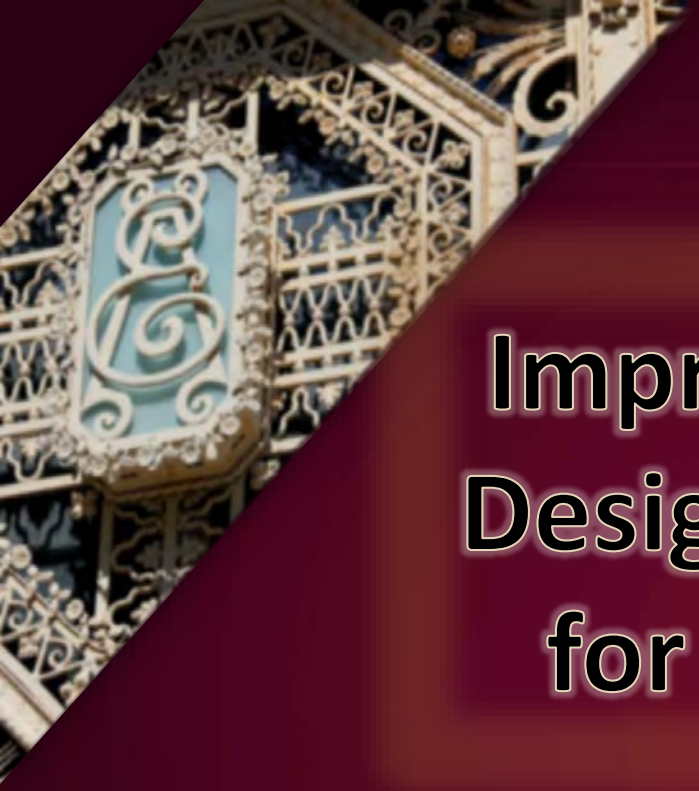


Improving Drainage System Design in Bioretention Areas for Optimal Performance

Michelle Wood-Ramirez

Water Management and Hydrological Science
Texas A&M University

TEXAS A&M AGRILIFE RESEARCH | EXTENSION

Goals and Hypothesis

- Need:
  - Understand the impact of bioretention drainage design on performance
  - Establish “flexible” design criteria vs. “one size fits all”
- Goals
  - Optimize volume reduction from bioretention as a function of underdrain pipe size
- Hypothesis
  - DRAINMOD can be used to develop pipe size criteria for optimal volume retention

What is Bioretention?

