

This presentation premiered at WaterSmart Innovations

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The U.S. Army and Graywater – Current Status

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Water Smart Innovations

Las Vegas, NV

4-7 October 2011



US Army Corps of Engineers
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- Thanks to Mal McLeod and USACE for sponsorship of the Public Works Technical Bulletin program
- A PWTB on Graywater is available on the Whole Building Design Guide website





Water Thoughts



- **“Water is the oil of the 21st Century.” Andrew Liveris, CEO, Dow, 2008**
- **Half the world does not have access to an adequate, safe water supply**
- **“Water has become a highly precious resource. There are some places where a barrel of water costs more than a barrel of oil.” Lloyd Axworthy, 1999, Foreign Minister of Canada**
- **“Water is the best of all things.” Pindar**
- **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**



True Cost of Water

- **Water itself**
- **Wastewater disposal**
- **Energy for heating, pumping, treating**
- **Pretreatment for some wastewater**



Decreasing Supply

- Over Withdrawal
- Climate Change
- Cost and Financing
- Quality Degradation



Overview

- Background
- Water Issues
- Graywater
- Summary



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
- Some military water/wastewater systems are privatized
- 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**



Background

- **Water - Historically, Low Rates**
 - ▶ Department of the Army installations used over 41 billion gallons of potable water at a cost of \$67.4M in FY10.
 - ▶ By 2013, 36 states will face shortages
 - ▶ ASCE Scorecard for Infrastructure – Drinking Water D-
 - ▶ North America – 12.3 percent non-revenue water
 - ▶ Leaks – 7 billion gallons per day in U.S.
 - ▶ 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



Net Zero Installations

- **“A Net Zero Water Installation limits the consumption of freshwater resources and returns water back to the same watershed so not to deplete the groundwater and surface water resources of that region in quantity or quality over the course of a year.”**



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



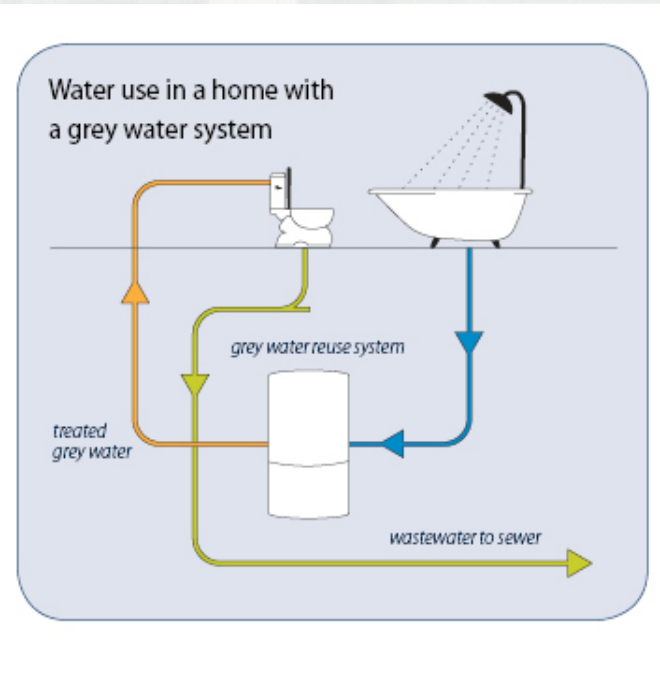
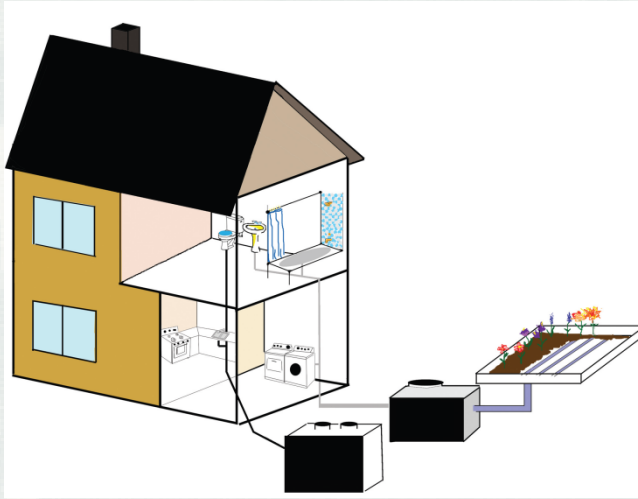
What People Think



