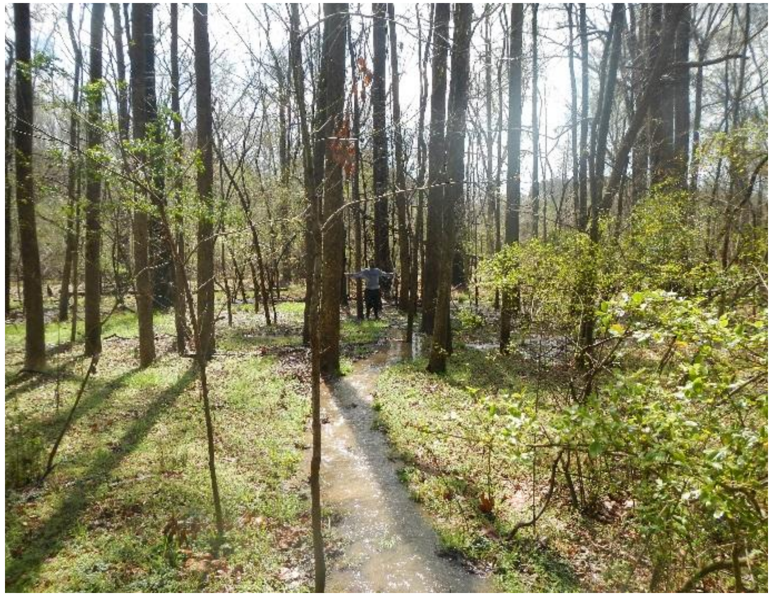
Mitigation of Septic-System Derived Nutrients and Fecal Bacteria by a Natural Wetland



Charles P. Humphrey Jr.

