Technology and Design Advances in Passive Treatment System Flushing

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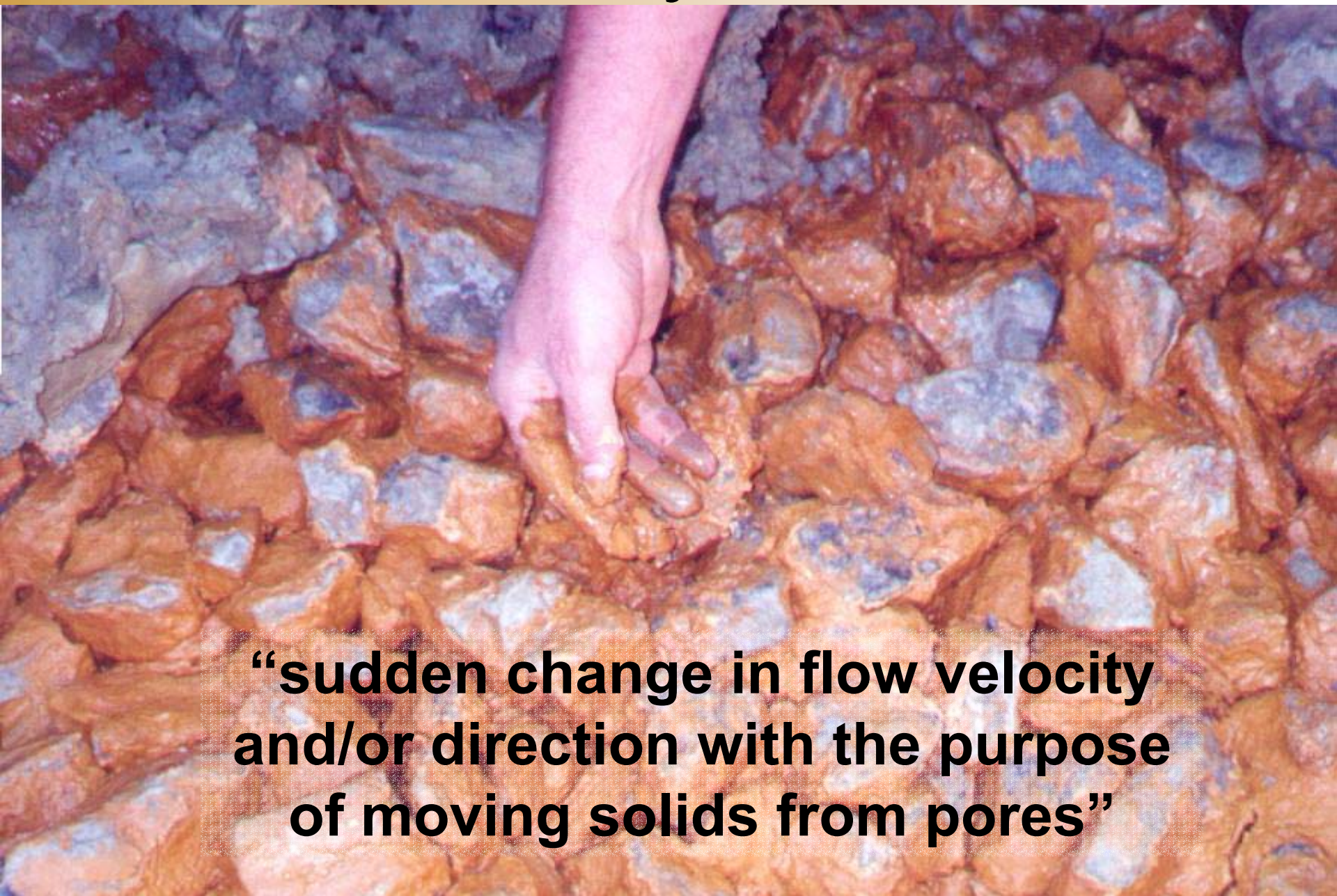
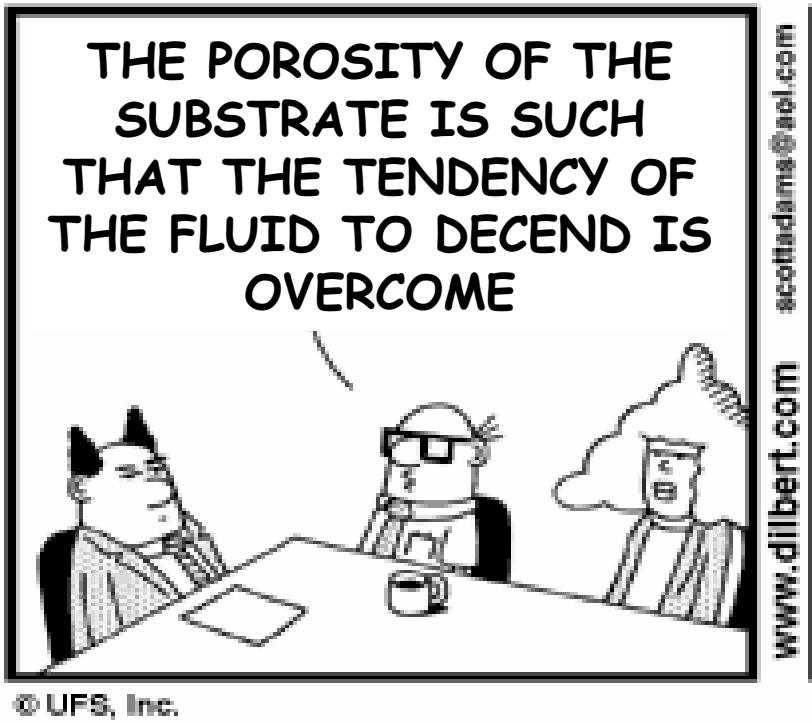
HedinEnvironmental

