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Understanding the Impact of Mesh on Tank Overflow System Capacity

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Outline

- Introduction – What was known & Why there was more to be done
- Methods – What was done
- Results – What was found
- Conclusions

Introduction

- Utilities rely on water storage tanks to maintain supply throughout the day (maintain pressure, balance uneven demand or supply patterns)
- Utilities can use tanks to manage energy consumption
- Storage tanks help system be resilient to disasters
- Tank overflow systems help to ensure that an overfilling incident does not result in tank over pressurization and subsequent damage

Results of Lack of Overflow Capacity

Generalized Model of Overflow Capacity

Backpressure Limited
What can get **through** the system limits capacity

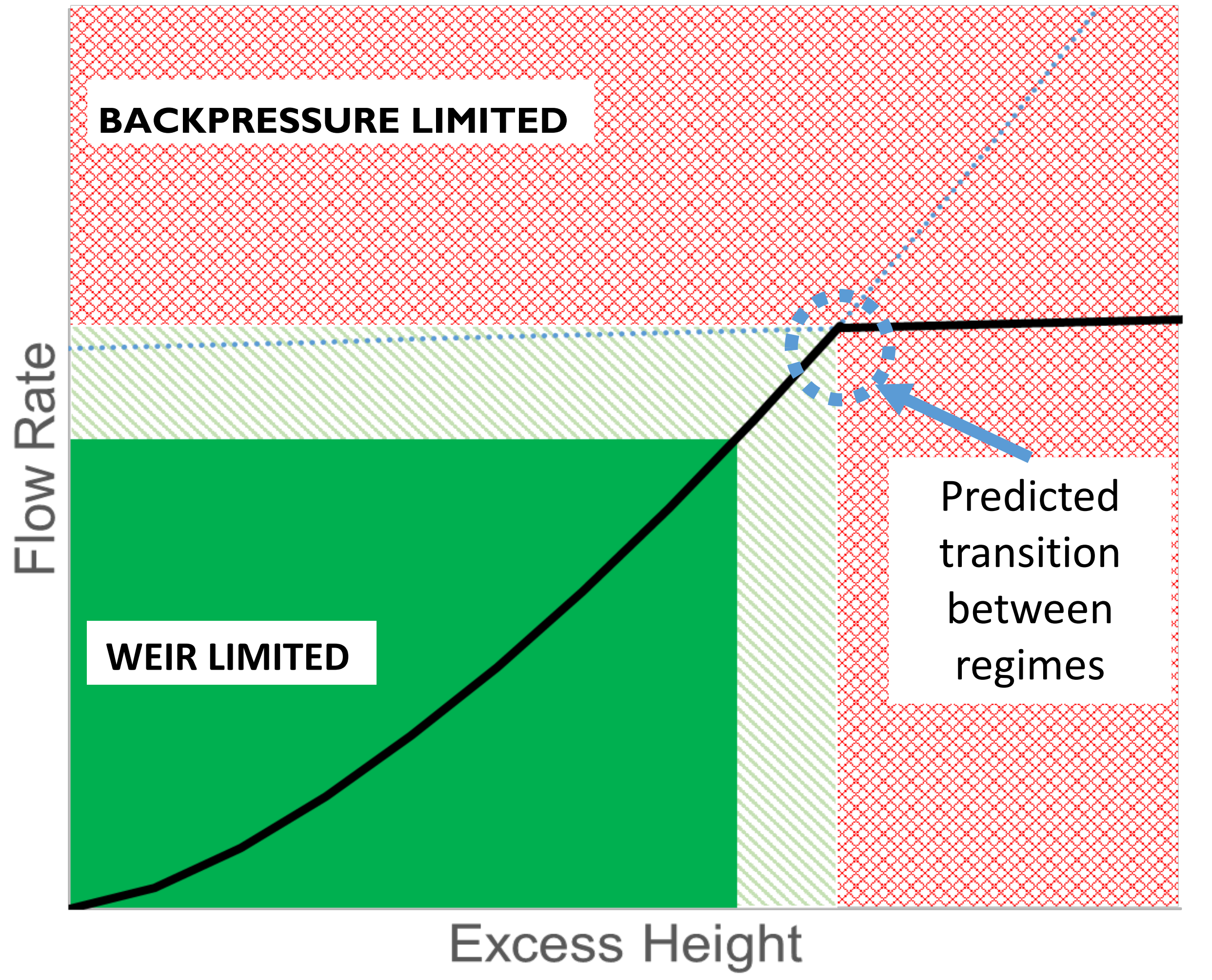
Predicted by Bernoulli's Equation

Flow Rate is limited when
Head Gained by System = Head Lost by System

Weir Limited
What can get **into** the system limits capacity

Predicted by Francis Formula

Flow Rate Predicted =
(factor) * (weir length) * (excess height)^(3/2)



Questions to Consider

- Given a Desired Pumping Capacity (Inlet):

What size overflow system is needed?

OR

- Given a Tank Overflow System is Already Installed:

What size pump can be installed to ensure excess overflow capacity is available?

What the Guidance Says

- AWWA D100 – Welded Carbon Steel Tanks for Water Storage
  - The overflow shall have a capacity at least equal to the **specified inlet rate**, with a head above the lip of the overflow of **not more than 12 in**. (304 mm) for side-opening overflows and **not more than 6 in**. (152 mm) for other types of overflows
  - The overflow pipe should have a coarse mesh to prevent debris or animals from entering the tank
  - The overflow should not be connected directly to a sewer or a storm drain without an air break
- AWWA D115 – Tendon-Prestressed Concrete Tanks
  - The overflow should pass **the design inflow rate** at a **maximum head equal to 75 percent of the freeboard** between the weir elevation and lowest roof structural element, i.e., bottom of beam or roof" and the system should "terminate with a flap gate"