Professor of Environmental Health Sciences

East Carolina University

Greenville, NC 27858

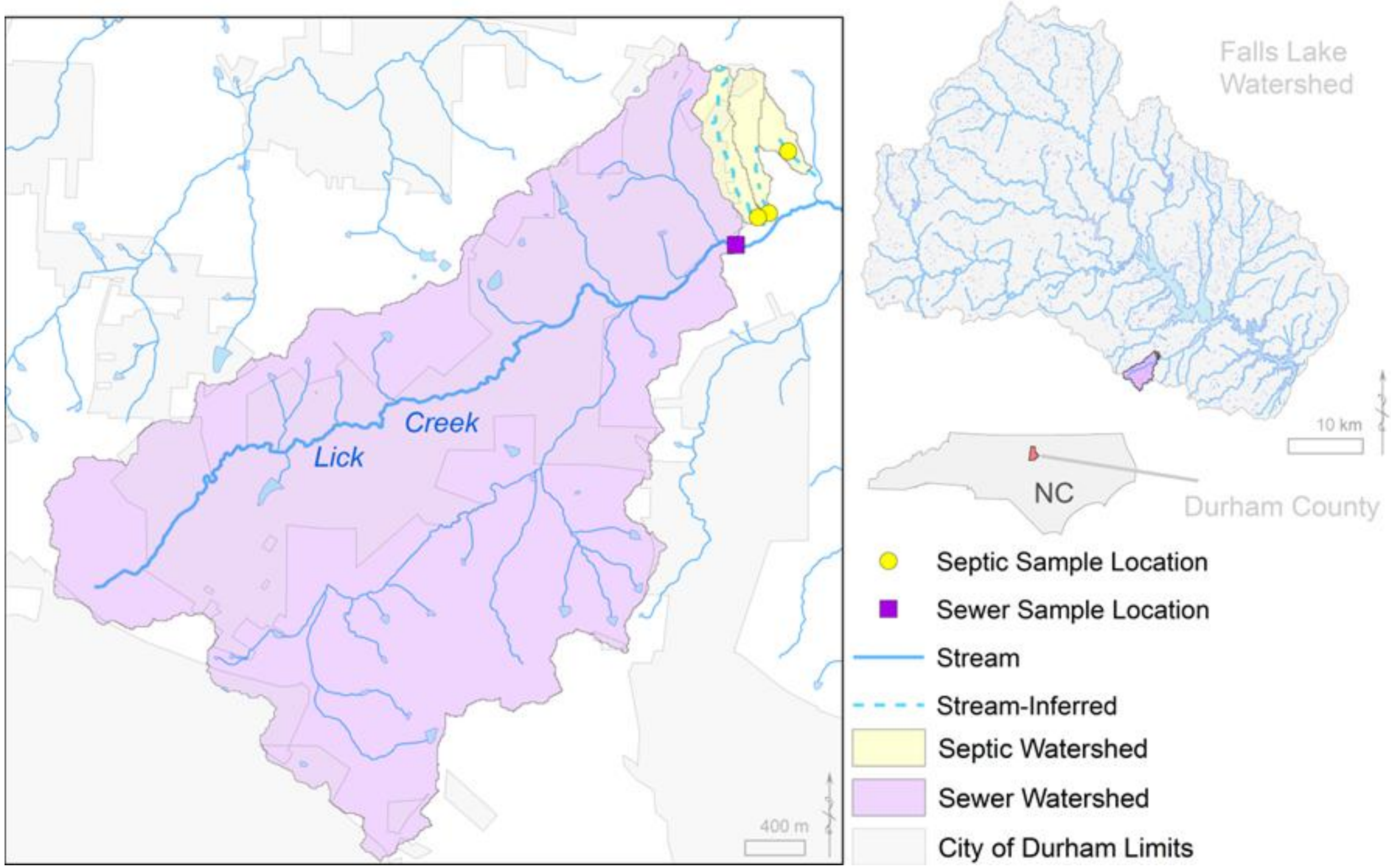
Humphreyc@ecu.edu

Coming Up

- Overview of Lick Creek watershed and natural wetland
- Project Objectives
- Methods
- Results
- Summary
- Questions

- Materials in this presentation do not reflect the opinions of NOWRA

Lick Creek and Falls Lake (Impaired Waters)

