

# Graywater Use by the Army – Is it Time Yet?

**Richard J. Scholze, Martin Page**  
US Army ERDC-CERL, Champaign, IL

Environment, Energy & Sustainability  
Symposium, New Orleans, LA

11 May 2011

12206



®

US Army Corps of Engineers  
**BUILDING STRONG**®



| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                                           | Form Approved<br>OMB No. 0704-0188                  |                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|-----------------------------------------------------------|-----------------------------------------------------|---------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. |                                    |                                     |                                                           |                                                     |                                 |
| 1. REPORT DATE<br><b>11 MAY 2011</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    | 2. REPORT TYPE                      |                                                           | 3. DATES COVERED<br><b>00-00-2011 to 00-00-2011</b> |                                 |
| 4. TITLE AND SUBTITLE<br><b>Graywater Use by the Army -Is it Time Yet?</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                    |                                     |                                                           | 5a. CONTRACT NUMBER                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5b. GRANT NUMBER                                    |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5c. PROGRAM ELEMENT NUMBER                          |                                 |
| 6. AUTHOR(S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                                           | 5d. PROJECT NUMBER                                  |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5e. TASK NUMBER                                     |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 5f. WORK UNIT NUMBER                                |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Army Engineer Research and Development Center,Construction Engineering Research Laboratory,PO Box 9005,Champaign,IL,61826-9005</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                    |                                     |                                                           | 8. PERFORMING ORGANIZATION REPORT NUMBER            |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                    |                                     |                                                           | 10. SPONSOR/MONITOR'S ACRONYM(S)                    |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     |                                                           | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)              |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |                                                           |                                                     |                                 |
| 13. SUPPLEMENTARY NOTES<br><b>Presented at the NDIA Environment, Energy Security &amp; Sustainability (E2S2) Symposium &amp; Exhibition held 9-12 May 2011 in New Orleans, LA.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                    |                                     |                                                           |                                                     |                                 |
| 14. ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |                                                           |                                                     |                                 |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |                                                           |                                                     |                                 |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                    |                                     | 17. LIMITATION OF ABSTRACT<br><b>Same as Report (SAR)</b> | 18. NUMBER OF PAGES<br><b>38</b>                    | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                                           |                                                     |                                 |

# Water Thoughts

- “Water is the oil of the 21<sup>st</sup> Century.” Andrew Liveris, CEO, Dow, 2008
- Half the world does not have access to an adequate, safe water supply
- The ultimate source of all of our fresh water is precipitation
- 8% of all energy use in the USA is directly related to pumping, treating or heating water – Clark Reed, USEPA
- The cheapest water you will ever have is the water you already have.
- 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



# Decreasing Supply

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



# 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.
  - ▶ Costs, value increasing
  - ▶ Military costs cheaper than private sector
  - ▶ Vulnerability to water scarcity, approx. 25% of Army installations
  - ▶ Shortages
  - ▶ Competition for water
  - ▶ Withdrawals unsustainable in some locations
  - ▶ Many uses of water could use lower quality
- Drivers
  - ▶ Executive Orders 13423, 13514 require reductions in water use
  - ▶ Incorporate water efficiency/conservation measures
  - ▶ LEED (Leadership in Energy and Environmental Design) USGBC
  - ▶ Green Building Initiative
  - ▶ Net Zero Water Initiative in the Army



# True Cost of Water

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



# History

- What are the water supply challenges of today?
- Current centralized infrastructure.
  - ▶ Aging
  - ▶ Expensive to repair and expand
  - ▶ Designed around one high level of treatment for drinking water quality
- Available sources of water dwindling.
- Quality of available sources declining.



# Other Water Use/Alternate Water Sources Options

*What can be done to increase available supply?  
How can we efficiently use what's available?*

- ▶ Produced Water
- ▶ Rainwater Harvesting
- ▶ Water Reuse
- ▶ Ground Water Recharge
- ▶ GRAYWATER REUSE
- ▶ Sewer Mining
- ▶ Desalination



# History of Graywater Use

- Long history in arid parts of the U.S.
  - ▶ Common in rural areas
  - ▶ Technically still illegal in many places
  - ▶ 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



# 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 residential plumbing infrastructure to accommodate partially treated water.
- Lack of enabling regulatory codes.
- Lack of product evaluation standards.



