# RESEARCH OVERVIEW OF THE AU – STORMWATER RESEARCH FACILITY

CLEAR WATER ALABAMA – SEPTEMBER 20TH & 21ST, 2023

AUBURN UNIVERSITY

**Wesley N. Donald, Ph.D.**
Research Fellow
Civil & Environmental Engineering

# Construction Activities are the Largest Human Induced Non-Point Source of Sediment


Waterkeeper Alliance

## Needs: Improve Performance of Existing Practices, Advance E&SC Design Standards, Insure Proper Implementation

2021 REPORT CARD
FOR AMERICA'S INFRASTRUCTURE
ASCE

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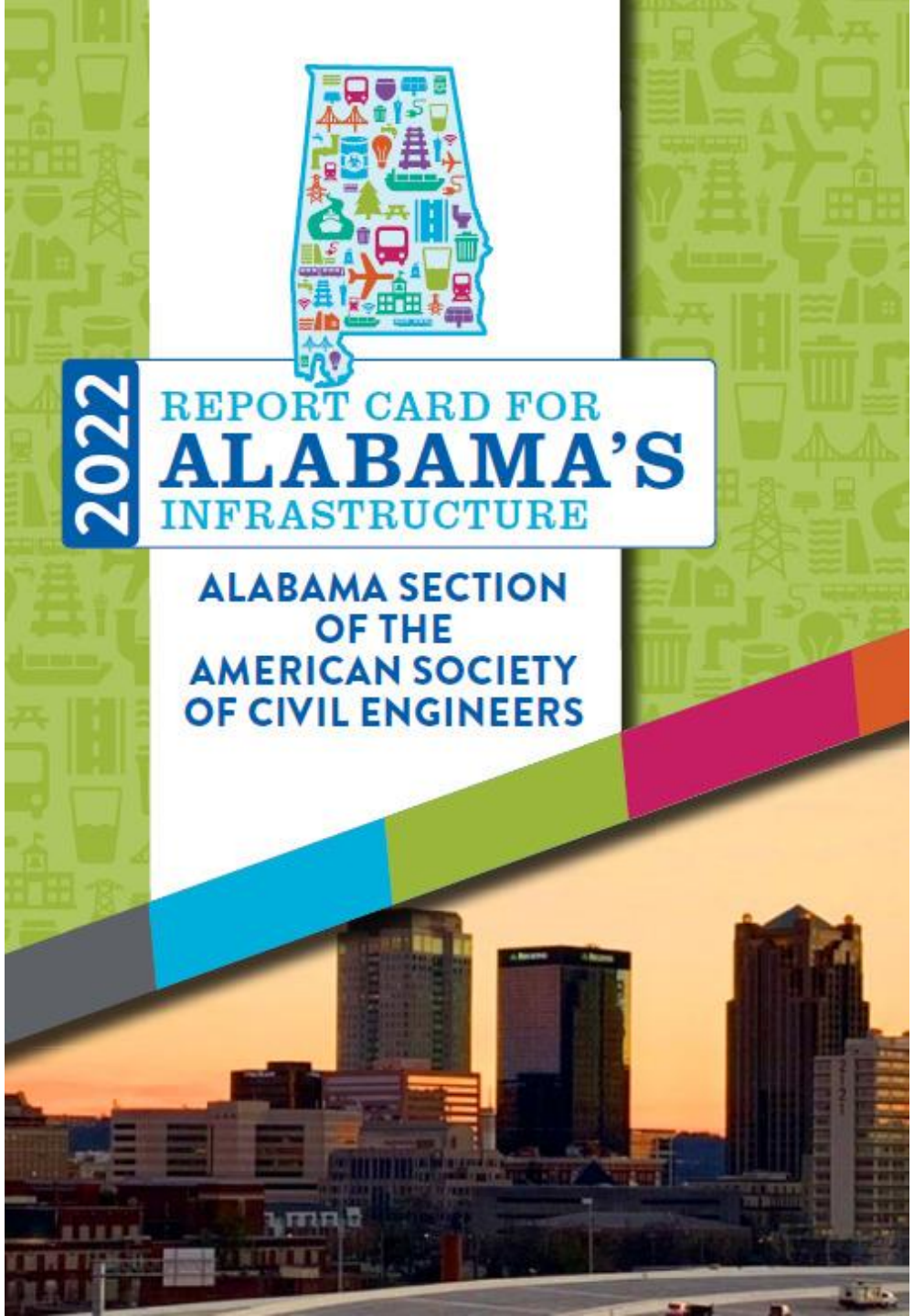
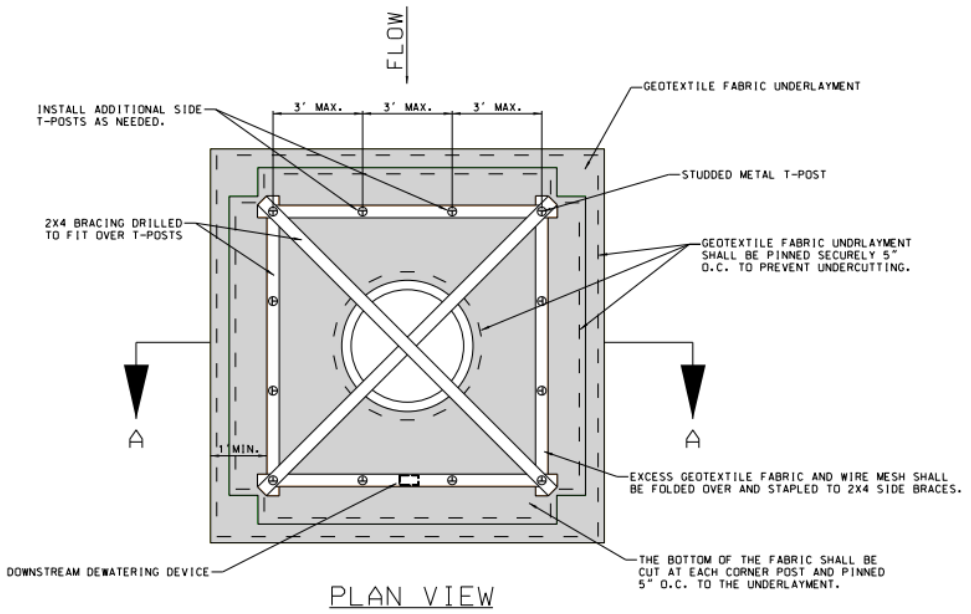
# STORMWATER

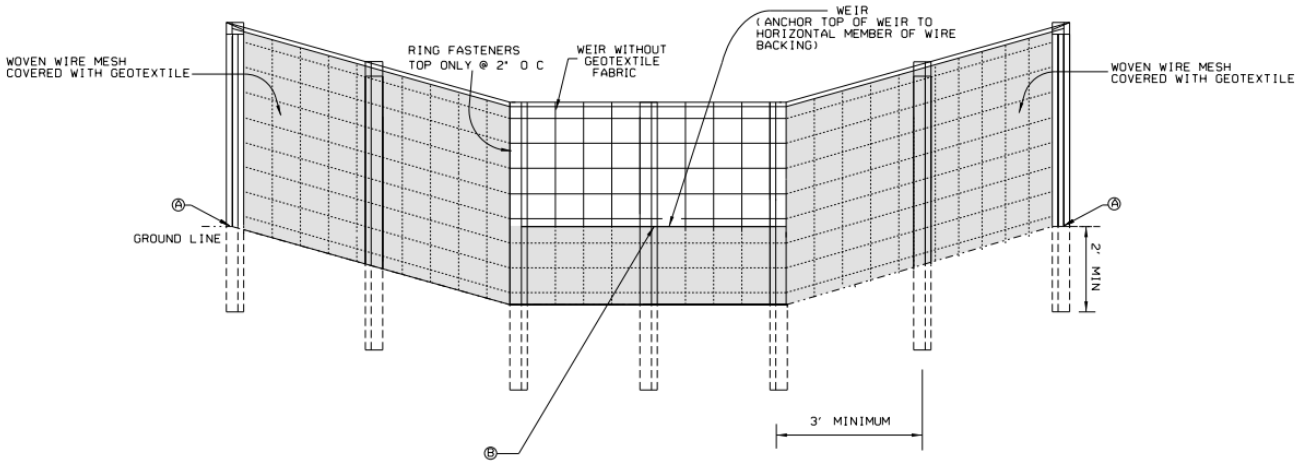



# AU - EROSION & SEDIMENT CONTROL TESTING FACILITY


Track-out Control
Sediment Barriers
Channelized Flow Demos
Floc Flume
Skimmer Testing
Floating Turbidity Curtain
Floc Shed
Diversion Swale
Rainfall Simulator
Rainfall Simulators
Slope Drains
Level Spreader
Ditch Checks
Inlet Protection
J-Hooks
Tree Protection
Sediment Basin
Ditch Checks + Floc
Silt Fence
TRM's
Hydroseeding
Erosion Control Blankets
Straw Blowing
Slope Interrupters
Sodding
Vegetation Plots
Vegetated Buffer
Stockpile Mgm't
AUBURN STORMWATER
IECA International Erosion Control Association
Protecting Soil and Water Resources
STORMWATER RESEARCH FACILITY
au-stormwater
@StormwaterAU
Auburn Stormwater
stormwater.auburn.edu
ALDOT
Alabama Department of Transportation
NEBRASKA
Good Life. Great Journey.
DEPARTMENT OF TRANSPORTATION
IOWA DOT
SMARTER | SIMPLER | CUSTOMER DRIVEN
dot
transportation.ohio.gov

# ALDOT STANDARD DRAWINGS

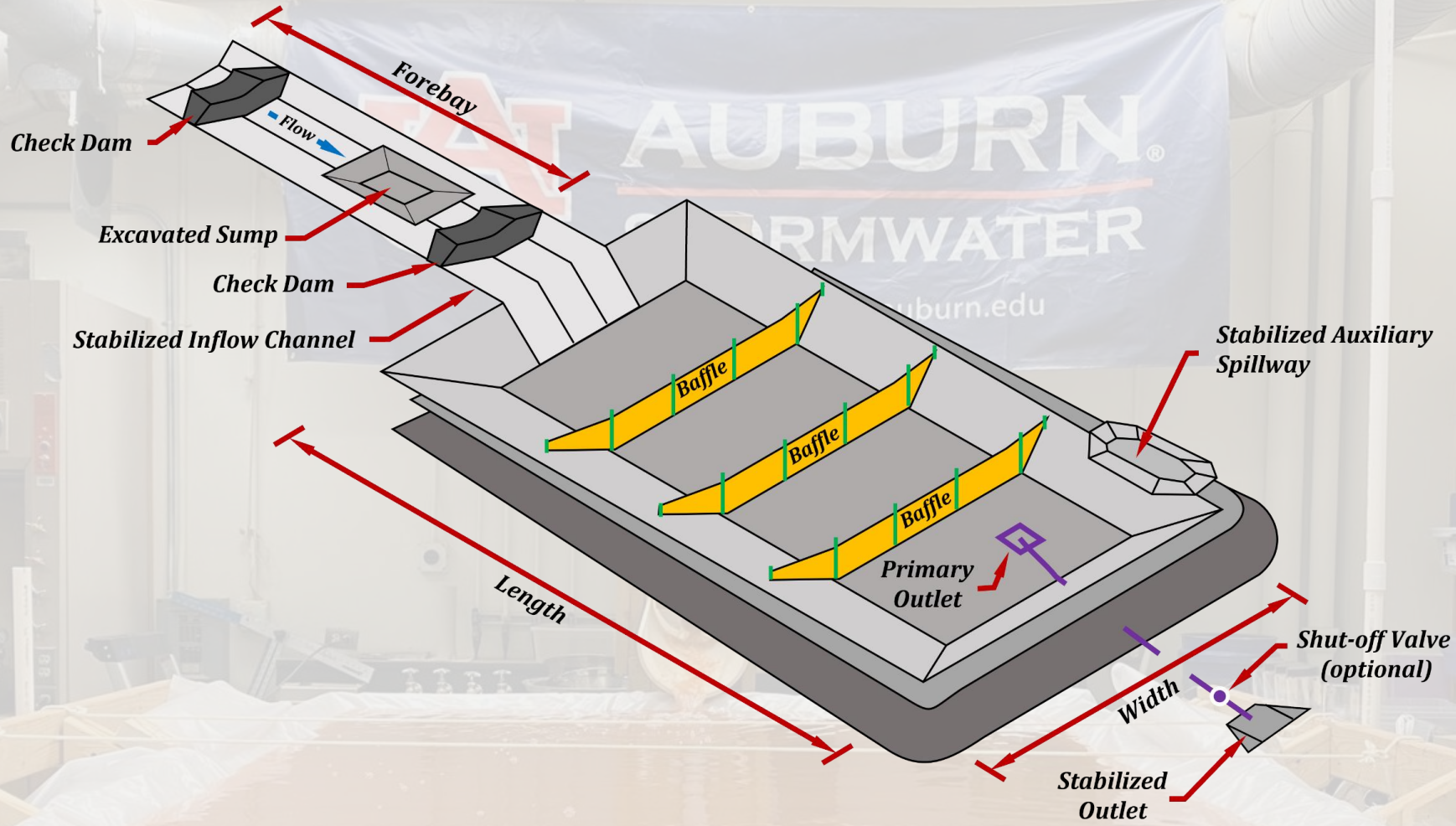


# OPTIMIZATION OF SEDIMENT BASIN CONFIGURATIONS

AUBURN
STORMWATER

# ALDOT STANDARD




Credit: B. Fagan

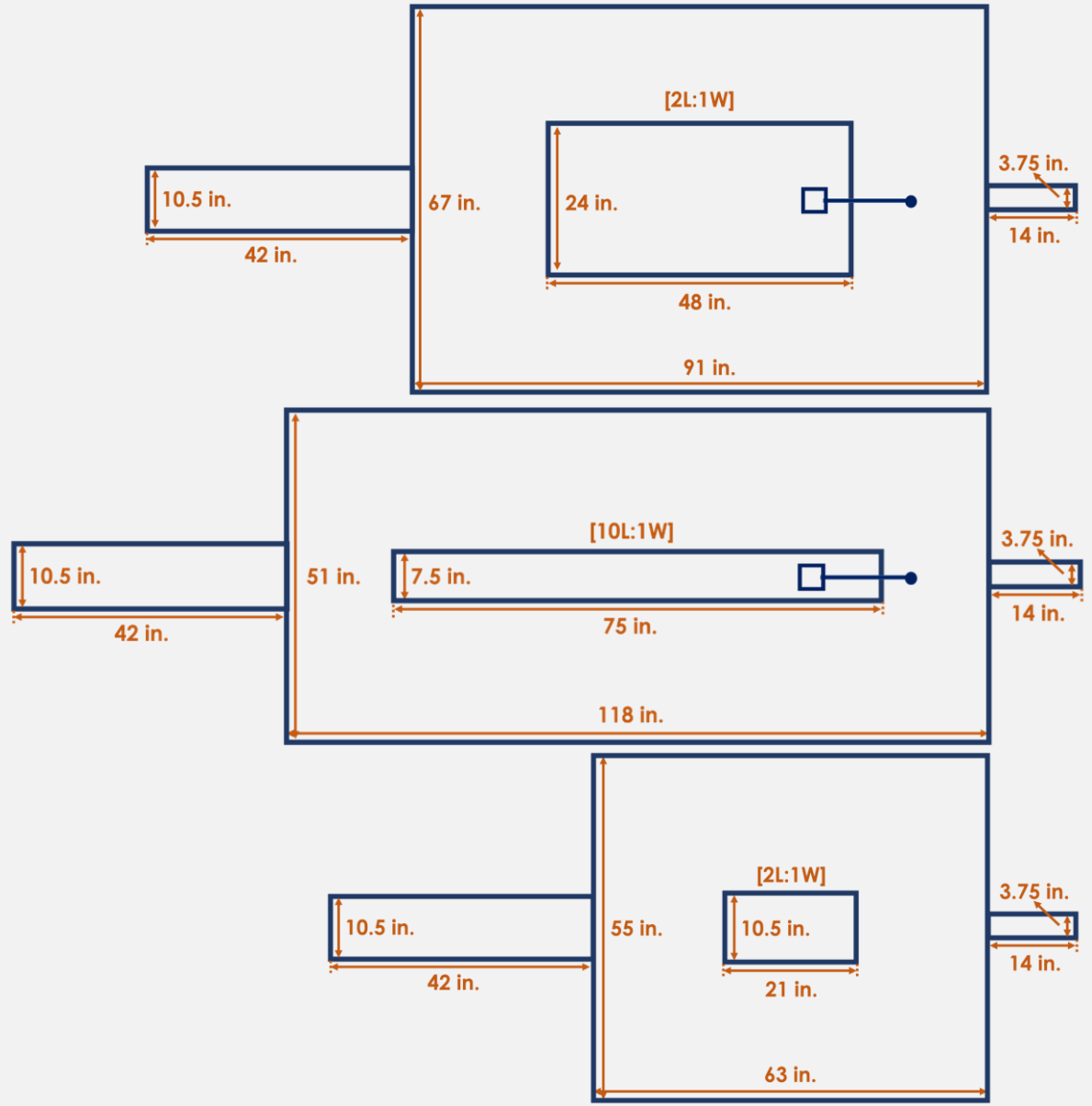
**Purpose:** capture & passively treat stormwater runoff by providing extended detention & promoting gravitational settling

# BASIN SIZING

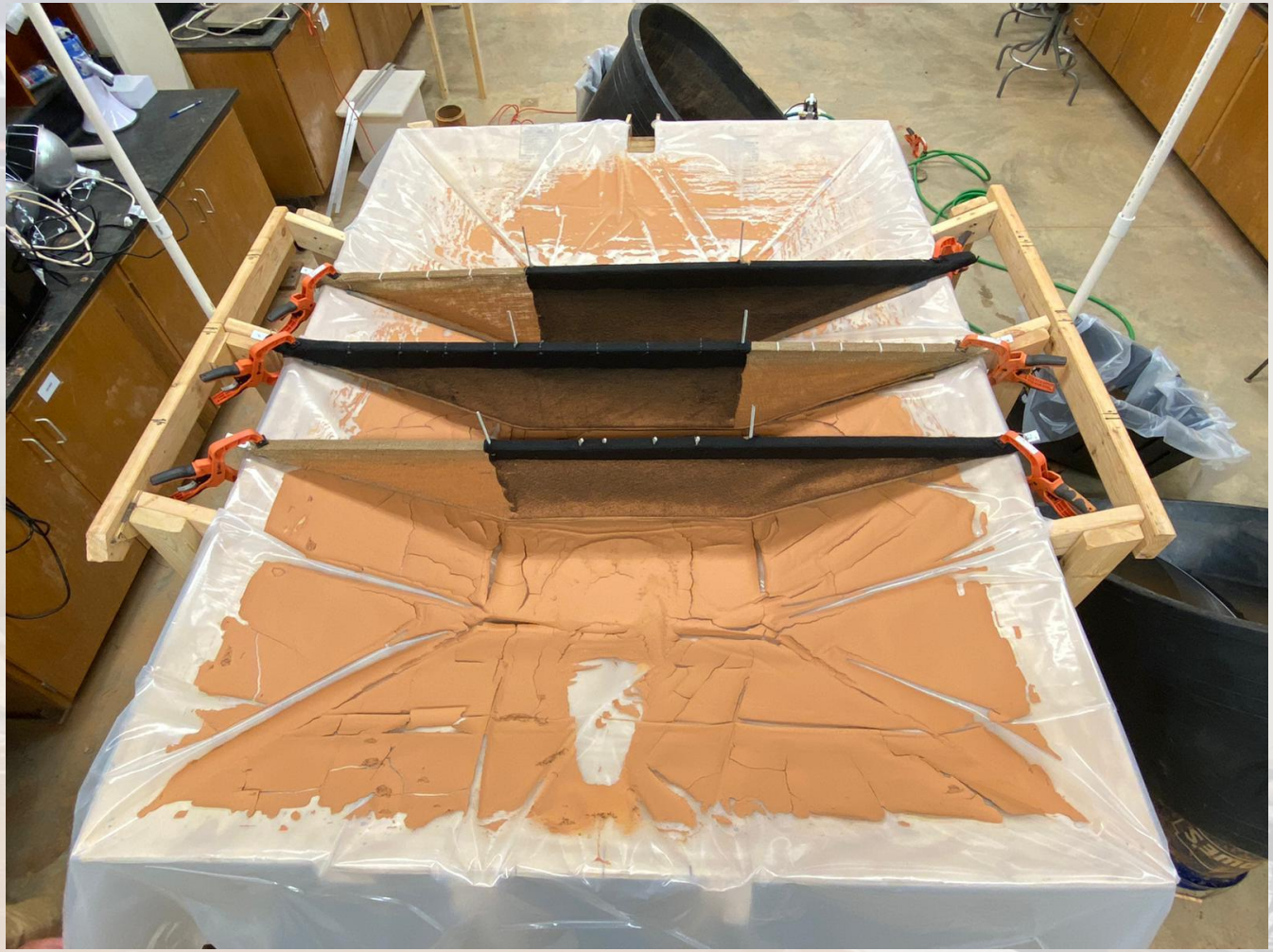
- Basin size/shape influences trapping efficiency
- Volume design
  - Volume sizing factor: 3,600 $ft^3$/ac
  - Hydrologic design: 2-yr, 24-hr event
- AL dimension recommendations
  - Basin length to width (L:W) ≥ 2:1
  - Side slopes H:V ≥ 2:1
  - Depth 2-5 ft
- Max. drainage area: 10 ac

# BASIN DESIGNS

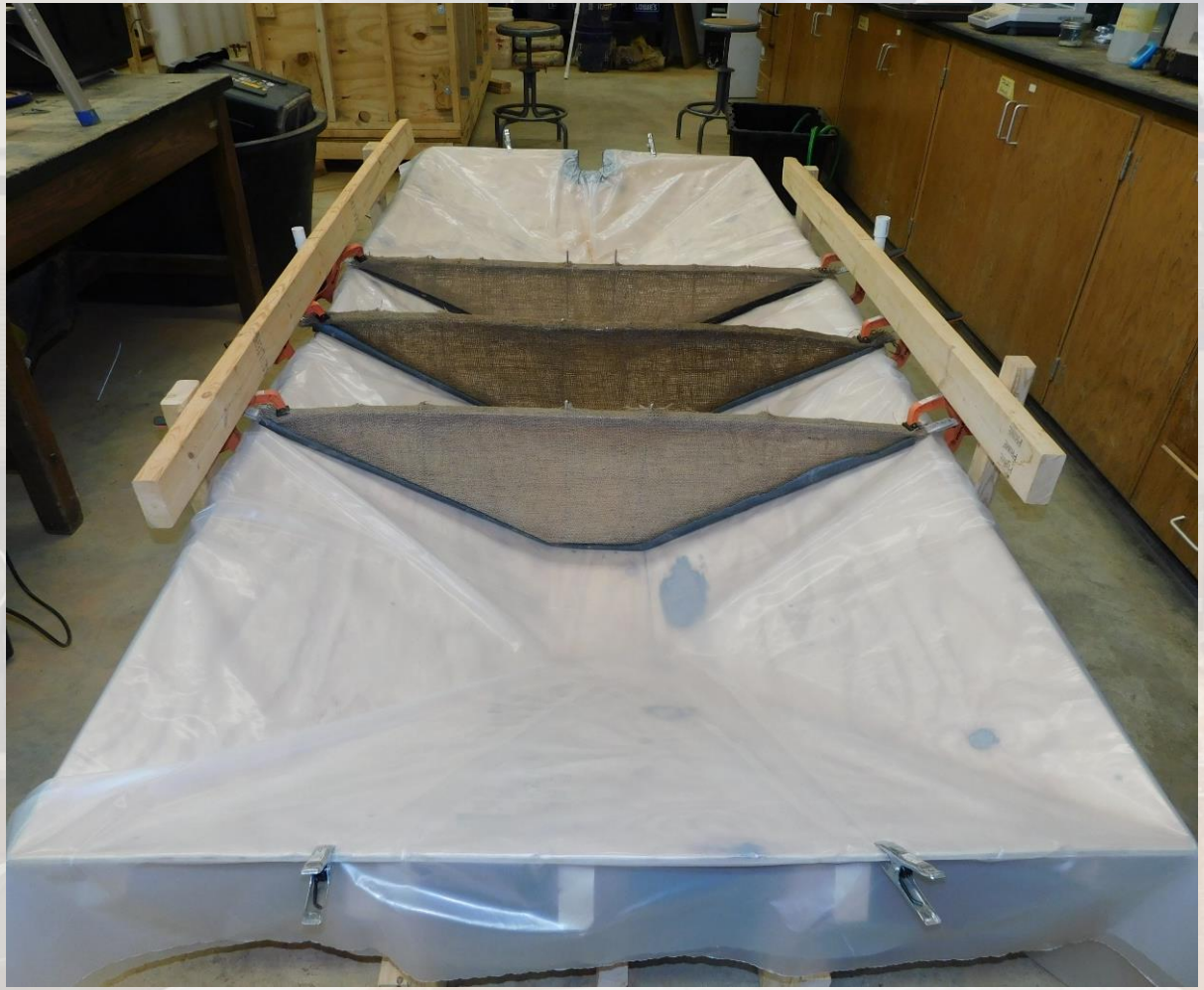
| | Standard | In-Channel | Undersized |
|---|---|---|---|
| Top Length [ft] | 7.6 | 9.0 | 5.3 |
| Top Width [ft] | 5.6 | 4.2 | 4.6 |
| Volume [$ft^3$] | 15.3 | 13.5 | 7.0 |
| L:W | 2:1 | 10:1 | 2:1 |
| Side Slope [H:V] | 2:1 | 2:1 | 2:1 |
| Depth [ft] | 0.77 | 0.77 | 0.77 |
| Residence Time [min.] | 15.3 | 13.5 | 7.0 |