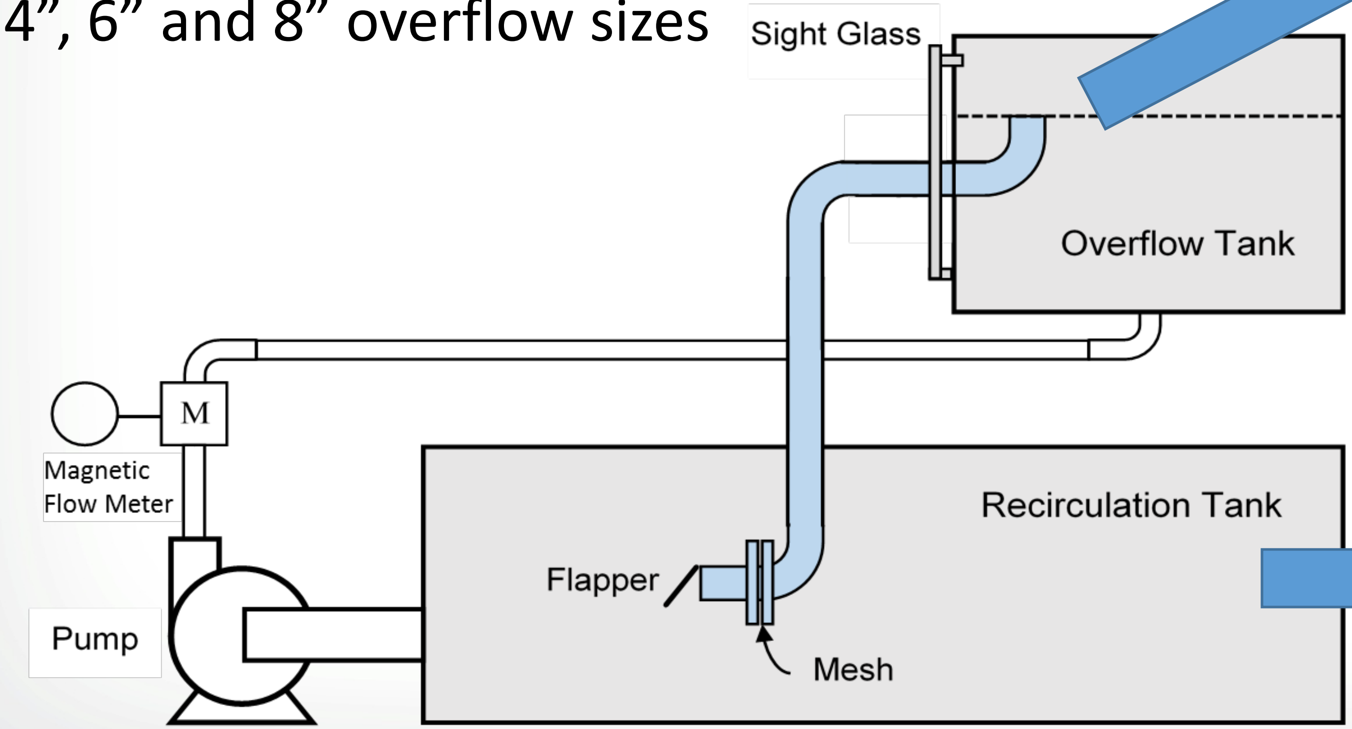
What the Guidance Says

- Ten State Standards
  - Has required a #24 mesh on vents and overflows for ground storage tanks since the original 1962 version
  - Mesh is specified to prevent all organisms (as small as insects) from entering the tank
  - Requires that the overflow outlet should be located on the outside of the tank, be visible, terminate not more than 2 feet above a splash plate and not be connected into "a sewer or storm drain"

Experimental Setup

- 1900+ gallon capacity overflow tank
- ~6000 gallon recirculation tank capacity

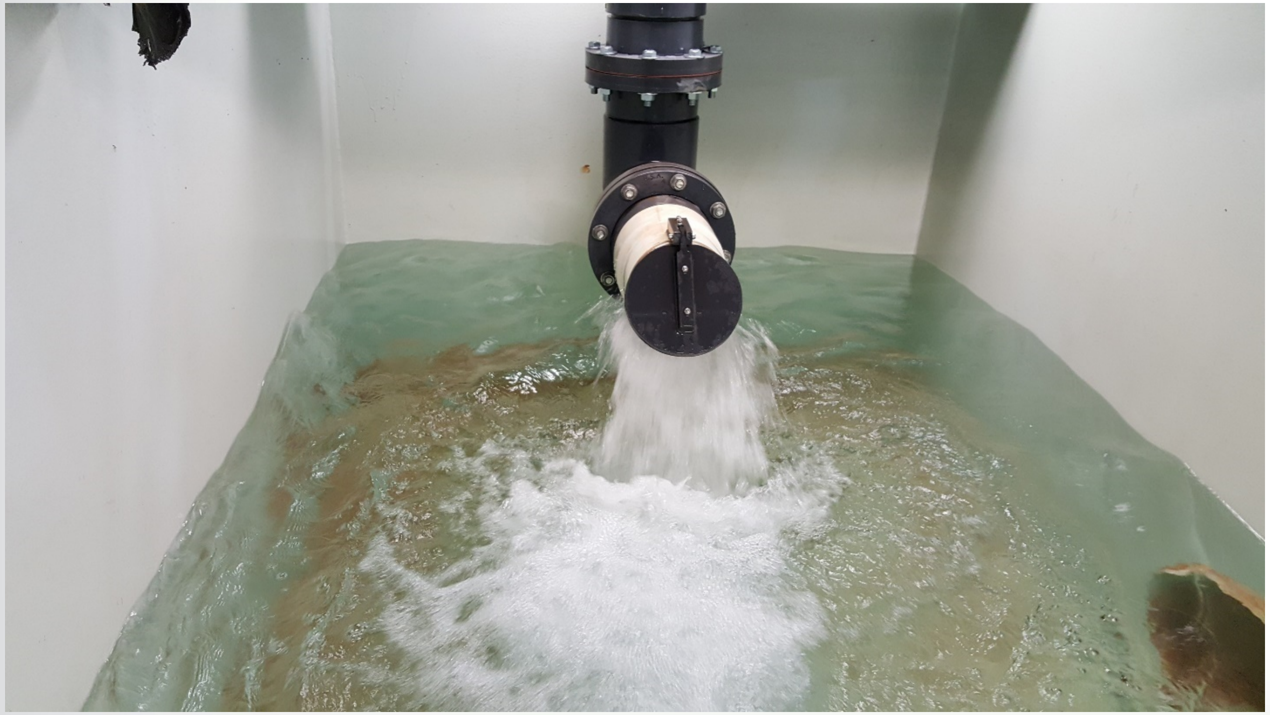
- 1,100 gallon per minute max flow rate
- 4”, 6” and 8” overflow sizes