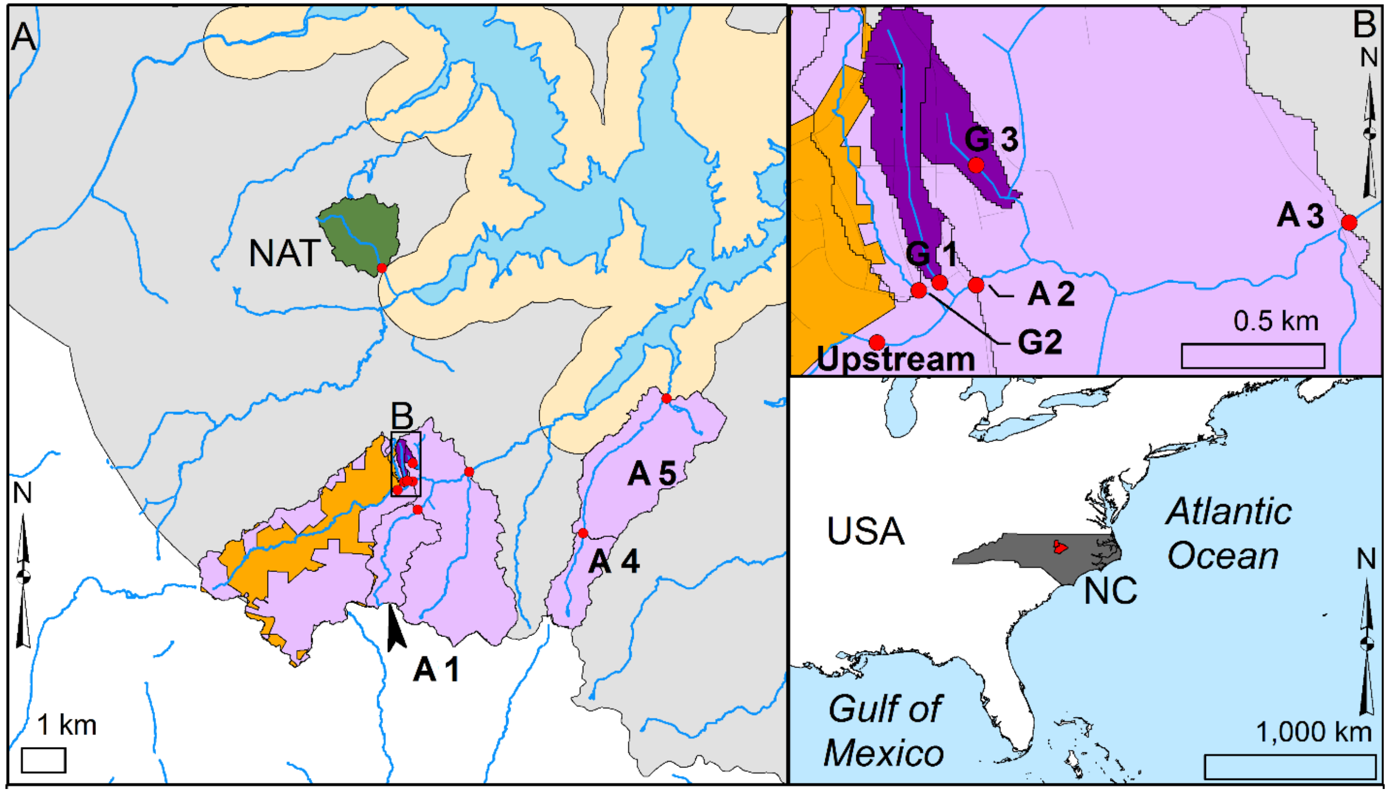


- Fecal coliform – human and animal waste
- Oxygen demanding substances – nutrients, human and animal waste (BOD)
- Turbidity – erosion of soil

Watershed restoration plan developed in 2009

Lick Creek Water Quality Management Strategies

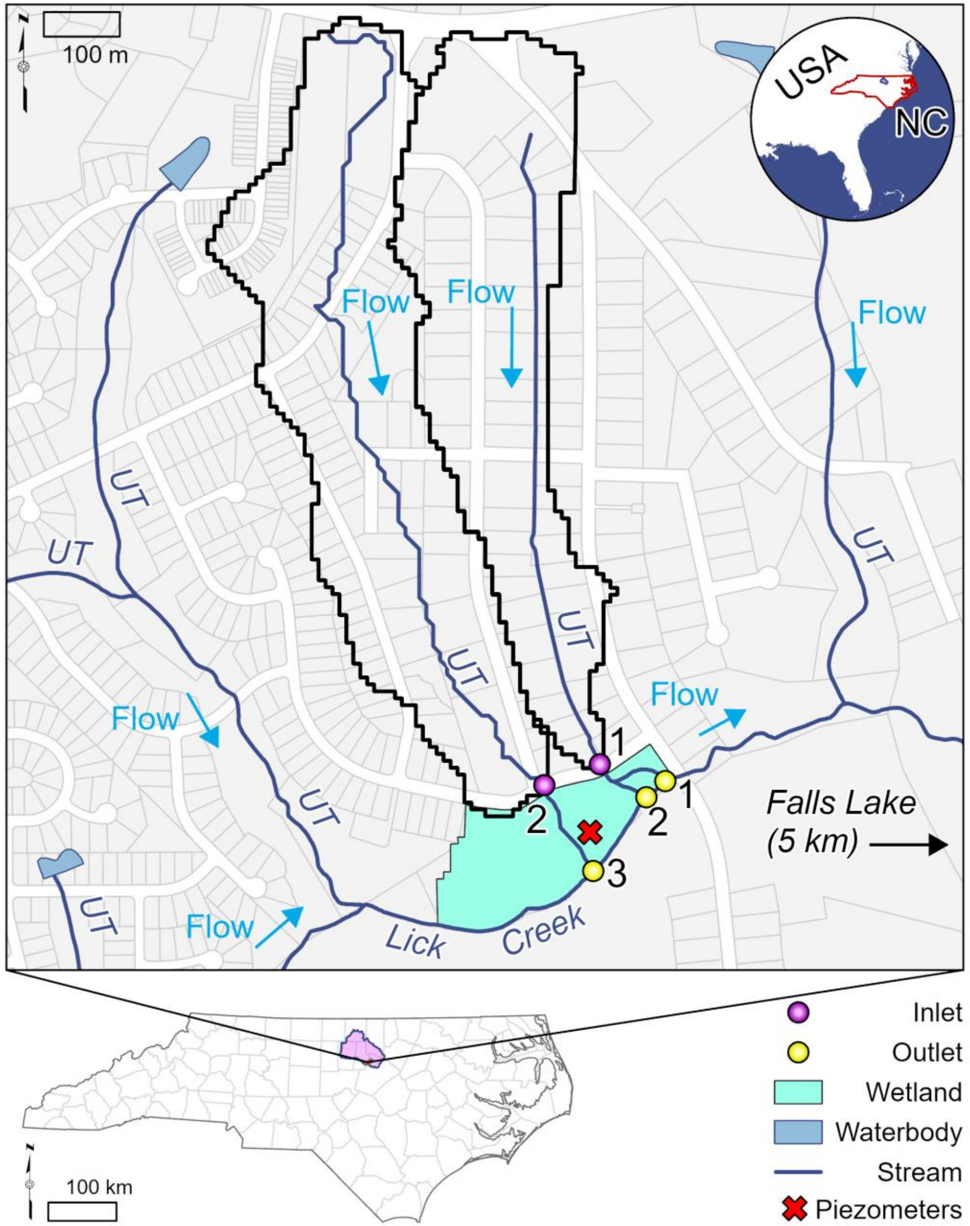
- Restore riparian habitat, protect water quality functions by protecting critical lands such as wetlands and floodplains
- Mitigate suspicious discharges from septic systems
- Better stormwater controls throughout the watershed needed to reduce erosion and sediment transport
- Funding available via EPA 319 nonpoint source funds (NC DEQ)



