Portable Alternative Sanitation System

FINAL REPORT | KIVALINA, ALASKA

ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM

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1.0 EXECUTIVE SUMMARY

The following report describes a pilot project designed to address immediate water and sanitation needs in Kivalina, Alaska. The report assesses the feasibility of portable in-home water and sanitation units to provide an immediate improvement in quality of life for residents across rural Alaska that are currently without sanitation systems in their homes.

The village of Kivalina is located on a narrow barrier island in the Chukchi Sea. Erosion due to diminishing sea ice, increasing storms, and tidal surges continues to threaten the community, increasing the need to relocate. As such, infrastructure improvements are limited to small capital projects that consist of moveable, non-permanent, low-water use infrastructure to address basic water and sanitation needs. Currently, residents must haul their own water and waste to and from their homes. Community members must haul solid waste and human waste about a mile to the village dump, resulting in bags of waste accumulating outside the homes, frozen in the ice during the winter months, and vulnerable to spread via animals and birds. Residents told us about spring conditions and concerns about their children, who lack other options, playing in the street in sewage contaminated puddles.

ANTHC was motivated to improve the situation in Kivalina in order to protect public health and thus worked with the community and partners to design and construct the Portable Alternative Sanitation System (PASS). The system is designed to complement the centralized infrastructure and provide for basic water and sanitation needs in the home. PASS replaces the handwashing basin with treated flowing water from a bathroom sink to provide for hand washing at critical times. The PASS unit also eliminates the need for the honeybucket and thus reduces exposure to human waste by reducing the haul volume.

PASS is a low-cost alternative to piped infrastructure. The unit costs $47,726 to install with a monthly operating cost for homeowners averaging about $30. The systems are simple to operate and accepted by community members as a feasible and desirable option to provide immediate improvements. Over the year-long pilot, ANTHC identified some key areas for improvements and addressed those with the help of participants in the community. The following report shares lessons learned, results of the pilot evaluation and recommendations for future work. One key finding that must be emphasized is the importance of partnering with the community to ensure homeowner buy-in, to develop good rapport to facilitate successful user training, and to address the human factor that is critical but often overlooked in infrastructure projects.

2.0 SCOPE OF WORK

The scope of this project was to address the immediate sanitation needs for homes in Kivalina where piped water and sewer is not readily available. What is ultimately called the portable alternative sanitation system (PASS) is entirely home-based, designed to address the most basic hygiene needs. The systems are stand-alone models; if homes are moved to a new village site, residents can bring their clean water and toilets with them.

3.0 NEED FOR THE PROJECT

Figure 3-1. Aerial photo of Kivalina, Alaska (2015).

For communities like Kivalina that are threatened by flooding and erosion, constructing and improving permanent infrastructure—like piped water and sewer—is not feasible under current funding mechanisms due to the fact that the community may need to relocate in the future. Also, if and when these communities do decide to relocate from threatened areas, immediate sanitation needs will continue to be an issue: it can take many years to fully fund and completely construct permanent piped sanitation facilities for communities. While this may seem like a problem that will affect only one or two communities, the number of communities facing this situation in Alaska is considerable and could grow. A 2009 Government Accountability Office (GAO) report identified at least 31 Alaska Native villages that are threatened by some form of erosion. Of that number, at least 12 identified in the report have either decided to move or elected to "explore relocation options." According to 2010 census data provided on the state of Alaska's Department of Commerce, Community and Economic Development website, those 12 communities contemplating or moving forward with relocation consist of over 1,000 households.

The erosion and flooding behind a community decision to relocate takes a couple of different forms. First, storms on the coast of western Alaska have increased in intensity and frequency, threatening the long term sustainability of coastal communities like Kivalina and Shishmaref. Both are on narrow barrier islands. Based on a U.S. Geological Survey report on Unalakleet, another community on the west coast of Alaska, nine of the ten storm events with the highest storm surges (above one meter) have occurred during the last twenty years (2015). Also, the 2009 GAO report notes that the village was a state declared disaster area because of flooding in 2003 and 2005. Second, communities on rivers—such as Koyukuk, Hughes, and Huslia—are also threatened because ice jams during the spring break-up season cause water to back up into the communities. For instance, in 2006, Koyukuk was declared a state disaster area; at least half the residents were evacuated due to an unexpected flood (GAO 2009). Despite the desire to relocate, or a willingness to explore it as an option, brought on by these sorts of flood events, these communities still have immediate sanitation needs.

Failing to meet these needs poses a health risk to those living in the communities. Due to limited availability of potable water, residents in some of these communities ration water and are using a self-haul honeybucket system for sewage. In communities like Kivalina, there is no approved location or safe method for honeybucket waste disposal. This leads to sewage regularly being spread throughout the community during spring break-up. A 2008 study by Hennessy et al. published in the American Journal of Public Health found that diseases like influenza and pneumonia disproportionally affect the very young (four and under) and the elderly (those over 65) in homes without running water or a flush toilet. Hospitalization rates for these age groups were twice as high when compared to those living in homes with plumbing. Additionally, hospitalization rates for skin and staph infections were significantly higher for people living in homes without running water or a flush toilet, showing that these basic plumbing fixtures can affect the health of a community considerably. Therefore, a solution that is both mobile and able to provide basic sanitation while a community is in the process of relocating is still needed.

In order to provide Kivalina with mobile sanitation infrastructure, the Kivalina water and sewer feasibility study (Attachment No. 1) recommended low water use plumbing fixtures, separating toilets, rainwater catchment systems, and greywater (urine and wash water) disposal using individual seepage pits. The combined city and tribal councils cast their support for these recommendations (see Attachment No. 2 - Resolutions).

4.0 PROJECT COST

The overall project was funded by four projects: ANTHC project nos. AN 12-Z14, AN 15-N5E, AN 15-N8D, and AN 16-Y07.

4.1 COST ESTIMATE TABLE

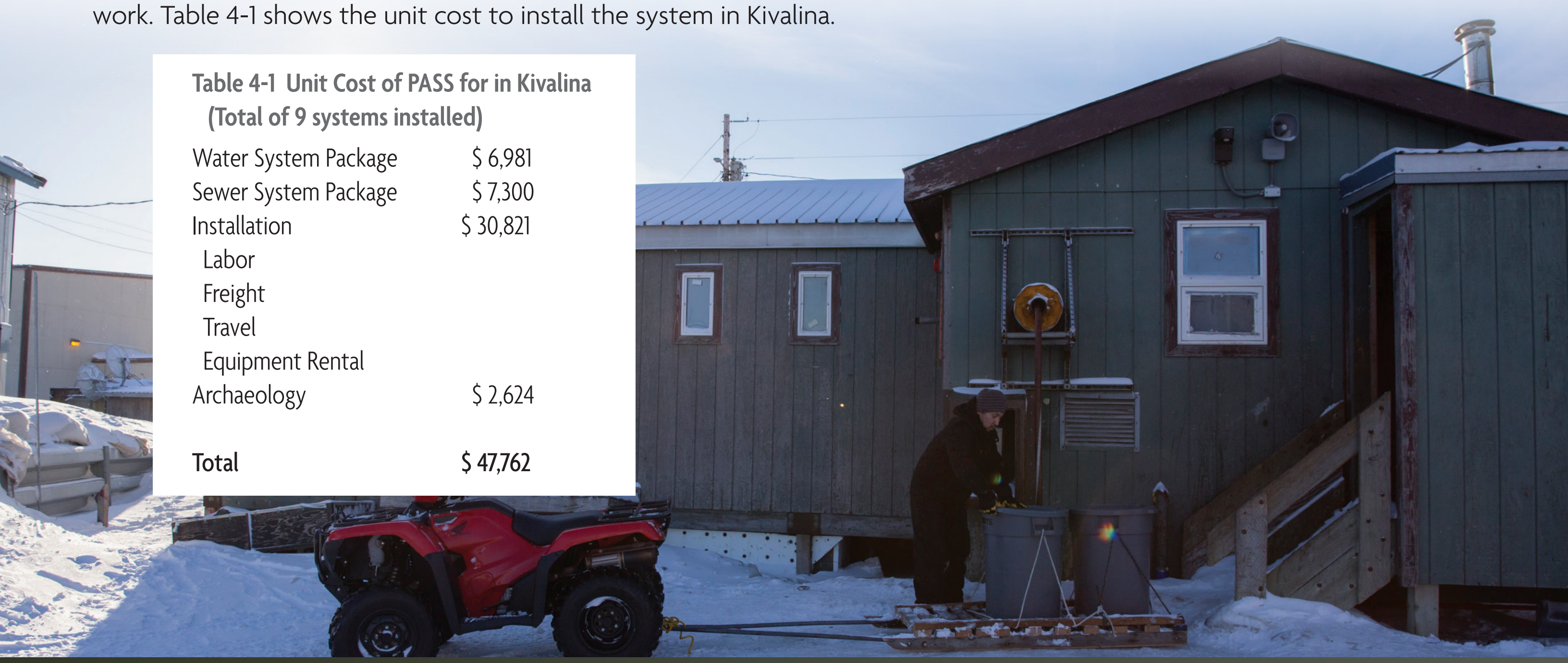
ANTHC Project No.	Scope of Work	Qty	Units	Total Cost
AN 12-Z14*	Feasibility Study	1	LS	$80,000
AN 15-N5E	Design and Installation	1	LS	$225,000
AN 15-N8D	Installation	1	LS	$250,000
AN 16-Y07	Performance Evaluation & Product Refinement	1	LS	$48,000
			Total	**$603,000.00**

*ANTHC project no. AN 12-Z14 was funded for $150,000. The remaining funds were managed by the Northwest Arctic Borough and were not used for this project.

The PASS is site specific and, as such, the installation costs may vary. Some homes may need retrofitting to add space for a toilet and a sink while others may not. In the case of Kivalina, an archaeologist was required to be onsite for all subsurface work. Table 4-1 shows the unit cost to install the system in Kivalina.

