estimate graywater production**
- **Office –probably not**
- **Barracks – potentially**
- **Cost-effective? Water restrictions?**
- **Determine applications – end use**
- **Separate systems**



# Graywater Treatment

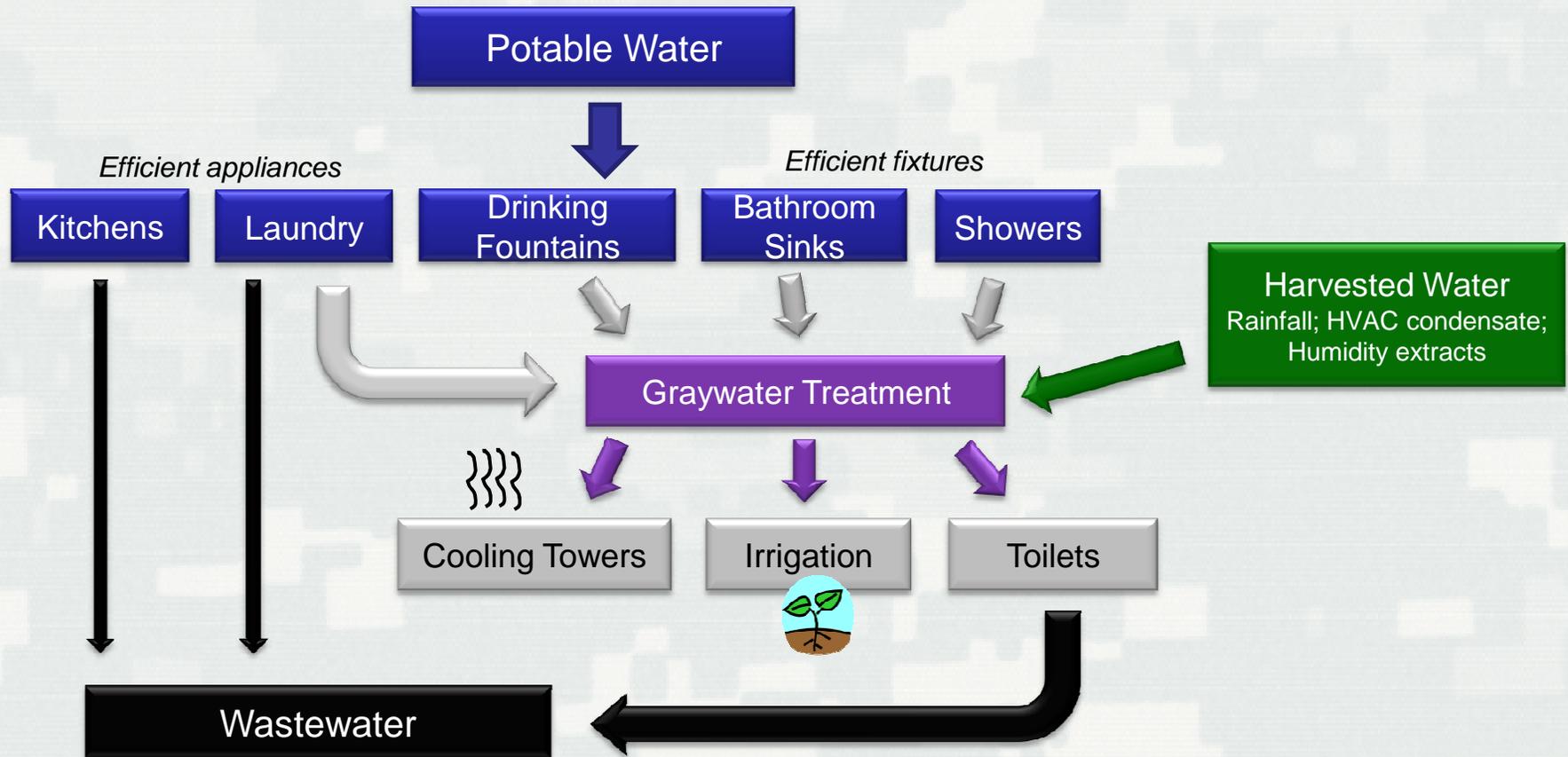


# Tri-Service ESTCP Project

- **Partners: ERDC-CERL, NFESC, AFCEE**
- **Reduce potable water consumption by 35%**
- **3 buildings**
- **Looking at centralized and distributed graywater treatment and reuse system**