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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

Reclaimed water

Wastewater treated to high standards at municipal treatment facilities, delivered to customers via "purple pipe" system



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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
 - ▶ 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



Graywater Sources and Percent of Household Flow

Source	Percent	Category
Toilet	40	Blackwater
Kitchen waste	10	Blackwater
Misc	5	Graywater
Laundry	15	Graywater
Bath/Shower	30	Graywater



Quality of Graywater

- **Biological**
 - ▶ **Microorganisms**
- **Chemical**
 - ▶ **Dissolved Salts – sodium, nitrogen, phosphates, chloride**
 - ▶ **Others – oils, fats, soap, detergents**
- **Physical**
 - ▶ **Soil**
 - ▶ **Lint**



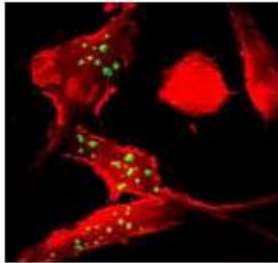
Compared to Combined Wastewater

- **Lower in BOD**
- **Lower in Suspended Solids**
- **Lower in nitrogen**
- **Lower in phosphorous**
- **More alkaline**
- **Higher in salts**

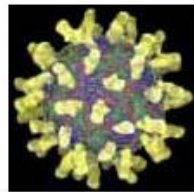


Human and Ecological Hazards in Graywater Pathogens

(Water-based) Pathogens (Fecal)



Lung
macrophages



Viruses



Bacteria



Parasitic protozoa

Chemicals



Cleaning agents



Pharmaceuticals
Antibiotic resistance

20

From: Ashbolt 2010

Using Graywater Advantages

- ▶ **Saves water**
- ▶ **Less discharge**
- ▶ **Less energy and chemical use**
- ▶ **Recovery of nutrients**
- ▶ **Reduction of hydraulic load to existing system**
- ▶ **Reuse of water onsite**
- ▶ **Water already available onsite; no more cost or energy needed to deliver water.**
- ▶ **Indoor or outdoor uses**



Using Graywater 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 for Indoor Use

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



Other Concerns

- **Fixture flushing**
- **Cooling towers**
- **Irrigation**

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



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.**



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**



Considerations for Endpoint Devices

- What is the average PPM output of the system
 - Potable water averages 1.5 to 4 ppm
 - Excess PPM will cause degradation of the internals of the tank for gravity type and degradation of the u-cups in piston valves - See Photos
- What is the Turbidity of the system
 - How will this impact the disinfection characteristics of Chlorine? UV?
 - Is there concerns about discoloration of ceramic products
- Most Greywater systems prescribe a tank dwell time of less than 72 hours.
 - Consider flushing of dead legs in distribution system
 - Impact on toilet tanks
 - Main storage area
 - Below the flush line storage area