Table 4-1 Unit Cost of PASS for in Kivalina (Total of 9 systems installed)

Water System Package	$ 6,981
Sewer System Package	$ 7,300
Installation	$ 30,821
Labor	
Freight	
Travel	
Equipment Rental	
Archaeology	$ 2,624
Total	**$ 47,762**



5.0 PROJECT SCHEDULE

The project was completed according to the following timeline:

PROJECT ACTIVITY	DATE	PROJECT ACTIVITY	DATE
Feasibility study start	December 2013	Evaluation start	May 2015
Feasibility study complete	May 2014	Evaluation complete	September 2016
Design start	November 2014	Final inspection	December 2015
Design complete	May 2015	Warranty inspection	September 2016
Participant selections	December 2014	Final report	December 2016
Construction complete	August 2015		

6.0 TYPICAL SYSTEM LAYOUT

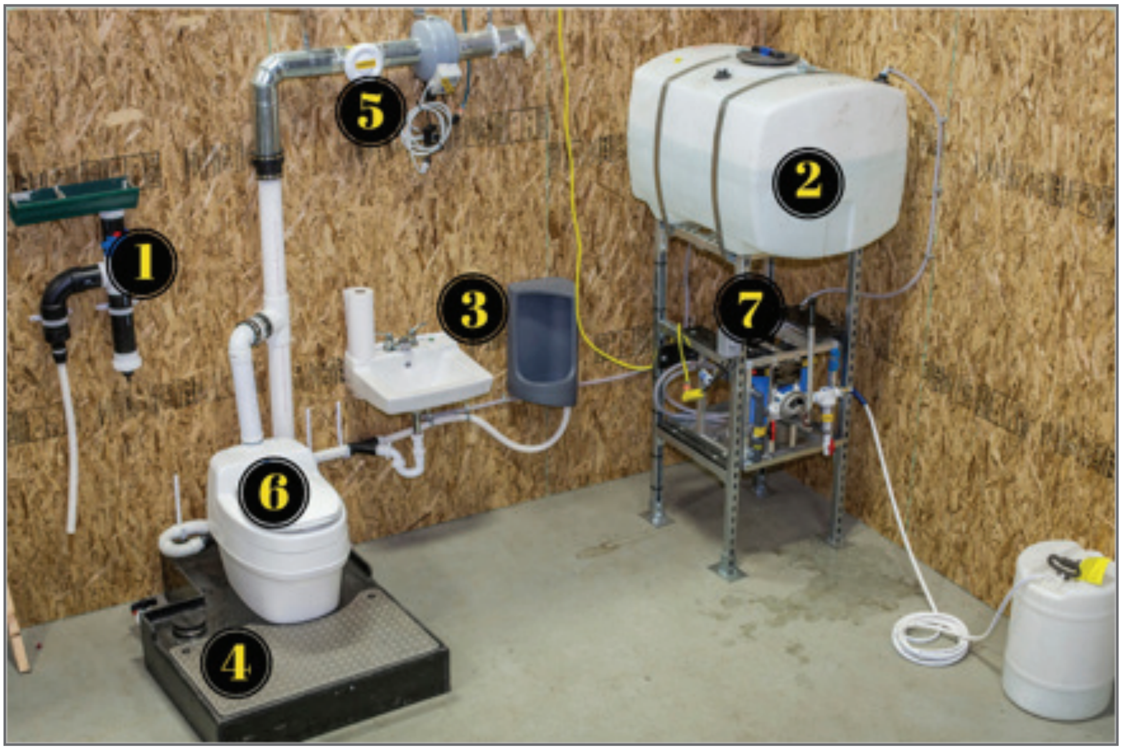


Figure 6-1. The systems are entirely homeowner based and designed to address the most basic sanitation needs.

1. **Rain catchment system.** With an average rainfall of 7-inches between May and October and an 800 square foot home with a catchment area of approximately 1,200 square feet, it is possible to recover nearly 3,000 gallons at 60% collection. This can be used to supplement the quantity of water hauled to the home.
2. **Water storage tank.** The 100-gallon, gravity-fed tank does not require electricity.
3. **Low flow sink and waterless urinal.** The sink (0.25 gallons per minute) and urinal conserve water while providing for hygiene and sanitation needs.
4. **Greywater tank.** The greywater tank purges urine and greywater from bathroom sink into a buried seepage pit located adjacent to the home when full.
5. **Integrated ventilation.** An energy-efficient combined ventilation system dries the waste, reduces odors, and ventilates the home.
6. **Separating toilet.** Waste is separated into liquid and solid components where the liquid is disposed of into the seepage pit and dried solids are disposed of in the landfill.
7. **Water treatment system.** The water treatment system incorporates membranes and chlorination for point-of-use treatment to ensure the water is safe to drink—independent of the water quality of the source or potential contamination through hauling and storage practices.

Figure 6-2. Typical layout of the infiltration system.

6.1 TYPICAL SEEPAGE PIT

The seepage pit was constructed with an infiltrator placed on non-compacted sand approximately five feet below existing grade. Greywater from the sink and separation toilet drains through an insulated two inch PEX (cross-linked polyethylene) line to the pit. At the one year follow-up, heat trace was added to the drain lines.

7.0 OPERATION AND MAINTENANCE

At construction completion, homeowners or their representatives were provided training on the system in-person with an ANTHC-National Tribal Water Center (NTWC) representative and then again with the installer. The training included an overview of the system, walking through the operation and maintenance requirements, and answering any questions that arose. Homeowners were left with a comprehensive system manual (Attachment No. 3) and a training video that was filmed locally in one of the homes. The pilot project demonstrated that the system was easily operated and maintained by residents. It also identified key modifications and operations and maintenance areas to highlight in subsequent phases of the project to further reduce potential issues with the systems.

7.1 MONTHLY HOMEOWNER COSTS

Given that most rural Alaskans live a subsistence lifestyle, the operational and maintenance costs were intended to be kept to a minimum. The primary maintenance costs for PASS are replacing the filters and operating the heat trace during the winter months.

Table 7–1 Additional Monthly Cost to Operate Fan and Heat Trace*

Appliance	Power Rating	Energy Rate	Unit	Hours	Energy Consumption	Energy Cost
AXC ventilation Fan	0.044 kW	$ 0.20	$/kWh	720	31.68 kWh	$ 6.34
Heat Trace	0.005 kW	$ 0.20	$/kWh	720	72.00 kWh	$ 14.40
					Total Energy Cost	$ 20.74

* Does not include heat loss associated with ventilation fan operation. Ventilating the home will increase fuel costs for heating. Homeowners can vary the flow of ventilation air based on odor control needs or other indoor air quality preferences.

Table 7-1 shows the electrical costs required to operate the fan and the heat trace. It is anticipated that the heat trace will need to be on continuously in Kivalina during the coldest winter months or approximately six months out of the year.

The cost to replace the cartridge filters are approximately $30-35. The rate for replacement has been different for each volunteer, but the average usage per cartridge is four months, or less than $100 dollars a year to replace the filters.

8.0 PROJECT EVALUATION

The second phase of the project consisted of an evaluation of the systems as they were being used. The criteria by which the systems were evaluated included water usage, mechanical functionality, and customer satisfaction. Health impact was not able to be measured due to the small sample size.

Surveys were conducted with homeowners or their representatives over the course of a year. A pre-installation survey gathered baseline information on each of the households. The team followed up with homeowners and collected feedback one month post construction, at a community meeting in February 2016, one year post-construction, and during check-in calls conducted every one to two months throughout the year. Most of the data collected was self-reported by participants during on-site interviews (sample of survey questions are included in Attachment No. 4).

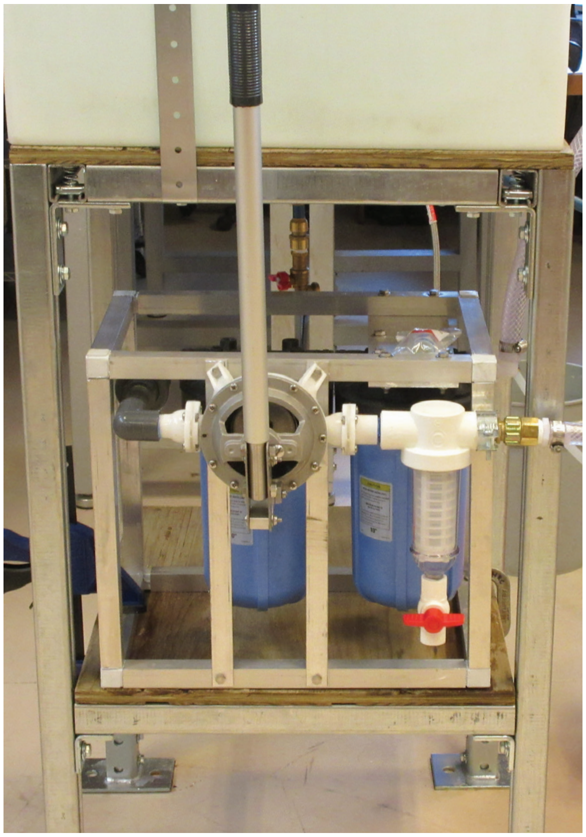


Figure 8-1. The filtration system.

8.1 WATER USAGE

Water quantity is related to improved health. In 2003, the World Health Organization reviewed the evidence of the relationships between water quantity and access as it is related to health in order to help establish a minimum quantity and/or access targets for domestic water supplies (Howard and Bartram 2003). In communities with basic levels of service, "public health gains are primarily achieved through providing protected water sources, promoting good water handling hygiene practices, and household treatment of water and in other key hygiene behaviors (notably hand and face washing) at critical times" (Howard and Bartram 2003).

Specific to rural Alaska, a 2008 study by Hennessy et al. demonstrated an association between the lack of complete plumbing and elevated rates of respiratory and skin infections in rural Alaska. These findings are supported by two other studies of respiratory disease in Alaska Native children (Gessner 2008; Wenger et al. 2010). Recently, a prospective study by Thomas et al. (2016) demonstrated a significant relationship between water service and disease rates in four rural Alaska Native communities. Rates of respiratory, skin, and gastrointestinal disease decreased by 16%, 20%, and 38% respectively in communities that transitioned from self-haul to in-home piped water and sewage. On average communities went from approximately 1.4 gallons per capita per day (gpcd) to 25 gpcd, however one community in the study had an average water use of 9.6 gpcd following installation of the piped system and still demonstrated significant reductions in both respiratory and skin infections (Thomas et al. 2016).

The Kivalina demonstration showed an overall increase in water quantity usage in the home from a baseline of 2.60 gpcd to 3.01 gpcd. Water usage was calculated categorically such as whether or not households used their unit for all their water needs or if they supplemented their water use for activities such as laundry at the washeteria. This was based on homeowner information and a water meter that was installed upstream of the storage tank. In 2016, the Water Research Foundation published the typical water usage per fixture in the home based on a study of over 23,000 homes across 23 study sites in the United States. The study indicated that the average water usage per faucet use was 30 seconds at 1 gallon per minute (gpm) (DeOreo et al 2016). Because Kivalina has a limited water supply during the winter, faucets in the project provided an average of 0.25 gpm in order to reduce unnecessary water loss.

