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Biological & Agricultural Engineering

Nutrient plant uptake and phosphorus deposition in a Constructed Stormwater Wetland

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National Water Conference 2008

Research Objectives

- Determine if a particular plant species accumulates more nitrogen than another
- Monitor phosphorus accumulation in a constructed wetland
- Monitor water quality at the inlet and outlet

Expected Outcomes

- Determine the significance of harvesting plant biomass to remove nitrogen
- Better understand phosphorus accumulation to develop a maintenance strategy to maximize phosphorus removal
- Evaluate the ability of a constructed wetland to remove pollutants from stormwater

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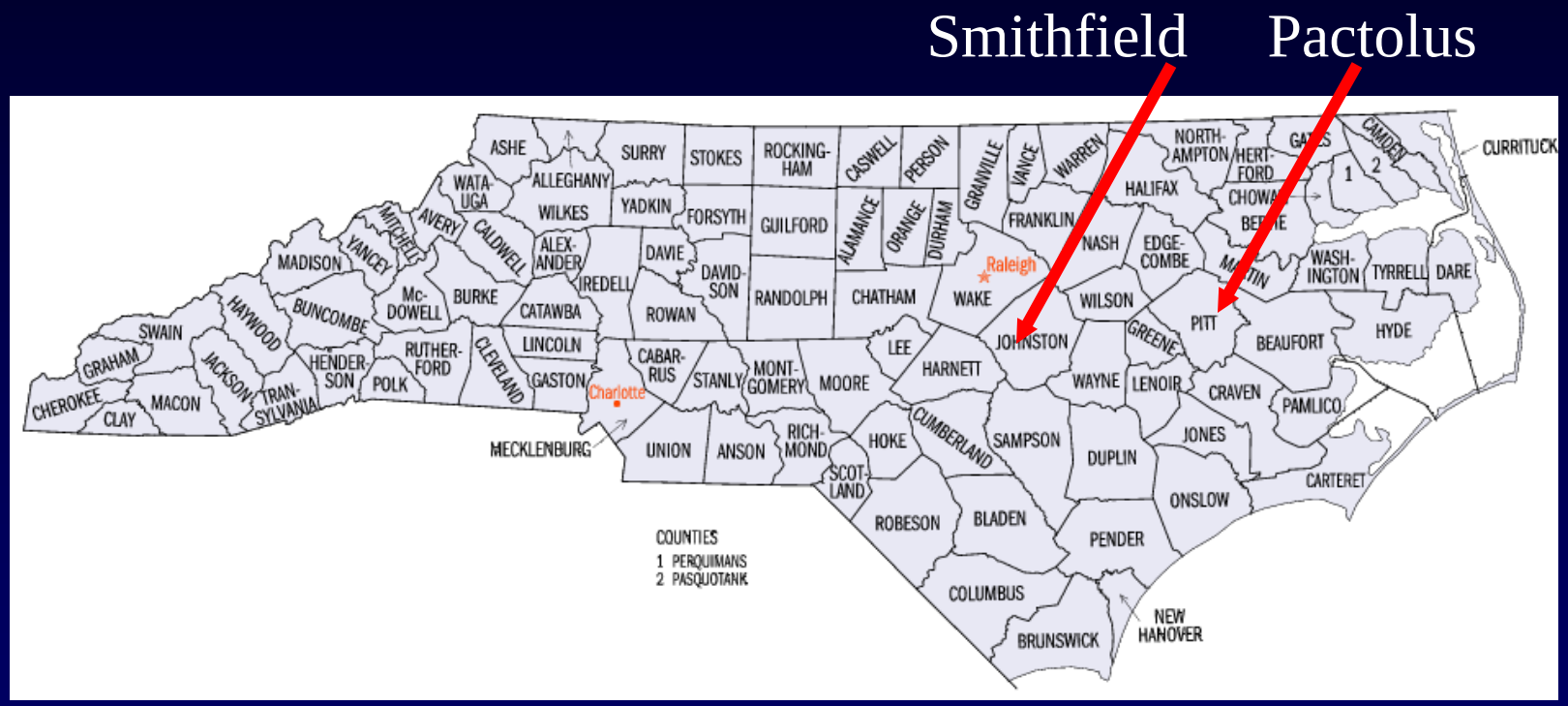
Research Methods: Plant Uptake



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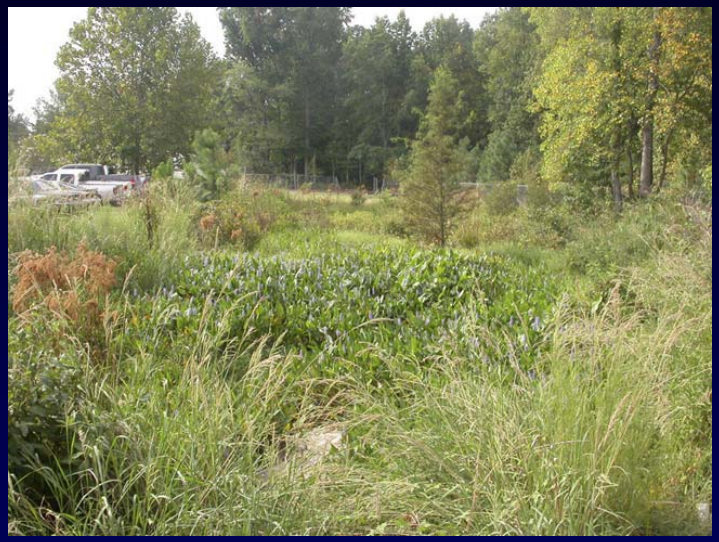
Research Methods: Plant Uptake

- Smithfield-Selma High School
  - Constructed in 2001
  - 27 acre watershed (CN = 87) consisting of a large parking lot, grass fields, and rooftops
- Pactolus Elementary School
  - Constructed in 2006
  - 9 acre watershed (CN=71) consisting of a school and farmland



Research Methods: Plant Uptake

- Plant Species Chosen

Pickerelweed
(Pontederia Cordata)

Lizard Tail
(Saururus Cernuus)

Wool Grass
(Scirpus Cyperinus)

Softstem Bulrush
(Schoenoplectus Tabernaemontani)

Arrow Head
(Sagittaria L.)