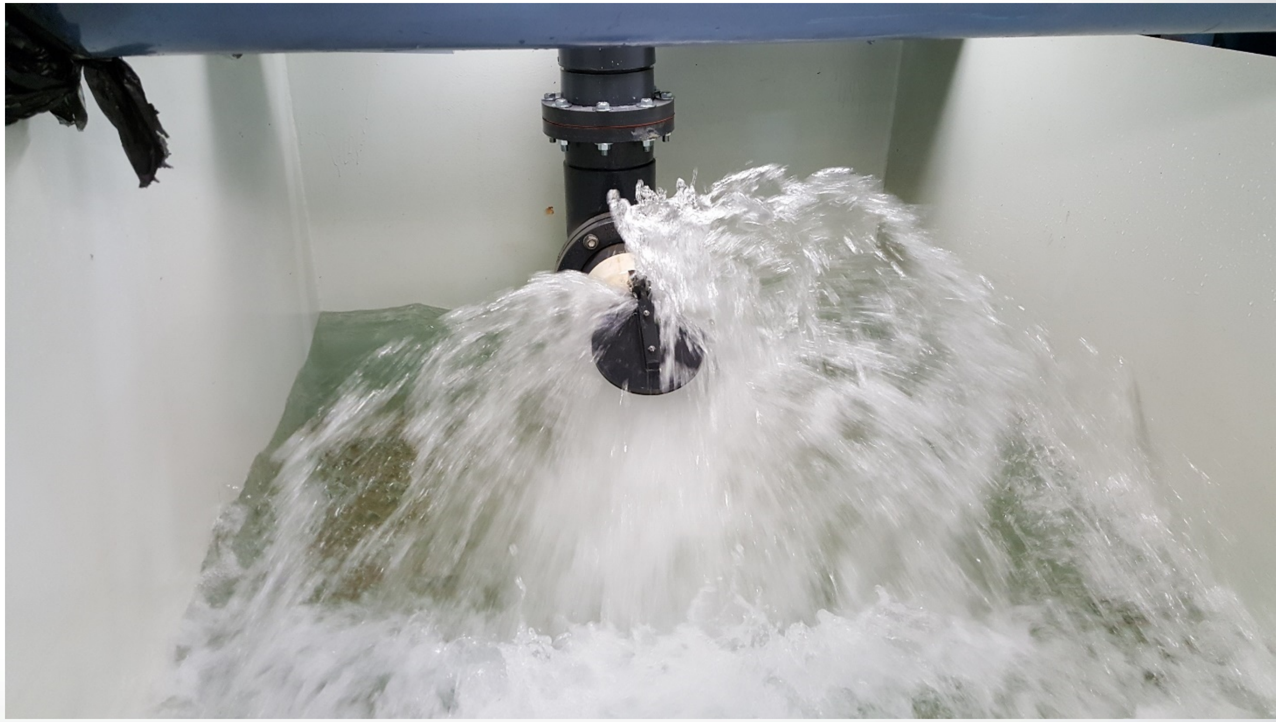
What Flowrates Look Like

8” System

~300 gpm

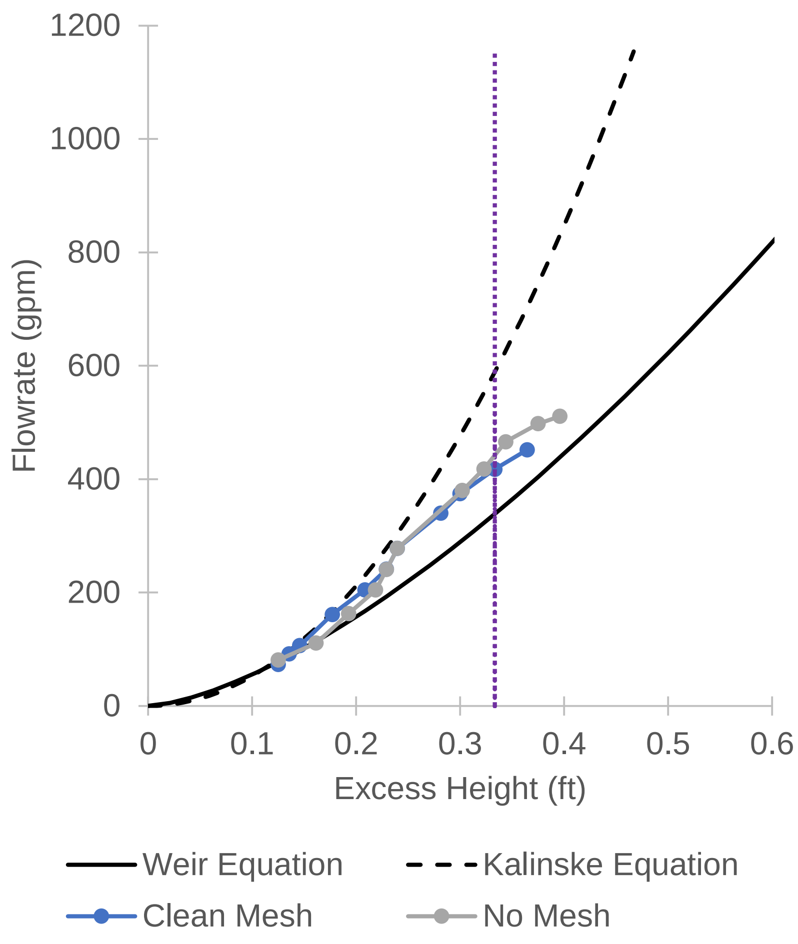


~920 gpm

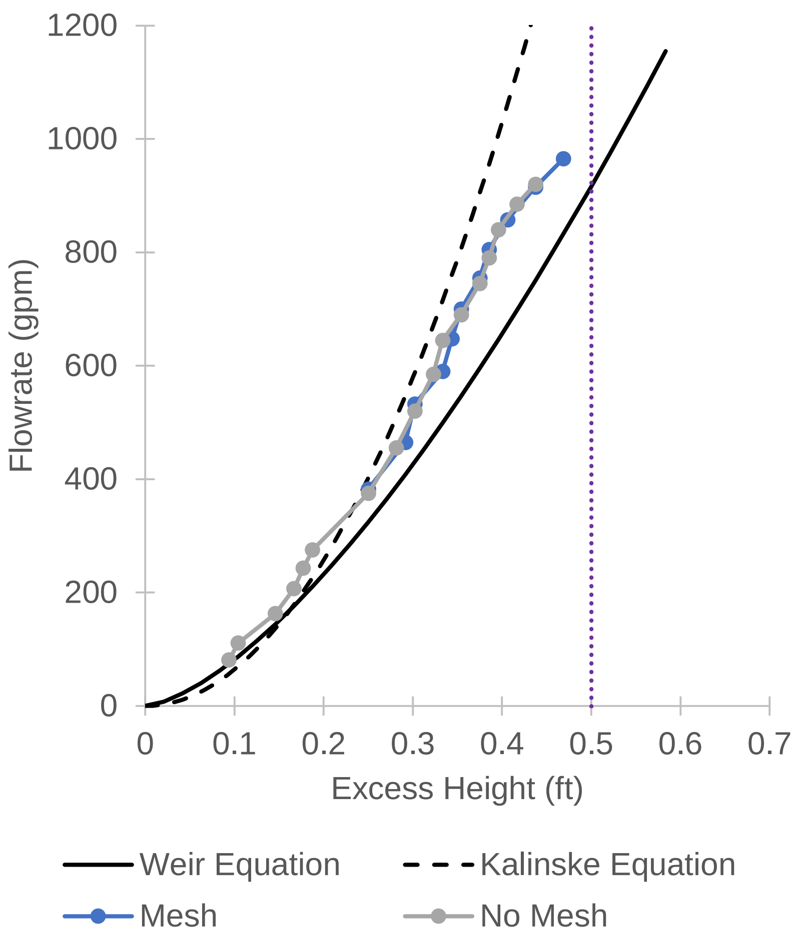


Results: Clean Mesh

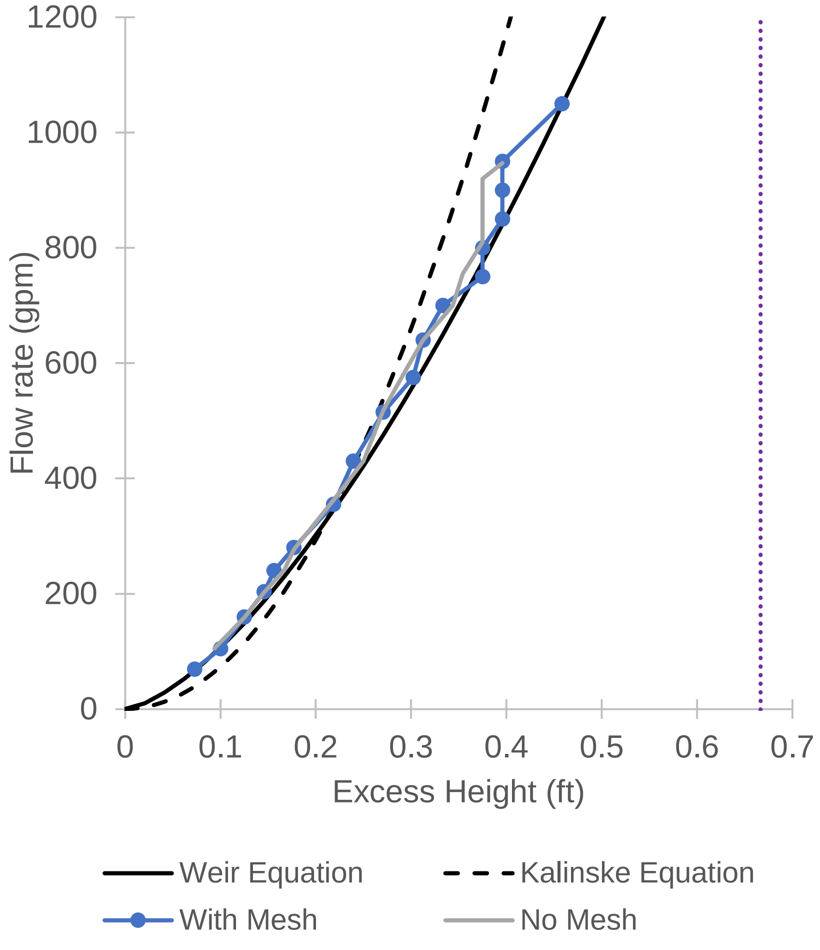
4” System



6” System

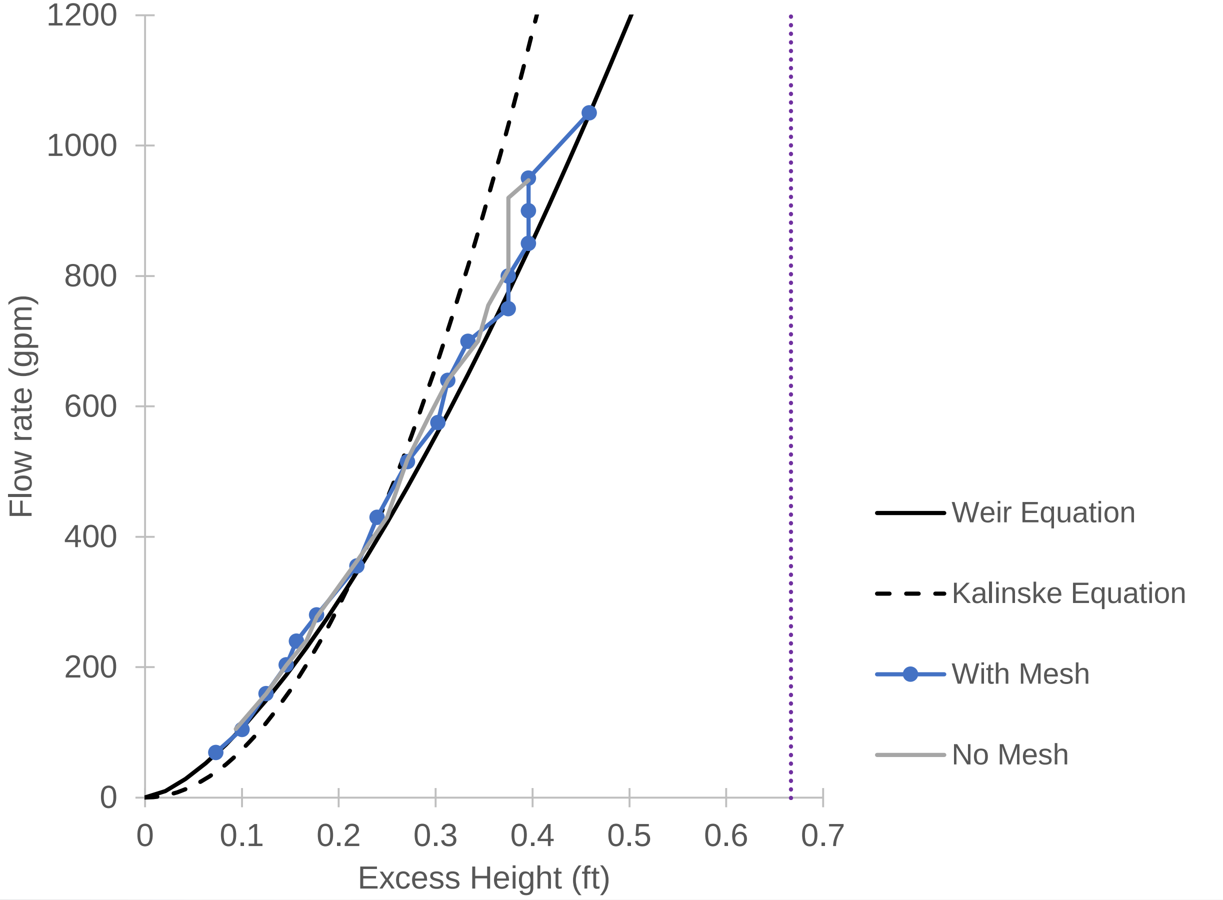


8” System

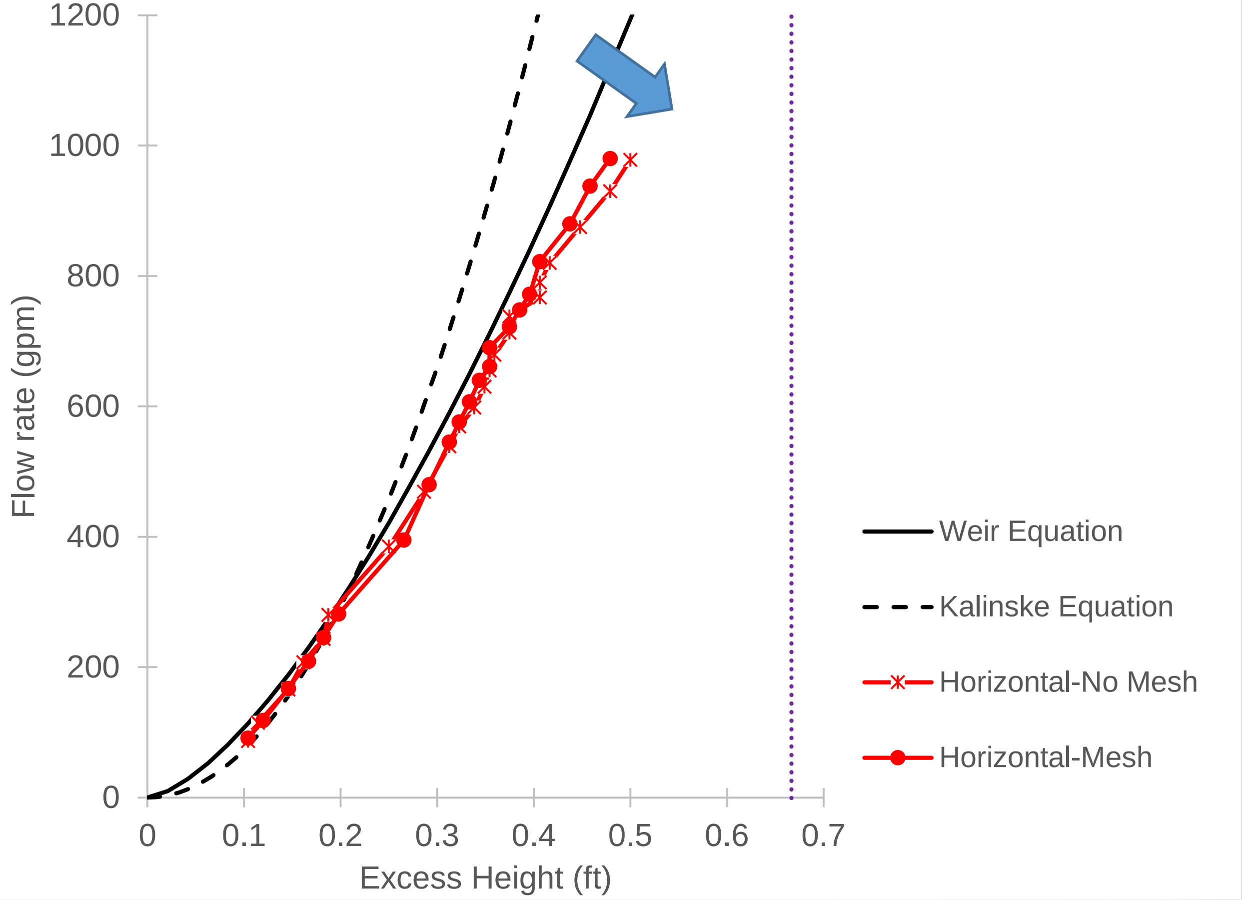