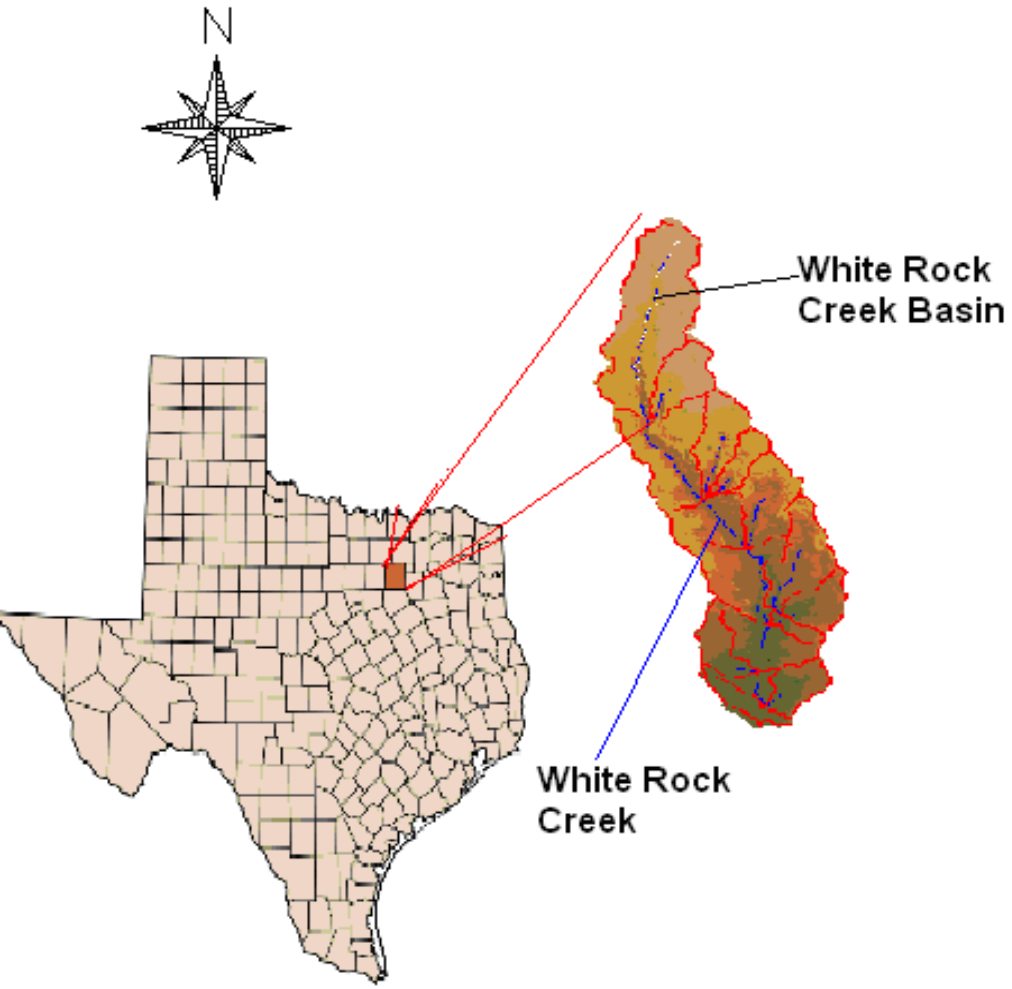
- A rain garden
- A *beautiful* landscape feature consisting of a planted shallow depression
- Collects runoff
- Residential vs. Commercial

Benefits of bioretention

- In addition to aesthetic value, rain gardens add ecological value:
  - Stormwater volume reduction
  - Stormwater treatment
  - Groundwater recharge
  - Temperature buffer
- Collects rainwater runoff from roofs, parking lots, and other impervious surfaces.