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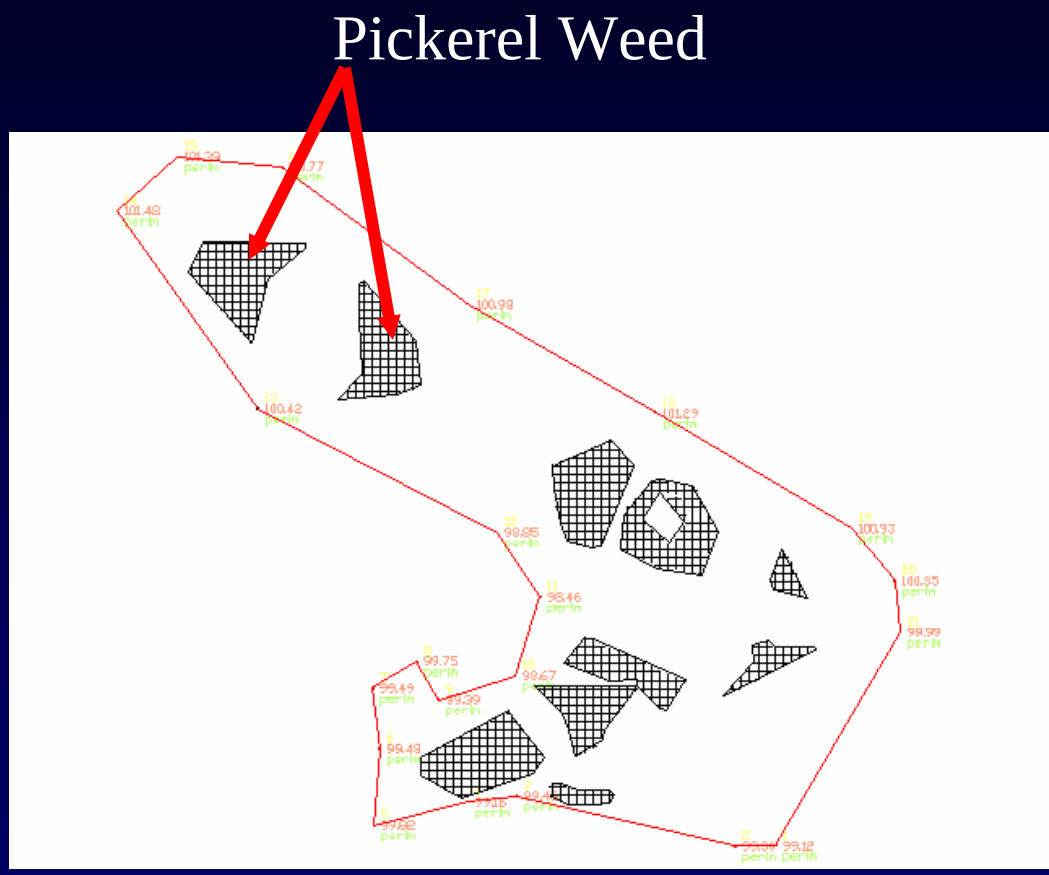
Research Methods: Plant Uptake

- Plant Comparison
  - Vegetation survey for both wetlands
  - ½ meter grid
  - Randomly selected 5 plots from each species for harvest



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Research Methods: Plant Uptake

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Research Methods: Plant Uptake

- Plant Tissue Analysis
  - Plants were dried at 80°C for 24 hours
  - Biomass was then milled to produce workable samples for lab analysis
  - Samples analyzed at NCDA Agronomics Division

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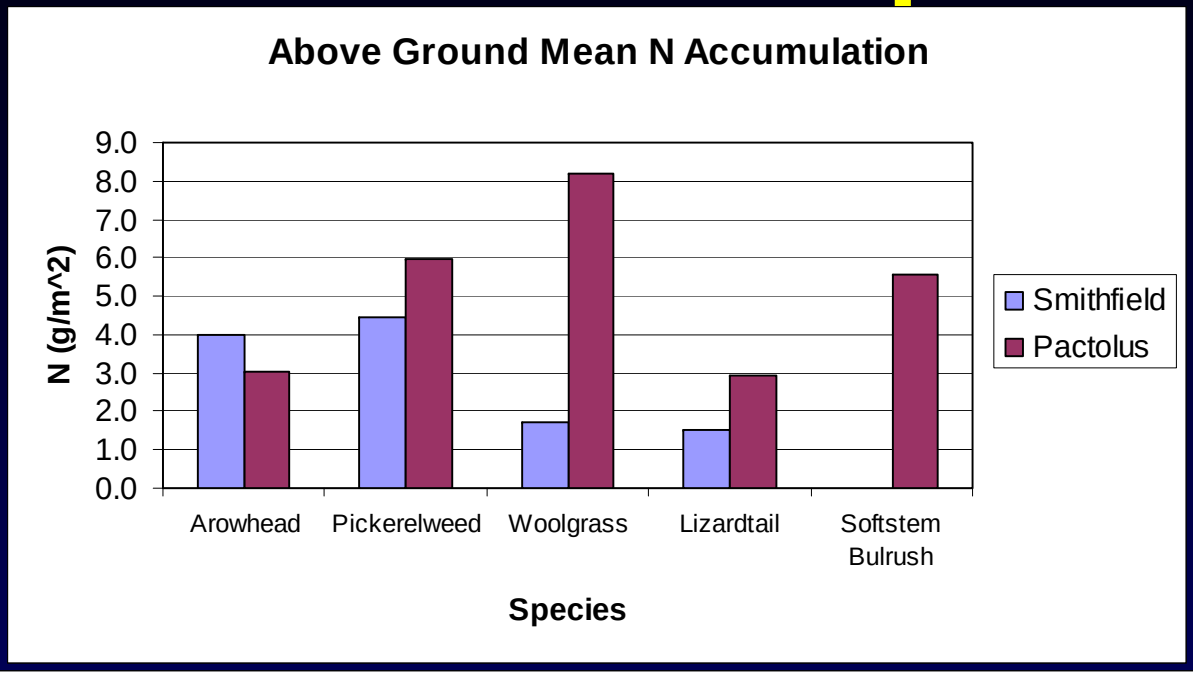
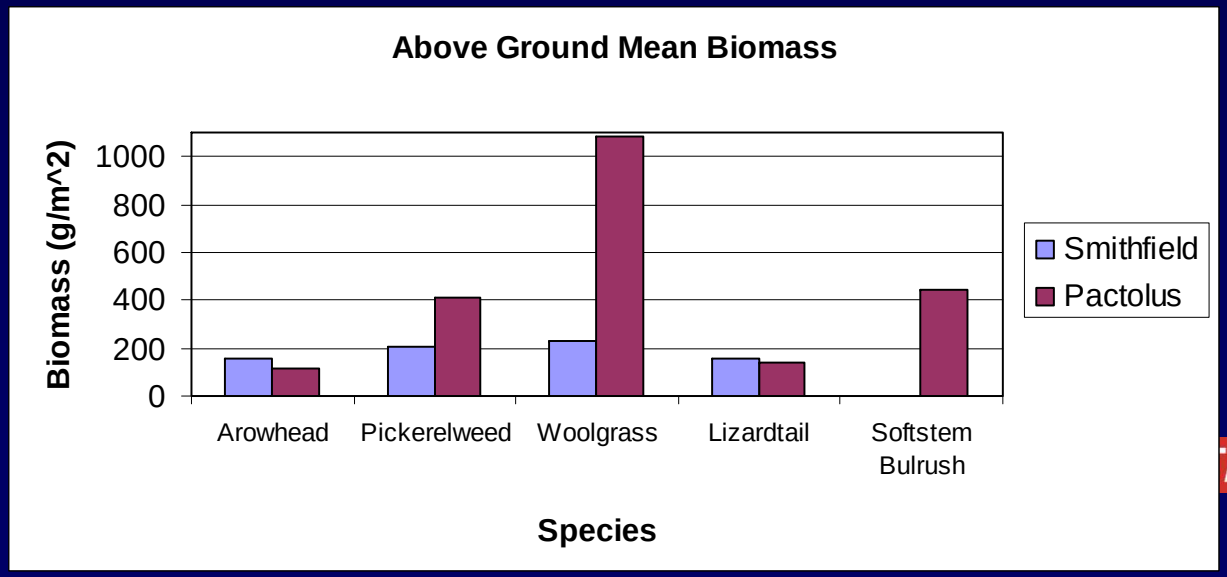
Results: Plant Uptake