Handwashing is related to improved health. The Ryan et al. study of a handwashing education campaign among U.S. Navy recruits (2001;) "showed a 45% reduction in outpatient respiratory infection visits." Households in Kivalina went from reusing water in handwashing basins (average of 3.56 basin water changes per day, range of 0-14) at baseline to using clean, flowing water in a sink located in the bathroom for each handwashing event after installation of the systems. Households had an average of 7.7 people (range 1-11) living in the home at baseline. This means that handwashing basins on average were changed less than one time per person per day prior to installation of PASS, requiring reuse of the same water multiple times by different people for handwashing and increasing the risk of cross-contamination and spread of disease. In a typical rural home, washbasin use may include handwashing from daily activities, including working on machinery (snowmobiles and ATV's), processing of raw game, bathroom use, and kitchen work.

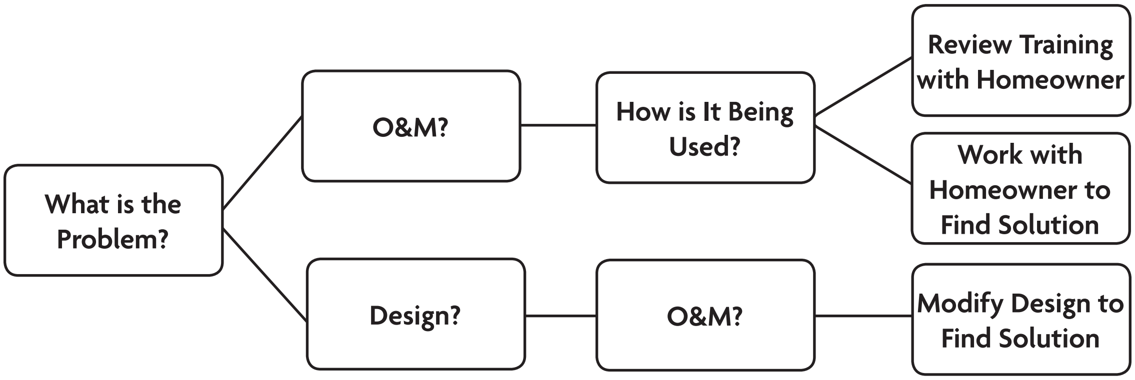
Participants' perspectives on health impact of PASS. Though we did not ask participants about health, multiple respondents reported that they perceived health improvements in their families. One participant stated, "I love it. it's way better than using honey buckets and washing with the same dirty water. We don't get as sick as before, because before that we just, you know, just use the same water over and over to wash, and now it's real good." A second homeowner with 6 kids in the home shared with us, "Haven't been going to clinic for sickness or anything, and yeah- I can say we haven't been going to the clinic as much as we used to." A third respondent with an elderly mother in a wheelchair said, "My family likes the system, my mother especially because she's elderly. It wasn't really sanitary for her because- you know, it's a lot easier for her to catch a cold or sickness."

PASS reduces the amount of water necessary to haul by 40%. The design was intended to provide treated water necessary for healthy water use practices in the home. The system was not designed to replace the centralized laundry and shower services which are available at the community washeteria; however, with the addition of rainwater catchment, PASS has provided clean water in the home for consumption, handwashing, and cleaning in a way that complements the existing infrastructure. This innovative approach has greatly reduced the amount of water necessary for the system to function and meet household needs. A standard toilet uses the largest proportion of water in a typical piped home at 24%, followed by the faucet and shower both at 20%, and the clothes washer at 16% (DeOreo et al. 2016).

8.2 MECHANICAL FUNCTIONALITY

The team expected to encounter challenges throughout the one year evaluation period as this was a pilot project. The system was evaluated both technically and through homeowner usage and report. When an issue occurred, the team assessed whether the design needed refinement or if the problem was an operations or maintenance (O&M) issue. In most cases this was an iterative process between the homeowner and the project team. It is important to note that no matter the perceived cause, a solution was always pursued. The following figure is a general outline of the problem-solving process used during the evaluation period.

Figure 8-2 Process used to problem solve during the evaluation period.



The first identified concern was that the majority of the homeowners were unclear as to when the greywater tank was empty. During the design phase, the Alaska Department of Environmental Conservation (ADEC) requested two inches of liquid at the bottom of the tank to settle out any solids. This caused confusion for the homeowners, as they believed that the tank was not draining correctly and used the emergency drain valve to drain the tank entirely.

The solution was to modify the water level indicator window so that the gauge would signify "empty" when the tank was drained to the level required by ADEC. The solution was both easy and acceptable to the homeowners.

Figure 8-3. Fill indicator prior to fix.

Figure 8-4. Fill indicator after fix.

Figure 8-5. Ventilation Tee.

The outside ventilation stack presented the team with another opportunity to refine the system with the homeowners. Ventilation for the drying toilet was connected to the homes' existing ventilation system, which exited through the walls. Drying waste produces a concentrated odor, so the odor would drift back into the house if the vent was located near a window or door. The team collaborated with a homeowner and determined that an immediate solution was to attach a tee at the end of the stack, diverting the airflow. See Figure 8-5. A long term solution for future designs would be to install the ventilation stack through the roof.

A year after PASS was installed, 100% households reported having experienced no mechanical problems in the past month. However, during the pilot phase, some homes reported freezing issues. The issues were for varying lengths of time and to varying degrees: two froze once heat tape was introduced (the heat tape made the overall pipe diameter narrower resulting in clogging and subsequent freezing) and another froze when the resident left the home for two months. A fourth one froze due to use outside of the design intent. In August 2016, ANTHC installed new wastewater discharge piping with a heat trace included to better prevent freezing. The value of keeping a record of events as they occurred allowed the team to identify whether or not there was a common thread among seemingly separate issues.

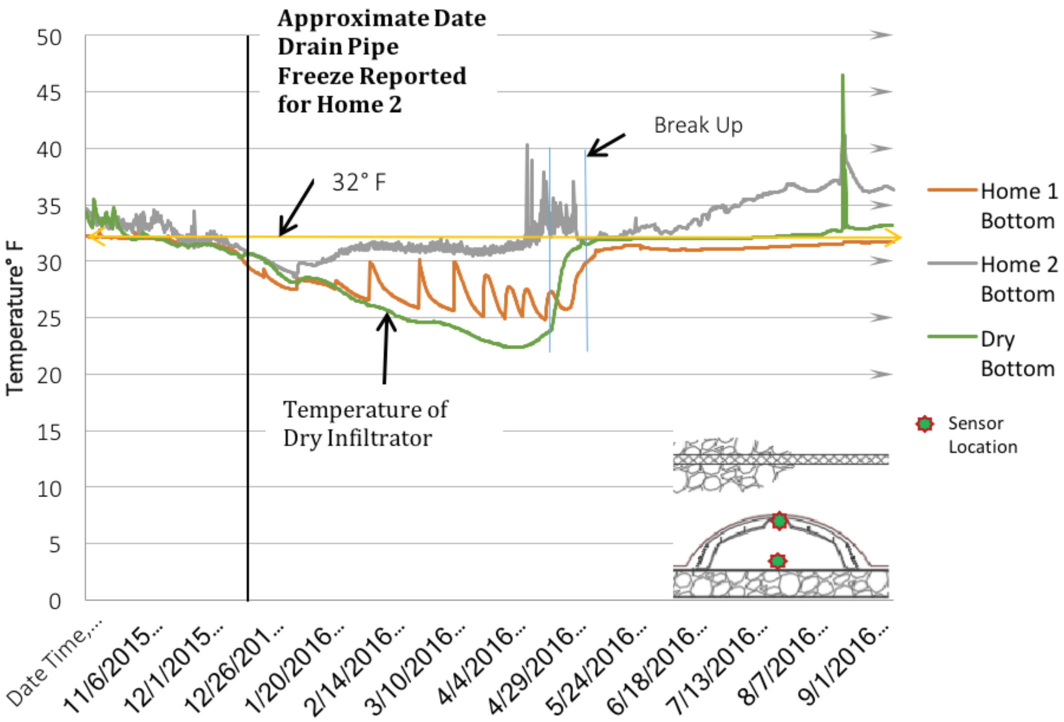


Figure 8-6. Record of freezing events and homeowner greywater tank flushing habits.

A total of six temperature data loggers were installed in three infiltrators (one on the top of the infiltrator and one on the bottom) to track the varying temperature inside the seepage pit where the urine was to collect. One infiltrator did not receive water throughout the period of the study and thus served as a baseline. The figure below shares many things about flushing habits of the homeowners as well as how the seepage pit collected water. The figure indicates that Home One drained its tank every two-three weeks, while Home Two drained its tank every day. This correlates with homeowner reports.

What is noteworthy is that Homeowner Two reported freezing in December and Homeowner One did not. The graph shows that both infiltrators dipped below freezing during that period. It may be that there is better drainage near Home One than Home Two. Note that the temperatures in all infiltrators rose around the end of April, which correlates with the ambient air temperature at the time. See Attachment No. 5 for the complete set of results.

8.3 CUSTOMER SURVEY RESULTS

Overall satisfaction with the new sanitation system is rated at very positive. During the evaluation period, the number of homes was reduced to eight because one home removed the system when their home was being remodeled and it was not reinstalled by the end of the pilot project. Of the remaining homes, all eight were satisfied. One homeowner did elect to remove the waste system. Comments ranged from, "Really satisfied. I like it really well" to "100 stars." One homeowner stated that she "wouldn't change the system for anything," and that she "wouldn't go back to the honeybucket." Another participant reported, "I'd like to see the whole town get the system, because especially during the springtime- it's a real bad time of year, we have a bad problem with human waste when you're walking on the road. I don't even like my kids to be playing out because it's so bad, you know. So when I'm walking down the road I just cover my mouth and walk, because I don't want to smell that."

According to respondents, the process of disposing of waste is lighter, easier, and more convenient. When asked how they felt about the process of disposing of the waste from the new system, 7/8 of the households responded positively, with the final household having no comment. Respondents primarily compared the new system to the honey bucket system. PASS makes the waste lighter, easier, and more convenient to haul to the dump. As compared to the honeybucket system, 100% of the respondents stated that their experience with the new system is a positive one. As one resident put it, "The honey buckets were - it's a real hassle to try to haul that to the dump with the pee and anuk together. You have to make sure the bag doesn't tear, and we make a whole trail out to the dump with pee and anuk, and it just takes a lot of space and a lot of time and a lot of work. This system takes a lot of work out of- you know, versus the honey buckets." Another shared, "Before, it was disgusting. I didn't want to do it [haul the honeybucket] so I paid labor. It smelled. It was just gross. Cleaner. Don't smell. I'd rather that [the PASS system] than going back to the honeybucket. Dad always said don't take my bathroom. He loved it. [an elder who had recently passed]."

"Before, it was disgusting. I didn't want to do it [haul the honeybucket] so I paid labor. It smelled. It was just gross. Cleaner. Don't smell. I'd rather that [the PASS system] than going back to the honeybucket. Dad always said don't take my bathroom. He loved it."

