

Alaska Water & Sewer Challenge

AK

WIHAH Conference
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Designing a Household Water & Wastewater System for Underserved Villages in Alaska

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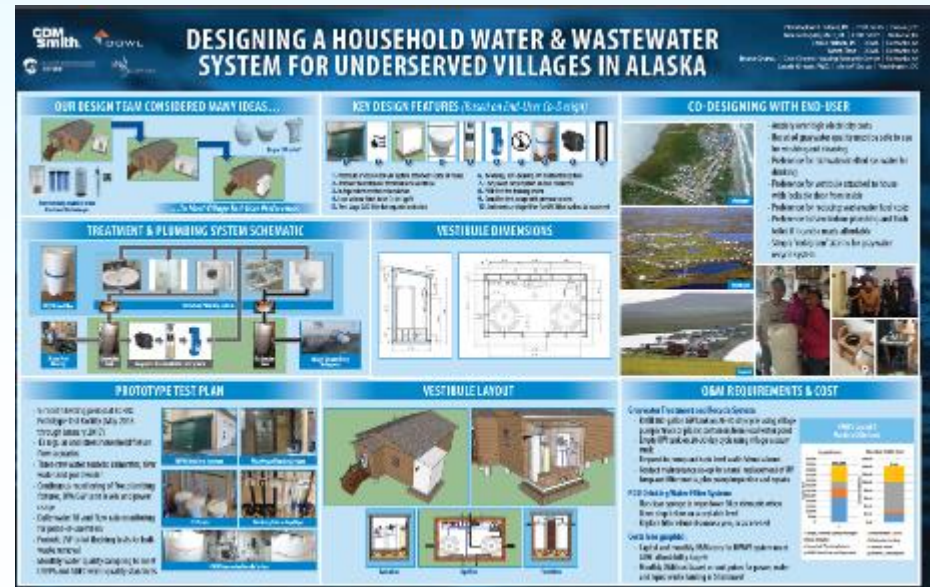


COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC



Presentation Topics

- AWSC design-think process
- Village trips and co-designing with end-users
- Key design features and system schematic
- Vestibule layout and dimensions
- HWWS prototype test plan and preliminary results
- O&M requirements and costs



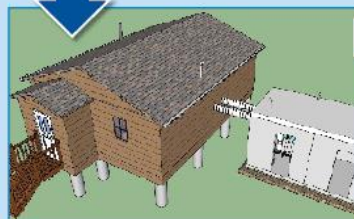


AWSC Design-Think Process

OUR DESIGN TEAM CONSIDERED MANY IDEAS...



Commercially available water treatment technologies



Bag or LVF toilet?



...To Meet Village End-User Preferences



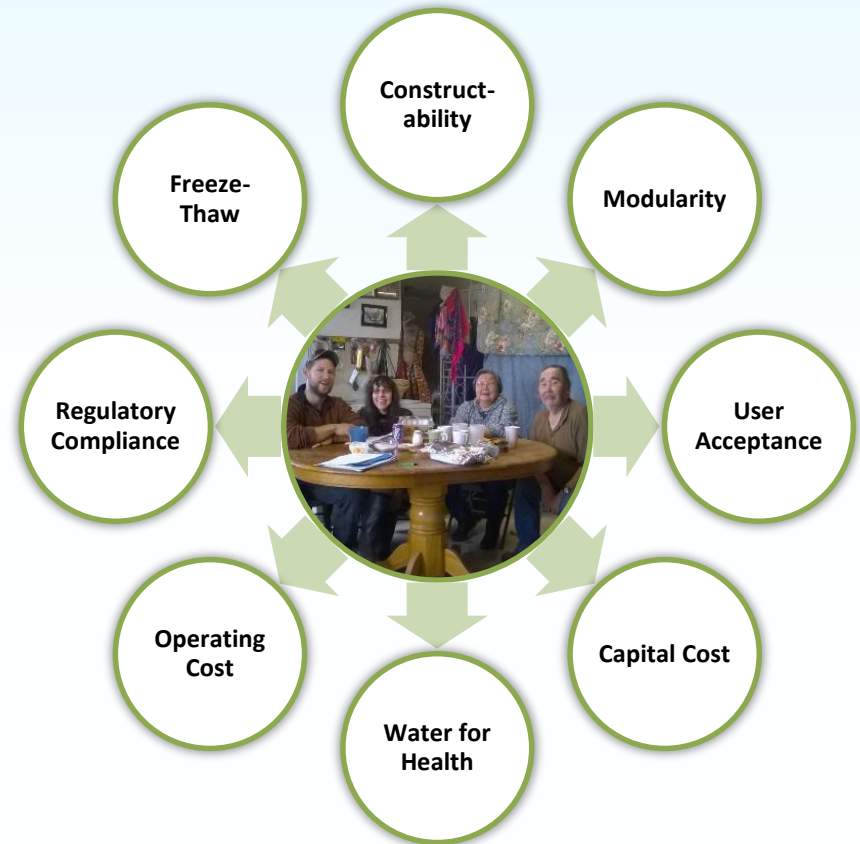
What We Mean by Design-Thinking

Old Way

(design and then try to get buy-in)



New Way with Design Thinking
(End users tell us what they want)





We developed initial design concepts using “off-the-shelf” (chemical-free) components...



