DECEMBER 12TH, 2022

# STORMWATER RESEARCH UPDATES

**MICHAEL A. PEREZ**, PH.D., P.E., CPESC
CIVIL & ENVIRONMENTAL ENGINEERING
AUBURN UNIVERSITY

## AU STORMWATER RESEARCH FACILITY

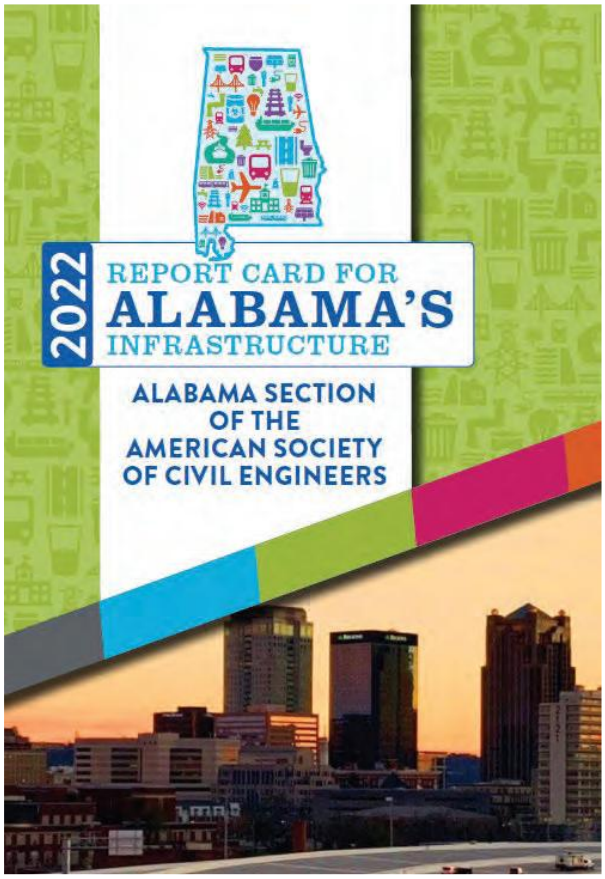
STORMWATER.AUBURN.EDU

ASCE ALABAMA SECTION Montgomery Branch

ASCE INNOVATION CONTEST

## 1st Place Champions – Society Wide

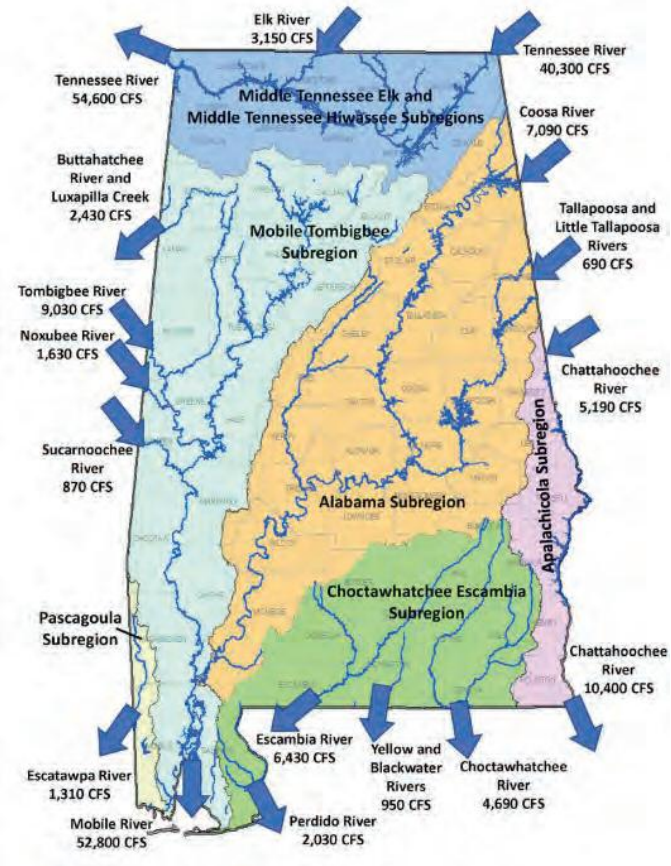

**STORMWATER**





## Alabama Waters

- 132k mi. of streams and rivers
- 3.6M ac of wetland
- 563k ac of ponds, lakes, and reservoirs
- 303 freshwater species of fish, 20 of which are endemic to Alabama
- 38% of NA's fish species
- 43% of NA's gill-breathing snails
- 51% of NA's freshwater turtle species
- 60% of NA's freshwater mussel species



CLEAN WATER ACT

# Clean Water Act - 1972

**Purpose: Restore and maintain chemical, physical, and biological integrity of our Nation's waters.**

**Prohibition of toxic pollutants**

**"Fishable" and "swimmable" goal by 1983**

**Elimination of pollutant discharge by 1985**

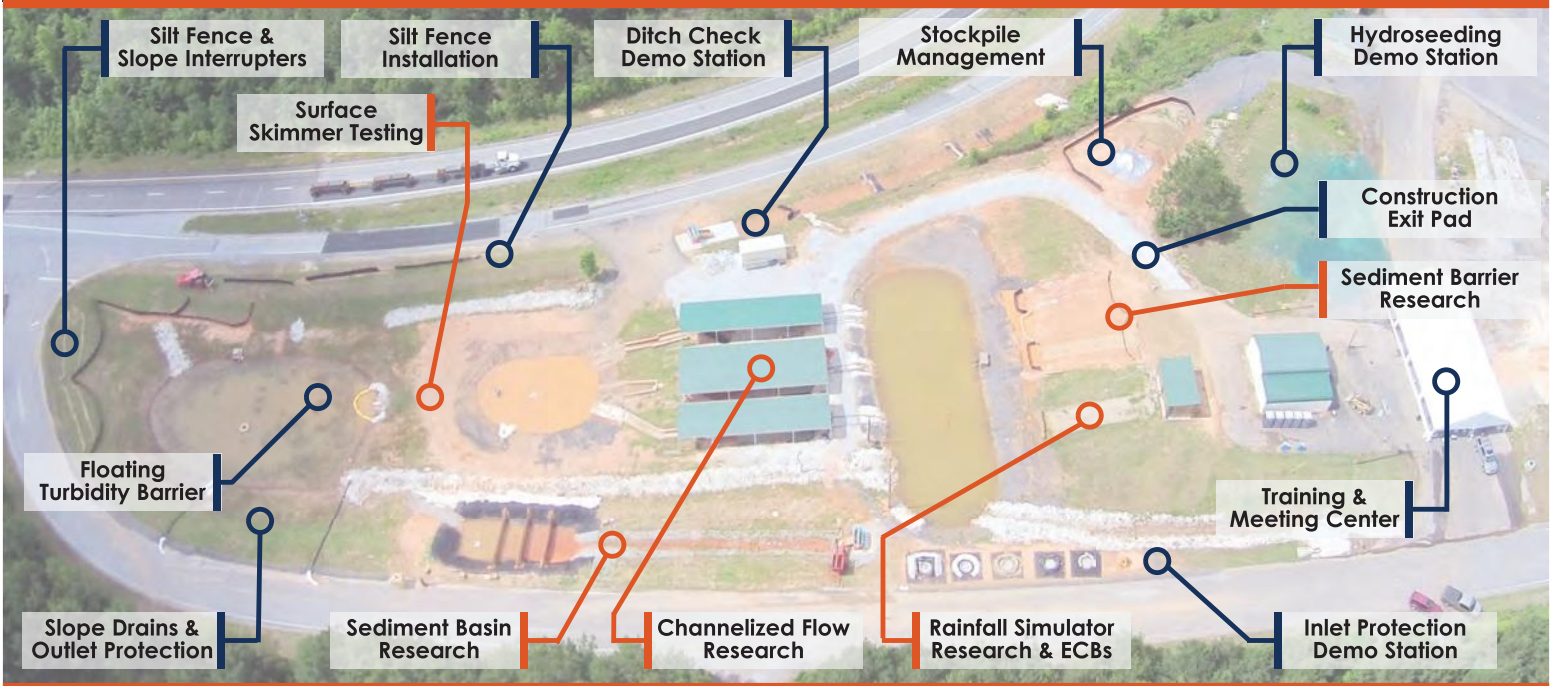
***Modified in 1987 to create NPDES & MS4***

# CONSTRUCTION ACTIVITIES DRIVE & ACCELERATE EROSION.


## CONSTRUCTION STORMWATER NEEDS

# STORMWATER RESEARCH FACILITY


# STORMWATER RESEARCH FACILITY

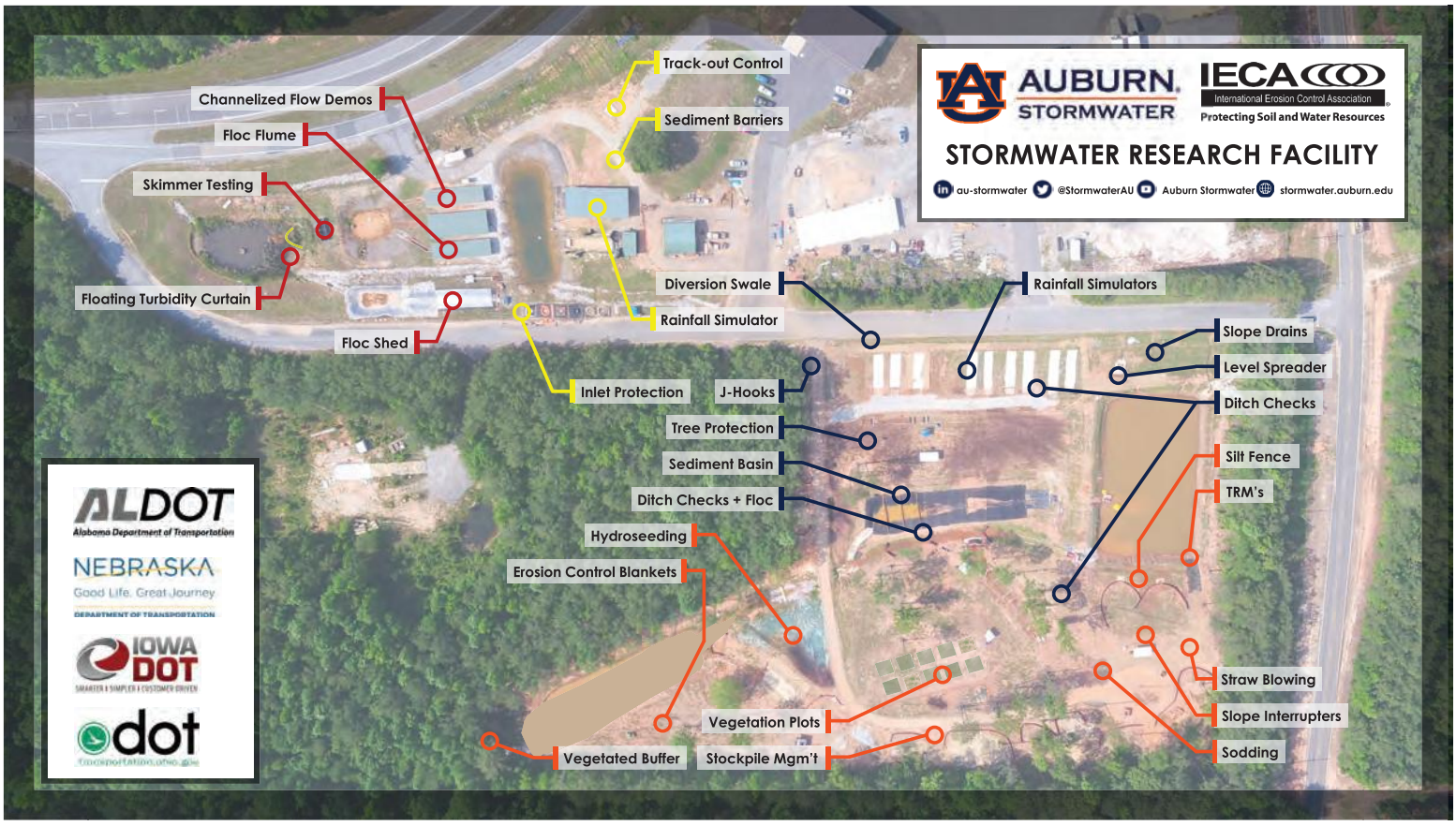



*Research · Testing · Training*

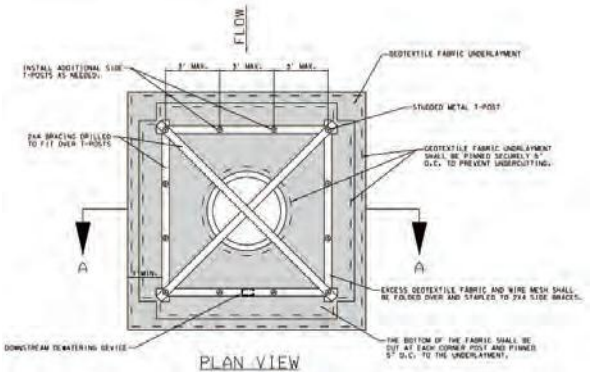
# STORMWATER RESEARCH FACILITY

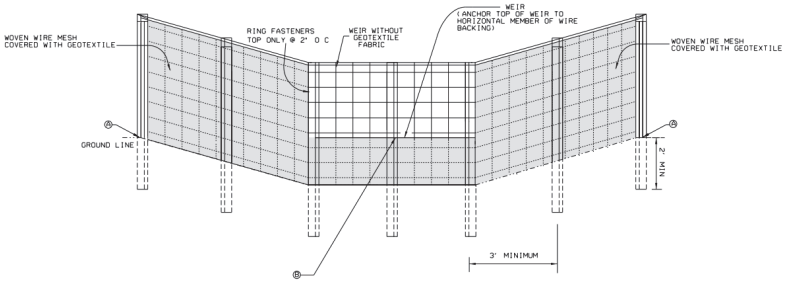
## Craft innovative & practical stormwater management solutions for the transportation sector