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Results: Plant Uptake

- Statistical Conclusions for Nitrogen Accumulation

- Smithfield
  - Pickerelweed
  - Arrow Head

Significantly greater than ($p<0.05$)

  - Wool Grass
  - Lizard Tail

- Pactolus
  - Pickerelweed
  - Wool Grass
  - Softstem Bulrush

Significantly greater than ($p<0.05$)

  - Arrow Head
  - Lizard Tail

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Preliminary Conclusions

- Plant Uptake
  - Pickerelweed was significant across both wetlands
  - Amount of biomass harvested influenced Nitrogen removal (Wool Grass and Arrow Head)
- Further Analysis
  - Nutrient budget to be performed on River Bend to quantify significance of plant uptake
  - Determine if using one plant species over another can increase the amount of harvestable nitrogen to significant levels

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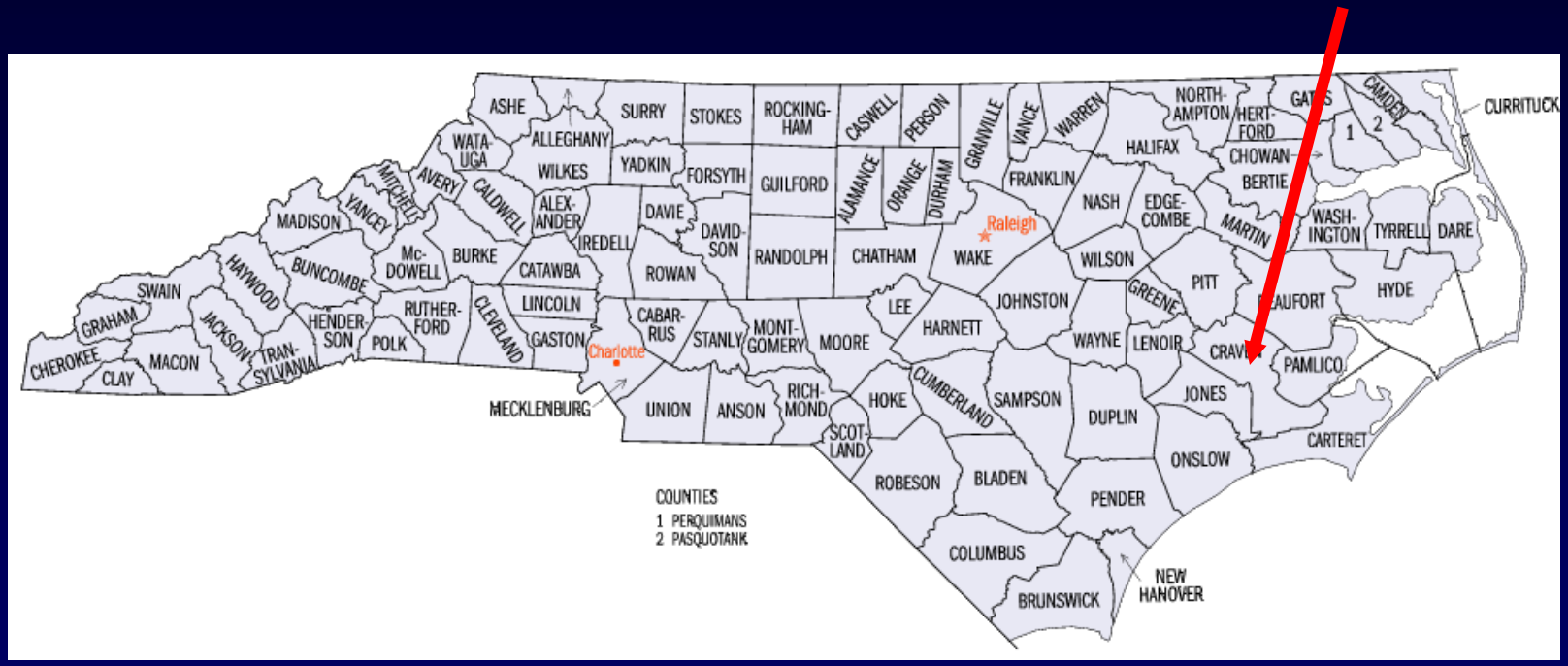
Research Methods

River Bend



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Research Methods

- River Bend
  - Funded by a grant from NCDENR and the Ecosystem Enhancement Program (EEP)
  - NC State Faculty from BAE selected to identify 20 retrofit BMP sites in the Neuse River Basin
  - BAE Faculty contracted to design and oversee construction of 3 sites
  - River Bend was one of those selected

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Research Methods

- River Bend Design and Construction
  - First constructed in 1998
  - 75 acre watershed consisting of ½ acre residential lots
  - Undersized, normal pool at 6-12”
  - Between 1998 and 2006 the Town of River Bend expanded the watershed by about 25 acres

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Project Background

- River Bend Design and Construction
  - Wetland expanded in March of 2007
  - Town donated land for expansion
  - Overall design, construction, permitting and monitoring cost an estimated $110,000

Research Methods

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Research Methods

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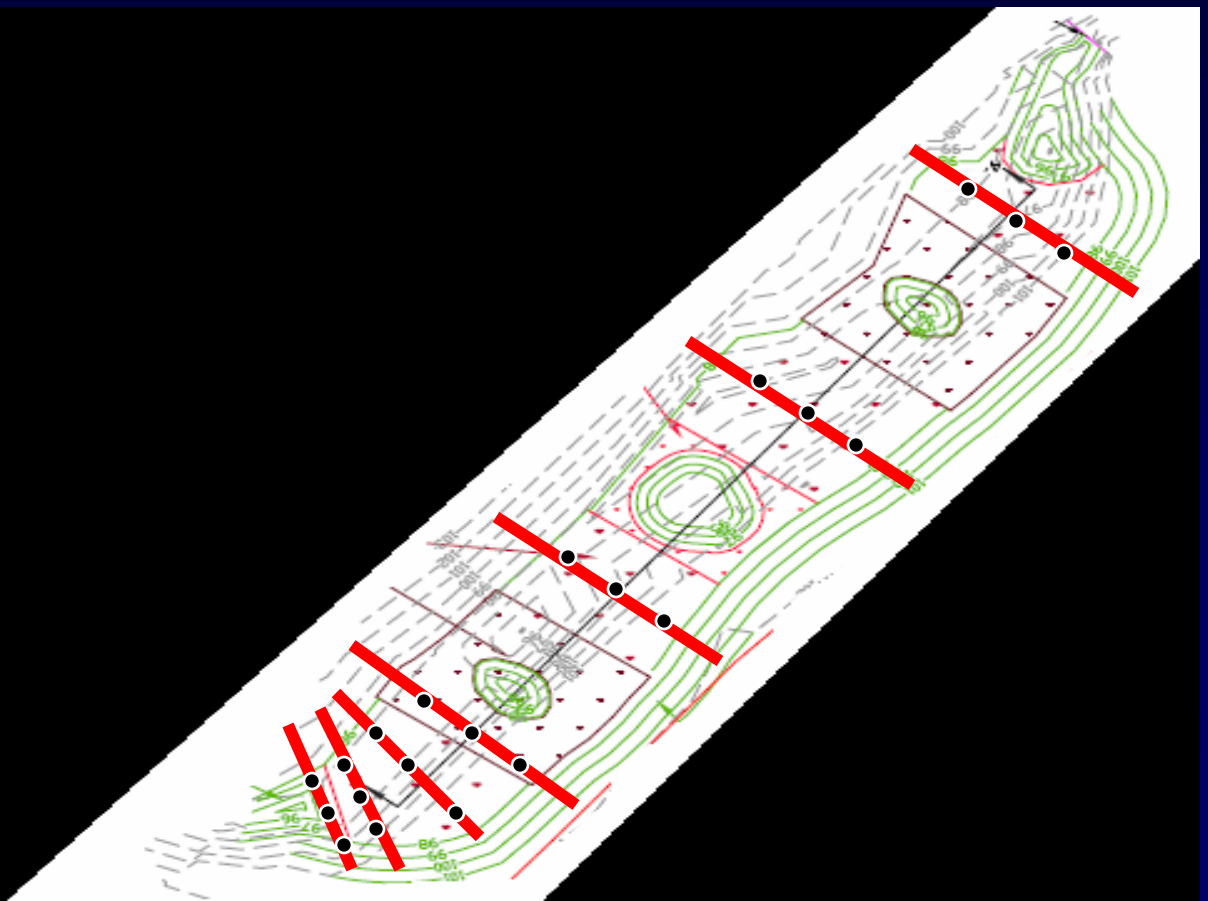
Research Methods: Phosphorus