From: Strang, 2010



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Planning a Solution



Corrosion above the water line on Brass parts

Corrosion above the water line on metal parts



Maintenance Considerations



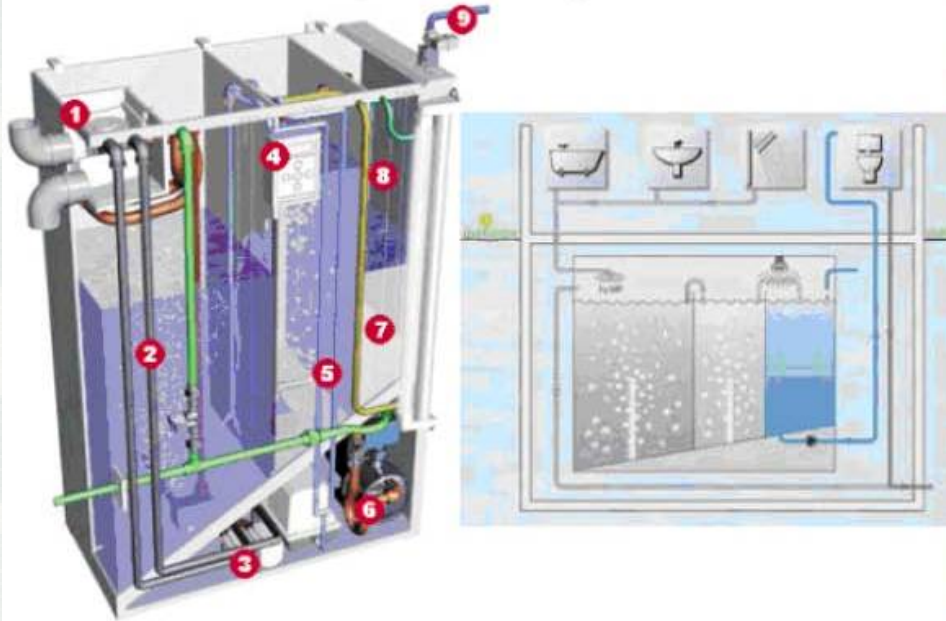
- 5 micron filter is recommended
- However, 3 micron is to remove protozoan parasites such as cryptosporidium and Giardia.
- Pressure differential gage or sensor to alert filter clogging
- UV standard for GA is 40 mJ/cm²
- PPE's for maintenance staff
 - Rubber gloves
 - Glasses
 - Mask
- **Maintenance is the single most impactful aspect related to a sustainable greywater systems**

From: Strang, 2010



Many European Manufacturers

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



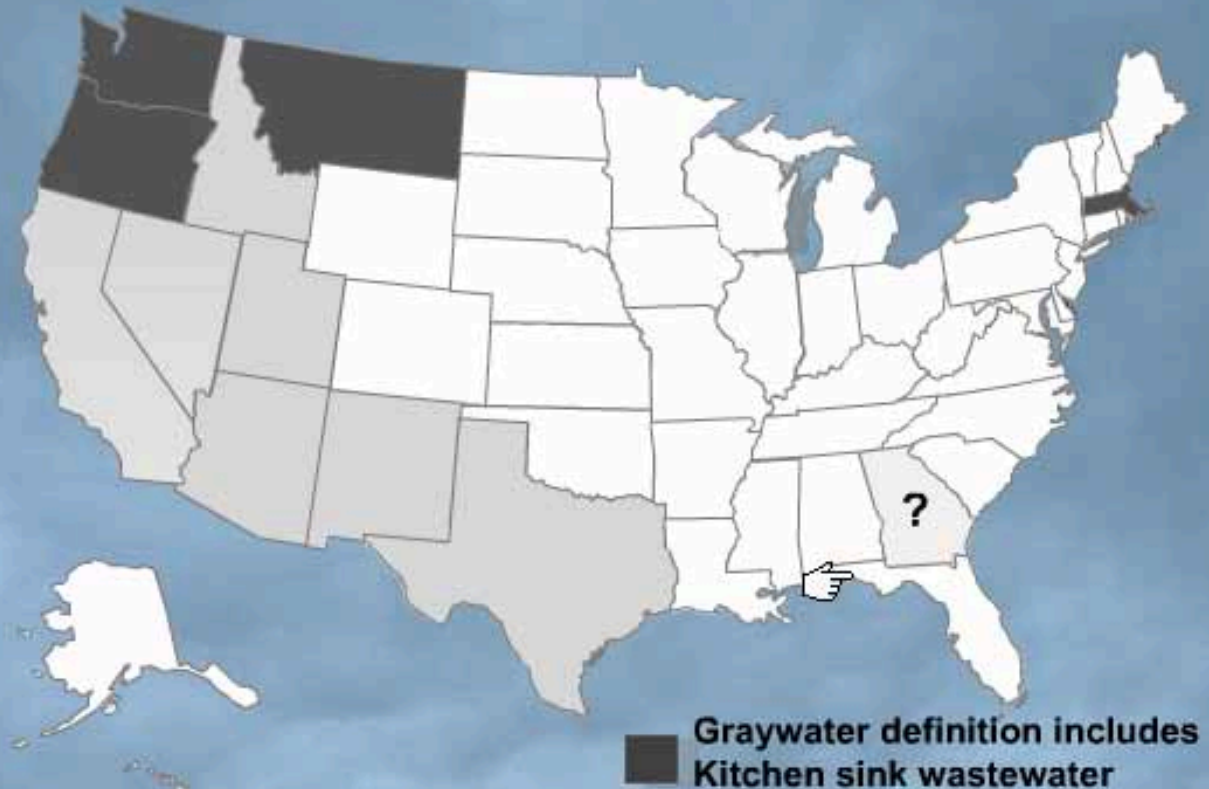
Towards Standardization and Wider Use

- **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**



States with Graywater Programs

- Arizona
- California
- Georgia (?)
- Hawaii
- Idaho
- Nevada
- New Mexico
- Texas
- Utah
- Washington
- Montana
- Oregon
- Massachusetts