*Research · Testing · Training*



# ALDOT STANDARD DRAWINGS

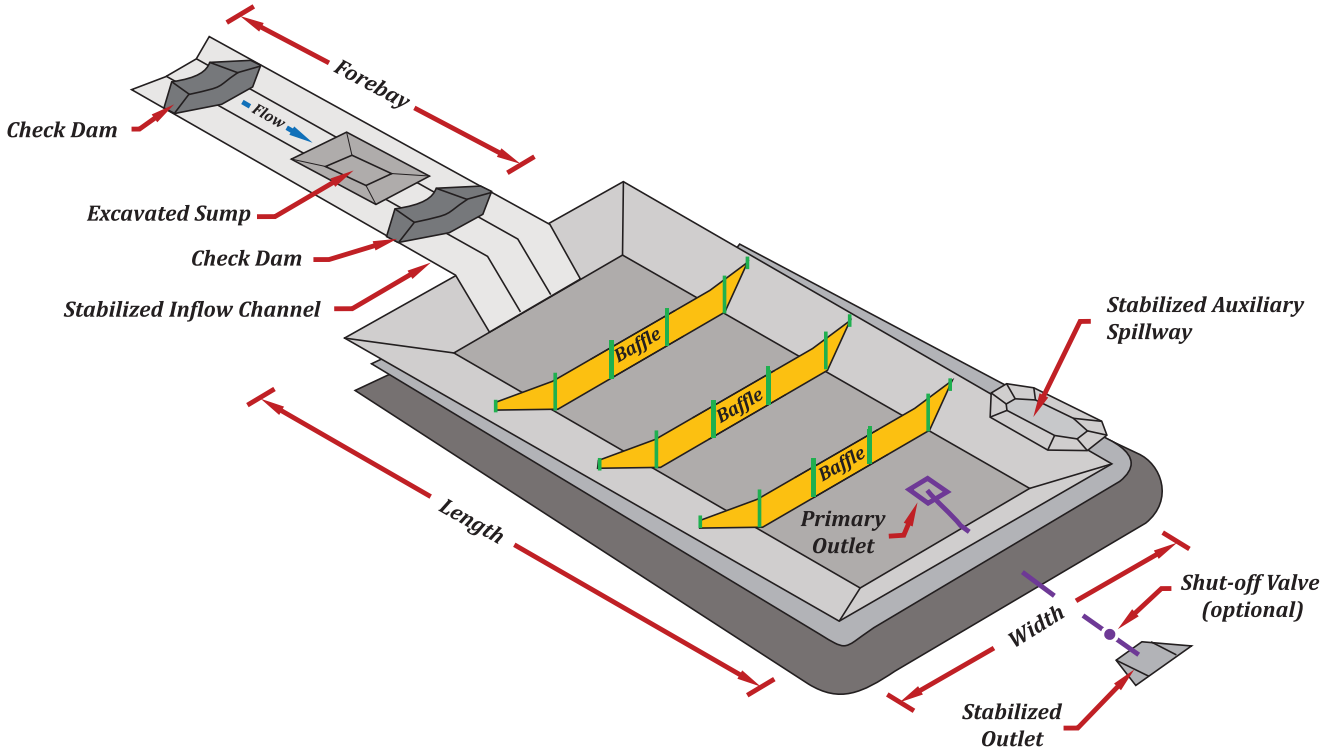


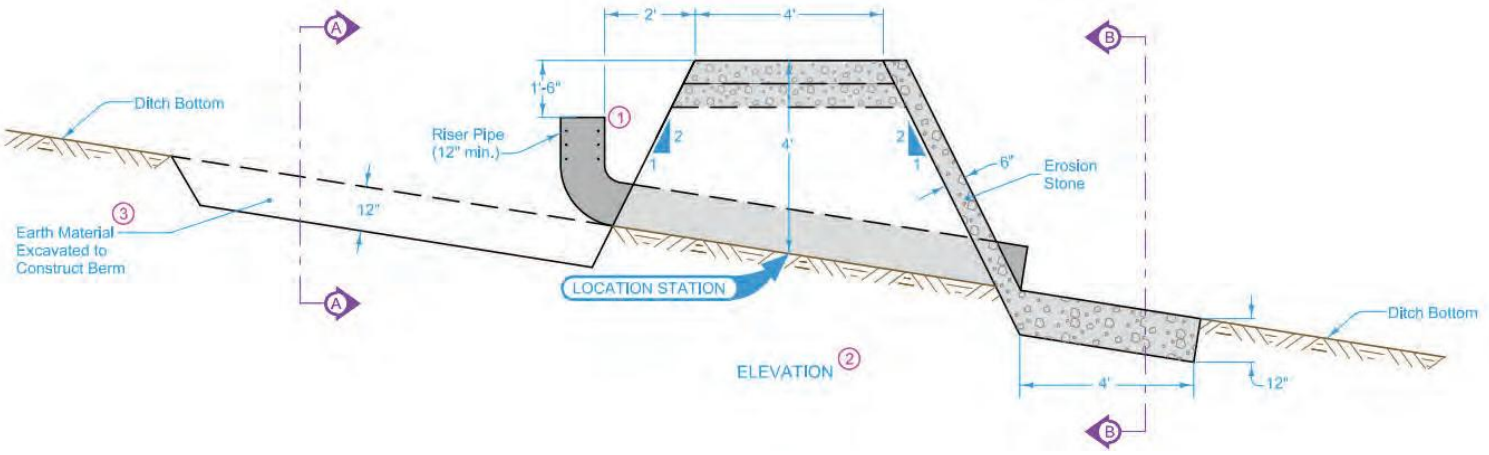

# FROM RESEARCH TO IMPLEMENTATION

# SEDIMENT BASIN PERFORMANCE RESEARCH


## TYPICAL SEDIMENT BASIN DESIGN

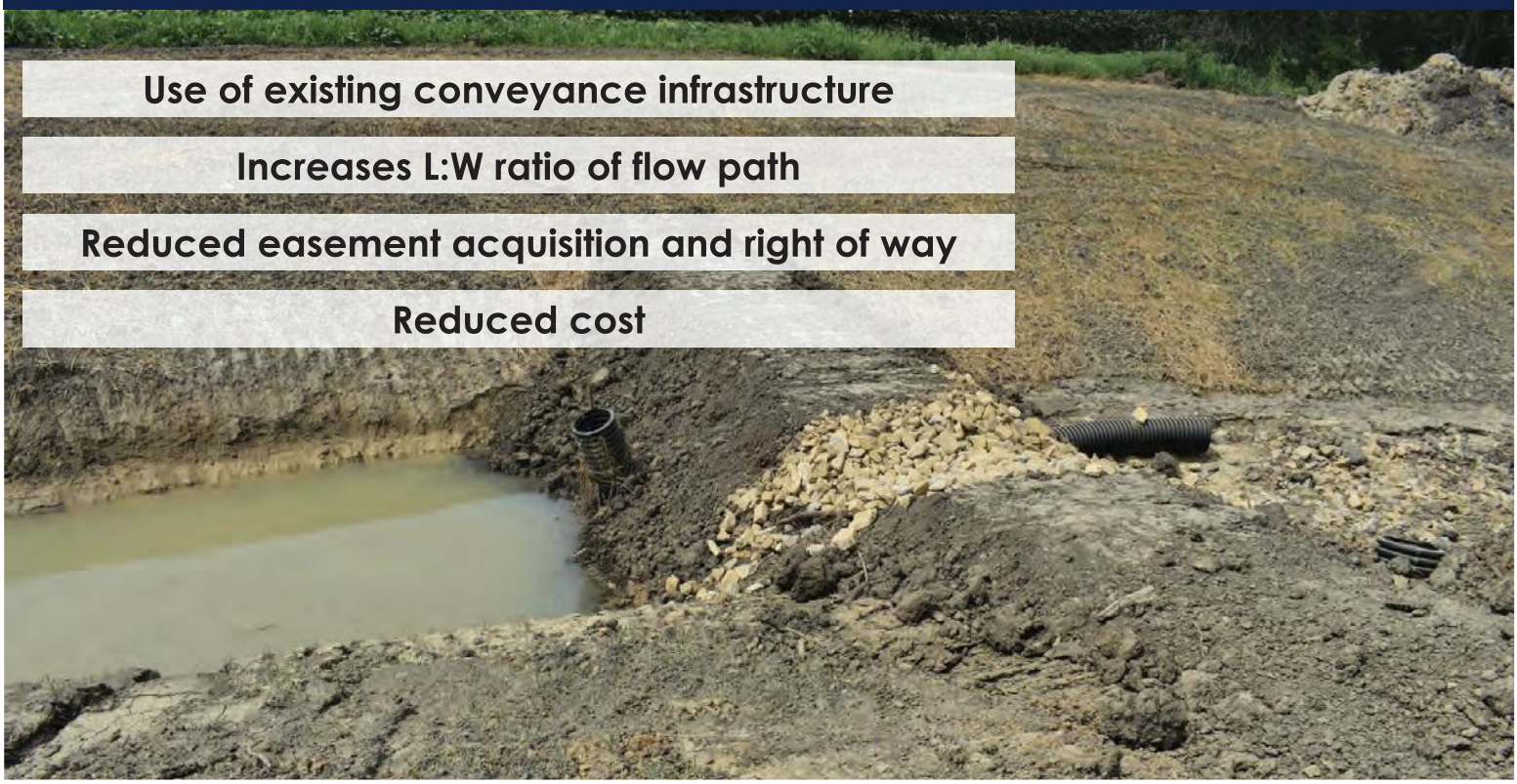



# IOWA DOT SEDIMENT CONTROL BASIN (EC-601)



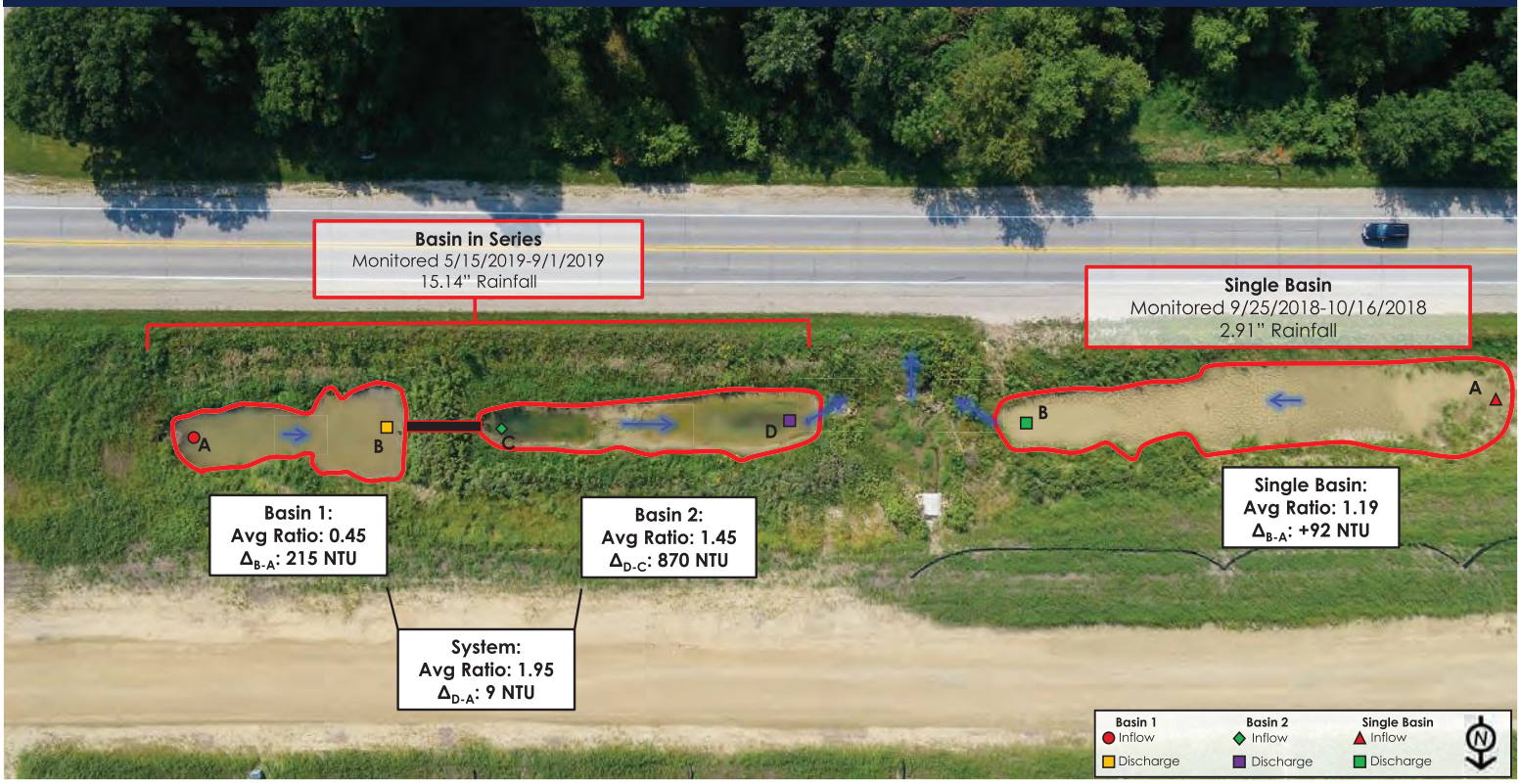
# IOWA DOT SEDIMENT CONTROL BASIN (EC-601)


# IOWA DOT SEDIMENT CONTROL BASIN (EC-601)

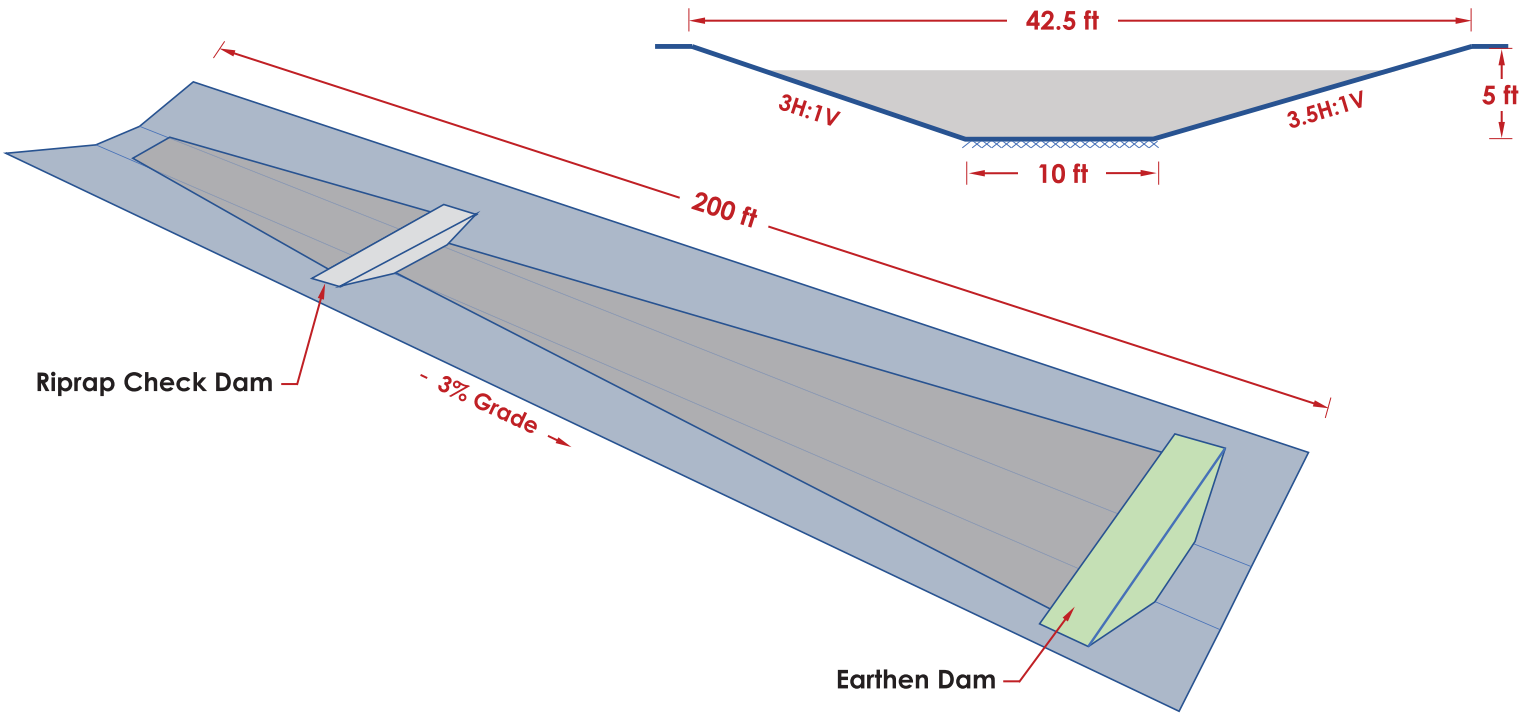


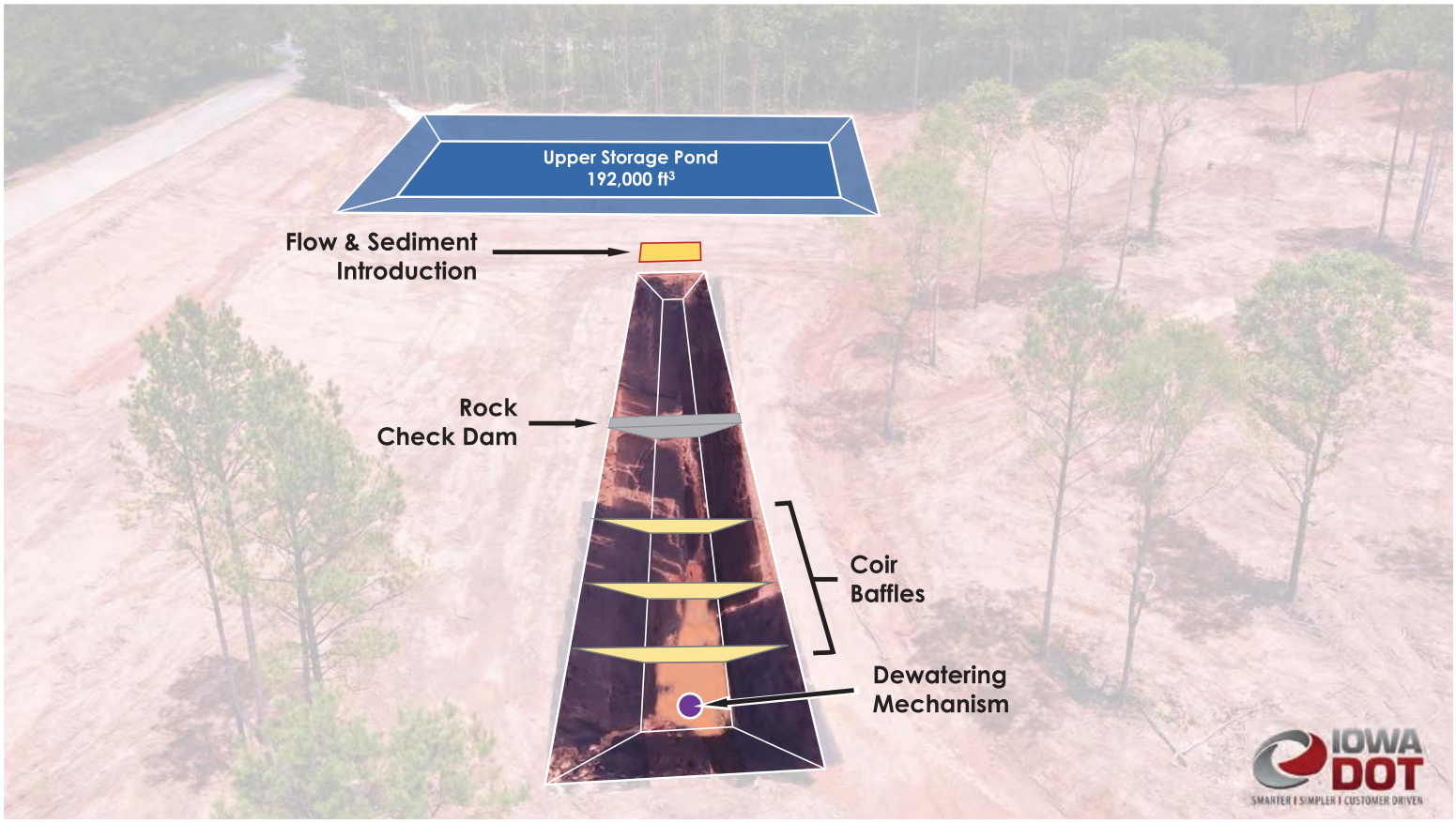
- Use of existing conveyance infrastructure
- Increases L:W ratio of flow path
- Reduced easement acquisition and right of way
- Reduced cost