- Location of Sampling Sites



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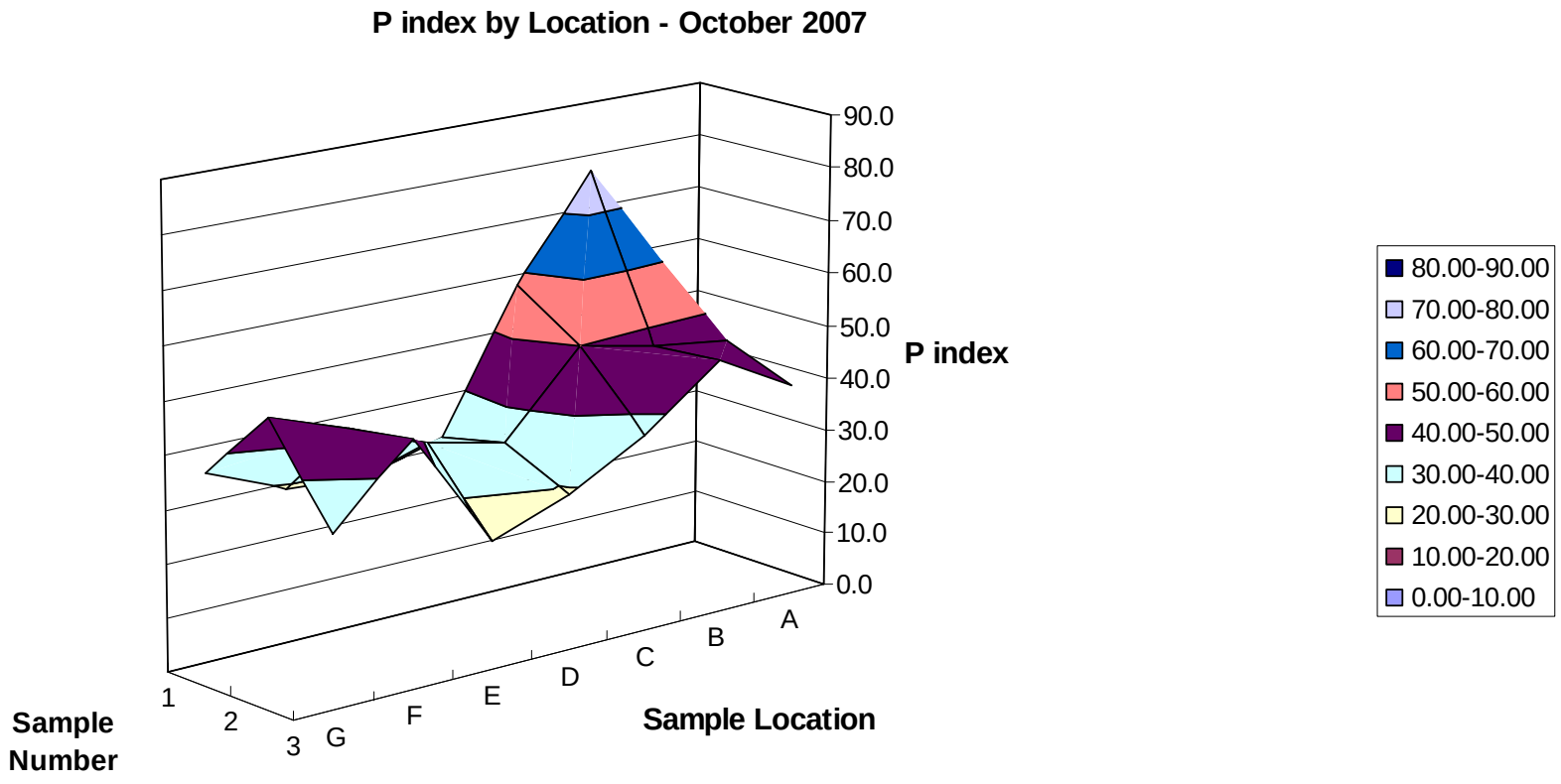
Research Methods: Phosphorus

- Major Goals
  - Determine if phosphorus concentration differs by location
  - Develop a maintenance plan to maximize phosphorus removal

Results: Phosphorus

- Sampling every two months since April 2007



Research Methods: Water Quality

- Topography
  - Approximately 1.5 ft of elevation change between inlet and outlet weir
- Instrumentation
  - Two ISCO Automatic Samplers
  - ISCO tipping bucket and manual rain gage