- **Combining graywater with rainwater and AHU condensate**
- **Use high efficiency fixtures**
- **Technical risks: implementation and acceptance**
- **Assumptions: state laws, plumbing code and public health requirements will be met**
- **Estimate 9.5 year payback**



# Cascade Concept



**Use all water efficiently.**

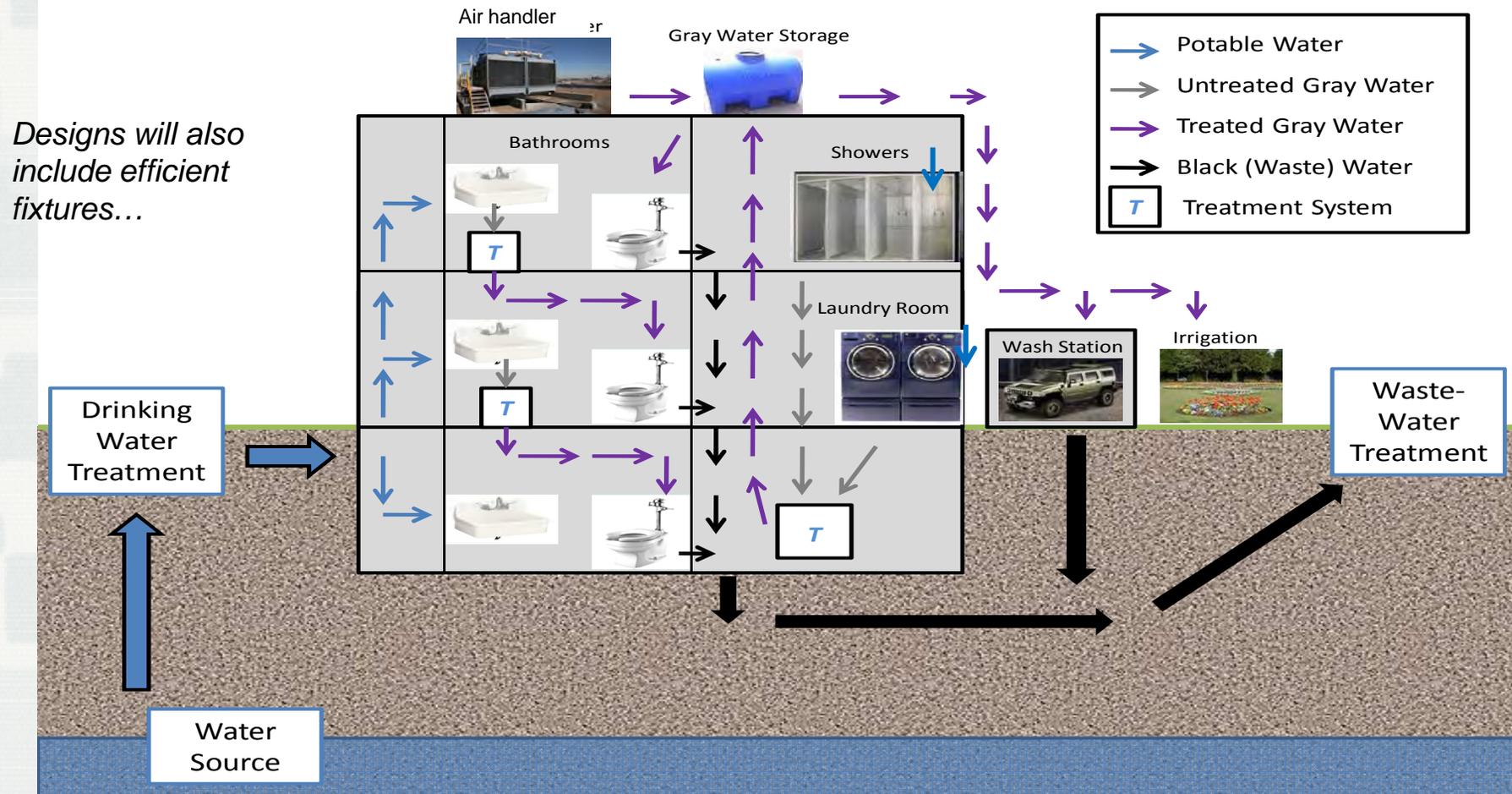
**Harvest and reuse water in a practical manner.**