Countries Actively Promoting Graywater Reuse

India, Israel, China, South Africa, Australia



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710.5 Non-potable water for plumbing fixture flushing water project elective. Where projects are intended to qualify for a *non-potable* water for plumbing fixture flushing *project elective* in accordance with Section 303.4, *non-potable* water shall be used for flushing water closets and urinals.

710.5.1 Water quality. *Non-potable* water for water closet and urinal flushing shall meet minimum water quality requirements as established for indoor flushing applications by local codes and regulations. Where chlorine is used for disinfection, the *non-potable* water shall contain not more than 4 mg/L of chloramines or free chlorine. Where ozone is used for disinfection, the *non-potable* water shall not contain gas bubbles having elevated levels of ozone at the point of use.

710.5.2 Filtration required. *Non-potable* water utilized for water closet and urinal flushing applications shall be filtered by a 100 micron or finer filter.

710.5.3 Labeling and signage. The entries to rooms having water closets or urinals that are supplied with *non-potable* water shall be provided with signage in accordance with Section 706.2.

INTERNATIONAL GREEN
CONSTRUCTION CODE™
PUBLIC VERSION 1.0

First Printing

Publication Date: March 2010

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INTERNATIONAL CODE COUNCIL,
INC.

*With the Cooperating Sponsorship
of*

American Institute of Architects

ASTM International

ISBN: 978-1-58001-630-8

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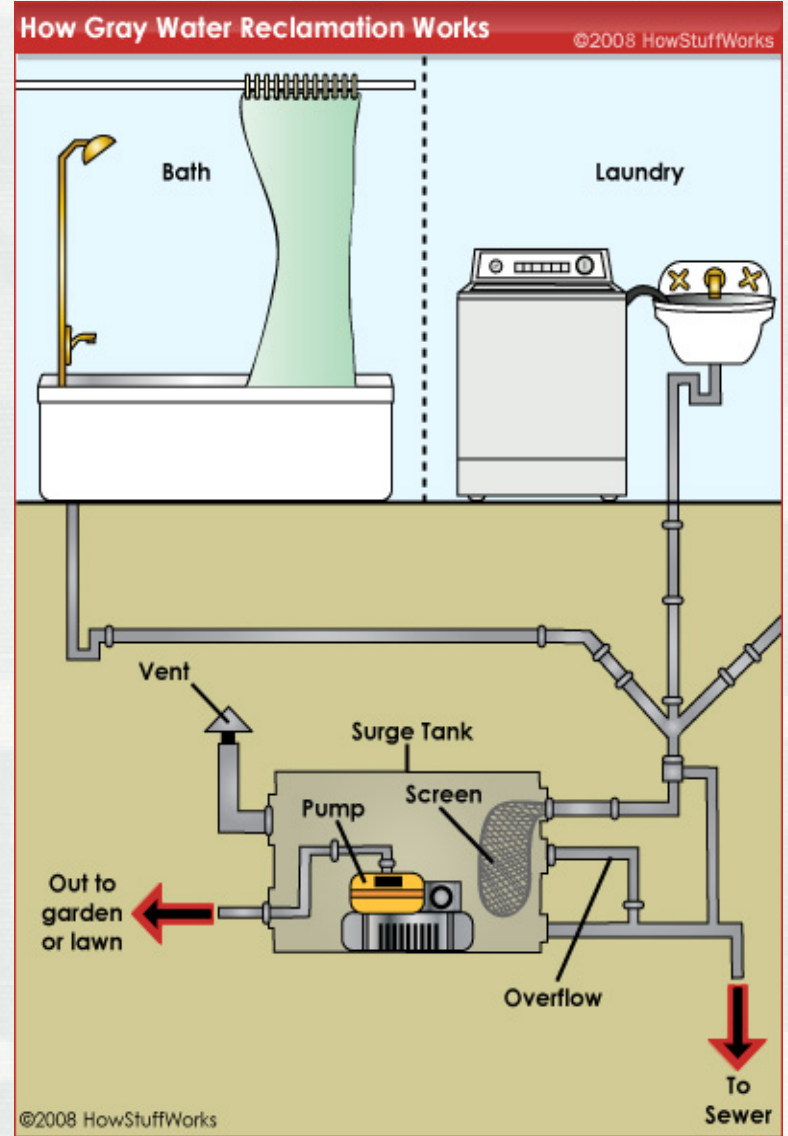
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When to Use

