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High G Flocculation

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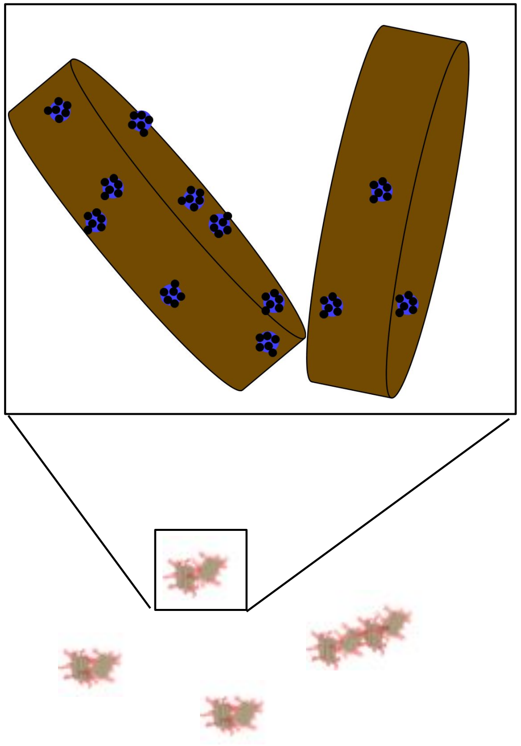
Optimizing Flocculation

More at https://github.com/AguaClara/

Background

- Clay particles aggregate to form flocs in flocculator
- Flocs at critical size settle more easily in sedimentation tank.

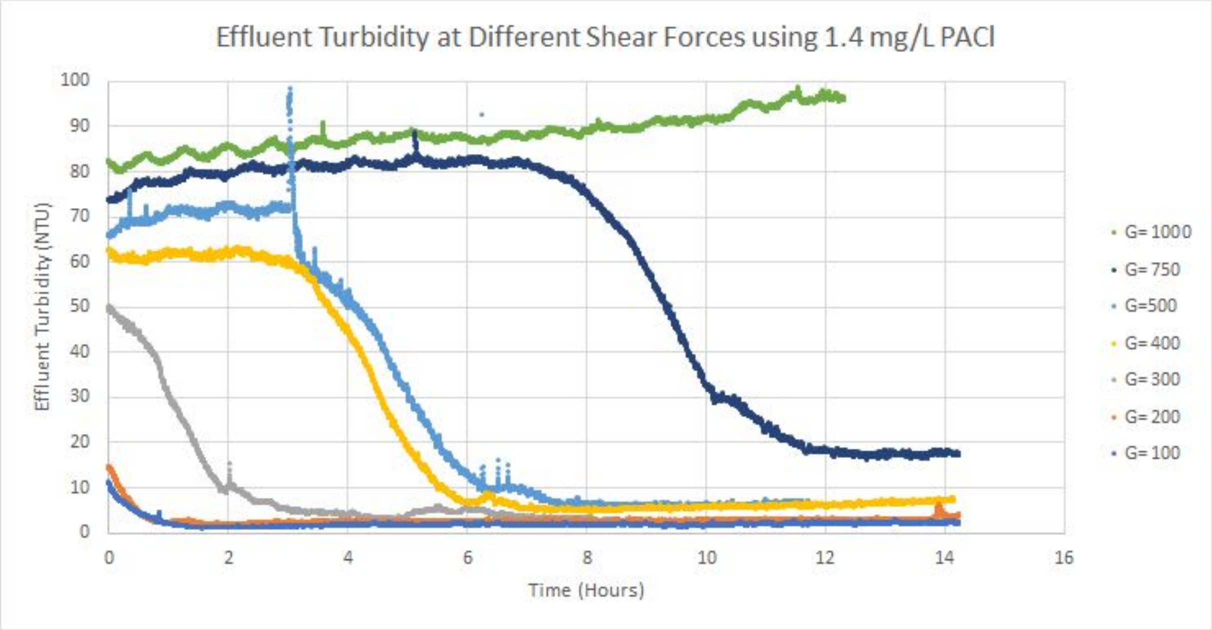
We want as many flocs as possible to be above a critical size.



Background

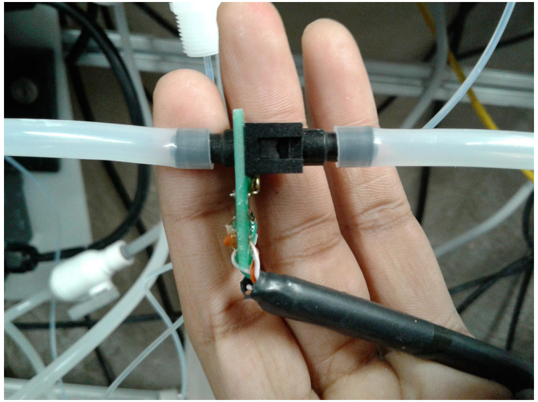
- Last semester, High G researched optimal values of G

