Product Launch

Latrine Pit Pumping System

Mzuzu, Malawi

Client: Willy Chipeta
Advisor: Dr. Kochersberger
Facilitator: Austin Floeter

Team Members: Cody Reese, Brett Rush, Saud Alfouzan, Grant Baumgardner, Daniel Miller

Problem Description

- Diarrheal diseases cause 8,800 deaths in Malawi annually, 4,500 of which are children under five years of age.
- Pit latrines are used to improve sanitation, but must be emptied to remain useful
- Emptying can be dangerous and unsanitary

Challenge: Use locally available materials to provide a means of safely and efficiently removing sludge from pit latrines.

Current Pit Emptying Methods

Specific constraints identified by our client

Access

There is currently no standard design for pit latrines in Malawi

Variety of latrine types and latrine entrances

Latrine hole sizes vary from latrine to latrine

Transportation

Bicycles and motorbikes will be the common means of transporting the product

Physical characteristics of sludge

Sludge can be stratified, with the most dense section at the bottom

Sludge is liquidized by pouring water into the keyhole, and a stirring process

Requirements and Specifications

Client provided list of specs from previous research with information on:

- Available materials and manufacturing processes
- Minimum required performance
- Safety requirements
- Size and weight restrictions
- Environmental, social, and economic considerations

Requirements and Specifications

Requirement	Category	Specification	Threshold	Target
The pump shall work regardless of latrine size or sludge composition/stratification	Sludge Properties	Maximum Size of Debris	0.05 m	0.075 m
		Flow Rate	2m^3/hr	2.5 m^3/hr
	Modularity	Availability of Resources	1	0
		Characteristic Length of Pump	2 m	0.6 m
The pump shall not cause harm to the operator	Safety	Number of Contact Incidents	1	0
		Ergonomic	180 W	160 W
		Number of Exposed Moving Parts	3	2
The pump shall cost no more than $1,500	Durability	Pumping Time for 1 Latrine	3 hours	2 hours
		Life Expectancy	5 years	15 years
		Cost	$1,500	$1,000
		Drop Height for Shipment	0.5 m	1 m
The pump and lever shall be easily maneuvered and transported	Portability	Length of Lever	2.5 m	1.5 m
		Weight	25 kg	20 kg
The pump shall incorporate common and readily available parts/hardware	Simplicity	Minimize rare and inaccessible items	1	0

First Iteration of Pump

- Based upon existing gulper design
- Single piston check valve system
- Minimally effective
  - Long Stroke
  - Leaking Piston
  - Full body pumping action

Second Iteration of Pump

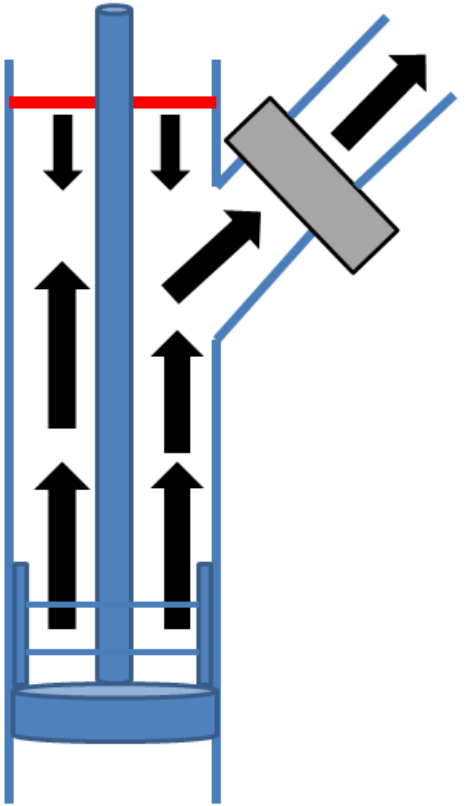
- Added second check valve
- Decreased stroke length
  - Increased effectiveness
  - Reduced need for larger lever
- Downside: not adjustable