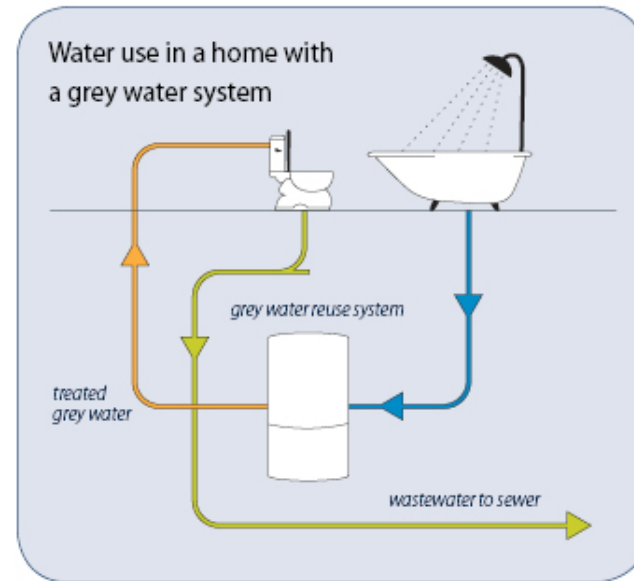
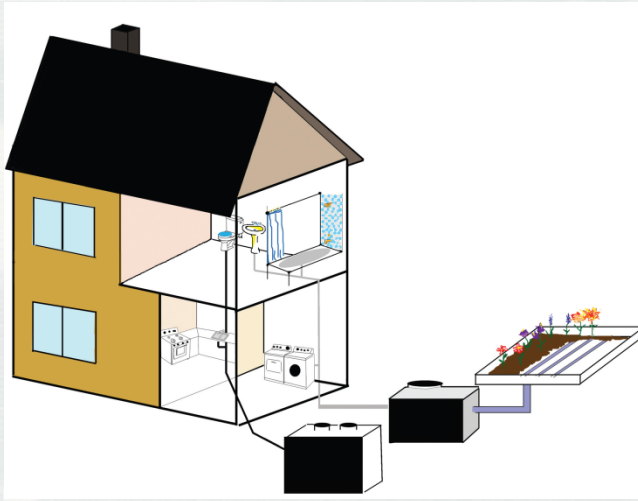
# What People Think



**BUILDING STRONG®**

# 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



**BUILDING STRONG®**

# 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



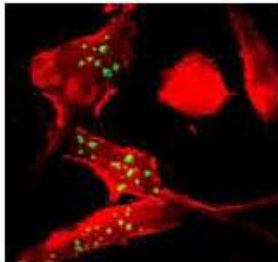
# Compared to Combined Wastewater

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

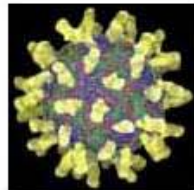


# Human and Ecological Hazards in Graywater Pathogens

(Water-based) Pathogens (Fecal)



Lung  
macrophages



Viruses



Bacteria



Parasitic protozoa

## Chemicals



Cleaning agents



Pharmaceuticals  
Antibiotic resistance

20

From: Ashbolt 2010

# 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



# 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



# 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.
- ▶ Large percentage - minimal level of contamination.
  - Treated onsite to meet final application needs. Non-potable uses
- ▶ Indoor or outdoor uses