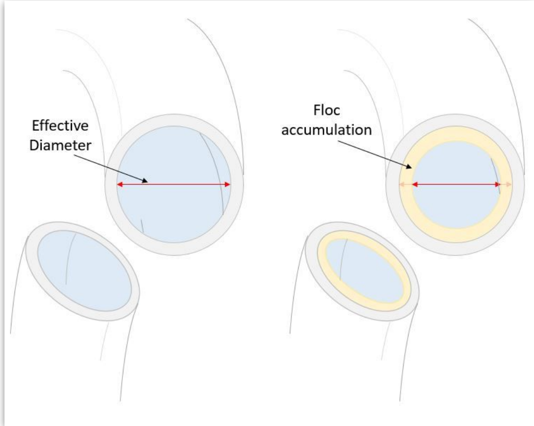
- Shear forces above 100 Hz had higher effluent turbidity

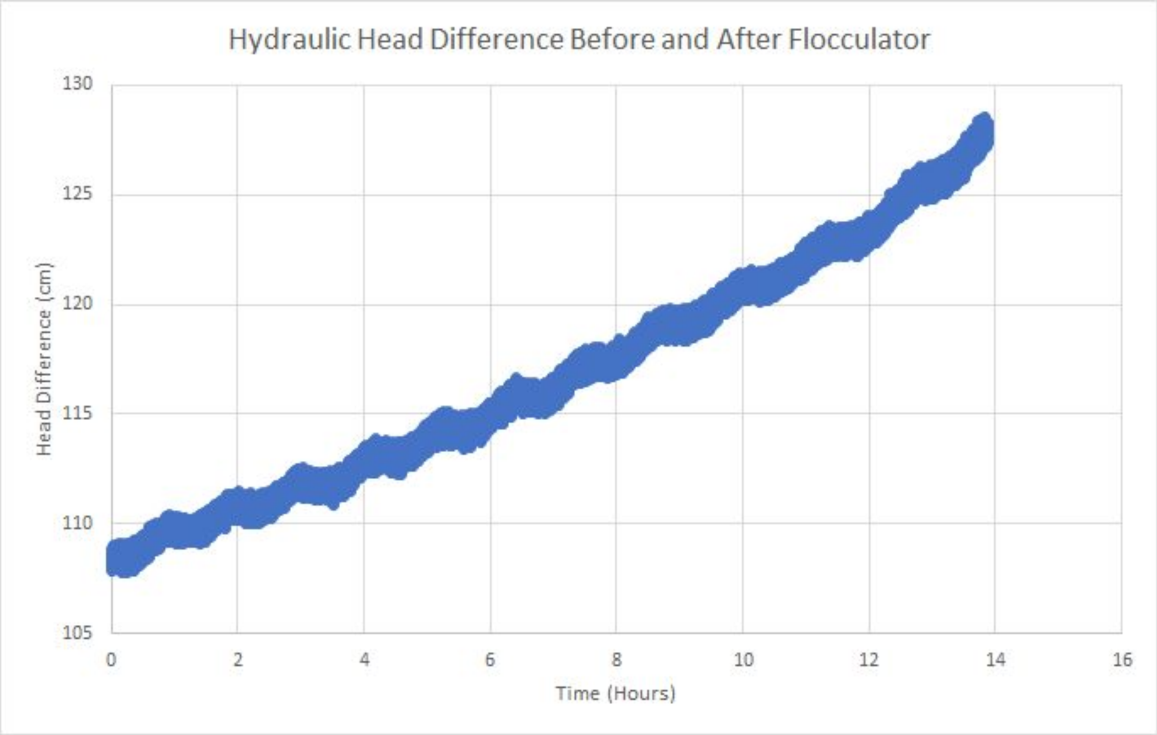


Higher G's ≠ Better Removal

Background

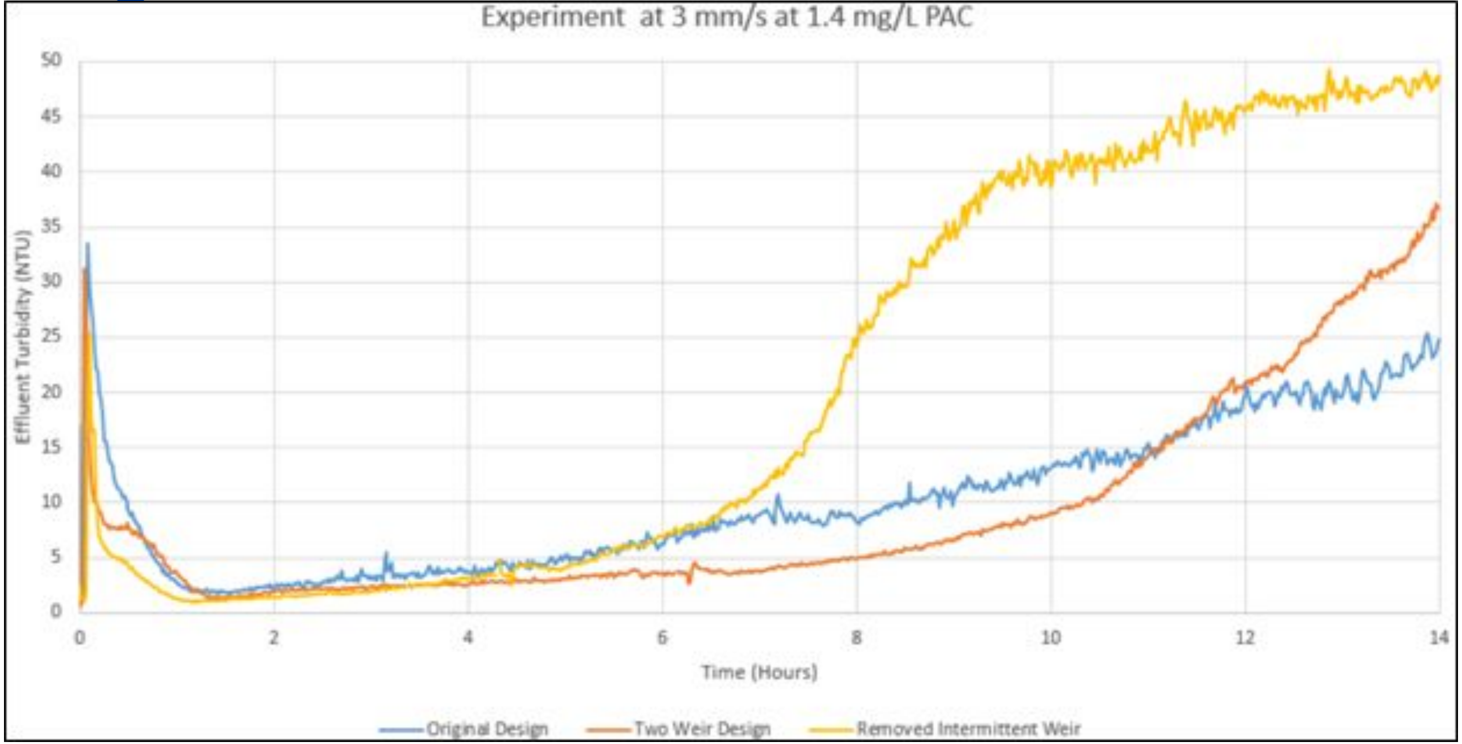






Pressure Increased Throughout our experiments

Background



Pressure increase is a problem in our particle removal research!

Background

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Pressure increase in flocculator tubing is an issue that affects particle removal teams, although not our AguaClara flocculators.

Goals for This Semester

- New flocculator design= better particle removal research!
- Aid in becoming more open-sourced!
- Find that optimal G!

