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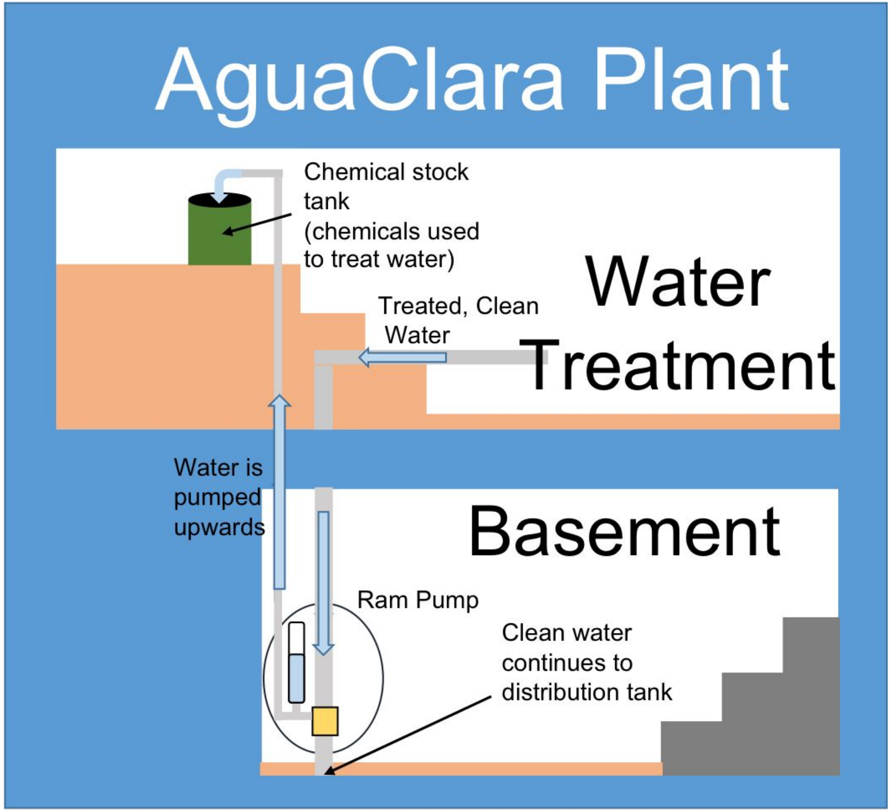
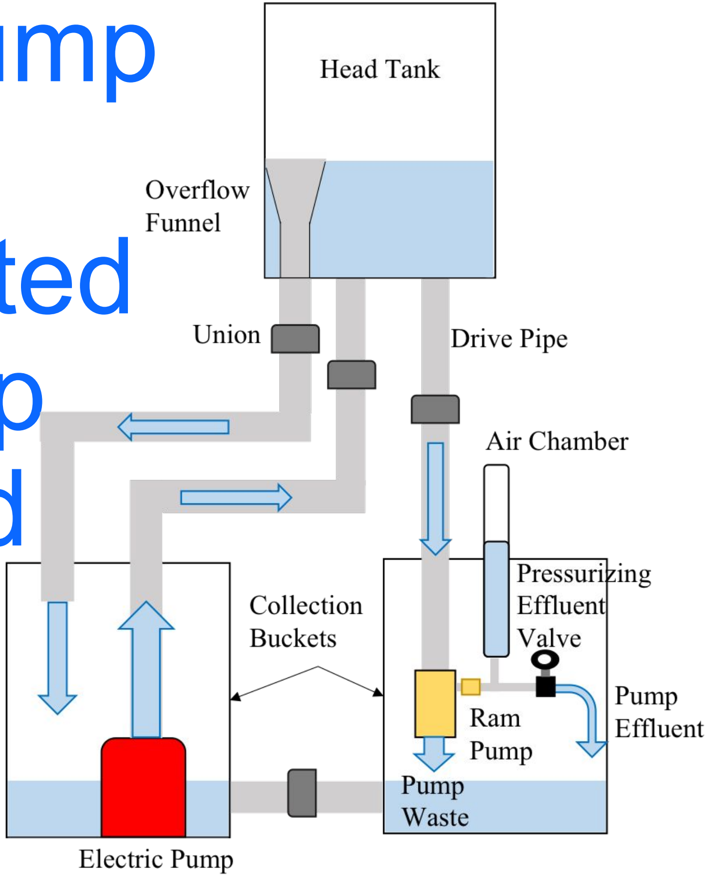
Ram Pump Fall 2016

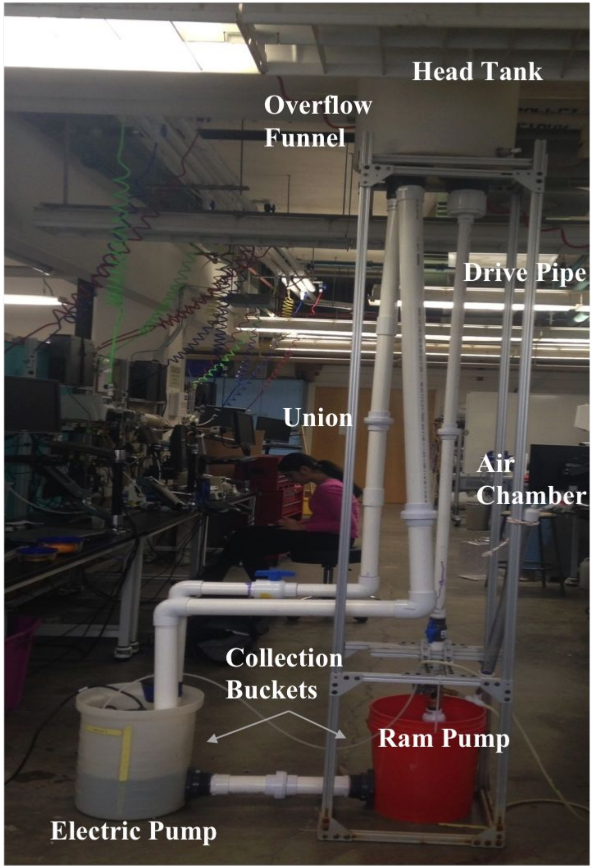
Hydraulic pump to carry water from below a plant to higher elevations in order to restore chemical mixing tanks and other processes