# BASIN MONITORING - U.S. 30



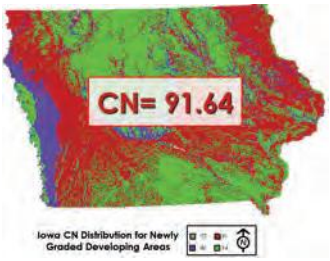

# BASIN DESIGN




# Flow & Sediment Introduction

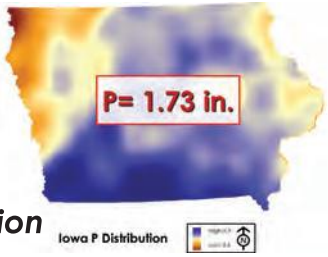
*MUSLE for Soil Introduction*




*1,960 lbs*

*62.7 lbs/min*

*TR-55 for Flow Intro*




*3,053 ft³*

*1.7 ft³/s*

*30 min. duration*


Iowa Soil Delivery

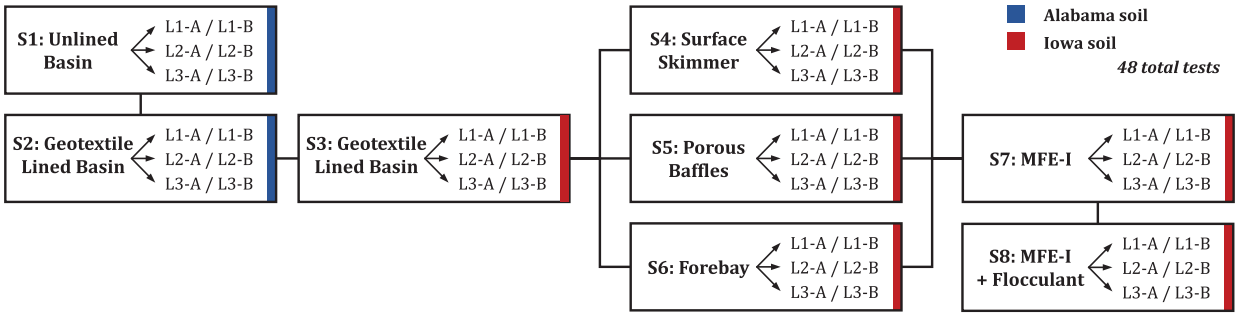

LINING

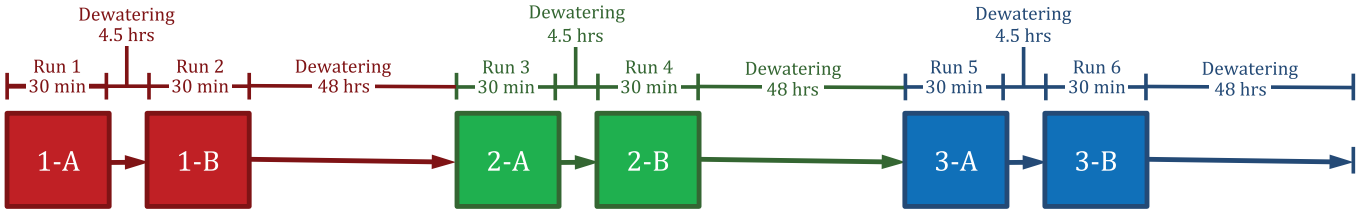

SURFACE SKIMMER


FLOW BAFFLES

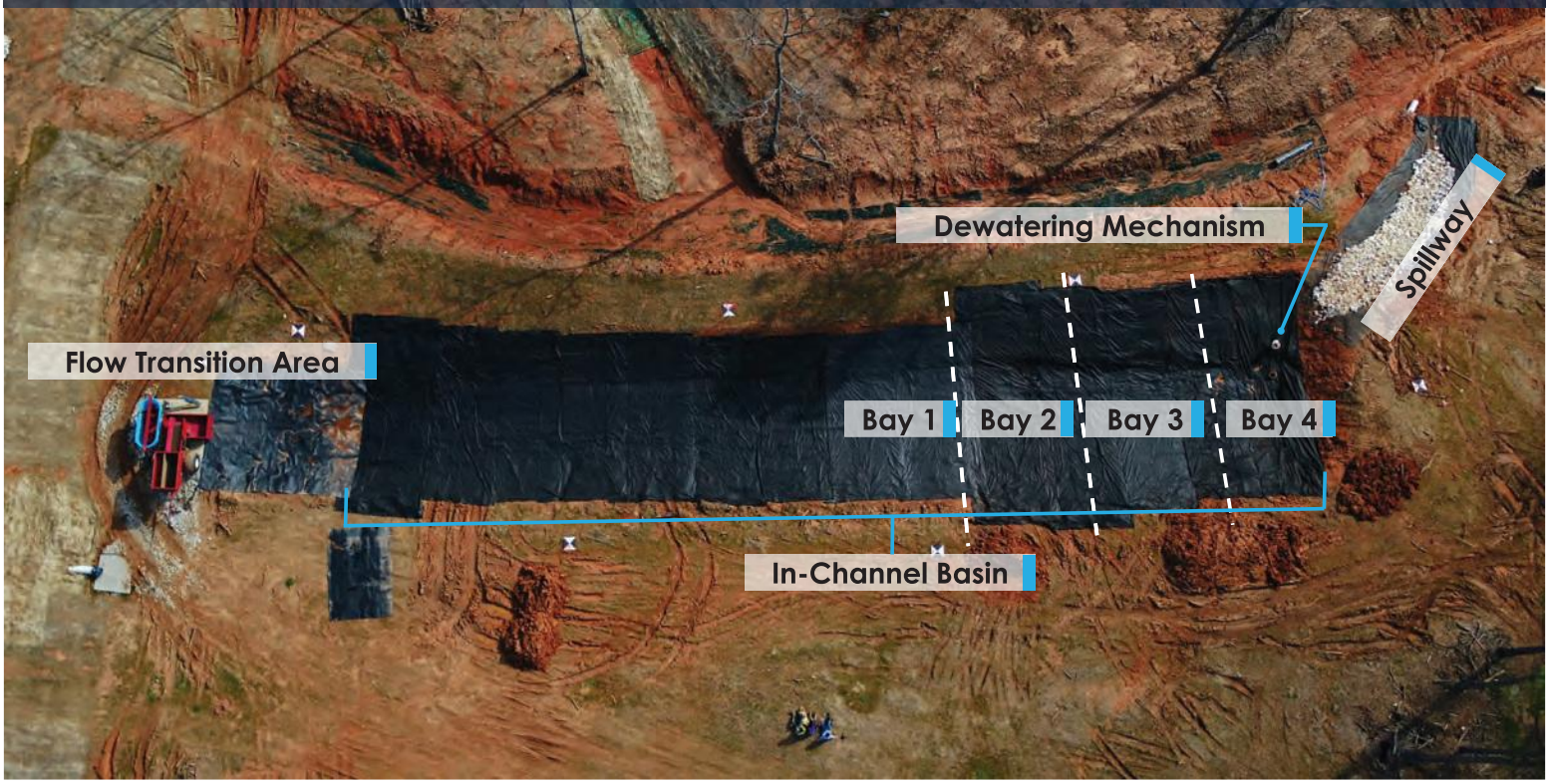

FLOW
FOREBAY

# EXPERIMENTAL TESTING REGIMEN

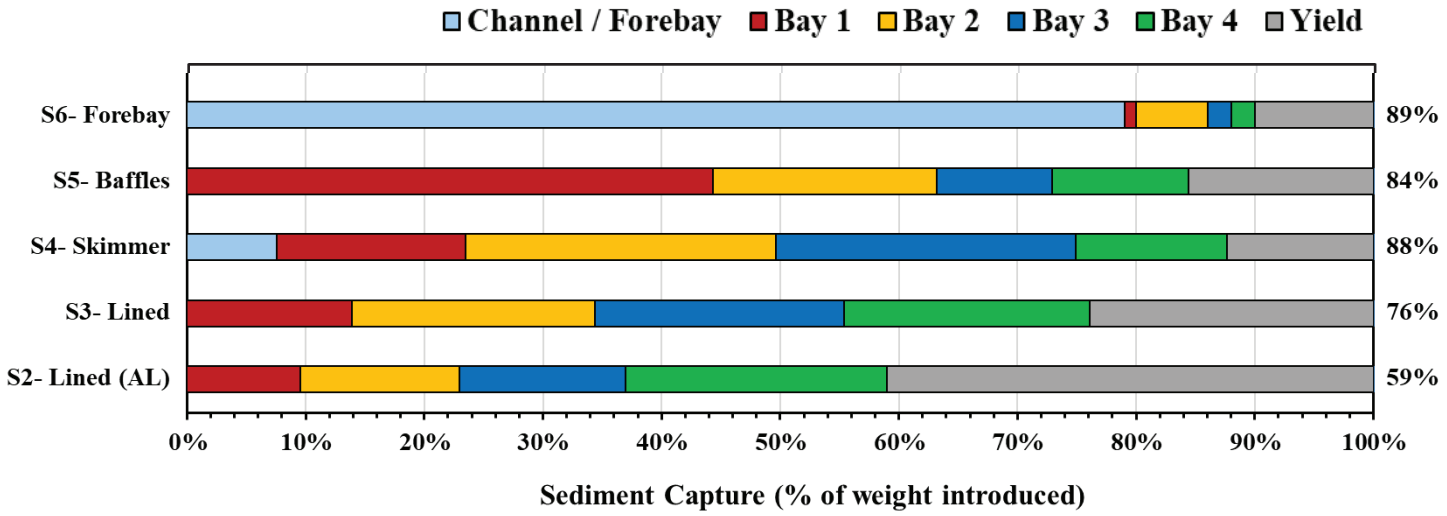


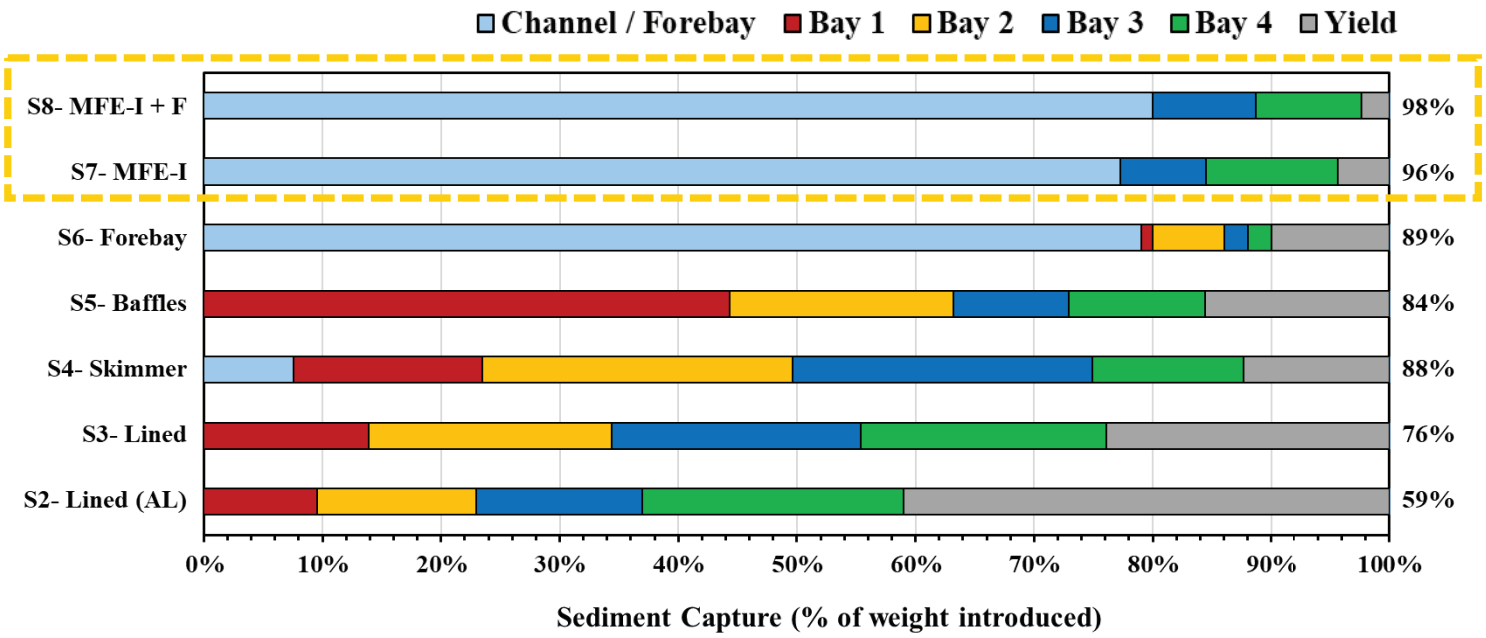

# SEDIMENT BASIN SETUP



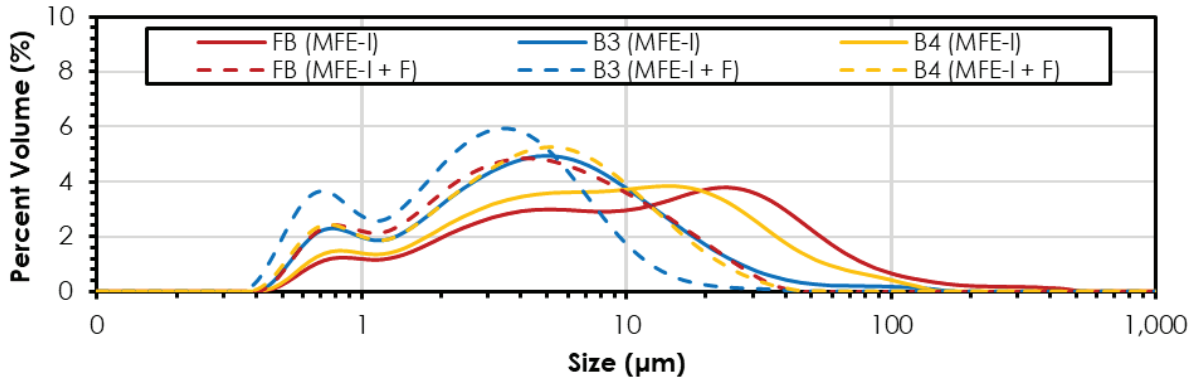
# COMBINED COMPARISON - SEDIMENTATION




# COMBINED COMPARISON - SEDIMENTATION

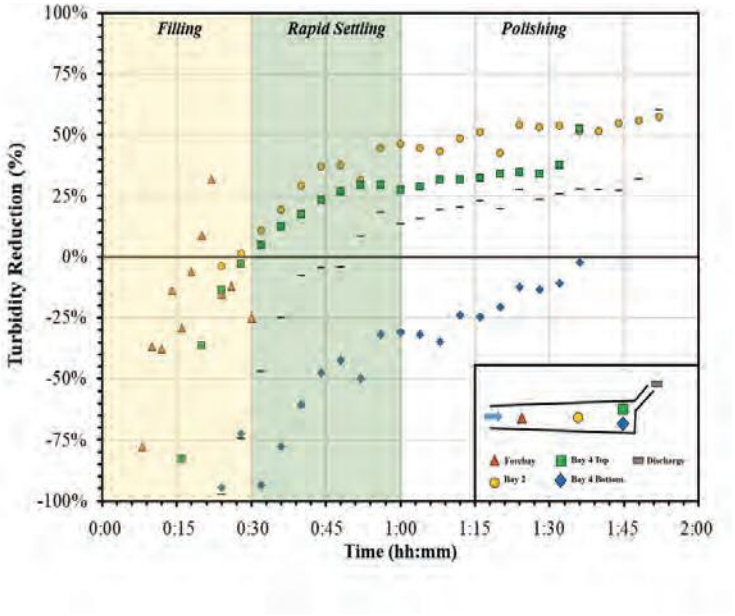


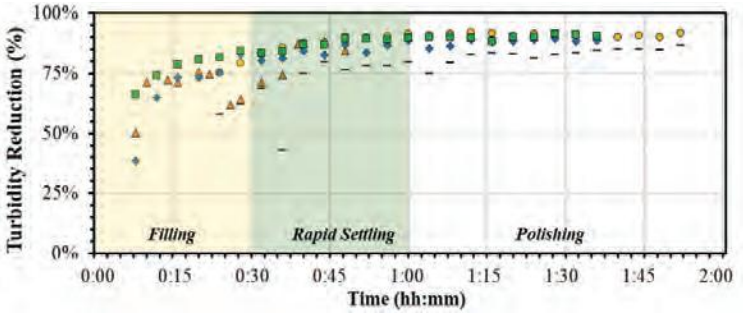

# GRAIN SIZE CAPTURE W/ DISPERSANT




Decreased $D_{50}$ by 51% when flocculant was applied

# TURBIDITY REDUCTION

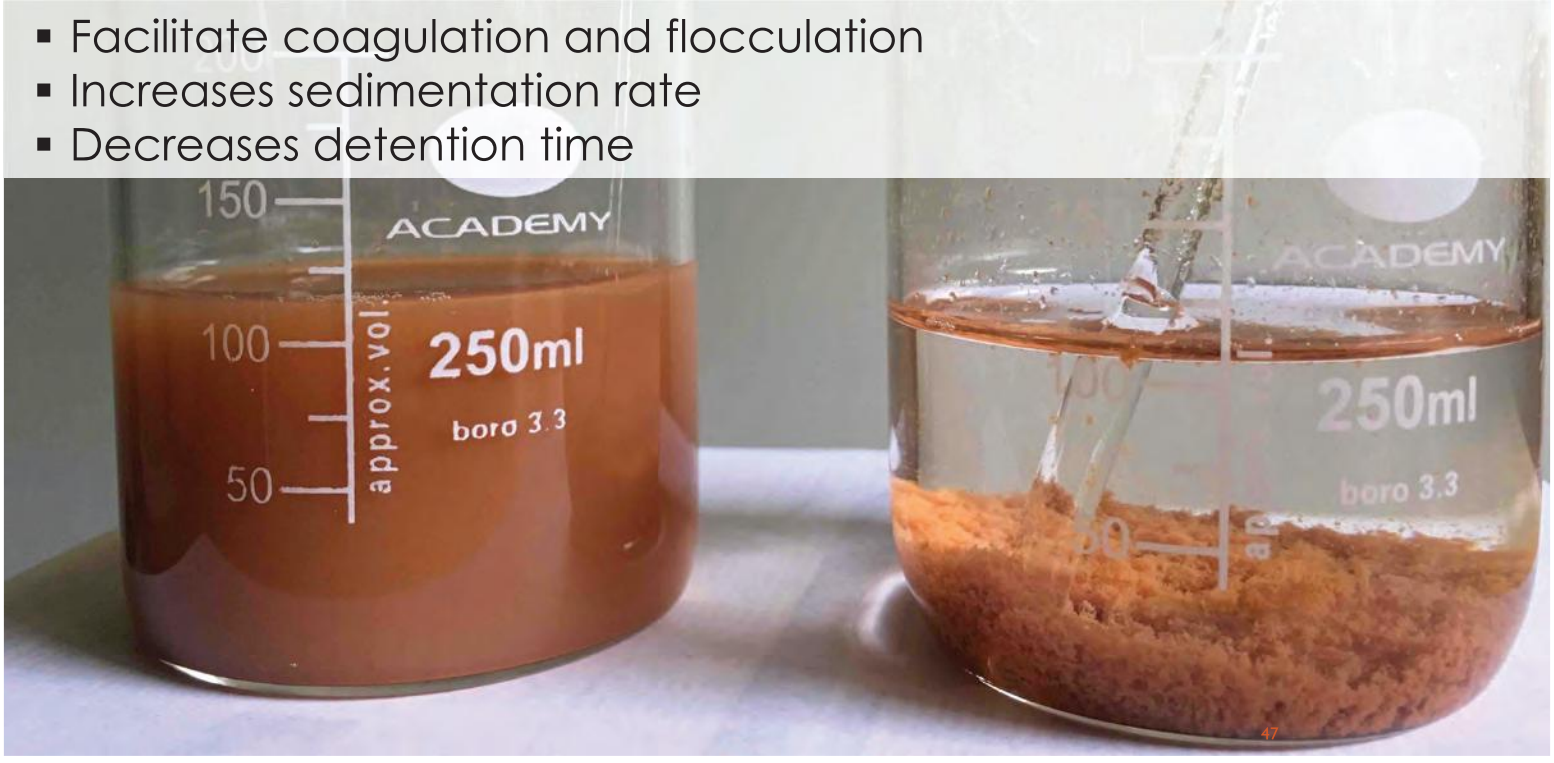


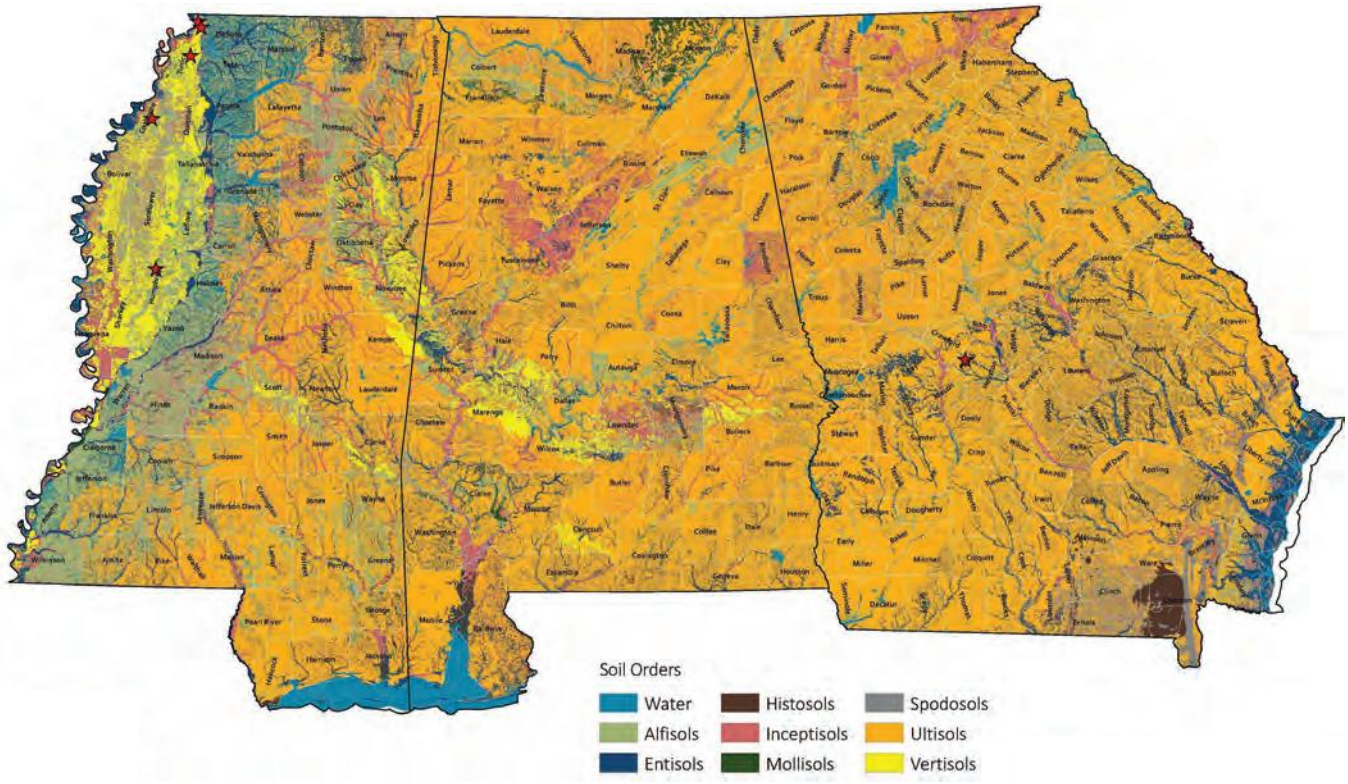

**MFE-I** | **MFE-I + FLOCCULANT**

## Flocculants

- Facilitate coagulation and flocculation