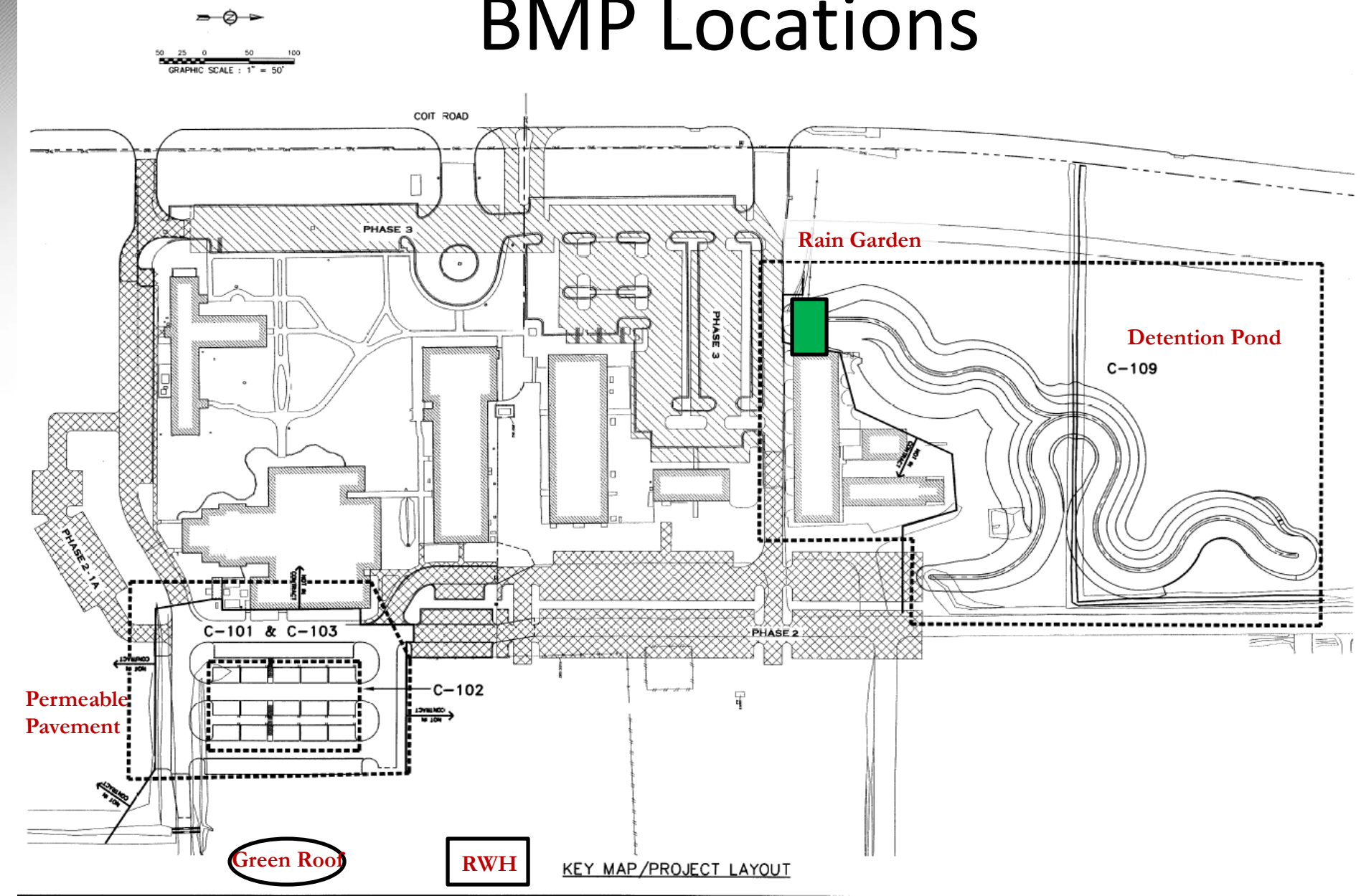
Commercial Raingarden

Project Location



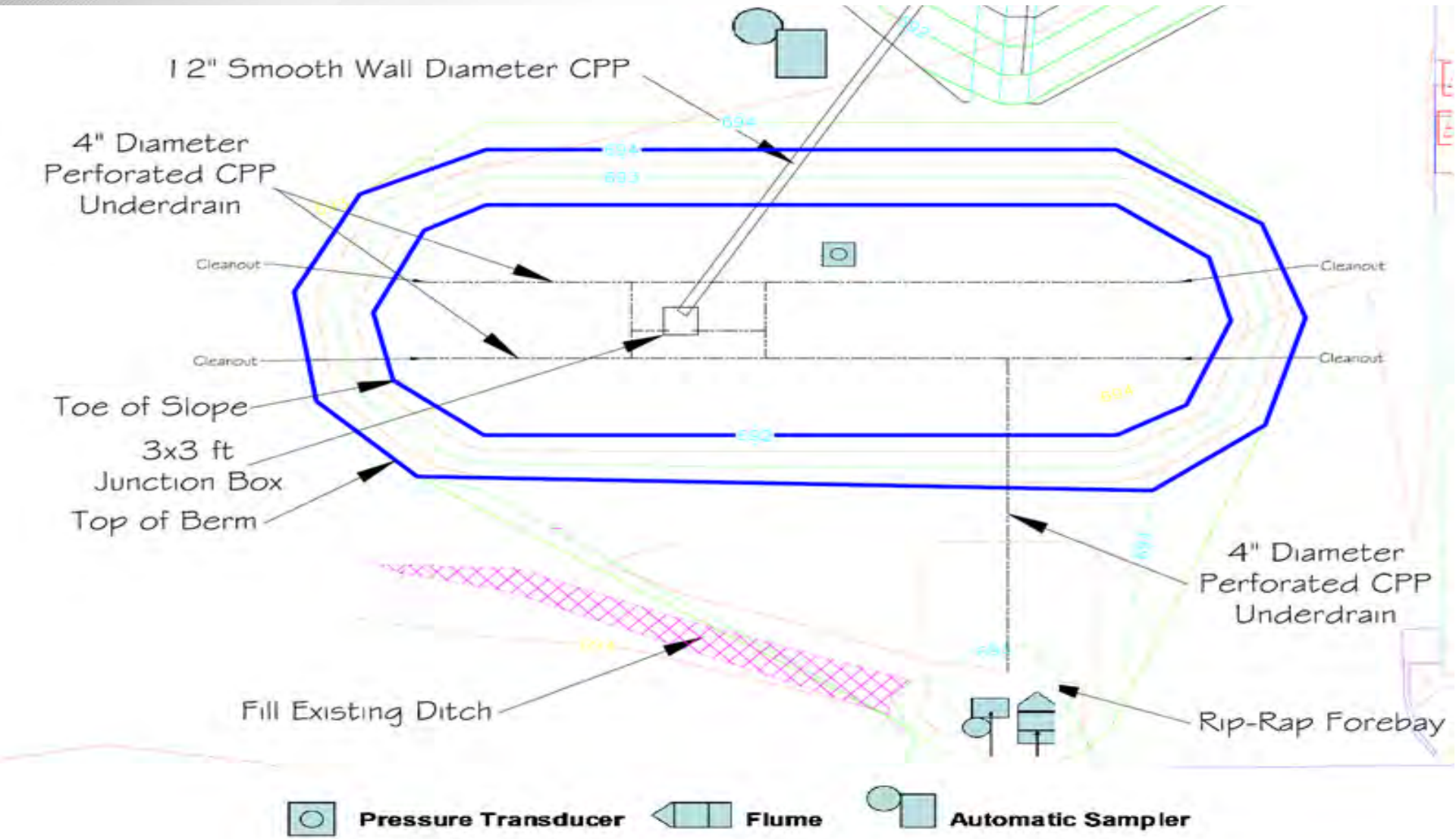
- Upper Trinity - White Rock Creek Watershed
- Clayey soil with underlying calcareous layer (Blackland Prairie Ecosystem)
- Representative of typical urban watershed