Why Flush?

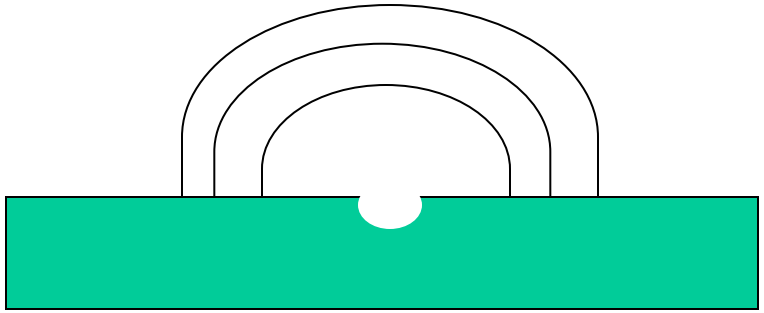

“sudden change in flow velocity and/or direction with the purpose of moving solids from pores”

Variables

- Δh = elevation "head" difference (ft, m)
- Q = flow rate (gpm, m^3/sec, ft^3/sec)
- V = velocity (feet/sec, m/sec)
- A = area (ft^2, m^2)



Q



- Flow rate during the flush
- Larger flow rate is more likely to move particles
- Individual orifices have small areas of influence
- Systems compared based on the “superficial velocity”