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



Graywater Treatment



Graywater Reuse Opportunities



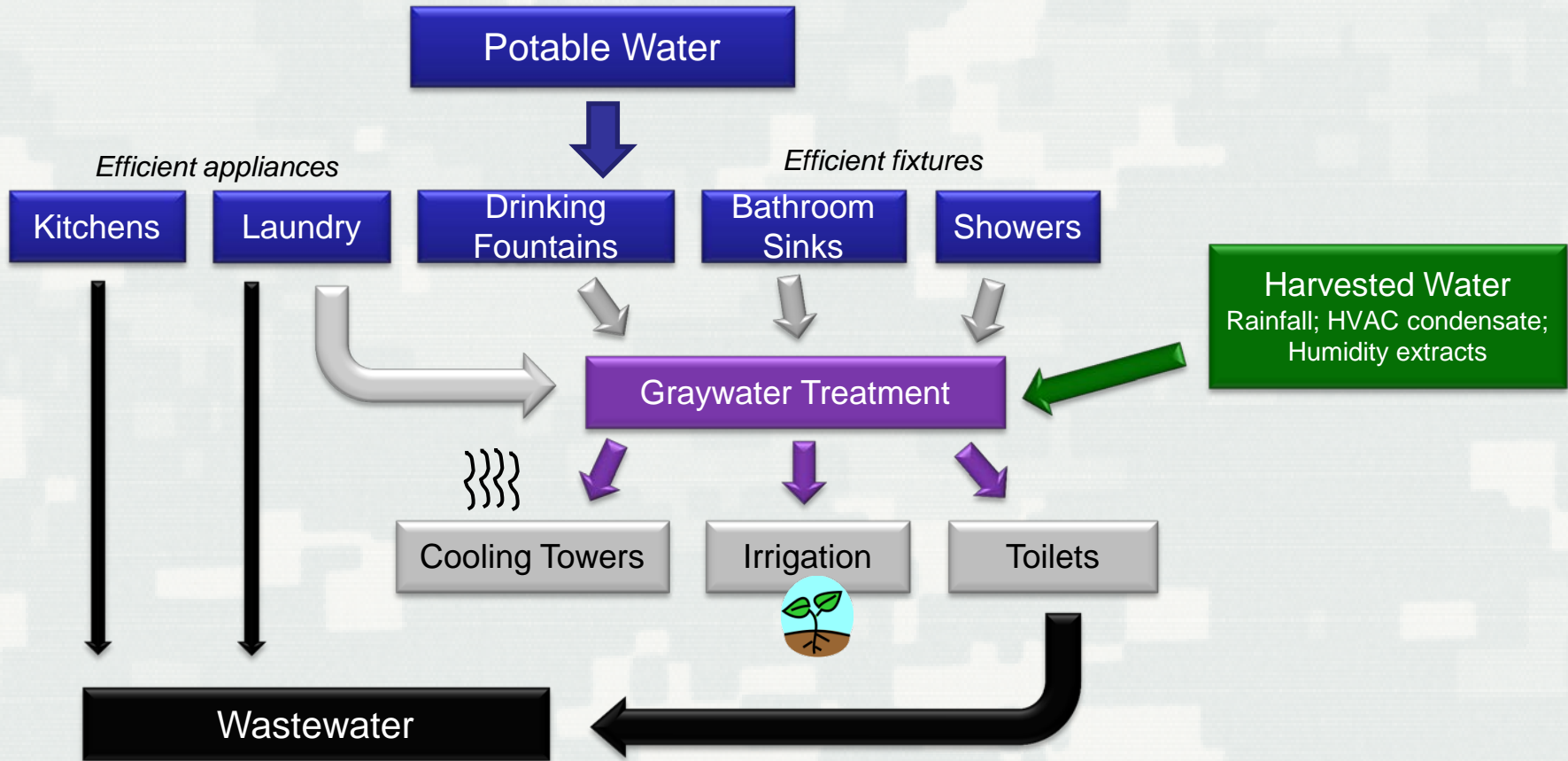
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Tri-Service ESTCP Project