Results: Additional Horizontal Pipe

8” System



8” System with 30’ of Horizontal Piping Near System Bottom



Reduced capacity throughout range, even without mesh

Impact of Mesh Formula

- Mesh reduces the available area for flow
- Impact of mesh is not simply an additional pressure drop

$$Q_{max} = \pi\left(\frac{D}{2}\right)^2 (\%_{open})(1-\%_{blocked})\sqrt{\frac{2g(z+EH)}{1+(\%_{open})^2(1-\%_{blocked})^2\left[K_{mesh}+f\frac{L}{D}+N_eK_e\right]}}$$

%open is a mesh specific value

%blocked accounts for further blockage

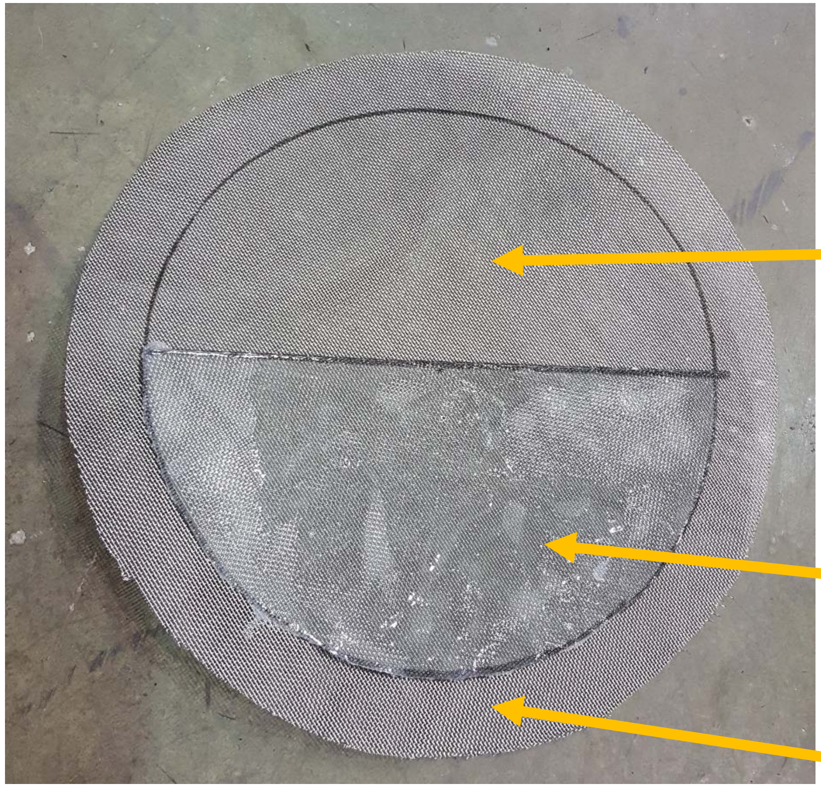
Example Mesh Information Table

Diameter of Wire		Width of Opening		Open Area Percent
inch	mm	inch	mm	%
0.014	0.3556	0.02767	0.7027	44.09