Experimental Setup

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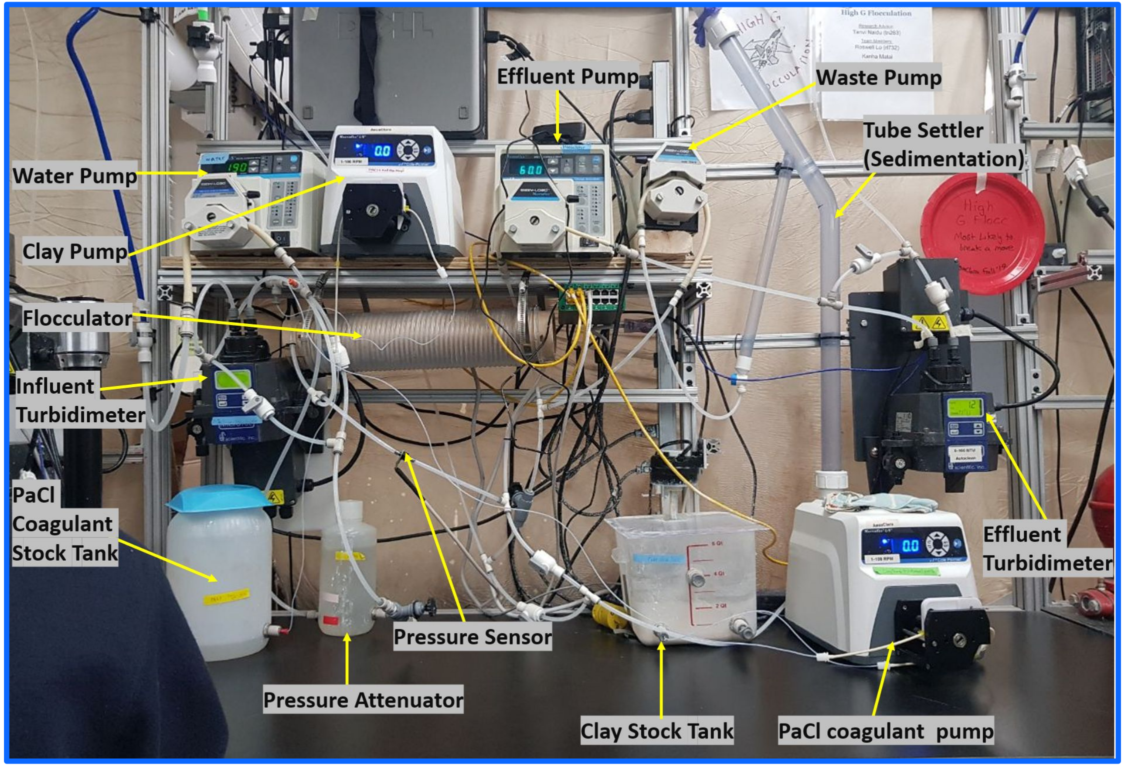