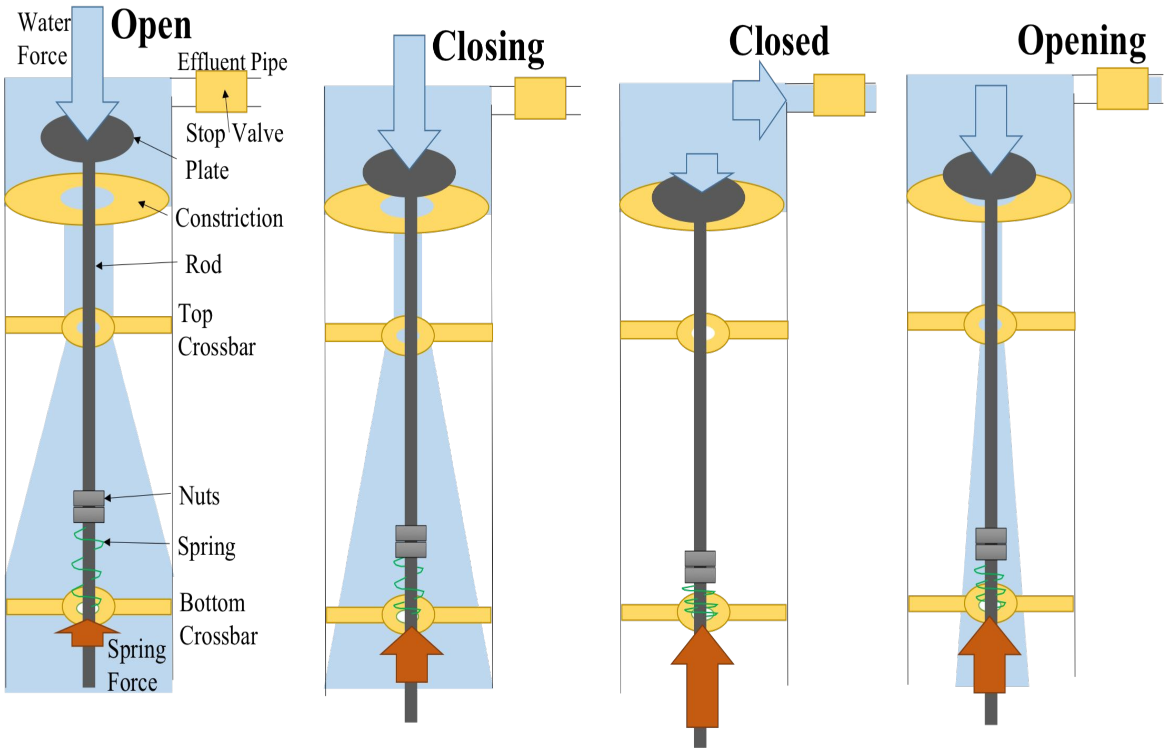
The ram pump brings water to higher elevations.



The ram pump is supplemented by the sump pump, head tank, and drive pipe.