- Increases sedimentation rate
- Decreases detention time



# FLOCCULANTS ARE SOIL SPECIFIC

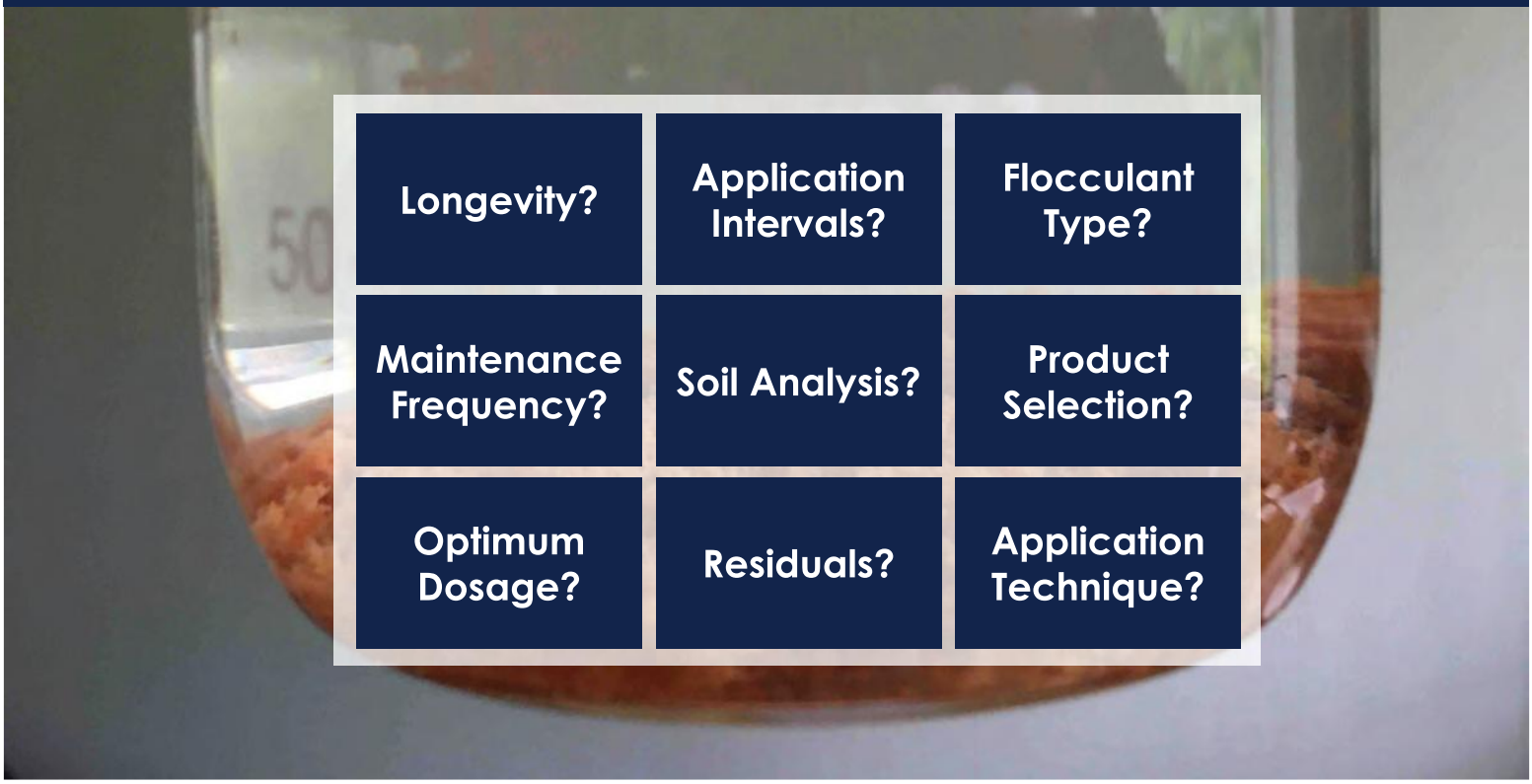



# SOILS VARY ACROSS A SINGLE PROJECT

# CURRENT RESEARCH: FLOCCULANT GUIDANCE

- Develop best practices for use
  - design-based guidance
  - provide more effective and responsible use on job sites
- Performance of market-available products and practices
- Determine optimum dosage requirements and delivery mechanisms

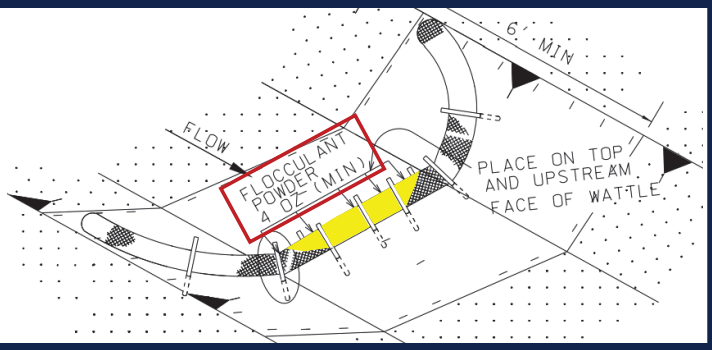

# RESEARCH GOAL: DEVELOP GUIDANCE



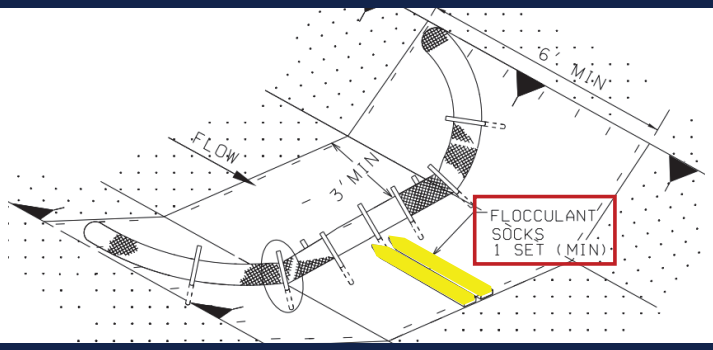
| | | |
|---|---|---|
| Longevity? | Application Intervals? | Flocculant Type? |
| Maintenance Frequency? | Soil Analysis? | Product Selection? |
| Optimum Dosage? | Residuals? | Application Technique? |

# DO CURRENT TECHNIQUES WORK?

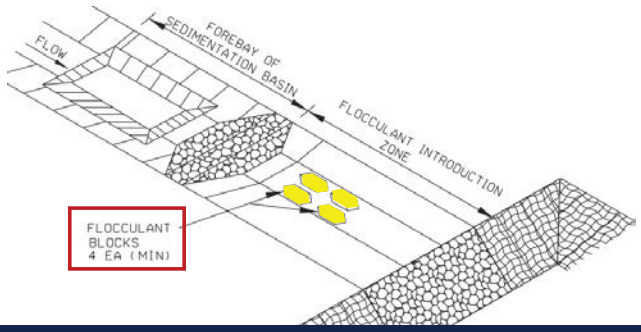
ALDOT IMPLEMENTATION



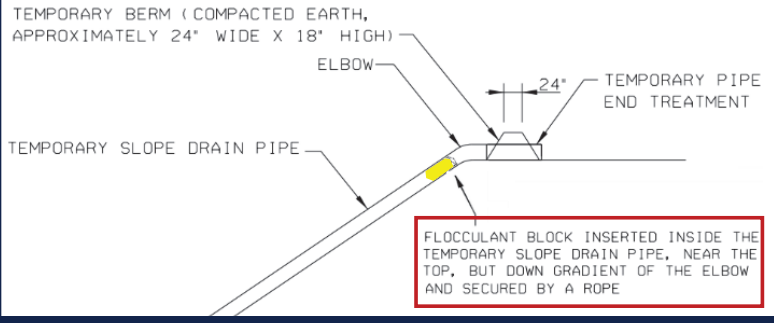

DITCH CHECK - POWDER




DITCH CHECK - SOCK




SEDIMENT BASIN




SLOPE DRAIN

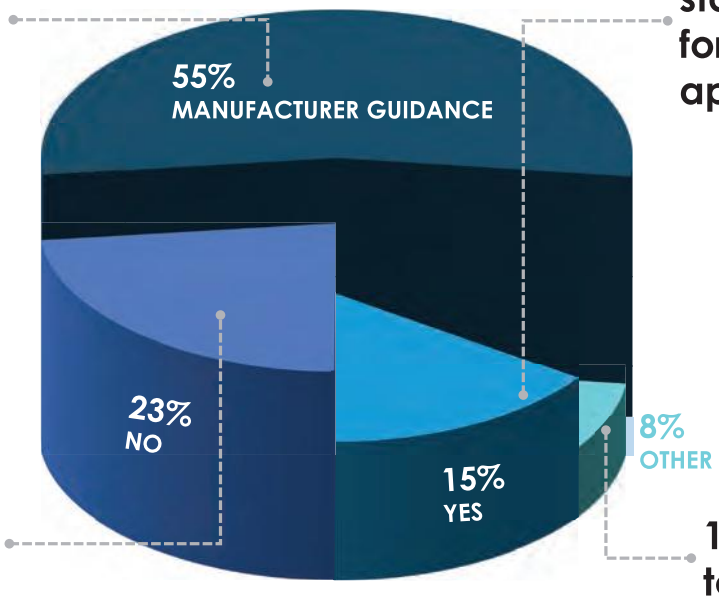
# WHAT ARE OTHER STATE DOTS DOING?

