Design Proposal: Hose
"Not-your-average" Hose

Overview
The proposed hose solution is simple and inexpensive, but it has a high probability of minor, localized leakage during disassembly. It utilizes a majority of off the shelf, industry standard parts that are easily acquired and replaced in country.

Technical Specifications

Three main categories comprise the fecal sludge conveyance system: hose, couplings, and accessories. A 3" or 75mm inner diameter suction style hose, such as the Tiger Flex TG300X100 or similar in country hose, in seven 50 feet or 15 meter segments acts as the base of the system. The TG300X100 or hoses similar to it will have the following ratings:

Length Density	1 lb/ft (1.49 kg/m)
Working Pressure Limit	3 bar @ 68℉ (20℃)
Turning Radius	7" (0.18 m)
Environment Protection	UV and Abrasion Resistant

Kamlok, cam and groove, connectors will be installed at the each hose section. These connectors will allow for secure reliable connections that are leak proof and simple to use. The cam and groove connectors are constructed out of cast aluminum with a stainless steel interior.

The following are some of the technical specifications of the hose:

Working Pressure Limit	12 bar
Weight/Assembly	7 lbs (3.18 kg)
Seal Material	Buna-N

The final category, accessories, contains all of the ancillary equipment to operate the fecal sludge conveyance. This includes a 3" force disc curb plunger with flexible ½" threaded pipe to remove clogs from the hose segments. Buckets will also be a necessary component to capture any errant fecal sludge during the tear down process. REINFORCED RUBBER?

Business Case

In the current model, an owner operator would purchase an initial kit that would contain all of the necessary parts to have an operational conveyance system. Then as components wear or break, those can be purchased individually. Currently, the cost of materials for this design proposal would be $2766. A cost breakdown is shown in the table below.

Item	Quantity	Unit Price	Total Price
Cam Lock	14	$26	$364
Storage Rack	1	$150	$150
Buckets	2	$2.50	$5
Industrial Plunger	1	$20	$20
Hose (50ft Length)	7	$316	$2,212
Total CAPEX			**$2766**

The hose itself is the most expensive part of the system at ~80% of the total conveyance system.

Process

There are four processes the FSOI workers would employ while operating the proposed hose solution: set up, unclogging during usage, disassembly and storage, and cleaning. The subsections below outline the steps for each procedure. While the amount of time required for each of these tasks will vary based on the context (ex. the distance between the PSU and RSU), we have established time estimates through basic testing.

Setup (20-30 minutes)

This system can be set up by two small women (~100-120 lbs, 5’3”) in 20-30 minutes. The setup procedure will be performed every time the system is used. The procedure can be modified based on the pits distance from the road and personal preference/skill, but our recommended procedure is listed below

1. Remove a 50 ft section of hose from truck by disconnecting cam lock on each side which is connecting it to storage rack.
2. Connect one end of hose to RSU 3 inch output and drag the other end of hose towards the pit
3. Repeat steps 1-2 for next several sections of hose, to distance as needed to access PSU. Instead of connecting to RSU, connect end to the piece of hose already set up.
4. Double check all cam lock connections to ensure they are fully attached.
5. Activate PSU to begin pumping FS through conveyance assembly to truck

Unclogging during Usage (15 minutes)
For the proposed system, we recommend each truck purchase a three inch industrial force disc curb plunger. Clogging in the system is an issue that could stall the entire pit latrine emptying process and could be mitigated with the purchase and use of this plunger.

In the event the hose has been clogged while removing fecal sludge we recommend:

1. Stop the use of the pit-side unit.
2. Identify the section of hose where the clog is.
3. Retrieve three inch industrial force disc curb plunger and attach it to the flexible ½" threaded pipe.
4. Disconnect clogged section of hose from neighboring sections (other sections will close automatically)
5. Open kamvalok connector on each side (manual opening is necessary to prevent sealing and allow for unclogging)
6. Place one open end into designated bio-waste bucket; attach industrial plunger to other end
7. Push plunger forward, forcing material out other end and into bio-waste bucket
8. Cap bucket & reconnect hose section to neighboring sections.
9. Clean plunger
10. Resume use of the pit-side unit as before.