- **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.

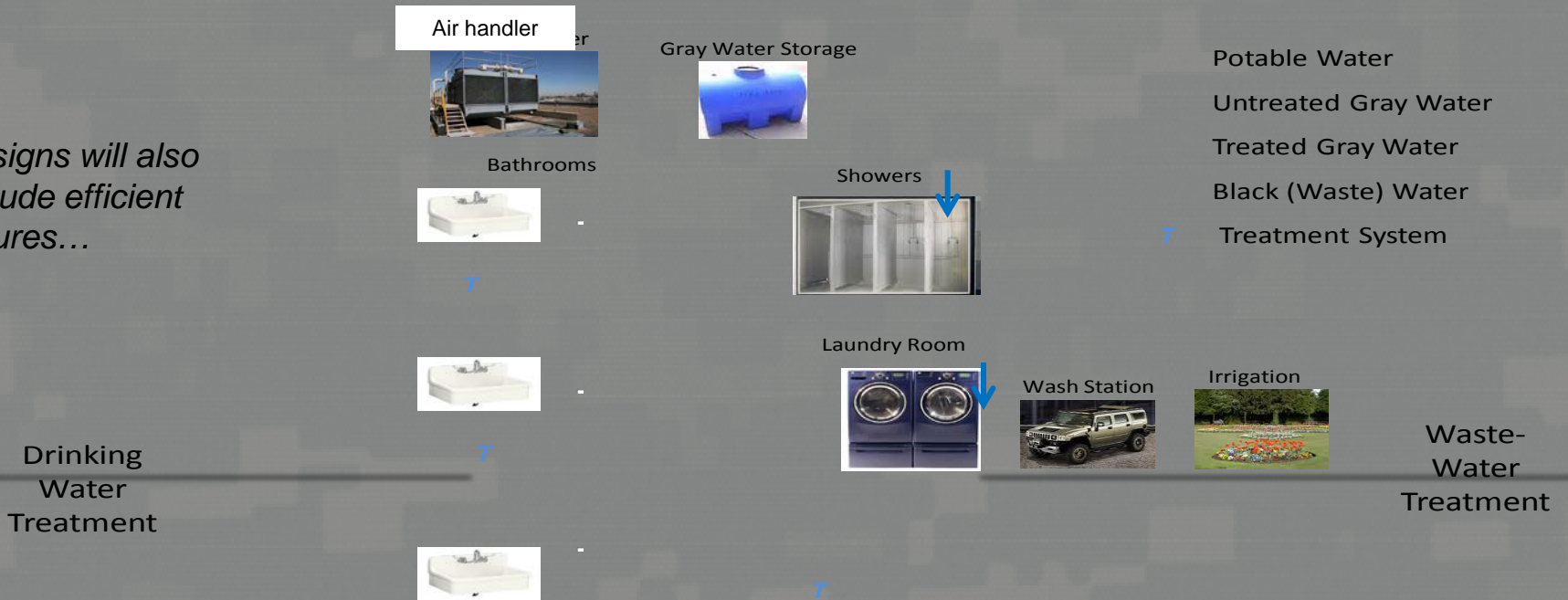
Harvest and reuse water in a practical manner.

Match water quality with the appropriate end use.



Example Cascading System

Designs will also include efficient fixtures...