- 39% of DOTs use flocculants
- Main concern: unknown risks posed to receiving waters

## STATES DO NOT HAVE GUIDANCE...

7 DOTs rely on manufacturer guidance for dosage and application rates

2 DOTs have their own standard guidance for dosage and application rates




3 DOTs do not use any guidance for dosage and application rates

1 DOT has toxicology limits

## EXPERIMENTAL APPROACH

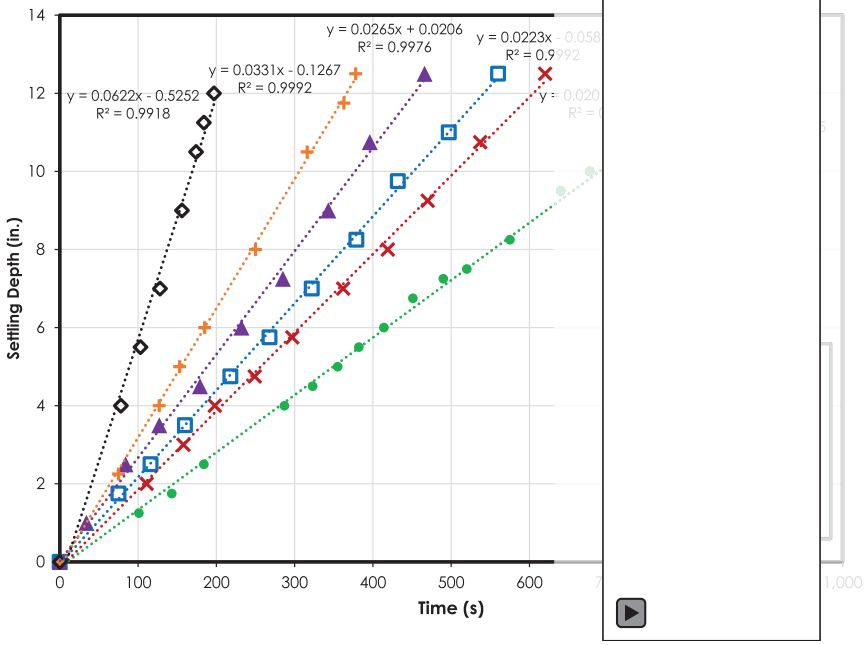
| Experiment | Research Question |
|---|---|
| 1 – Match Tests | Which products / flocculant types work with which soils? |
| 2 – Dosage Tests | What is the optimal flocculant dosage? |
| 3 – Residual Tests | How can we measure concentrations being discharged? |

# DOSAGE TEST – SUPERNATANT

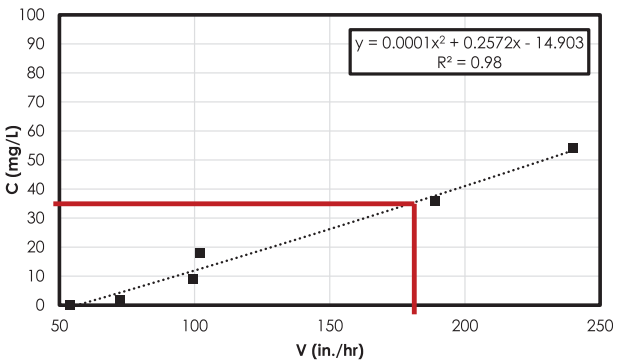

| Dosage | 0 mg/L | 10 mg/L | 20 mg/L | 40 mg/L | 50 mg/L | 100 mg/L |
|---|---|---|---|---|---|---|
| ΔNTU (%) | 72.6 | 98.8 | 97.6 | 97.3 | 97.0 | 96.4 |
| ΔpH | 0.05 | 0.04 | 0.10 | 0.10 | 0.07 | 0.09 |
| Color | Light yellow | Clear | Clear | Clear | Clear | Clear |
| Size Floc | N/A | 0.75-1.0 | 0.75-1.0 | 1.0-1.5 | 1.0-1.5 | 1.0-1.5 |

# 3 - RESIDUAL TESTING METHOD – SETTLING VELOCITY

**Product: B1**




- **Dosage target: 50 mg/L**
- **Residual: 35 mg/L**
- **Residual of application dosage: 70%**



# LARGE SCALE DOSAGE TESTING

# FLOCCULANT INJECTION SYSTEM

# EVALUATION OF EROSION CONTROL PRODUCTS USING RAINFALL SIMULATION

ALDOT
Alabama Department of Transportation

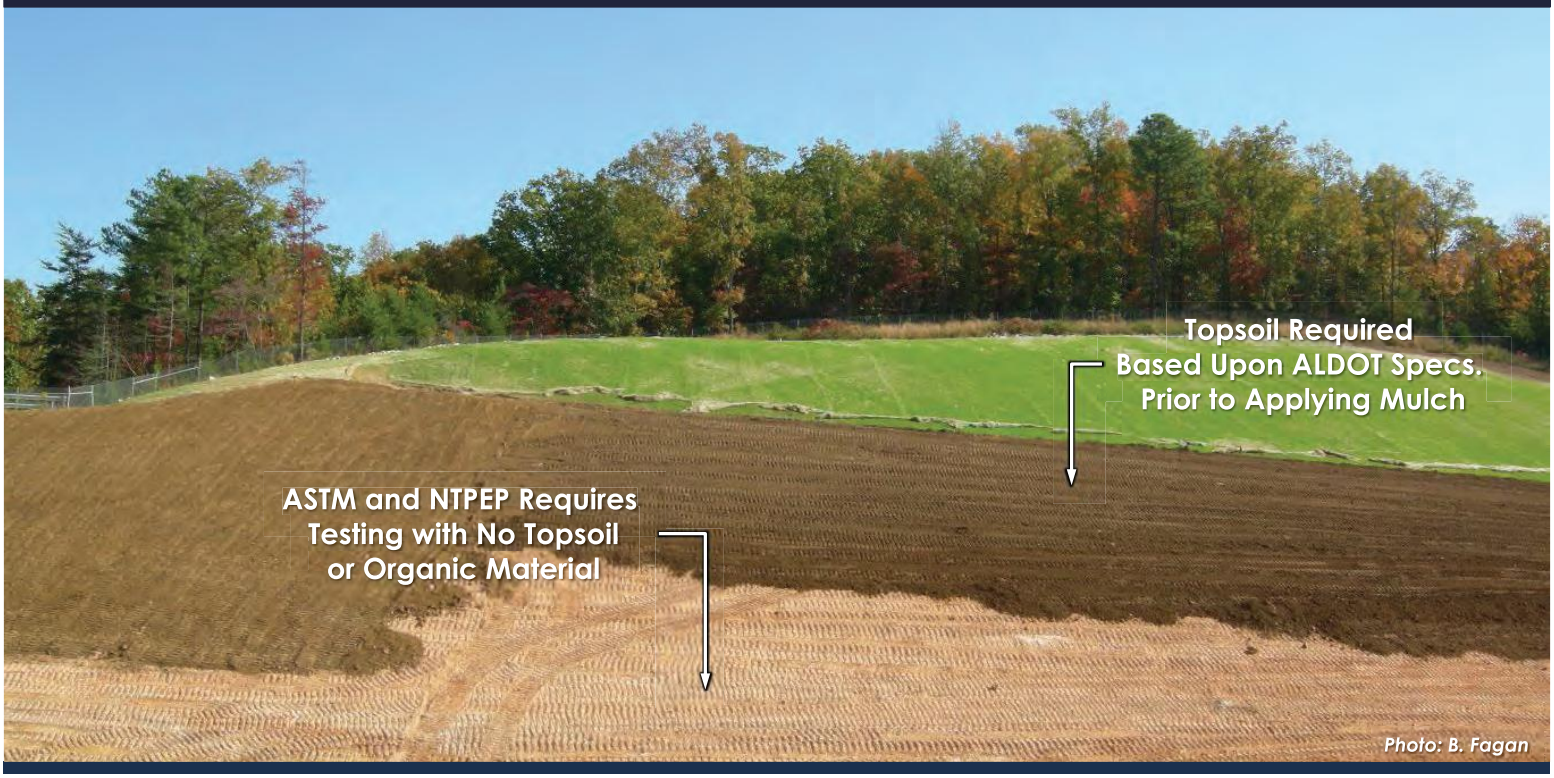

## Objectives

- Design and construct 12 simulators
- Observe various rainfall distributions and erosion patterns
- Develop erosion control techniques

## Features

- 4:1 and 3:1 Slopes
- Benchmark soils for ALDOT sites
- Two sets of portable sprinklers

# TOPSOIL PLACED & TRACKED PRIOR TO EROSION CONTROL




# CURRENT RESEARCH: RAINFALL SIMULATION

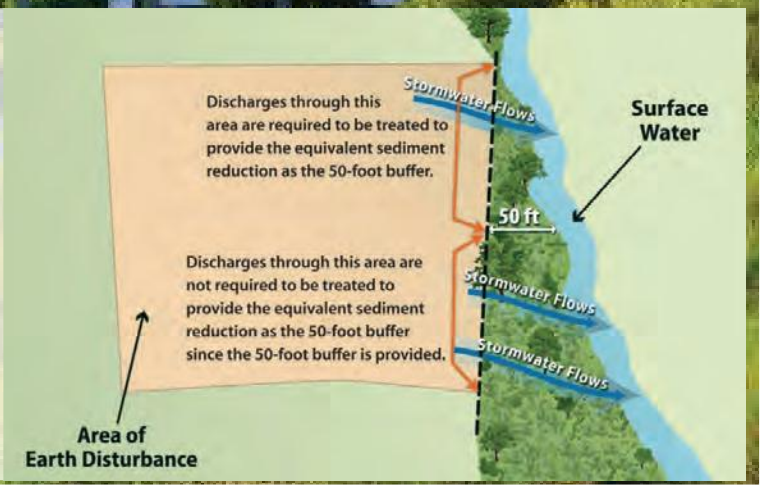
- Varying configurations: slope, soil type, topsoil
- Develop design-based guidance on practice selection

# SEDIMENT BARRIER TESTING


## 50 FT BUFFER REQUIREMENT – NDEE & U.S. EPA

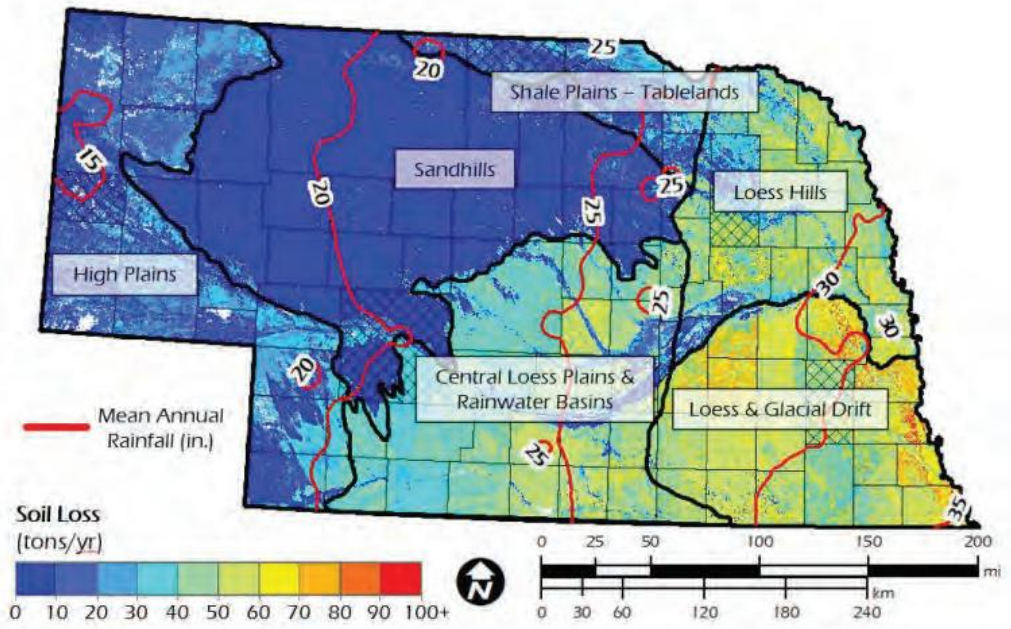
**A 50 ft buffer is required between construction activity and WOTUS. If infeasible, then BMPs must achieve equivalent stormwater treatment to a 50 ft buffer.**

- **Option 1:** 50 ft buffer
- **Option 2:** >50 ft buffer + additional E&SCs
  - Together achieves sediment load reduction of a 50 ft buffer
- **Option 3:** E&SCs that achieve sediment load reduction equivalent of a 50 ft buffer

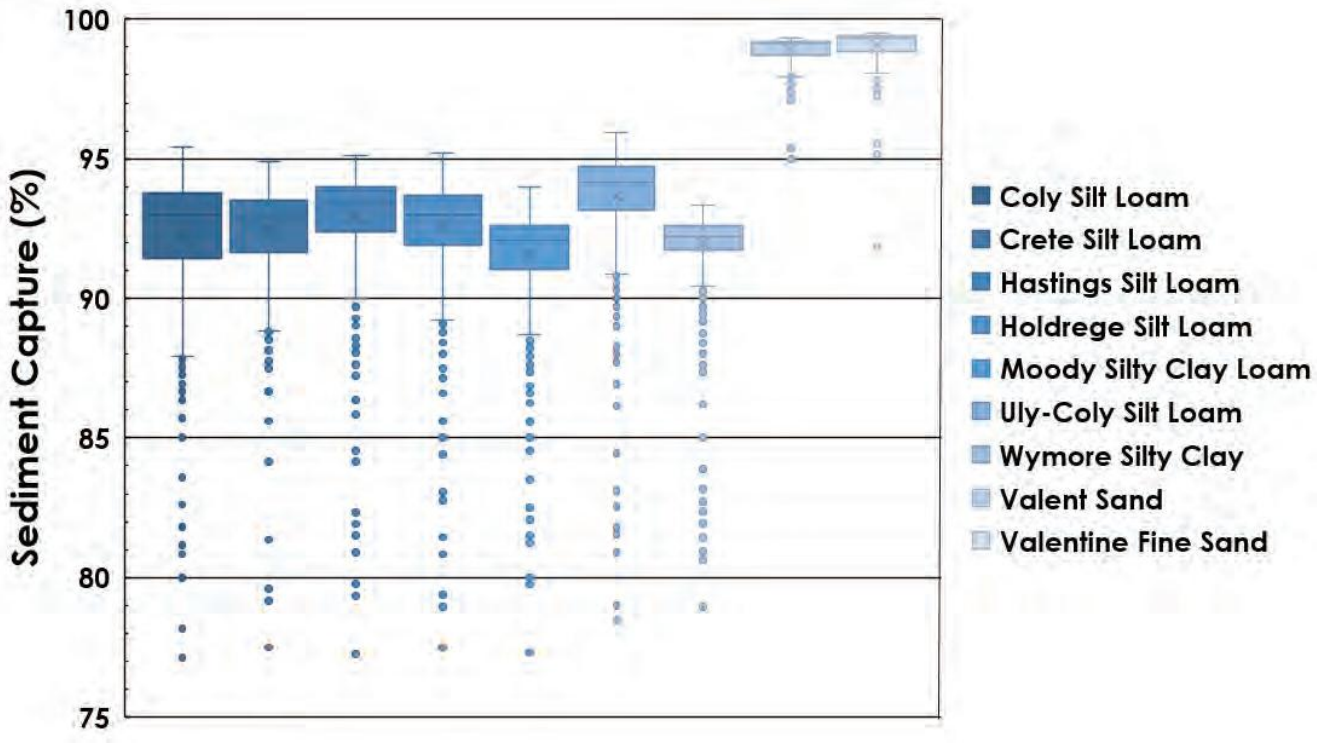


# BUFFER EFFICIENCY

- RUSLE2 modeling
- Factors representative of 6 NDOT Landscape Regions
- Varying soil loss risk and rainfall