Introducing Flow Restrictions

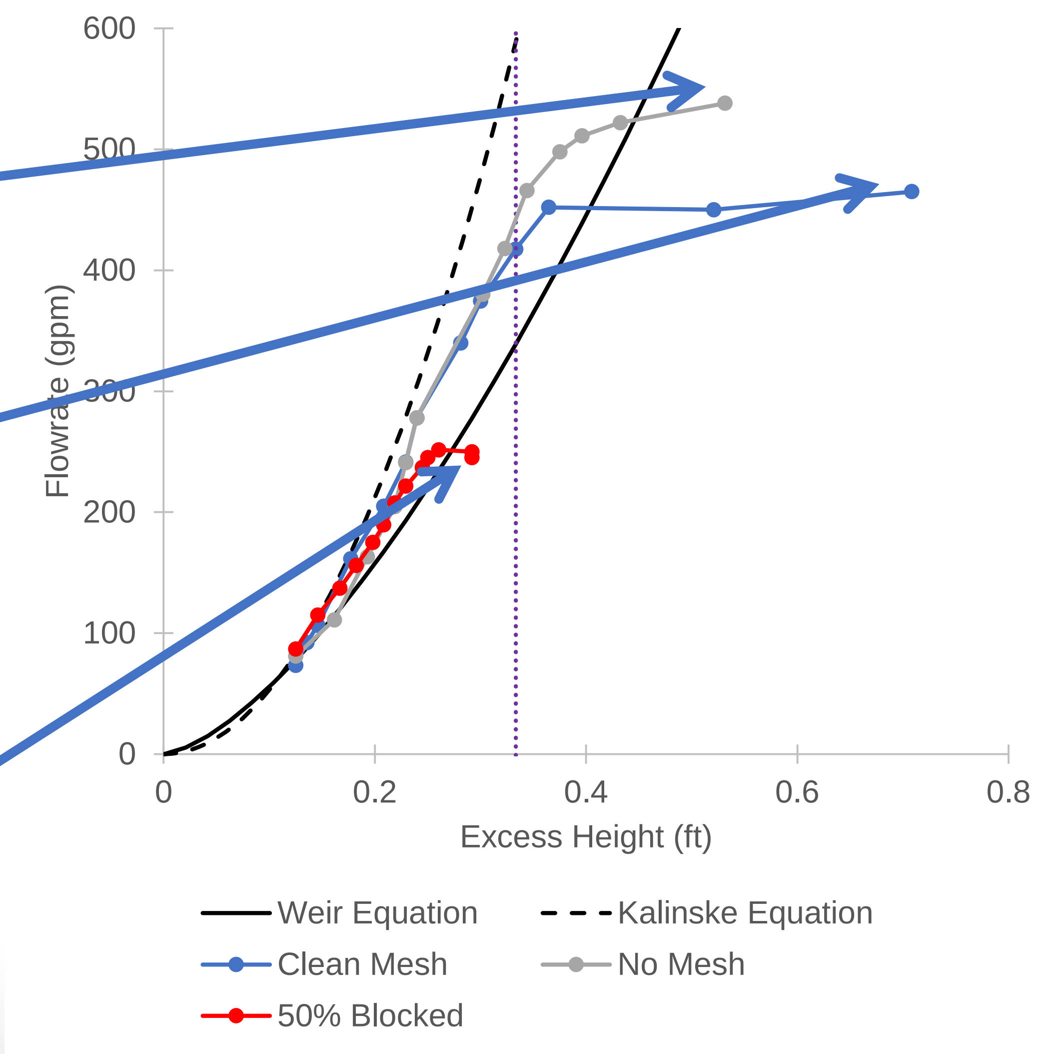
Blocking the mesh

- Impact of mesh is not simply an additional pressure drop
- Mesh reduces the available area for flow
- Bernoulli's equation can be used to calculate the maximum velocity, but it occurs as the water passes through the mesh, with a reduced area



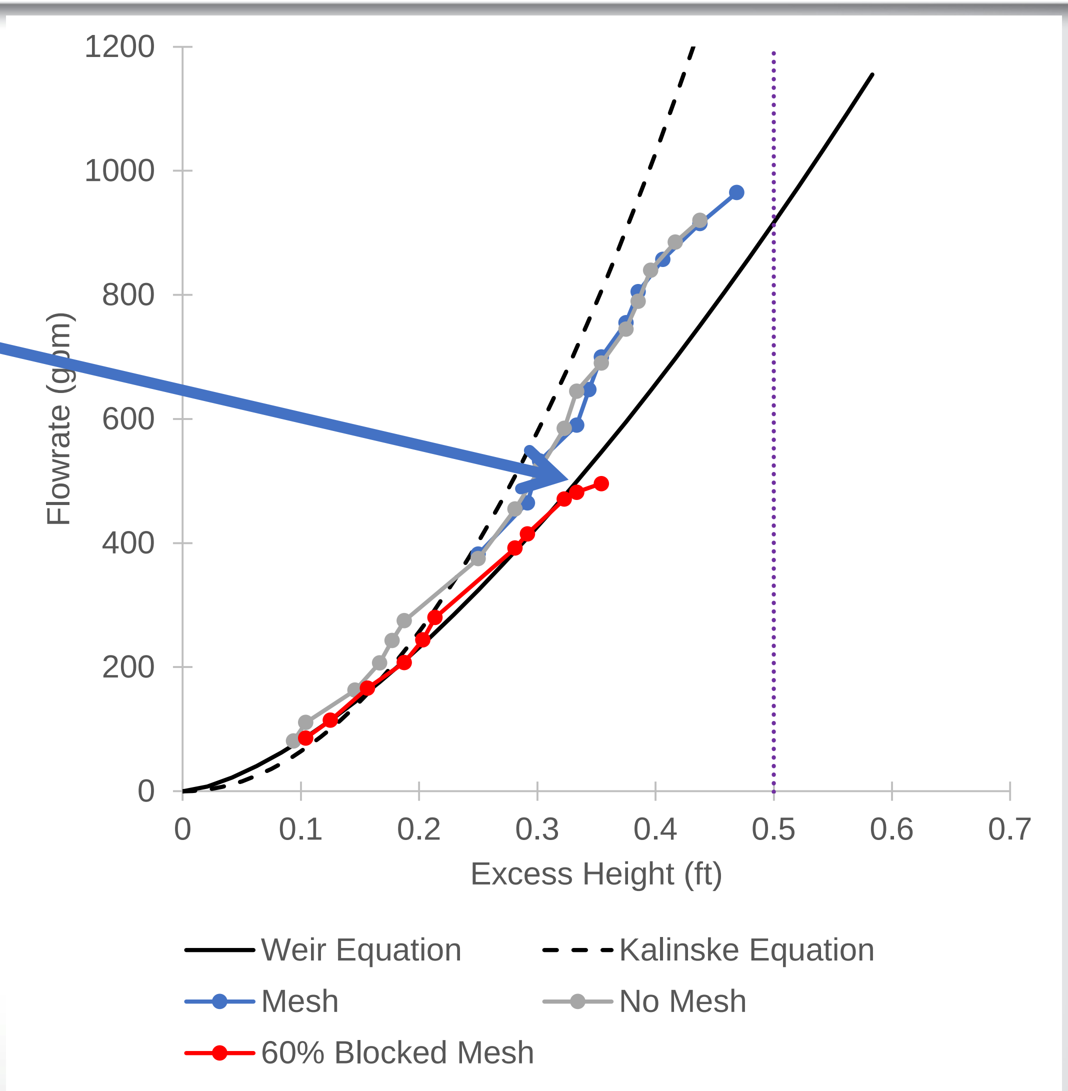
Results: 4" System

- No Mesh:
  - Maximum Predicted – 537 gpm
  - Maximum Measured – 538 gpm
- Clean Mesh:
  - Maximum Predicted – 445 gpm
  - Maximum Measured – 465 gpm
- 50% Blocked Mesh:
  - Maximum Predicted – 250-260 gpm
  - Maximum Measured – did not reach stable height at flows greater than 250 gpm