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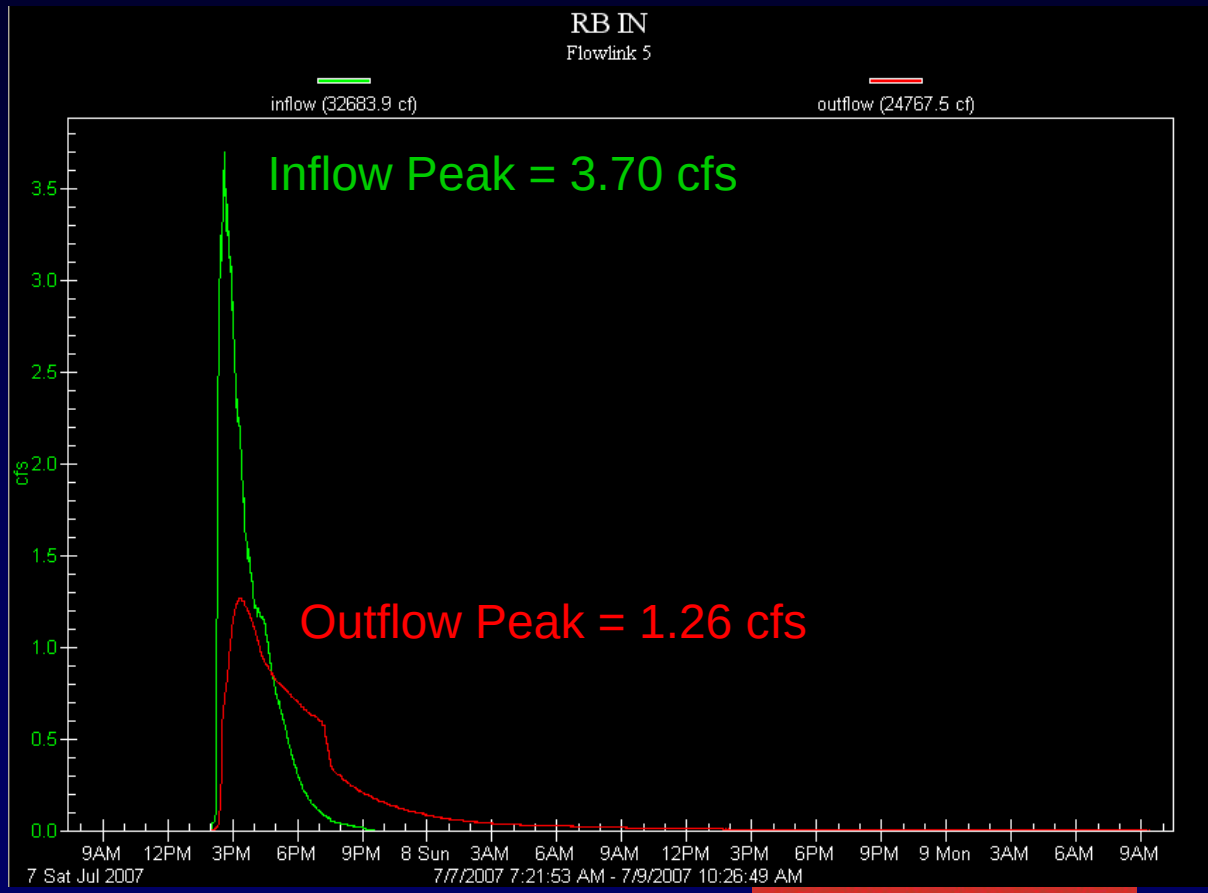
Results: Water Quality

- Water Quality
  - Flow Monitoring
    - 9 Storms
    - Average peak flow reduction of 80%
    - Average runoff volume reduction of 49%



Peak Reduction 66%

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Results: Water Quality

- Water Quality
  - Collected 7 storms for lab analysis from June 07 through December 07
  - Sample collection will continue through June 08
  - Pollutants
    - Total Kjeldahl Nitrogen (TKN),
    - Nitrate and Nitrite (NO3, NO2),
    - Ammonia (NH3-N),
    - Total Phosphorus (TP),
    - Ortho Phosphorus,
    - Total Suspended Solids (TSS)

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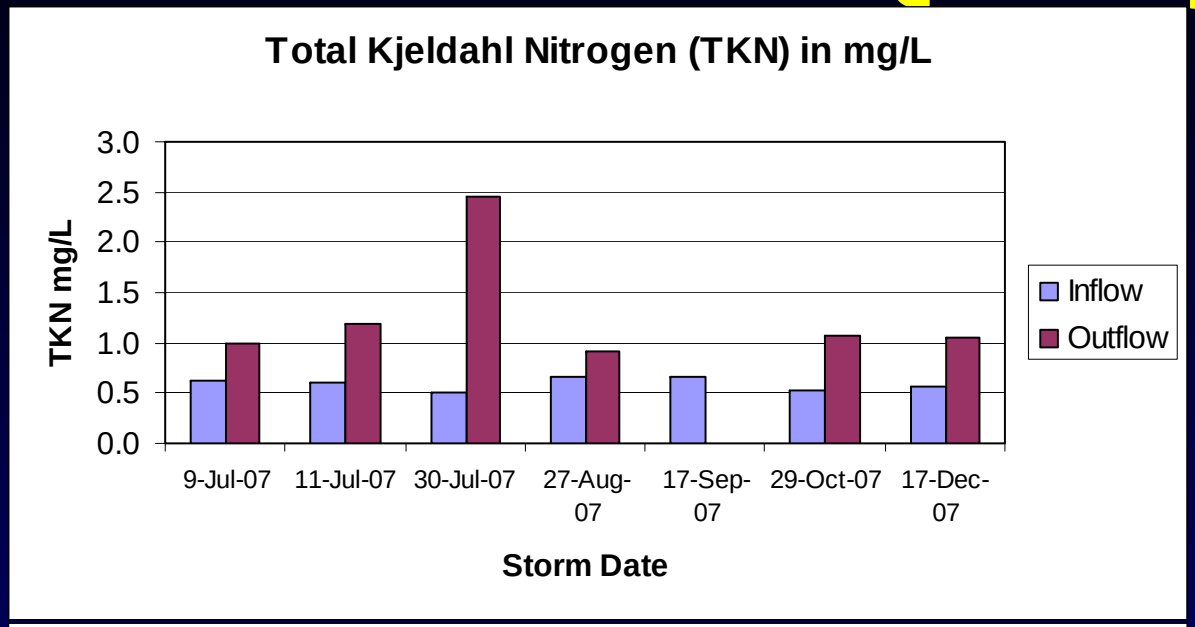
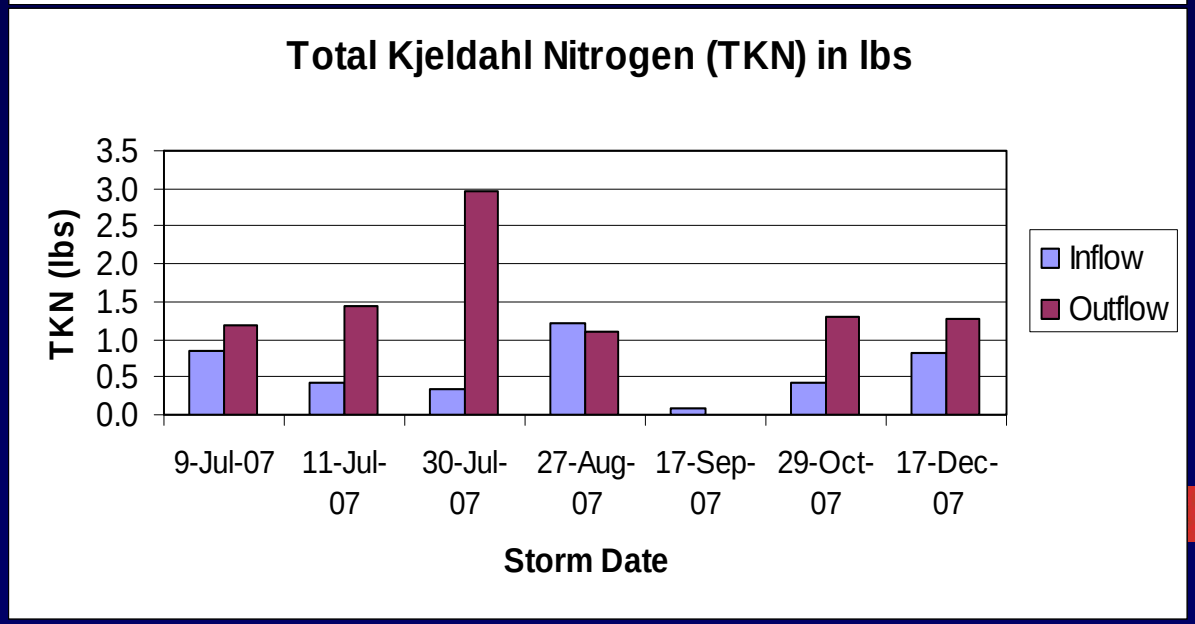
Results: Water Quality