**Match water quality with the appropriate end use.**



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# Example Cascading System



# Water Use at Contingency Bases

- **Main concern is managing consumption and effective use of water**
- **13 gpcd standard – basic subsistence**
- **20-30 gpcd apparent use, depending on size, begin to add more functions, i.e. laundry, wash rack**
- **Goal: Maintain quality of life while reducing amount**



# Contingency Base Concerns

- **Water = Fuel, Extremely valuable commodity \$5 -\$50 per gallon**
- **Security is a concern**
  - ▶ **Minimize convoy traffic**
- **70-80 percent of resupply weight is fuel and water**
- **Future: Congress in general may take an interest, water will be a likely focal area**
- **Maintain compatibility with legacy systems and transition**
- **Simplicity desirable**
- **On base wells are preferable**

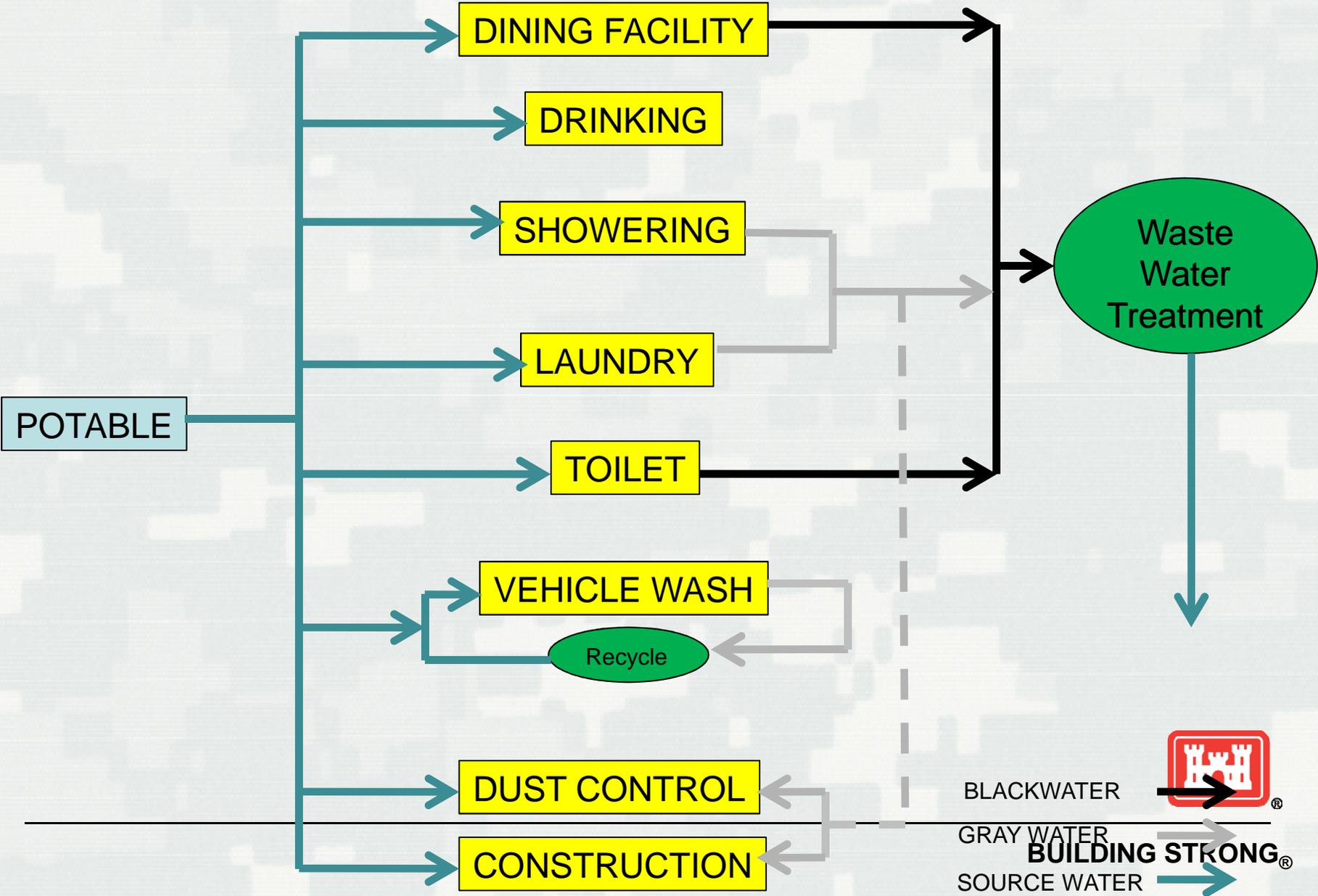


# Contingency Base – In-theater Definitions

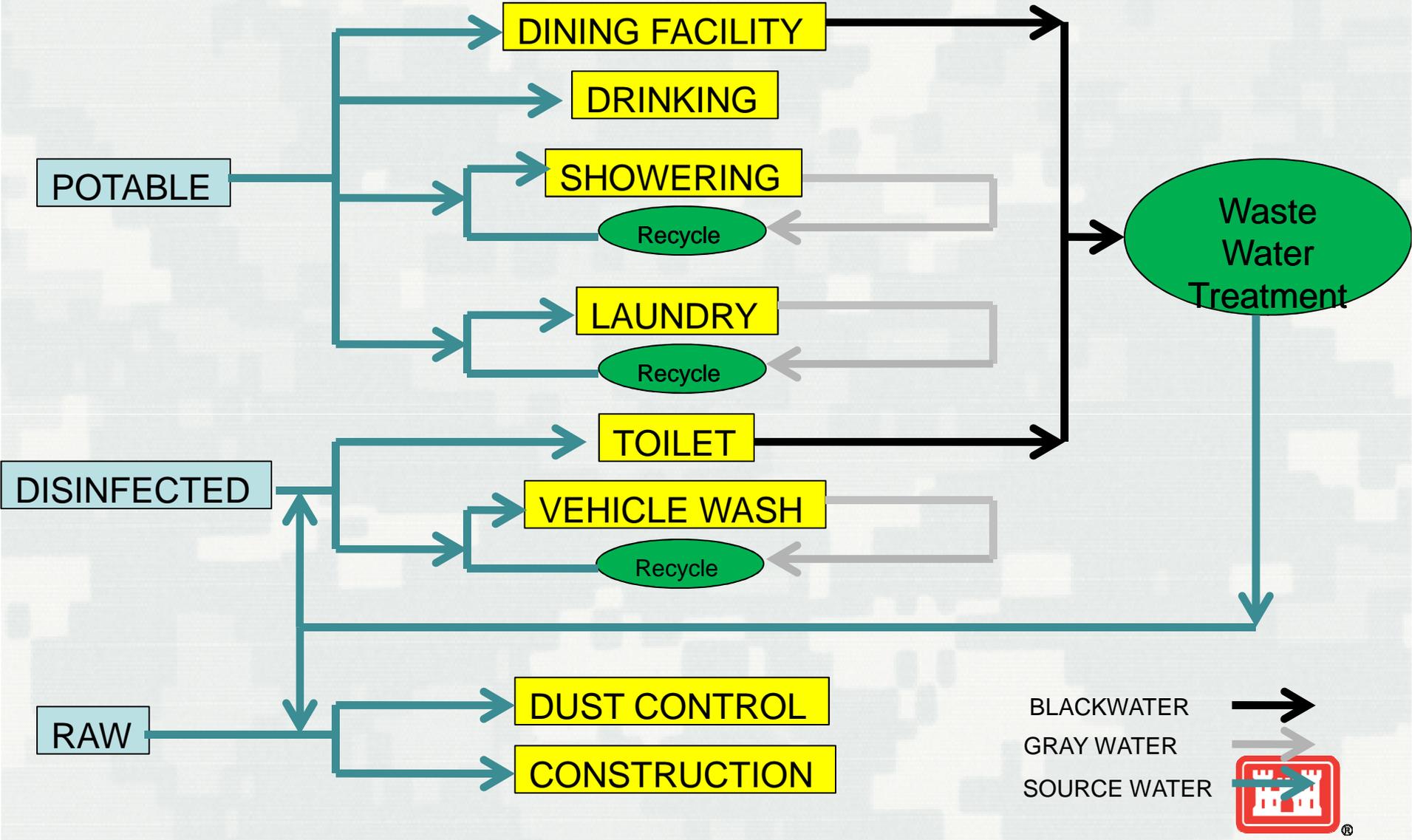
- **White – potable water**
- **White – nonpotable, used for showers, laundry**
- **Black- Sanitary waste stream**
- **Gray – everything else that's not black water, example: washrack**