The greatest benefit of PASS. When asked about the greatest benefit of the in-home system, the answers varied. The responses were, "the faucet," "healthier (despite a lot of hauling of water) and less mess," "running water," "less work," "more clean," "healthcare," "sanitary part," and a "lack of germ spreading." A homeowner expanded further by stating, "Healthcare. My babies got cleaner water to wash in... It's just cleaner health-wise."

9.0 DISCUSSION

The PASS pilot was conducted in a community where basic sanitation is still needed and piped water and sewer to the home will not be available for the foreseeable future. The immediate response to the pilot and evaluation results indicate that the system will provide affordable water and sewer in areas where piped water and sewer to the home is not feasible. Community members appear to accept the system as a good alternative to the honeybucket when piped water and sewer are not available; one that will immediately improve the quality of life of those who use it. PASS provides an alternative option to bridge the wide gap between a fully piped system and a self-haul system with a honeybucket and wash basin.

In order to determine the true potential of PASS, more data is required to measure the long-term effectiveness of the systems. Additionally, there needs to be research to better understand the quantity of water that must be available immediately in a rural Alaska home to reduce sanitation related health risks and the amount of water that can be provided centrally (e.g. at the washeteria for laundry and showering) to supplement the quantity provided in the home. Many in the water and sanitation field reference the 13.2 g/c/d estimate provided by Howard and Bartram for a low level of health concern (2003) and by Gleick to meet basic human water needs (1996). It should be noted that the 13.2 g/c/d quantity is not directly applicable to many situations though. Howard and Bartram's estimate includes the amount of water necessary for bathing and laundering on-site (2003), and Gleick's estimate also includes the water necessary for bathing (1996).

The scenario that is typical for many rural Alaska communities with a centralized laundry and showering facility and often mechanical modes of transportation available at the household level was not considered by the authors listed above and offers an opportunity to think more critically about water needs in the home versus those that could be provided with a reasonable amount of effort. Removing the need for water to bathe and launder clothes in the home greatly reduces the amount necessary to improve health. The Alaska public health community needs a better understanding of how centralized facilities coupled with in-home infrastructure can effectively protect health in communities while also increasing the amount of homes that can receive such benefit by offering lower cost non-piped solutions.

Finally, since the conclusion of the pilot, both the City of Kivalina and the Native Village of Kivalina have passed resolutions in support of ANTHC identifying funding to install more PASS units in Kivalina (Attachment No. 2 – Resolutions). The community feeling seems to be best expressed in the words of the participants, "I hope they bring more here, and I hope they find money to put in the systems to whoever wants it." And "Send me five more if you guys can!"

9.1 LESSONS LEARNED

More often than not water and wastewater reside below the public conscious. In most cases, they are commodities that arrive by pipe and leave by pipe. In a honeybucket community, the perception of sanitation is no different than that of a hub or urban community. Today, more than ever, people can easily travel to the city and stay in hotels where individuals have access to flush toilets. In addition, if the school in the community is able to have running water, residents wonder why piped water cannot be connected to their homes. This logic is sound regardless of any technical explanation that states otherwise. In an effort to provide a honeybucket community with an in-home sanitation system, like PASS, there is an expectation on the user's end that the system will provide piped-like amenities. Therefore, an important and understated aspect of this project was social engineering and managing expectations. For future PASS projects, it is important to keep in mind that training and building rapport is critical. Face-time with homeowners and repeated training should be planned for.

It is recommended that future trainings are a requirement of project participation. ANTHC recommends that at least all able-bodied adult and adolescent members of households should participate, and the trainings should include an introduction and overview of the resources so that residents are comfortable referring to them when questions come up. Residents also recommended that those with systems participate as trainers, building self-efficacy among the trainees through peer modeling. This will increase the understanding of the operations and maintenance of the system and may encourage a feeling of ownership and responsibility in exchange for the time invested in learning the system.
PASS is designed to be placed in remote locations. Future systems would benefit with local infrastructure that could provide replacement parts and assistance with troubleshooting. For example, some elders may not be physically able to fix problems on their system should they arise.

Other noted outcomes of the project include the following items:

- Water use measurement is challenging.
- Social context affects everything.
- Residents do not mind hauling water.
- Residents would like an emergency discharge designed to easily allow homeowners to haul away greywater in the case of freezing. It is possible with the current design but could be more convenient.
- Some residents were effective problem solvers and assisted with refinements.
- The discharge of gray water is site specific; meaning ground conditions, such as those with permafrost will not be able to accept gray water while others, such as those with non-frost susceptible free draining soils will have no problem with discharge.

9.2 RECOMMENDATIONS

In summary, the following are our recommendations for moving forward:

- Serve the remaining homes in Kivalina with the PASS units.
- Conduct research on how much water is necessary in the home and what can be centrally provided in communities to ensure a low health risk for residents
- Offer the systems in a modular form so that residents can choose what configurations, features, and space allocation will work best for them.
- Set up local infrastructure for troubleshooting and repairs (i.e. local worker and basic parts available).
- Set aside more time and travel money for project team to troubleshoot.
- Training needs to be a prerequisite for at least all able-bodied adolescents and adults.

10.0 ACKNOWLEDGEMENTS

ANTHC thanks the households who participated in the pilot and recognizes their contributions to the effort. As the local experts, their collaboration was invaluable. To the Tribal and City Councils in Kivalina, ANTHC offers thanks for the willingness to allow the community to take part in the pilot and for the feedback provided throughout the project. Third, ANTHC acknowledges the funding invested by the Northwest Arctic Borough, ANTHC leadership, ANTHC-NTWC, and the Indian Health Service to make this project happen. Finally, ANTHC thanks its partners who helped design the PASS units: Cold Climate Housing Research Center, Lifewater Engineering, and CampWater Industries LLC.

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12.0 CONTRIBUTORS

JOHN WARREN, P.E.
ENGINEERING SERVICES DIRECTOR
Tel (907) 729-3511 • jwarren@anthc.org

MIA HEAVENER, P.E.
SENIOR CIVIL ENGINEER
Tel (907) 729-3539 • Mia.Heavener@anthc.org

KORIE HICKEL, MPH, REHS, CHES
SENIOR ENVIRONMENTAL HEALTH CONSULTANT
Tel (907) 729-3505 • khickel@anthc.org

TIMOTHY THOMAS, M.D.
CLINICAL RESEARCH SERVICES DIRECTOR
Tel (907) 729-3511 • jwarren@anthc.org

COMPANY INFORMATION

Alaska Native Tribal Health Consortium
Environmental Health and Engineering
4500 Ambassador Drive
Anchorage, Alaska 99508
Tel (907) 729-3600
www.dehe.org

LIST OF ATTACHMENTS:

Attachment No. 1: Feasibility Study (Contact for document)
Attachment No. 2: Resolutions
Attachment No. 3: Homeowner Training Manual
Attachment No. 4: Sample of Survey Questions
Attachment No. 5: Infiltration Sensors

ATTACHMENT NO. 1: FEASIBILITY STUDY
(CONTACT FOR DOCUMENT)

ATTACHMENT NO. 2: RESOLUTIONS

Native Village of Kivalina

P.O. Box 50051 Kivalina, AK 99750 **Ph:** (907)645-2201 or 645-2153 **Fax:** (907)645-2250 or 645-2193
e-mail: tribeadmin@kivaliniq.org

"Advocating for our people, land, waters and subsistence way of life"

RESOLUTION 17-01

A RESOLUTION IN SUPPORT OF ALASKA NATIVE HEALTH CONSORTIUM PORTABLE ALTERNATIVE SANITATION SYSTEM (P.A.S.S.) PROJECT IN KIVALINA FROM THE CITY OF KIVALINA AND THE NATIVE VILLAGE OF KIVALINA.

WHERAS: The Native Village of Kivalina (IRA) Council is the governing body with full authority over its membership; and recognized by the federal government to receive assistance; and

WHEREAS: The Native Village of Kivalina (IRA) Council support Alaska Native Tribal Health Consortium P.A.S.S. project in Kivalina.

WHEREAS: The Alaska Native Tribal Health Consortium DEHE is in need of funding more P.A.S.S. systems and will seek funding on behalf of the community of Kivalina.

NOW THEREFORE BE IT RESOLVED THAT the Native Village of Kivalina (IRA) Council approves the Alaska Native Tribal Health Consortium plan to seek funding for additional in-home systems to eliminate the honey bucket use in Kivalina, Alaska.

CERTIFICATION

We the undersigned, do certify that the Kivalina IRA Council is comprised of 7 members of whom ____ members were present and the above resolution we adopted by a vote of 7 ayes, ___ nays, and ____ abstaining.

President [signature]

Secretary Dolly E. Foster

Date: 1/11/17

Kivalina City Council
P.O. Box 50079
Kivalina, Alaska 99750

Phone: 907-645-2137
Fax: 907-645-2175
email: kivalinacity@aol.com

RESOLUTION 17-02

A RESOLUTION IN SUPPORT OF ALASKA NATIVE HEALTH CONSORTIUM PORTABLE ALTERNATIVE SANITATION SYSTEM (P.A.S.S.) PROJECT IN KIVALINA FROM THE CITY OF KIVALINA.

WHEREAS, the Kivalina City Council is the governing body for the City of Kivalina; and

WHEREAS: The Kivalina City Council support Alaska Native Tribal Health Consortium P.A.S.S. project in Kivalina.

WHEREAS: The Alaska Native Tribal Health Consortium DEHE is in need of funding more P.A.S.S. systems and will seek funding on behalf of the community of Kivalina.

NOW THEREFORE BE IT RESOLVED THAT the City of Kivalina Council approves the Alaska Native Tribal Health Consortium plan to seek funding for additional in-home systems to eliminate the honey bucket use in Kivalina, Alaska.

PASSED AND APPROVED BY THE Kivalina City Council on the 19th day of January, 2017.

IN WITNESS THERETO:

Signature: [signature] Title City Mayor

Attest: [signature]
Marilyn Swan, City Clerk

ATTACHMENT NO. 3: HOME OWNER TRAINING MANUAL

Contents

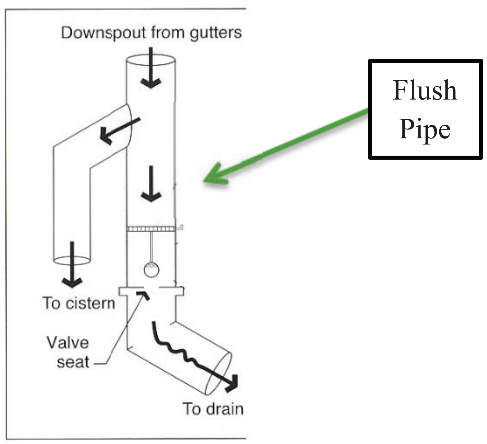
Pictures

Water System

Rain Catchment

The rain catchment system works very simply.