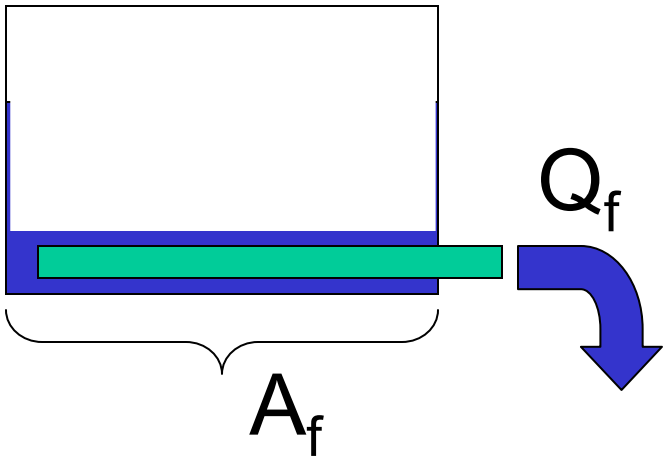
Superficial Velocity

$$V_s = \frac{Q_f}{A_f}$$

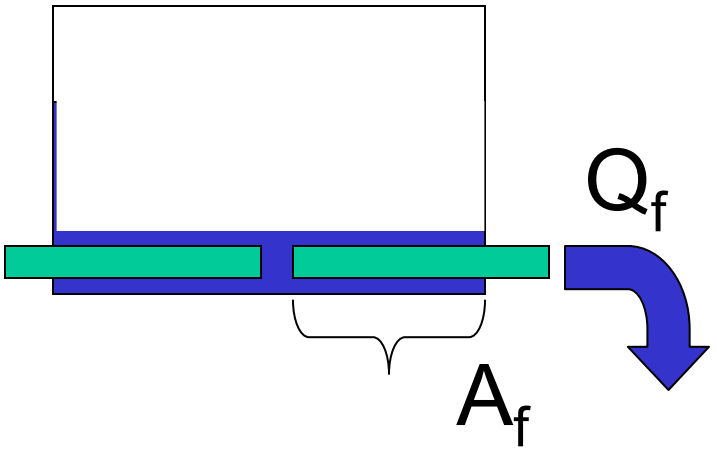
Flush Flow Rate (gpm or m^3/sec)

Area being flushed (ft^2 or m^2)

- If the entire pond is flushed, Vs ~ rate of water level drop



- Not the case if pond has "zones"



What Vs is Required?

- Vs related to actual pore velocity
- Pore velocity causes shear forces
- Shear forces cause particles to move
- Shear strength (ie, “stickiness”) of AMD particulates not known
- In the meantime, maximize Vs