Disassembly and Storage (30-40 minutes)

Once the PSU has pumped all material through the conveyance assembly to the truck, leaving little to no liquid left in the conveyance assembly after use, the conveyance system may be disassembled and stored in 30-40 minutes by the operators. At disassembly, there is a moderate to high risk of minor, localized FS leakage, which we propose to mitigate with the use of a designated, lidded, biowaste bucket which can then be emptied at the truck, pit, or treatment facility at the operator's discretion. To properly disassemble the conveyance system, the following steps must be taken.

1. Allow PSU to pump all material through conveyance assembly to truck (there should be little/no liquid left in assembly after use)
2. Place weighted, biohazard storage bucket beneath connection
3. Carefully disconnect coupler, allowing any stray FS to leak into the bucket rather

than the surrounding environment.

4. Carefully place dust caps on both open cam lock connectors, preventing any further leakage
5. Rest one section on the ground, now that it has been safely capped.
6. Place a lid on the biohazard storage bucket until it is needed for further disconnects.
7. Carry disconnected section to truck (2-3 operators)
8. Lock each end of the section into corresponding cam locks on storage rack (uncap each section prior to locking into place, place caps in designated cap storage area)
9. Lift the center of section onto hook on rear of truck
10. Repeat steps 2-9 for each section unloaded from truck.

Cleaning (60 minutes)
There is no suggestion as to how often the FSOI workers should clean the hoses, as the context will vary. FSOI workers in some environments may find more frequent cleaning to be beneficial for the smell, operation, and longevity of the hoses, while FSOI workers elsewhere might find infrequent cleaning to be sufficient. However, we do recommend that all cleaning take place at a waste treatment facility, as the proposed method of cleaning requires water and it is essential the dirty hoses not touch any water source that will not then be treated.

The cleaning procedure is laid out below; it assumes the FSOI truck is at a treatment center (presumably it has just delivered its solid waste) and there is an easily accessible source of water at the facility.

1. Move the PSU to a contained source of water that will be processed and treated before being released into a waterway.
2. Connect the PSU to the water source.
3. Remove one 50 foot length of hose from the FSOI truck.
4. Connect one end of the hose to the PSU and place the other end of the hose into the water source.
5. Turn on the PSU and pump water through the hose for approximately 2 minutes
6. Turn off the PSU.
7. Disconnect the hose from the PSU.
8. Store the hose back on the FSOI truck.
9. Repeat steps 3-8 for each 50 foot length of hose.
10. Ensure the used water goes through a processing unit.

Limitations

The proposed system, while meeting many system requirements, faces the following limitations when compared to the benchmark hose solution.

CAPEX:
While much less expensive ($2800 as opposed to $4500 USD) than the benchmarked hose solution, the CAPEX for this solution is still extremely high, and may still presenta a barrier to purchase by local entrepreneurs and operators when combined with the CAPEX of the entire system.

Pressure:
Similar to the benchmarked system, the hose utilized in this sytem is rated for 3 bar. It can withstand pressures of 4 bar or greater, but these pressures greatly reduce the lifespan of the hose (from approximately 5-7 years to 3-5 years). This does not produce any changes to OPEX from this system vs. the benchmark, as the benchmark was calculated for an LRU with a lifespan of approximately 3-5 years.

Cleaning:
The recommended cleaning cycle for this system depends heavily on water availability and time, both of which may present a barrier to cleaning to local operators and entrepreneurs. Lack of regular cleaning could dramatically reduce the system's lifespan, and potentially result in a 3 year OPEX of $2800+ as the entire system may need replacing, rather than just certain components.

Availability:
The parts and manufacturing capabilities for this system are available in Sub-saharan africa, but we have thus far been unable to obtain a quote. This presents the possibility that the system may be available at a much higher CAPEX/OPEX in developing countries, which would present a higher barrier to use and availability to local operators and entrepreneurs.

Leakage:
This system has a high risk of minor, localized FS leakage into the surrounding environment. If procedures outlined are followed correctly, no leakage into an uncontrolled environment will occur. However, there is a high probability of user error resulting in some leakage.