The rain gutter will catch the rain as it falls and channel it to the flush pipe. See Picture 1. Because the first rainwater may carry dirt and dust from the roof, it will first collect in the pipe that is capped at the bottom. This pipe is called the **diverter pipe or flush pipe.** When the flush pipe is full, water will then flow in the pipe that leads to the rain barrel.



Baffle first-flush

Source: Adapted from SafeRain ©2003

Picture 1: First-flush pipe

Occasionally you will want to unscrew the valve at the bottom of the flush pipe and clean out any dirt or build-up. Unscrew the bottom fitting, and everything will fall out, including the filter and a green plastic ball that is used to slow down the water flow. Carefully clean everything, and put everything back in place. See Pictures 2 and 3.

Picture 2: Unscrew bottom to clean

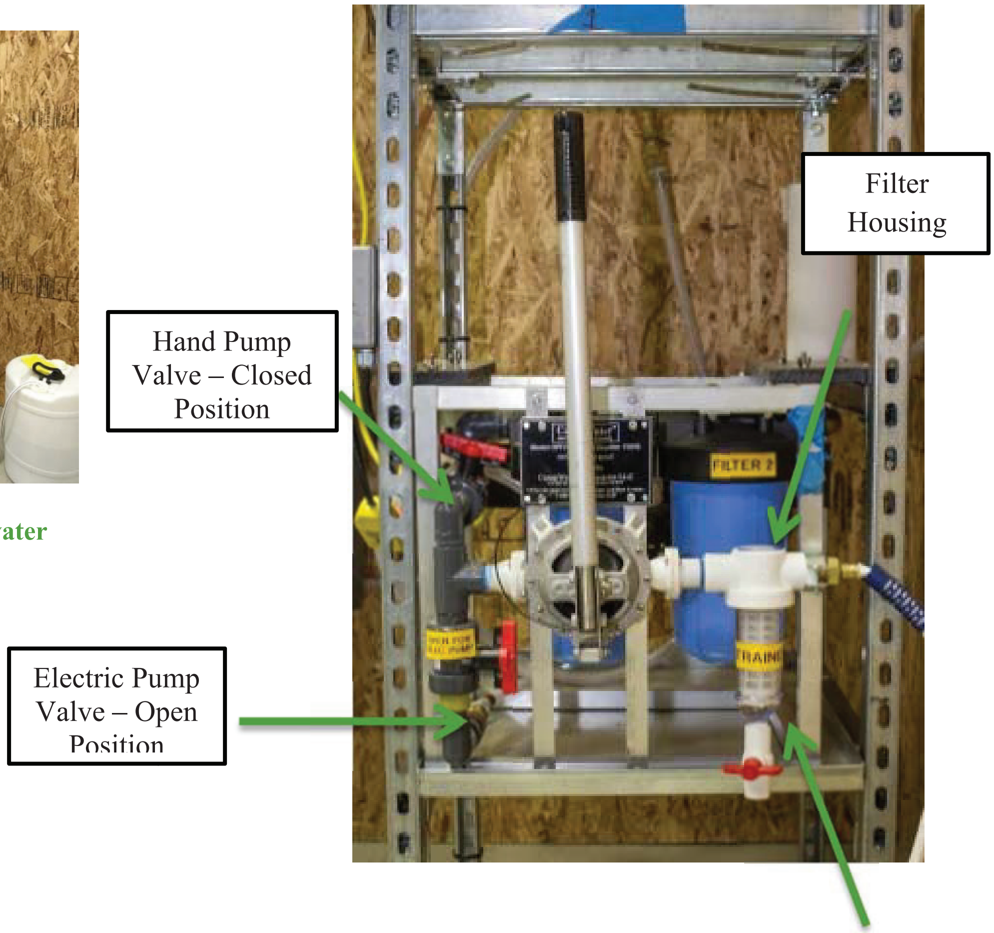
Picture 3: Clean sediment from filter

You should not let children play with the catchment system. They shouldn't touch the inserts in the pipe. The diverter will not work without the ball and inserts. Prior to freeze up, the flush pipe should be drained to avoid water freezing in the pipe. To do this, unscrew the bottom piece and flush all of the water. Replace the cap and screw it back on.

Filling the Water Tank

The water tank in your new system will hold one hundred gallons. It can be filled in two different ways—with a hand pump or an electrical pump. The hand pump and electrical pumps cannot be used at the same time. As a part of the water treatment process, the pumps will filter water through a strainer and two filters. The strainer takes out larger particles while the filters screen out fine sediment and harmful bacteria.

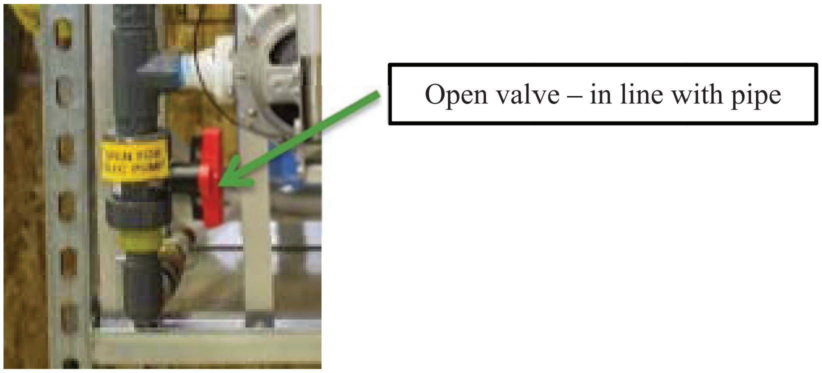
Picture 4: Complete water system



Picture 5: Front of water system

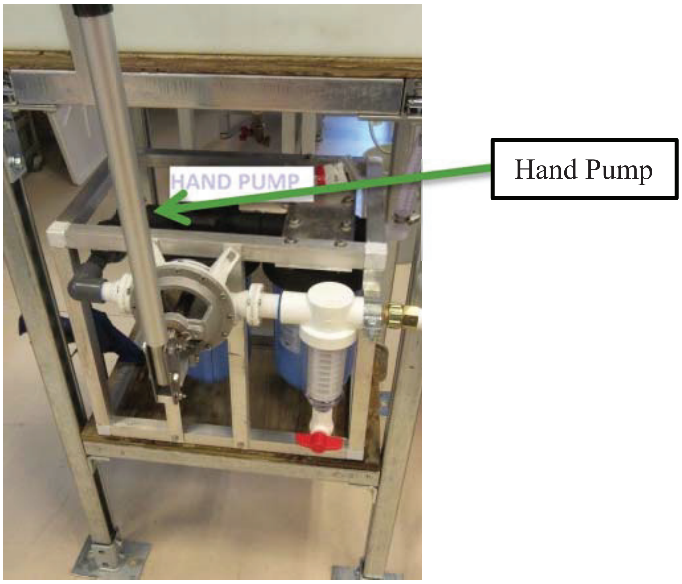
Hand Pump

To use the hand pump, open the valve with the label "open for hand pump" and close the valve labeled "open for elec". You will know the valve is open when it is in the same position as the sticker, in line with the pipe.



Picture 6: Example of open valve - in line with pipe

The hand pump brings water from the fill bucket through a strainer that catches larger particles of dirt. The water then passes through two filters. After passing through the filters, the water goes to the tank.



Picture 7: Hand pump

Electrical Pump

To use the electrical pump, open the valve for the electric pump and close the valve for the hand pump. This lets the water bypass the hand pump. Plug in the pump and make sure that the light on the yellow plug in is on. If it isn't, press the reset button. Turn on the electrical switch. The electrical pump will force the water through the strainer and filters to the tank. Never run the electrical pump dry – that is, without water flowing through it.

Picture 8: Turning on electrical pump; electrical pump valve open and hand pump valve closed

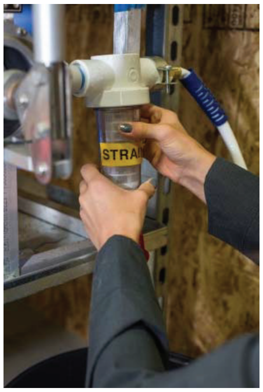
System Maintenance

Strainer

You will need to clean the strainer screen occasionally. Look at the strainer from time to time. If it is getting dirty, shut down the pump. Open the strainer drain valve to get rid of the particles. If it still looks dirty, unscrew the strainer, remove the screen, and swish it in a bucket of water. Be careful not to damage the screen. Use only a soft rag or old tooth brush to clean it if necessary. Check that the O-Rings are properly seated when reassembling, and close the drain valve. If the O-Rings are not in place, the strainer will leak.

Picture 9: Strainer

Picture 10: Opening drain valve



Picture 11: Unscrewing strainer

Picture 12: Rinsing screen

Filters

From time to time you will need to change the filters. When it becomes harder to use the hand pump or the flow into the tank becomes slower, it's time to change the filters. It isn't always necessary to replace both filters at once. Try replacing Filter #1 first. It is more likely to become clogged first. Filter models and sizes are located in the Replacement Part Section.

Picture 13: Filters to be placed inside the blue filter housing

FILTER #1

Filter #1 is a particulate filter designed to remove particles, bacteria, and protozoans. When changing the filter, remove the housing bowl with the provided filter wrench. Remove the cartridge, dump the dirty water out of the bowl and clean it, put the new cartridge in making sure it's centered, check the O-Ring, and screw it back in. Tighten with no more force than required to prevent leaks.

Picture 14: O-Ring

Picture 15: Filter wrench

FILTER #2

Filter #2 removes smaller particles and bacteria effectively and also reduces tastes and odors and some organics in the water. The same maintenance procedure applies as for Filter #1.

If the water tank, pump, and filters are to be shut down for more than one day, **remove the filters** and let them air-dry.

Pump

The pump will operate as long as the strainer ahead of it is intact and the strainer isn't damaged, frozen, or overheated. The back pressure on the hand pump handle will increase as the filters load up. If it gets too hard to push, it is probably time to check the filters and perhaps change them. Try changing just Filter #1 first, as it will catch the bigger particles.

If the suction strainer gets plugged, the pump handle will be more difficult to pull up; in this case shut down and clean the strainer (see Strainer section).

Faucet

The faucet has an aerator screwed onto the faucet head that slows the rate of water flow. From time to time, the aerator may collect fine solids and need to be cleaned off. To do this, unscrew the faucet head, take out the aerator, clean it, and screw it back on.