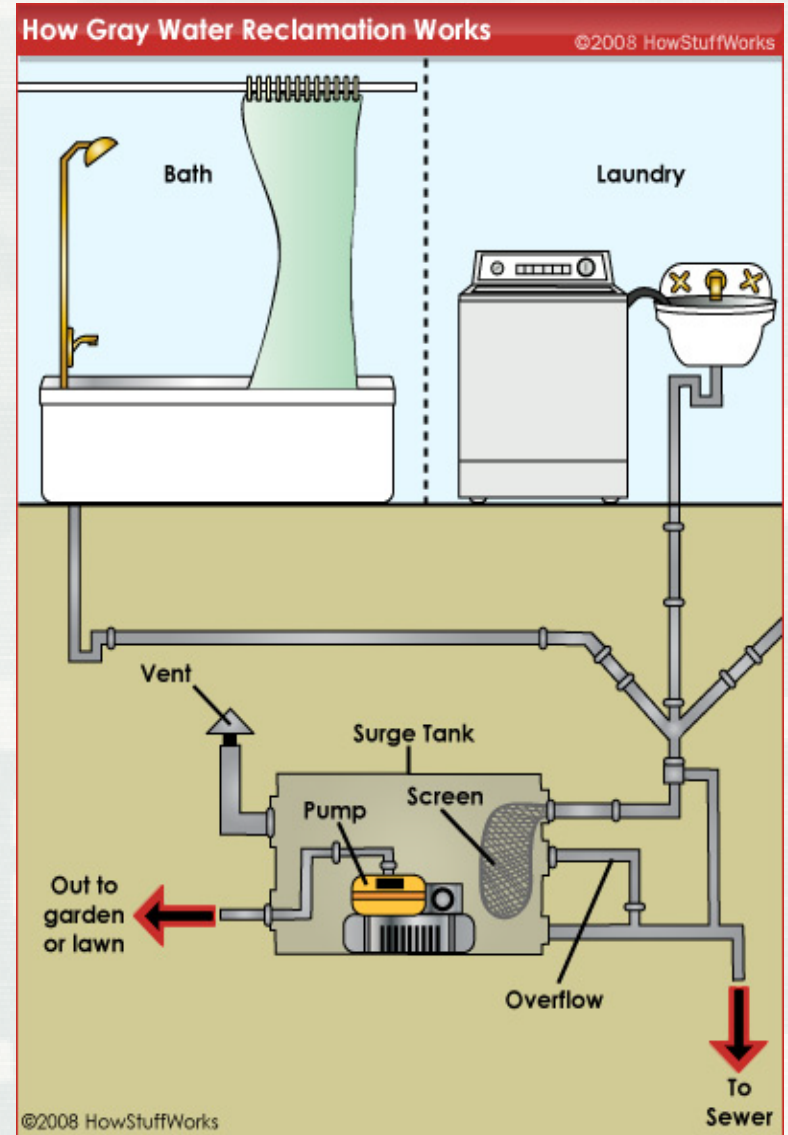


# Using Graywater Disadvantages

- ▶ 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

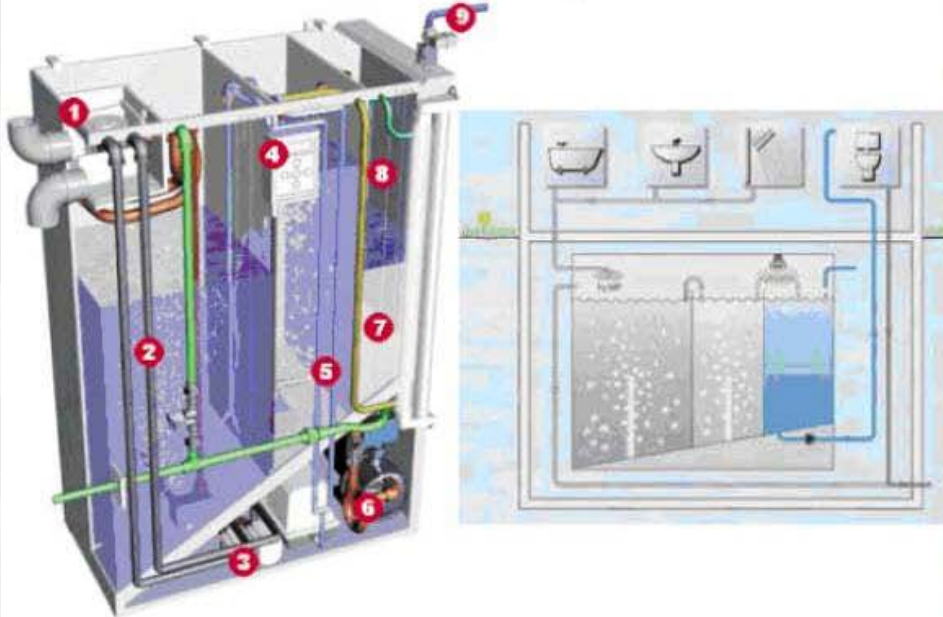


# Graywater Treatment



# Many European Manufacturers

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



# Graywater Reuse Opportunities



**BUILDING STRONG®**

# 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



# When to Use

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



# Towards Standardization and Wider Use

- NSF standard
  - ▶ 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



**TOTO®**

**INTERNATIONAL CODE COUNCIL®**

People Helping People Build a Safer World™



SAFE & SUSTAINABLE BY THE BOOK



**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

COPYRIGHT © 2010  
INTERNATIONAL CODE COUNCIL,  
INC.