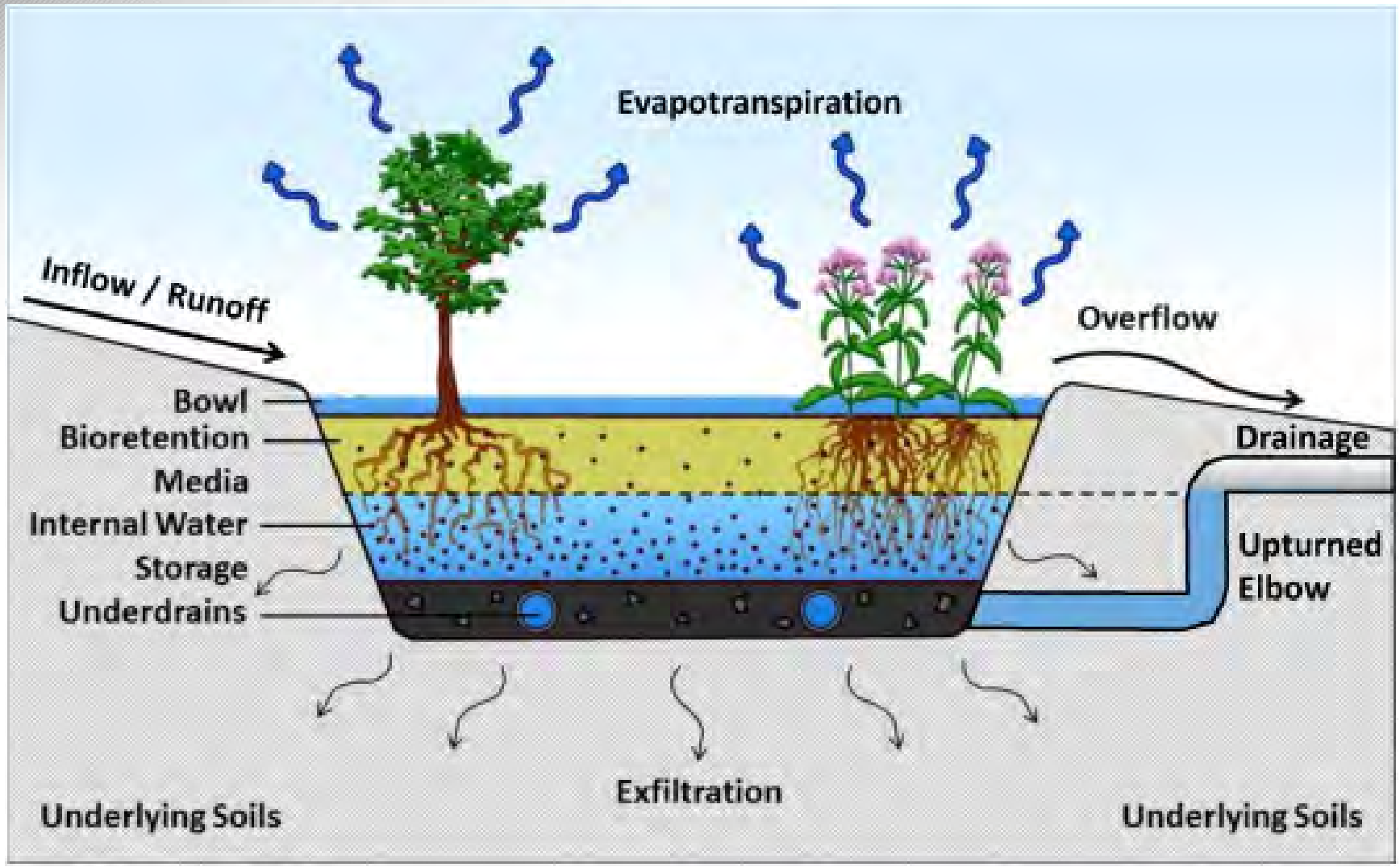
BMP Locations



RAIN GARDEN
RETENTION POND
TEXAS A&M AGRILIFE RESEARCH | EXTENSION

Bioretention Area





Winston et al., 2016

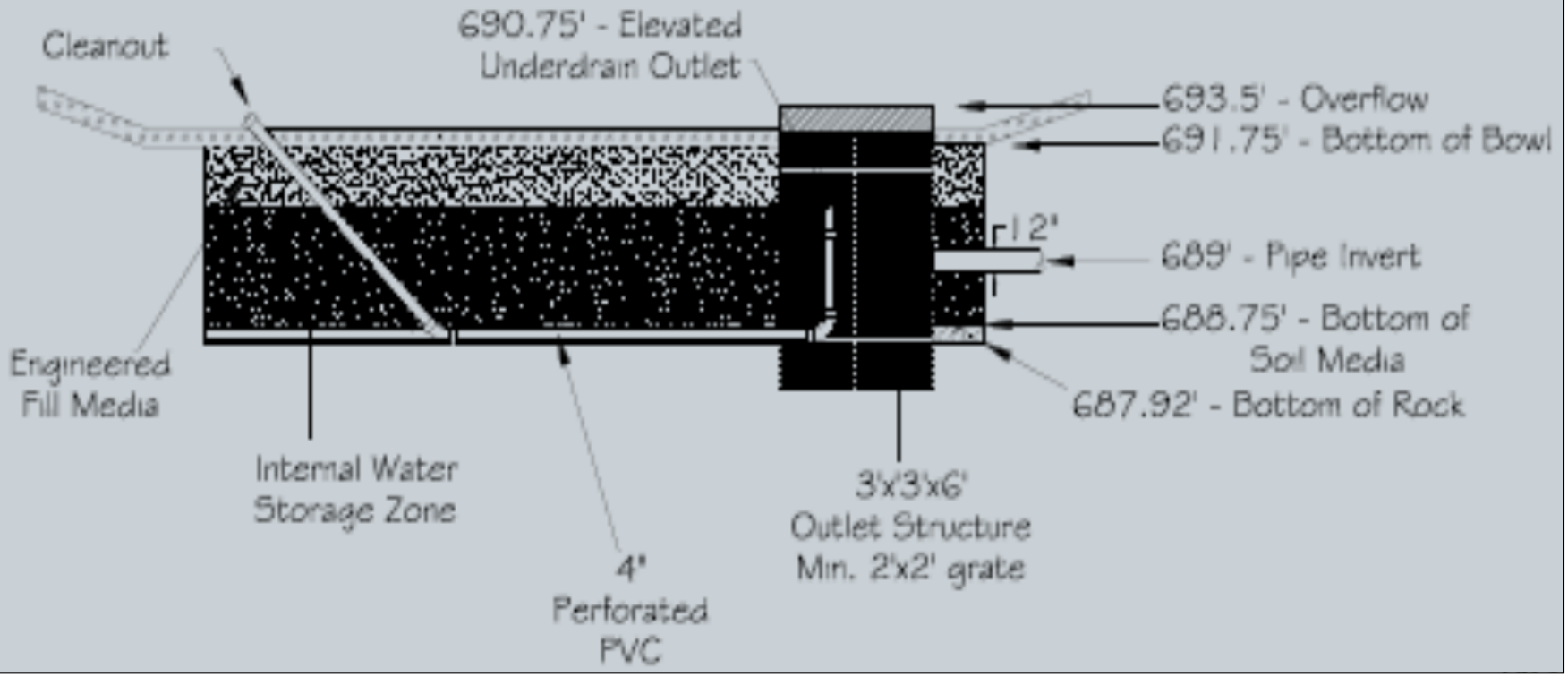
Bioretention Cross Section

Washed Sand

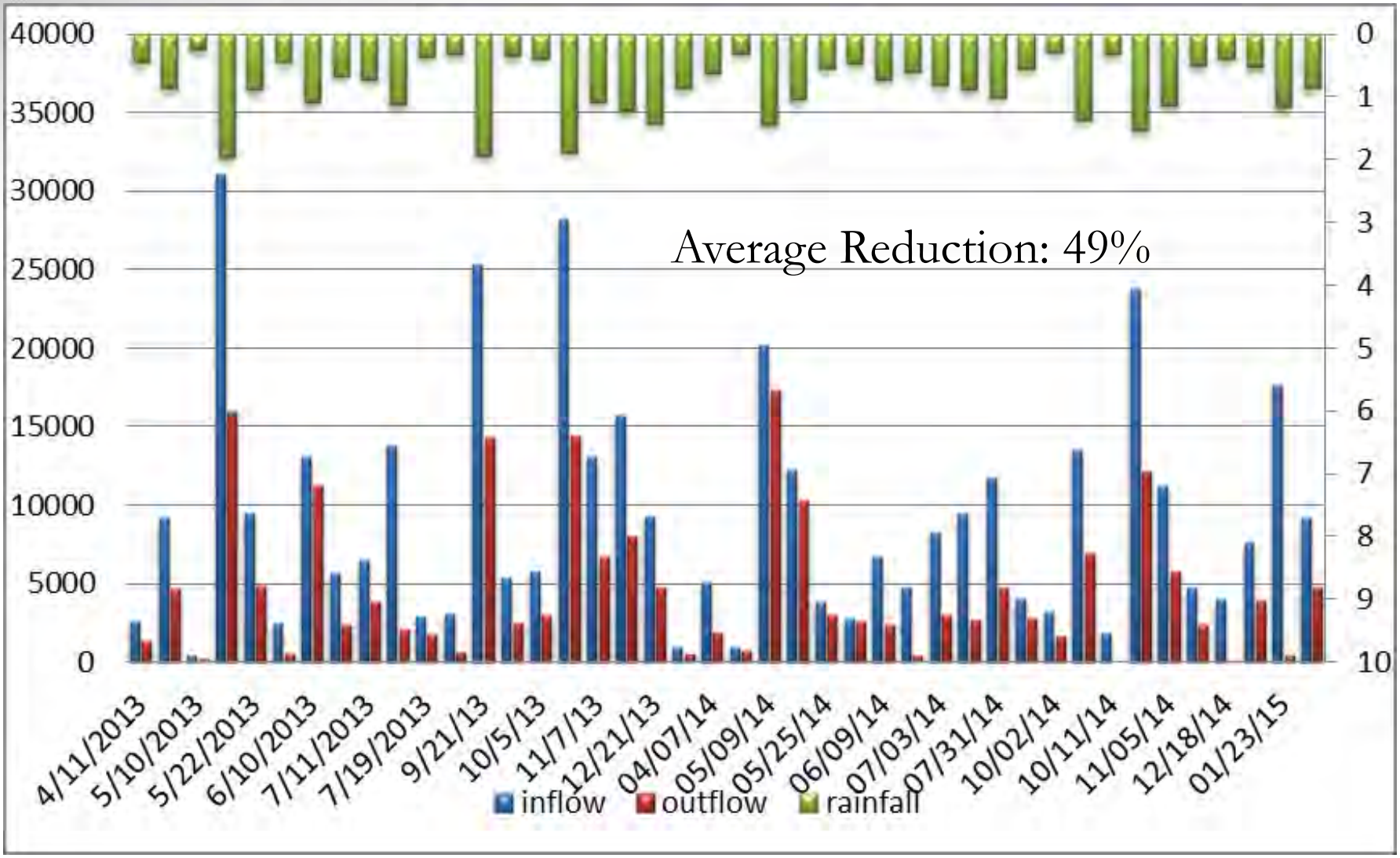
Washed #70 choking stone

Washed #57 stone

Underdrain and Outlet Structure Detail



Volume Reduction

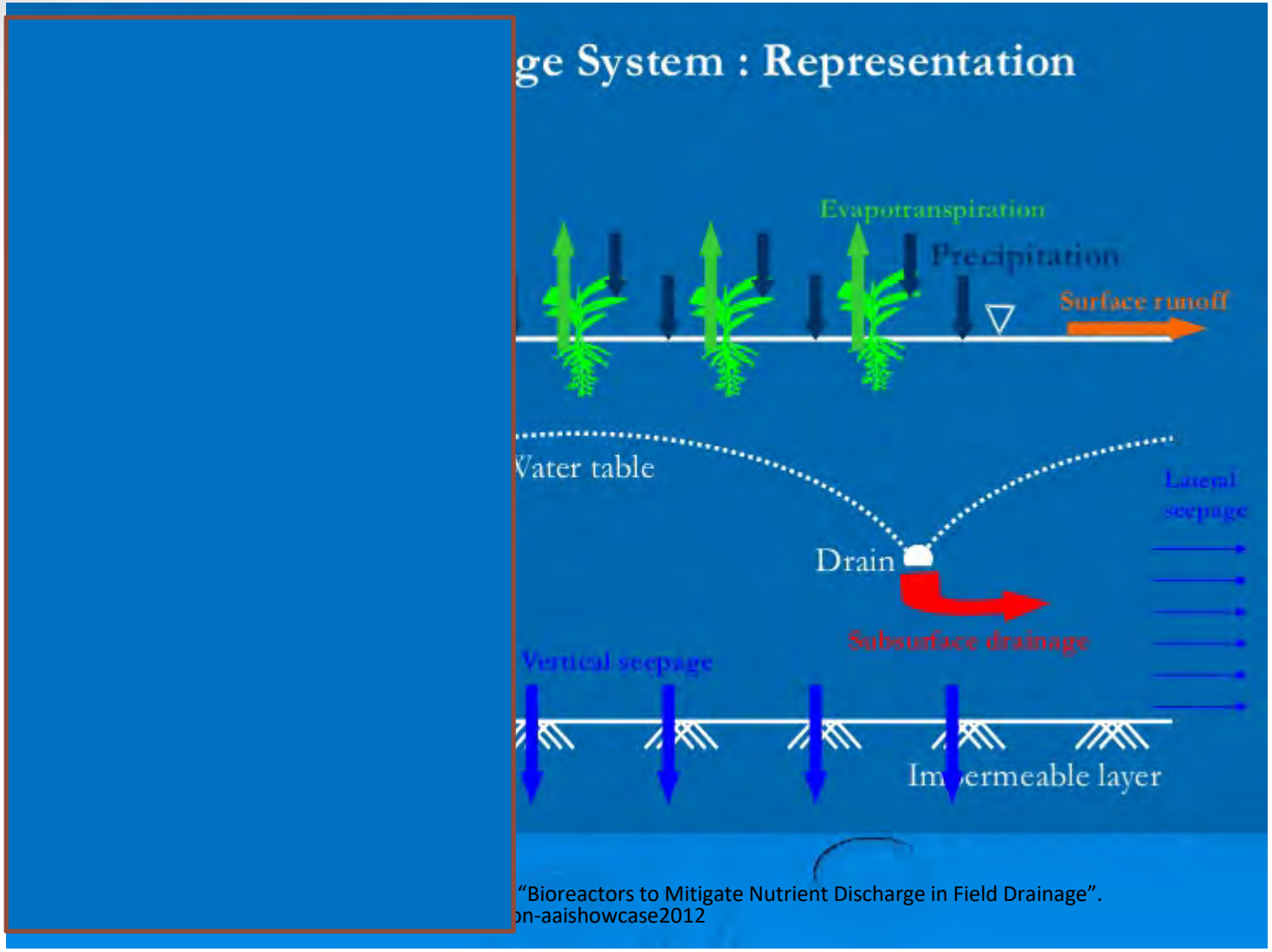


DRAINMOD 6.1

- Predict the effects of stormwater on water table depths, run-off, and the soil-water regime.
- Successfully tested and applied in wide variety of
  - Geographical,
  - Soil, and
  - Land and Water use conditions

http://www.bae.ncsu.edu/soil_water/drainmod/

DRAINMOD for Bioretention



"Bioreactors to Mitigate Nutrient Discharge in Field Drainage".