Storage Tanks



POE UV/Filter



POU Filter



Activated Media



Ozone Generator



Feed Pump



PEX Plumbing



UV Disinfection



GAC Filter



Saniflo Pump



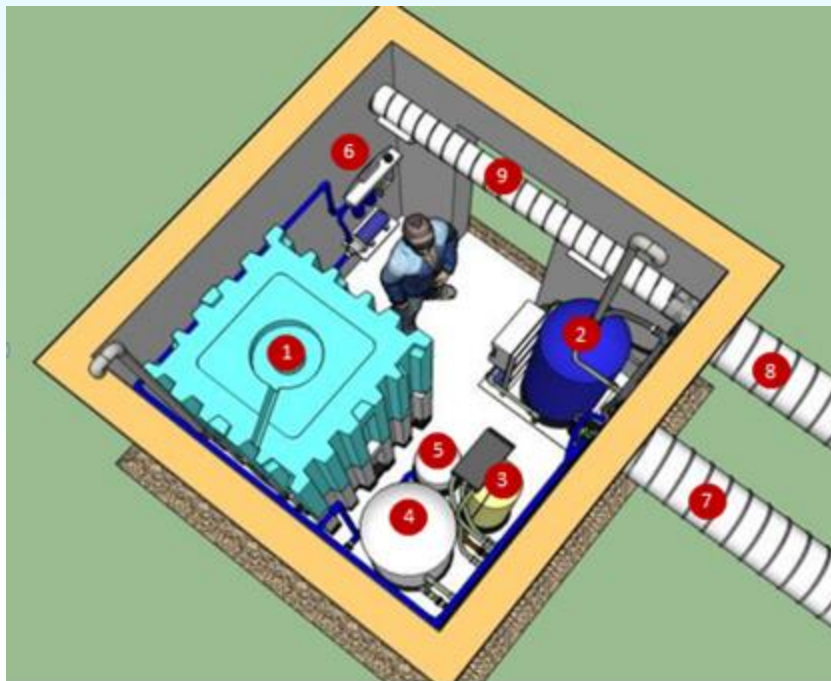
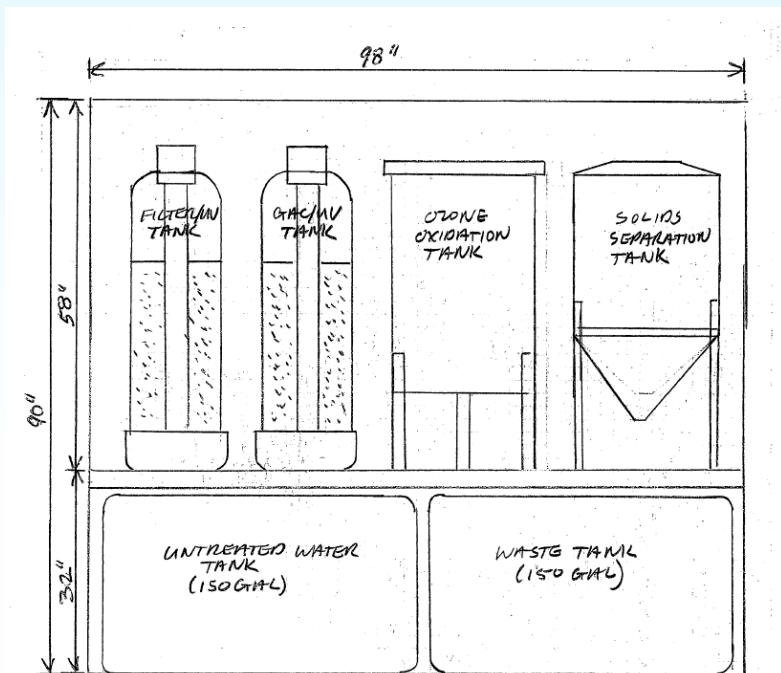
Hydropneumatic Tank



Membranes



...configured in different ways to meet ADEC design requirements





We considered low-volume flush and odor-free bag toilets....



Separett Bag



Pedal LVF



Push Button LVF

...to replace unsanitary honey buckets





We compared POE treatment and plumbing system for drinking water...



POE UV/Filter



Dual Tap Sink

...against counter-top POU filters without plumbing



POU Kohler Filter



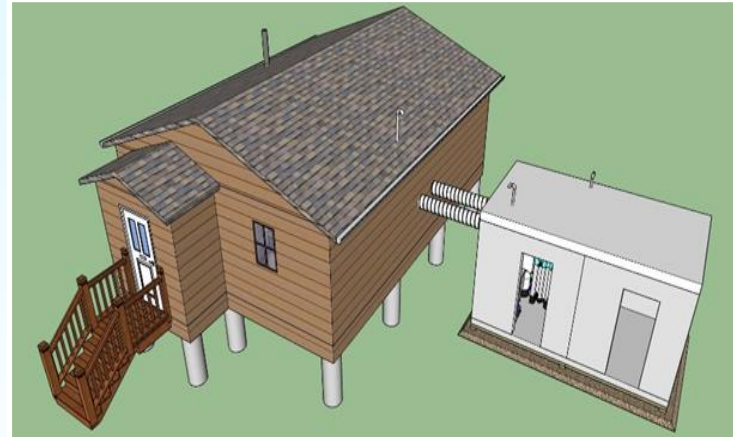
POU Bucket filter



...and we evaluated attached vs. detached buildings for housing the HWWS equipment



Detached HWWS



Detached HWWS with Storage



Attached HWWS



Village Visits and Co-Designing with End-Users

CO-DESIGNING WITH END-USER



Shishmaref



Kwigillingok



Tununak

- Anxiety over high electricity costs
- Recycled greywater quality must be safe to use for washing and cleaning
- Preference for rainwater/melted ice-water for drinking
- Preference for vestibule attached to house with lockable door from inside
- Preference for reducing wastewater haul costs
- Preference to have indoor plumbing and flush toilet if it can be made affordable
- Simple “red/green” alarms for greywater recycle system





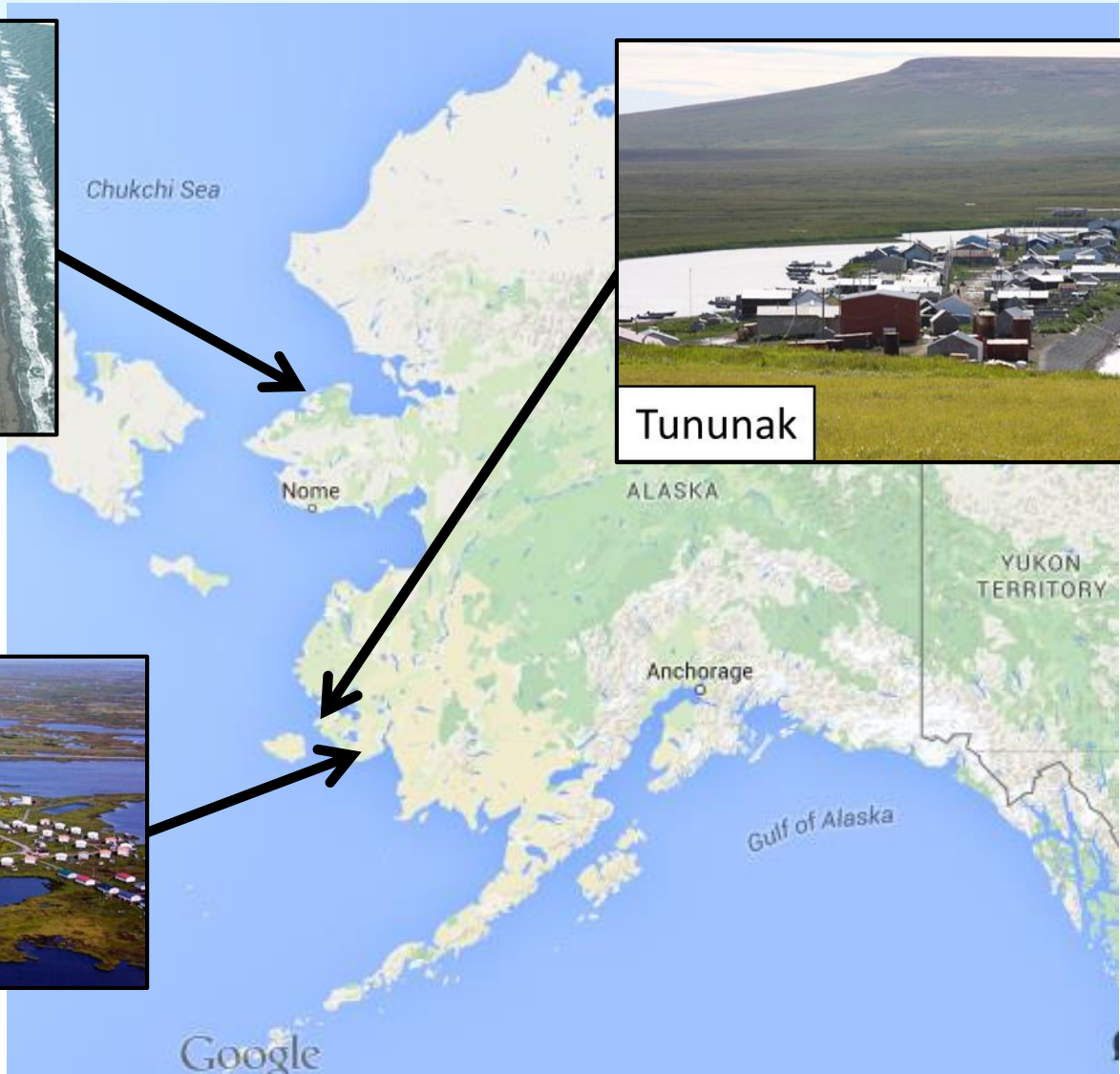
In March 2015 and March 2016 the DOWL Team travelled to three villages