*With the Cooperating Sponsorship  
of*

American Institute of Architects

ASTM International

ISBN: 978-1-58001-630-8

From: Strang 2010



**BUILDING STRONG®**

# 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/cm<sup>2</sup>
- 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



**BUILDING STRONG®**

# 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



**BUILDING STRONG®**

# Planning a Solution



**Corrosion above  
the water line on  
Brass parts**

**Corrosion above  
the water line on  
metal parts**



# 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 focus on health aspects
  - ▶ Drainline research
- Academia promotion and use
- Code development

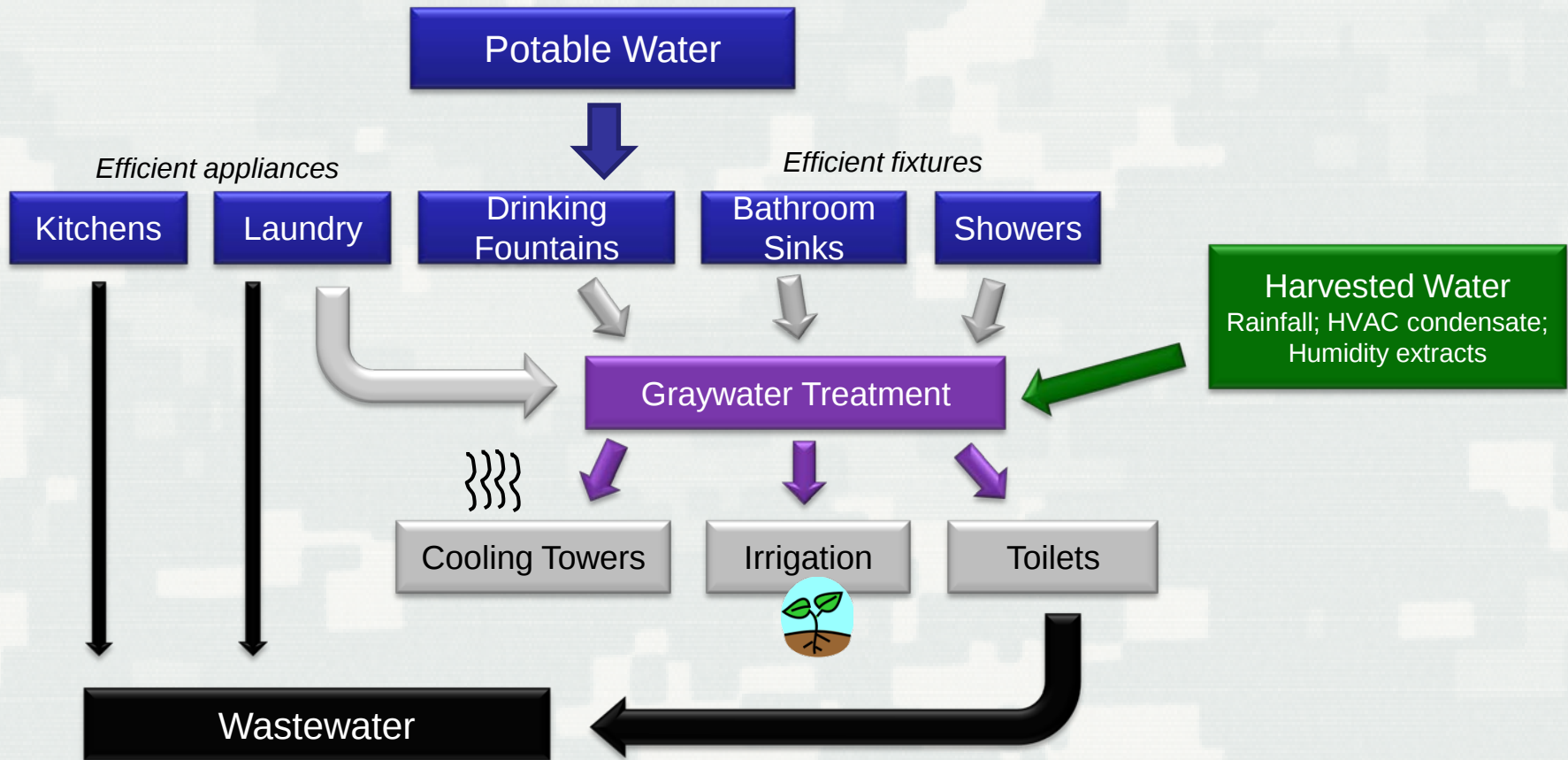


# Tri-Service ESTCP Project

- 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.**

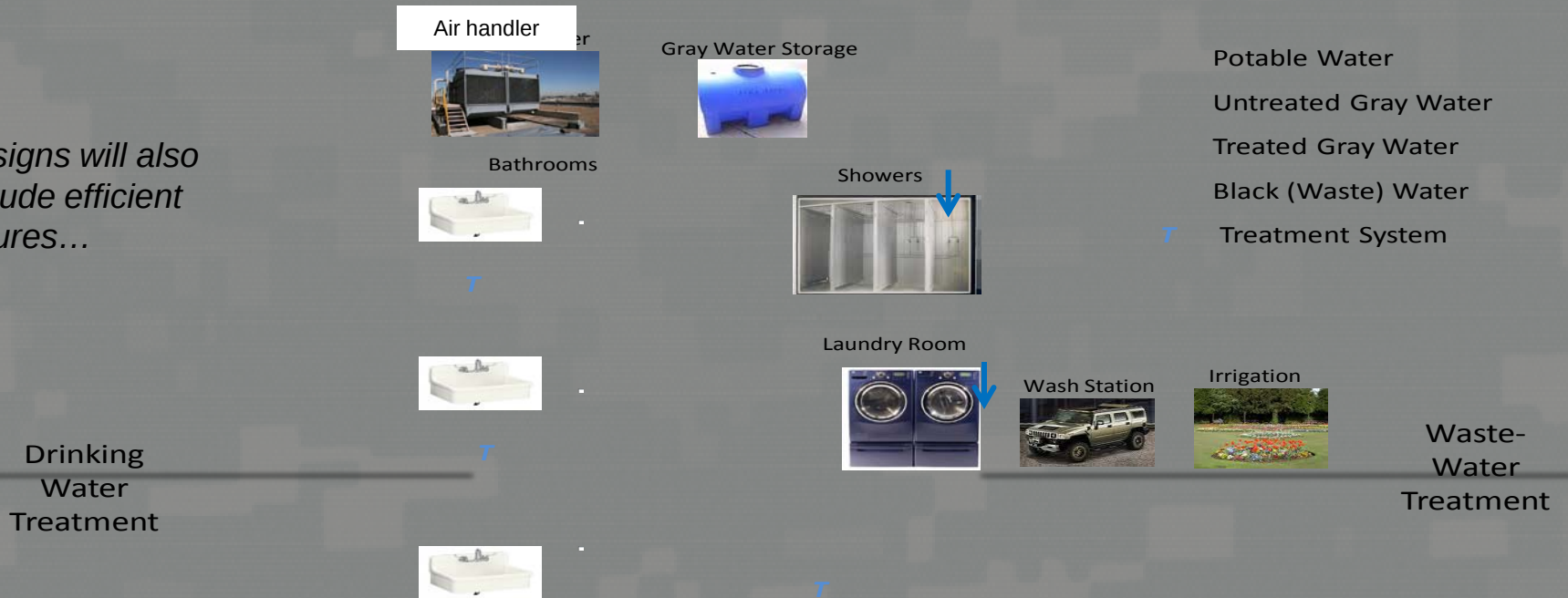
**Match water quality with the appropriate end use.**



**BUILDING STRONG®**

# 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



# 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



# Questions, Comments?

Contact information or for additional information or resources

[Richard.J.Scholze@usace.army.mil](mailto:Richard.J.Scholze@usace.army.mil)

217-398-5590



---

**BUILDING STRONG®**