# STANDARD BASIN



# IN-CHANNEL BASIN



# UNDERSIZED BASIN

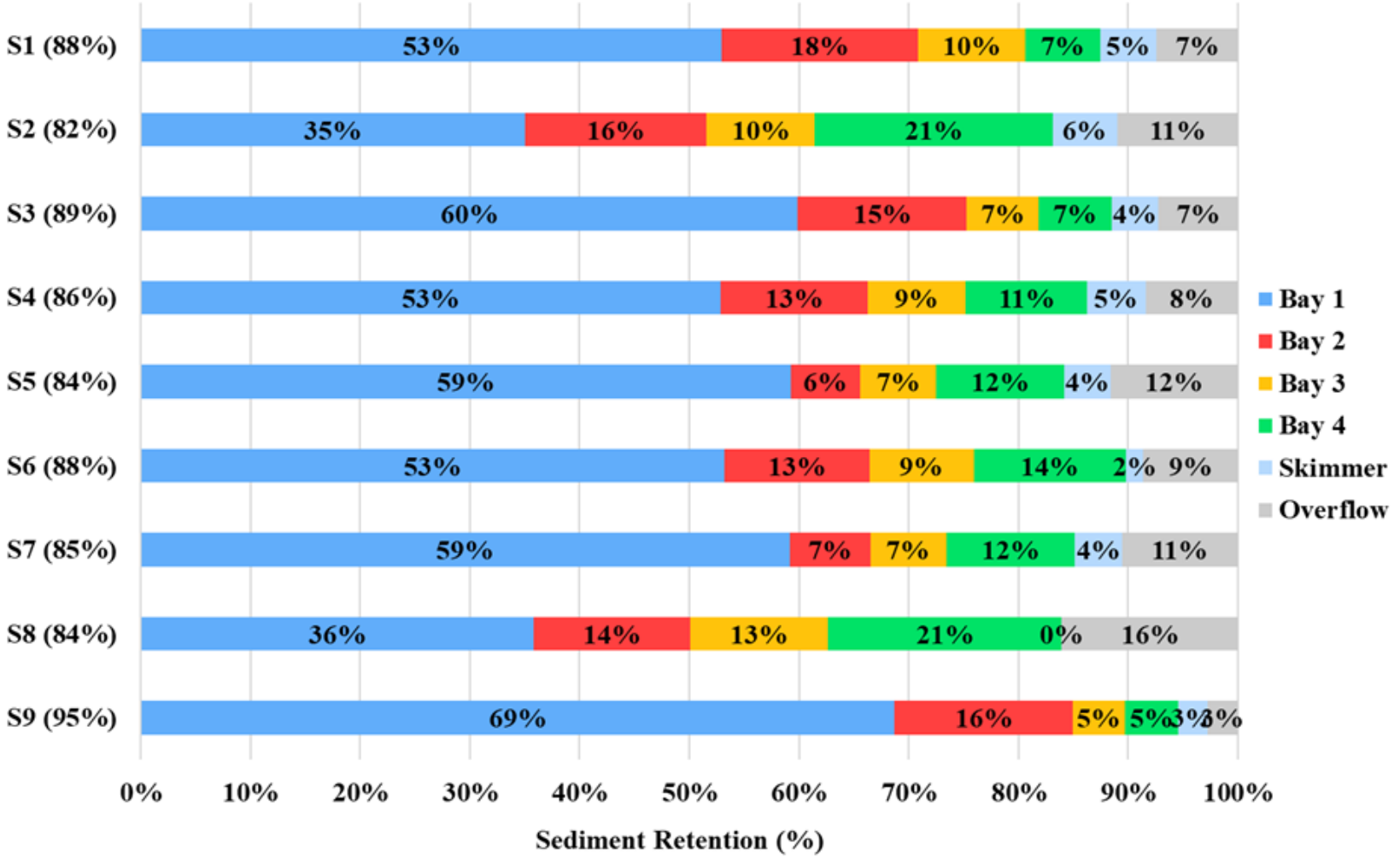
# SAMPLE PROCESSING

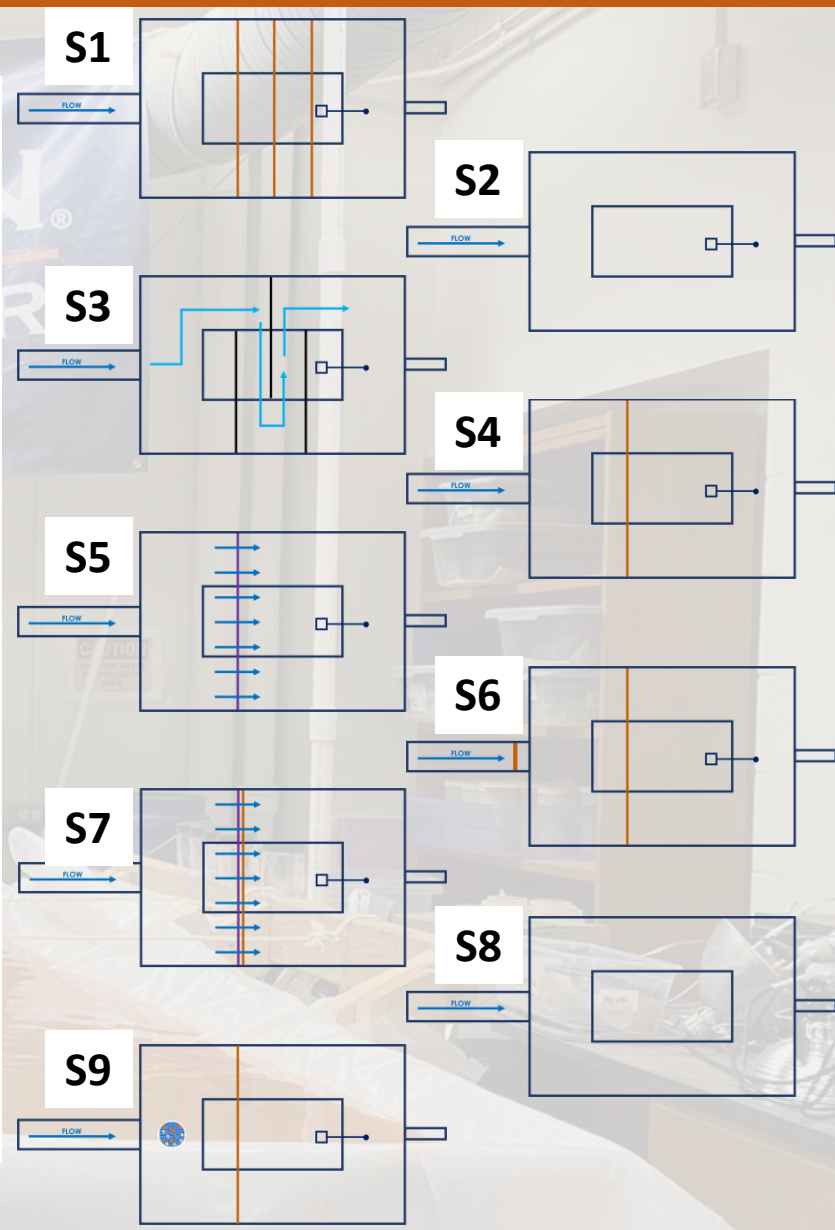

- Basin dried with heat lamps
- Sediment split by location of bays

# SAMPLE PROCESSING


- Spillway & skimmer discharge troughs floc'd
  - H30 flocculant
  - 2 mg/L
  - 24 hours of settling

# STANDARD BASIN (2:1) SEDIMENT RETENTION



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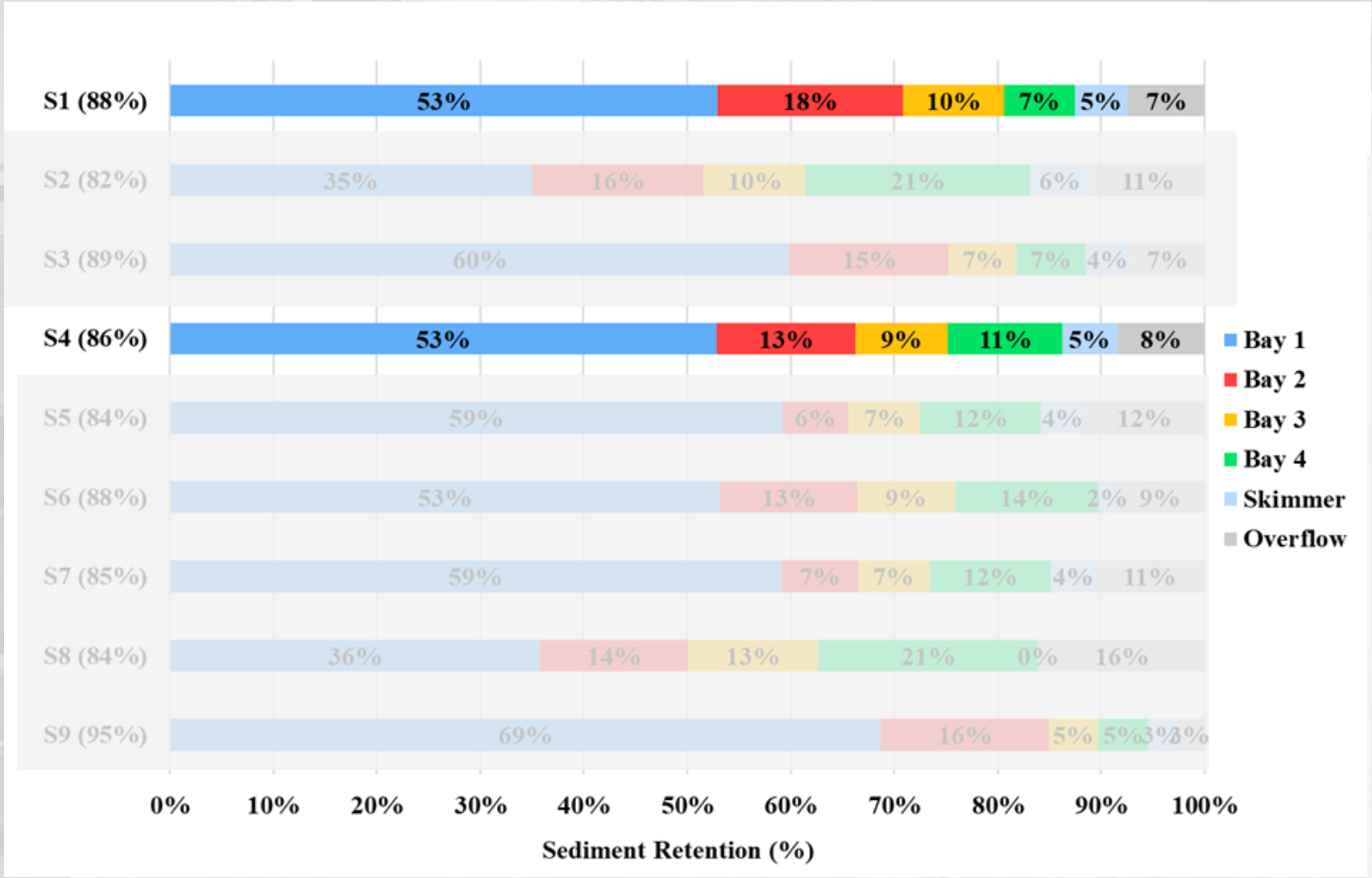


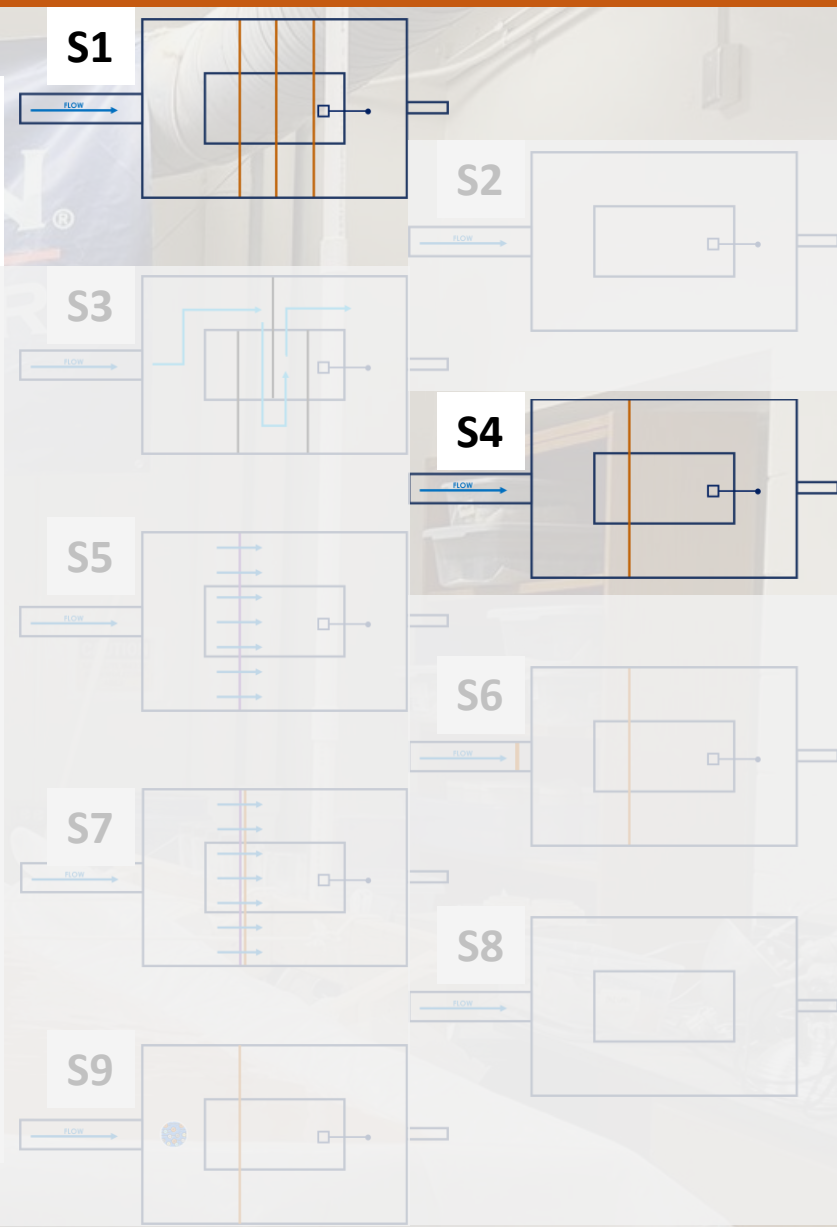

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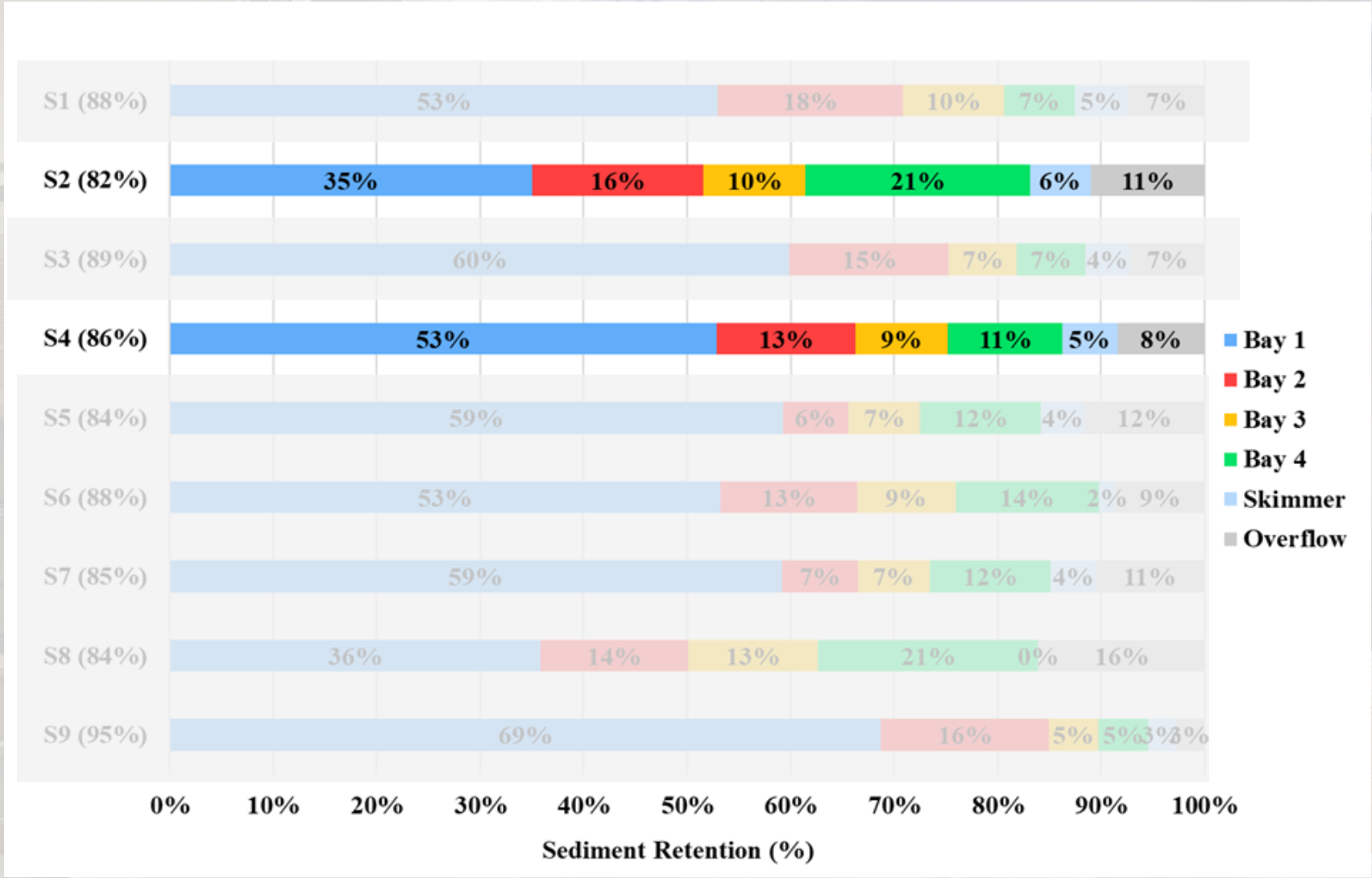


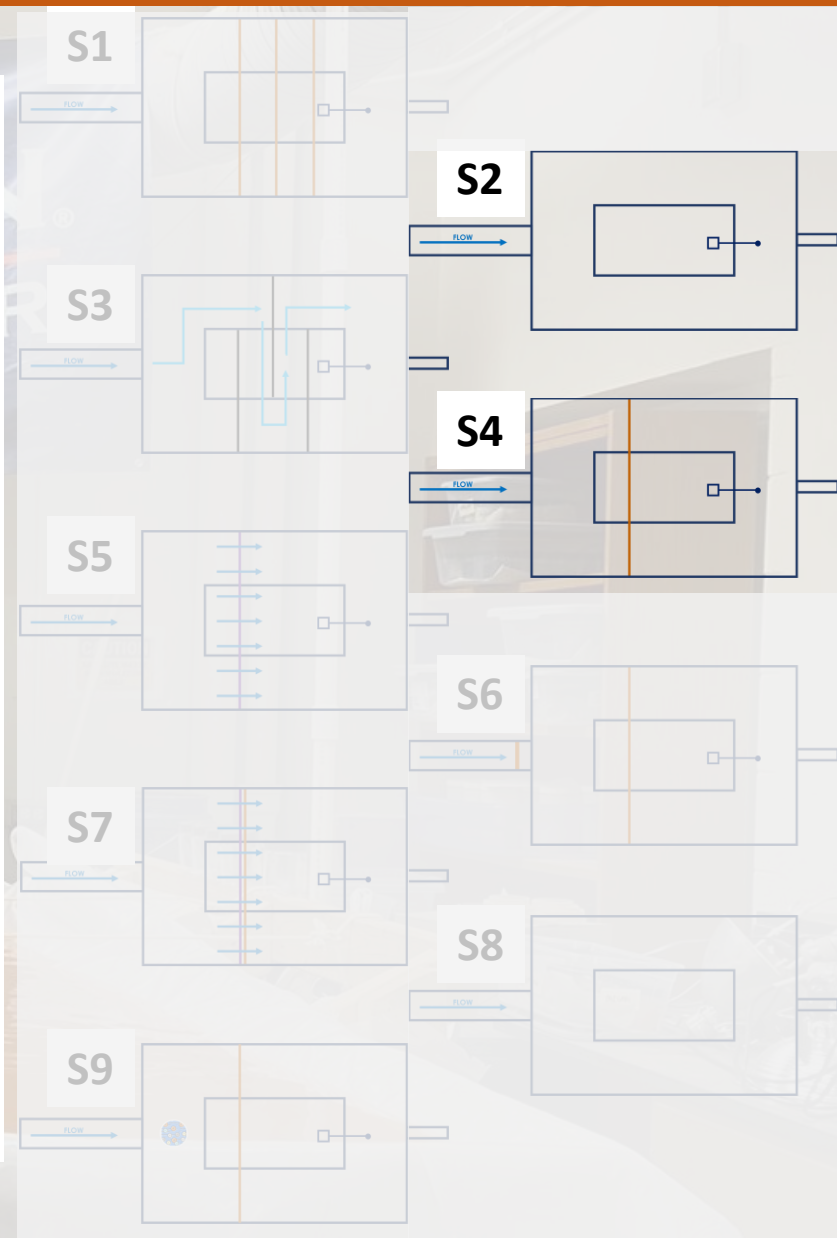

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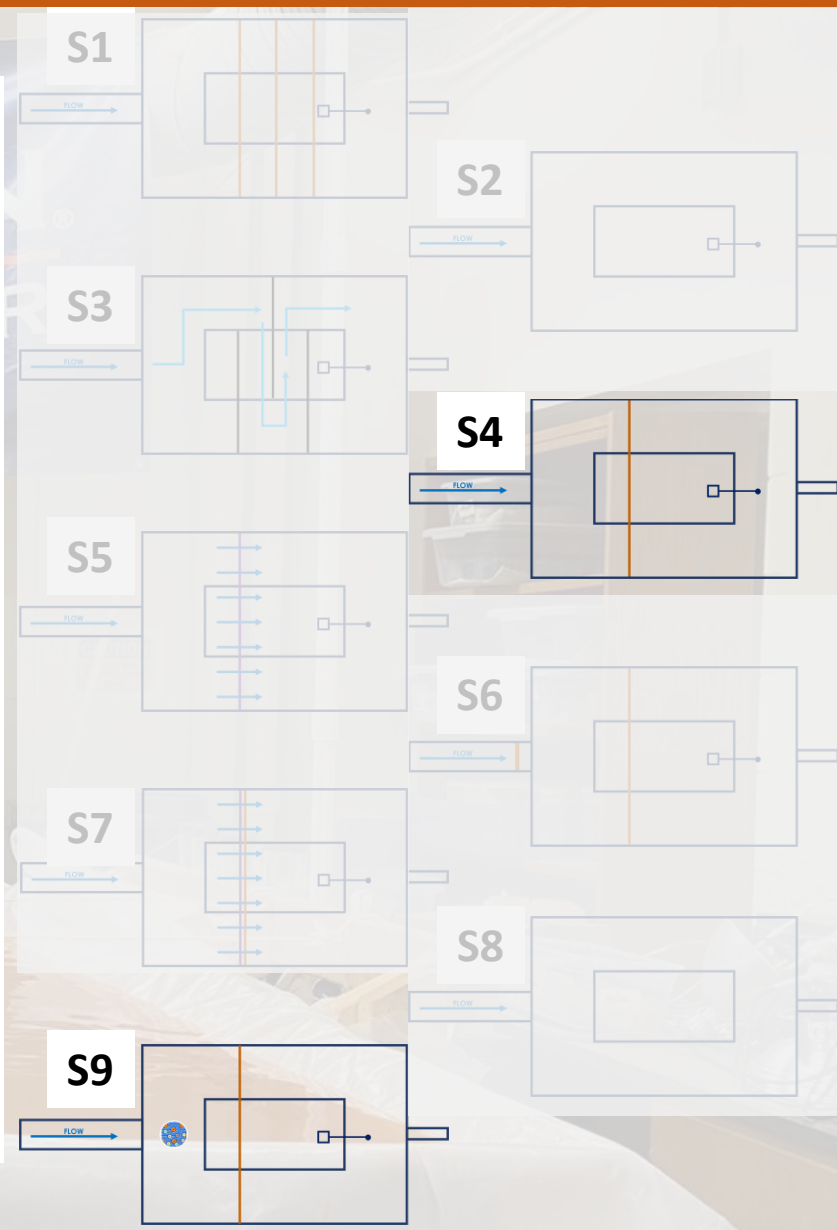
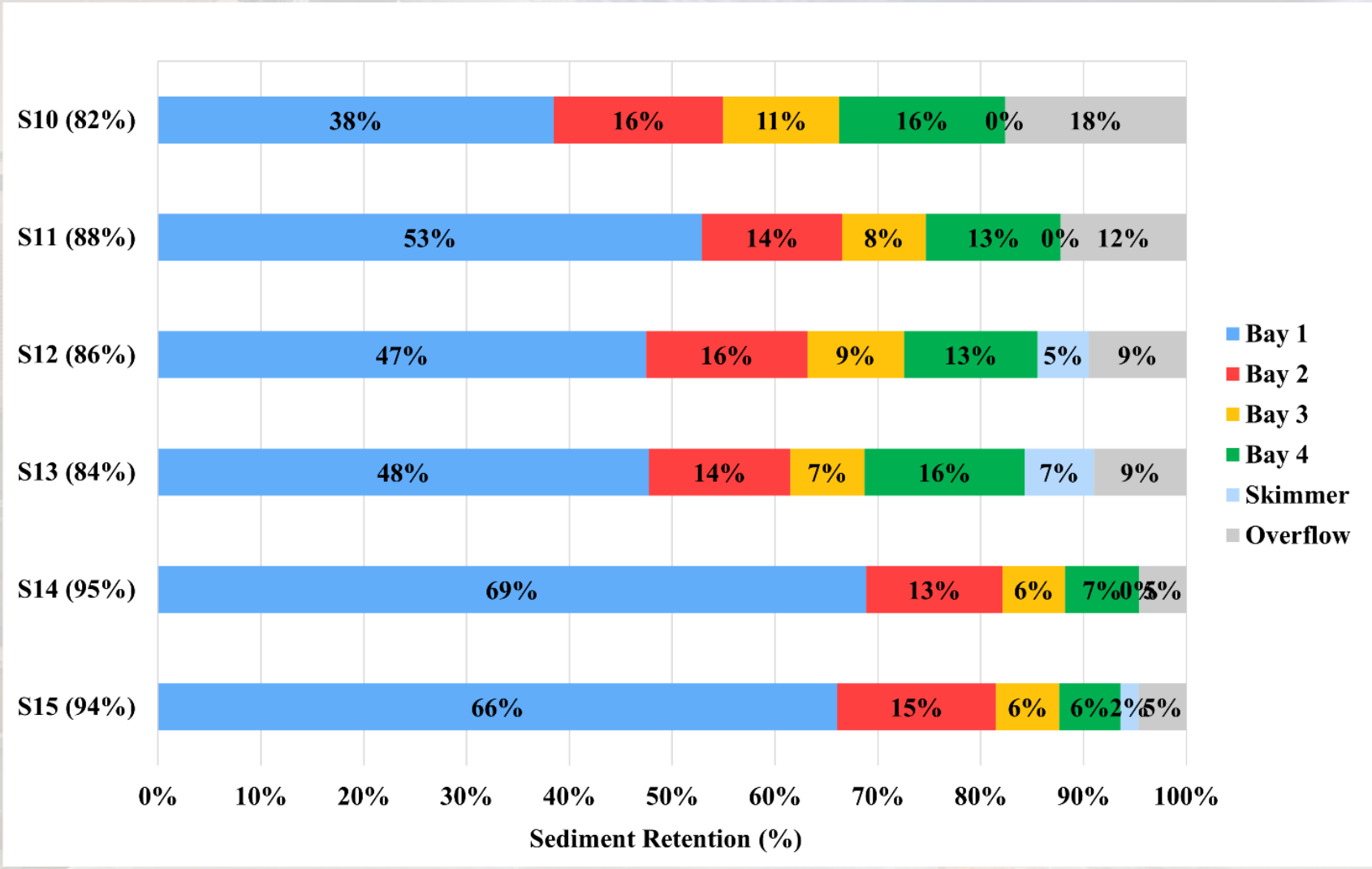
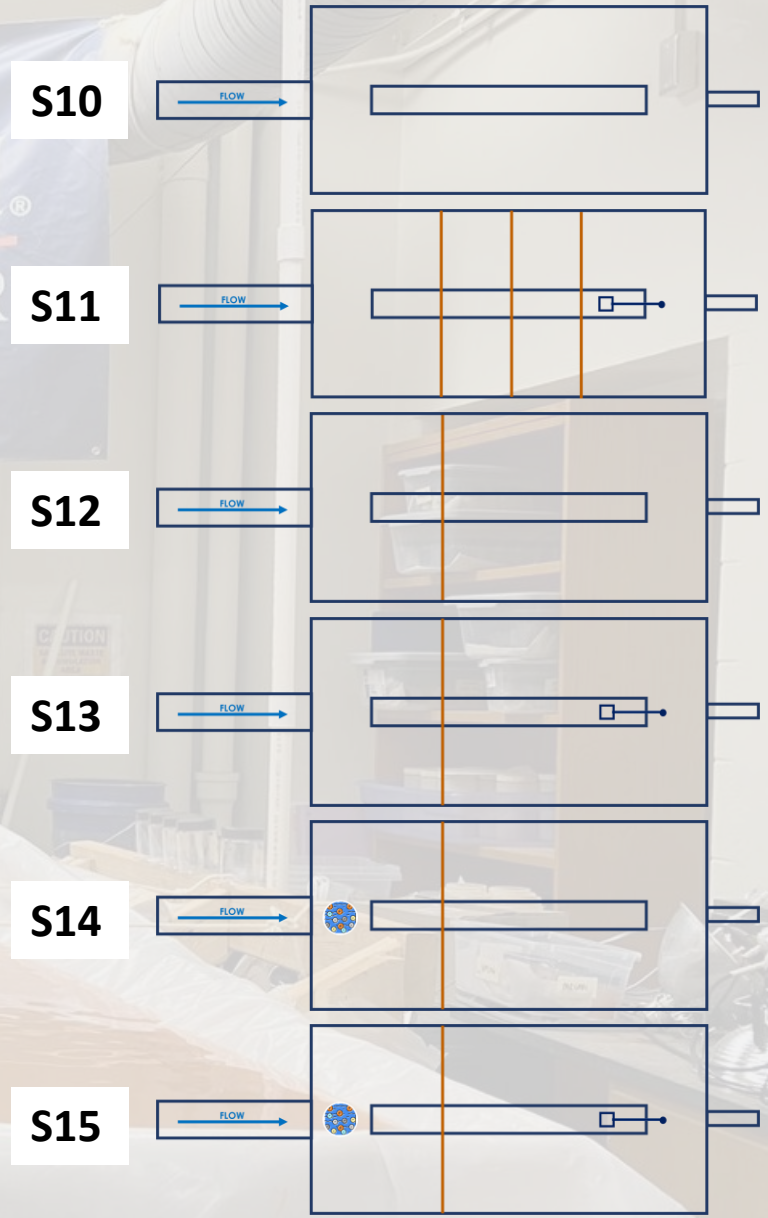
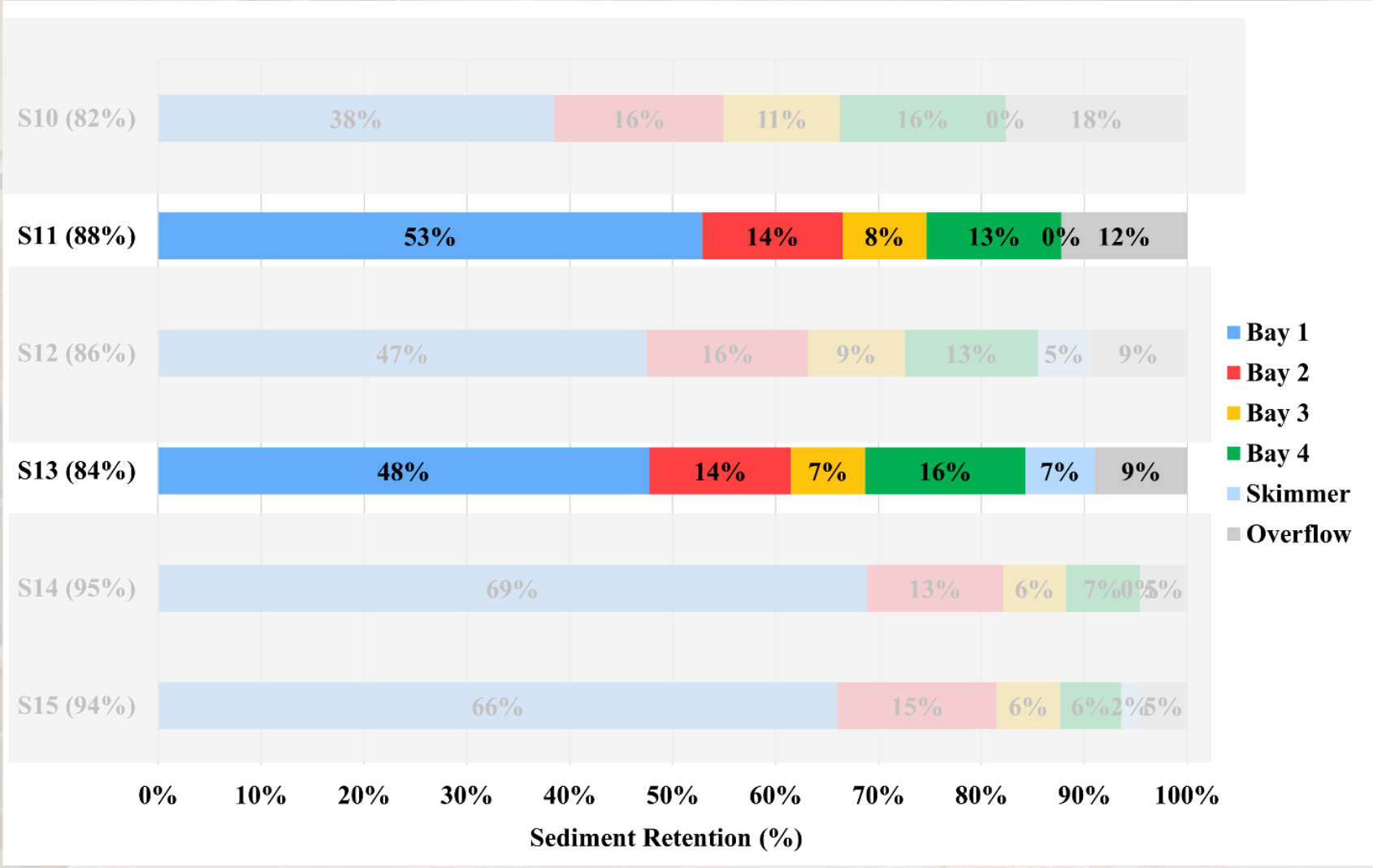