Shishmaref



Kwigillingok



Tununak



We visited numerous homes and talked with potential end-users

- Interviewed 64 residents in three villages, plus a 6 person focus group in Shishmaref and 19-person community meeting in Tununak





We observed existing “pump and haul” systems





Key Village Findings—Drinking Water

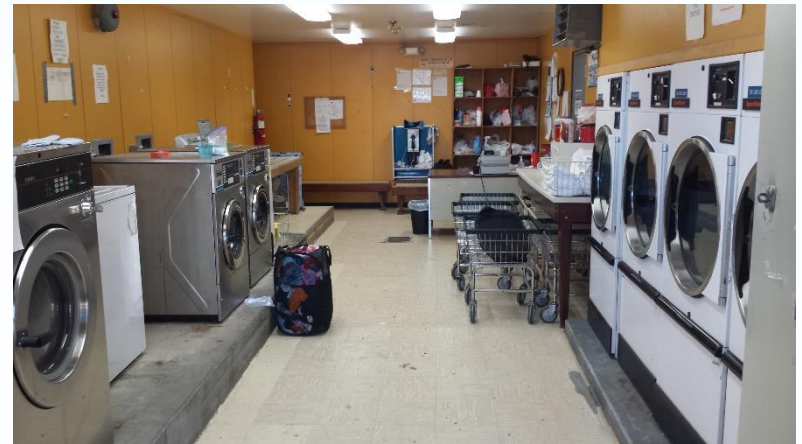
- Strong preference for drinking with ice melt or rain water – several people used Brita filters
- Dislike of chlorine and chlorine taste
- Preference for POU filter instead of separate tap





Key Village Findings—Washing and Cleaning

- Community treated water used for cleaning and dish washing
- Household greywater stored in outdoor tank (for village hauling) or thrown on ground
- Washeteria used for laundry and showers (if available in village)
- Reuse of greywater a concern—understood cost benefits but must be safe



High cost of electricity is big concern (\$0.65/kWhr in Shishmaref)



Key Village Findings—Toilets and Wastewater Collection

- Observed variety of toilets & honeybuckets
- Villages charge monthly fee for collection of honeybucket waste bags
- Hauling of wastewater expensive and unreliable in some villages



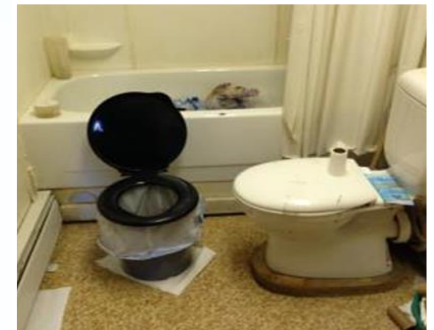
Macerator Toilet



Honeybucket



Toilet flushing with
used sink water



Honeybucket used
instead of toilet due to
high electricity costs



Summary of End-User Input for Co-Designing HWWS

- Attach vestibule to house with lockable door
- Use POE filter for treating rainwater/melted ice-water
- Use indoor plumbing and LVF toilet
- Recycled greywater quality must be safe to use
- System must be freeze-proof
- System must not damage house structure



Focus Group in Shishmaref



Key Design Features and System Schematic

KEY DESIGN FEATURES *(Based on End-User Co-Design)*



1. Vestibule enclosure for GW system attached to side of house
2. Ambient heat transfer from house to vestibule
3. Independent vestibule foundation
4. Low-volume flush toilet (< 0.5 gpf)
5. Two-stage GAC filter for organics reduction
6. Two lamp, self-cleaning UV disinfection system
7. Low power consumption and no chemicals
8. POU filter for drinking water
9. Grundfos feed pump with pressure control
10. Sediment cartridge filter for GAC filter backwash treatment

TREATMENT & PLUMBING SYSTEM SCHEMATIC

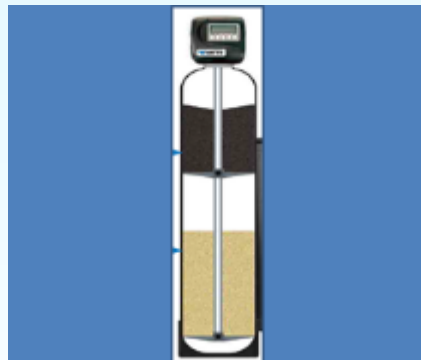




Key Design Features—Greywater Recycle and Drinking Water Treatment Components



Grundfos Feed Pump



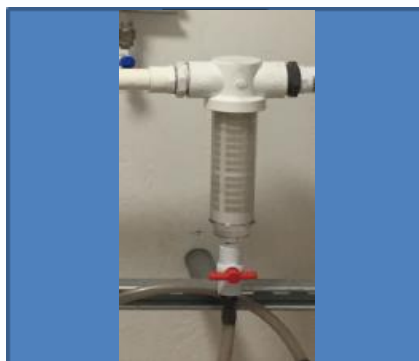
Two-Stage GAC Filter



Activated Media
Disinfection unit



Two-Lamp, Self-Cleaning
UV System



Sediment Cartridge Filter



PE Vertical Tanks



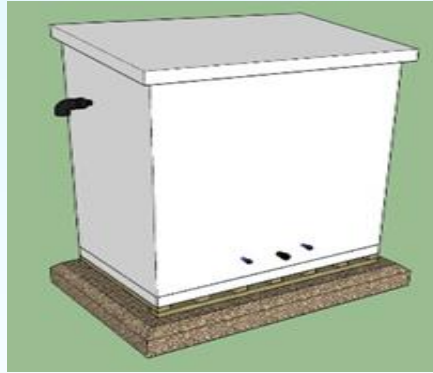
POU Drinking Water Filter



Key Design Features—Vestibule and Household Plumbing Components



Vestibule Attached to
Side of house



Independent Vestibule
Foundation



LVF toilet (< 0.5 gpf)