New Check Valve Impact

Vertical Flow is impeded by stopper and redirected through a check valve

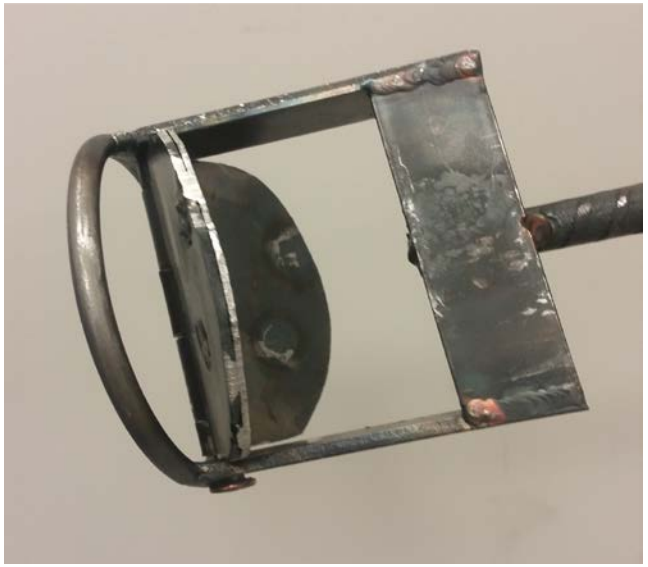
This enables us to use a shorter stroke length and mitigate piston rod tilt

In turn the shorter stroke length reduces the weight of the sludge in the tube while only slightly affecting flow rate