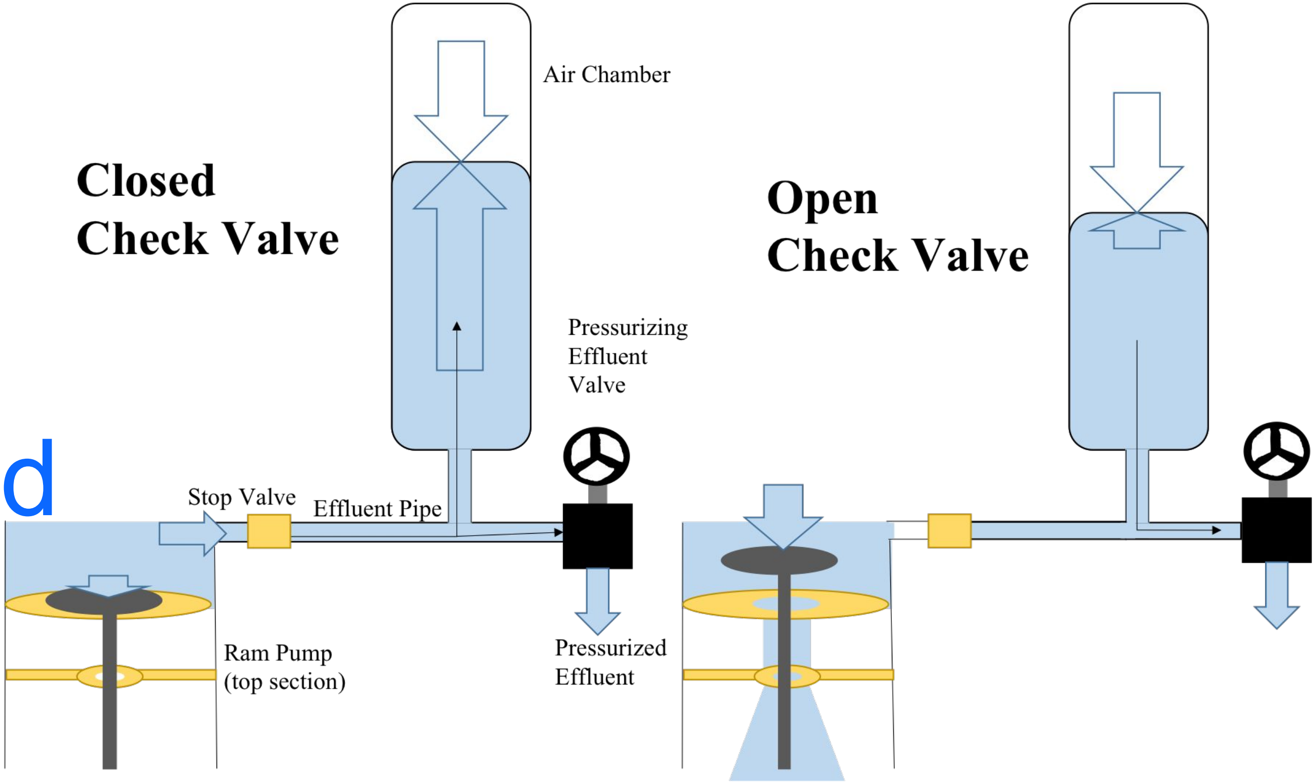


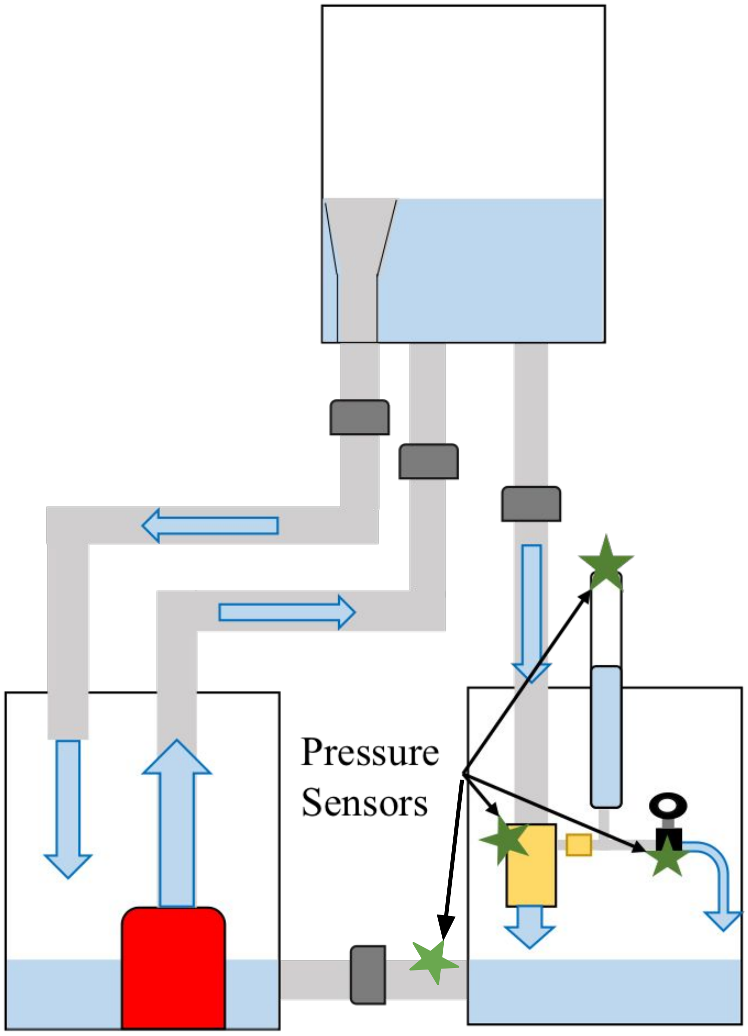




The ram pump is powered by gravity and pressure differences in air and water.

The air chamber controls effluent outflow and simulates high elevations.





Pressure sensors are located at the air chamber, ram pump, effluent, and waste bucket.

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Threshold Test

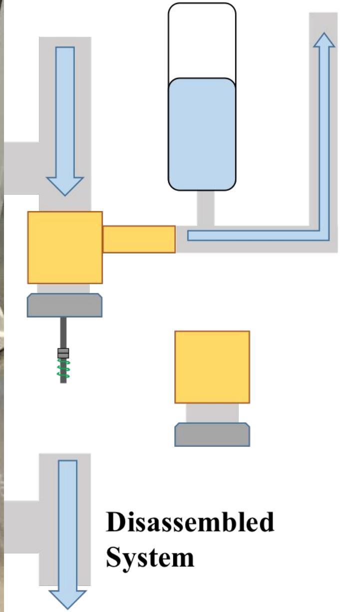
- Measures flow rate of the effluent (water pumped).
- Multiplied by hydraulic head for energy of water pumped.

Efficiency Test

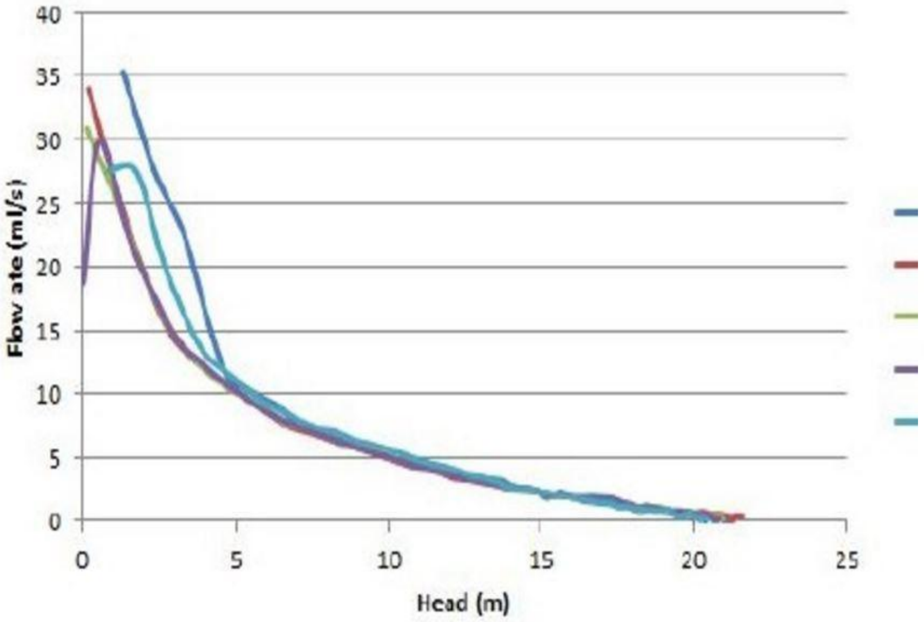
- Measures flow rate of water entering system.
- Multiplied by height of head tank for energy of system.