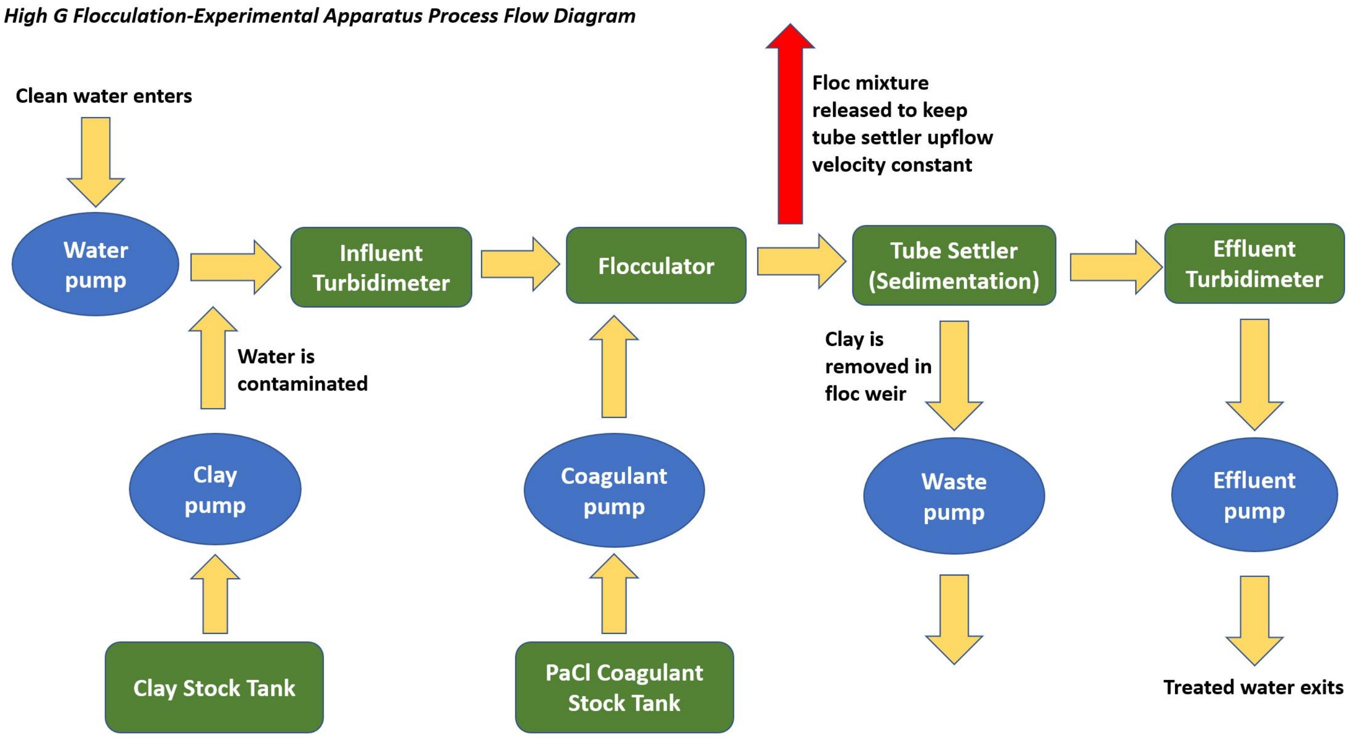
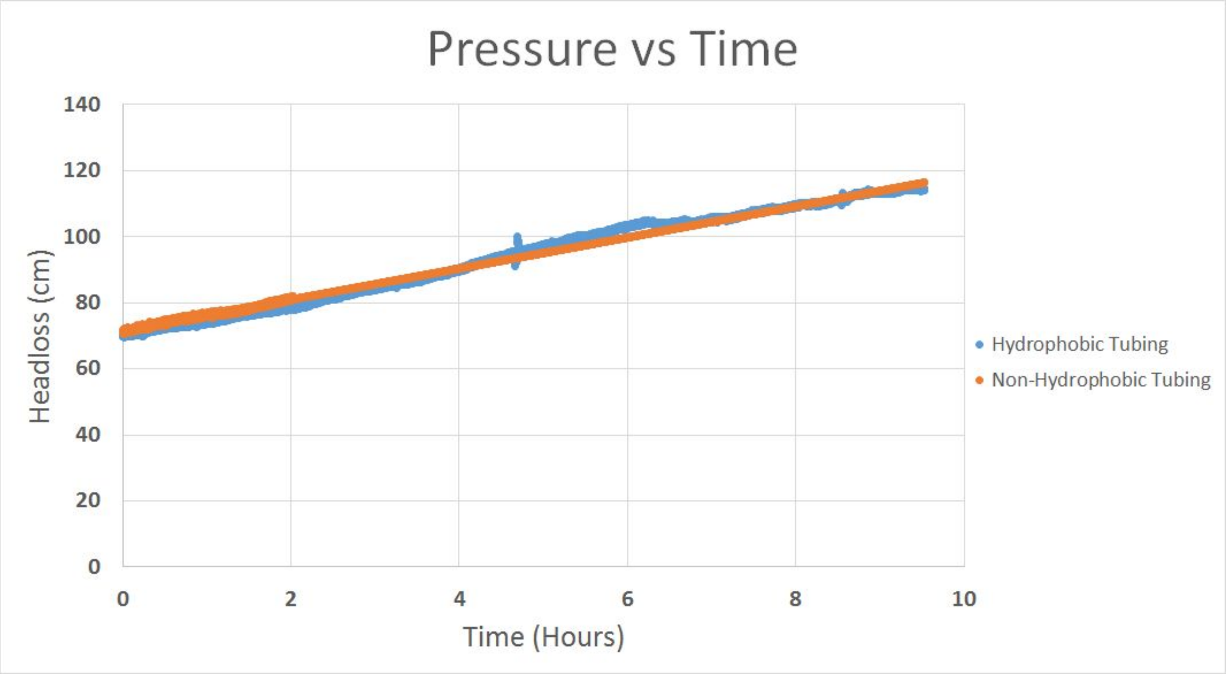