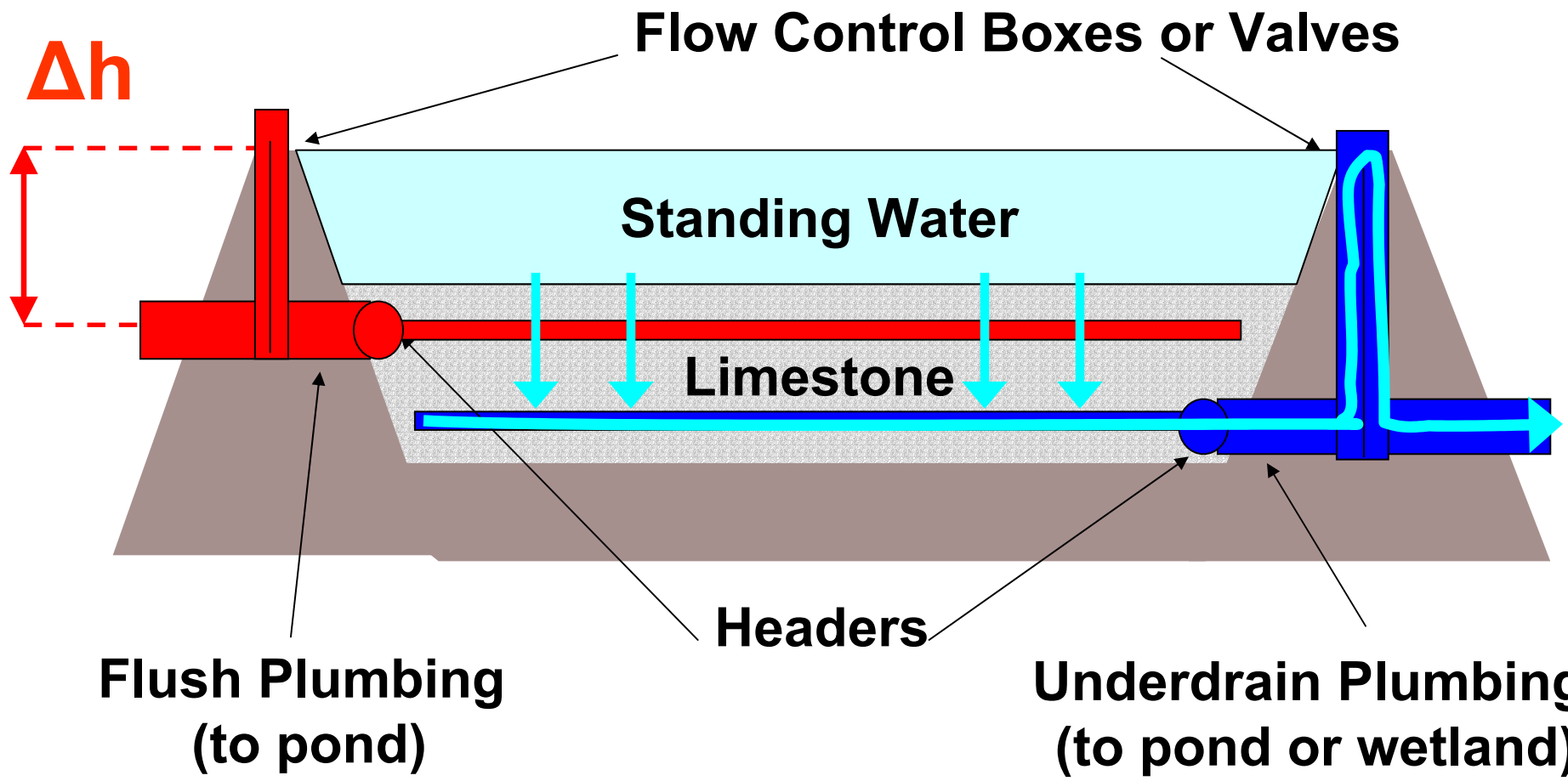
VFPs versus Self-Flush

- Compost over limestone
- Large retention time (days)
- Downflow / Downflush
- Operator controls frequency and duration of flush
- Flush flow rate limited by plumbing network design

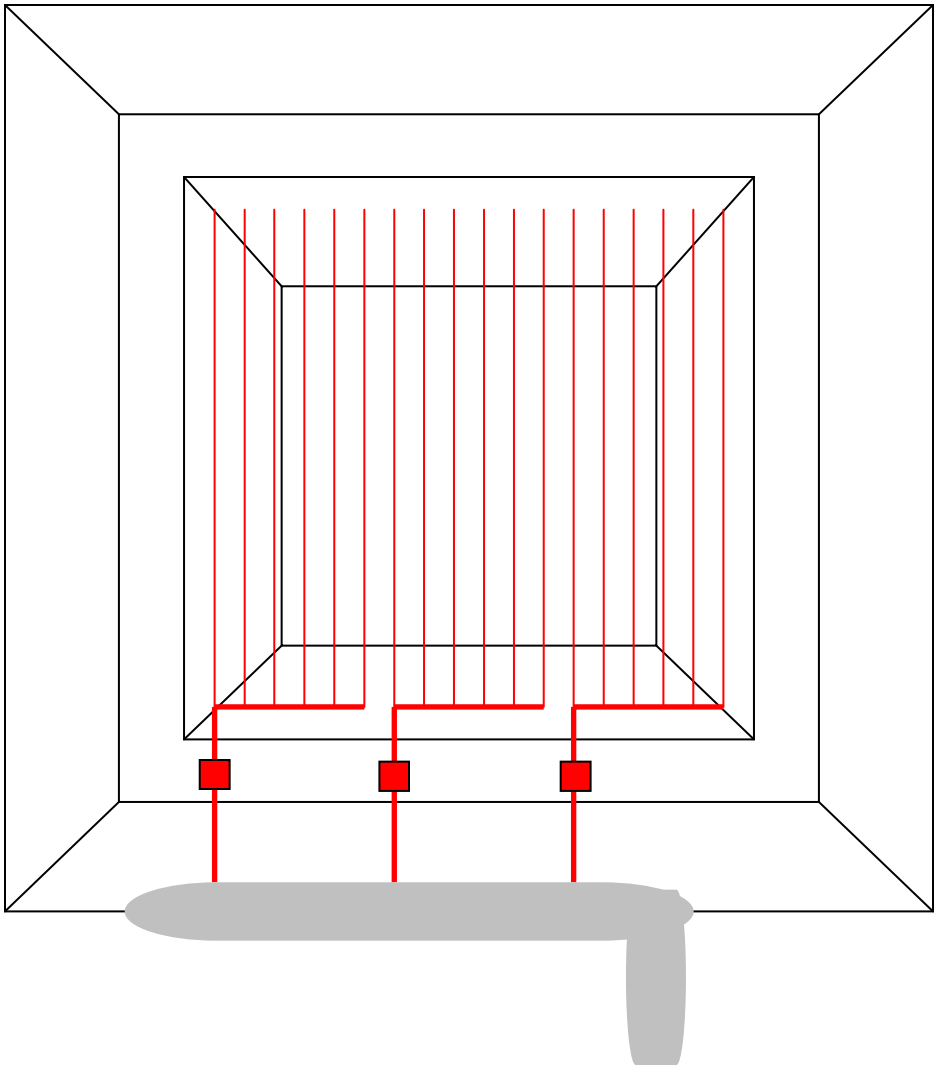
- Usually just limestone
- Low retention time (hours)
- Upflow / Downflush
- Design (capacity and flow rate) controls frequency and duration of flush
- Flush flow rate limited by siphon

Designed and operated based on “best guesses” because few studies on solids removal, life cycle costs, cost/effectiveness, etc.