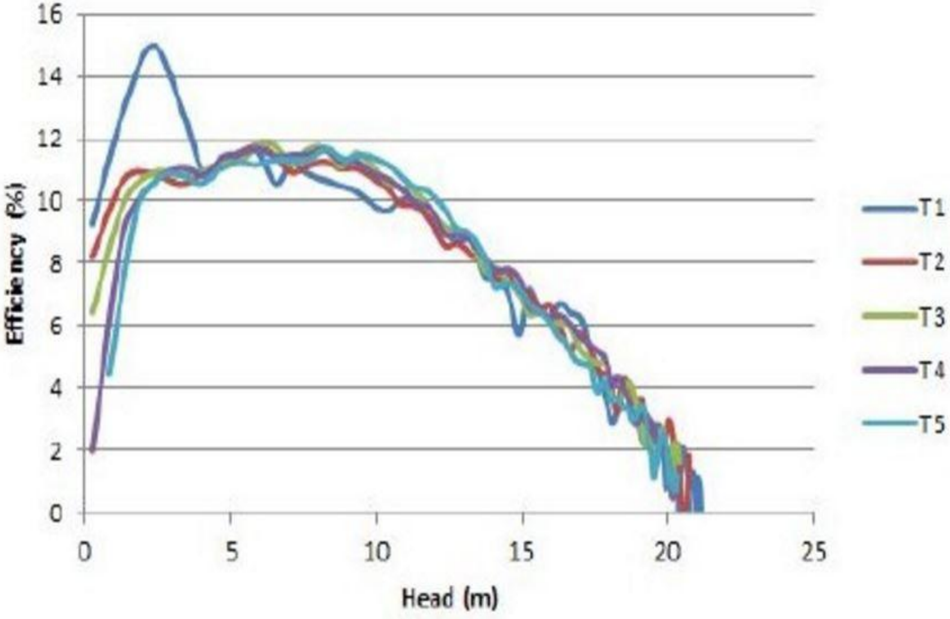
Adding the distribution piping halted the pump.

Resolved when position of metal collar was reduced (22.86 mm to 18.24mm).



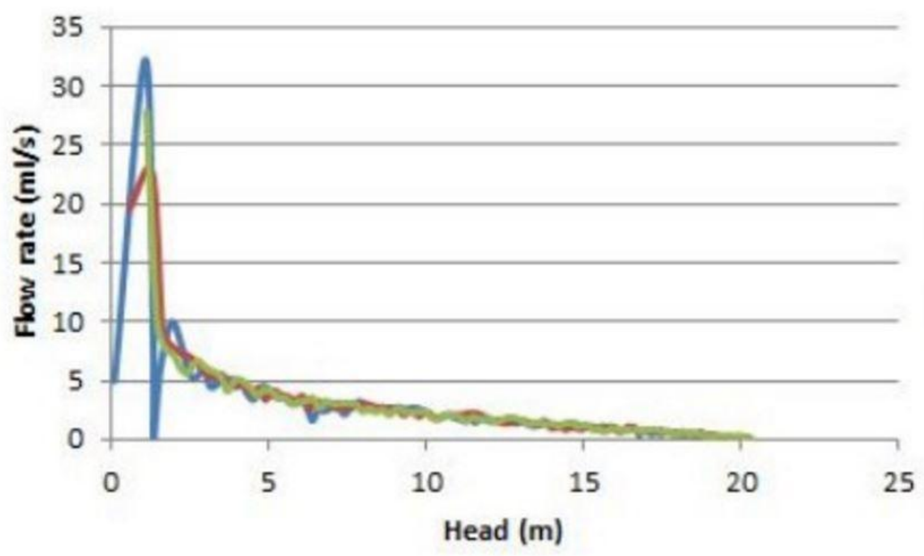
Threshold and efficiency tests before distribution pipe addition

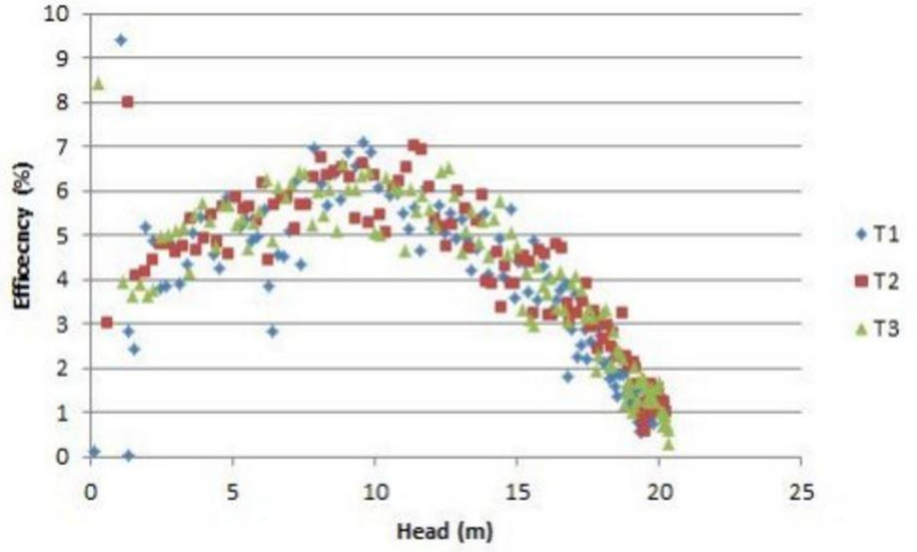




At 8 m head: 8 mL/s flow rate, 11.8% efficiency

Threshold and efficiency tests after distribution pipe addition





At 8 m head: 3.7 mL/s flow rate, 5.97% efficiency

The pump stopped functioning yet again a week afterwards.