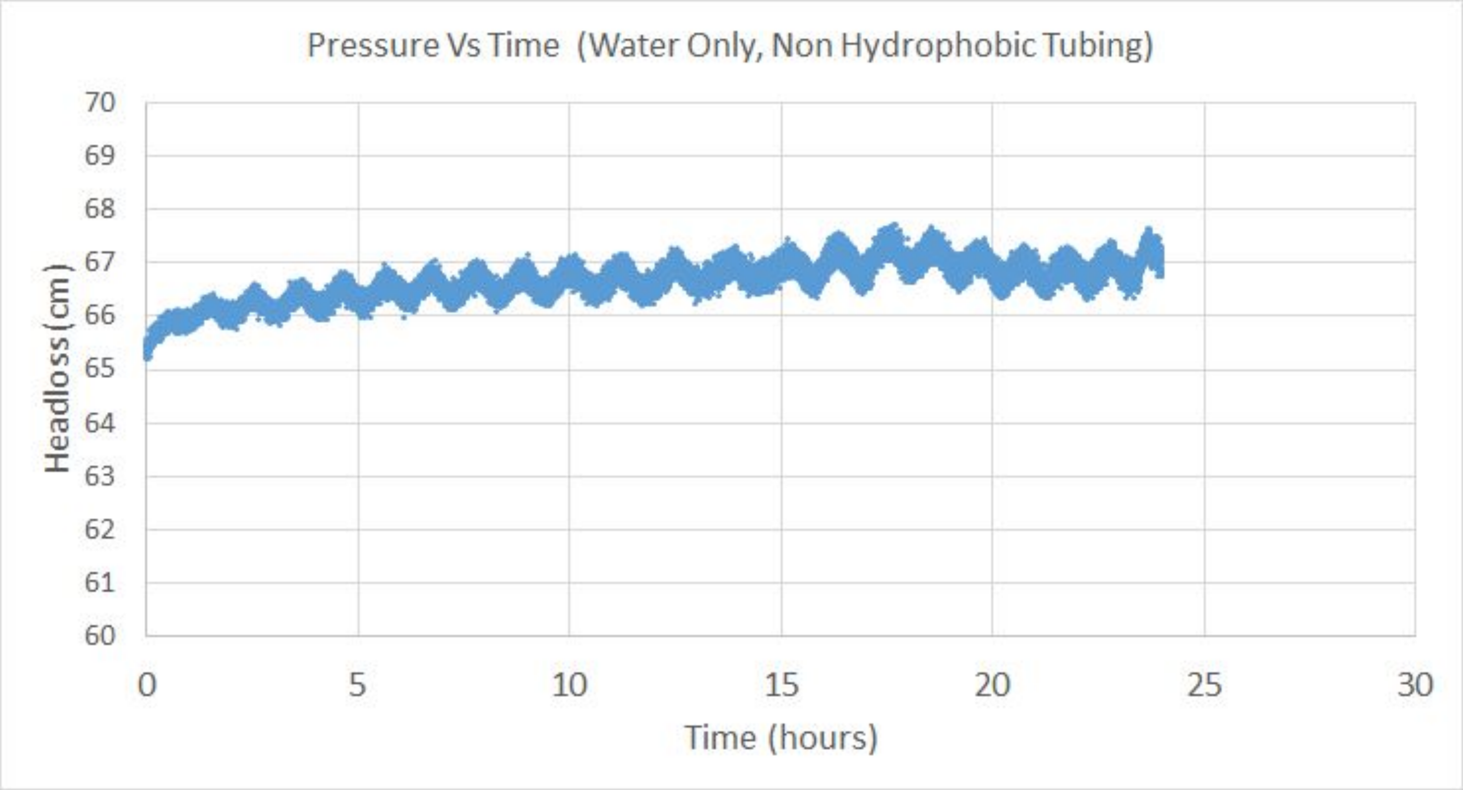
Trial Process Flow Diagram



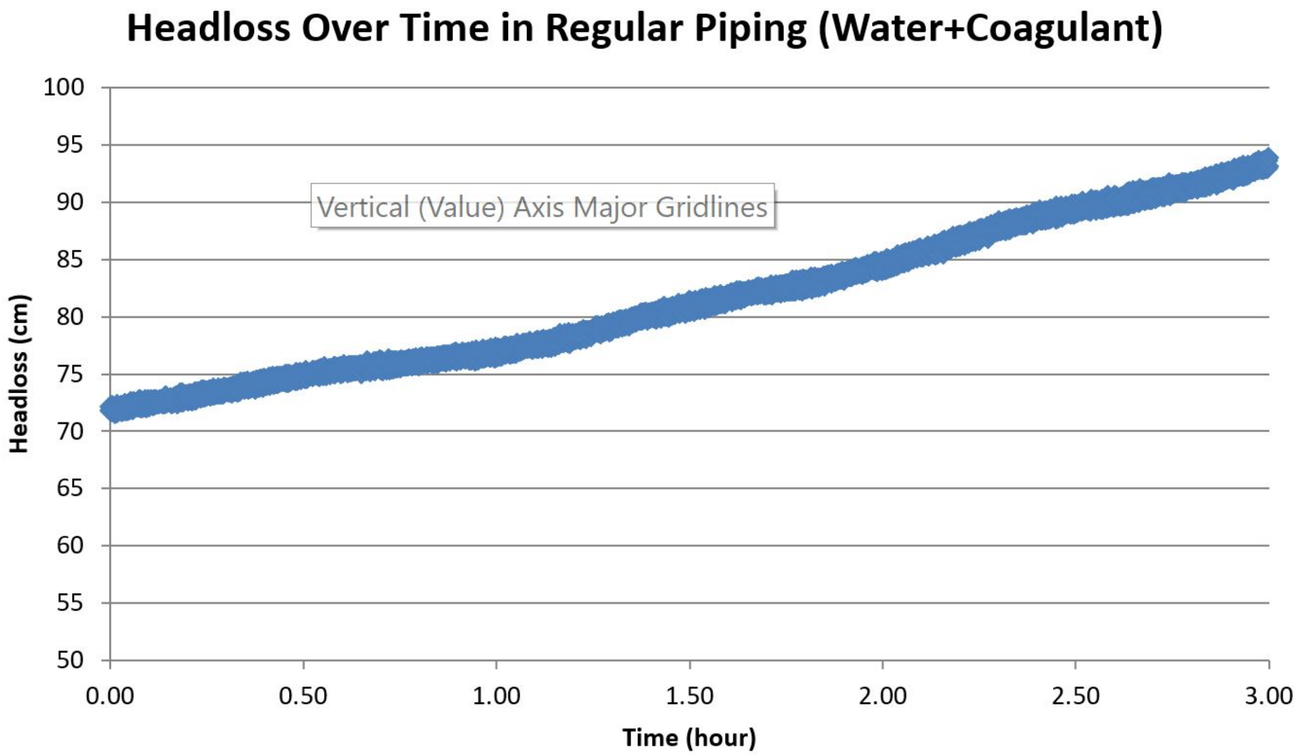
Effect of Hydrophobic tubing on pressure build up