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



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**

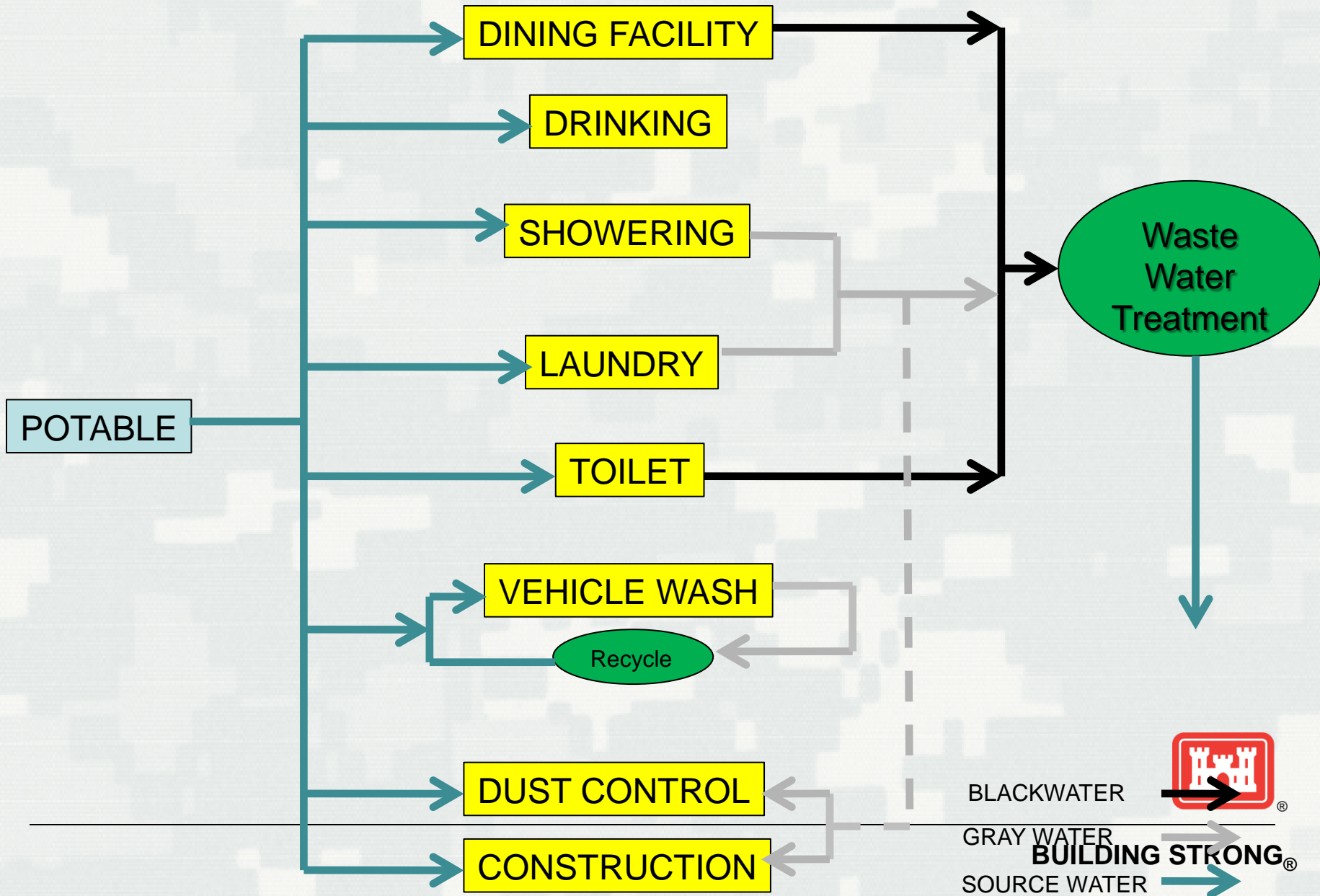


Contingency Base – In-theater Definitions

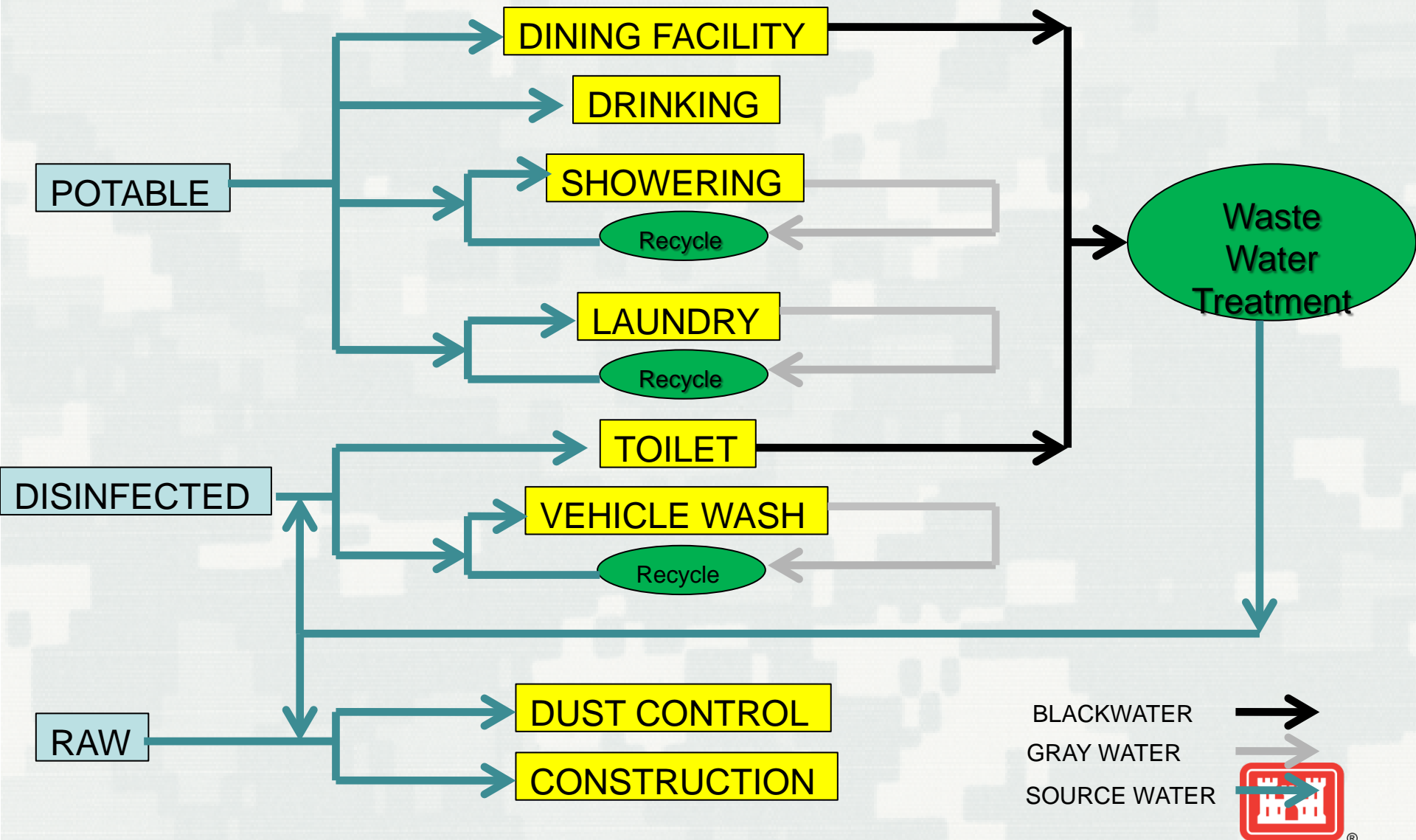
- **White – potable water**
- **White – nonpotable, used for showers, laundry**
- **Black- Sanitary waste stream**
- **Gray – everything else that's not black water, example: washrack**



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



Summary

- ▶ **Graywater use - One option to using less potable water**
- ▶ **Graywater quantities can be significant**
- ▶ **Using graywater for urinal and toilet flushing reduces potable use**
- ▶ **Saves user money by reducing potable water bill**
- ▶ **Stretches water supply supporting current uses and growth**
- ▶ **Reduce capital and operation expense for water treatment**
- ▶ **Saves energy by reducing potable water treatment costs**
- ▶ **Match water quality with end use**
- ▶ **Treatment processes variable**
- ▶ **Health considerations important**
- ▶ **Regulations changing and variable**
- ▶ **U.S. playing catch-up**
- ▶ **New/emerging technologies should be demonstrated/adopted and validated**
- ▶ **Contingency bases have completely different rules**



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Questions?

Contact information or for additional information or resources

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