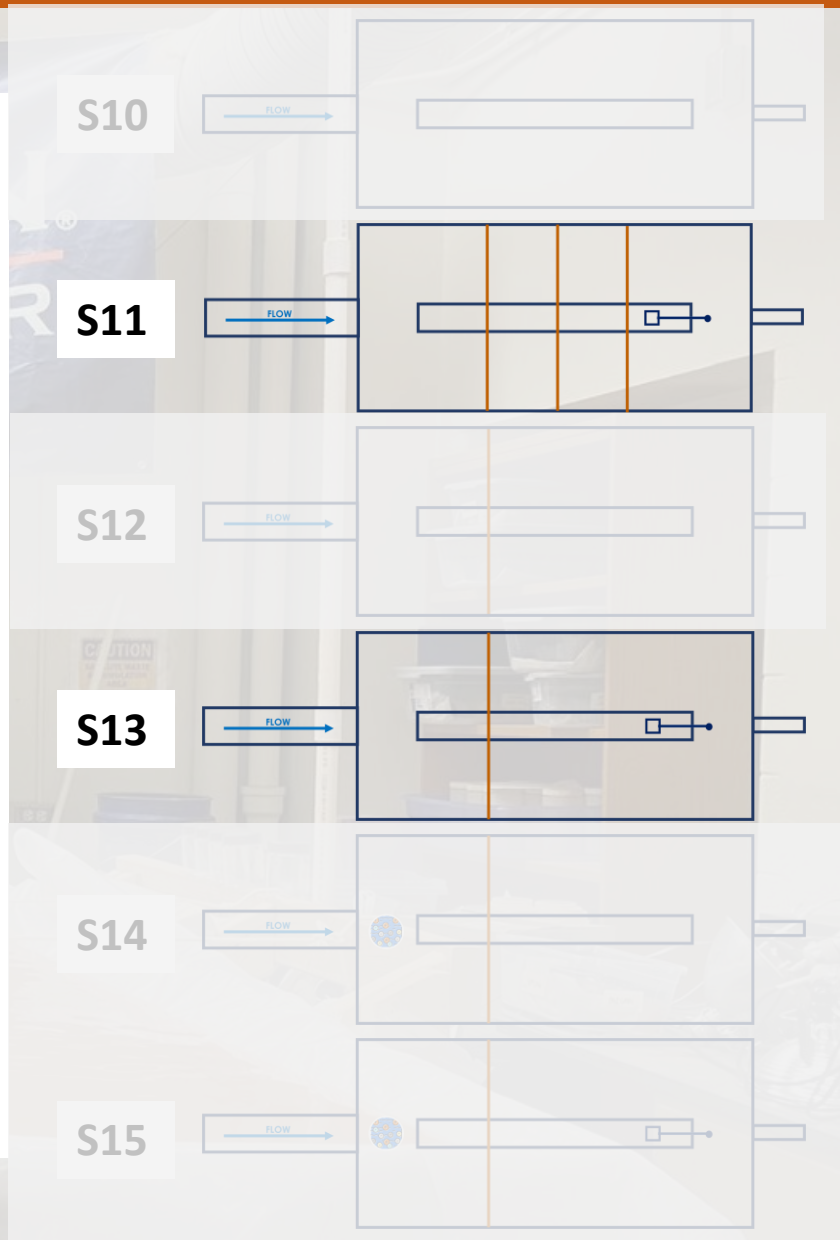
# IN-CHANNEL (10:1) SEDIMENT RETENTION



# IN-CHANNEL (10:1) SEDIMENT RETENTION



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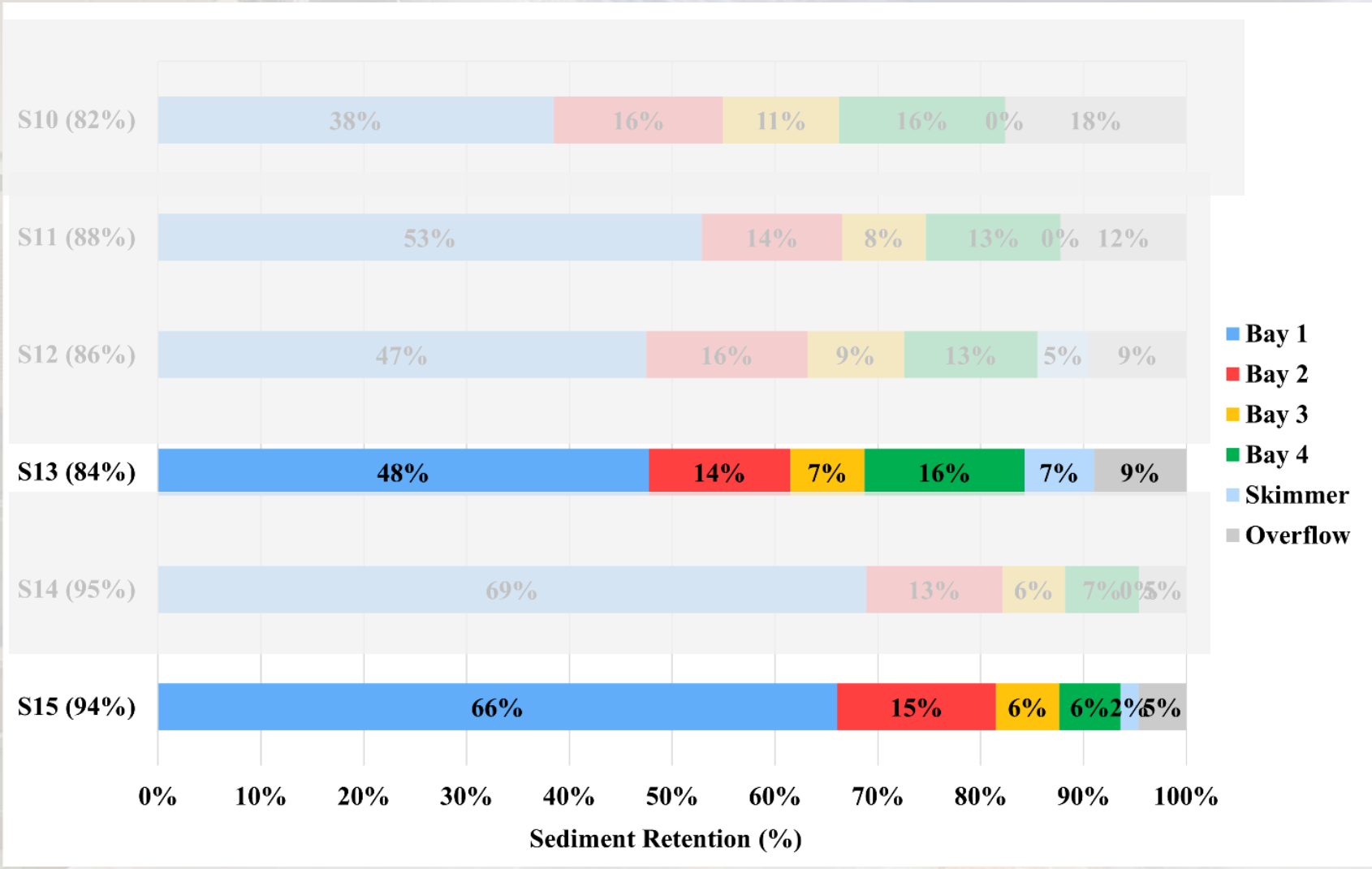
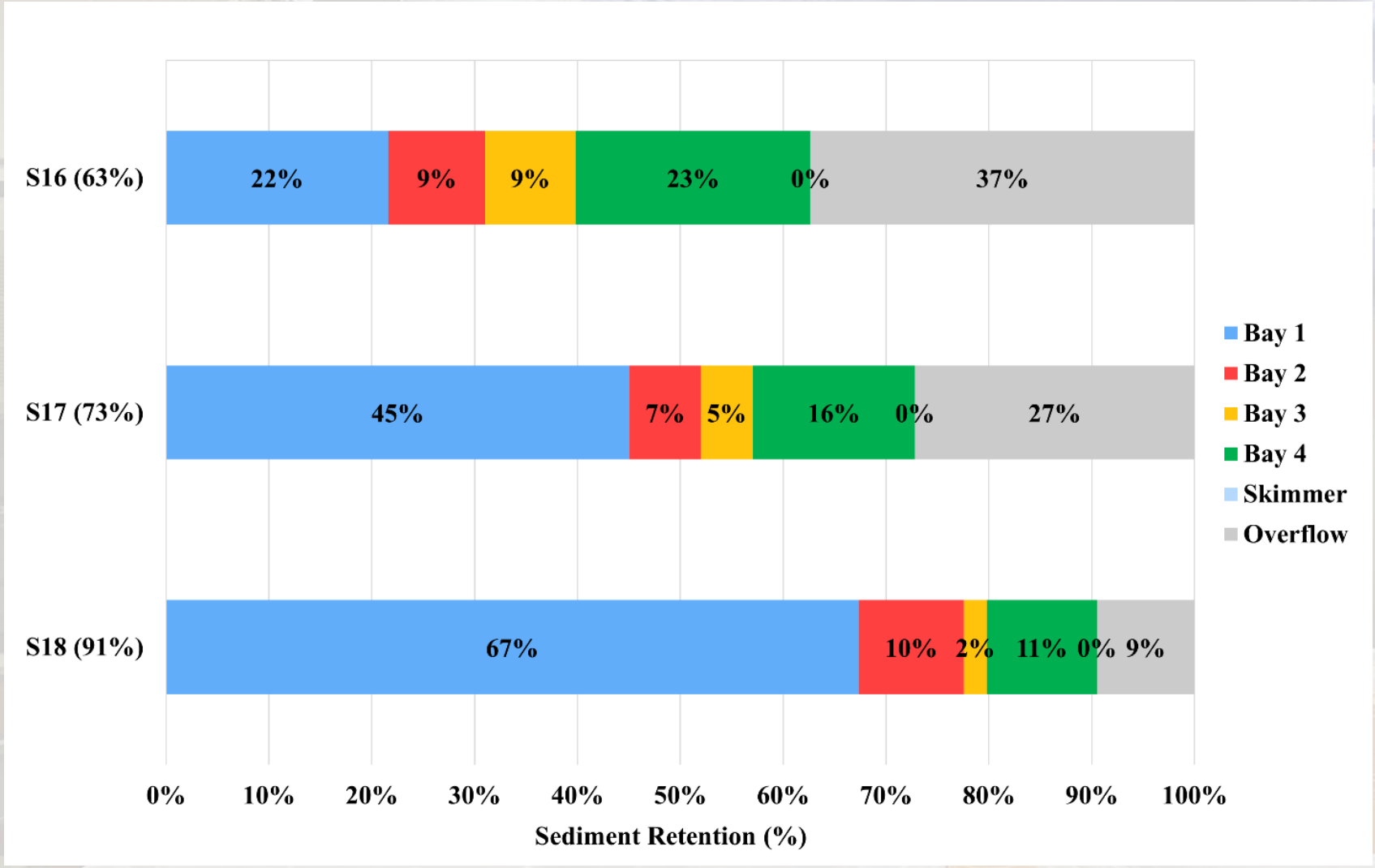
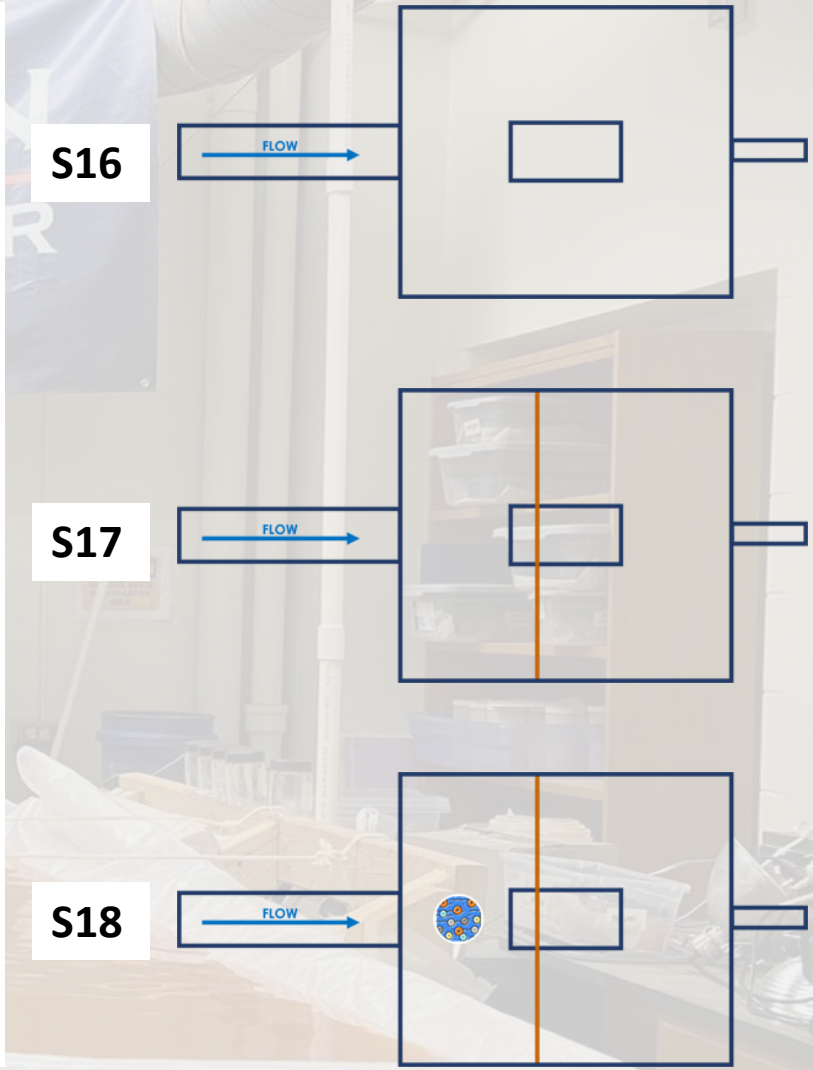
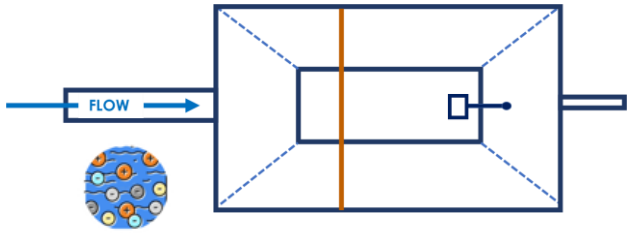
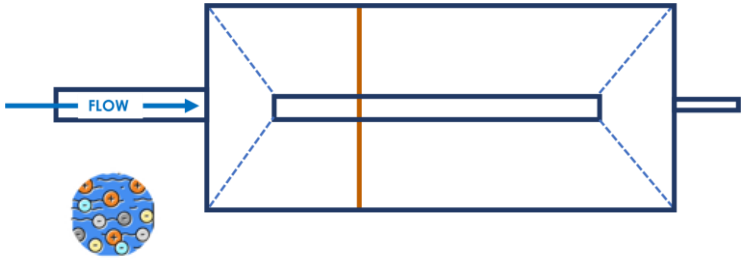
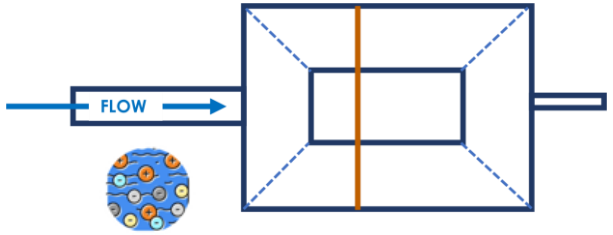



# UNDERSIZED BASIN SEDIMENT RETENTION



# FLOCCULANT TEST SERIES: SPILLWAY DISCHARGE (%)

| CONFIGURATION | DRAWING | SP TURBIDITY REDUCTION % |
|---|---|---|
| Standard [2L:1W] |   | 3%<br>8% w/o flocculant |
| In-channel [10L:1W] |   | 4%<br>9% w/o flocculant |
| Undersized [2L:1W] |   | 9%<br>27% w/o flocculant |

# UAS FOR VEGETATION ESTABLISHMENT

ALDOT
Alabama Department of Transportation


Construction General Permit Requires Regular Inspection and Maintenance of E&SC Practices
Notice of Termination relives ALDOT of I&M Obligations

# FINAL STABILIZATION

**100% of soil surface uniformly covered in permanent vegetation with density of 85% or greater**

ADEM
Alabama Department of Environmental Management

# KEY CHALLENGES

Vegetative establishment currently determined using visual assessments

There is a need to better document vegetative establishment, species coverage and density

# IMAGING METHODS

## Canon EOS Rebel


Ultra-High-Res RGB image
for ground truthing and
AI-based vegetation mapping

## Skydio 2

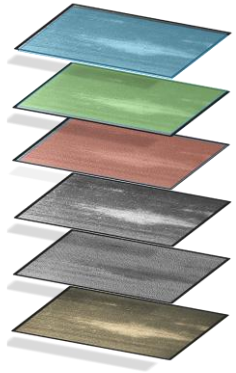
High-Res RGB image
for vegetation species mapping
at 30-foot altitude

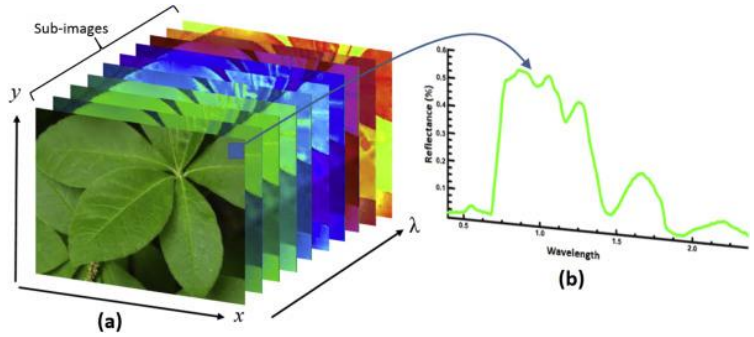
## DJI Matrice 600 Pro

## Sentera 6X

## Headwall NanoHyperSpec

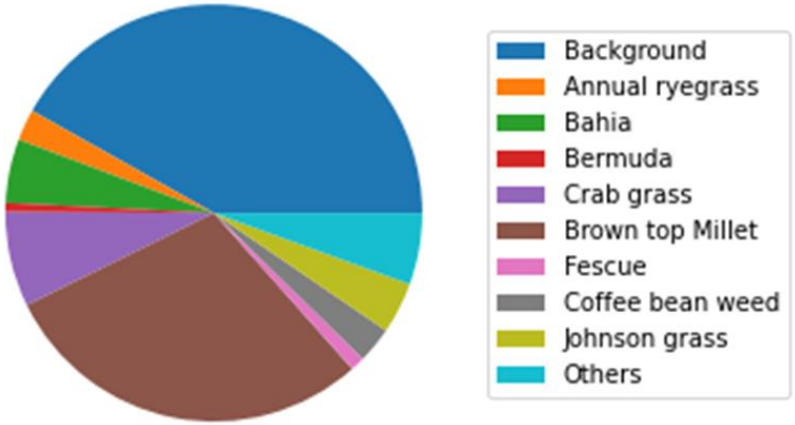

Multi/Hyperspectral image
for vegetation cover mapping
at 200-foot altitude





# IMAGE DATASET

- 9 Grass categories

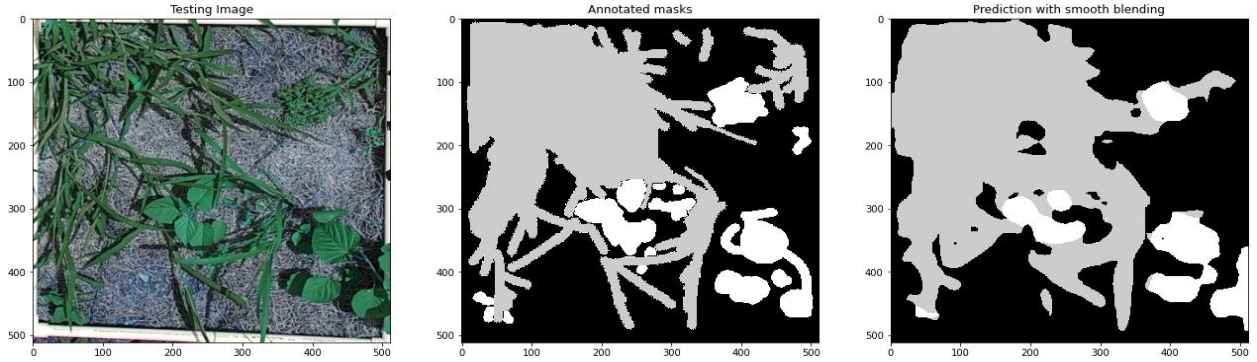



**Percentage of pixels for different grass categories**

**Original images** **Annotated images**

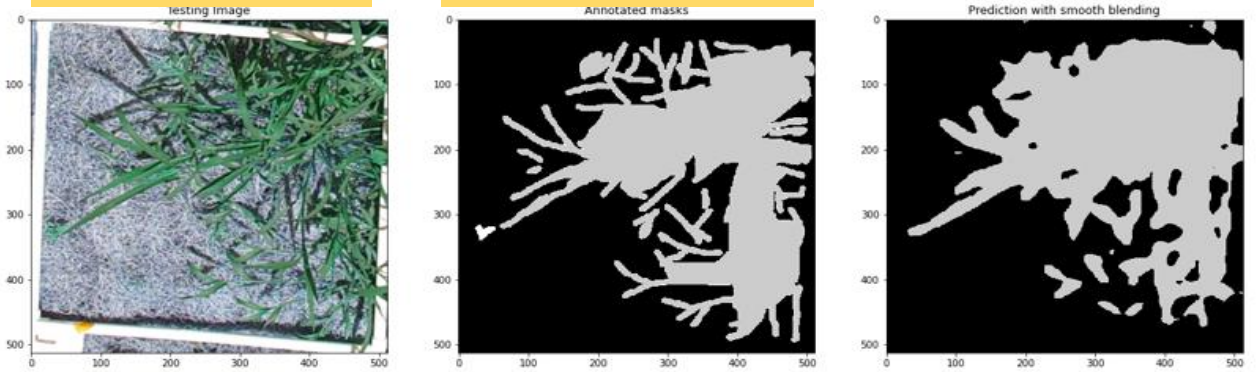
# DEEP LEARNING – VEGETATION SPECIES PREDICTION

| Original RGB Image | Labelled Ground Truth | Prediction |
|---|---|---|

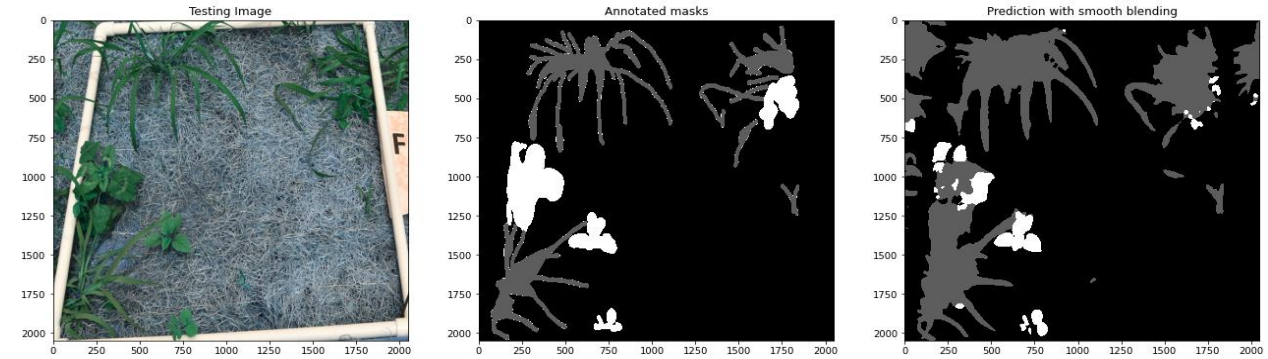



**Bahia Weeds**

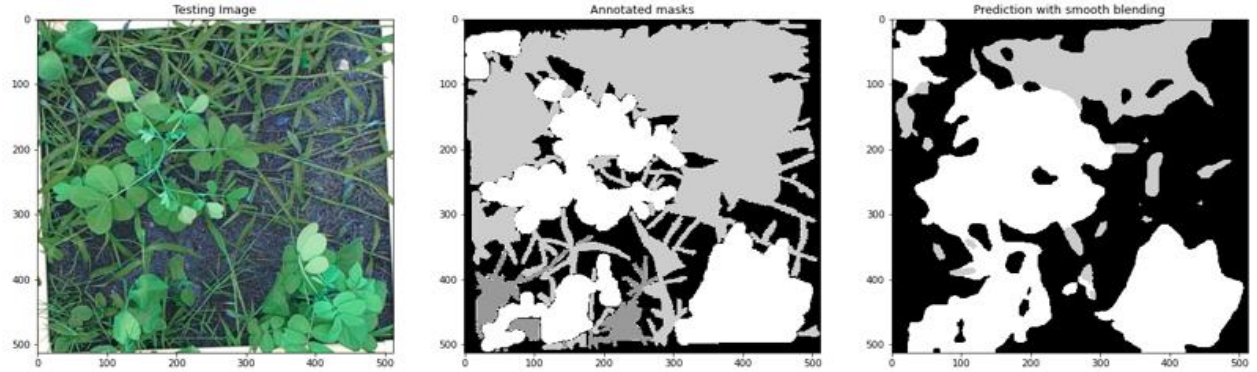
| Original RGB Image | Labelled Ground Truth | Prediction |
|---|---|---|