The Driving Force



Limits to flush flow rate



Plumbing Suspects:

1. Orifice size and number
2. Lateral size
3. Header/valve size

Other Potential Culprits:

4. Plugged compost
5. Plugged limestone

Gravity Flow Design

- Maximize flush flow rate (Q)
- Make sure the headers can accommodate all of the flow from all laterals
- Make sure the laterals can accommodate all of the flow from the orifices
- Space orifices equally

Self Flushing Basics

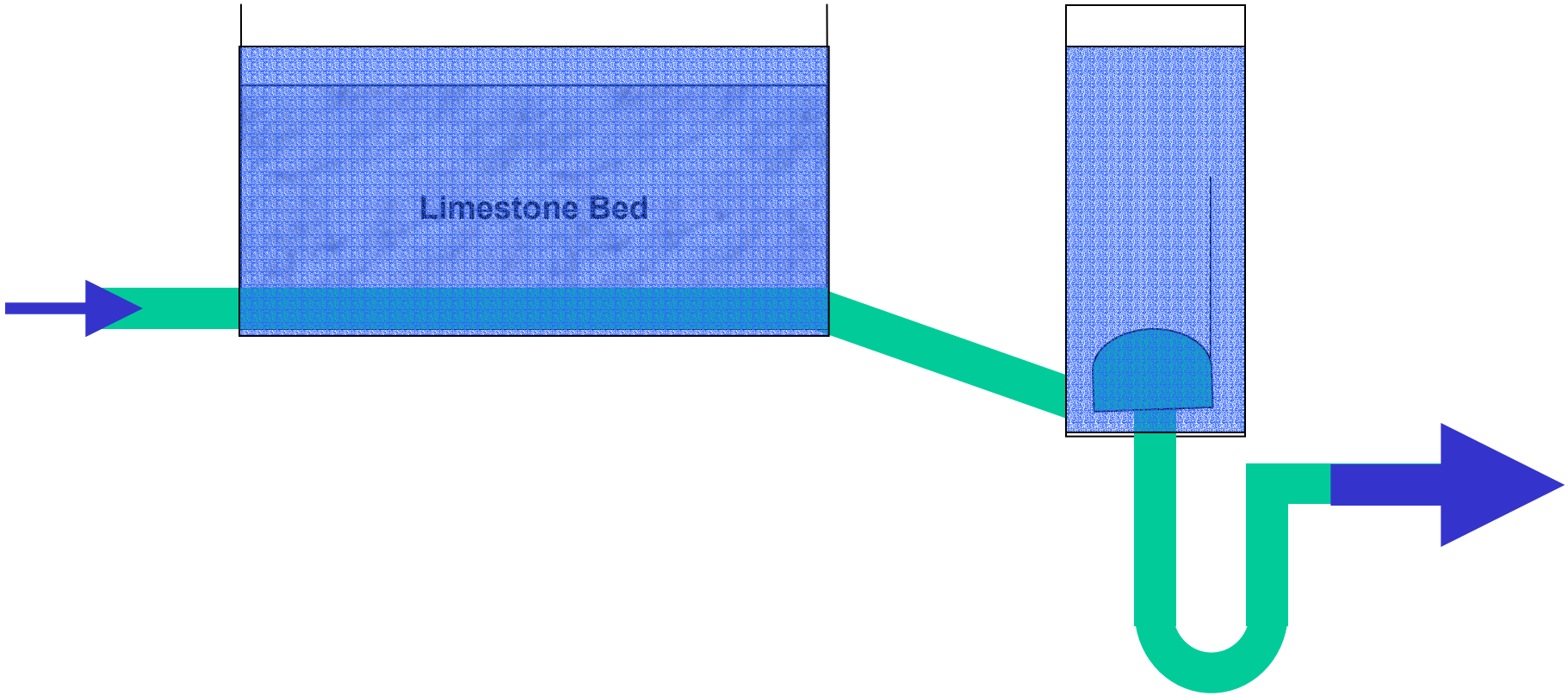


Figure 2A

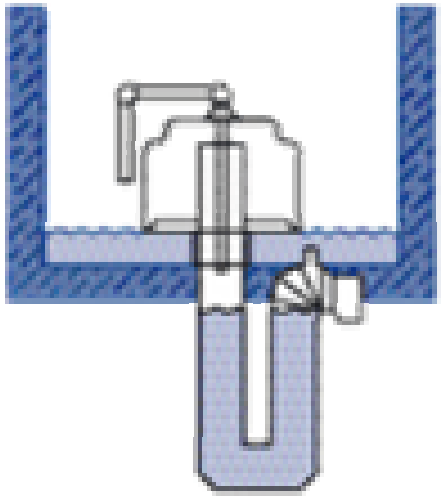


Figure 2B

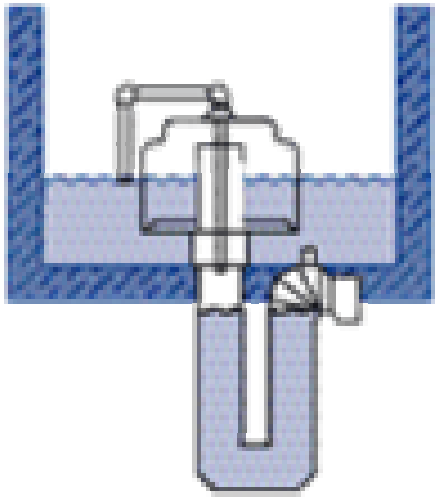


Figure 2C

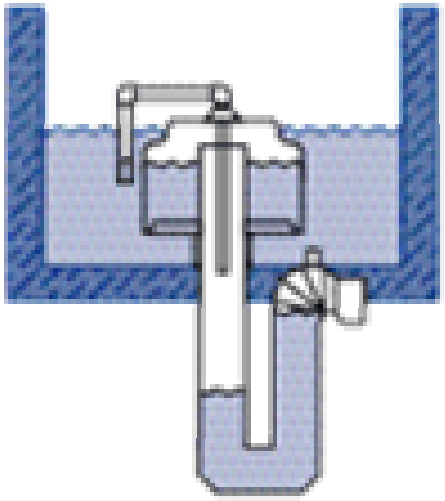


Figure 2D

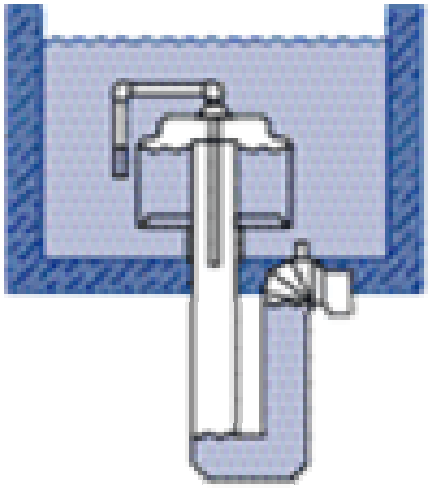


Figure 2E

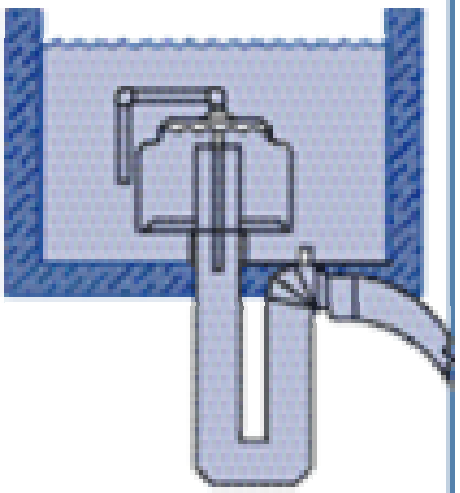
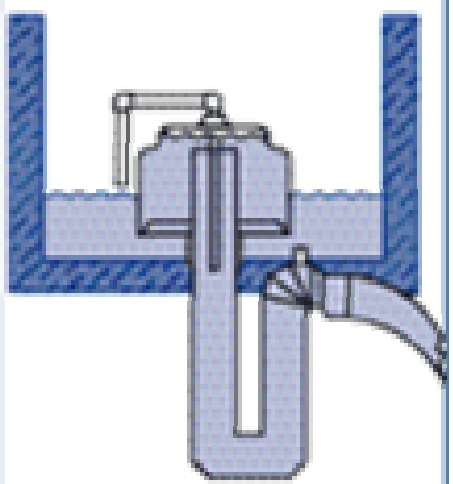