Picture 16: Aerator - unscrew and clean

Picture 17: Unscrewed aerator

Trouble Shooting

	Possible Causes	Possible Remedies
Filter Housing Leaks Water	O-Ring may be worn out	Replace O-Ring
	Thread may be damaged on housing	Replace filter housing
	O-Ring may need to be to be sealed	Grease O-Ring with plumber's grease
	Filters may not be centered in the filter housing	Make sure the filters are centered

	Possible Causes	Possible Remedies
Pump Does Not Pump Water	Suction hose may be clogged	Use the hand pump to push water to flush the hose
	Air may be trapped in the pump	Use the hand pump to prime the electric pump
	Plugged filters	Replace filters that are full
	Valves may be cracked	Check valves; replace cracked valves
	Strainer valve may be open	Close strainer valve
	Pump may have lost its prime	Use the hand pump to prime the electric pump

	Possible Causes	Possible Remedies
Low Flow from Faucet	Drain line from tank may be clogged	Remove aerator from the faucet; flush out the line
	Aerator may need to be cleaned	Clean aerator; refer to System Maintenance section on how to clean aerator

Disinfecting the Water

Disinfecting the water is step two of the treatment process. It kills bugs and germs—the same bugs and germs that can cause stomach aches and diarrhea. Bleach makes sure that the water is safe for you and your family to drink.

Make sure that you use glasses to protect your eyes and gloves to protect your hands during this process.

To disinfect the water, follow these steps:

1. Fill 1 milliliter (ml) disposable dropper with unscented 8.5 percent bleach up to the 1 ml line.
2. Squirt one dropper of unscented 8.5 percent bleach into the small port on the tank.

Picture 18: 1 ml disposable dropper

Picture 19: Take 1 dropper of bleach from the bottle cap

Picture 20: Add 1 dropper of bleach to small port on tank for every 10 gallons of water

3. Add ten gallons of water.
   ***Always** fill the tank ten gallons at a time and always use the bleach cap to fill the dropper.*

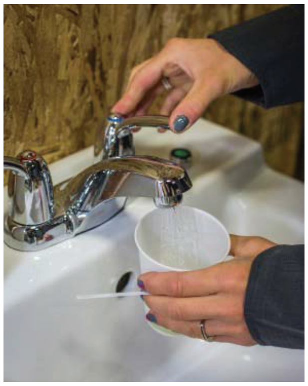
4. Each time you add another ten gallons, start by adding one dropper full of bleach.

5. Before you add the last ten gallons, wait thirty minutes.

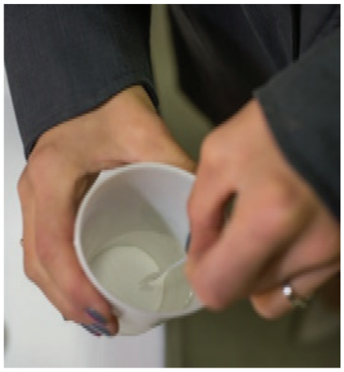
6. Turn on the water at the sink and let it run for one minute.

Picture 21: Let Water run for 1 minute before testing

7. Using the chlorine test strips, check the water. The test strip will show the level of the chlorine in the water. The amount of **chlorine–** that is, the amount that registers on the strip – **should be over 1 and less than 4.**



Picture 22: Fill cup with ~50 ml of water (Use provided cup if available)



Picture 23: Swish test strip back and forth slowly for ~20 seconds

8. If the color shows that the level is below 1, then add one more dropper if the tank is holding about 30 gallons (i.e. $1/3^{rd}$ full). Add two droppers if it is holding a little over 65 gallons (i.e. $2/3^{rds}$ full).

Picture 242: Compare test strip to instructions - pictured strip reads too little chlorine (<1.0)

9. Add 5 more gallons of water to mix the contents in the tank.

10. Turn on the sink water again and let it run for one minute.

11. Test the water again. Follow the instructions with the test strip.

12. When the strip shows the chlorine residual above the 1, wait at least an hour before using the water.

Picture 253: Compare test strip to instructions - pictured strip reads level of 1.0

Disinfecting the water with bleach is one of the most important steps in making sure your water is safe for drinking and other uses. It will take some time, but having clean, safe water for your family and yourself is worth the wait.

If you use the correct amount of bleach, you shouldn't be able to taste it. If the test strip shows that the water is ready to drink, but there is still a chlorine smell that bothers you, fill a pitcher with drinking water and leave it in the refrigerator overnight. Any smell should be gone by morning.

If the water is not disinfected with bleach, it must be boiled at a rolling boil for at least one minute to kill the germs in the water before you drink it, cook with it, or use it to brush your teeth.

Safety: Only adults should add the bleach. Since bleach can burn the eyes and skin, you should always use rubber gloves and safety glasses when putting it into the tank. You should allow at least ninety minutes to disinfect the water before you need to use it.

Summary

- Use household unscented bleach at 8.5 percent concentration.
- Use the disposable dropper to add the bleach.
- Always test the water for the correct chlorine level following the instructions on the package.
- Allow 30 minutes before testing the water and another 60 minutes before using it to make sure that it is treated correctly and safe to drink.
- Always use rubber gloves and safety glasses.
- Only adults should add the bleach to the tank, not children.

Traveling with Your Filtration System

Your water filtration system can be removed from the water tank unit and taken with you to fish camp or other locations where you may want access to treated water. Just remember that after you pump the water through the filters, you still need to disinfect with bleach or boil the water to kill all of the bugs and make sure it is safe for you and your family to drink.

To remove the filtration system, unscrew the four bolts holding the filter frame in place. Pull the unit out carefully, as the drip pan will come out with it. Set the water filter system on the floor, disconnect the hoses, empty the water out of the filter housing, and you are ready to go!

Picture 26: Unscrew 4 bolts, and pull unit out - drip pan will come out

Picture 274: Unit is out - unhook hoses, and it's ready to go!

Wastewater System

Picture 28: Sit back on the toilet seat, and throw toilet paper in the solid waste disposal only; make sure to put nothing but human waste (feces) and toilet paper in the system

Toilet Maintenance

The toilet is designed to separate liquids from solids. This arrangement will make disposal easier, more sanitary, and less odorous. When a person is sitting on the toilet, it may be necessary to move forward a little so that all urine goes into the funnel. It may also be necessary to move backward a little to get all solids to go into the plastic bag in the bucket. Males SHOULD NOT pee into the toilet while standing up. To do so could cause urine to enter the plastic bag. Males who want to pee standing up MUST use the urinal.

Every few days a quart of water should be poured rapidly into the urinal. This will help flush urine crystals from the white tube and keep the trap primed to prevent odors from the tank from getting into the room.

Picture 29: Urinal and trap

Solids will go into the bucket below the toilet seat. It is lined with a compostable or plastic bag. There is a fan to dry the waste and to control odor. When the plastic bag is full, you will need to replace it with a fresh bag. You lift the seat to remove the bucket with the bag. Make sure the two latches drop to lock the seat in place to prevent pinched fingers. Remove the bag, close it off, and take it to the landfill. Put a fresh bag into the bucket. Make this a regular practice to prevent odors and keep the system working properly.

It is recommended to NOT use the compostable bags if the homeowner does not have a compost heap outside the toilet. If a green, compostable bag is not changed every 2 to 3 weeks it will begin to soften and decompose in the toilet.

Picture 30: Lifting lid to remove waste

Picture 31: Clean bag and absorbent pad

You can clean the toilet parts with bleach and water and simply wipe them down. You should clean the toilet whenever you change the solid waste bag or even more often. Regular cleaning will help control odors.

Safety: You should wear rubber gloves for cleaning to protect your health.

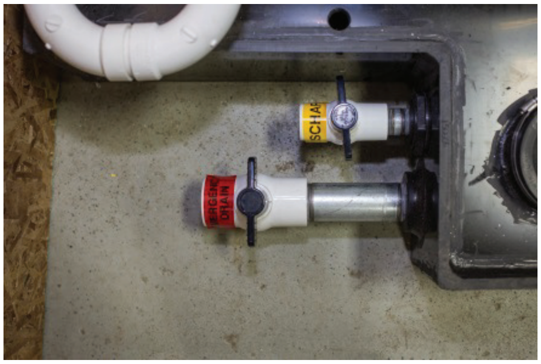
Gray Water Tank

Liquids, urine, and water from the sink, will go into the grey water tank below the toilet. You will need to empty the tank whenever it is full or every two weeks - whichever comes first. The gauge on the side will tell you when the tank needs to be emptied.

When the indicator reaches the fill line (or every two weeks, whichever comes first), it is time to discharge the tank

Picture 32: Fill level indicator

There are two valves on the back corner of the tank. Use the discharge (upper) valve to empty the waste fluids into the seepage pit. After the tank is emptied, the valve **must** be closed or the tank and pipe may freeze during the winter. **CLOSE** valve after the tank drains to prevent freezing. The lower valve is the tank drain valve. It drains directly onto the ground. This valve is to flush accumulated solids out of the tank or to drain the tank if the seepage pit or the pipe freezes. It is labeled "Emergency Drain."



Picture 33: Discharge valve - top; emergency drain valve - bottom

Picture 34: Opening discharge valve

When you drain the grey water tank, the level indicator (Picture 32) will drop to the colored tape. When the level indicator no longer moves, then the tank is completely drained. The level indicator will NOT drop to the bottom during normal usage.

Ventilation

Your system has two fans, one on the wall and one in the toilet. The fans in this system use very little energy, and it is extremely important that one of the fans is running all the time when the house is occupied and the system is being used.

Wall Fan

Make sure that the wall fan is *always* on. This will provide ventilation to the whole house, providing cleaner air to your family and controlling odors from the toilet. The damper can control how much air is pulled through the fan. The damper should only be opened just a small amount. This will ensure the toilet is properly vented and will help control odors. If you want more odor control, close the damper all the way.

Picture 35: Closing the damper

Picture 36: Damper fully closed

Toilet Fan

The fan in the toilet can provide even more ventilation to control odors or serve as a back-up if the wall fan breaks. The fan in the toilet has two settings—adjust to position two if you want more air flow through the toilet.

Picture 37: Switch for toilet fan

The screen over the fan inside the toilet will need to be cleaned periodically. To clean it, unclip the screen, wipe it, and reattach it.

Picture 38: Fan screen removed for cleaning

Preventing Freeze-Ups

It is extremely important that you wait to discharge the entire gray water tank all at once, especially during the winter. The release of a large amount of room temperature liquid will help prevent freezing of the pipe.

If the system will not be used for long periods of time or the home is allowed to go cold during the winter, the entire system -- the water storage tank, water treatment system, and gray water tank -- must be drained to prevent growth of bacteria or damage from freezing. Drain the water storage tank and leave all of the valves and sink faucets in the open position. Empty the water strainer and filter housings and leave the filters out of the housings to dry (if they are not plugged they can be re-installed when the system is put back into service). Drain the gray water tank using the lower valve with the red tape and then close both the valves. Unplug all electrical connections.