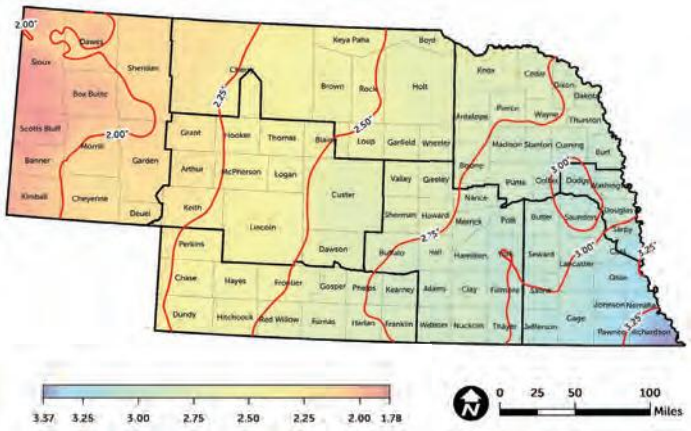



# CAPTURE BY SOIL SERIES



# LARGE-SCALE TESTING METHODOLOGY

- Flow and sediment introduction rate calculated based on common conditions observed on NDOT construction sites
- Modified ASTM D7351-13 Testing Apparatus




# SILT FENCE: SEDIMENT RETENTION

- 82% sediment deposited upstream on average
- Removed and weighed for analysis

# SLASH MULCH BERM MODIFICATION

- 18 in. tall, 3 ft wide, compacted in 6 in. lifts
- To facilitate more impoundment while using less material

# SLASH MULCH BERM MODIFICATION

- Higher impoundment than standard (2 in. more than baseline)
- Lower flow-through rate than standard
  - 17% lower average flow rate into catch basin
- 85.4% of sediment captured upstream, 0.4% captured in catch basin downstream
- Decreased impoundment and discharge turbidity and TSS compared to standard

| | |
|---|---|
| Water Surface of Impoundment Turbidity (NTU) | 7,470 |
| Bottom of Impoundment Turbidity (NTU) | 864.4 |
| Discharge Turbidity (NTU) | 490.0 |
| Difference: Bottom of Impoundment vs. Discharge | 43.3% |
| Water Surface of Impoundment TSS (mg/L) | 7,944 |
| Bottom of Impoundment TSS (mg/L) | 3,913 |
| Discharge TSS (mg/L) | 628 |
| Difference: Bottom of Impoundment vs. Discharge | 83.0% |

# IMPOUNDMENT VS. FILTRATION

# FINAL STABILIZATION


# KEY CHALLENGES

## ALDOT UAS FLIGHTS

- Pre-construction flight
- 6 week intervals during construction
- Post-construction flight

- 3D model captured at 1,000 ft intervals throughout corridor
- Drone deploy software

## RESEARCH OBJECTIVE

- Develop methodology using UASs that ALDOT inspectors can use to determine and document vegetative establishment on constructions sites

- Verify stabilization and vegetation requirements have been met prior to suspension of permit coverage

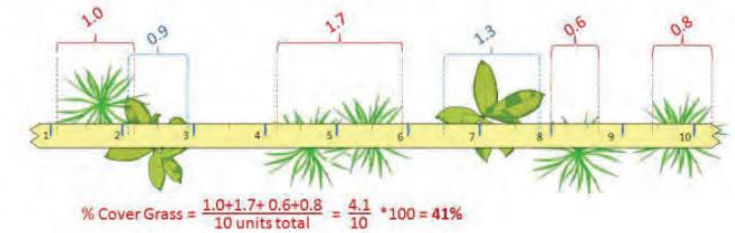
## VEGETATION COVER

**Basal Cover**
Portion of plant that grows into soil surface

**Canopy Cover**
Area below plant that covers soil surface.

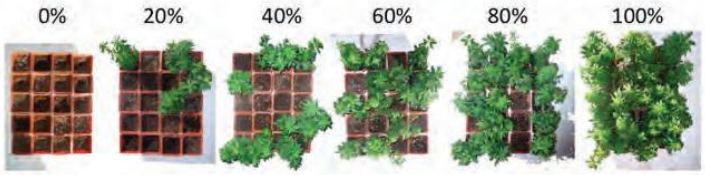
**Foliar Cover**
Soil surface with leaves direction above, not including space between leaves

## LINE TRANSECT METHOD




$$\% \text{ Cover Grass} = \frac{1.0+1.7+0.6+0.8}{10 \text{ units total}} = \frac{4.1}{10} * 100 = 41\%$$

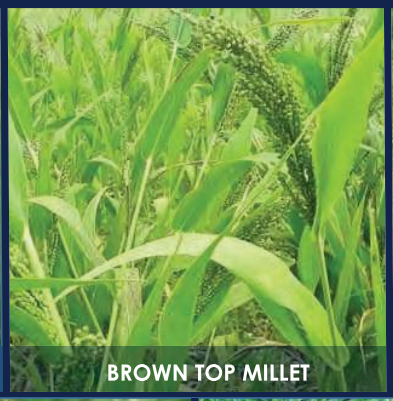
## QUADRAT METHOD

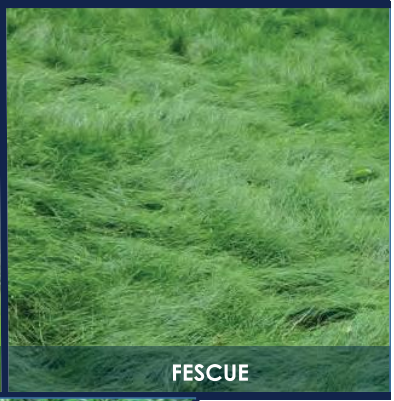


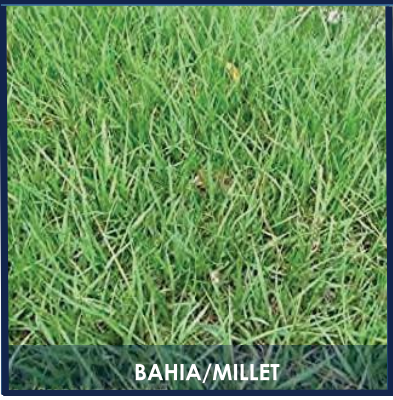

# SPECIES SELECTION


BERMUDA


BAHIA


BROWN TOP MILLET

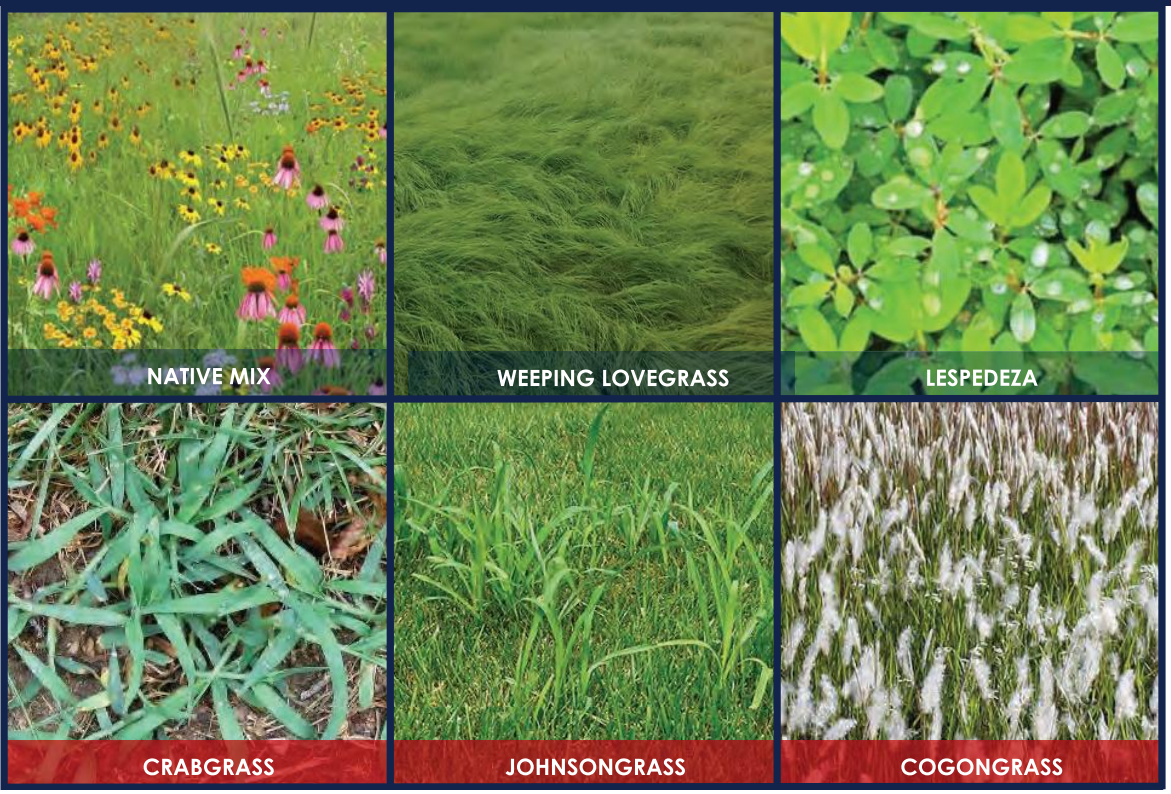

FESCUE


BAHIA/MILLET


ANNUAL RYEGRASS


ALDOT MIX

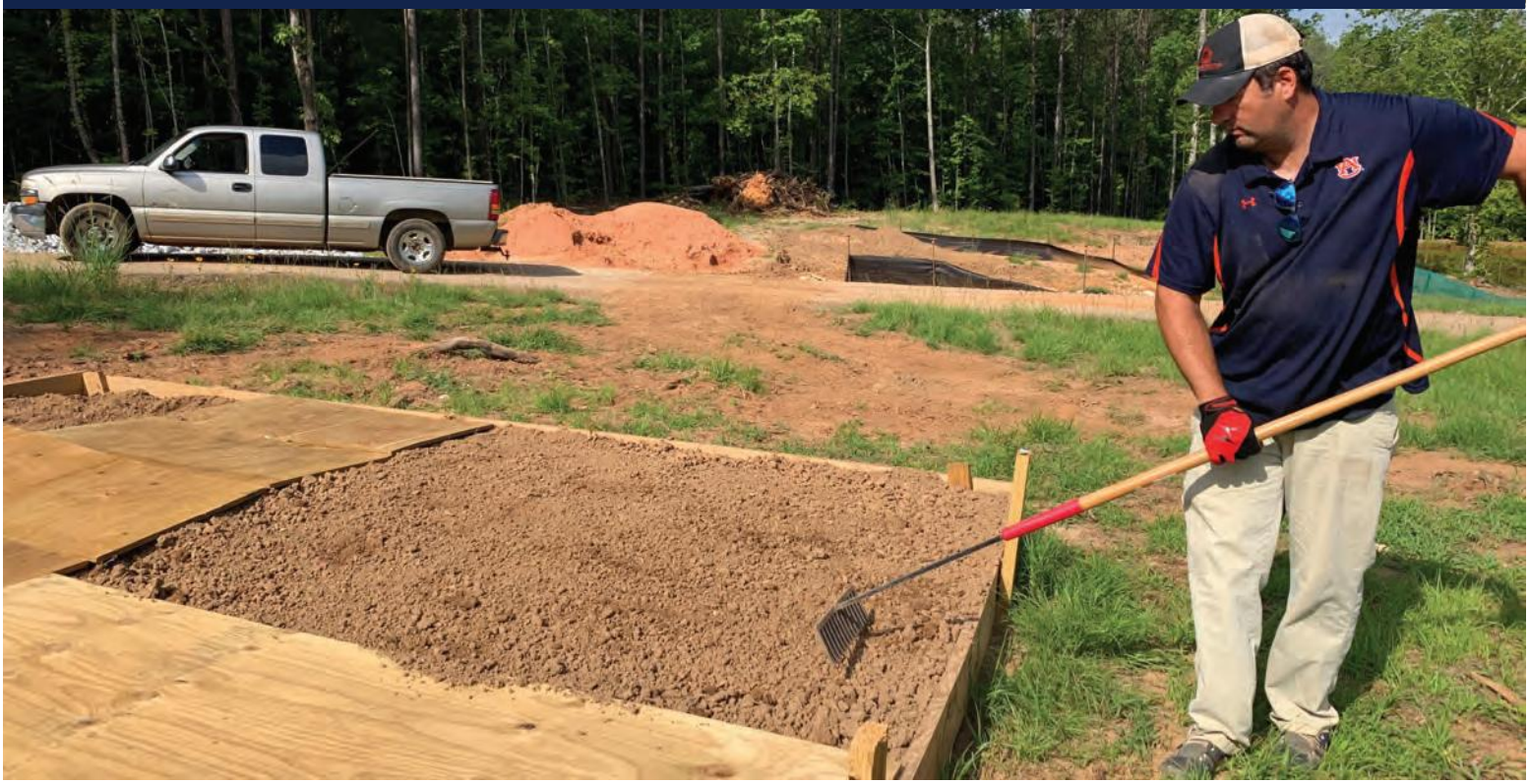
# SPECIES SELECTION



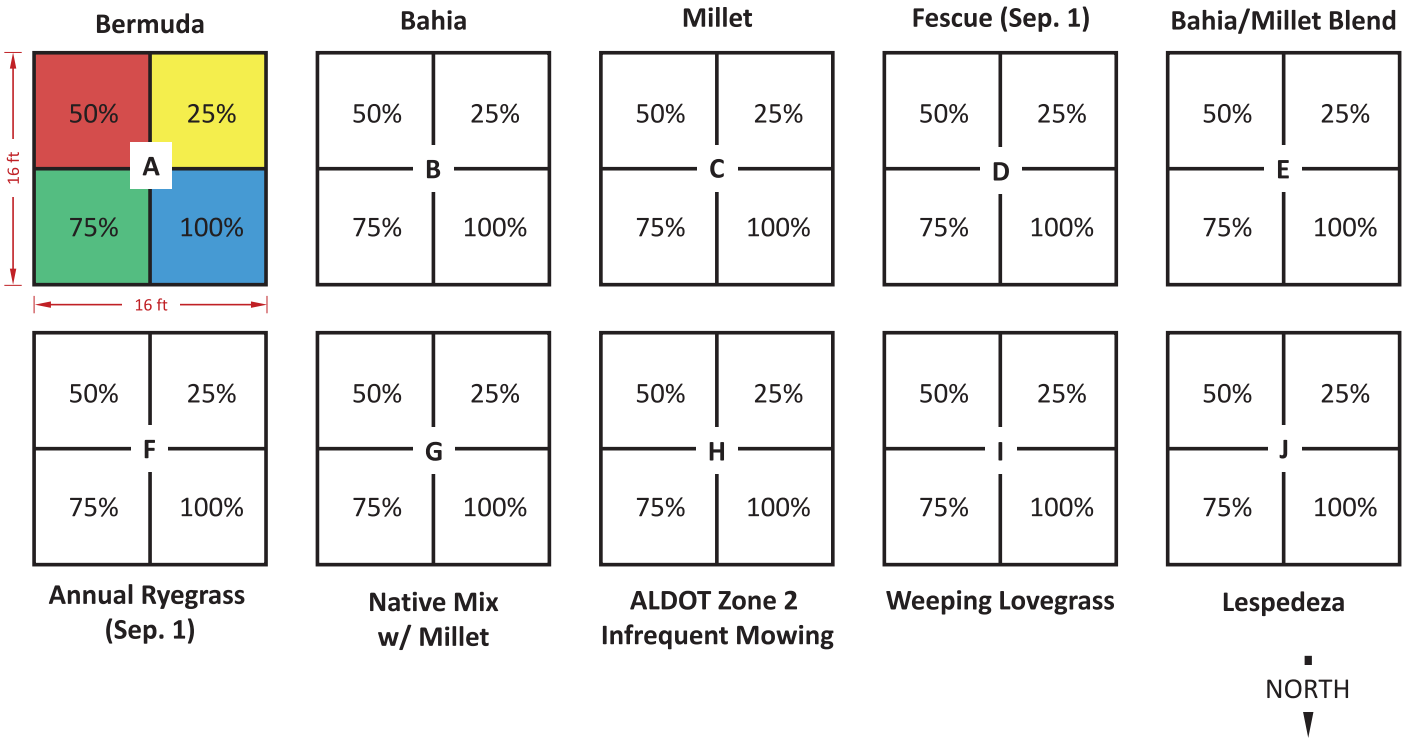

# TEST PLOT CONSTRUCTION

# TEST PLOT CONSTRUCTION

# TEST PLOT CONSTRUCTION



# TEST PLOT CONSTRUCTION




# ALDOT ROADSIDE MIX

**ZONE 2 - AREAS NOT SUBJECT TO FREQUENT MOWING**
REQUIRED POUNDS PER ACRE {KILOGRAMS PER HECTARE} OF PURE LIVE SEED

| Date of Planting | Jan. 1 to Feb. 15 | Feb. 16 to Aug. 31 | Sept. 1 to Nov. 15 | Nov. 16 to Dec. 31 |
|---|---|---|---|---|
| Annual Ryegrass | 10 {11} | 5 {6} | 10 {11} | 10 {11} |
| Hulled Bermudagrass | | 18 {20} | 12 {13} | |
| Unhulled Bermudagrass | 24 {27} | 12 {13} | 12 {13} | 24 {27} |
| Tall Fescue | 29 {33} | | 35 {39} | 29 {33} |
| Weeping Lovegrass | | 2 {2} | 2 {2} | |
| Annual Lespedeza (Kobe) | | 50 {56} | | |
| Reseeding Crimson Clover | 29 {33} | | 29 {33} | 29 {33} |
| Pensacola Bahia Grass | 29 {33} | 29 {33} | 29 {33} | 29 {33} |
| Required Permanent Plant | Mixed | | | |