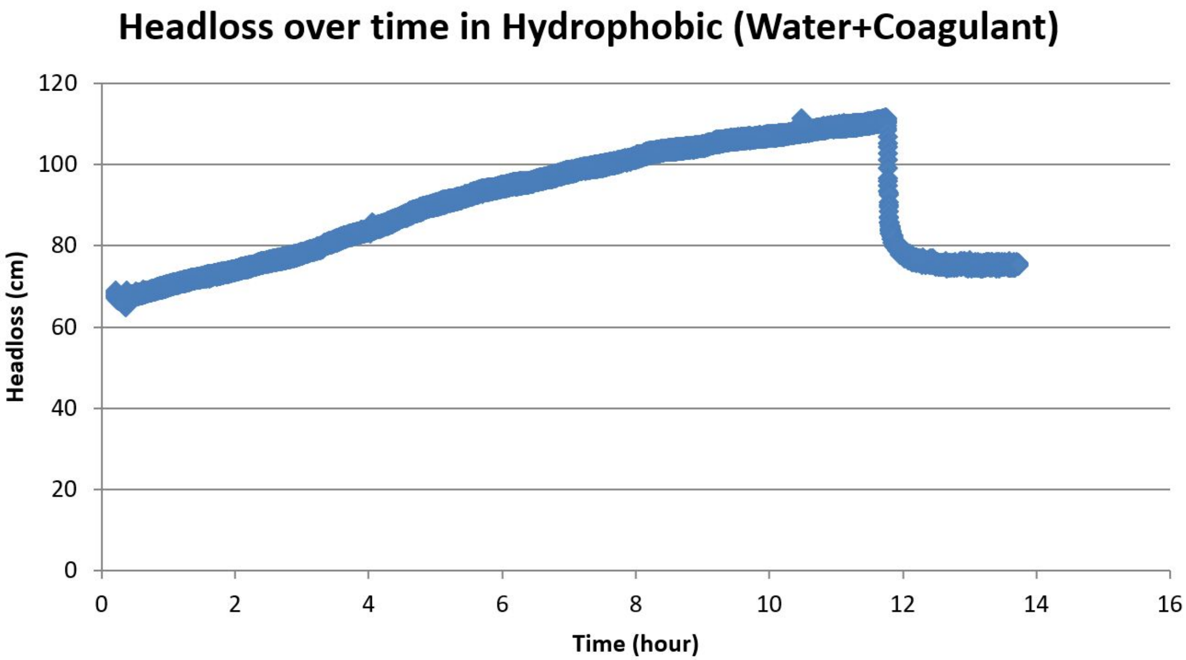
Control Experiment with Water Only



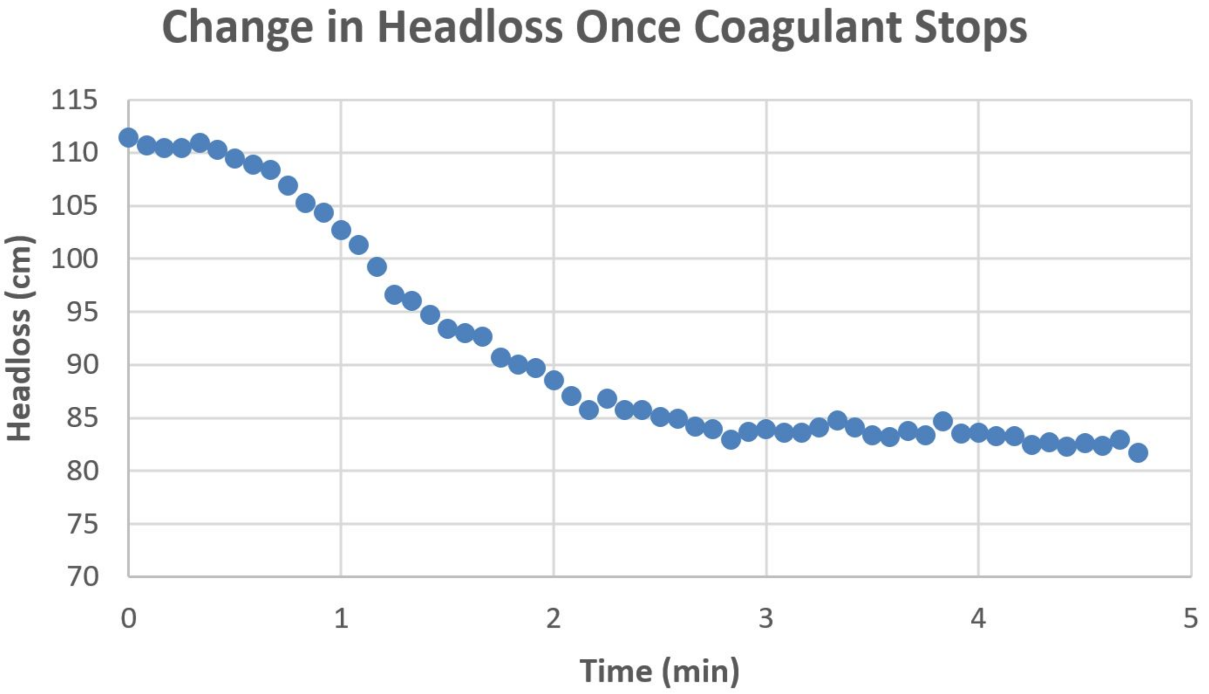
Coagulant shows an impact on pressure build up