To winterize the pump, remove dirt or grime that may trap moisture. Disconnect the inlet and outlet fittings and remove any water from the pump. Leave the fittings disconnected from pump.

Trouble Shooting

	Possible Causes	Possible Remedies
My Bathroom is Stinky	Waste is not drying	Close damper; turn on backup-fan
	Urinal needs to be flushed	Pour water down the urinal-enough to flush water trapped in the trap
	Grey water tank won't drain	Line to seepage pit may be frozen; open the emergency drain (lower) valve
	Urine is getting into the plastic bag and mixing with the solids	Males who pee standing up MUST use the urinal. All who pee sitting down must position themselves so that all urine goes into the funnel.

Parts List

Item	Purchase Locations
Pentek DGD-5005 Dual Gradient Density Filter Cartridge (5 micron)	Alaska Pure Water, Anchorage www.amazon.com www.waterfiltersonline.com
Pentek FloPlus 10BB Carbon Fiber Block (0.5 micron)	Alaska Pure Water, Anchorage www.amazon.com www.filtersfast.com
SenSafe Free Chlorine Water check Test Trips	Alaska Pure Water, Anchorage www.amazon.com
Aquatec Pump Series 55121E12, 115V, 3.2 gpm	
Droppers	
Gloves	
O-Rings	Alaska Pure Water, Anchorage
Filter Housing	Alaska Pure Water, Anchorage
Filter Housing Wrench-Pentek SW-3	www.waterfiltersonline.com

Toilet System

Item	Purchase Locations
Absorb Pads	Kotzebue or Local store or Lifewater Engineering, Fairbanks (info@LifewaterEngineering.com or 1-866-458-7024)
4-gallon small garbage trash bags	Kotzebue or Local store or Lifewater Engineering, Fairbanks (info@LifewaterEngineering.com or 1-866-458-7024)
Toilet Replacement Parts	Lifewater Engineering, Fairbanks (info@LifewaterEngineering.com or 1-866-458-7024) www.separett.com See attached sheet.

ATTACHMENT NO. 4: SAMPLE OF SURVEY QUESTIONS

Respondent and Household Information

1. How many people currently live in your home?__________________________

2. Do people who do not live in your home use your water? CHECK: □ Yes □ No

Water Use Practices

Now I'd like to ask you some questions about how you use water in your home.

3. Since the in-home water system was installed, has there been a change in how you use water around the home?

   CHECK: □ Yes □ No

   3.a. IF YES: Please explain

   ____

   ____

   ____

4. What do you use the water supplied by the system for?

   ____

   ____

   ____

5. Water meter reading:_________________

I have a few questions about some specific water use practices.

6. Do you treat your drinking water? CHECK: □ Yes □ No

   6.a. IF YES: What method do you use to treat?

   Filter Filter & add chlorine Boil Other (Specify)____________

7. How often do you change out the PASS filters?____________________

8. How many loads of laundry has your family washed in the last seven days?________ loads/week

9. Where do you wash your laundry? (CIRCLE ALL)

   Home Another home Washeteria Other (Specify)______

10. IF WASH AT HOME: Do you ever re-use water when you wash laundry at home?

CHECK: □ Yes □ No

10.a. IF YES: How many times do you use the water before you change it? _______________

11. Do you use a basin for washing hands? CHECK: □ Yes □ No

11.a. IF YES: How many times did you change the water yesterday? ______________________

12. TABLE TO BE FILLED OUT THROUGH DISCUSSION

Sources of water in the last two weeks				
Source	Amount	Reason	Collection Frequency	Time Required/ Collection

**For cost/collection, verify the price at the washeteria*

**Also look at cost of laundry load and the functionality or the washeteria*

Mechanical Reliability

13. In the past month, have you experienced any mechanical problems with the system?

CHECK: □ Yes □ No

13.a. IF YES: Please explain

____

____

____

13.b. IF YES: What will it/did it take to resolve the issue?

____

____

____

Cost

14. Has the amount of money that you spend on water for activities such as drinking, laundry, and showers changed since you got the in-home system?

CHECK: □ Yes □ No

14.a. Please explain

____

____

____

Quantity and Quality of Life

15. TABLE TO BE FILLED OUT THROUGH DISCUSSION

Waste Hauling Practices	
15.a. Waste haul frequency	
15.b. Time for one roundtrip waste haul	

How has the installation of an in-home water system affected you and your family?