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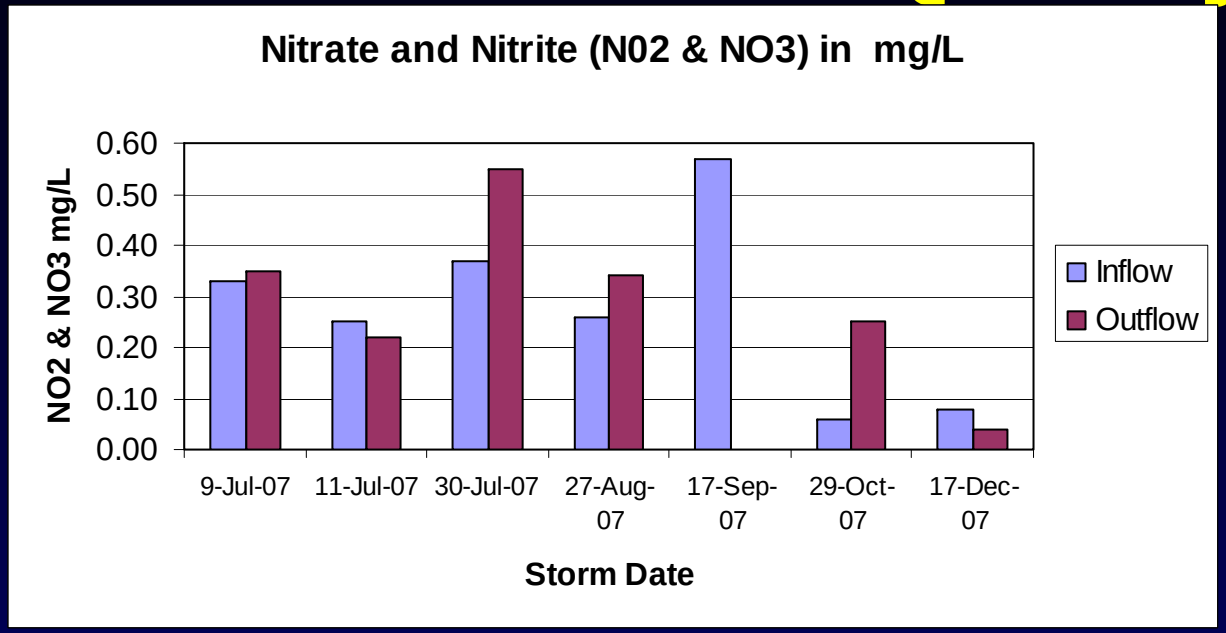
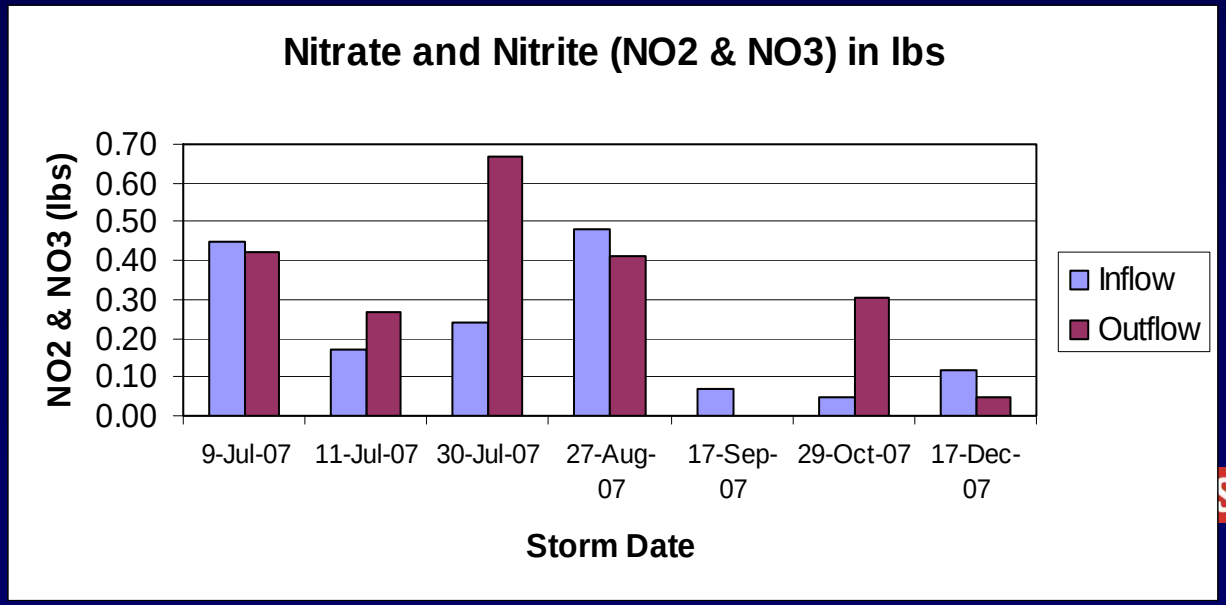
Results: Water Quality