**Annual ryegrass**




**Bermuda Weeds**

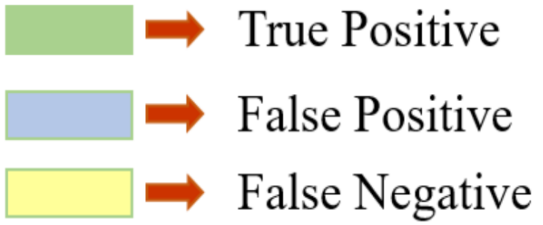



**Brown top millet**
**Coffee bean weeds**
**Weeds**

# DEEP LEARNING – VEGETATION SPECIES PREDICTION

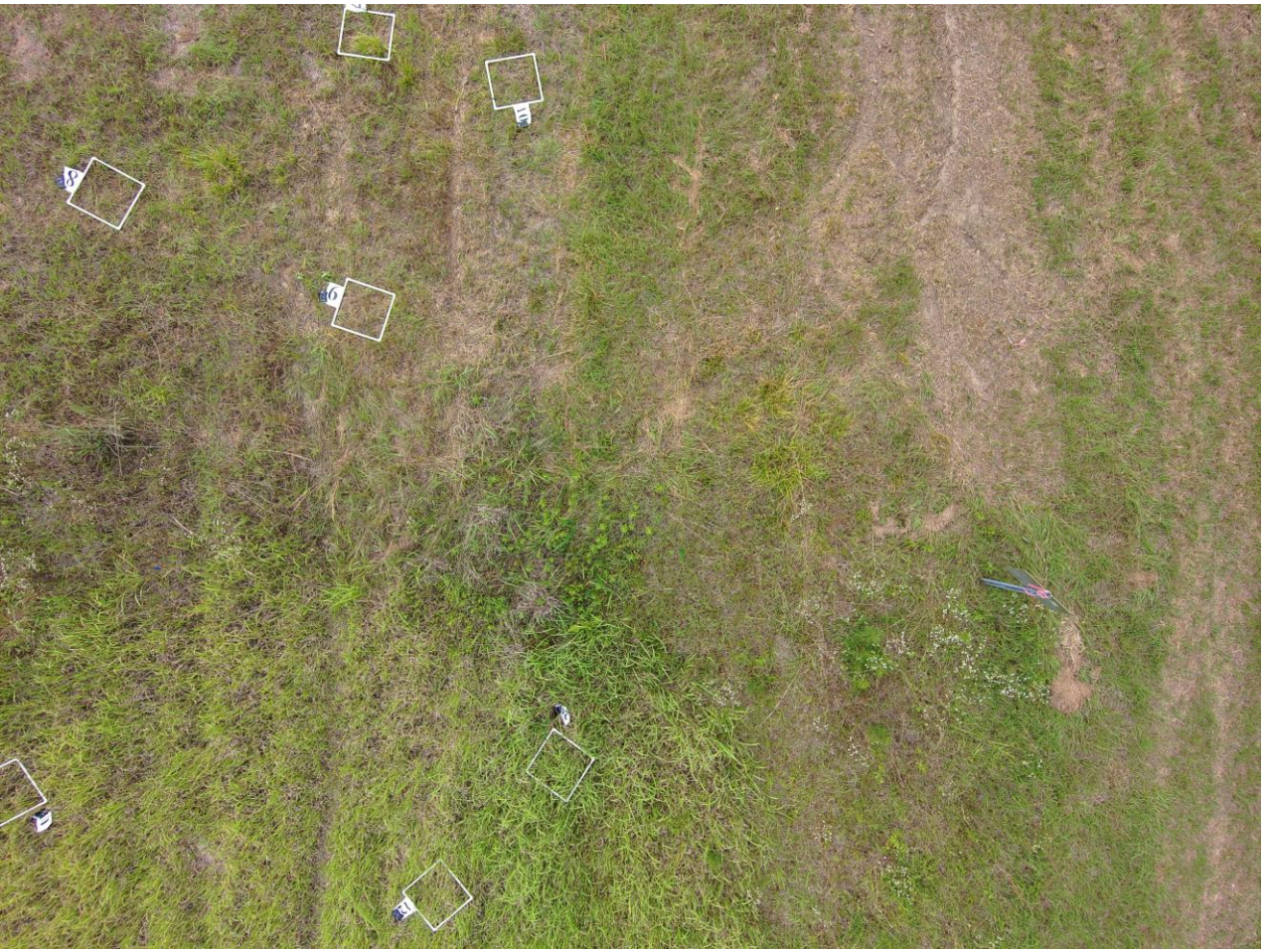
| Predicted \ Ground truth | Background | Annual ryegrass | Bahia | Bermuda | Crab grass | Brown top millet | Fescue | Coffee bean weed | Johnson grass | Other vegetation |
|---|---|---|---|---|---|---|---|---|---|---|
| Background | 0.807 | 0.021 | 0.008 | 0.079 | 0.145 | 0.065 | 0.09 | 0.059 | 0.013 | 0.163 |
| Annual ryegrass | 0.014 | 0.74 | 0 | 0.046 | 0.007 | 0 | 0 | 0 | 0 | 0.05 |
| Bahia | 0.006 | 0 | 0.917 | 0.083 | 0.001 | 0.007 | 0 | 0.005 | 0.086 | 0.006 |
| Bermuda | 0.001 | 0 | 0 | 0.399 | 0.006 | 0 | 0 | 0 | 0 | 0.001 |
| Crab grass | 0.048 | 0.037 | 0.007 | 0.241 | 0.724 | 0 | 0.015 | 0 | 0.004 | 0.035 |
| Brown top millet | 0.069 | 0.058 | 0.033 | 0.016 | 0.006 | 0.896 | 0.003 | 0.103 | 0.104 | 0.046 |
| Fescue | 0.018 | 0 | 0 | 0.064 | 0.02 | 0 | 0.841 | 0 | 0.001 | 0.002 |
| Coffee bean wee | 0.008 | 0 | 0.007 | 0.003 | 0 | 0.014 | 0 | 0.739 | 0.005 | 0.043 |
| Johnson grass | 0.009 | 0.124 | 0.011 | 0.008 | 0.062 | 0.006 | 0.05 | 0.03 | 0.78 | 0.03 |
| Other vegetation | 0.02 | 0.02 | 0.017 | 0.061 | 0.029 | 0.011 | 0.001 | 0.064 | 0.008 | 0.624 |

- **False negative (Yellow columns) – Actual other grass species but predicted as Johnson grass by our model.**
- **Blue columns – Actual other grass species but predicted as Johnson grass by our model**
- **Confusion matrix generated for InceptionResNetV2 architecture on the test dataset.**
- **Mean Intersection over union (mIOU) score achieved – 0.772**



# 2023 ALDOT SITES IMAGERY

## Montgomery on June 9



Sample images from Skydio 2

# Guidance for using Flocculants on Construction Sites

AUBURN UNIVERSITY HIGHWAY RESEARCH CENTER

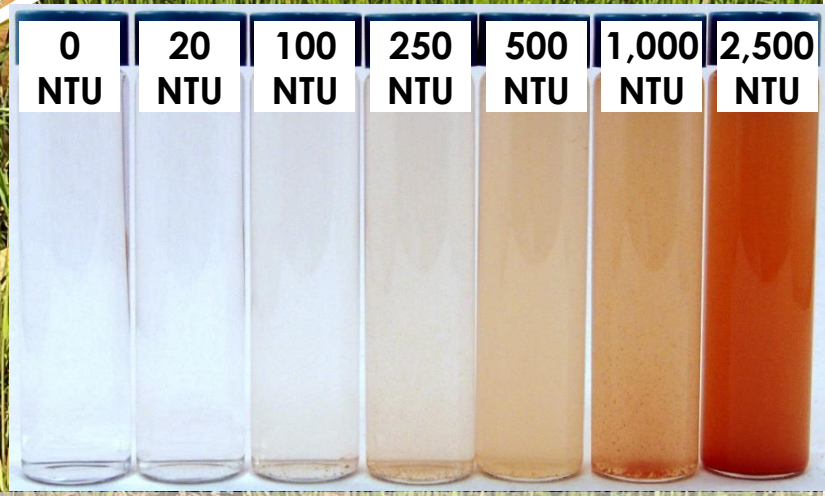
AUBURN UNIVERSITY

ALABAMA DEPARTMENT OF TRANSPORTATION

# E&SC Practices - Regulations

**Silts and clays are difficult to capture.**
**What can be done?**

**ADEM: Restriction of <u>50 NTU increase</u> to receiving waterbodies**

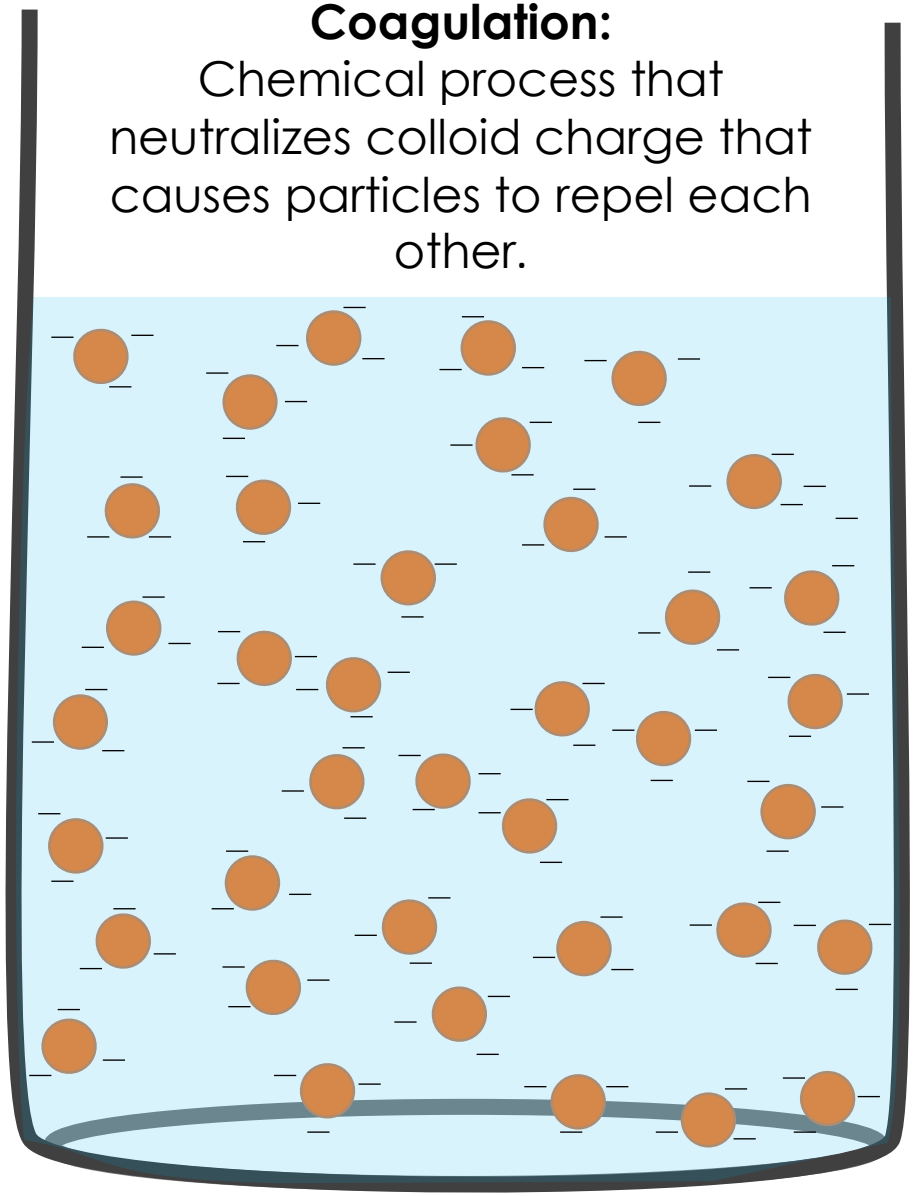



**FLOCCULANTS**

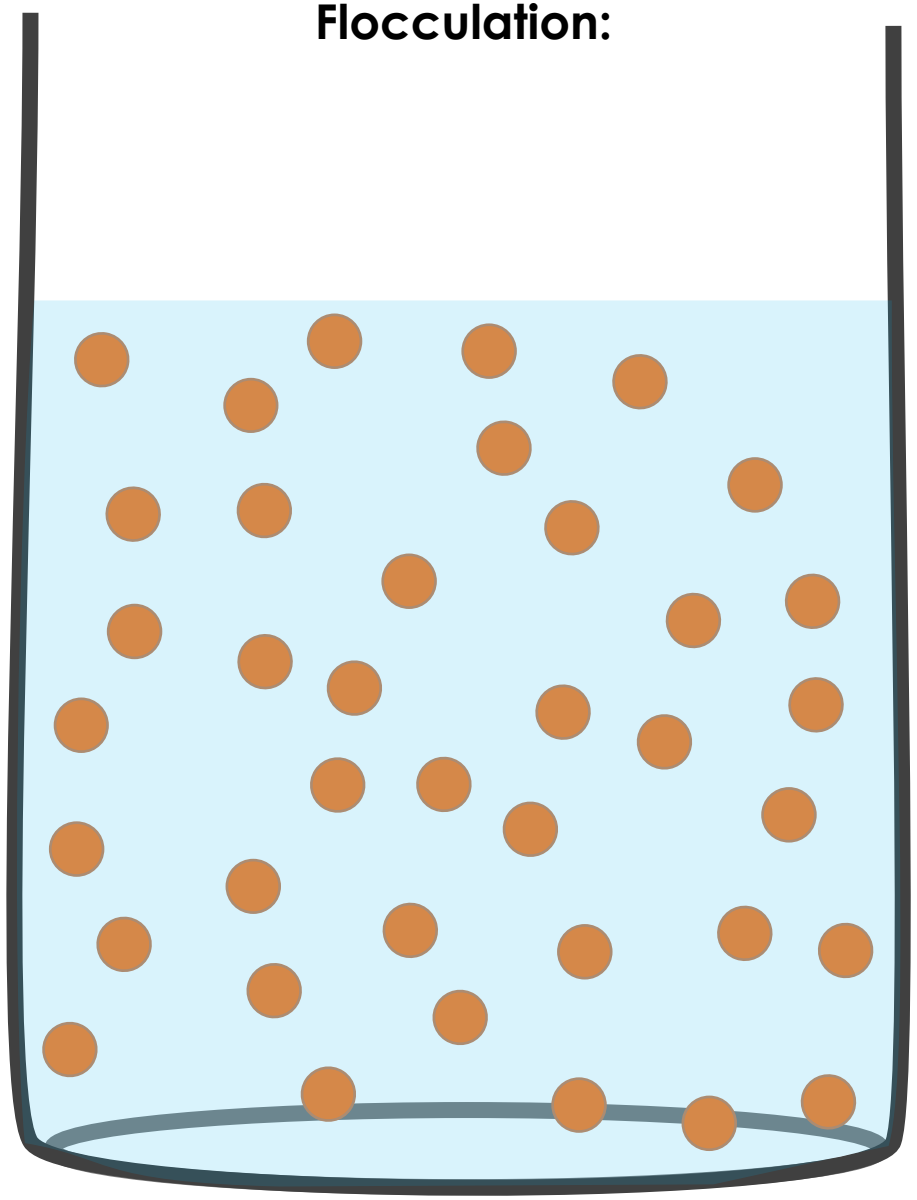
**<u>Turbidity</u>** is the **cloudiness or haziness** of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye.

# What Are Flocculants?

**Coagulation:**
Chemical process that neutralizes colloid charge that causes particles to repel each other.



**Flocculation:**



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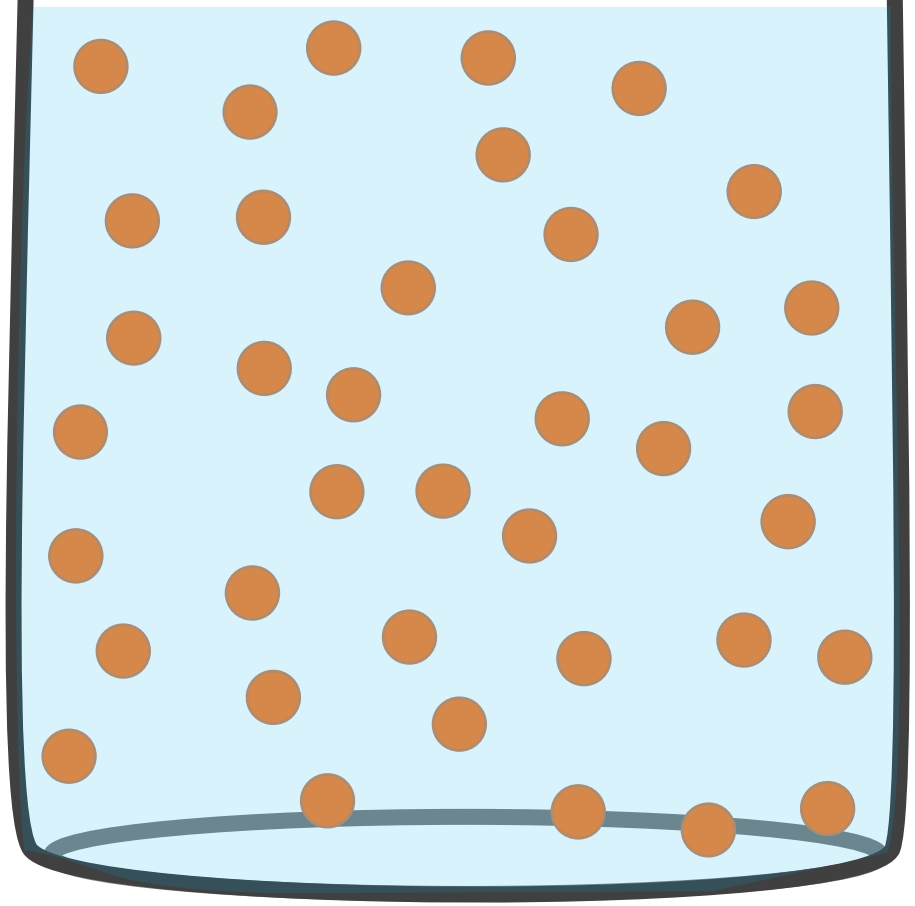
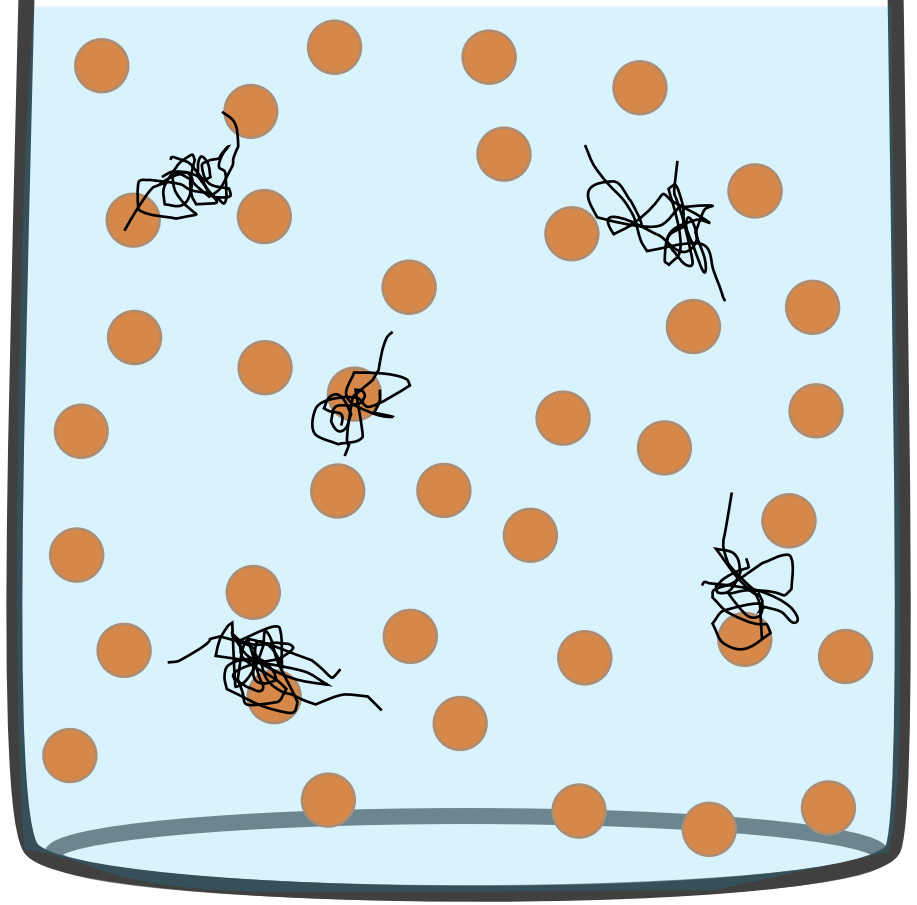


**Flocculation:**
Physical process that adheres neutral particles together to form larger flocs that can settle out of suspension.



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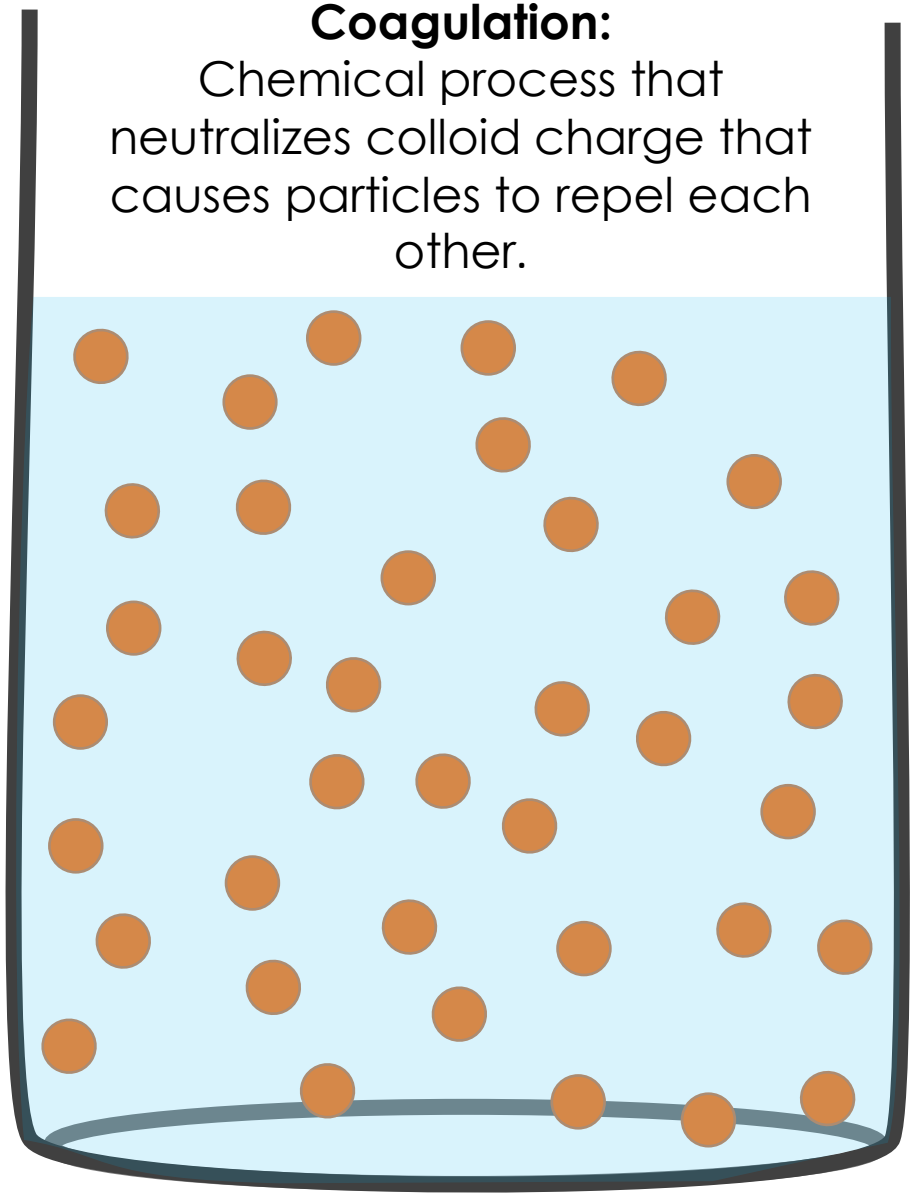

**Facilitate coagulation and flocculation**

**Increases sedimentation rate**

**Decreases detention time**

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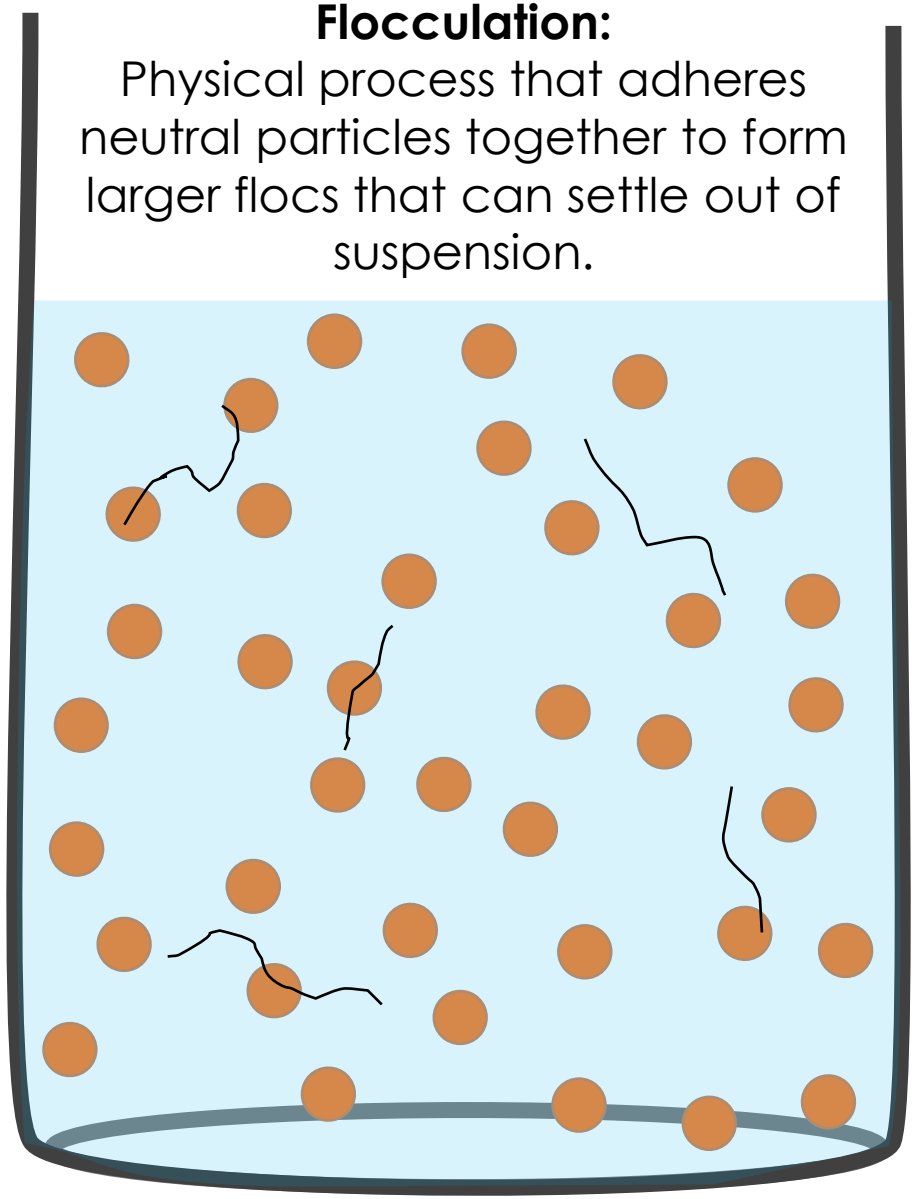