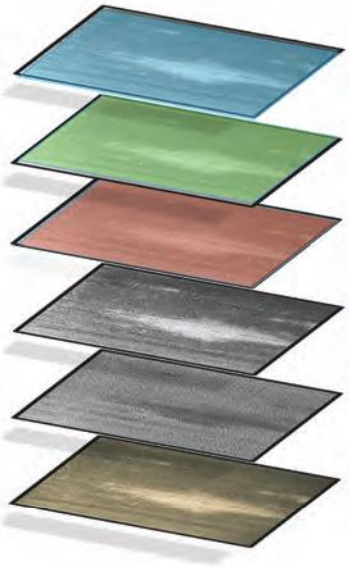

J
Lespedeza
25%
J
Lespedeza
50%
J
Lespedeza
75%
J
Lespedeza
100%

# TASK 3: DEVELOP UAS INSPECTION METHODS

**Flights at 60 ft AGL**

**DJI Matrice 600 Pro**


**Headwall Nano Hyperspec**
400-1000 nm Spectral range
272 spectral bands
640 spatial bands



**Sentera 6X Multispectral Sensor**
5X 3.2MP Monochrome Global Shutter
1X 20MP RGB Electronic Rolling Shutter

# TASK 3: DEVELOP UAS INSPECTION METHODS

## Skydio2 Autonomous Drone

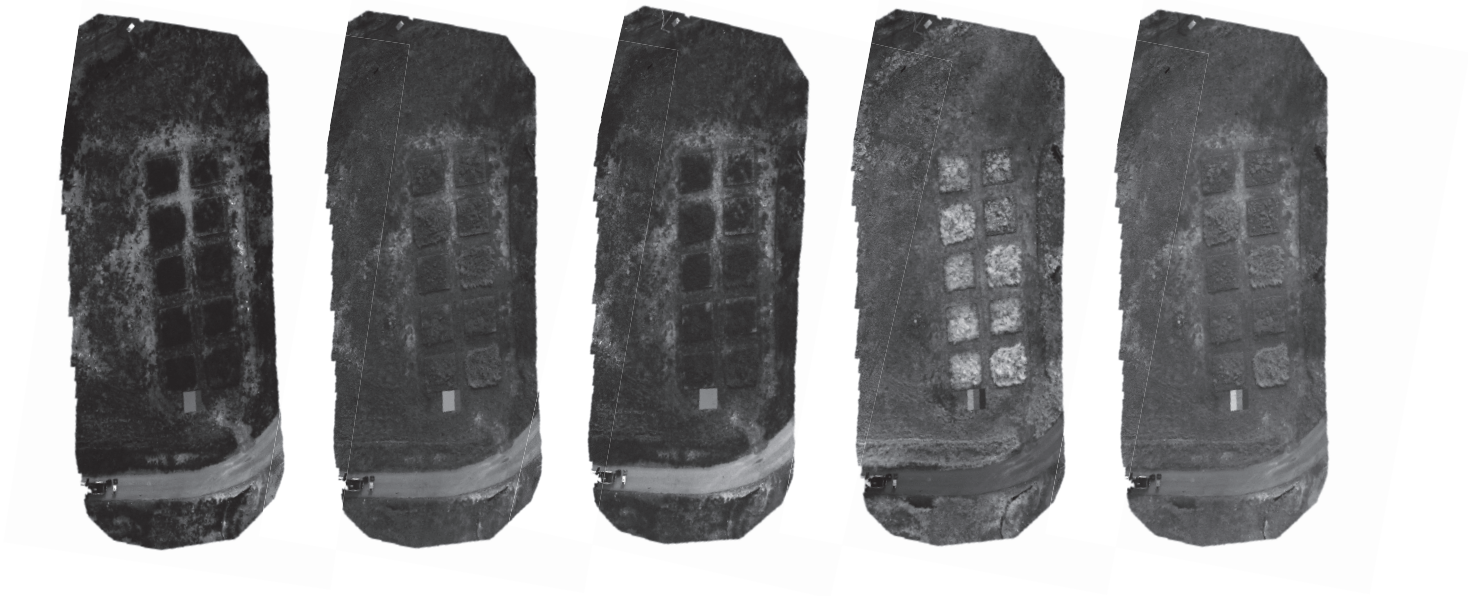
- Flights at 10 ft AGL
- 12.3 MP CMOS sensor
- Used for close-up imaging

# DEVELOP UAS INSPECTION METHODS

- Aerial inspection trials using various sensors and flight altitudes at AU-SRF plots
- Sensors: RGB, multispectral, & hyperspectral
- Flights at 10 ft and 60 ft AGL
- Post-processing
  - QGIS, ESRI ArcMap, Pix4DMapper™ (multispectral & thermal images) & Hyperspec III (hyperspectral images)
  - Compute vegetation indices (NDVI, NDRE)
- Train machine/deep learning models for composition assessment

# VEGETATIVE ESTABLISHMENT INSPECTIONS

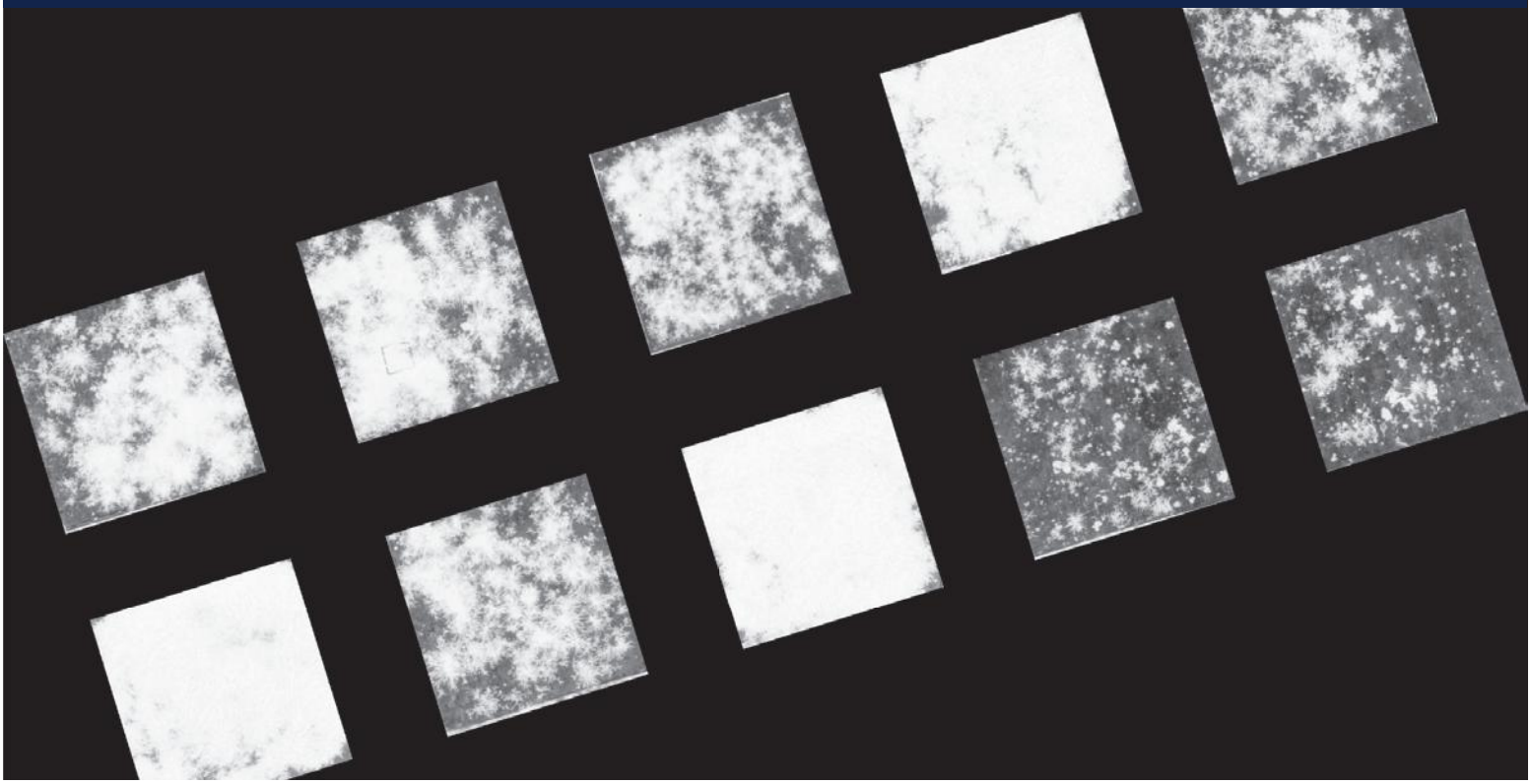
# AERIAL RGB IMAGES TAKEN BY 6X MULTISPECTRAL