Effect of Coagulant on Pressure (No Clay)



Pumping air bubbles may reduce pressure build up



Current Conclusions

- Hydrophobic tubing is insignificant in reducing pressure build up
- Coagulant has an impact on pressure build up

Future Work

- Evaluate whether pressure build up can be mitigated by running the water pump at full speed for a short time.

- Determine an optimal G value by running trials at G values lower than 100 Hz.

- Conduct experiments to determine a relationship between coagulant dose and optimal G through varied coagulant dose trials.

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Questions and Recommendations

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Appendix Slides

Appendix 1: Python Code

PaCl Dosing Calculations

```
from aide_design.play import*

#inputs
C_sys = 1.4*(u.mg/u.L)
C_labstock = 70.9*(u.g/u.L)
Q_sys = 1.48*(u.mL/u.s)
K_dilution = .8*(u.mL/u.L)
V_resivor = 5*(u.L)
Frac_resivor = .76
Q_per_rpm = .001828 *(u.mL/u.s)

#Calculations
M_flow_coag = (Q_sys * C_sys).to(u.mg/u.s)
C_resivor = (C_labstock * K_dilution).to(u.gram/u.L)
Q_resivor = (M_flow_coag / C_resivor).to(u.mL/u.s)
V_lab = ((V_resivor * C_resivor) / C_labstock).to(u.L)

#Outputs
RPM = Q_resivor / Q_per_rpm
RunTime = ((V_resivor * Frac_resivor) / Q_resivor).to(u.hour)

print('The RPM needed for this coagulent dosage is' ,RPM)

print('The run time is ', RunTime)
```

Appendix 2: Python Code

Flocculator Design Calculations

```
from aide_design.play import*
import math as m


#Inputs
Q_reactor=(4/3) *(u.mL/u.s) # flow rate of the system
Gtheta_goal=20000 #target G*theta to design flocculator to
Diam_floctube=(3/16)*(u.inch)
R_c=5*u.cm #radius of curvature (the radius of the tube the flocculator is wrapped around)
Re_pipetransition=2100
v=(1*10**-6)*(u.m**2/u.s)
e_pvc=0.12*u.mm #roughness of PVC Re_pipetransition

#Calculations
Re_f= ((4*Q_reactor)/(np.pi*Diam_floctube*v)).to(u.dimensionless)


print(Re_f)


#def fric_function(Q_reactor,Diam_floctube,v,e_pvc)
if Re_f > Re_pipetransition:
  print('Re_f is greater than Re_pipetransition')
  fric=0.25/((m.log((e_pvc/3.7*Diam_floctube)+(5.74/(Re_f**0.9))))**2)
else:
  fric=64/(Re_f)
  print('Re_f is not greater than Re_pipetransition')
  print(fric)
L=1
h_f=fric*(8/(pc.gravity*np.pi**2))*((L*Q_reactor**2)/(Diam_floctube**5))



R=R_c.to(u.inch)

De=(((Diam_floctube/R)**2)*Re_f)
print(De)

friction_ratio=1+(0.33*m.log(De)**4)
print(friction_ratio)
```

Appendix 2 (Cont.)

Flocculator Design Calculations

```
h_friction=h_f*friction_ratio
Area=(np.pi/4)*Diam_floctube**2
theta=(Area*L)/Q_reactor

ED_floc=(h_friction*pc.gravity)/theta

epsilon=ED_floc.to(u.mW/u.kg)
print('Energy dissipation rate is',epsilon)

G_floc=((epsilon/v)**(1/2)).to(u.second**-1)
print(G_floc)

theta_goal=(Gtheta_goal/G_floc).to(u.minute)
print(theta_goal)

L_goal=theta_goal*(Q_reactor/Area)

L_floc=L_goal
print('The length of flocculator tubing should be', L_floc.to(u.ft))
```

Appendix 3:

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Calculating required Q plant based on sed tank uplow of 3 mm/s

$$V_{sed} := 2\frac{mm}{s} \qquad D_{sed} := 1\cdot in$$

$$A_{sed}(D) := \pi\cdot\frac{D^2}{4} \qquad A_{sed}(D_{sed}) = 5.067\times10^{-4}\,m^2$$

$$Q_{sed} := V_{sed}\cdot A_{sed}(D_{sed}) = 1.013\cdot\frac{mL}{s}$$

The upflow velocity in the tube settler needs to be fixed (2mm/s) to allow formation of a floc blanket