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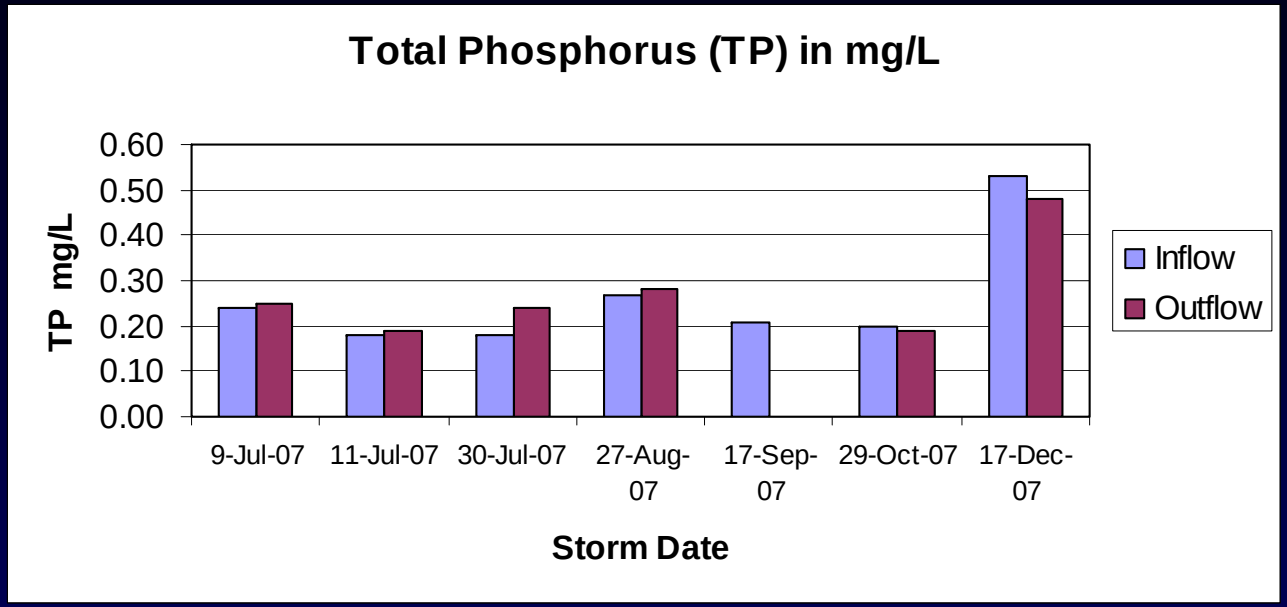
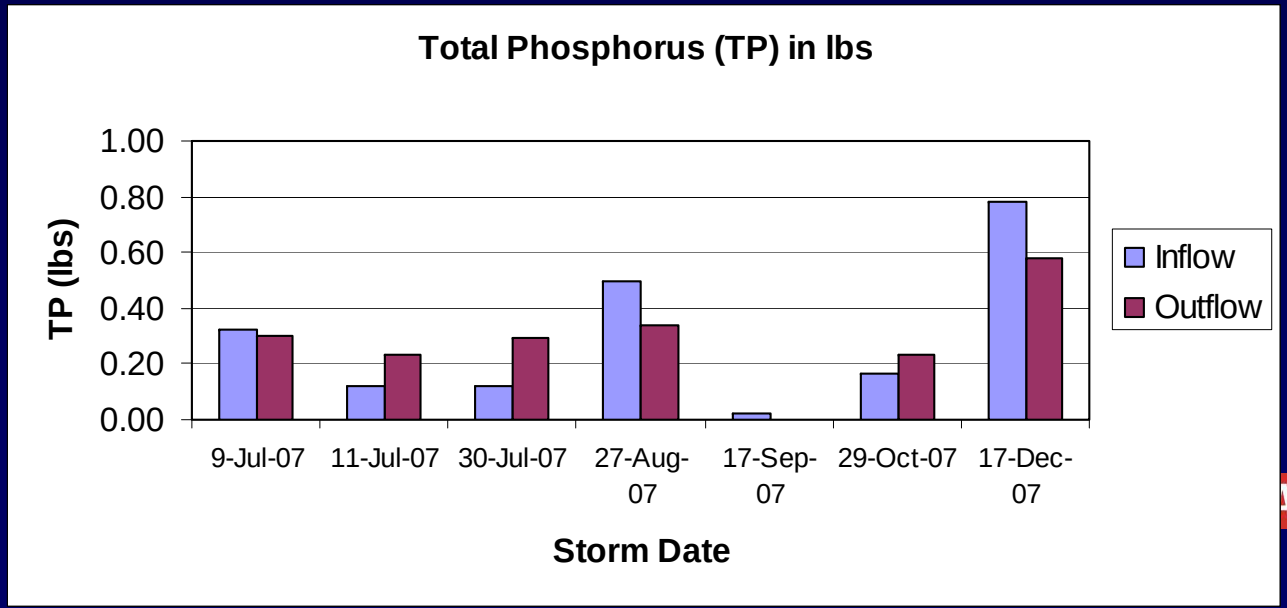
Results: Water Quality





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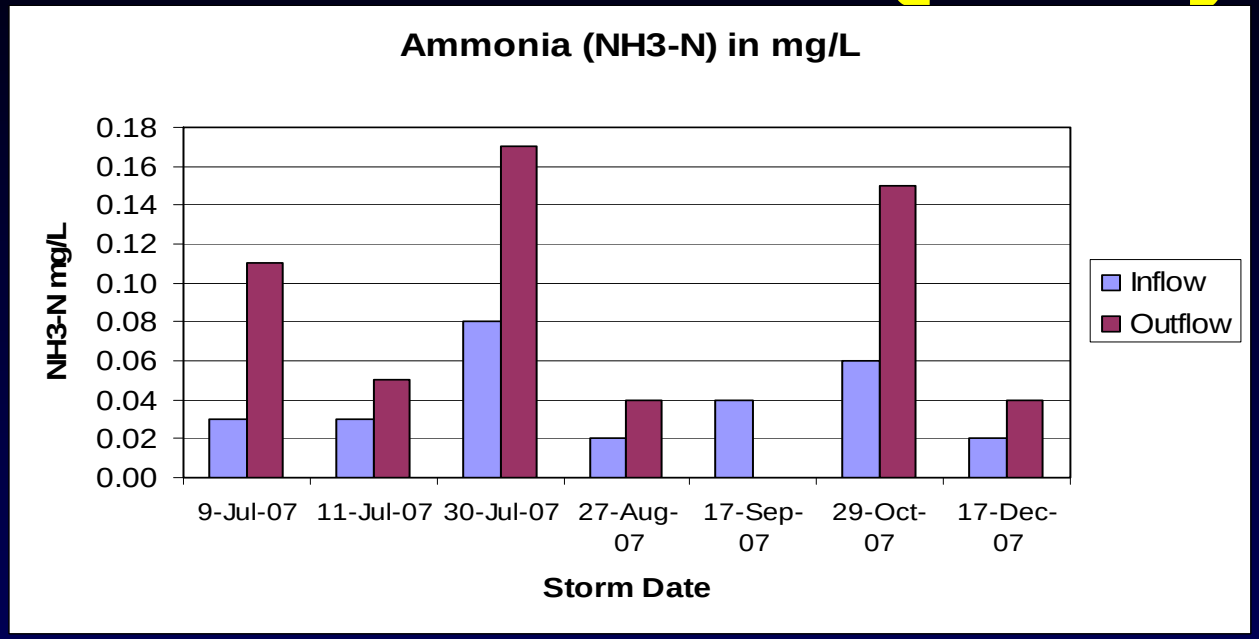
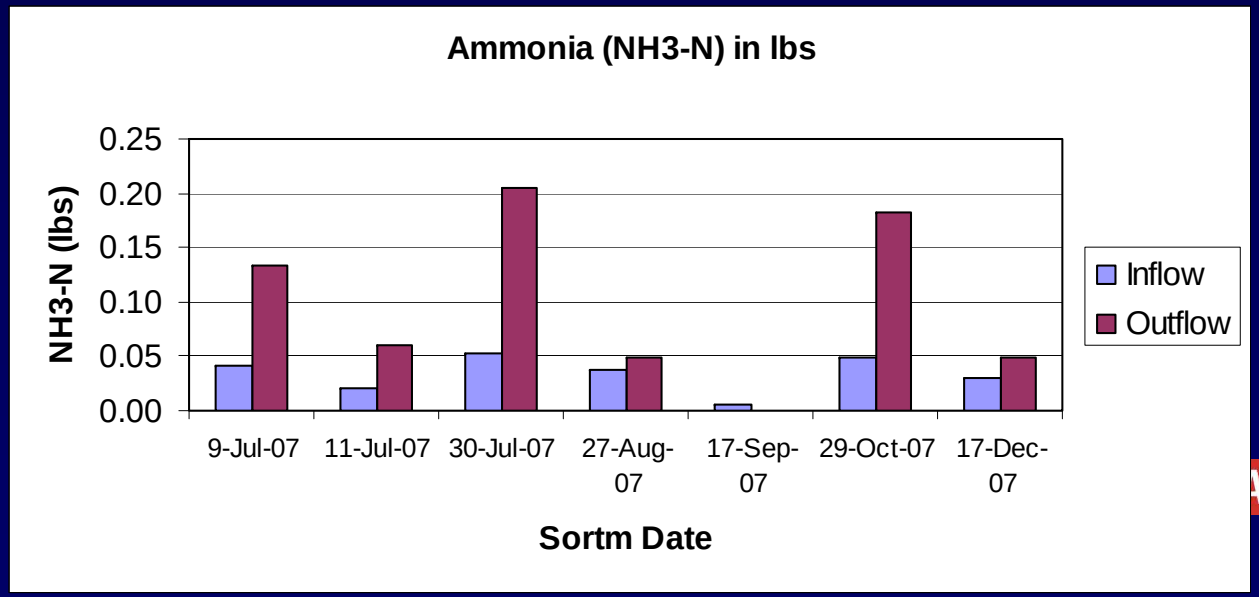
Results: Water Quality