Finding a Focus Area

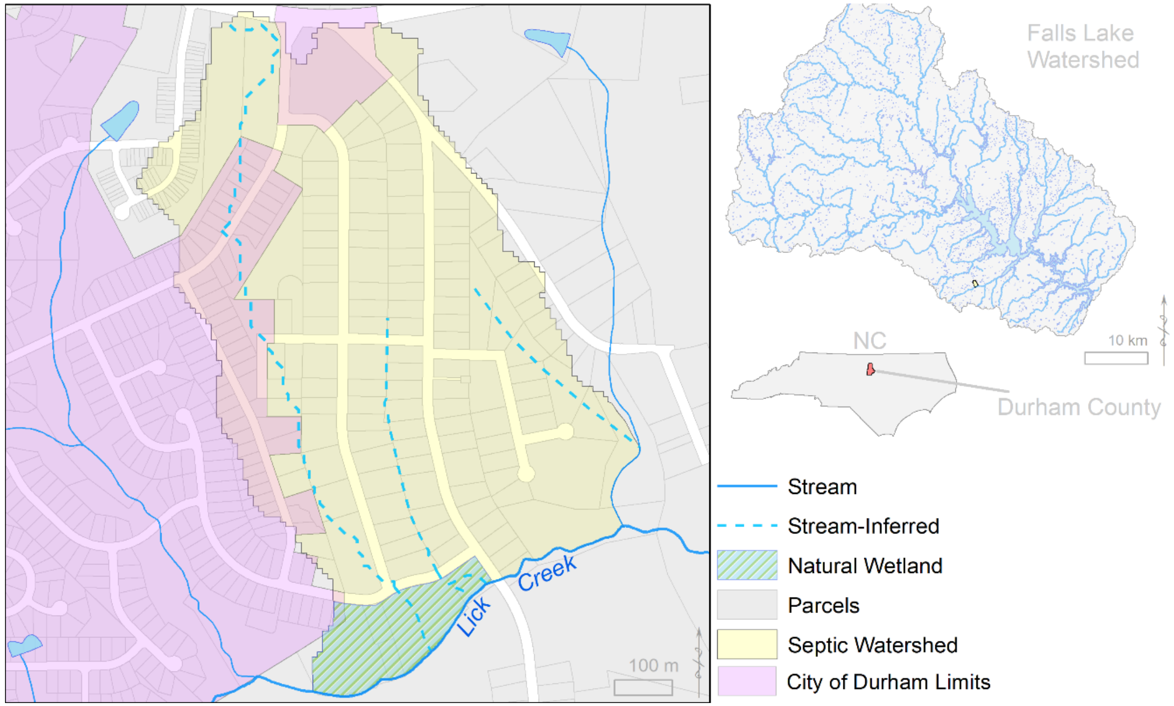
G1-G3 Sampling locations had elevated nutrients and bacteria and highest density of septic systems