Second Iteration of piston

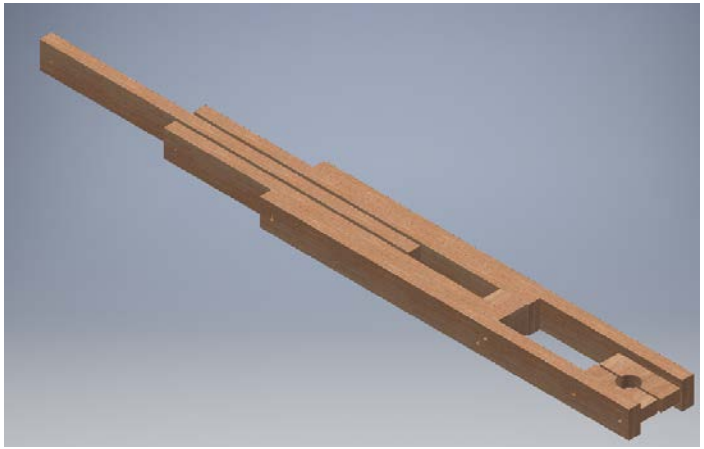
Old Piston Valve



New Piston Valve

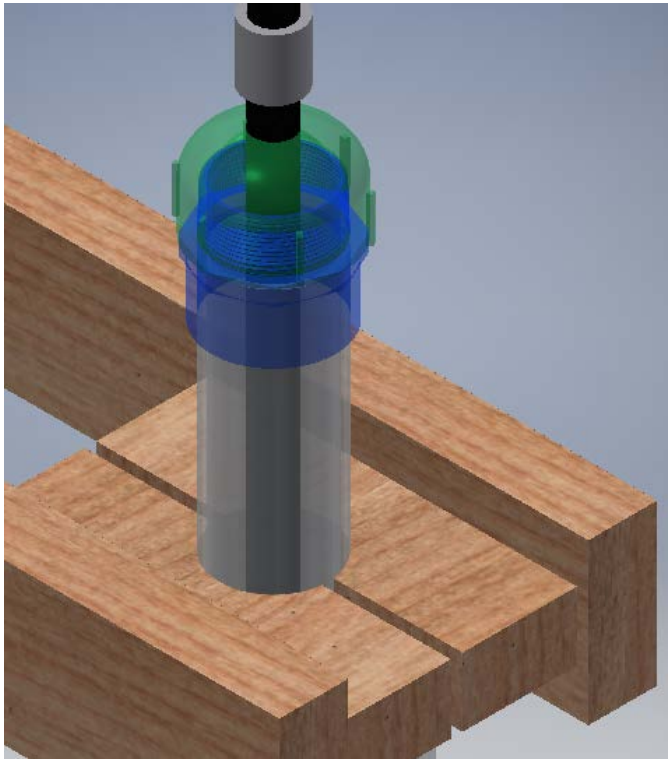
Current Detailed Design

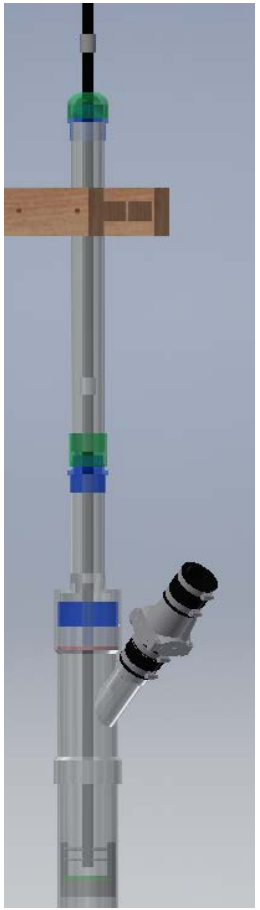
- Reduced lever size to increase portability and versatility in smaller latrines
- Collapsible to a linear design
- Single length for beams



Detailed Design (CAD Models)

- Modular components
  - PVC guide rods and steel piston pipe attached with threaded couplings
- Increases adjustability for different latrines
- Addresses stratification issues with variable depth





Product Photos

Analysis Supporting Design Decisions

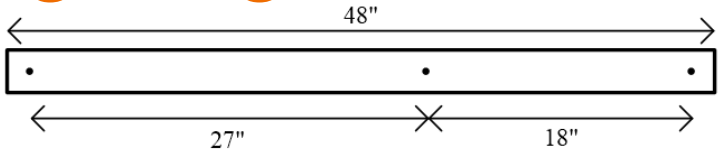
Simple, standard materials

- 24” extension pipes
- Linkage made from one 36” pipe
- Lever assembly made from three 8’ 2”x4”s
- All fasteners either ¼” or ½”
- Piston made from 4” door hinge and 3.5” pipe
- 4’ Wood beam lever construction
- Swing check valve

Construction requires simple hand tools

Analysis Supporting Design Decisions

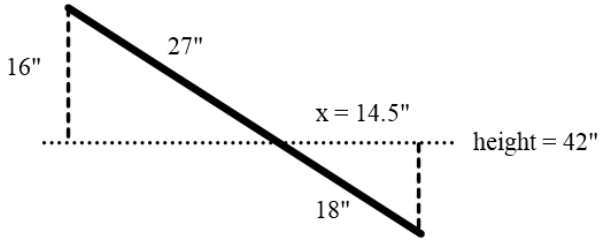
Ergonomics/Kinematics



Pumping motion stretches from shoulder to thigh

Input pump is 30”, output stroke is 20”

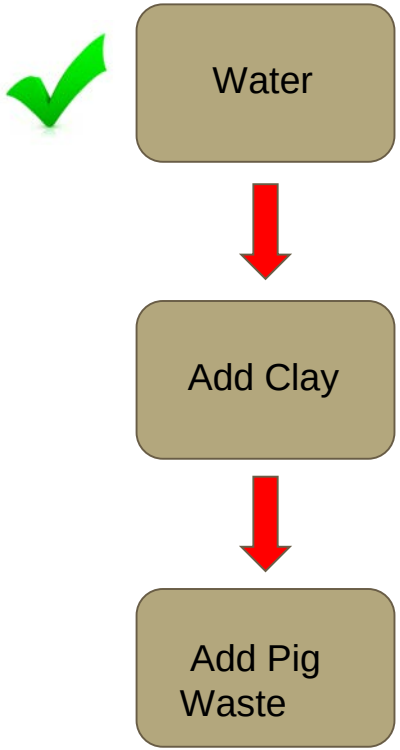
3:2 mechanical advantage (input:output)

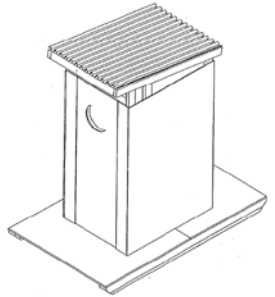


Fulcrum height lowered 1 inch

- Discourages linkage crossover issue at top of stroke
- Fulcrum positioned 14.5” behind pump axis to give maximum advantage at bottom of stroke