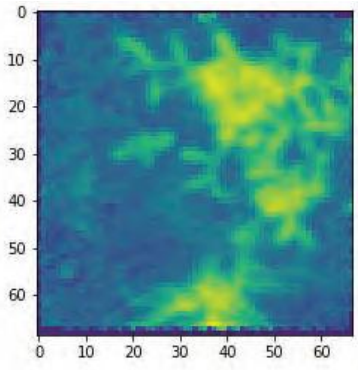
RED | GREEN | BLUE | NIR | RED EDGE

# GRID LAYOUT FOR MULTISPECTRAL SENSOR

# NDVI MAPPING

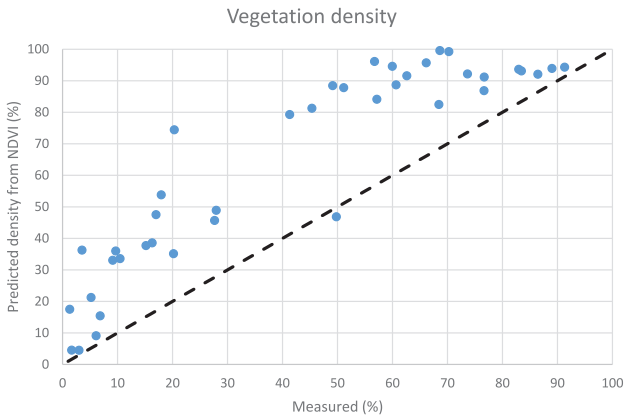


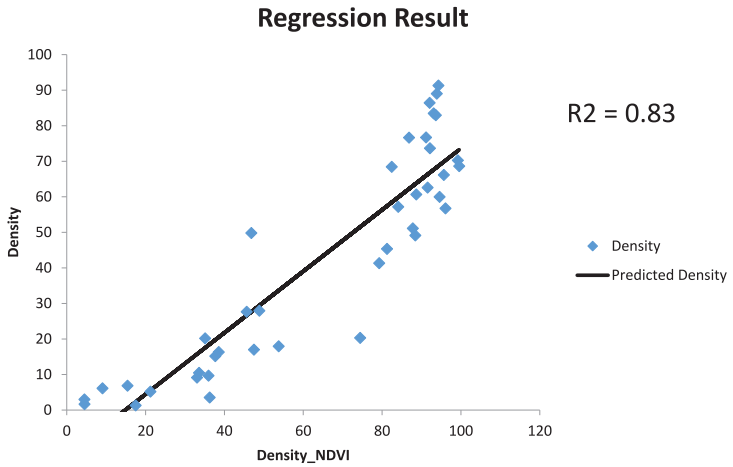
# TILE EXTRACTION


0
10
20
30
40
50
60
0
10
20
30
40
50
60


H_I_44

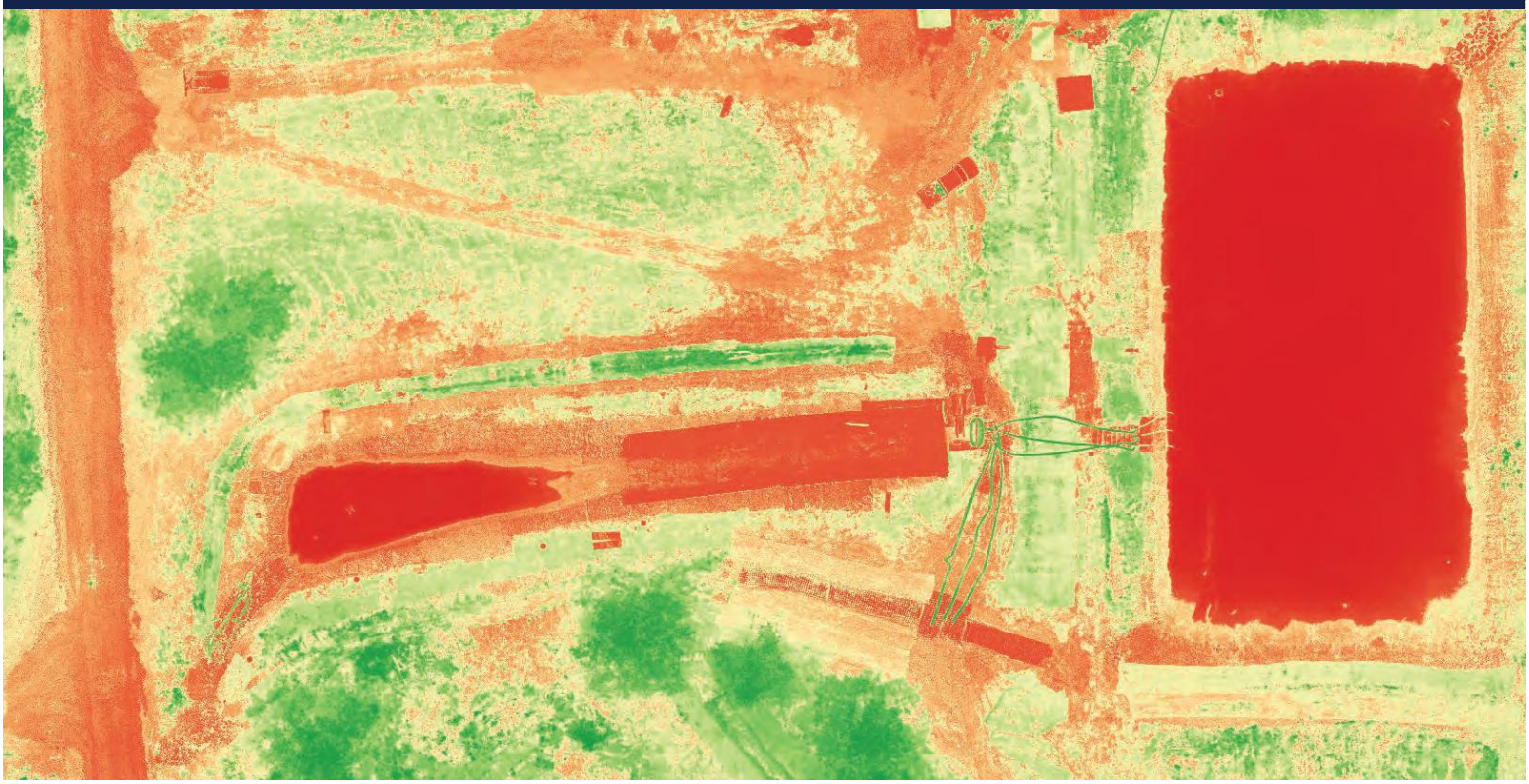

45% COVER
H_I_44

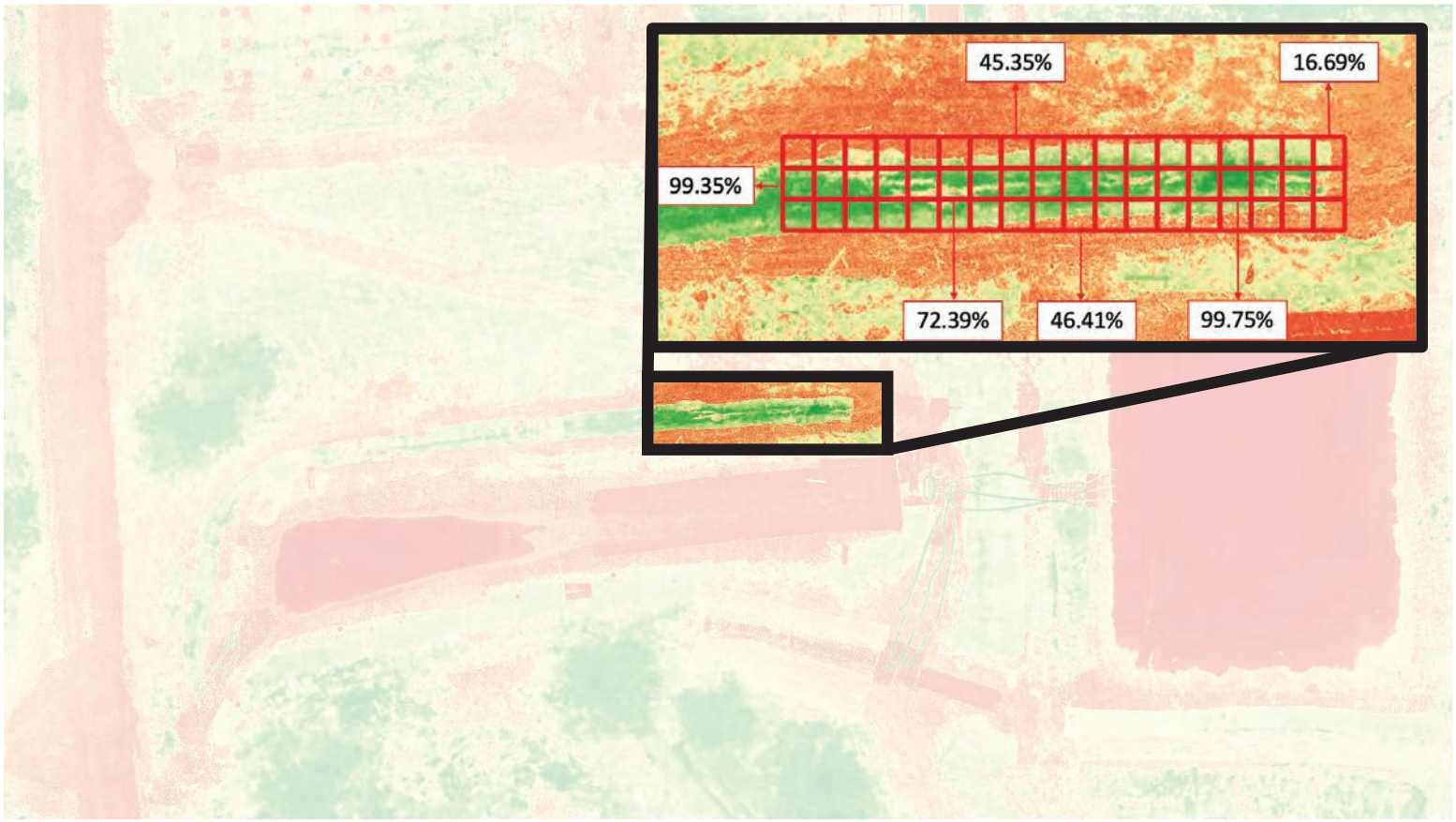

Vegetation density
Predicted density from NDVI (%)
Measured (%)
0
10
20
30
40
50
60
70
80
90
100


Regression Result
Density
Density_NDVI
R2 = 0.83
Density
Predicted Density
0
10
20
30
40
50
60
70
80
90
100
120

# CASE STUDY

# CASE STUDY




45.35%
16.69%
99.35%
72.39%
46.41%
99.75%

## EXPECTED OUTCOMES & BENEFITS

**Provide proper documentation of vegetative establishment**

- Ensure proper vegetative species
- Early detection of problematic areas
- Minimize vegetation maintenance
- Reduce CGP coverage duration
- Resolve disputes with seeding contractors

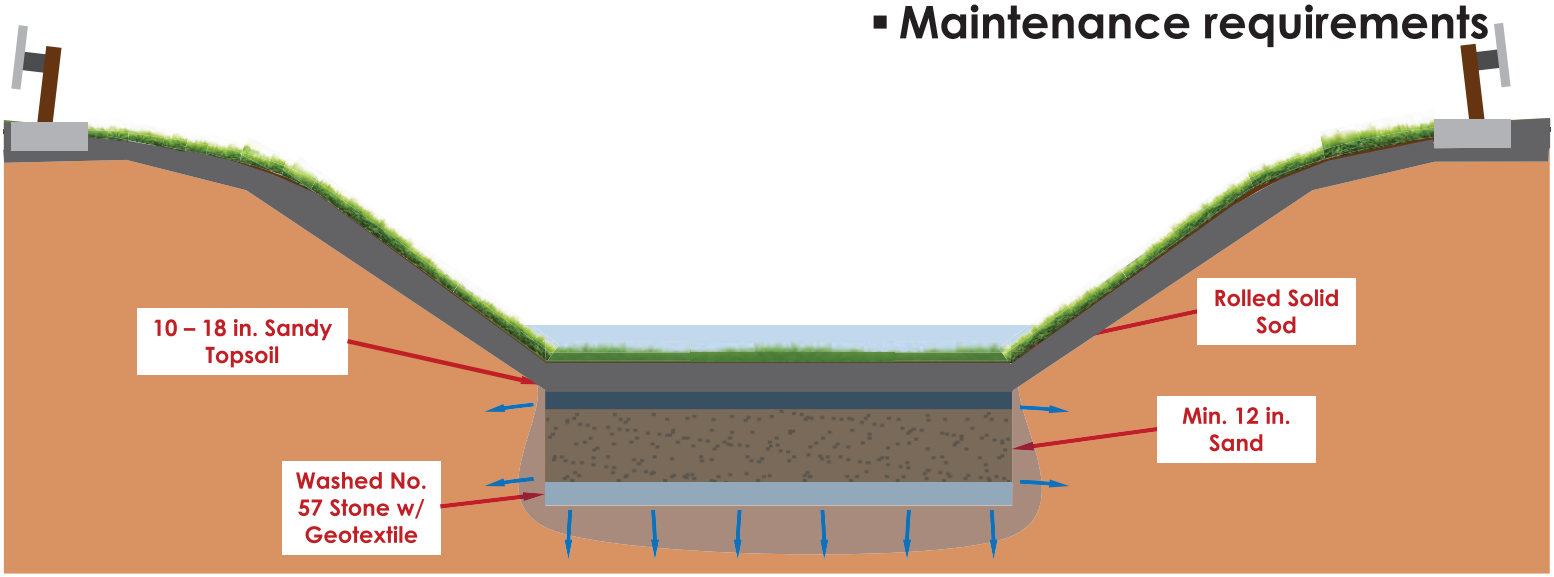
**Reduce I&M costs and permit liability**

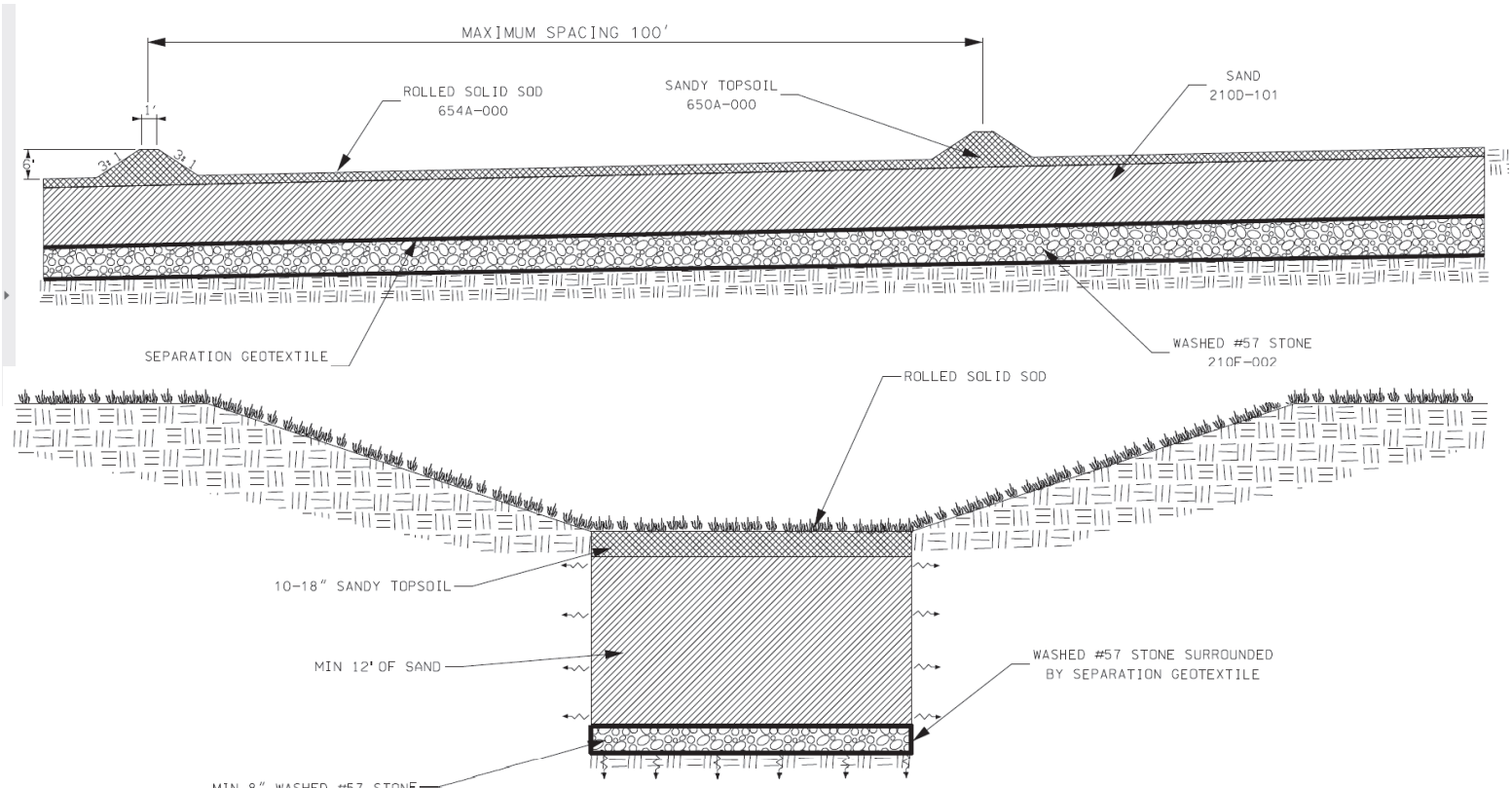
# EVALUATE SMALL-SCALE SEDIMENT BASIN CONFIGURATIONS

# INFILTRATION SWALES

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

- Material limitations
- Infiltration rates
- Flow rates
- Degradation
- Maintenance requirements






# ALDOT Standard Design

# PRODUCT EVALUATION

**Conduct third-party, independent, performance-based testing to evaluate manufactured devices/practices**

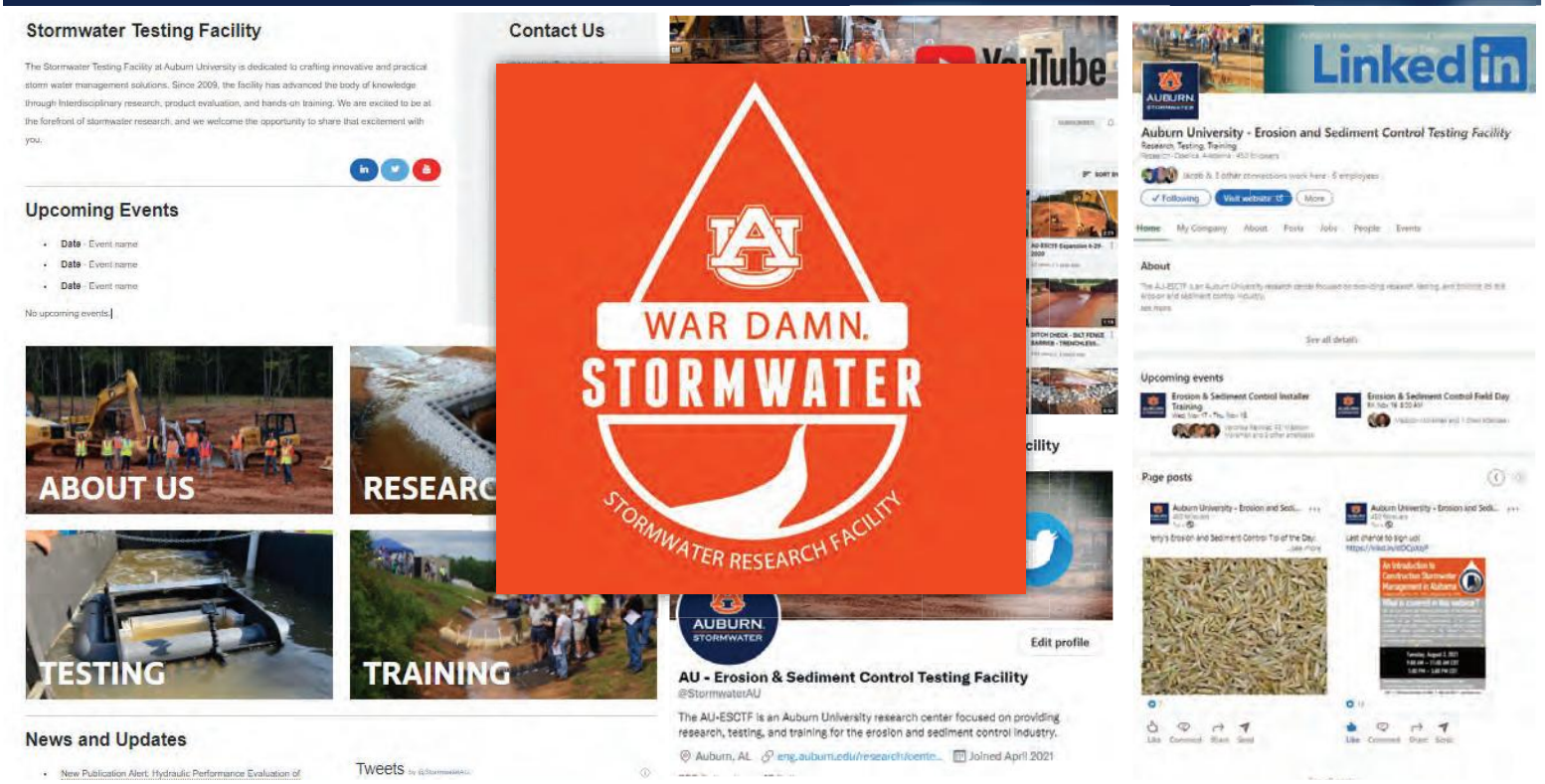
# TRAINING & OUTREACH

# SAVE THE DATE!

## Hands-on Installer Training: May 16-17, 2023
## Field Day: May 18, 2023

https://aub.ie/fieldday

# FOLLOW US!



## MICHAEL A. PEREZ, PH.D., P.E., CPESC

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


AUBURN STORMWATER

AUBURN UNIVERSITY
STORMWATER RESEARCH FACILITY

STORMWATER.AUBURN.EDU