Next attempts:

1. Bringing system back to atmospheric pressure
2. Further reducing plate amplitude
3. Unjamming internal parts
4. Preventing formation of vacuum under plate

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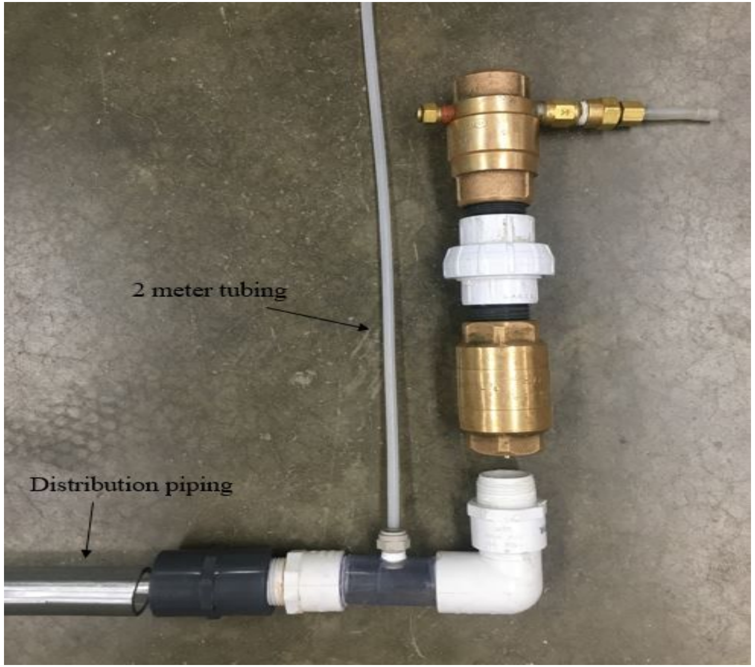
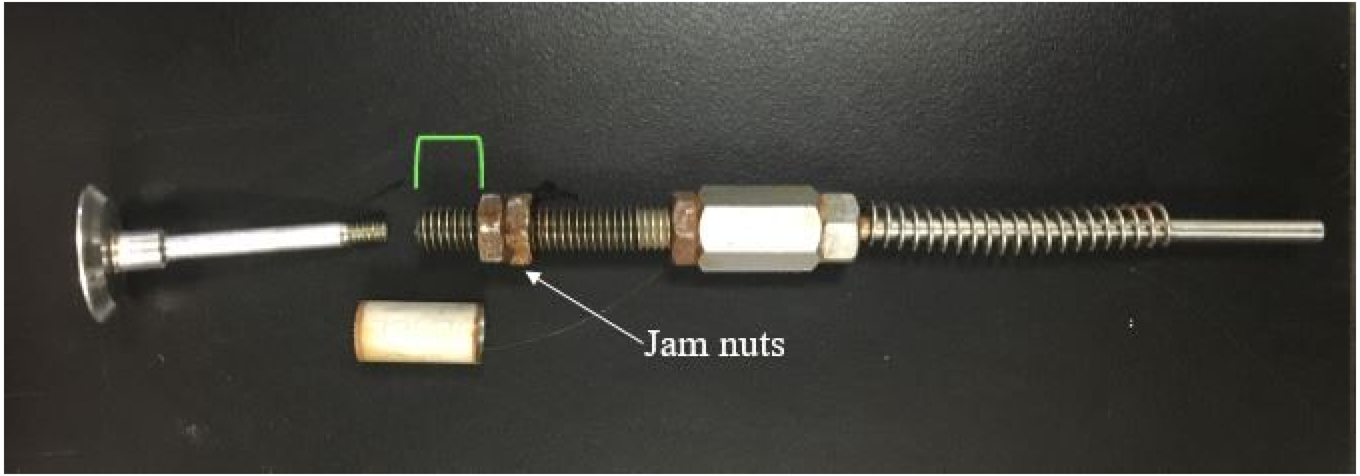
1) The system was brought back to atmospheric pressure.



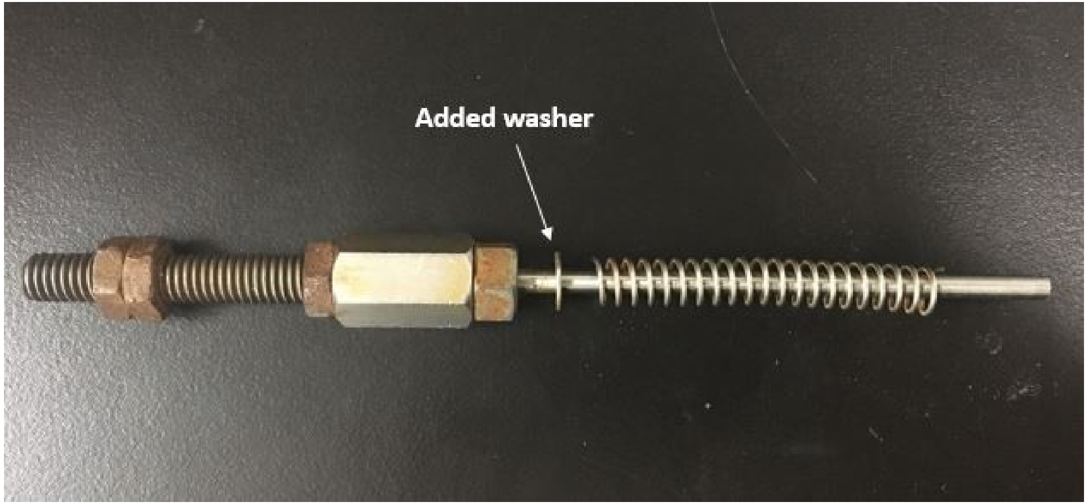
Opening in distribution pipe added.