on-aaishowcase2012

DRAINMOD for Bioretention

- DRAINMOD has been used for bioretention design
  - (Brown et al(2013), Brown and Hunt(2011))

- DRAINMOD was the favored model
  - ability to model the IWS Zone
  - accounts for soil-water content in the profile

DRAINMOD Inputs

Table 2
Comparison of DRAINMOD inputs to typical bioretention design parameters.

Bioretention design parameters	DRAINMOD inputs
Drain depth	Depth from soil surface to drain
Drain size	Effective radius of drains
Drain spacing	Spacing between drains
Average surface storage depth	Maximum surface storage
Depth from surface to bottom of gravel	Distance from surface to impermeable layer
Drainage coefficient	Drainage rate as limited by hydraulic capacity of the drainage system in bioretention cell
Media/gravel characteristics and depths	Inputs for soil–water characteristic curve andsaturated hydraulic conductivity for each layer
Internal water storage zone design	Weir setting for controlled drainage
Drainage area: bioretention area ratio	Field ratio of contributing land area
Vegetation root depth	Vegetation root depth
Exfiltration rate of subsoil	Vertical or deep seepage parameters
Weather conditions	Rainfall and temperature files
Evapotranspiration	Either enter a file of calculated PET or use Thornthwaite method (with or without adjusted paramete

Brown et al, 2013

Modeling Methods

- Three years of field data will be used to model and create recommendations that account for:
  - Saturated Hydraulic conductivity of native soil (Ks)
  - Evapotranspiration
  - Design time between rain events and
  - Desired reduction volume

- Regression data will be generated from these scenarios.

Expected Results

$$S_{pipe} = a(ET)^{w} + b(R_{Freq})^{x} + c(K_s)^{y} + d(V_{red})^{z}$$

Scenarios will be run and compared with a multiple regression analysis, linking pipe size to environmental factors

Michelle Wood-Ramirez
Water Management and Hydrological Science
Graduate Research Assistant
Texas A&M AgriLife Extension
Dallas Research and Extension Center
MWoodRamirez@tamu.edu
972-952-9689

Fouad H. Jaber, PhD, P.E.
Assistant Professor and Extension Specialist
Biological and Agricultural Engineering
Texas A&M AgriLife Extension
Dallas Research and Extension Center
F-Jaber@tamu.edu
972-952-9672

https://www.facebook.com/agrilifeecoeng