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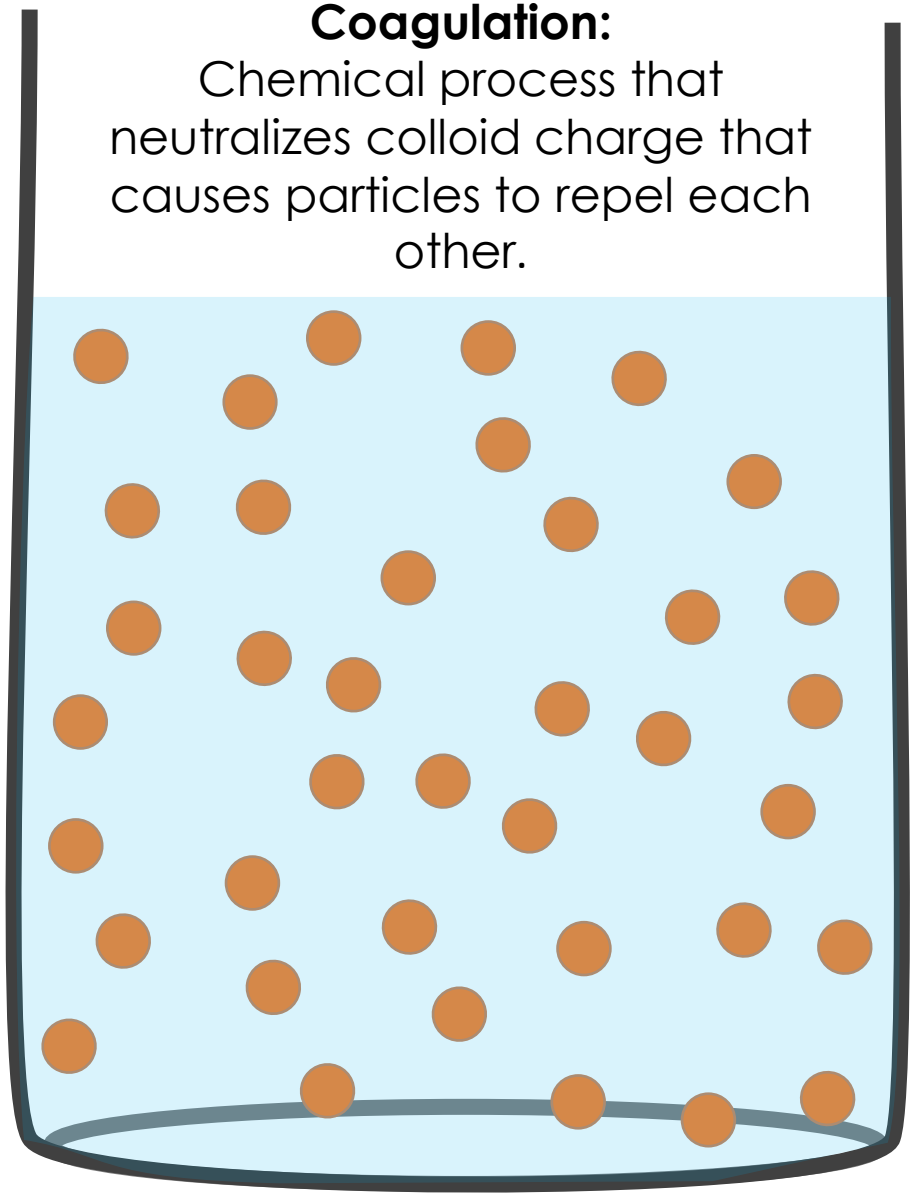

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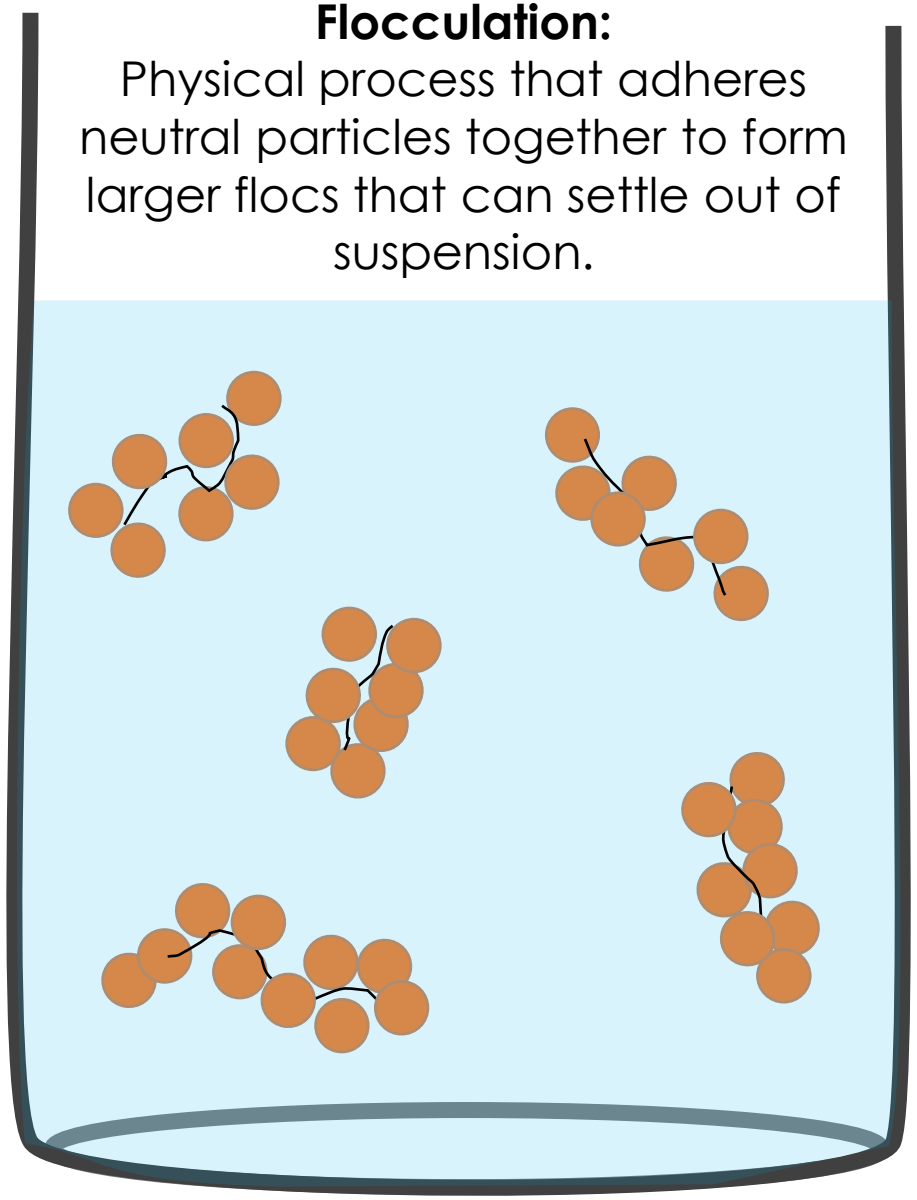
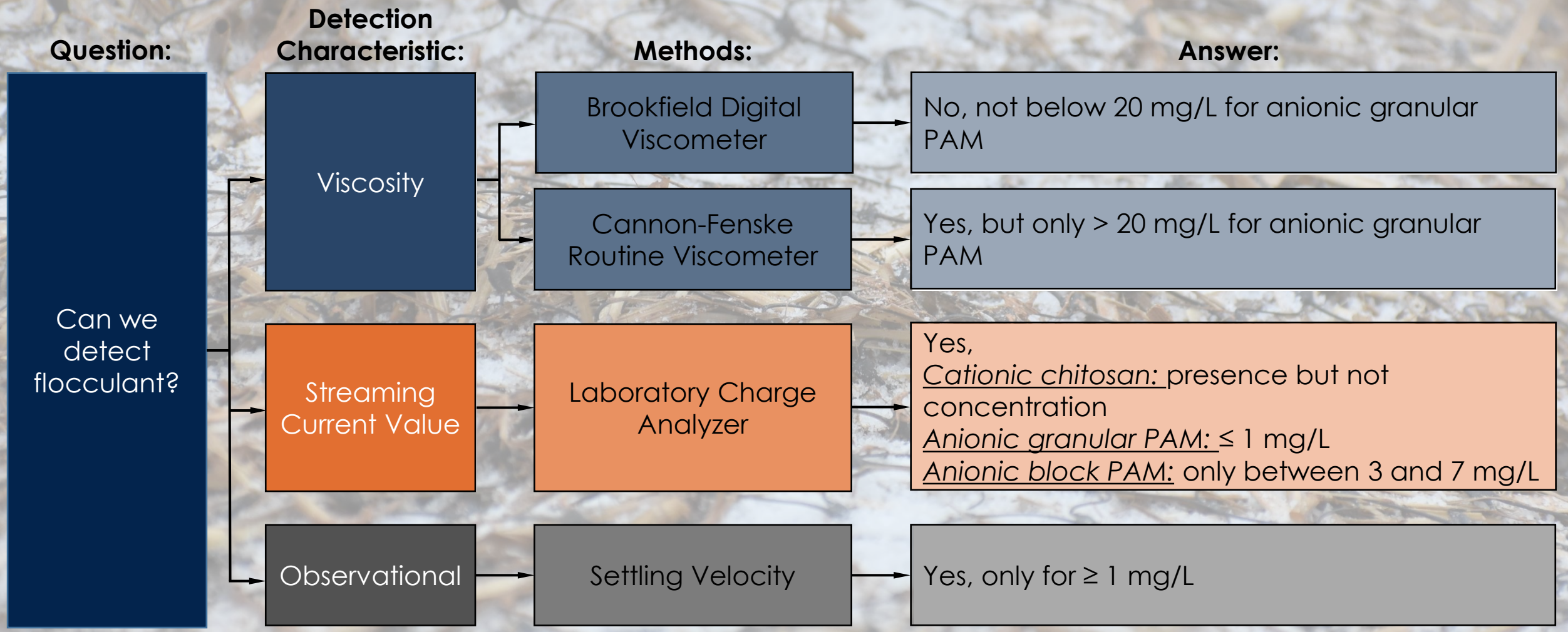


# Flocculant detection



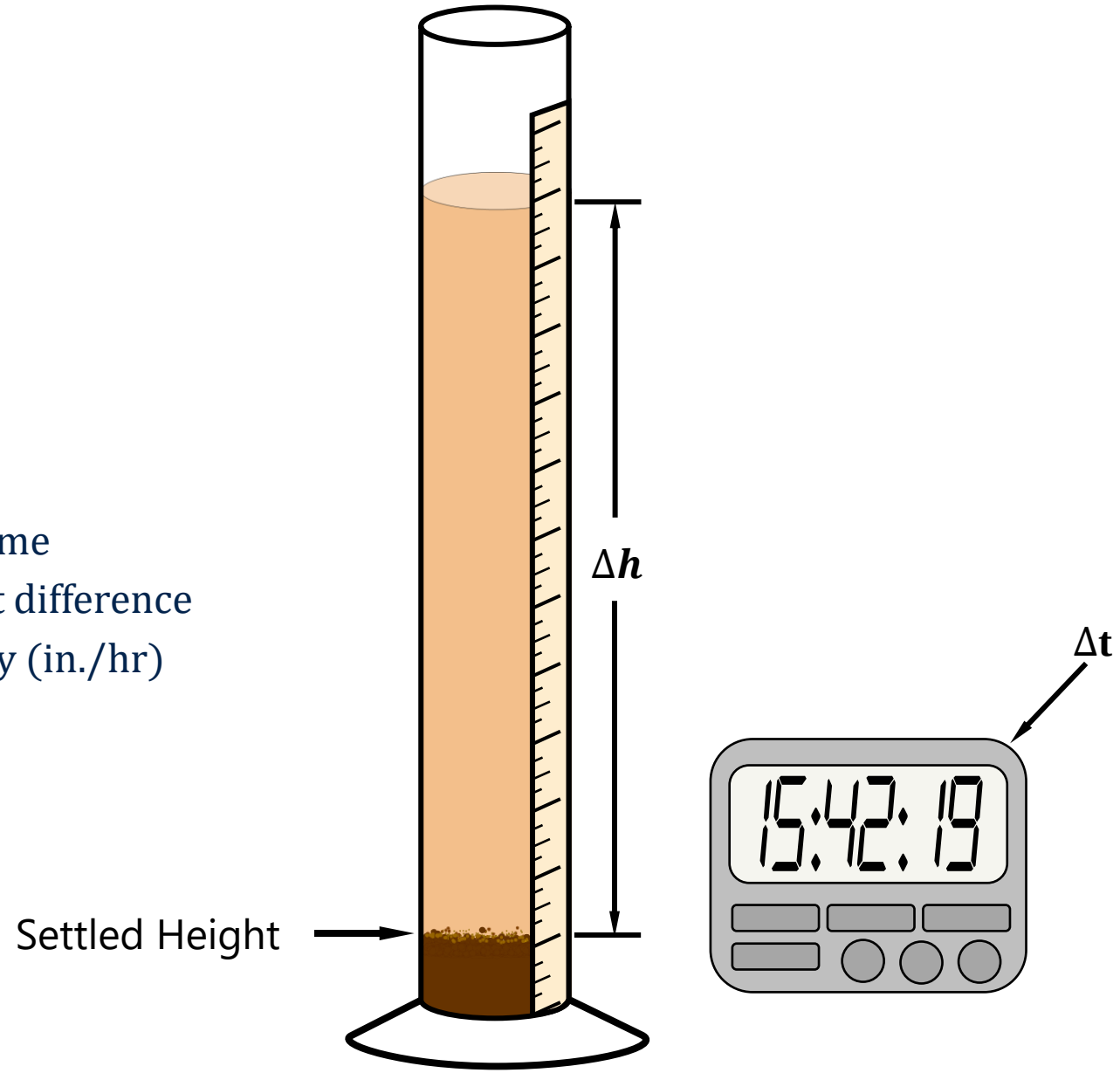
# Detection Method – Settling Velocity

$$v = \frac{\Delta h}{\Delta t}$$

$\Delta t$ = total settling time

$\Delta h$ = gradient height difference

$v$ = settling velocity (in./hr)



# Physical Forms of Flocculants

**Crystalline Powder/Granular**

**Emulsion/Aqueous/Liquid**

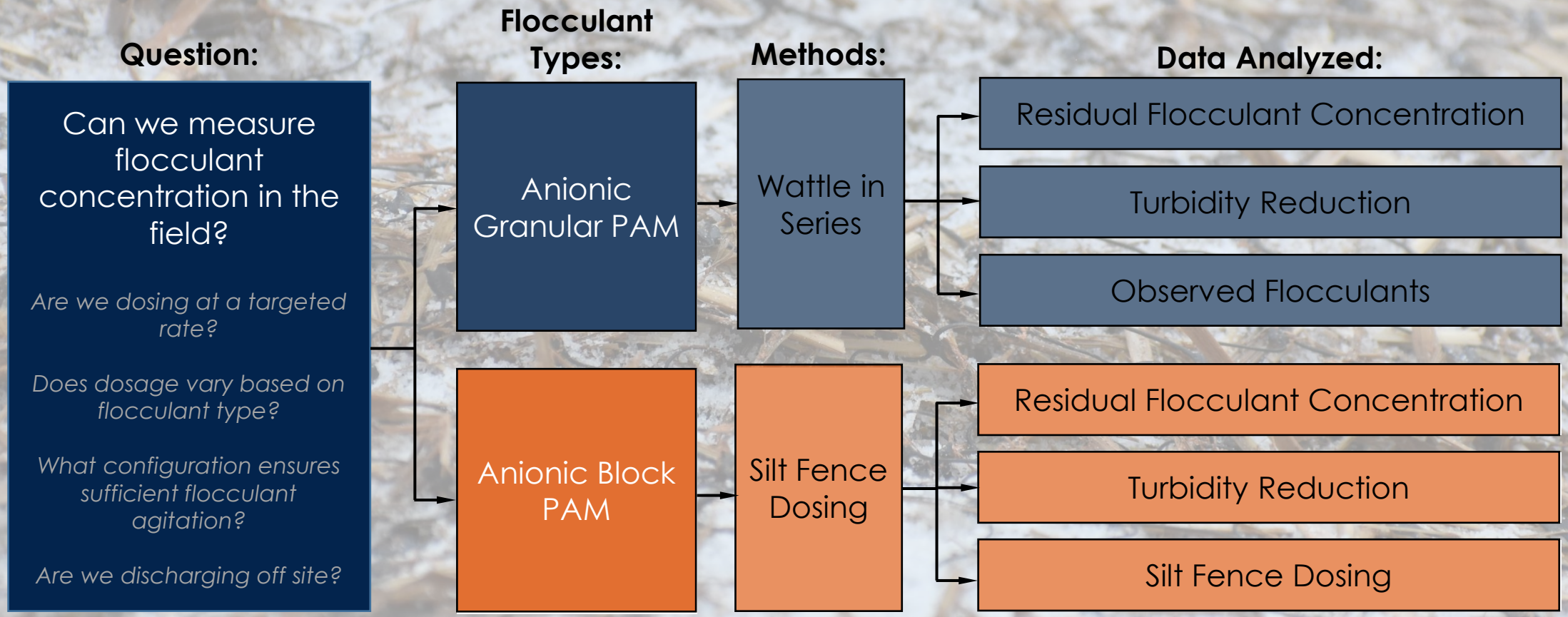


**Block/Log**


*Slide credit: Mike Perez*

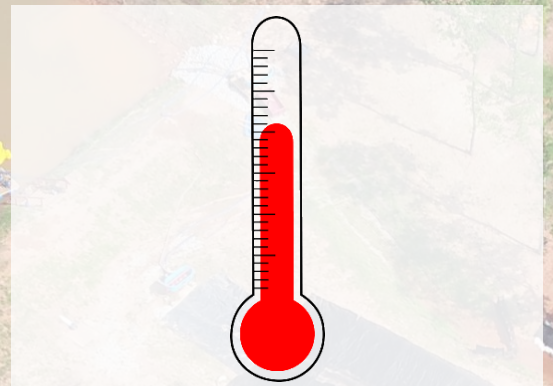
# Common Challenges

# Large-Scale Testing



# Influencing Conditions


pH



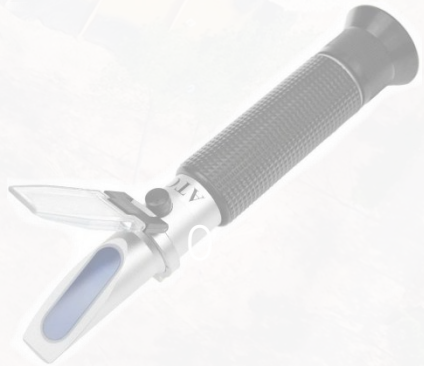
Temperature

Processing Time After Collection


Multi-Use Plastic Containers

Soil Type

Metal Salts



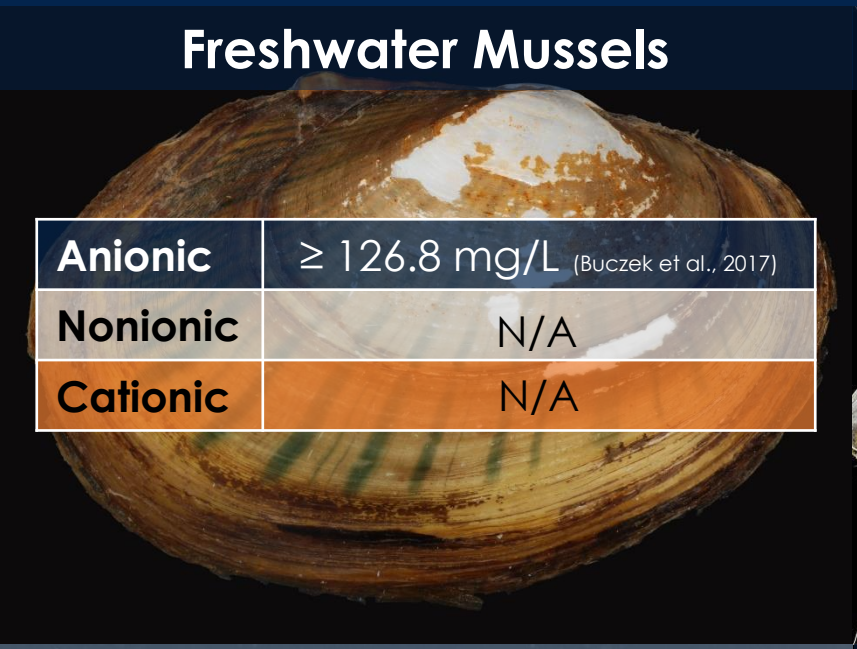
Salinity



Temperature Change

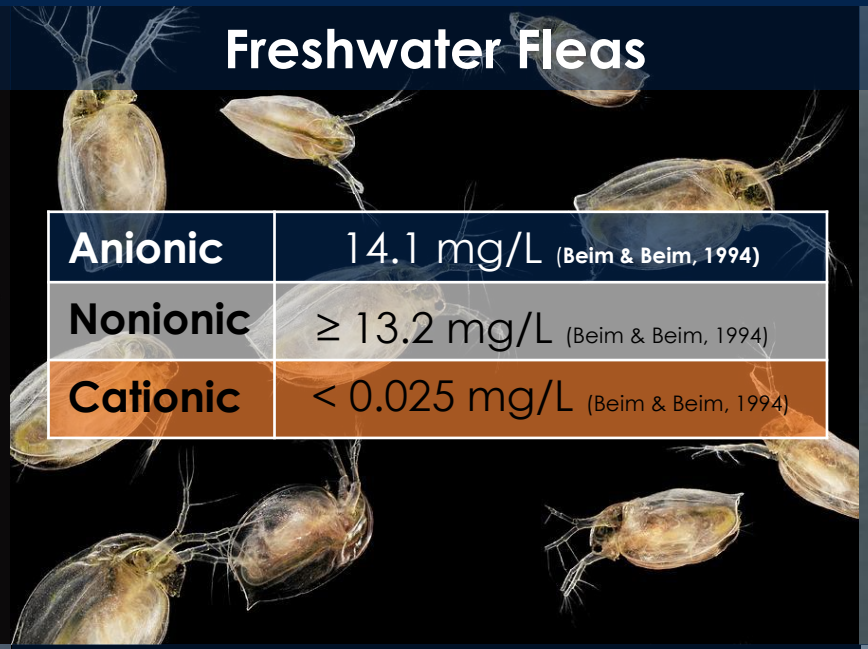
# PAM Lethal Concentration

## Freshwater Mussels



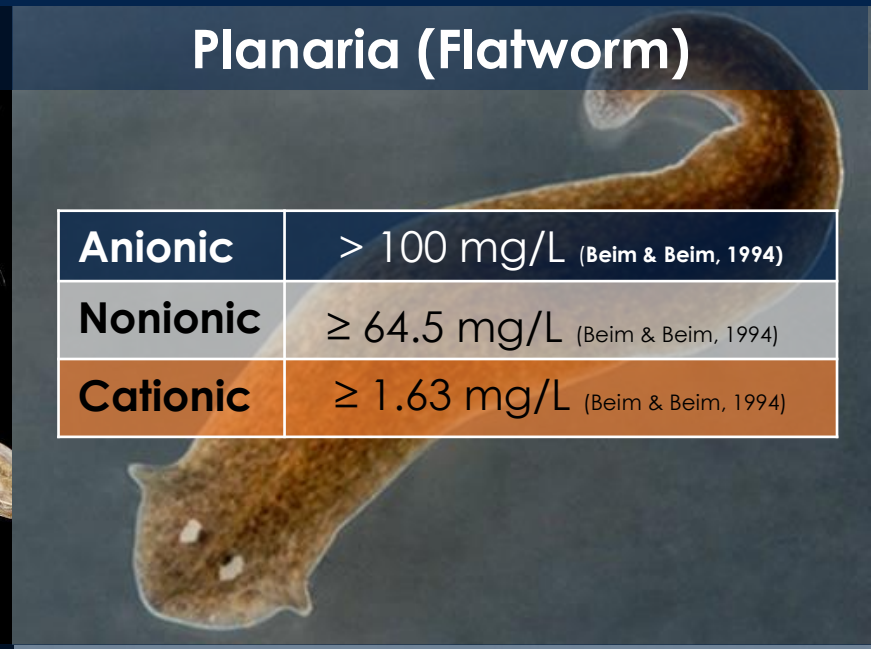
| | |
|---|---|
| **Anionic** | ≥ 126.8 mg/L (Buczek et al., 2017) |
| **Nonionic** | N/A |
| **Cationic** | N/A |

## Freshwater Fleas



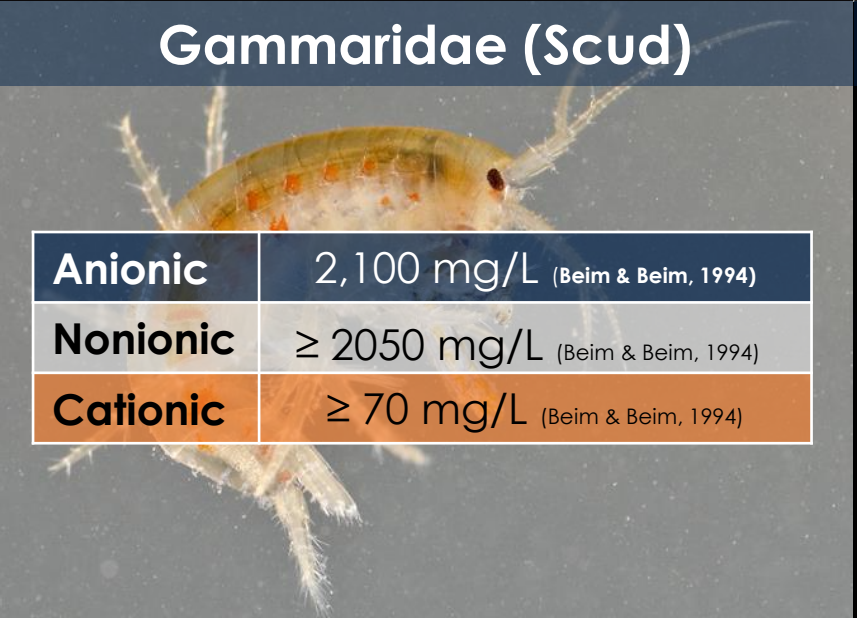
| | |
|---|---|
| **Anionic** | 14.1 mg/L **(Beim & Beim, 1994)** |
| **Nonionic** | ≥ 13.2 mg/L (Beim & Beim, 1994) |
| **Cationic** | < 0.025 mg/L (Beim & Beim, 1994) |