2) Plate amplitude was further reduced.



Distance between top of rod and nut was decreased.

3) Internal mechanism was unjammed.



Parts were separated by washers.

4) Vacuum under plate was eliminated.

Second air chamber was added.

Pump functioned again!!!!

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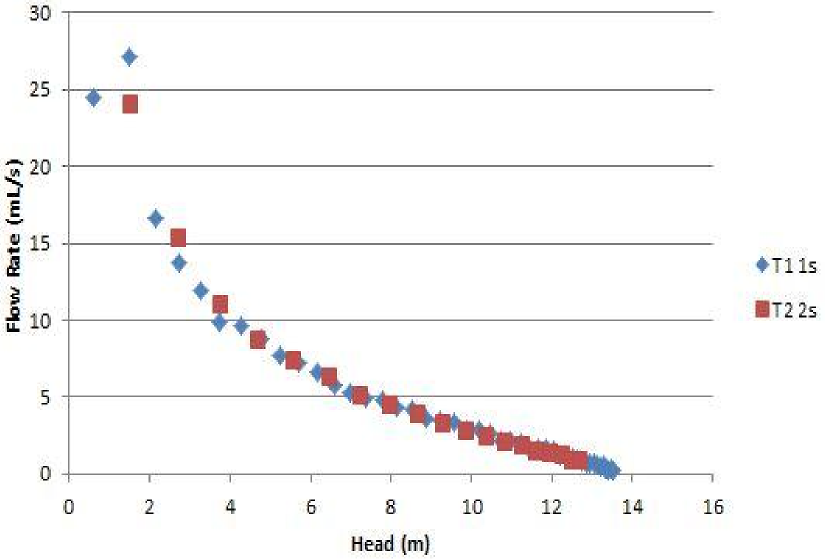
Threshold-Efficiency Test

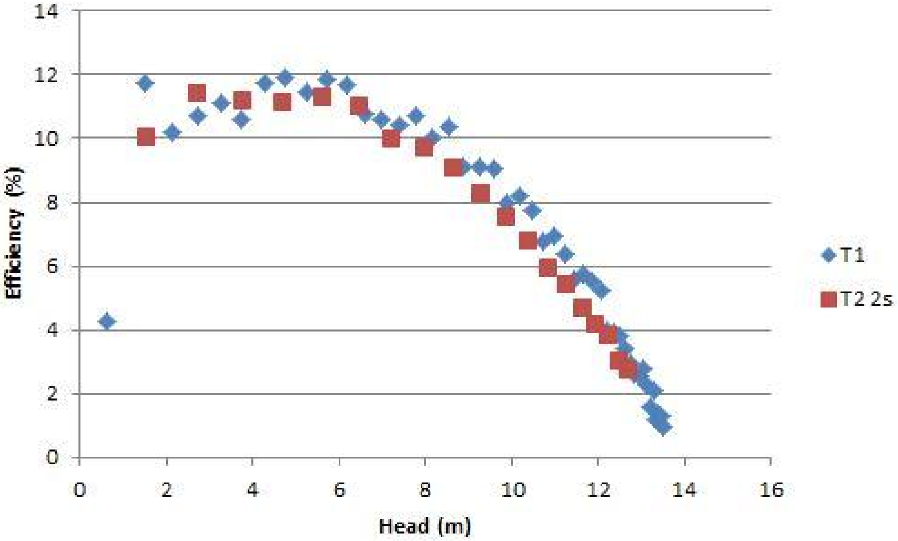
- Combines previous threshold and efficiency test.
- Flow rate of water pumped and water entering system in one set of data.
- Simplifies process of obtaining efficiency.
- Two graphs are obtained with a unique test.

Threshold-Efficiency Test

Threshold graph:



Efficiency graph:



Conclusion:

- Threshold-efficiency tests to plot efficiency against hydraulic head.
- Distribution pipe added, pump stopped.
    - Resolved with second air chamber.

Future Work

- Model union collar design with AutoCAD
- Snifter valve
- Increasing efficiency
- Implementation in Honduras!

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Questions and Recommendations