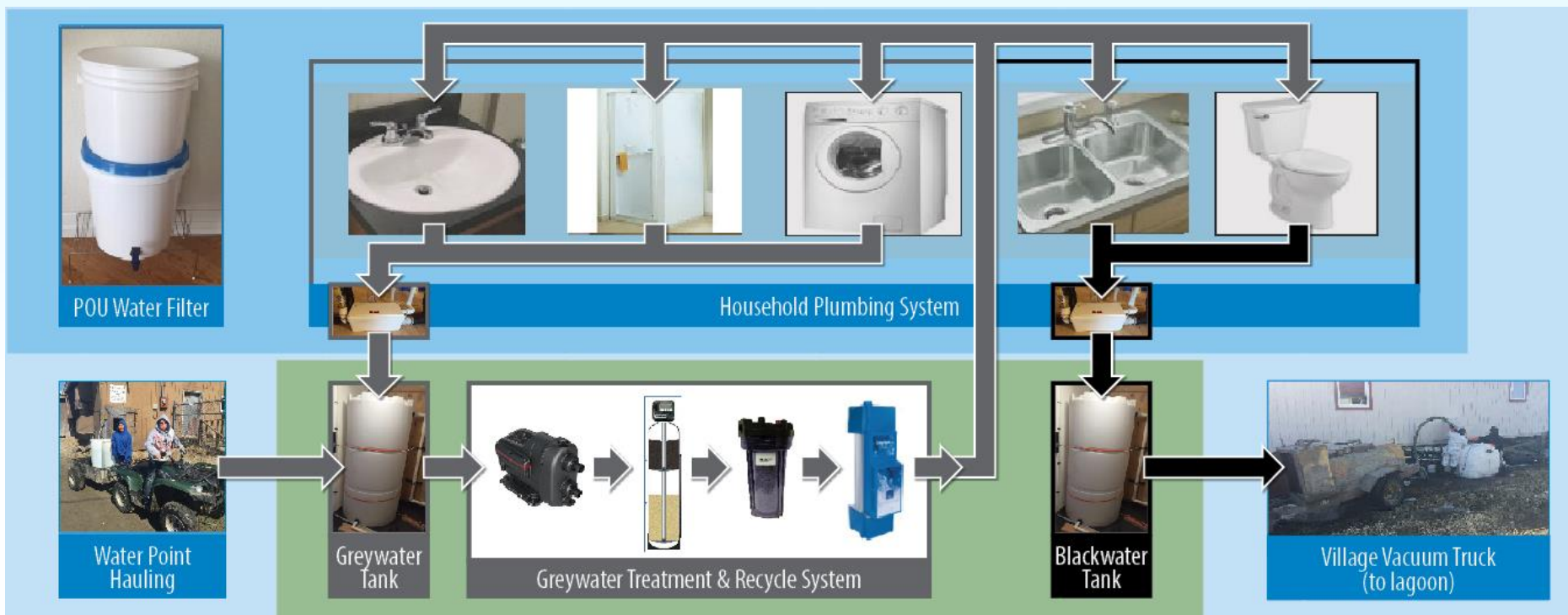
Accordion-Type Flexible Joint



Saniflo Return Pump



HWWS Simplified Process Schematic



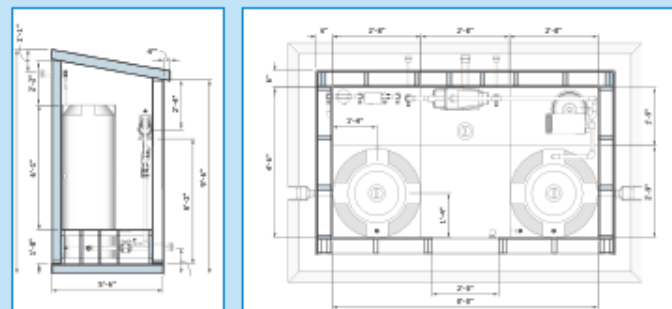


HWWS Vestibule and Mock Plumbing Layout and Dimensions

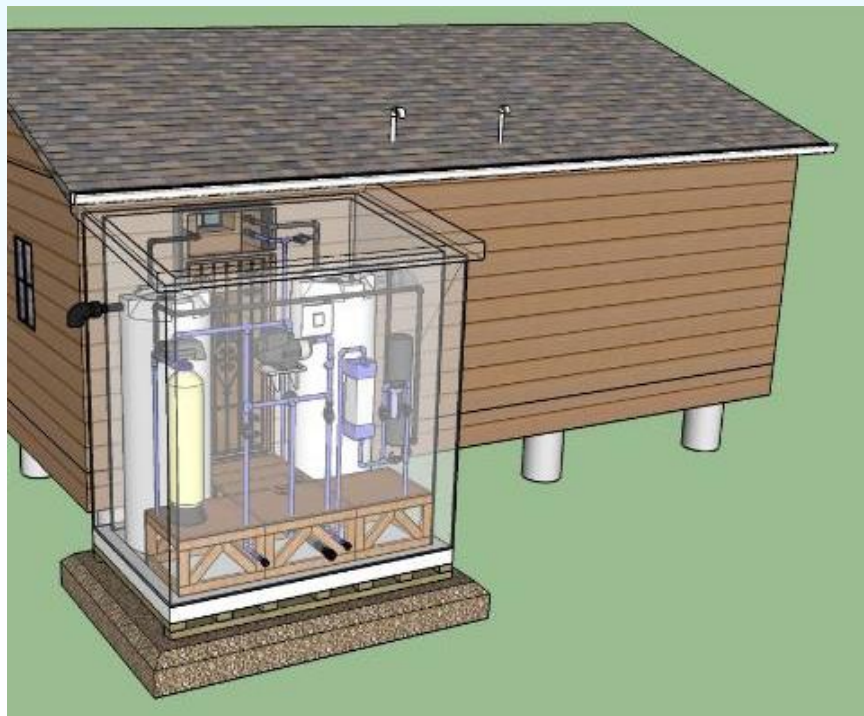
VESTIBULE LAYOUT



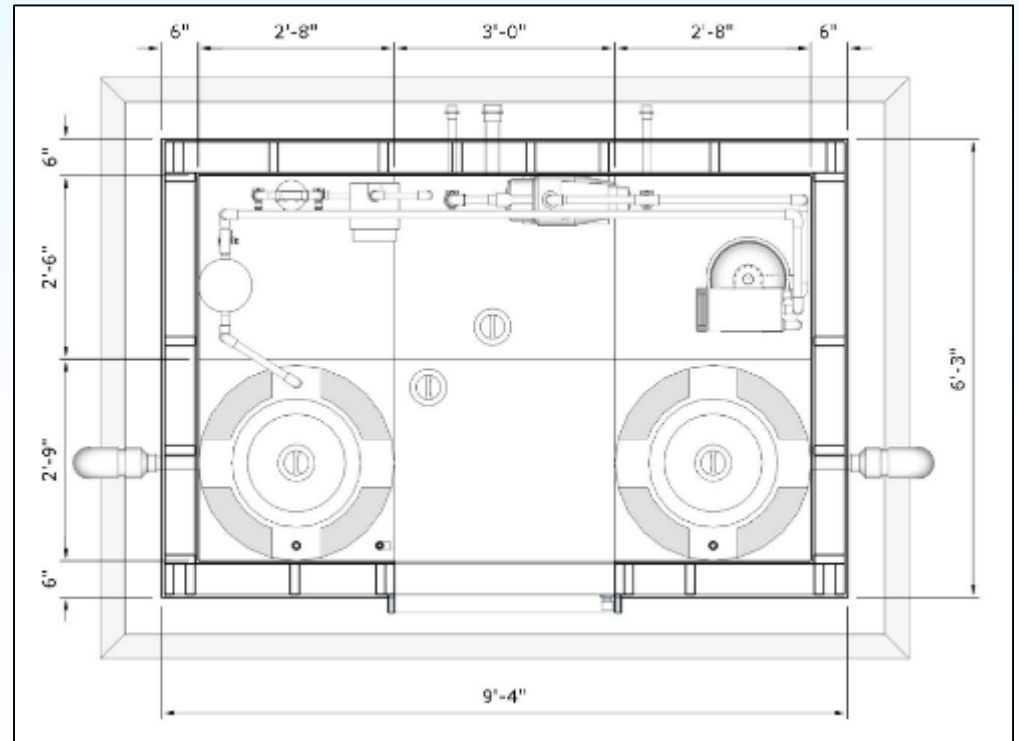
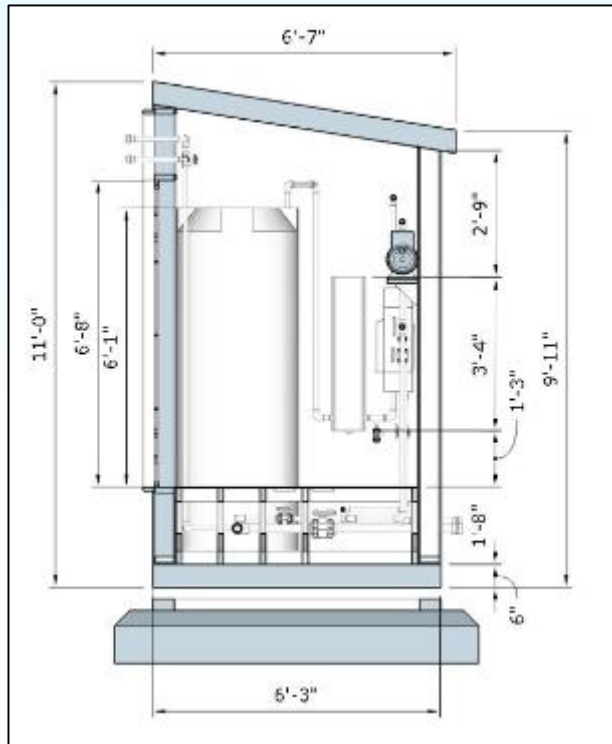
VESTIBULE DIMENSIONS



Vestibule Layout



Vestibule Dimensions



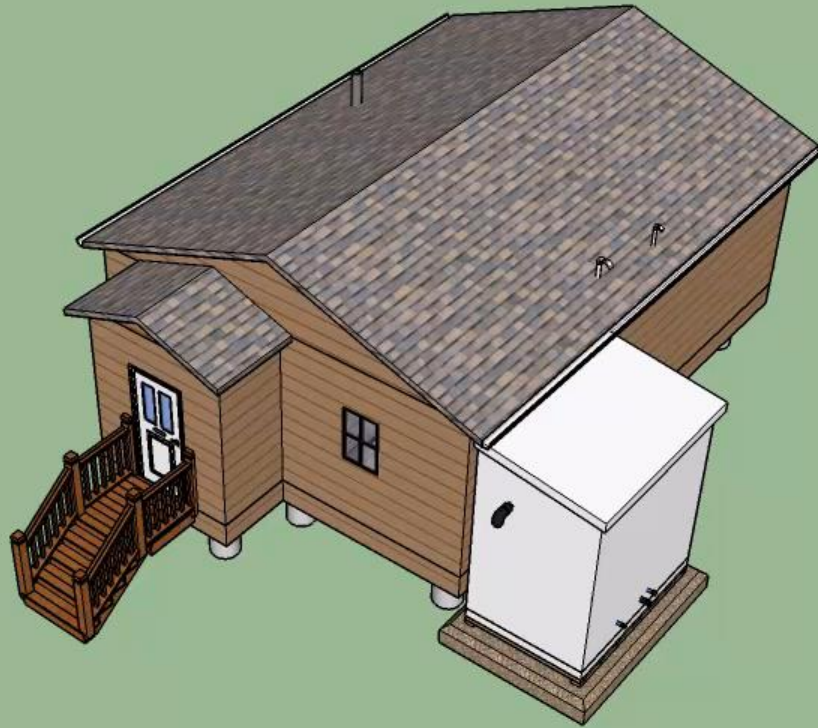


Mock Household Plumbing System





HWWS 3-D Virtual Tour





HWWS Prototype Test Plan and Preliminary Results

PROTOTYPE TEST PLAN

- 9-month testing period at CCHRC Prototype Test Facility (May 2016 through January 2017)
- 13 regular and stress household fixture flow scenarios
- Three raw water sources: rainwater, river water and pond water
- Continuous monitoring of five plumbing fixtures, BW/GW tank levels and power usage
- Daily water fill and flow rate monitoring for point-of-use filters
- Periodic LVF toilet flushing tests for bulk waste removal
- Monthly water quality sampling to meet USEPA and ADEC water quality standards



HWWS Vestibule Structure



Mock House Plumbing System



LVF Toilets



Plumbing Fixture Drop Pipes



HWWS Greywater Recycle System



HWWS Prototype Test Plan



9-month testing period at CCHRC
Prototype Test Facility (May thru
January 2016)

13 stress flow scenarios for five
household fixtures

Three raw water sources: rainwater,
river water and pond water

Continuous monitoring of fixture flows
BW/GW tank levels and power usage

Daily water fill and flow rate monitoring
for POU filters

Periodic LVF toilet flushing tests for bulk
waste removal

Monthly water quality sampling to meet NSF-350
and drinking water quality standards



HWWS Prototype Vestibule Construction





HWWS Equipment Inside Vestibule (see 360 photo on I Pad)





Mock Household Plumbing Structure (see 360 photo on iPad)