Sampling Location	TDN (mg L^{-1})	PO4-P (mg L^{-1})	E. coli (MPN 100 mL^{-1})	Enterococci (MPN 100 mL^{-1})	SC ($\mu S\ cm^{-1}$)
G 1	**3.14 (1.08)**	**0.16 (0.21)**	**2025 (1123)**	**210 (321)**	**252 (28)**
G 2	**1.07 (0.19)**	**0.03 (0.02)**	**555 (699)**	**347 (473)**	**309 (130)**
G 3	**2.33 (1.12)**	**0.07 (0.06)**	**2853 (2414)**	**417 (1537)**	**233 (149)**
Natural	0.85 (0.23)	0.06 (0.07)	297 (289)	190 (208)	99 (41)
Upstream	0.79 (0.20)	0.03 (0.03)	143 (104)	139 (224)	182 (58)



- Wetland receiving drainage from a 24-ha catchment
- Predominantly residential development with septic
- Lick Creek is incised, and stream bed is much lower than surface of wetland
- Nick points in wetland retreating, causing erosion of wetland

Lick Creek Project Goals & Objectives



1. Evaluate nutrient and bacteria treatment by wetland
2. Stabilize eroding stream and drainageway segments
3. Implement BMPs to reduce runoff during storm events and improve septic system performance by repairing faulty systems and pumping septic tanks

Water Quality Monitoring (Inlets and Outlets of Wetland)

Monthly (n = 22) and 4 Storms

Nutrients	Physical/Chemical
PO_4-P	Flow
TP	pH
Cl	DO
DOC	Temperature
TSS	Turbidity
TN	E. coli

High-Frequency (0.5 hours)