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Appendix

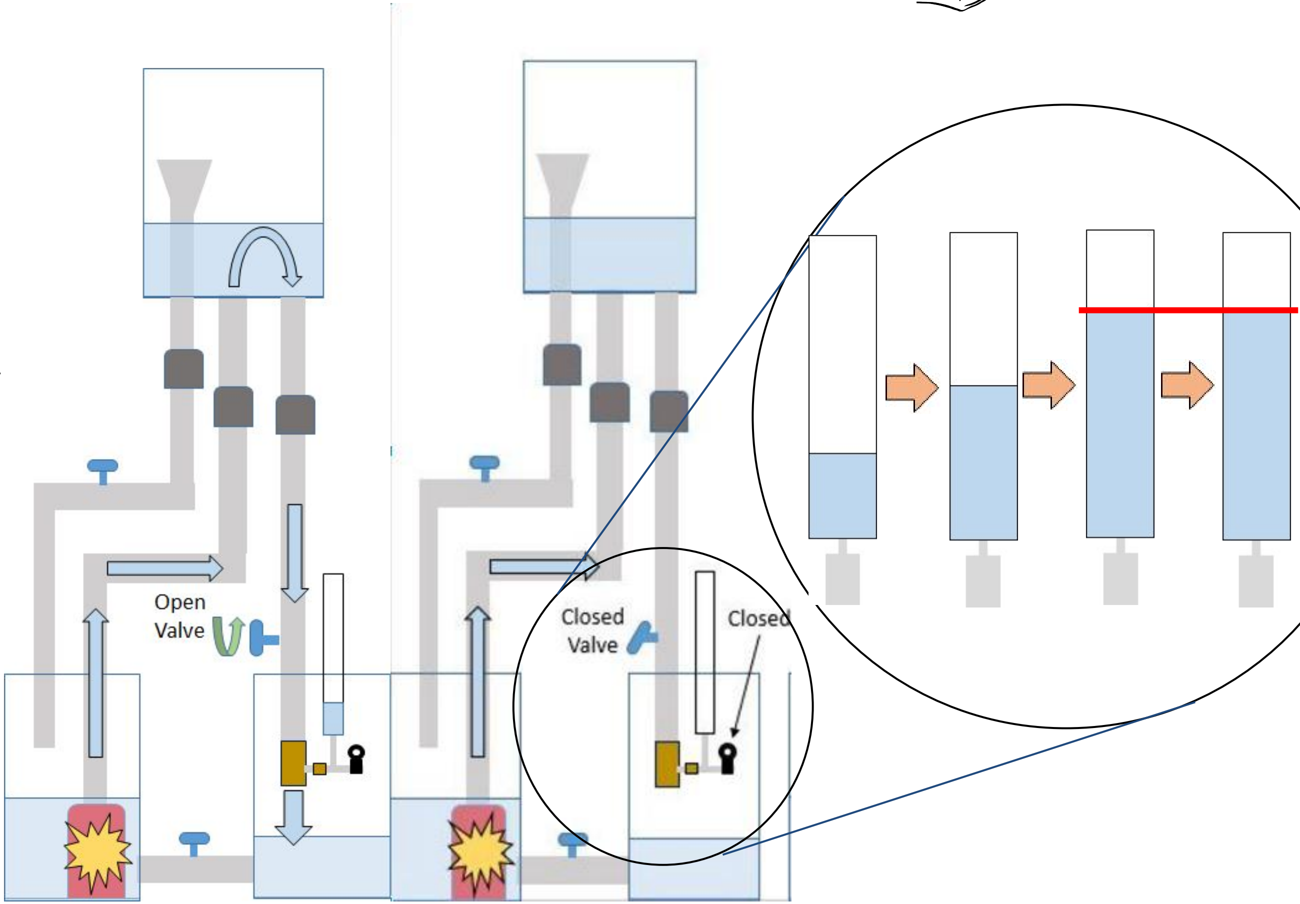
The cup and timer test gives unrealistic flow rates.

$$Q = V/t$$

- Effluent valve opened
- Flow rate at 1 atm is 23.99mL/s
- Unrealistic because head is not taken into account

The threshold test measures flow rate of the effluent (water pumped).

- ProCoDA: volts to cm head
- Effluent valve close, air chamber sensor used
- Start when chamber empty, end when water level constant
- End then because gas resists compaction, air leaks, and sensor isn't sensitive enough



Threshold test and the ideal gas law

$$P_1 V_1 = P_2 V_2$$

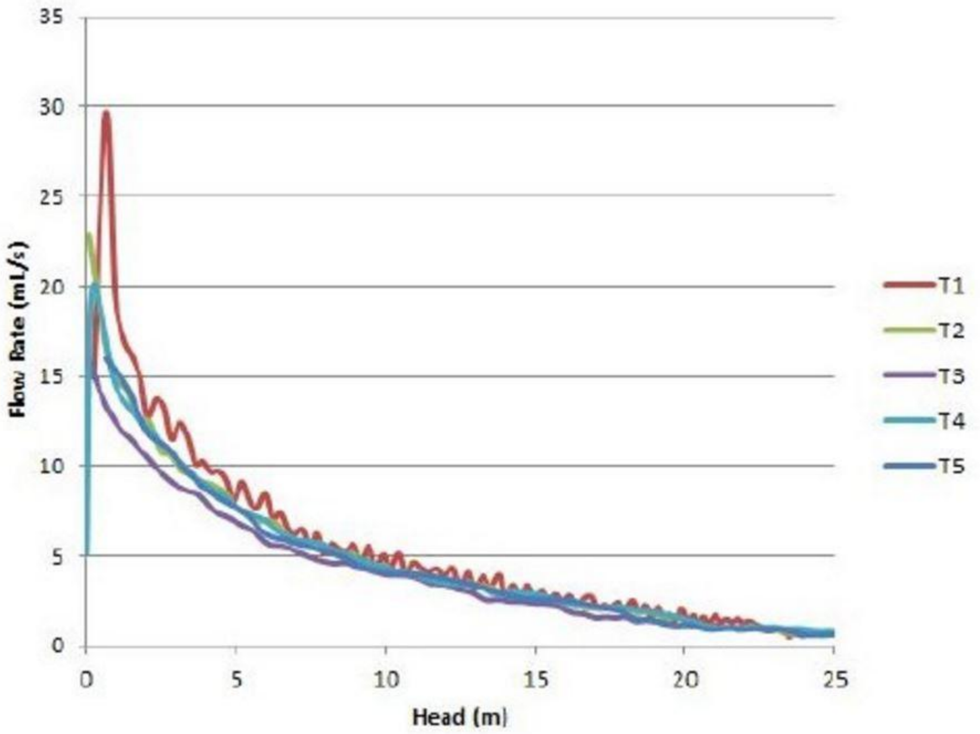
P_1 Atmospheric pressure
V_1 Volume of air in empty air chamber

P_2 Air pressure after time t
V_2 Volume of air after time t

The threshold test gives realistic flow rates.