## Planaria (Flatworm)



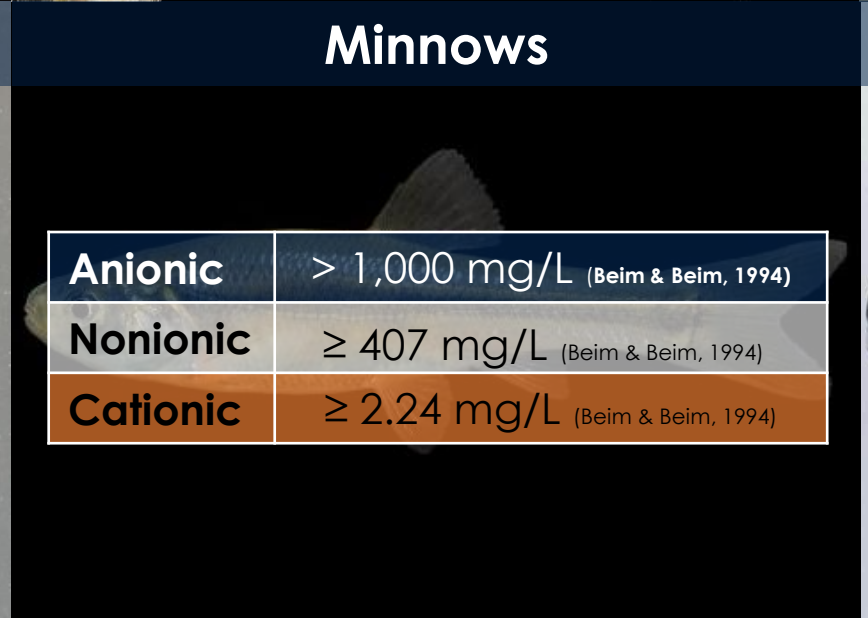
| | |
|---|---|
| **Anionic** | > 100 mg/L **(Beim & Beim, 1994)** |
| **Nonionic** | ≥ 64.5 mg/L (Beim & Beim, 1994) |
| **Cationic** | ≥ 1.63 mg/L (Beim & Beim, 1994) |

## Gammaridae (Scud)



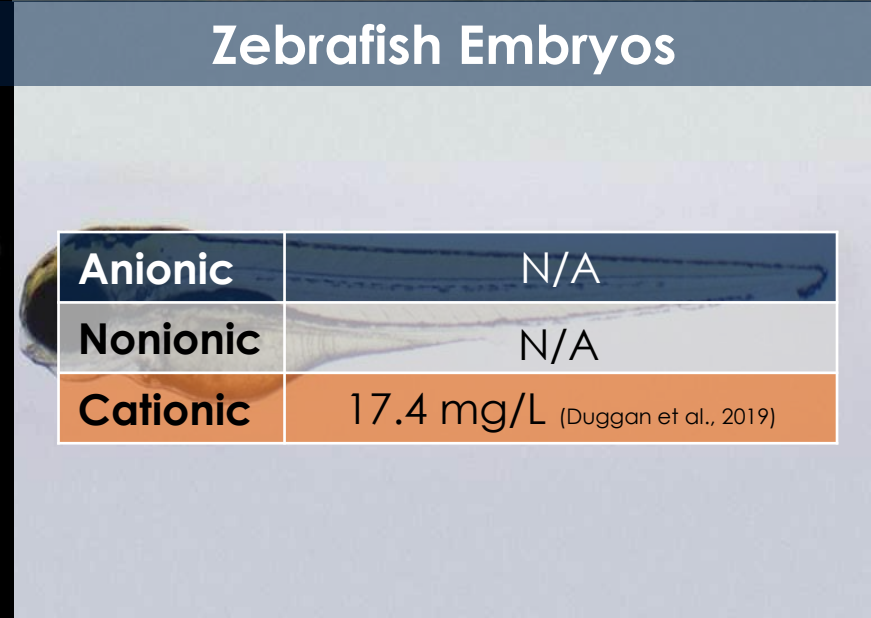
| | |
|---|---|
| **Anionic** | 2,100 mg/L **(Beim & Beim, 1994)** |
| **Nonionic** | ≥ 2050 mg/L (Beim & Beim, 1994) |
| **Cationic** | ≥ 70 mg/L (Beim & Beim, 1994) |

## Minnows



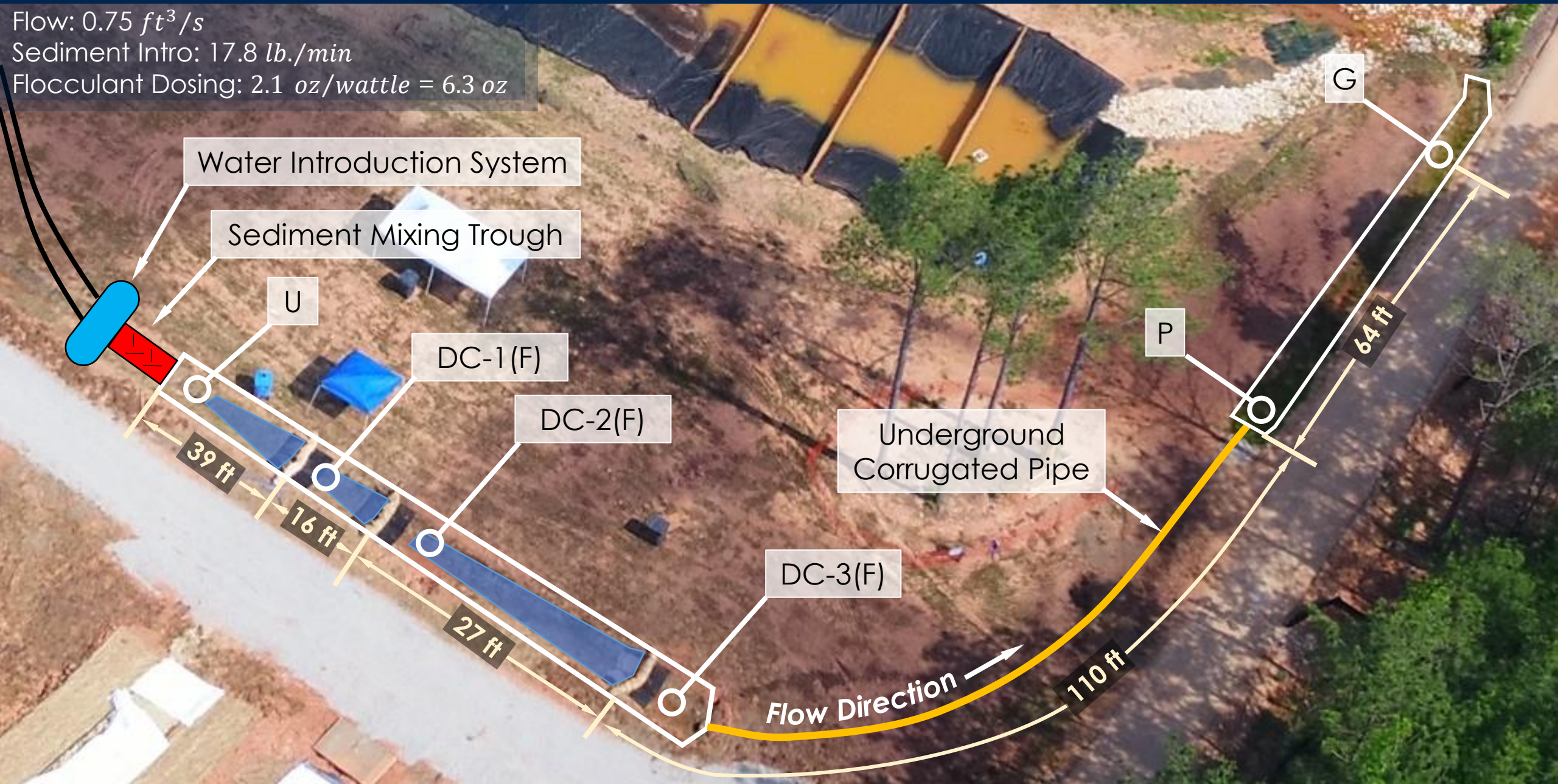
| | |
|---|---|
| **Anionic** | > 1,000 mg/L **(Beim & Beim, 1994)** |
| **Nonionic** | ≥ 407 mg/L (Beim & Beim, 1994) |
| **Cationic** | ≥ 2.24 mg/L (Beim & Beim, 1994) |

## Zebrafish Embryos



| | |
|---|---|
| **Anionic** | N/A |
| **Nonionic** | N/A |
| **Cationic** | 17.4 mg/L (Duggan et al., 2019) |

# Granular Field Testing



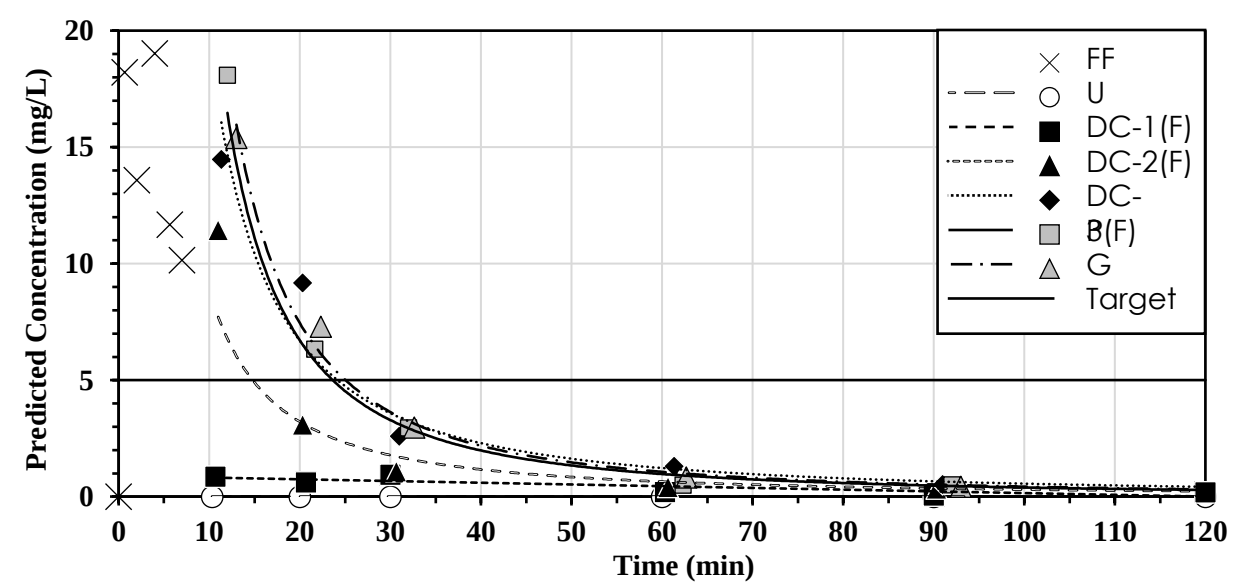
# Granular Field Testing

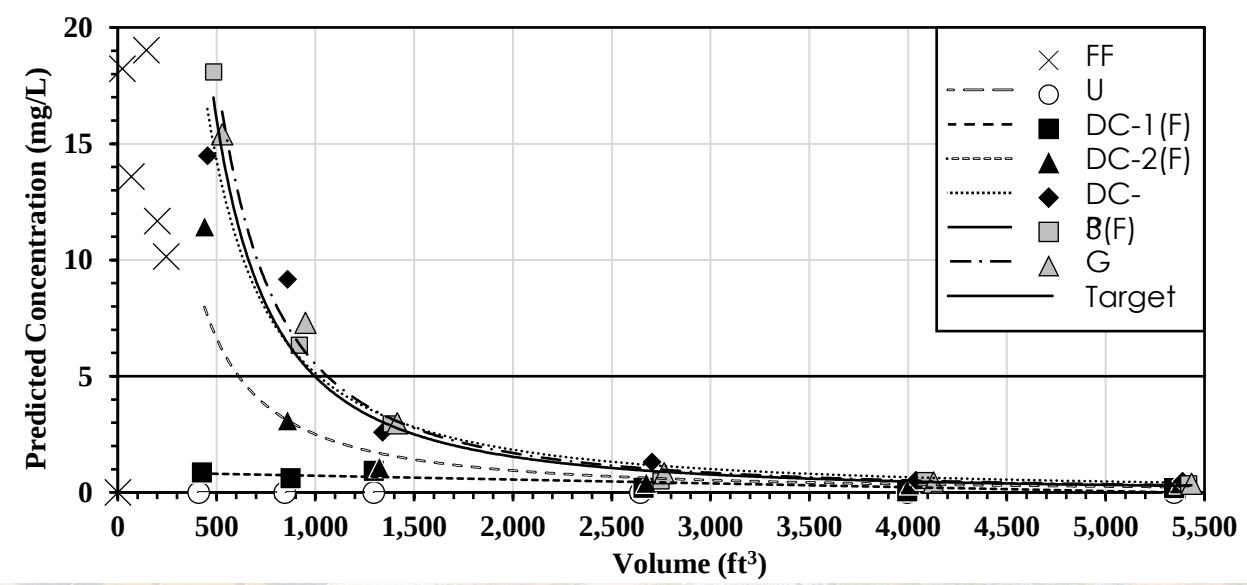
Flow: 0.75 $ft^3/s$
Sediment Intro: 17.8 $lb./min$
Flocculant Dosing: 2.1 $oz/wattle$ = 6.3 $oz$



10 ft Long 20 in. Straw Wattles

# Granular Field Test Results




**Recommendation:**

2.1 oz (60 g) per ditch check

Limit flocculant application to a maximum of three wattles within a 250 ft channel section.

**Recommendation:**

Reapply granular flocculant after 3600 $ft^3$ of flow or 1.0 in. of runoff per acre.

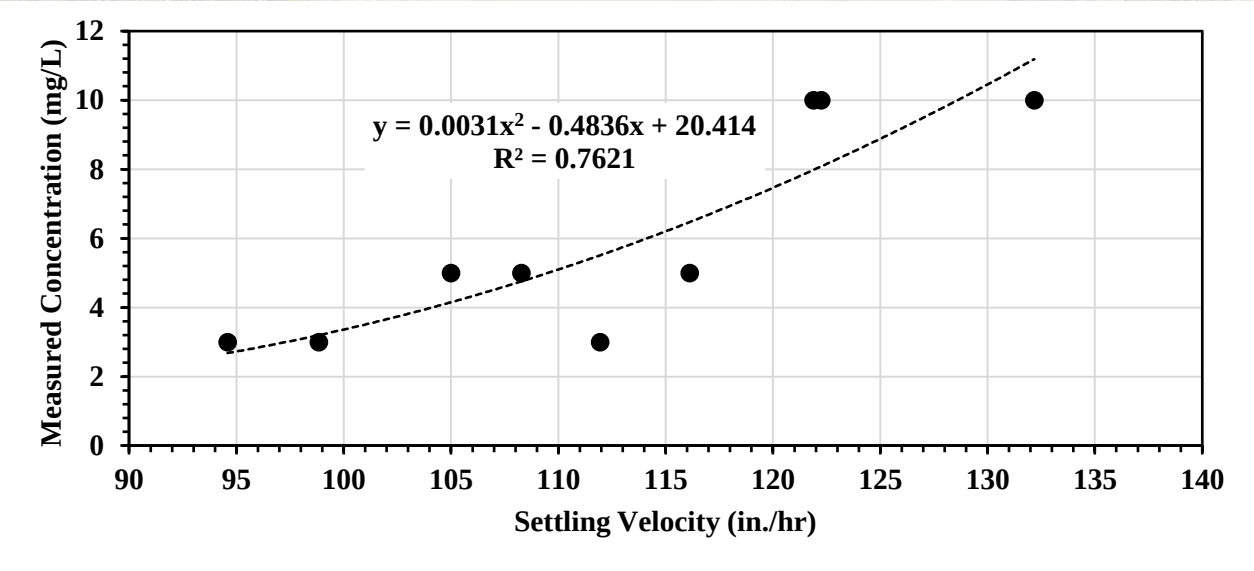
# Block Field Testing

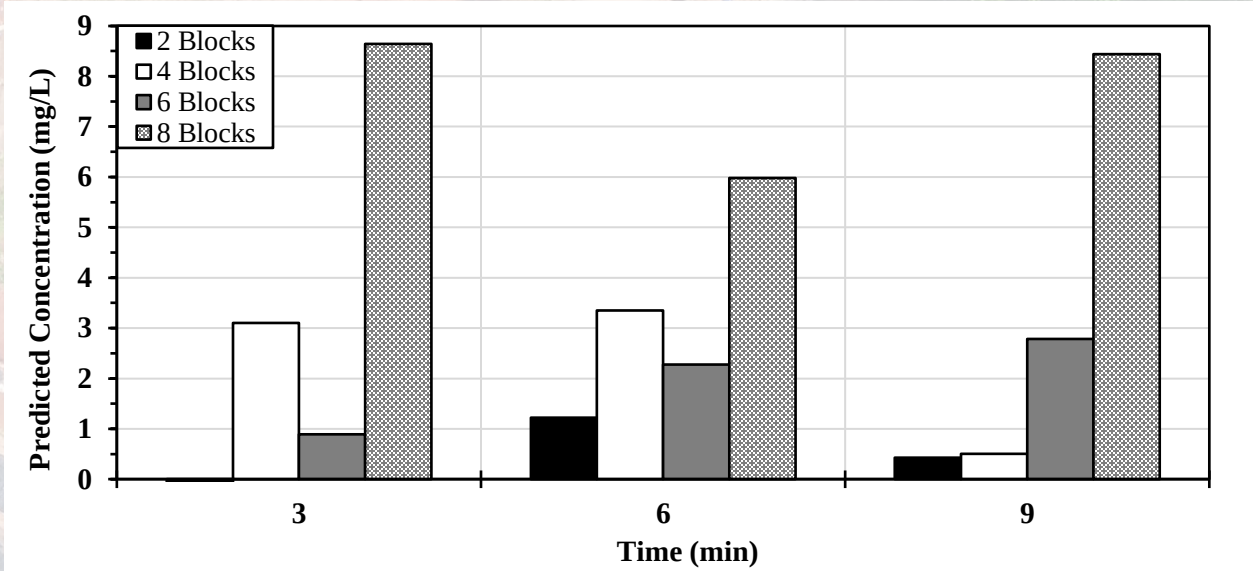
Flow: 1.8 $ft^3/s$
Sediment Intro: 17.8 $lb./min$
Flocculant Dosing: 2 $Blocks/9\ min = 8\ Blocks$

8 Blocks

# Block Field Testing

# Block Field Test Results



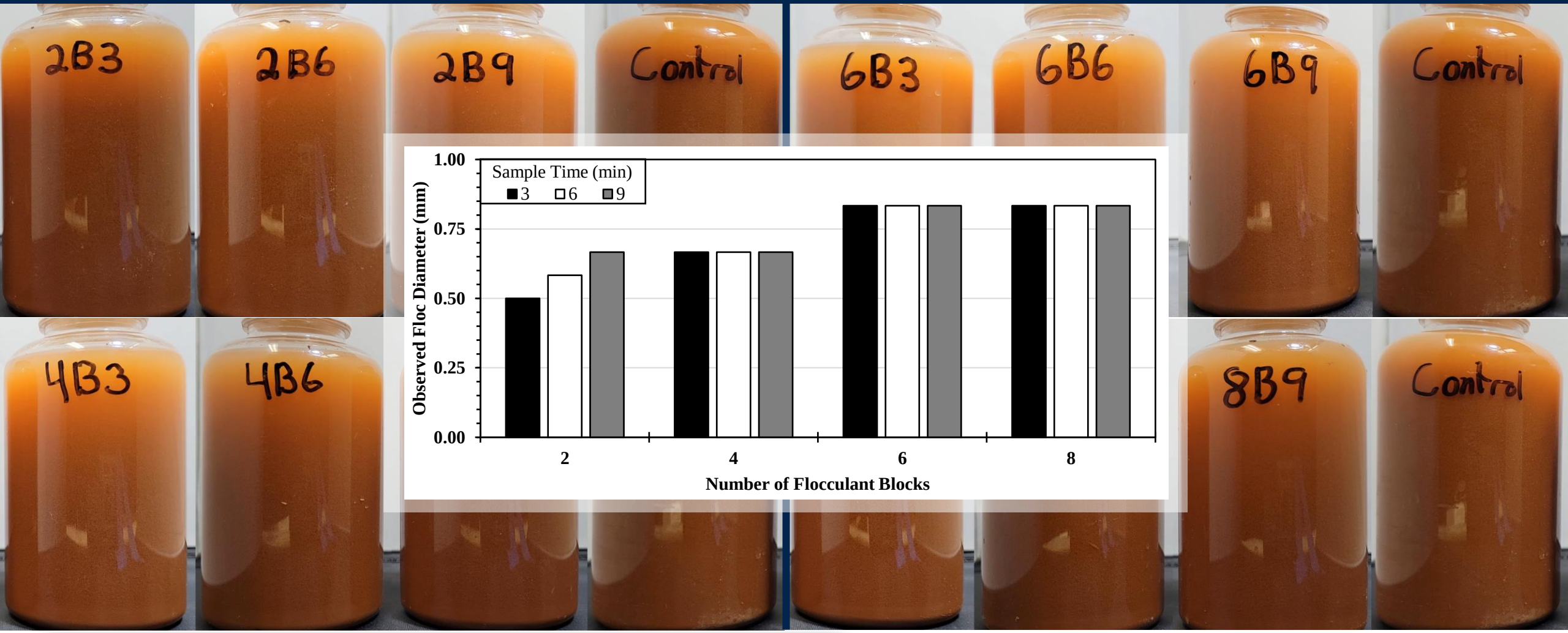


**Pond Prediction Equation**

**More Blocks = higher flocculant dosing.**

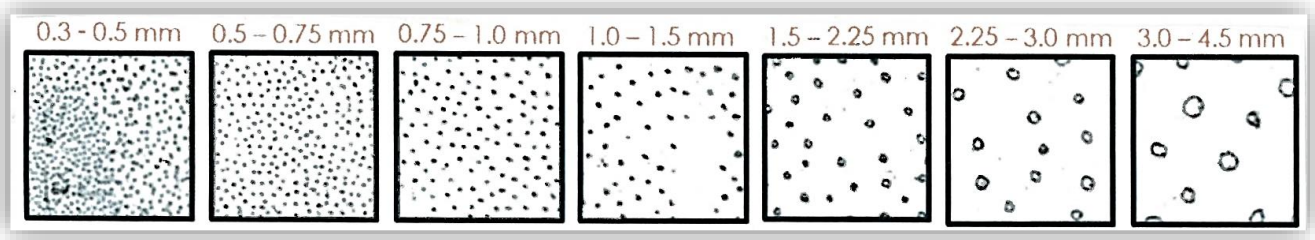
**Blocks are difficult to quantify residual concentrations.**

# Block Field Test Results










**Recommendation:**

1 block per 0.3 cfs

# Conclusion

## Collection Methods

- Avoid multi-use plastic
- Maintain consistent time until processing after sample is collected
- Protect samples from temperature changes

## Detection Methods

- Viscosity changes were not easily detectable with the desired concentration ranges
- Temperature and pH need to be accounted
- Block form flocculants require further analysis for quantifying

# Conclusion

**Dosage Recommendations**

- Granular = 2.1 oz (60 g) per ditch check and limit application to a maximum of three wattles within a 250 ft channel section. Reapply after 3,600 $ft^3$ of flow or 1.0 in. of runoff per acre
- Block = 1 block per 0.3 cfs

**Installation**

- At least 1 DC without flocculant at the end of the channel

**Overall**

- Accounting for environmental conditions, residual flocculant can be easily detected in the field

# Designing & Evaluating Infiltration Swales for Retaining & Infiltrating Roadway Stormwater Runoff

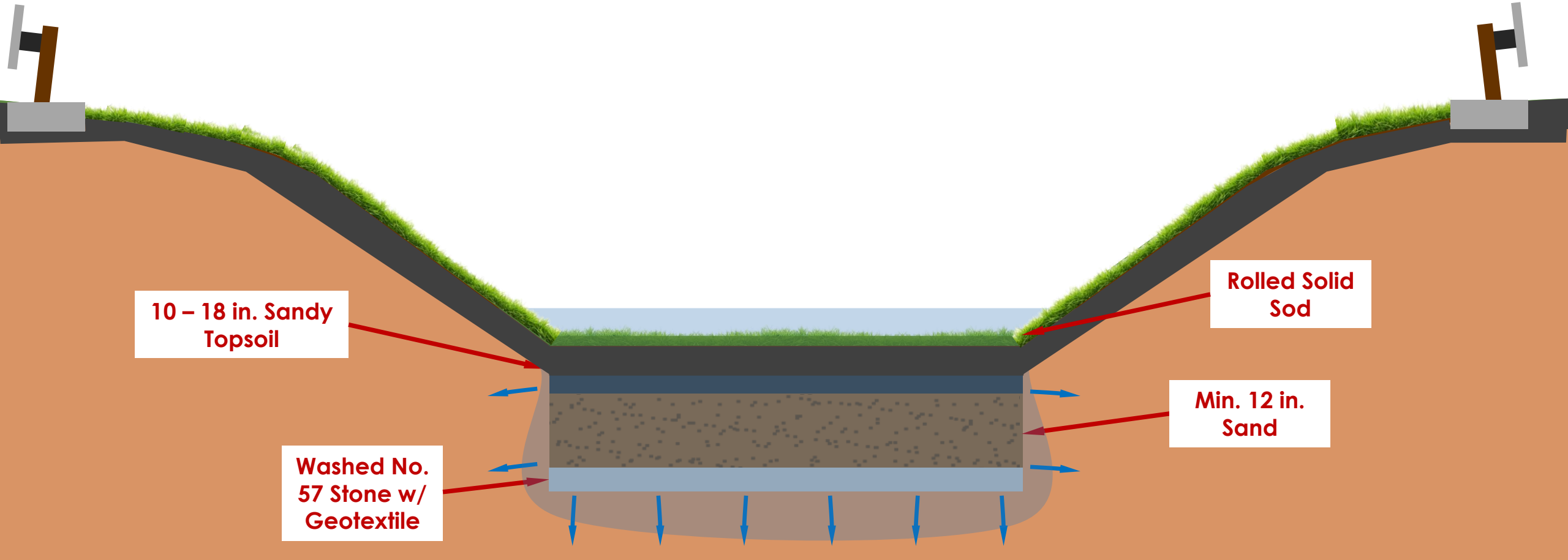
AUBURN UNIVERSITY HIGHWAY RESEARCH CENTER

AUBURN UNIVERSITY

ALABAMA DEPARTMENT OF TRANSPORTATION

# INFILTRATION SWALES

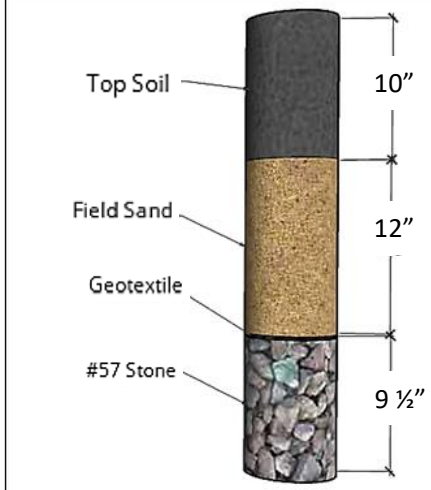
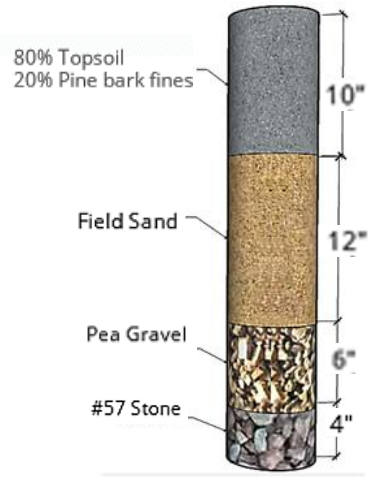
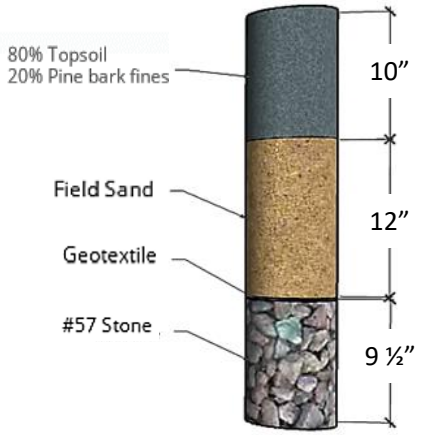
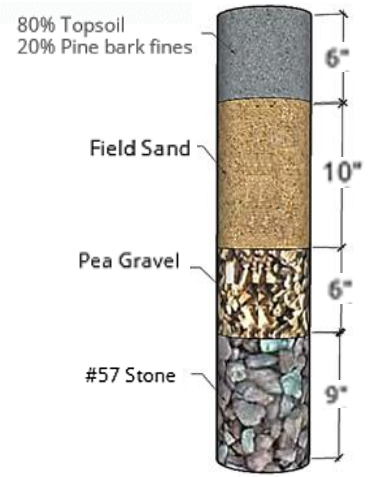
**Engineered system that promotes groundwater infiltration and reduces surface runoff**