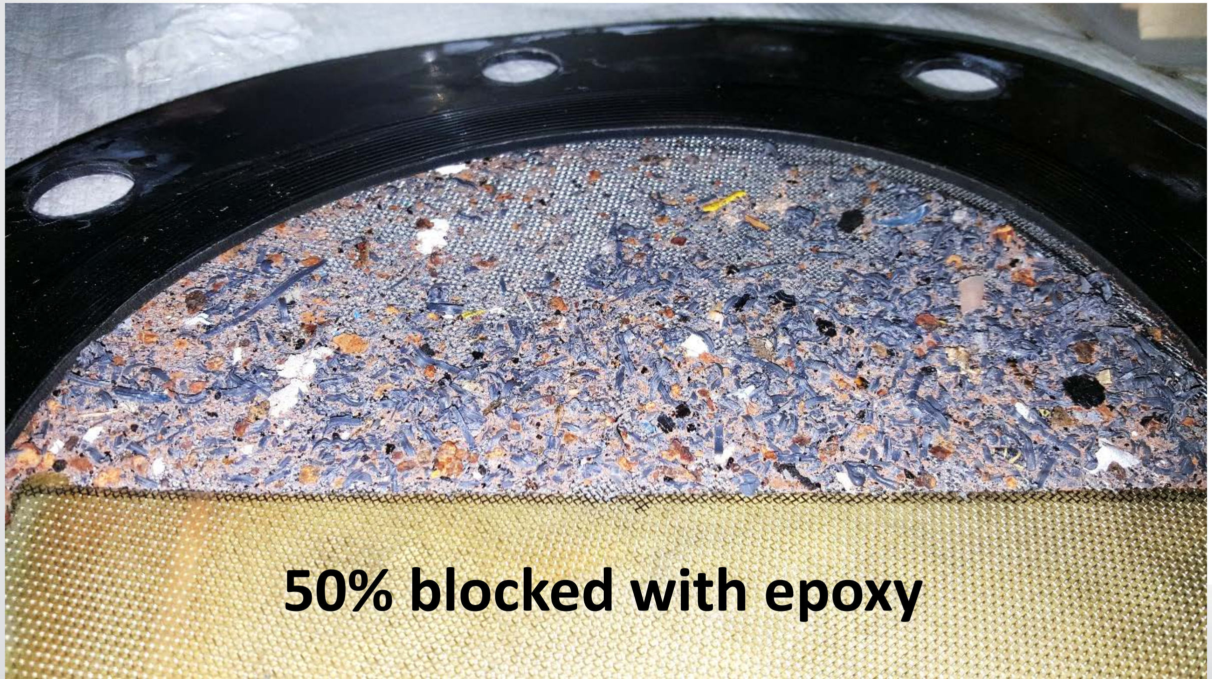
Results: 6” System

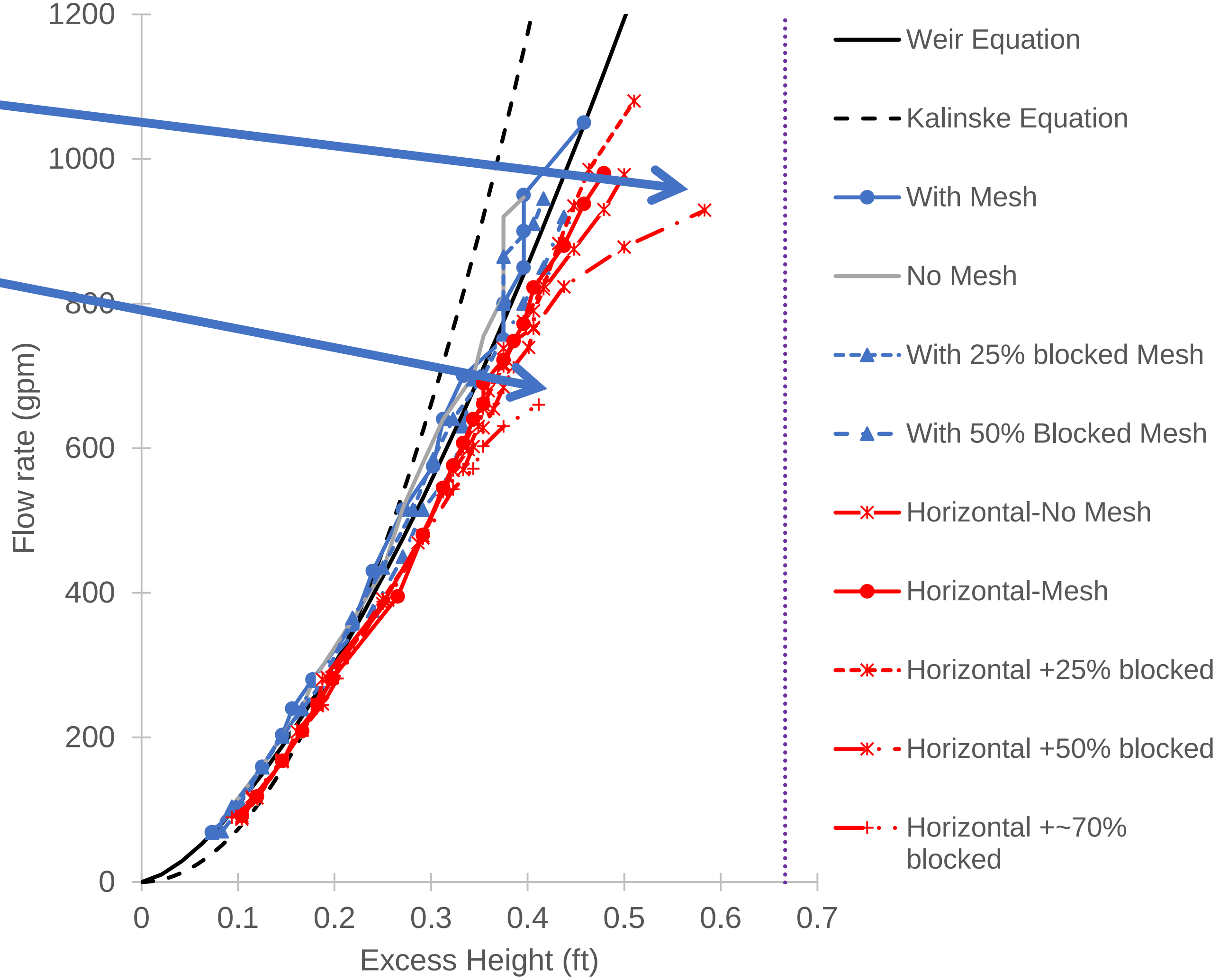
- 60% Blocked:
  - Maximum Predicted – 490 gpm
  - Maximum Measured – 496 gpm



Results: 8" System

- 50% Blocked Mesh
  - Maximum Predicted – 977 gpm
  - Maximum Measured – 924 gpm
- ~70% Blocked Mesh
  - Maximum Measured – 660 gpm