# Current Contingency Base Water Usage Flow



# Contingency Base Water Reuse Concept



# Waste Water Reuse



**Mobile Wastewater Treatment**

- **Ultraviolet treatment for dust control**
- **Chlorination for toilet flushing**
- **Membrane filtration for vehicle washing or other contact activities**



# Water Reuse: Semi Closed Systems

## Vehicle Wash Facilities

- Recaptures/filters/recycles up to 50% of water used
- Generally self-contained



# Water Reuse: Semi Closed Systems

## Shower Water Reuse System



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# Shower Reuse System

- **Developed by Natick Laboratory**
- **Attached to shower unit of Force Provider System**
- **40 gpm**
- **Filtration and membranes to remove soap, organics, viruses, bacteria**
- **Chlorine injection**



# Shower Water Reuse System

- **Recaptures 75-80% of gray water**
- **Treatment to potable quality**
  - ▶ **15 micron filter to remove hair**
  - ▶ **Micro-filter for suspended solids**
  - ▶ **Chlorination**
  - ▶ **Reverse osmosis for organic materials, bacteria, soap**
  - ▶ **Carbon filtration**



# Water Reuse: Semi Closed Systems

## Mobile Laundry

- Developed by Natick Laboratory
  - Processes 500 Soldiers worth of laundry per day
  - Uses 2000 liters of water per day: recycles 97%
  - Produces 150 liters waste water per day
- 



# Conclusions

- **Some Army installations may face water shortages limiting mission**
- **Water reuse and wastewater recycling are essential strategies to alleviate water scarcity and reduce use of potable water**
- **Army promotes water reuse and already reuses recycled wastewater for several applications**
- **Mandated potable water use reductions not being met, additional water reuse is needed**
- **Demonstrations of water reuse must be conducted to show applicability**



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# Summary

**Water is an essential resource vital to maintain quality of life and support the military mission**

**Military demands only one of many sectors needing water**

**Numerous drivers promote water efficiency/water reuse**

**Current practices and supplies are insufficient for the future**

**Must use less or find new sources or supplies**

**Match water quality with needs**

**New/emerging technologies should be demonstrated/adopted/validated**

**Variety of options exist for water reuse and to identify additional sources for activities**

**Health considerations important**

**Regulations changing and variable**

**U.S. playing catch-up**

**Contingency bases have completely different rules**



# Putting it All Together

- In the future look at self-contained community concept using water resource fully prior to release to the environment or recharge - example



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# Collect, Recharge, Reuse



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