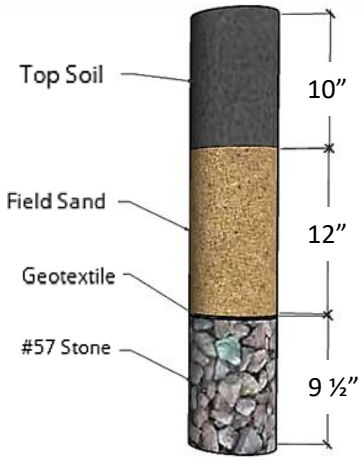
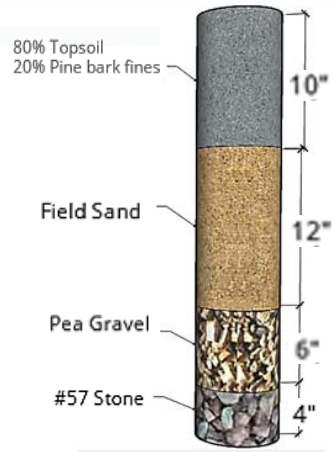
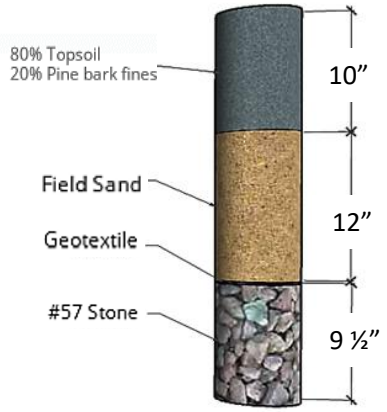
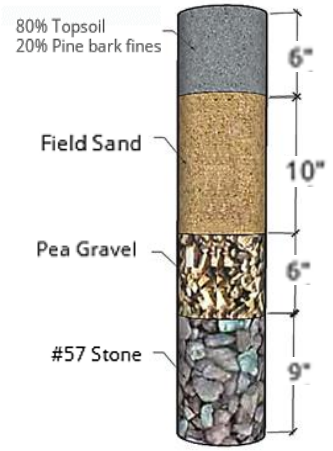
# T2: SMALL-SCALE TESTING




# INFILTRATION RATES OF VARIOUS LAYER CONFIGURATIONS – CONSTANT HEAD TEST

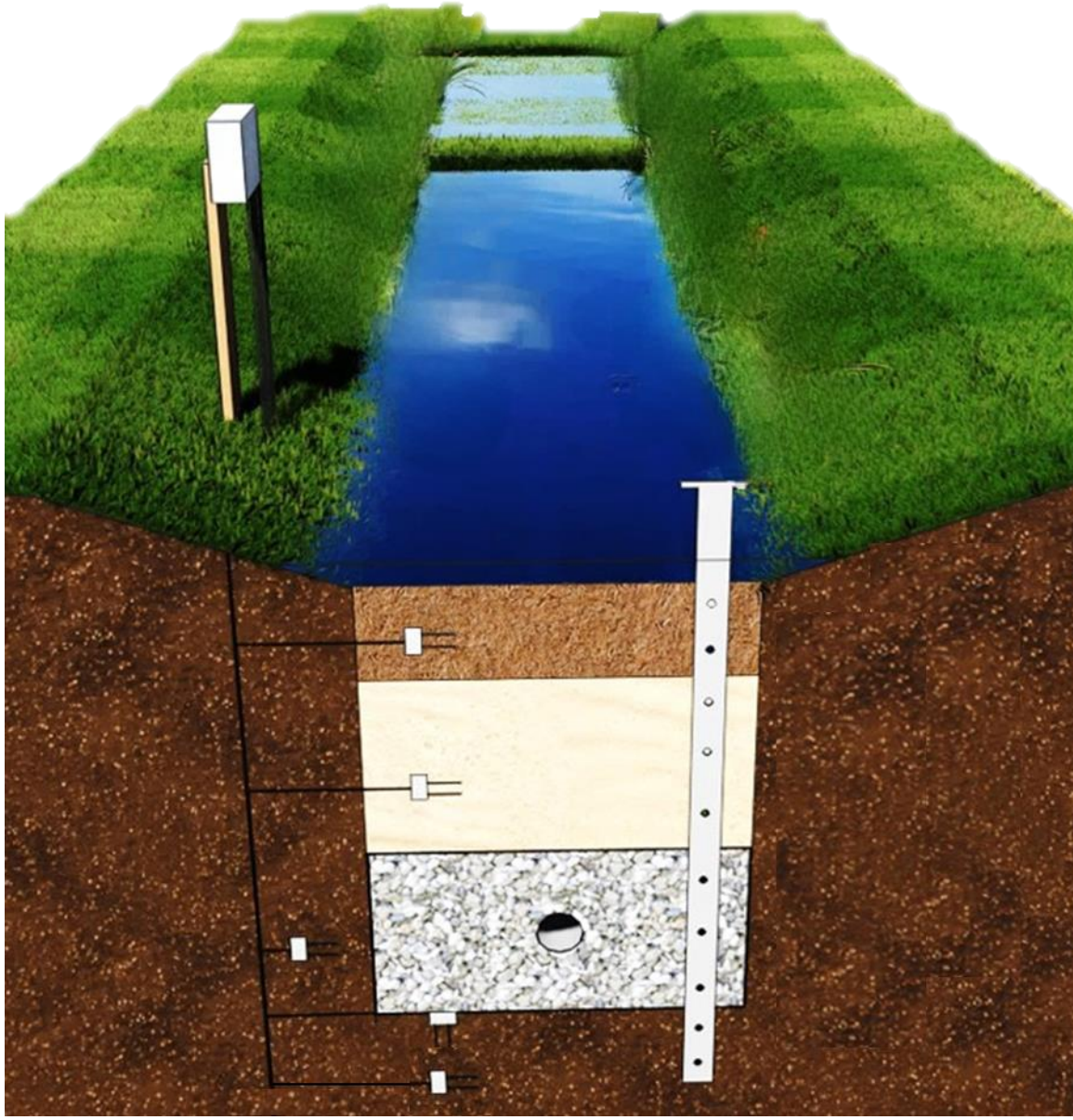
| SAMPLE OUTLINE | | AVERAGE INFILTRATION RATE | SAMPLE OUTLINE | | AVERAGE INFILTRATION RATE |
|---|---|---|---|---|---|
| **ALDOT**<br>Consolidated |  | **1.73 ft/day** | F<br>Consolidated |  | **5.31 ft/day** |
| A1 |  | **5.38 ft/day** | F3 |  | **5.75 ft/day** |

# INFILTRATION RATES OF VARIOUS LAYER CONFIGURATIONS – FALLING HEAD TEST

| SAMPLE OUTLINE | | AVERAGE INFILTRATION RATE | SAMPLE OUTLINE | | AVERAGE INFILTRATION RATE |
|---|---|---|---|---|---|
| **ALDOT** Consolidated |  | **0.49 ft/day** | F Consolidated |  | **1.26 ft/day** |
| A1 |  | **1.10 ft/day** | F3 |  | **2.24 ft/day** |

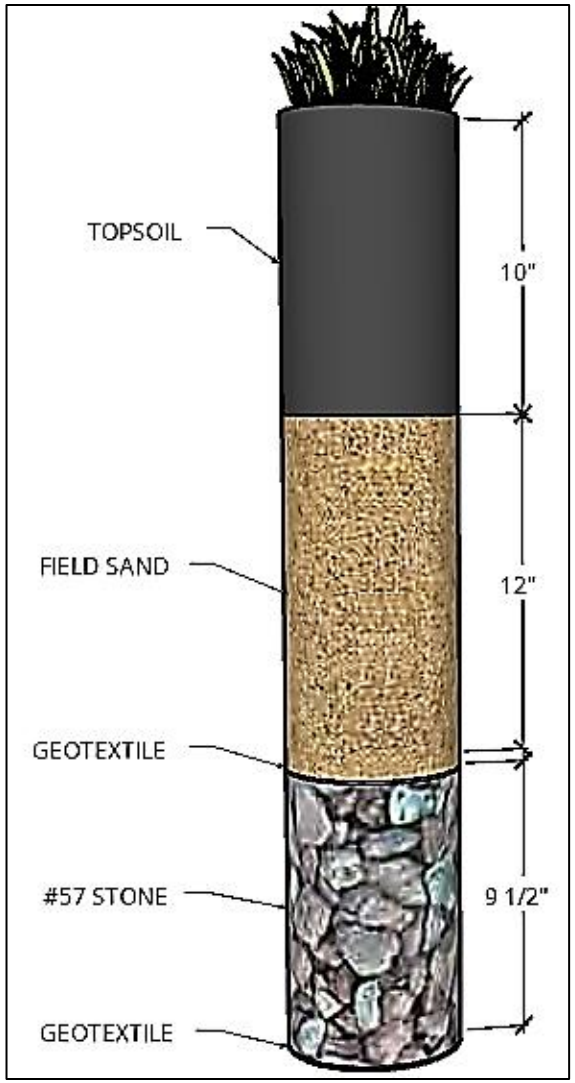
# COLUMN TESTING FINDINGS › FIELD APPLICATION

- Topsoil is limiting layer
- 80/20 pine bark fines amendment improves infiltration
  - Increased permeability by 9x
  - Column test infiltration improved by 2.6 to 3.1x
- Consider reducing 12 in. topsoil layer to 6 in.
- Geotextile reduces infiltration rate
  - Pea gravel increased infiltration rate by 2.2 to 3.1x