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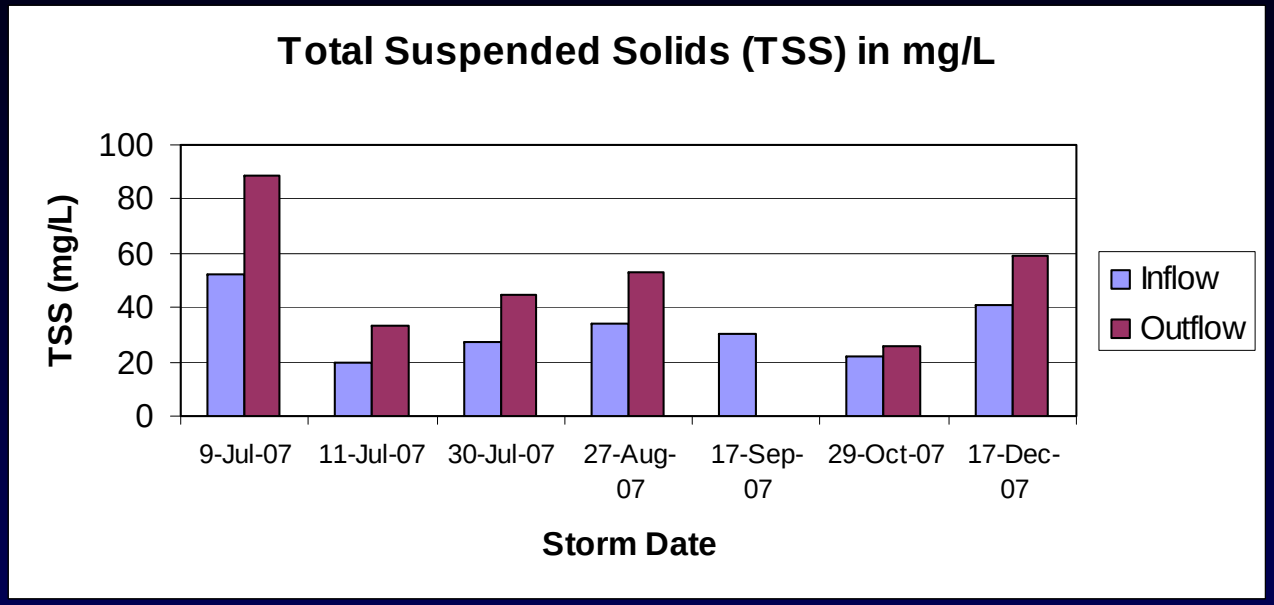
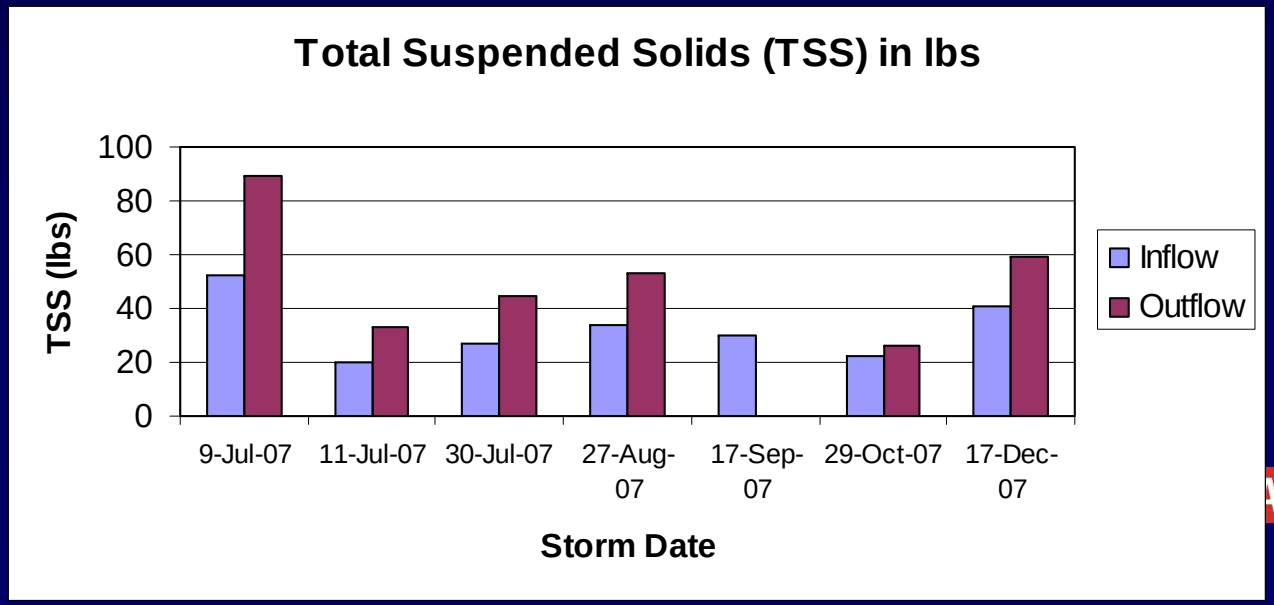
Results: Water Quality





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Results: Water Quality

- Statistical conclusions
  - Outflow loads for ammonia and TSS are significantly greater ($p < 0.05$) than inflow loads
  - Inflow and outflow loads for all other pollutants are not significantly different ($p < 0.05$)

Results: Water Quality

- Water Quality
  - Mean inflow and outflow comparisons

	TKN	NO2 & NO3	TSS	TP
Mean Inflow (mg/L)	0.59	0.27	32.29	0.26
Mean Outflow (mg/L)	1.28	0.29	50.83	0.27
Mean National BMP Database Outflow (mg/L)	1.26	0.13	27.03	0.21
UCL National BMP Database Outflow (mg/L)	1.48	0.36	70.54*	0.29

*Average of wetland basin and wetland channel

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Preliminary Conclusions

- Water Quality
  - Wetland is receiving irreducible concentrations from the watershed
- Further Analysis
  - Perform a nutrient budget to estimate added nutrient loads
  - Determine possible sources of added nutrients

Acknowledgements

- List of Cooperators
  - Town of River Bend
  - NC Department of Natural Resources
  - Ecosystem Enhancement Program
  - North Carolina State University

- Special Thanks
  - Dr. Hunt
  - Ryan Smith
  - Jon Hathaway
  - Jason Wright
  - Charlie Humphrey
  - NC Stormwater Team

Questions and Comments?

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