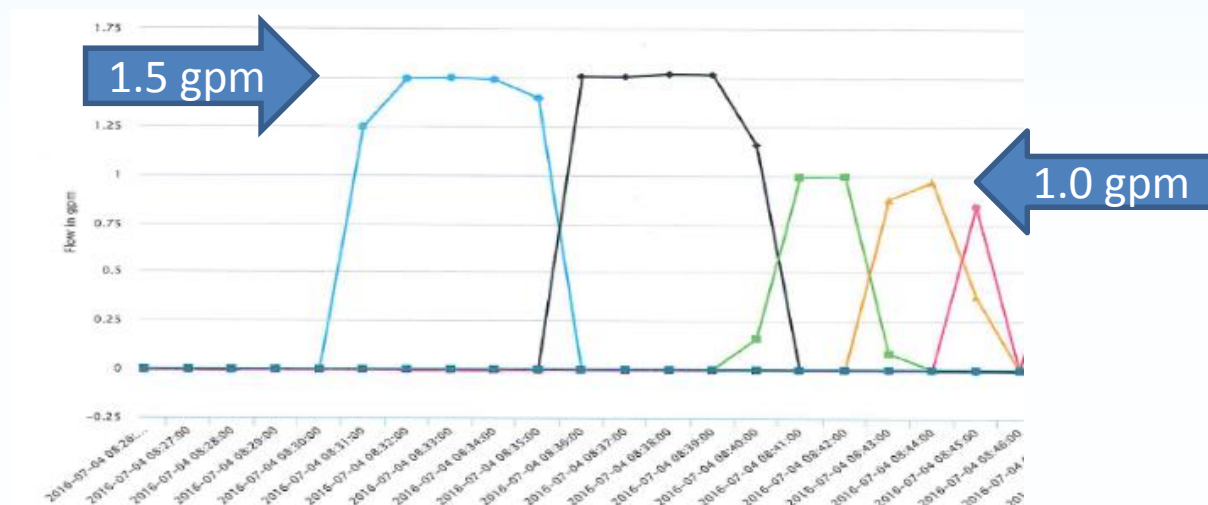
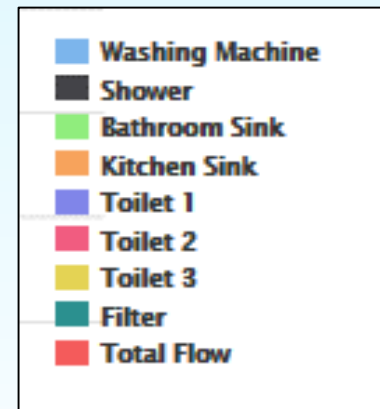
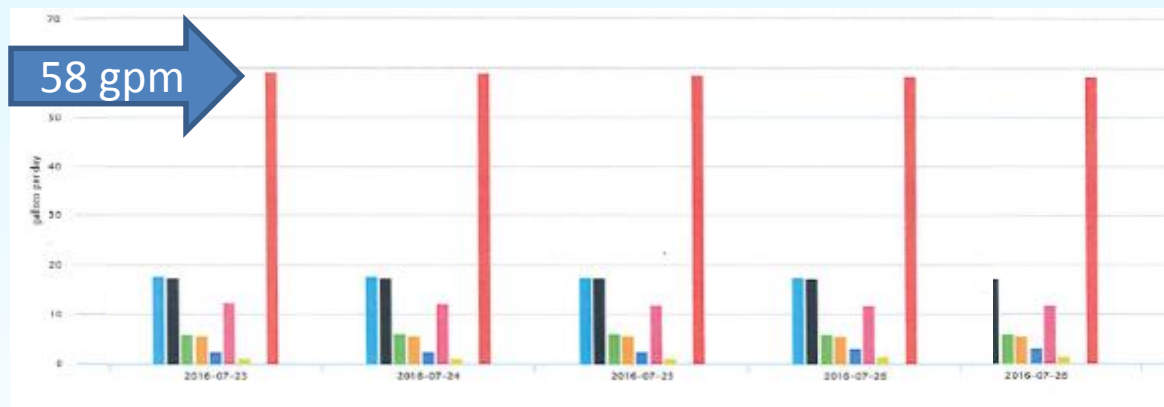


Mock Household Plumbing System





HWWS Typical Daily Water Usage Trends



Mock plumbing flows meet daily water usage target of 60 gpd



POU Filter Microbial Challenge Test Results (single filter element)

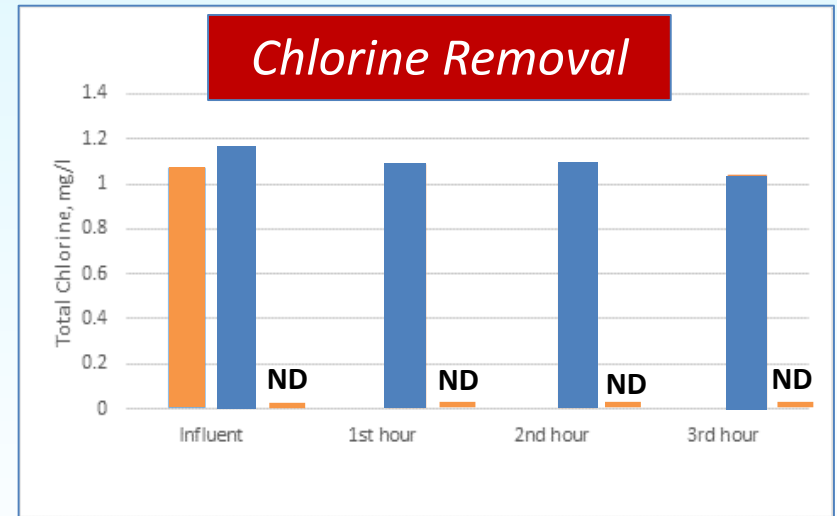
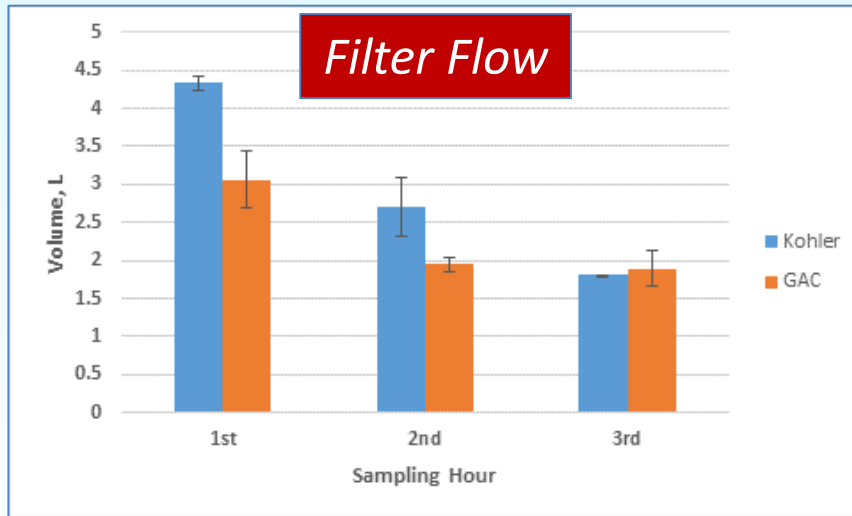
Water Depth Above Filter Cartidge - inches	Flow L/Hr	Kohler Clarity Filter		Stacked Bucket Filter	
		E. Coli Log Reduction (Log)	Outlet E.Coli concentration (CFU/100 mL)	E. Coli Log Reduction (Log)	Outlet E.Coli concentration (CFU/100 mL)
10.5	3.4	NA	<1	> 6.6	<1
7	2.3	NA	<1	> 6.6	<1
3 (5 liters)	0.9	> 7.1	<1	> 6.6	<1
1.8 (3 liters)	0.5	> 7.1	<1	> 6.6	<1
0.9 (1.5 liters)	0.3	> 7.1	<1	> 6.6	<1