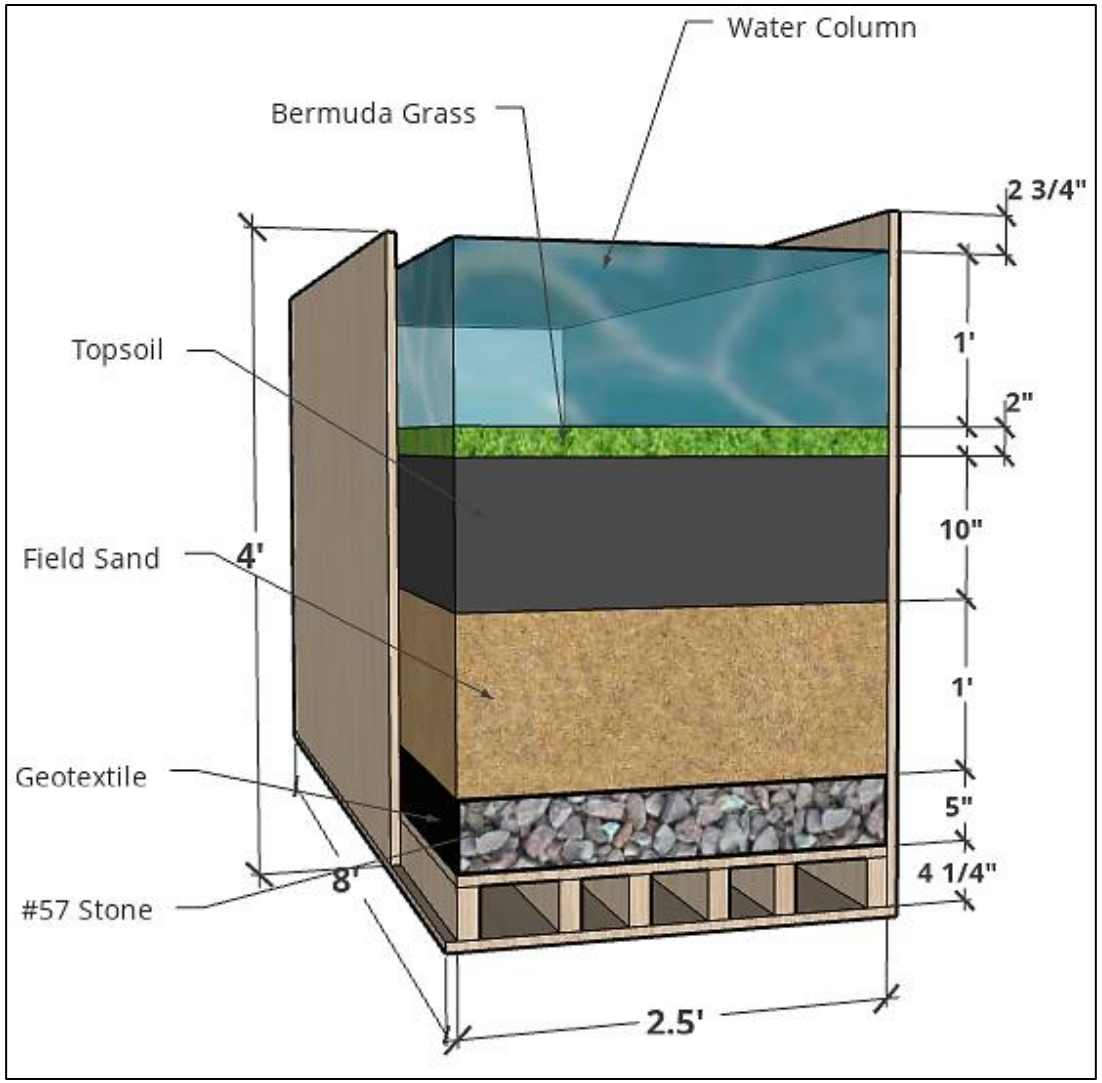


# INFILTRATION SWALE MEDIA – TEST IN SMALL BOX
# ALDOT SAMPLE

**ALDOT SAMPLE IN CLEAR COLUMNS**

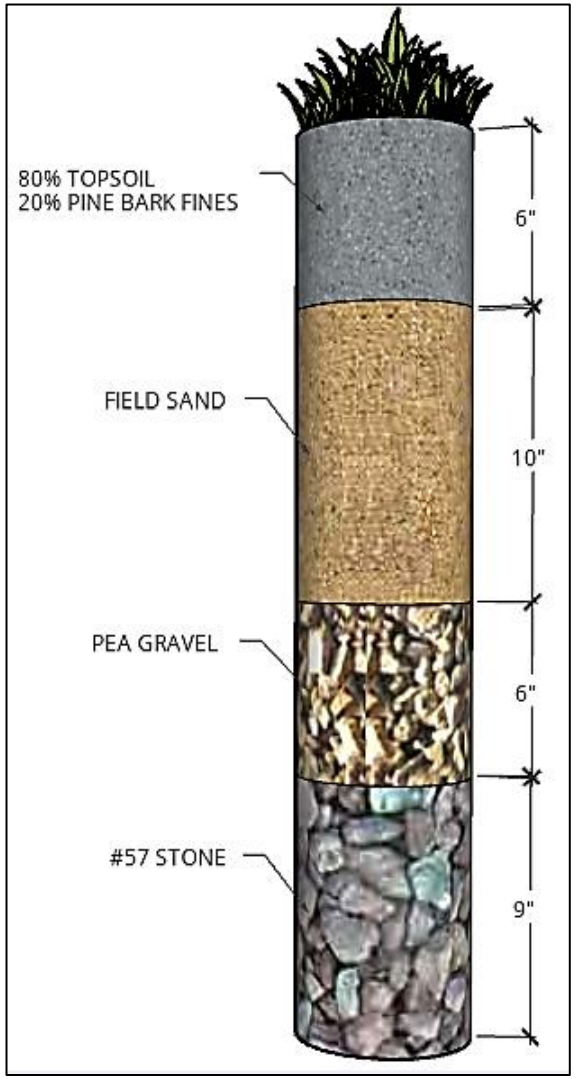



**F3 SAMPLE IN SMALL BOX**

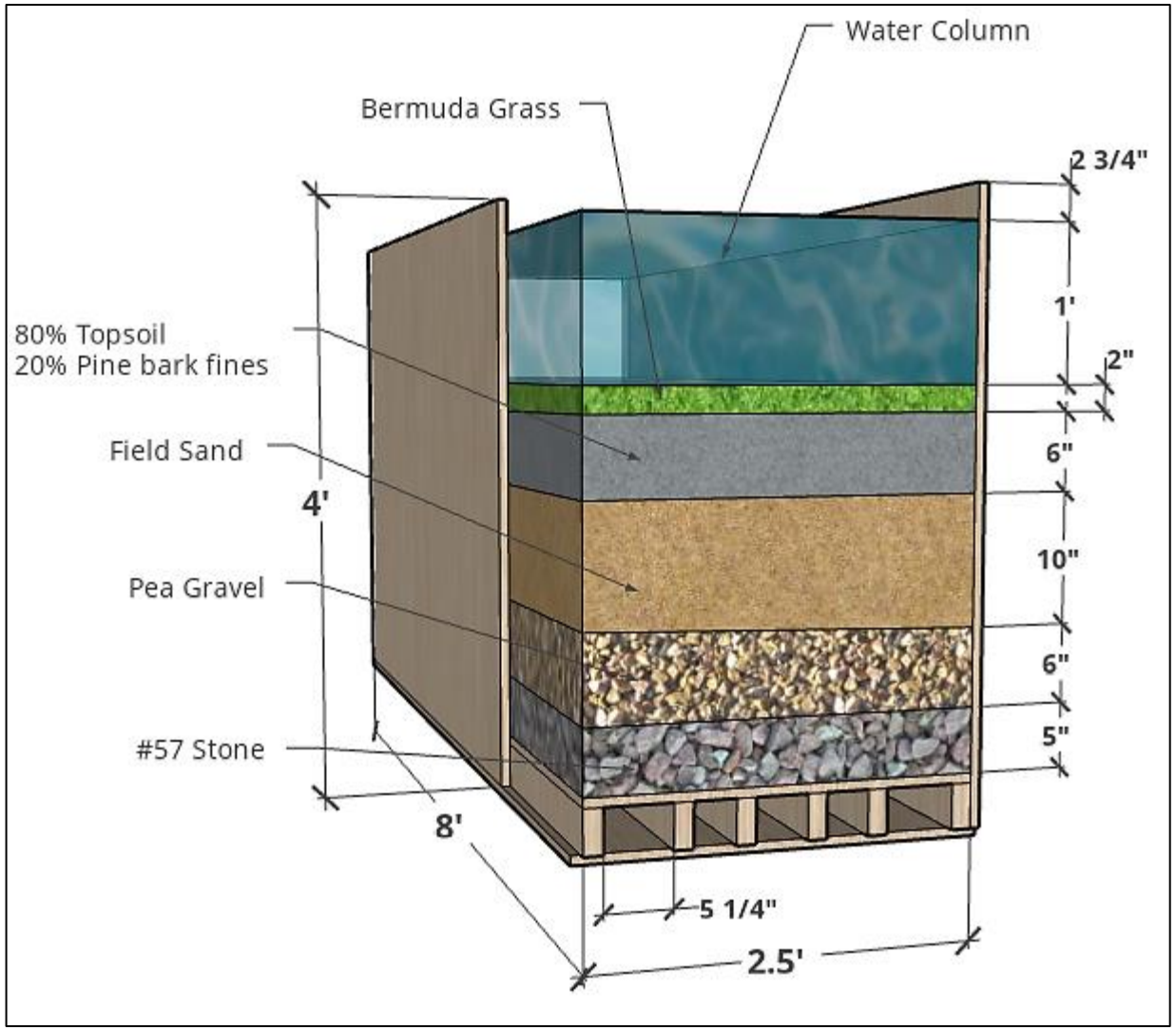


# INFILTRATION SWALE MEDIA – TEST IN SMALL BOX
# F3 SAMPLE

**F3 SAMPLE IN CLEAR COLUMNS**



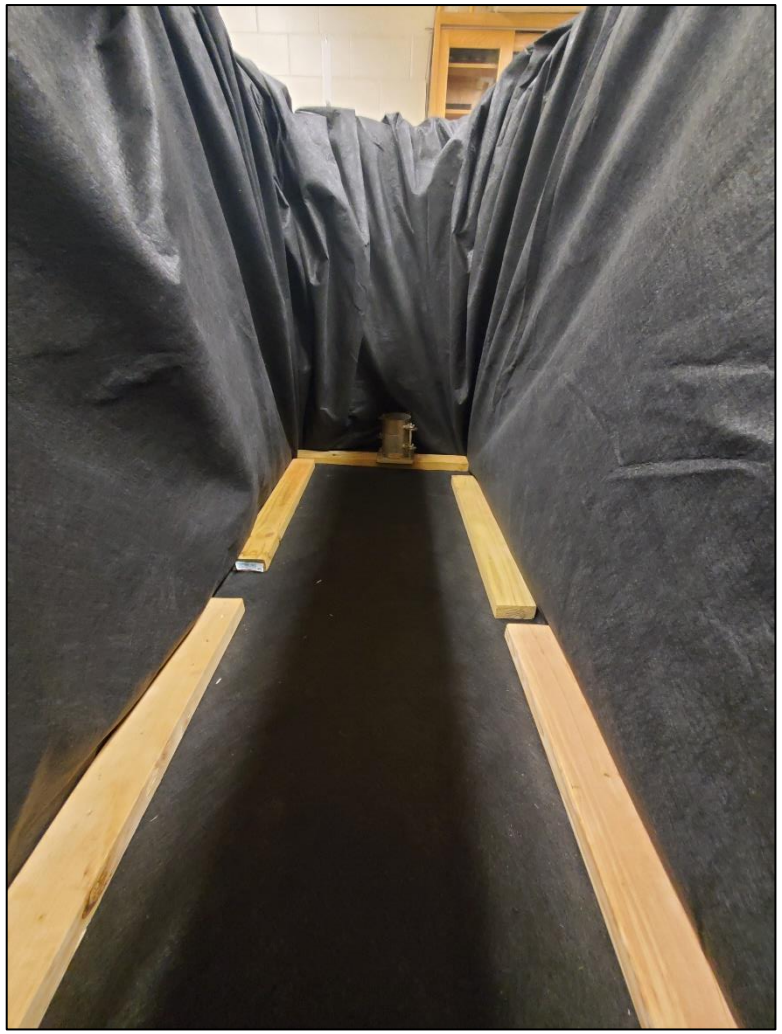

**ALDOT SAMPLE IN SMALL BOX**

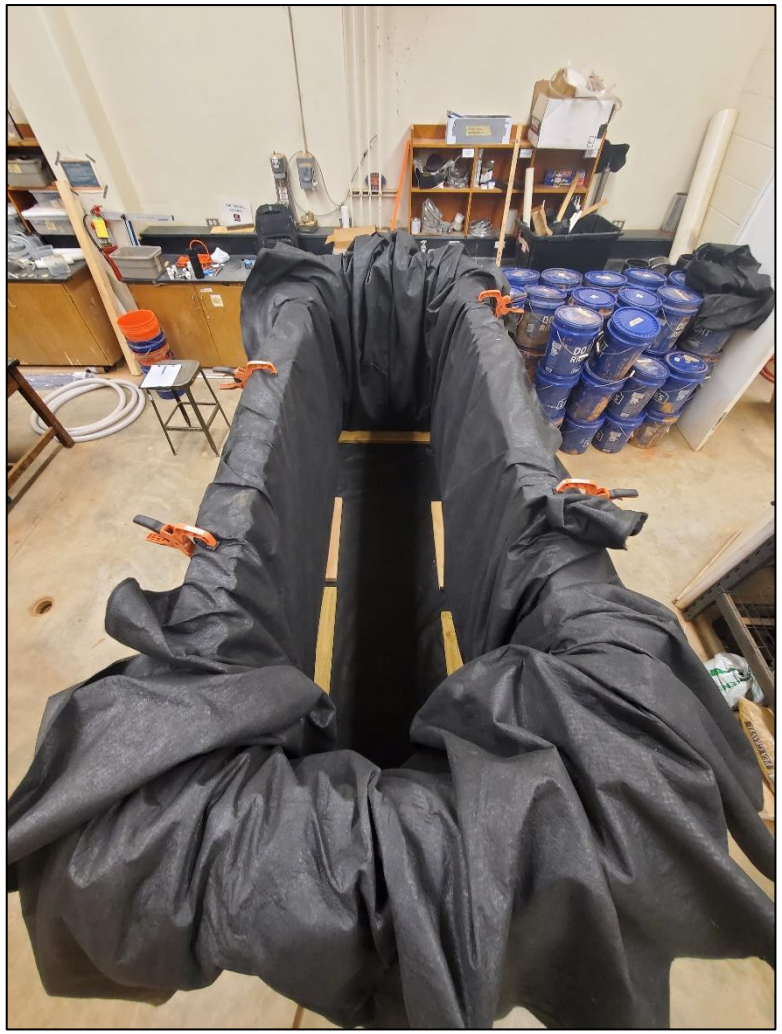


# PLASTIC INSTALLATION

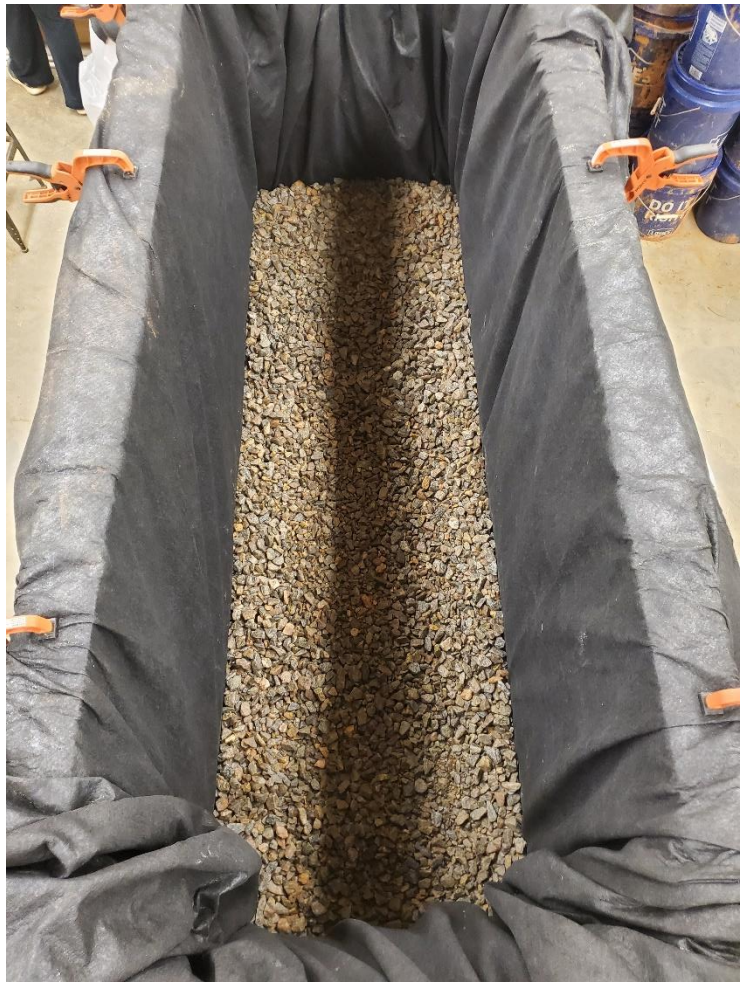

Elimination of folds with tape

# GEOTEXTILE INSTALLATION





# #57 SEVEN STONE PLACING

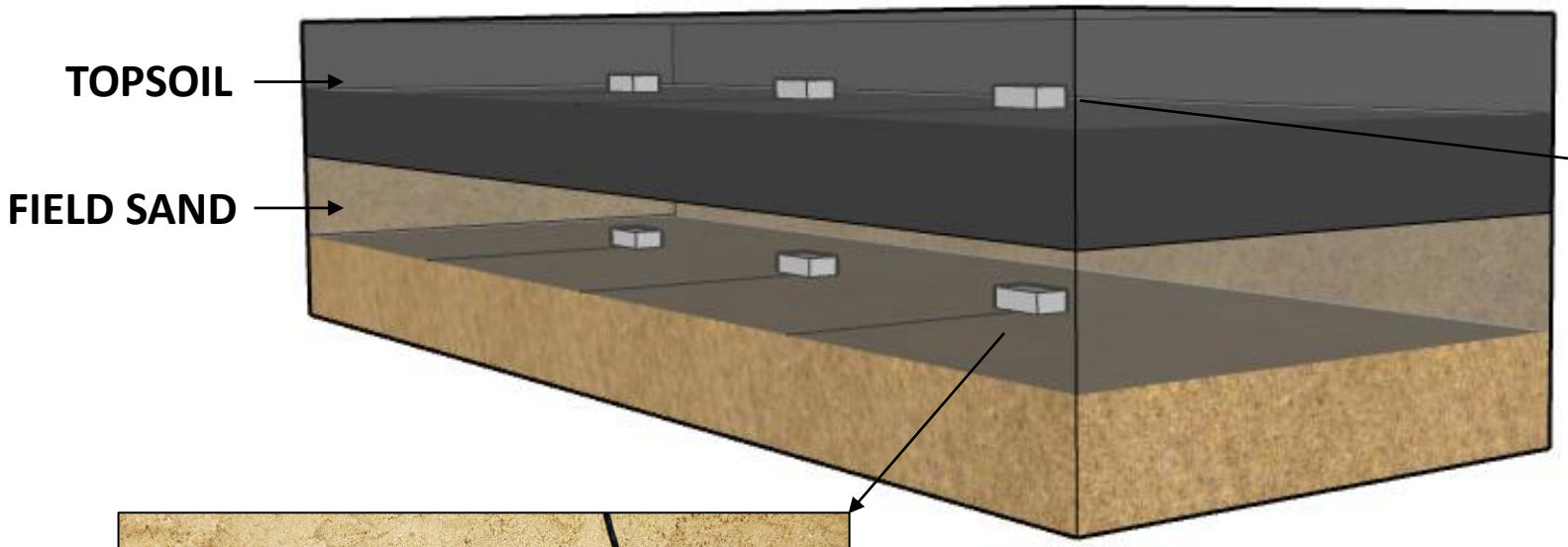


# GEOTEXTILE SEWING

# SAND INSTALLATION

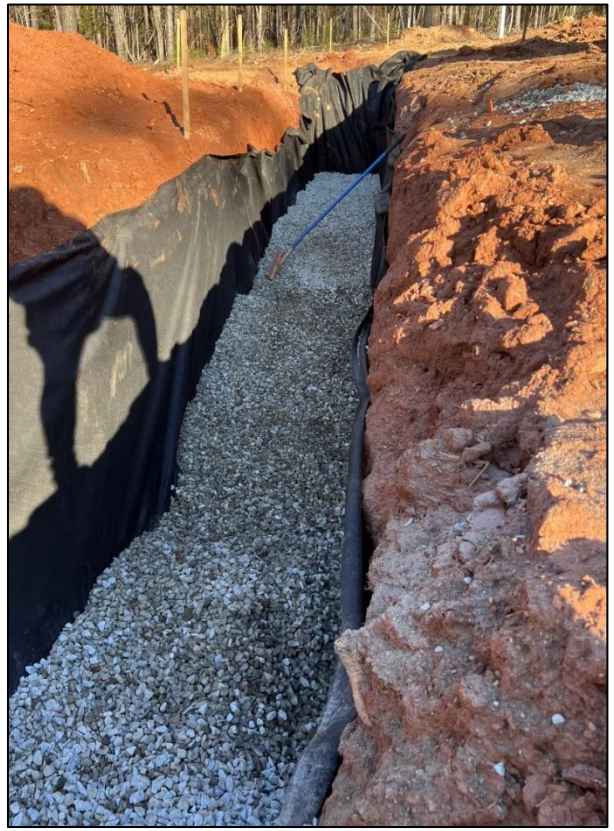

# TOPSOIL INSTALLATION


# 3D VIEW OF SENSORS LOCATION INSIDE THE INFILTRATION SWALE




# CONSTRUCTION OF ALDOT INFILTRATION SWALE

5 ft Excavation



Geotextile Mirafi 160N

2 ft Fill of #57 and Underdrain

Sealed #57 Stone

# CONSTRUCTION OF ALDOT INFILTRATION SWALE

Fill 2 ft of Sand and Grade at 1% Slope

Fill 1 ft Topsoil

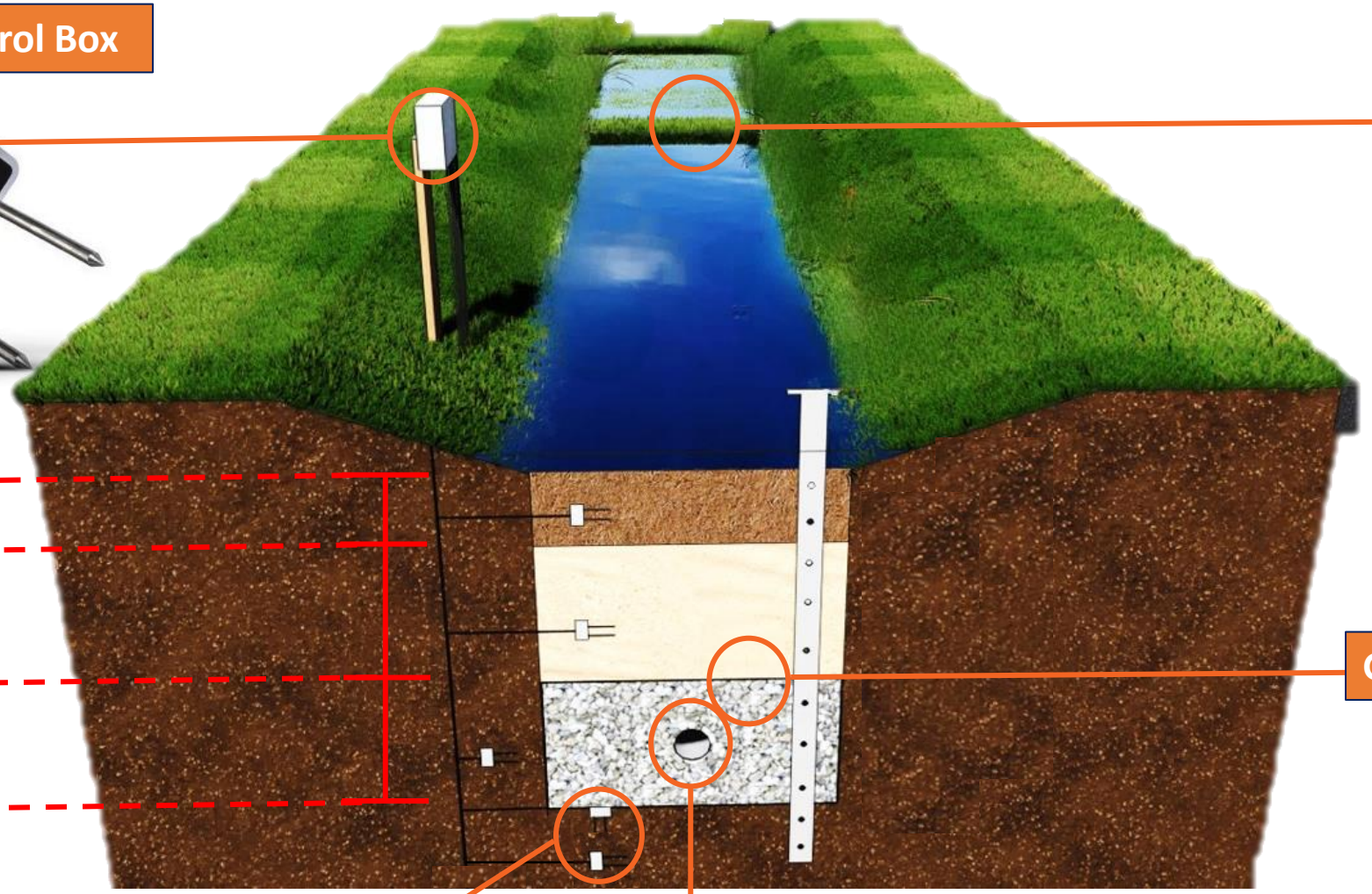
Grade Topsoil at 1% Slope

# BERMUDA ROLLED SOD

Bermuda Sodding

Compacting/Rolling

# INFILTRATION SWALE LAYERS W/ MOISTURE SENSORS



Moisture Content Control Box

6 inch Check Dams

1 FT TOPSOIL

2 FT SAND

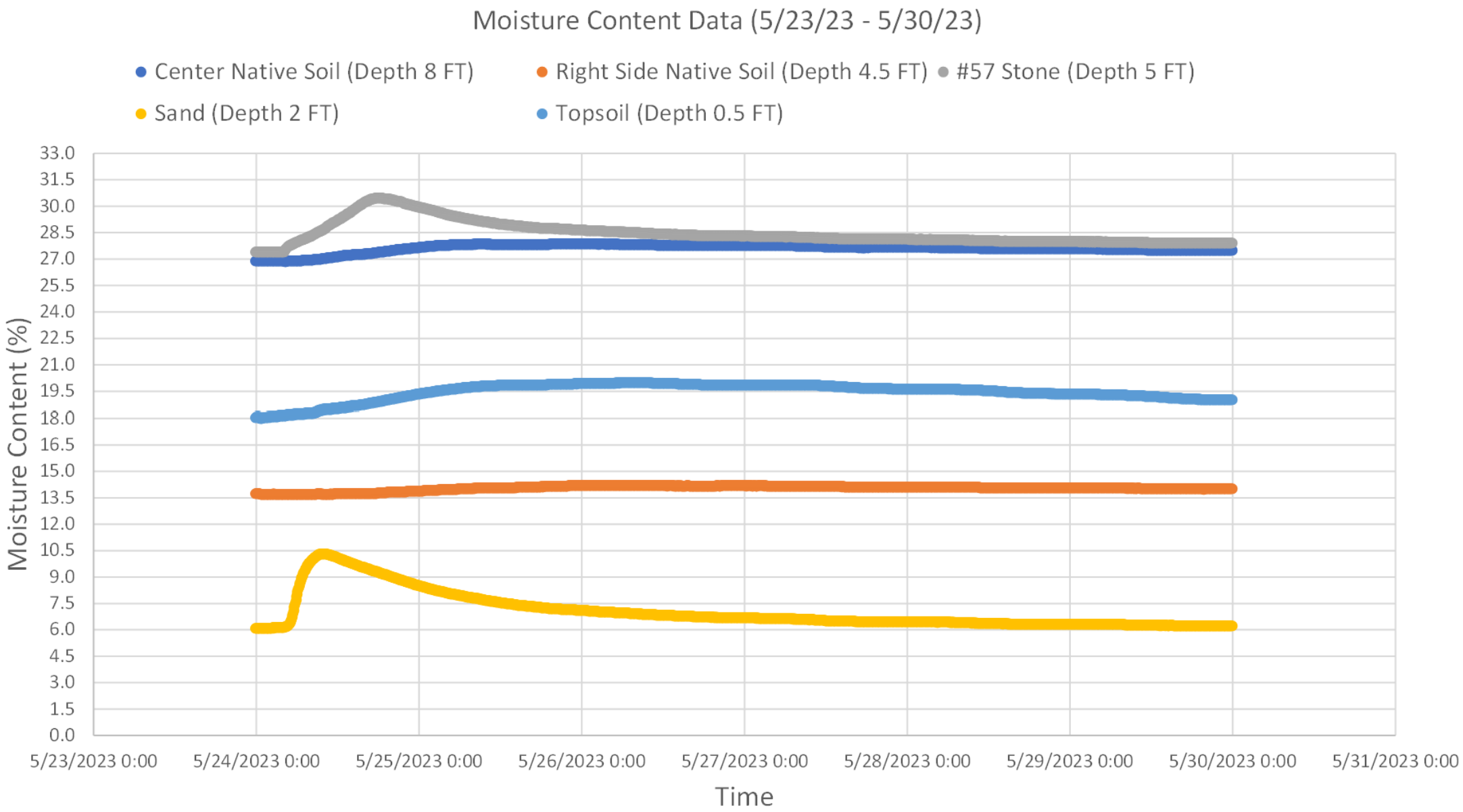
2 FT #57 STONE

Geotextile Mirafi 160 N

Moisture Content Sensors

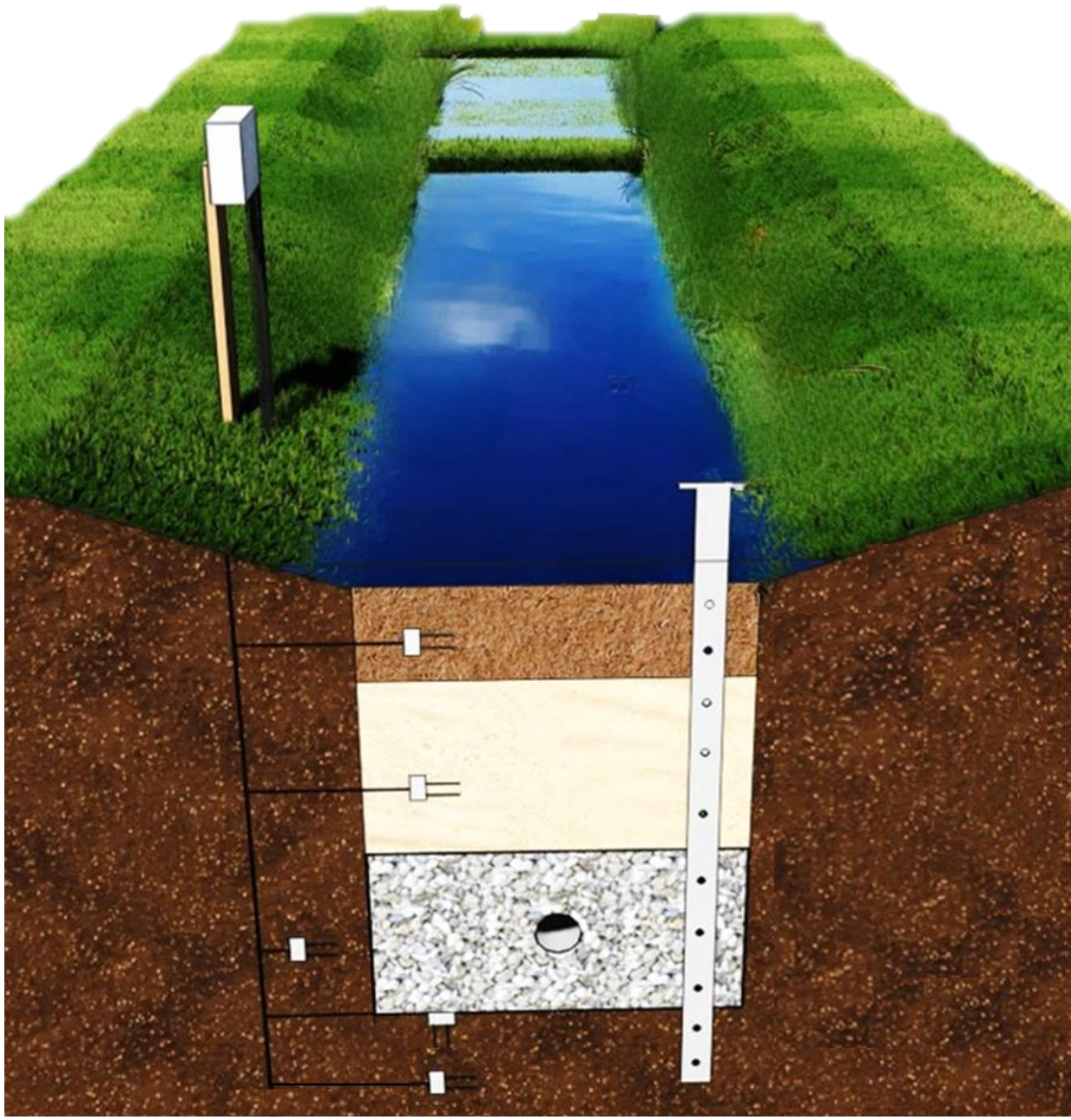
6-inch Underdrain

# TEROS 10 MOISTURE CONTENT SENSORS



# FUTURE TESTING

- Use small scale data to determine new large scale design
- Intermediate Lab-scale tests
  - Verify current ALDOT design testing results
  - Inform potential performance of new design
- Construct new design
- Test to compare performance to old ALDOT design
- Evaluate longevity and maintenance



# PERFORMANCE EVALUATION OF SLASH MULCH BERMS AS SEDIMENT BARRIERS

AUBURN UNIVERSITY

ALABAMA DEPARTMENT OF TRANSPORTATION

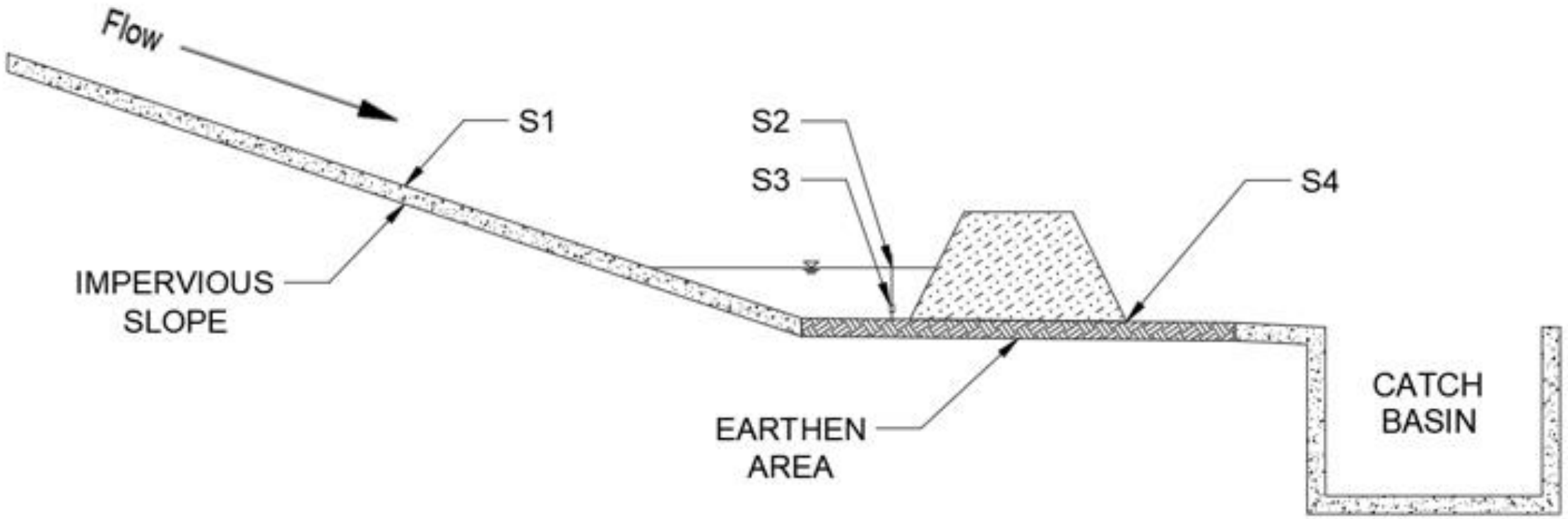
# METHODOLOGY

- Installed berms in three lifts, compacted using bucket of excavator
- 6 in. deep triangular key
- Subjected to peak 30 min of 2-yr, 24-hr storm in Alabama
  - Flow introduced: 0.2 $ft^3/s$
  - Sediment introduced: 37.6 lb/min of sediment
- Water grab samples taken at 5 min intervals

# METHODOLOGY

- Plastic was laid beneath berm and berm was installed at end of earthen area
- Upstream & downstream sediment collected and measured
- Mass balance of upstream and downstream
  - Deposited upstream
  - Captured within
  - Lost downstream

# SAMPLE LOCATIONS



# IMPOUNDMENT AND FLOW

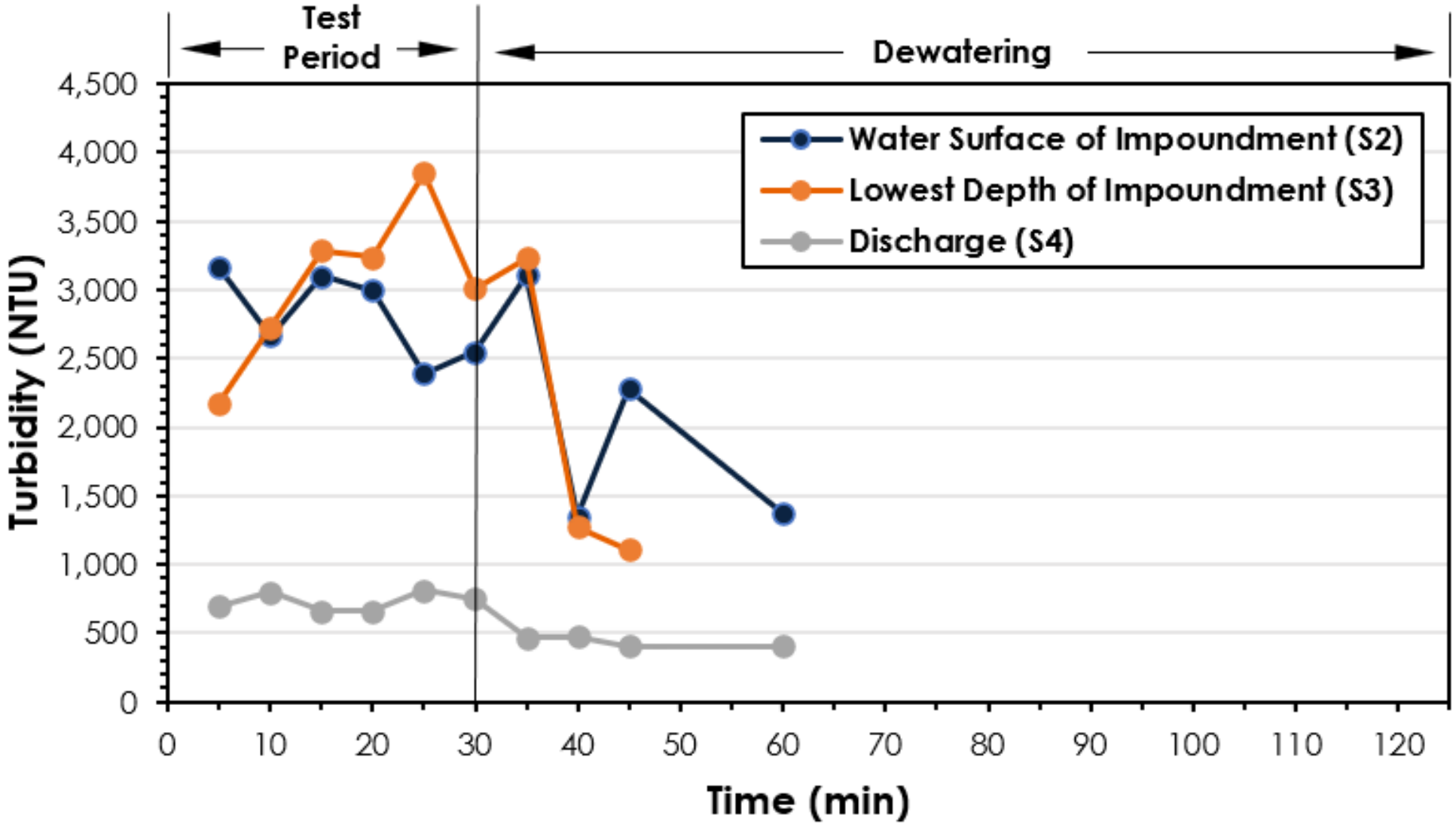
- Under 6 in. of impoundment depth during test period
  - For installations with berm at rear of test bed
  - 10 in. for installation in center of test bed
- Dewatered quickly, reaching under 1 in. of depth within 30 min of conclusion of flow
- 20% lower flow through rate than introduction flow rate

# SEDIMENT RETENTION

| | |
|---|---|
| Dry Weight of Soil Introduced (lb) | 3,209 |
| Dry Weight of Soil Retained Upstream (lb) | 2,838 |
| Percent Retained Upstream (%) | 88.4% |
| Dry Weight of Soil Captured Downstream (lb) | 57.5 |
| Percent Lost Downstream (%) | 1.8% |

- 98.2% sediment capture through installation

# WATER QUALITY



# WATER QUALITY

- Discharge turbidity less than impoundment turbidity
  - Indicates filtration
- Water quality degrades after each subsequent storm event
  - First storm event avg. 473 NTU
  - Third storm event avg. 780 NTU

| | |
|---|---|
| Turbidity at surface of impoundment (S2)(NTU) | 2,887 |
| Turbidity at bottom of impoundment (S3)(NTU) | 2,929 |
| Discharge turbidity (S4)(NTU) | 631 |
| Difference between S2 and S3 (%) | 1.5 |
| Difference between S3 and S4 (%) | 78.5 |

# CONCLUSIONS

- Treated water quality in Turbidity and Total Suspended Solids (78.5% and 83.9%, respectively)
- Captured 98% of introduced sediment
  - 88% occurring upstream
  - ~10% occurring within berm
- Low impoundment levels
  - Can likely be increased through increased compaction
- Discharge turbidity increased with each subsequent storm event
  - Third event discharge averaged 65% higher than first in turbidity

# BRANDING & MARKETING

## Stormwater Testing Facility

The Stormwater Testing Facility at Auburn University is dedicated to crafting innovative and practical storm water management solutions. Since 2009, the facility has advanced the body of knowledge through interdisciplinary research, product evaluation, and hands-on training. We are excited to be at the forefront of stormwater research, and we welcome the opportunity to share that excitement with you.

## Upcoming Events

- **Date** - Event name
- **Date** - Event name
- **Date** - Event name

No upcoming events.

## Contact Us

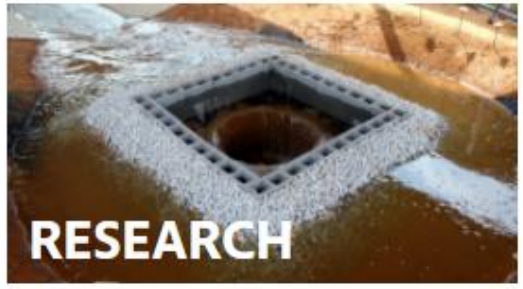
stormwater@auburn.edu

Stormwater Testing Facility:
1600 Lee Rd. 151
Opelika, AL 36840

Dr. Mike Perez
mike.perez@auburn.edu
(334) 844-6267

Dr. Wesley Donald
donalwm@auburn.edu
(334) 844-6249

**Sponsorship & Exhibitor Opportunities Available!**




## News and Updates

- New Publication Alert: Hydraulic Performance Evaluation of

Tweets by @StormwaterAU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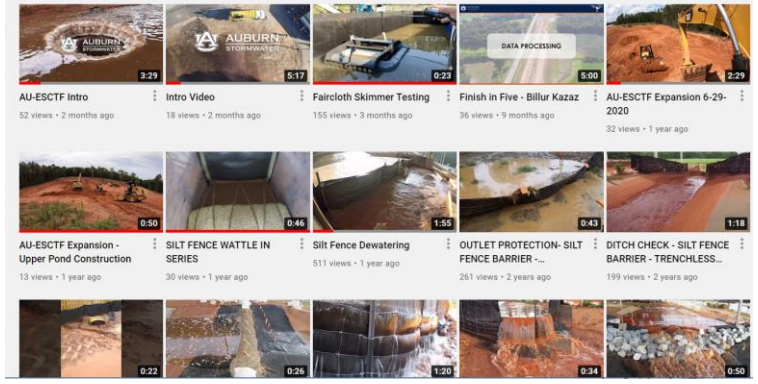


← **AU - Erosion & Sediment Control Testing Facility**
23 Tweets

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**AU - Erosion & Sediment Control Testing Facility**
@StormwaterAU

The AU-ESCTF is an Auburn University research center focused on providing research, testing, and training for the erosion and sediment control industry.

Auburn, AL | eng.auburn.edu/research/cente... | Joined April 2021


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### About

The AU-ESCTF is an Auburn University research center focused on providing research, testing, and training for the erosion and sediment control industry.
see more

See all details

### Upcoming events

**Erosion & Sediment Control Installer Training**
Wed, Nov 17 - Thu, Nov 18
Veronica Ramirez, PE, Madison Moreman and 3 other attendees

**Erosion & Sediment Control Field Day**
Fri, Nov 19, 8:00 AM
Madison Moreman and 1 other attendee

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IECA International Erosion Control Association

Protecting Soil and Water Resources

# 2024 Auburn University E&SC Installer Training | May 13 & 14

AUBURN UNIVERSITY

IECA International Erosion Control Association

Protecting Soil and Water Resources

2024 Auburn University E&SC Installer Training | May 13 & 14

# AU-SRF INSTALLER TRAINING & FIELD DAY W/ IECA


## Save the Date

**Wednesday, May 15 & Thursday, May 16th**
**With Optional Field Day on Friday, May 17th**

# Michael A. Perez, Ph.D., P.E., CPESC

(334) 844-6267 | MIKE.PEREZ@AUBURN.EDU

# Wesley N. Donald, Ph.D., CPESC

(334) 844-6249 | DONALWN@AUBURN.EDU


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