Results: Summary

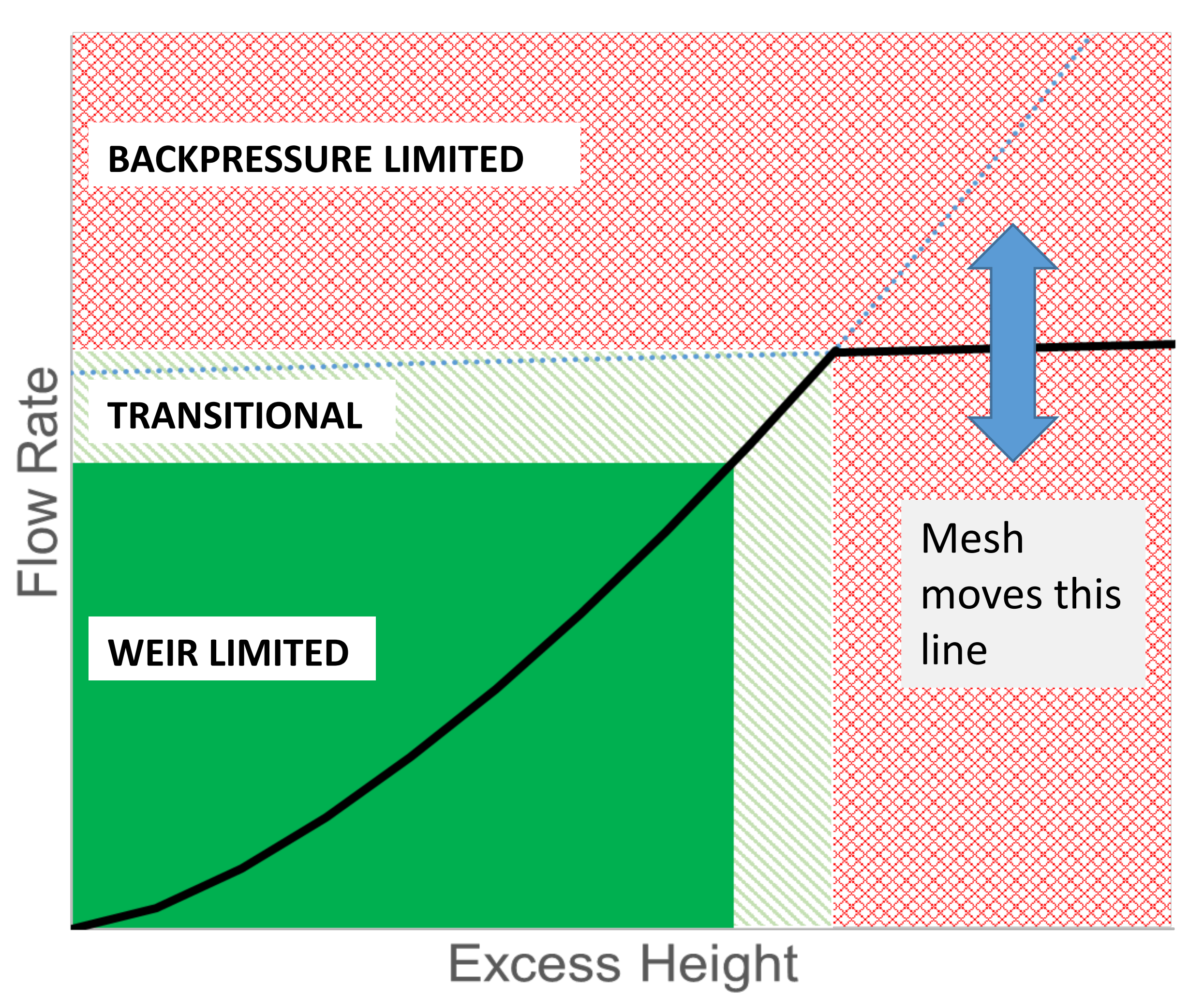
Measured Capacity Relative to Weir Predicted Capacity
(in weir limited regime)

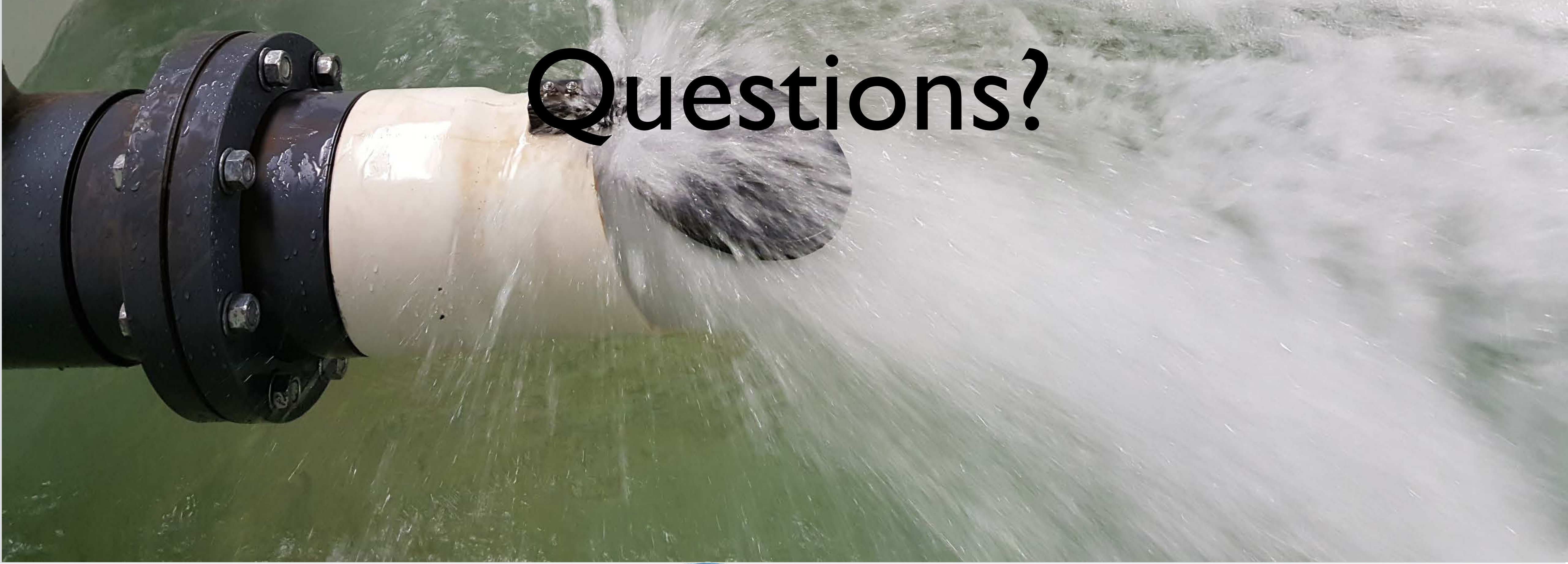
Percent blocked	4”	6”	8” vertical only	8” with horizontal section
No Mesh	1.19 ± 0.12	1.23 ± 0.05	1.08 ± 0.04	0.90 ± 0.05
Clean Mesh	1.19 ± 0.12	1.23 ± 0.06	1.06 ± 0.05	0.91 ± 0.04
25% Blocked	-	-	1.04 ± 0.03	0.91 ± 0.04
50% Blocked	1.10 ± 0.08	1.01 ± 0.03 (60% blocked)	0.98 ± 0.06	0.87 ± 0.07

Values over 1 mean the weir prediction under predicted measured capacity

Conclusions

- Clean mesh did not result in reduction in overflow capacity during weir limited flow
- The dominant impact related to mesh was found to be reduction in flow area
- This reduction in capacity can change where overflow capacity transitions from weir limited to backpressure limited flow regimes





Questions?

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