Testing Plan





Testing Matrix

Mixture	Flow Rate (m^3/hr)	Force Input (Newtons)
Water		
40% Clay (1113 kg/m^3)		
60% Clay (1183 kg/m^3)		
Pig Waste (1200 kg/m^3)		
Pig Waste w/ Trash		

Acceptance Criteria

Pump successfully emptied latrine (within 1.5 ft of latrine floor)

Pump empties the latrine in a reasonable amount of time (2 hours)

- 2 m^3 per hour

Zero occurrences of contact incidents

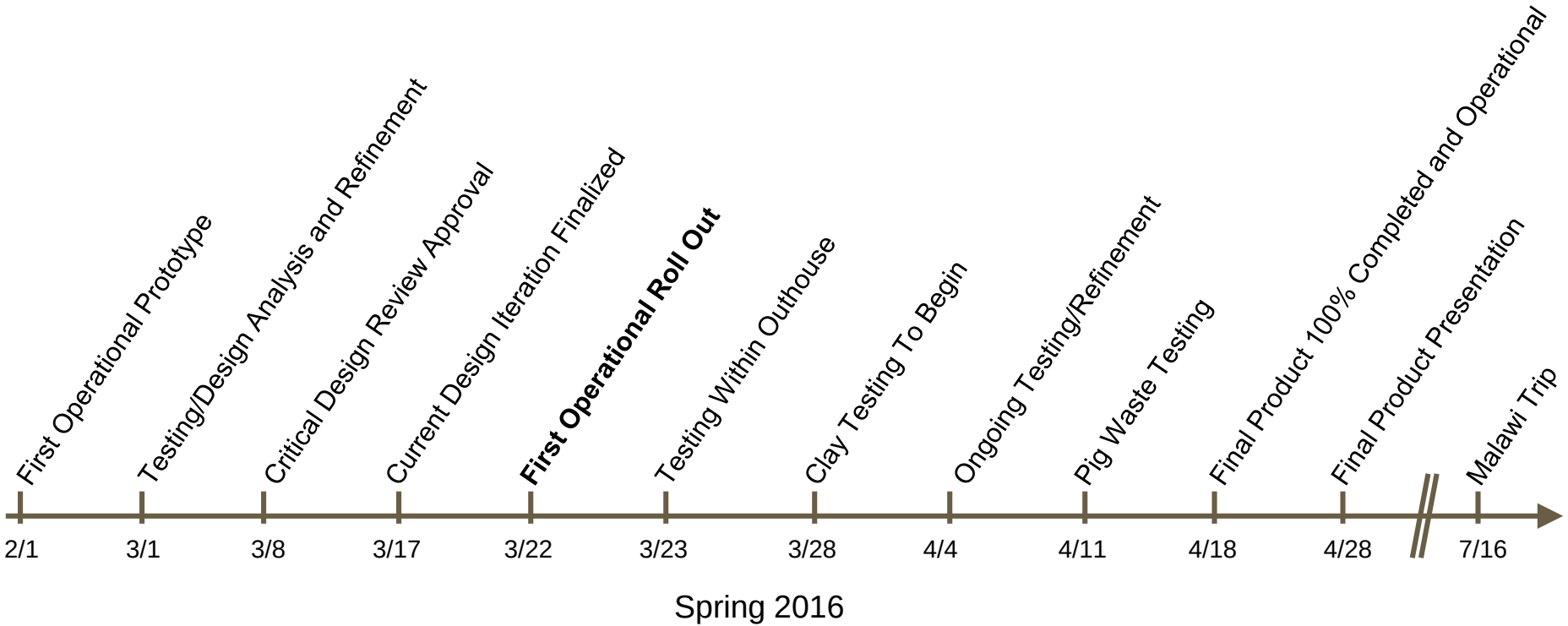
Ensure the pump and lever can be easily transported (by man or bike)

Operational in latrines between 4-8 ft deep

Test Photos

Demonstration Video

Project Schedule



Spring 2016

Budget

Total Budget for Project: $3,000

Project Duration: 30 weeks (2 semesters)

Large portion of budget was intended to be used for transportation to Africa

Amount Spent through project so far (23 weeks) : $521.14

Remaining Budget: $2,478.86