Figure 2F



Figures courtesy of Fluid Dynamic Siphons, Inc (www.siphons.com)

Jonathan Run

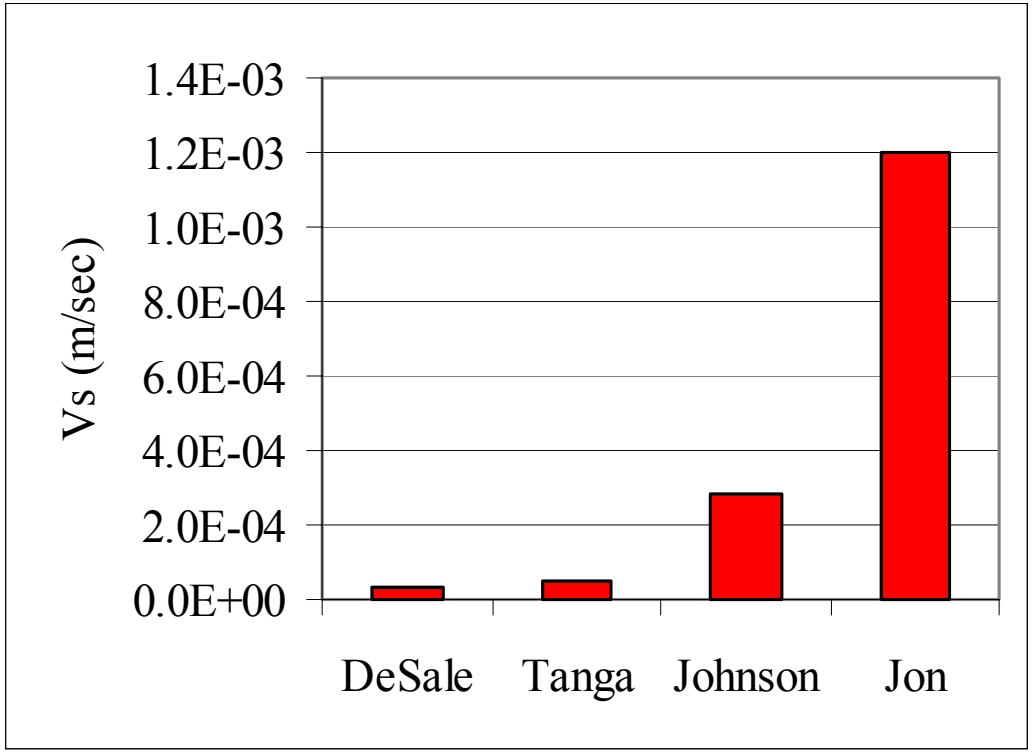
Pilot Scale Results

pH = 3.5
Net Acid = 304
Al = 49 mg/L (total as dissolved)

pH = 5 to 6
Net Acid = -10 to 100
Al = 20 - 40 mg/L total
= 0 – 5 mg/L dissolved

What Vs is out there

System
DeSale II (Butler County, PA)
Tangascootack I (Clinton County, PA)
Johnson Run (Elk County, PA)
Jonathan Run (Centre County, PA)



Flush studies on DeSale II and Tanga I show ~ 1% of solids in the pores removed

Flushing Performance

- Tanga and DeSale II Flushing events removed ~ 1 % of total solids in limestone
- Jonathan Pilot Systems converted all Al to particulate and flushed 50 – 100% of solids (average = 80%)
- No flushing studies on Johnson or other gravity flow design VFPs
- Follow-up study of Jon Run system being funded by PennDOT—stay tuned!

Cost Considerations

- Gravity-flow flush network for VFPs
  - Costs an additional $1.50 - 2.00 (installed) per square foot of VFP
  - Complicates rebuilding the system
- Self-flushing systems
  - Costs an additional $2,500 – 6,000 per siphon depending on design of the siphon (flow rate and flush depth)
  - Low retention times mean less limestone up-front but more frequent “recharging”

Questions

- What are the properties of AMD solids (shear strength, etc) and do these change over time?
- What frequency, duration, and intensity (Vs) are required for ‘effective’ flushing?
- How cost/effective can flushing be in extending treatment life?
- What is the upper limit for AI in passive treatment?

Any additional Questions?

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