Both POU filters achieved complete (100%) bacteria removal



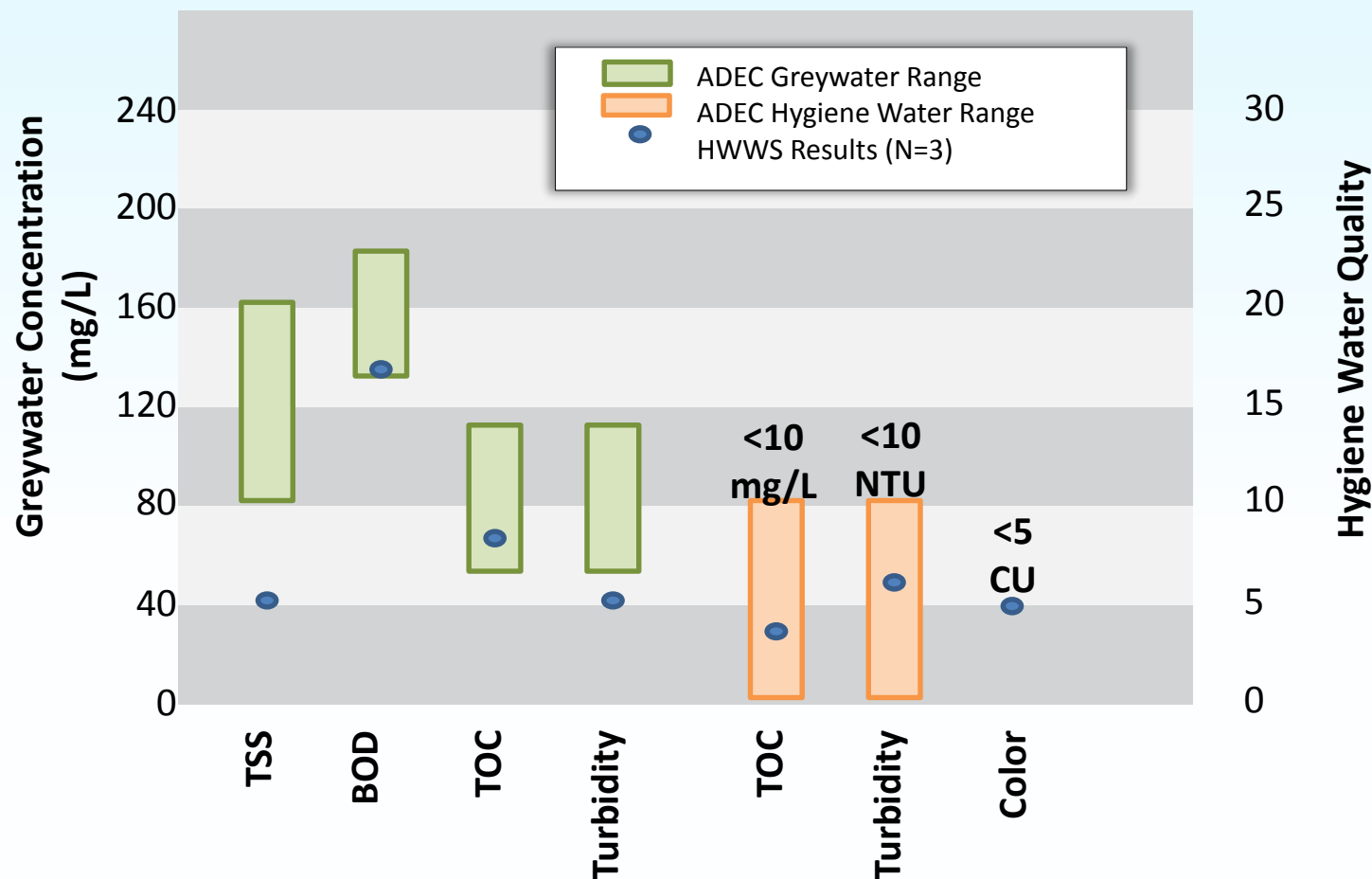
POU Filter Flow and Chlorine Removal Test Results (double filter element)



Dual filters with GAC packing achieved 100% chlorine removal



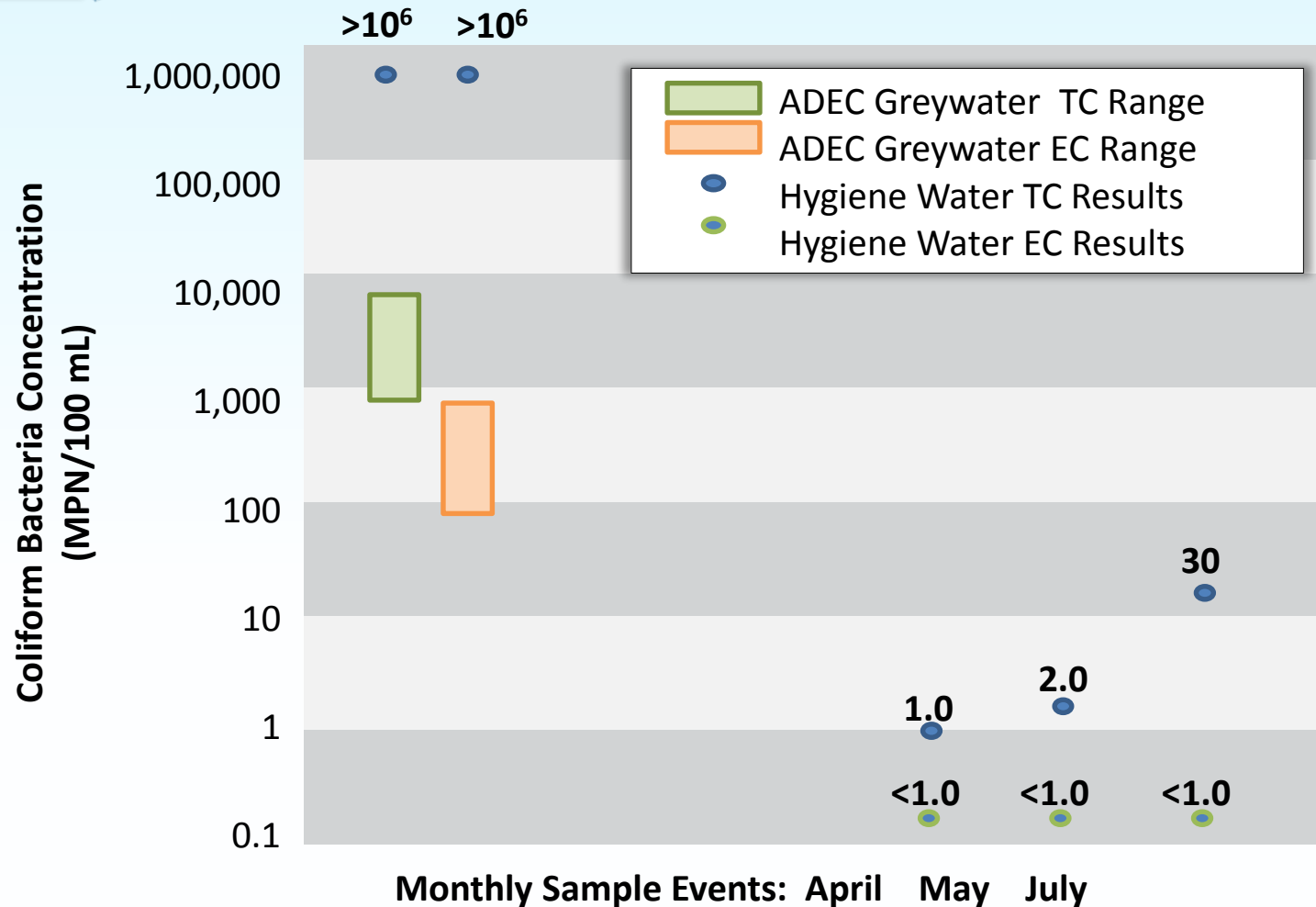
Greywater and Hygiene Water Preliminary Water Quality Results (Physical and Chemical)