____

____

____

____

16. How do you feel about the process of disposing of the waste from the installed toilet versus the honeybucket? ____

____

____

____

Consumer satisfaction as it relates to water service

17. How satisfied would you say that you are with the in-home water and wastewater system?

____
____
____
____

18. What do you see as the greatest benefit of having the in-home system?

____
____
____
____

19. What was the greatest challenge or problem that your family had with the in-home system? ____________

____
____
____
____

20. If you could change anything about the in-home system, what would you change? ____________________

____
____
____
____

21. How could we improve the homeowner training? _______________________________________

____
____
____
____

22. How would you recommend setting up a system to assist with operations, maintenance, and repairs? ______

____
____
____
____

23. Would you be willing to pay a monthly fee for someone to help with maintenance or repairs?

CHECK: □ Yes □ No

24.a. IF YES, how much?_____________

24. Is there anything else that you would like to share with me? ____

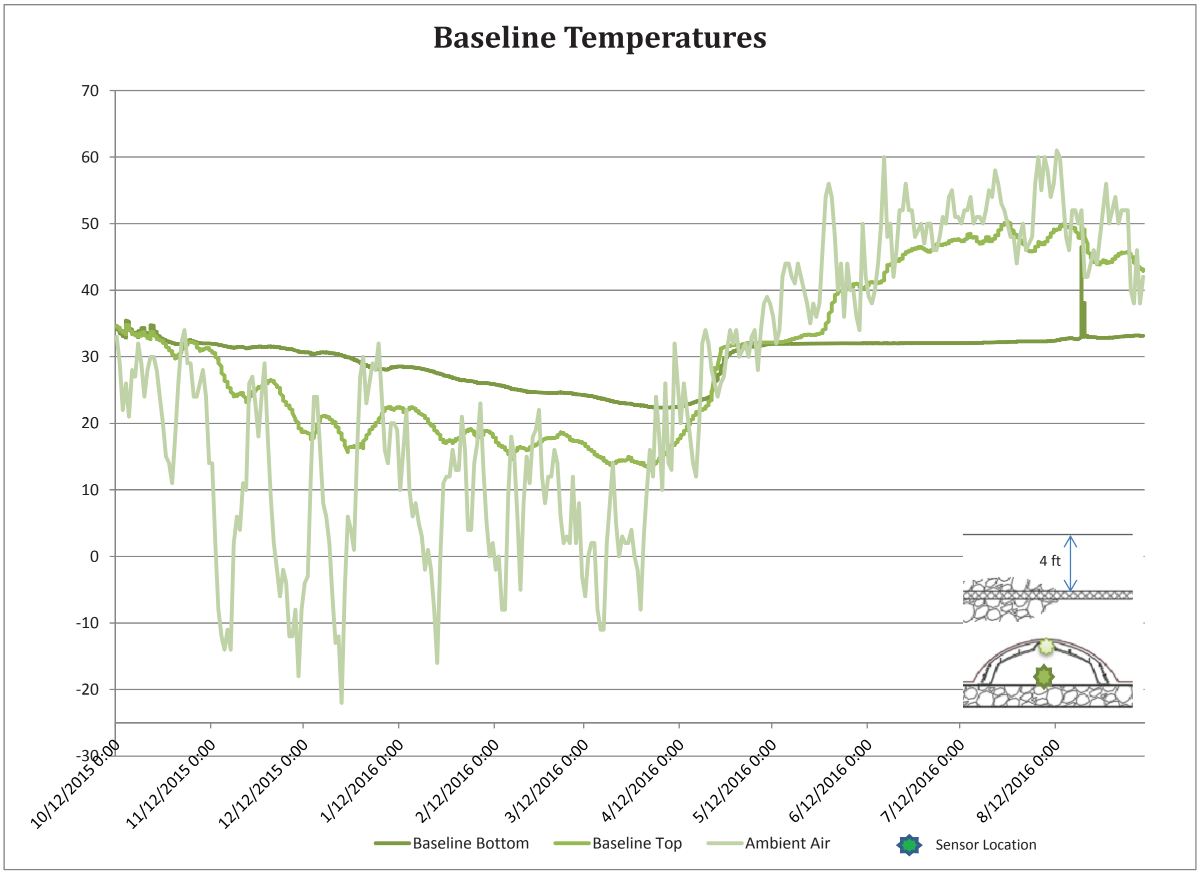
____

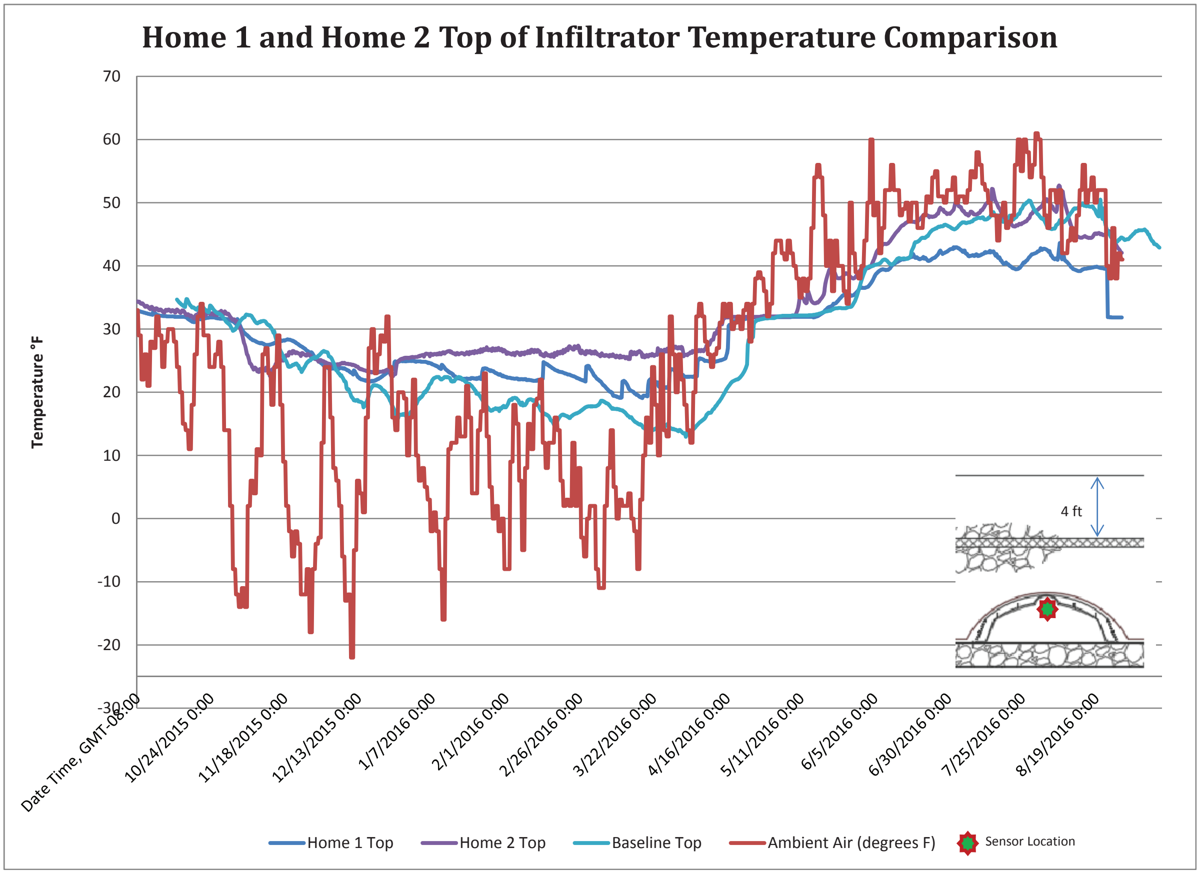
____

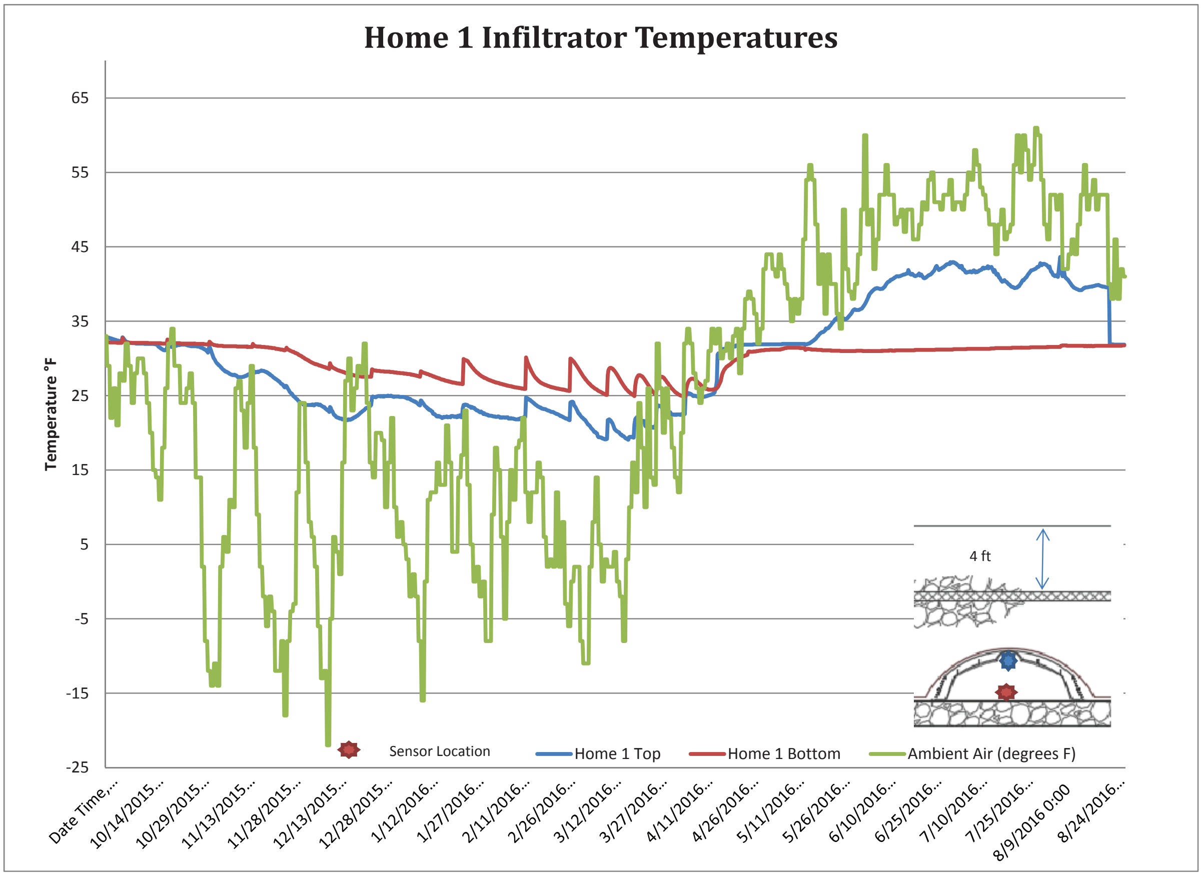
____

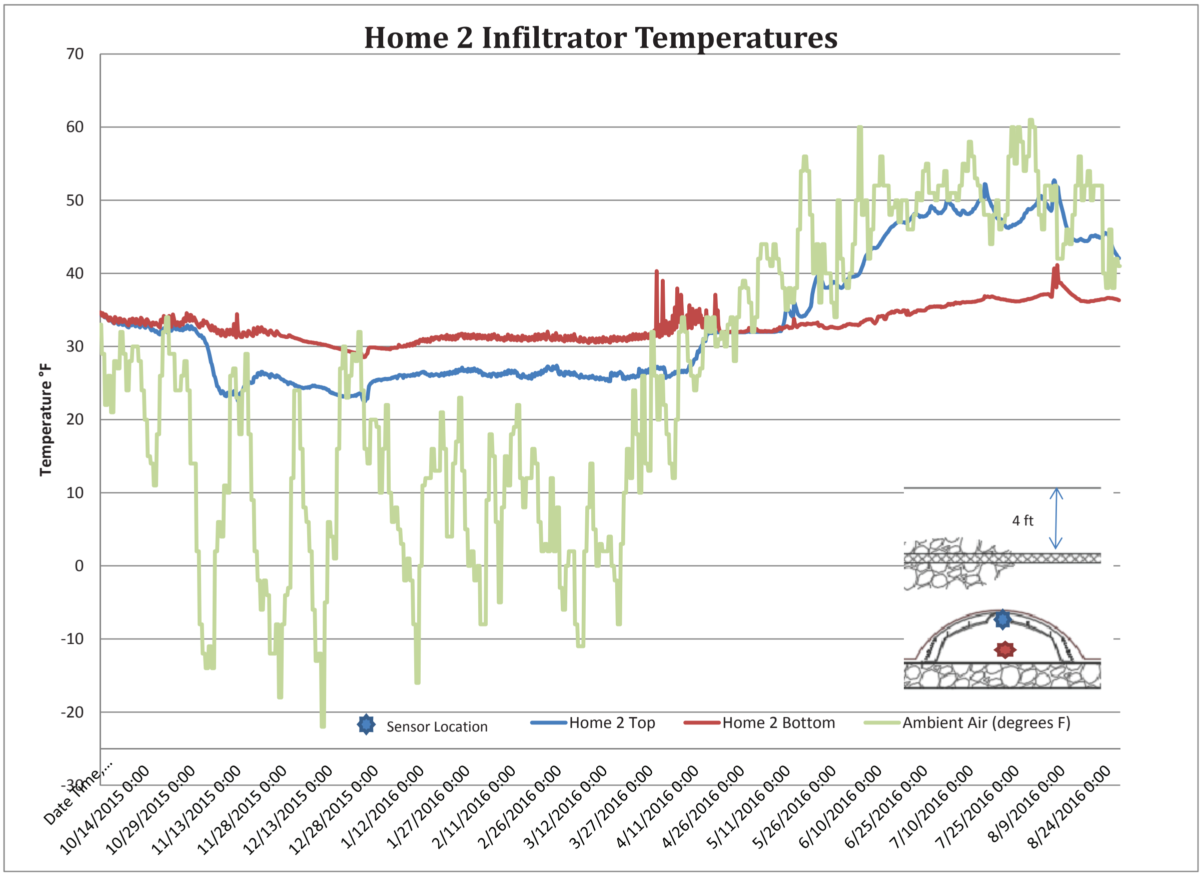
____

ATTACHMENT NO. 5: INFILTRATION SENSORS


Baseline Temperatures
70
60
50
40
30
20
10
0
-10
-20
-30
4 ft
10/12/2015 0:00
11/12/2015 0:00
12/12/2015 0:00
1/12/2016 0:00
2/12/2016 0:00
3/12/2016 0:00
4/12/2016 0:00
5/12/2016 0:00
6/12/2016 0:00
7/12/2016 0:00
8/12/2016 0:00
Baseline Bottom
Baseline Top
Ambient Air
Sensor Location


Home 1 and Home 2 Top of Infiltrator Temperature Comparison
Temperature °F
70
60
50
40
30
20
10
0
-10
-20
-30
4 ft
Date Time, GMT-08:00
10/24/2015 0:00
11/18/2015 0:00
12/13/2015 0:00
1/7/2016 0:00
2/1/2016 0:00
2/26/2016 0:00
3/22/2016 0:00
4/16/2016 0:00
5/11/2016 0:00
6/5/2016 0:00
6/30/2016 0:00
7/25/2016 0:00
8/19/2016 0:00
Home 1 Top
Home 2 Top
Baseline Top
Ambient Air (degrees F)
Sensor Location


Home 1 Infiltrator Temperatures
Temperature °F
65
55
45
35
25
15
5
-5
-15
-25
4 ft
Sensor Location
Home 1 Top
Home 1 Bottom
Ambient Air (degrees F)
Date Time,...
10/14/2015...
10/29/2015...
11/13/2015...
11/28/2015...
12/13/2015...
12/28/2015...
1/12/2016...
1/27/2016...
2/11/2016...
2/26/2016...
3/12/2016...
3/27/2016...
4/11/2016...
4/26/2016...
5/11/2016...
5/26/2016...
6/10/2016...
6/25/2016...
7/10/2016...
7/25/2016...
8/9/2016 0:00
8/24/2016...


Home 2 Infiltrator Temperatures
Temperature °F
70
60
50
40
30
20
10
0
-10
-20
-30
4 ft
Sensor Location
Home 2 Top
Home 2 Bottom
Ambient Air (degrees F)
Date Time,...
10/14/2015 0:00
10/29/2015 0:00
11/13/2015 0:00
11/28/2015 0:00
12/13/2015 0:00
12/28/2015 0:00
1/12/2016 0:00
1/27/2016 0:00
2/11/2016 0:00
2/26/2016 0:00
3/12/2016 0:00
3/27/2016 0:00
4/11/2016 0:00
4/26/2016 0:00
5/11/2016 0:00
5/26/2016 0:00
6/10/2016 0:00
6/25/2016 0:00
7/10/2016 0:00
7/25/2016 0:00
8/9/2016 0:00
8/24/2016 0:00