-Take change in volume over time for Q, plot against head.
-Threshold test results match cup and timer, and is more complete.

$$H = z + \frac{p}{\rho g} + \frac{v^2}{2g}$$

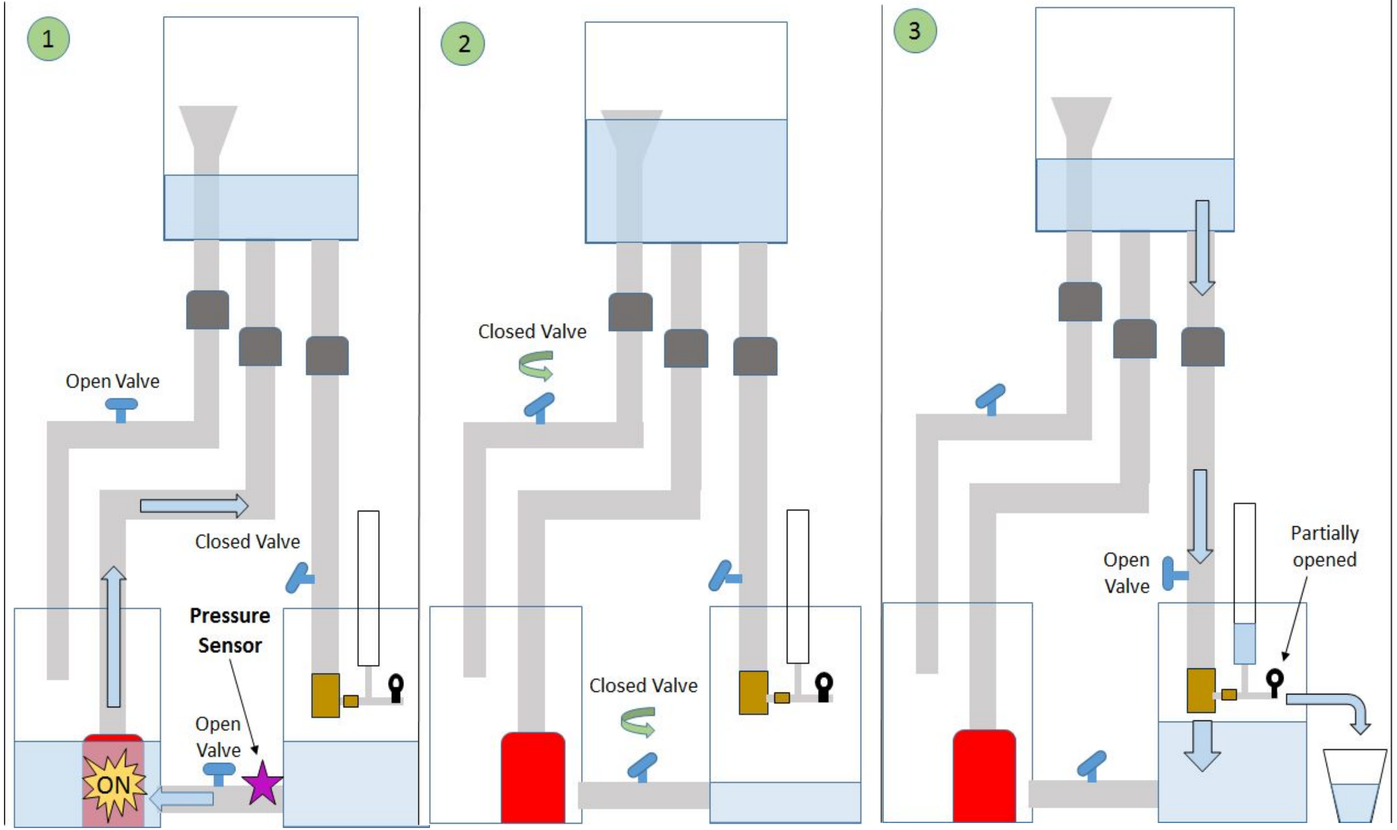


The efficiency test measures flow rate of the system.

1. Head tank full, sump pump off, bucket-connector closed

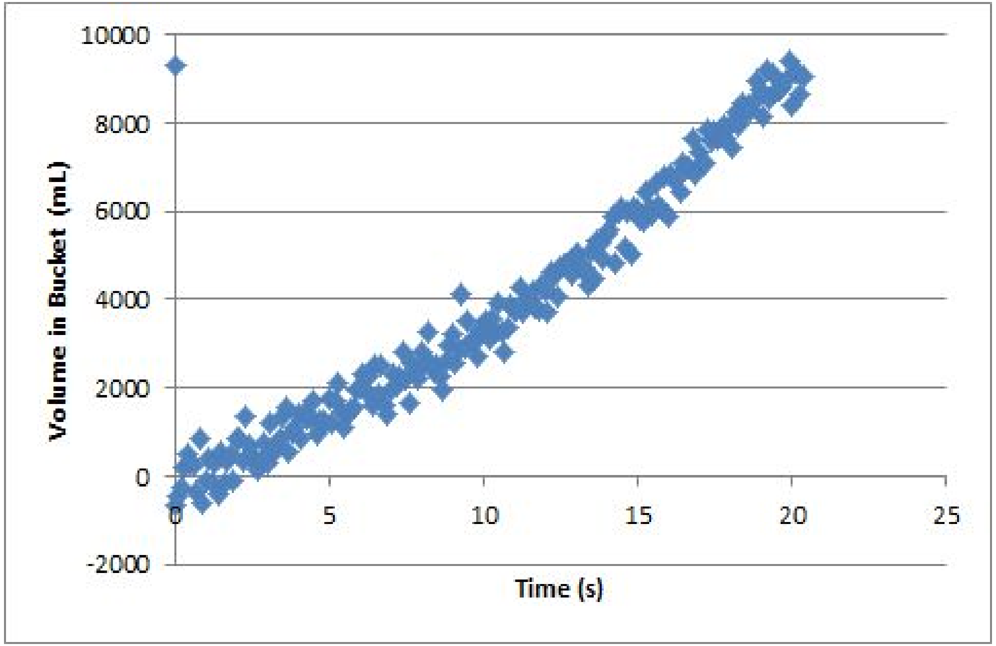
2. Separate receptacle for effluent

3. Bucket-connector sensor to measure change in water volume (in bucket)



Volume of water in bucket over time is flow rate.

- Slope is flow rate of waste outflow
- Multiply flow rate by height of system for energy of “waste”



The efficiency test relates energy, flow rate, and head.

$$P = \rho g Q h$$

- P directly proportional to Qh
- Efficiency peaks at 10 to 15 m head

$$\frac{Qh(effluent) * 100}{Qh(system - effluent)}$$