Greywater targets hard to hit, but hygiene WQ targets still met



Greywater and Hygiene Water Preliminary Water Quality Results (Coliform Bacteria)



Very high microbial growth rates in GW tank impacted hygiene WQ



O&M Requirements and Cost

O&M REQUIREMENTS & COST

Greywater Treatment and Recycle System:

- Refill 300-gallon GW tank on 20-30 day cycle using village pumper truck or plastic containers from local water point
- Empty BW tank on 20-30 day cycle using village vacuum truck
- Respond to pump and tank level audio/visual alarms
- Contact maintenance co-op for annual replacement of UV lamp and filter media, plus pump inspection and repairs

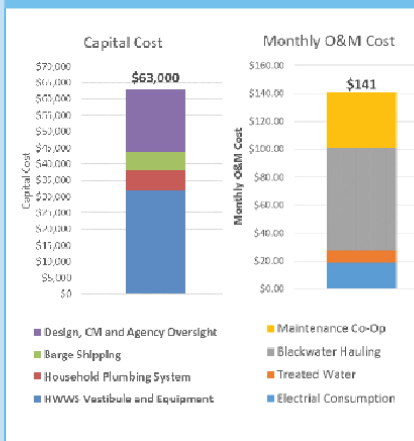
POU Drinking Water Filter System:

- Use clean sponge to wipe down filter elements when flows drop below an acceptable level
- Replace filter elements once a year, or as needed

Costs (see graphic):

- Capital and monthly O&M costs for HWWS system meet ADEC affordability targets
- Monthly O&M cost based on unit prices for power, water and liquid waste hauling in Shishmaref

HWWS Capital & Monthly O&M Costs





Household O&M Requirements

Greywater and Blackwater Systems



- Refill 300-gallon GW tank and empty BW tank on 20-30 day cycle
- Check sediment filter weekly and clean as needed
- Respond to pump and tank level audio/visual alarms
- Maintenance co-op:
 - Annual HWWS inspection and as needed repairs
 - Annual replacement of UV lamp, cartridge filter and GAC filter media





Household O&M Requirements

POU Drinking Water Filter System

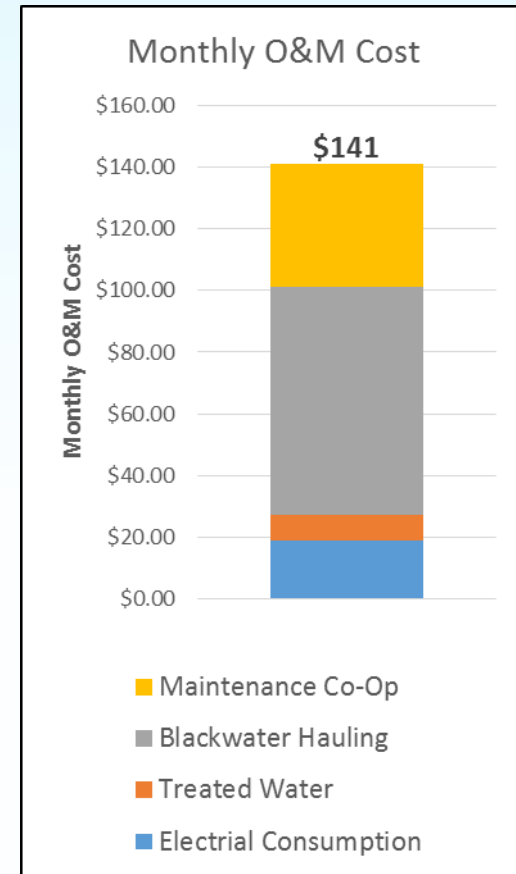
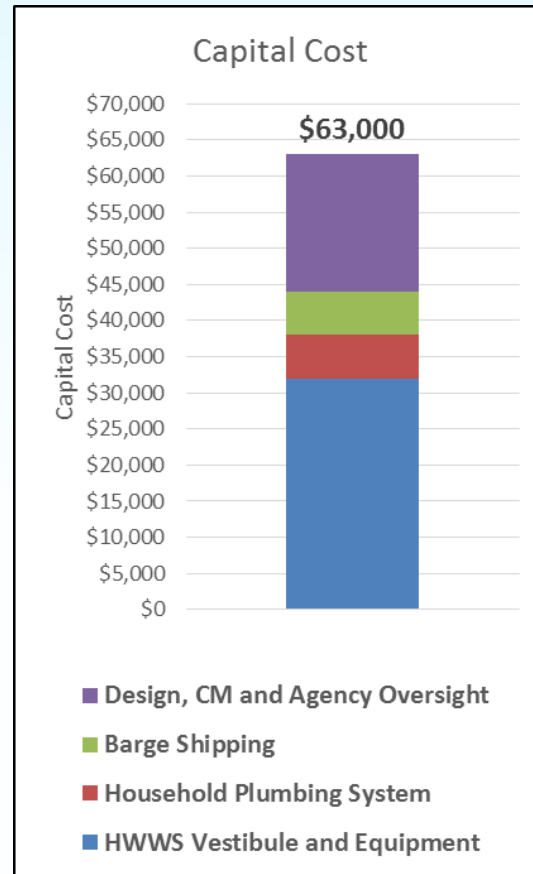
- Use clean sponge to wipe down filter elements when flows drop below an acceptable level
- Replace filter elements once a year, or as needed





Capital and O&M Costs

- Capital and monthly O&M costs for HWWS system meet ADEC affordability targets
- Monthly O&M cost based on unit prices for power, water and liquid waste hauling in Shishmaref



THANK YOU