Stream stage & temp. inlet and outlets

Source Identification

Bacteria source tracking

Isotopic analyses of NO_3

Watersheds surveys

Walking Survey of Watershed

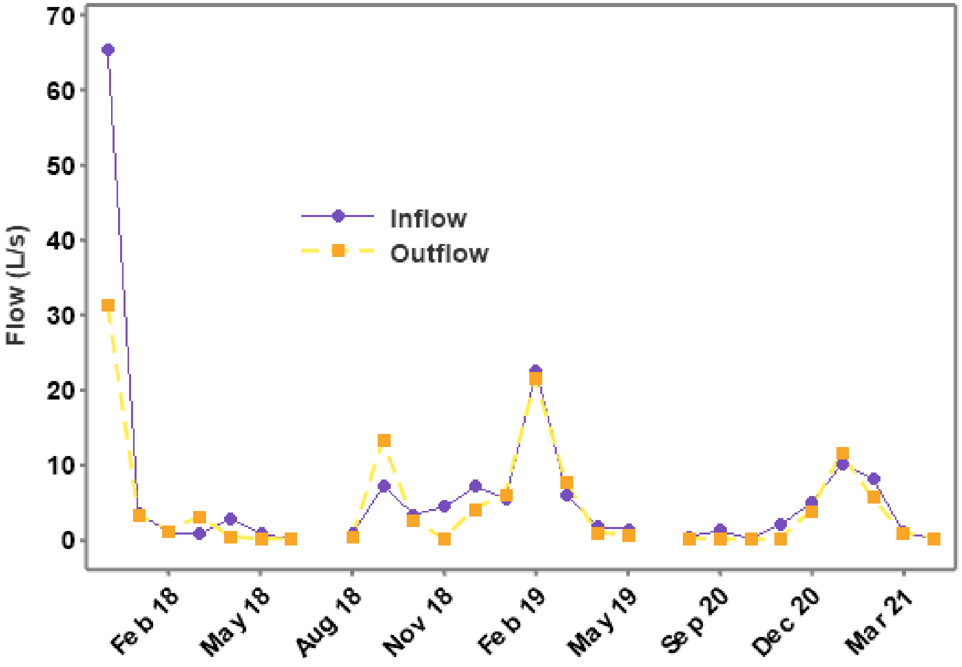
Groundwater Monitoring

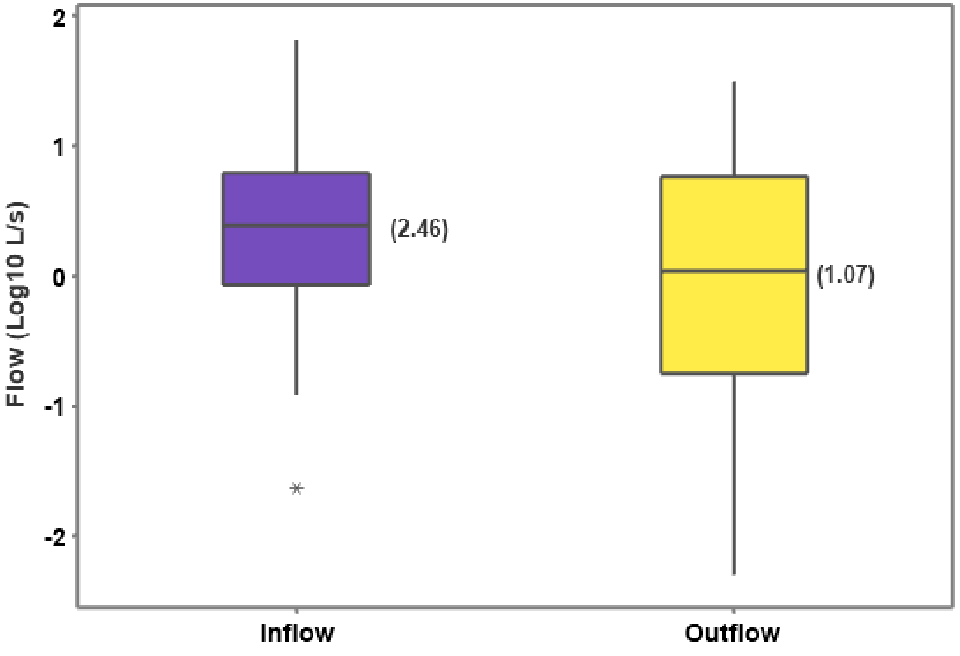
- 3 piezometers installed at different depths (shallow, intermediate, deep) to assess hydraulic head and water quality
    - Phosphorus, *E. coli*, physicochemical parameters (pH, ORP, temp)

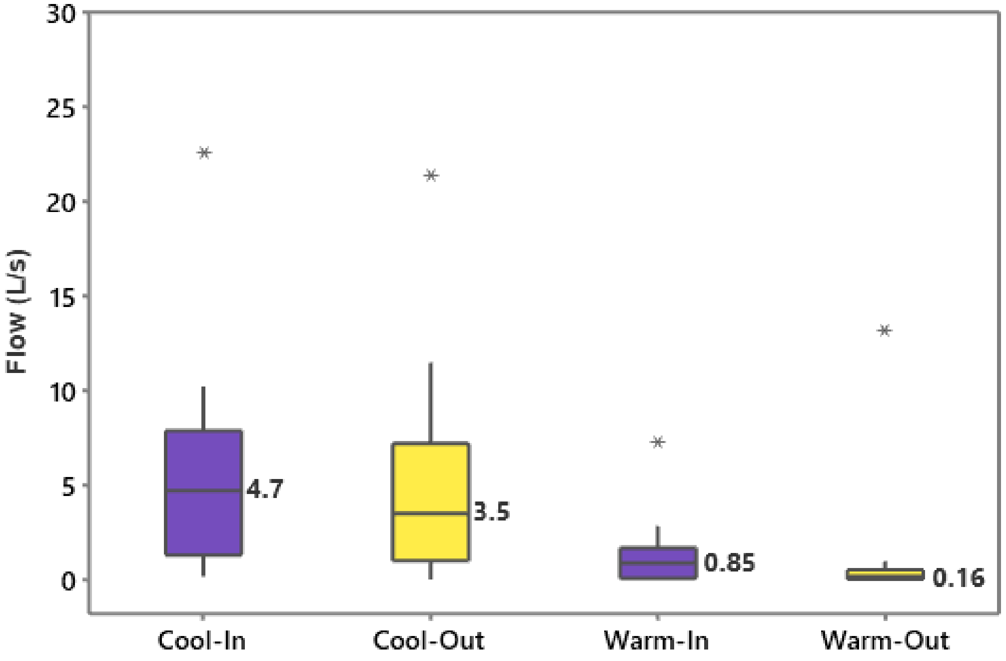
Results and Discussion

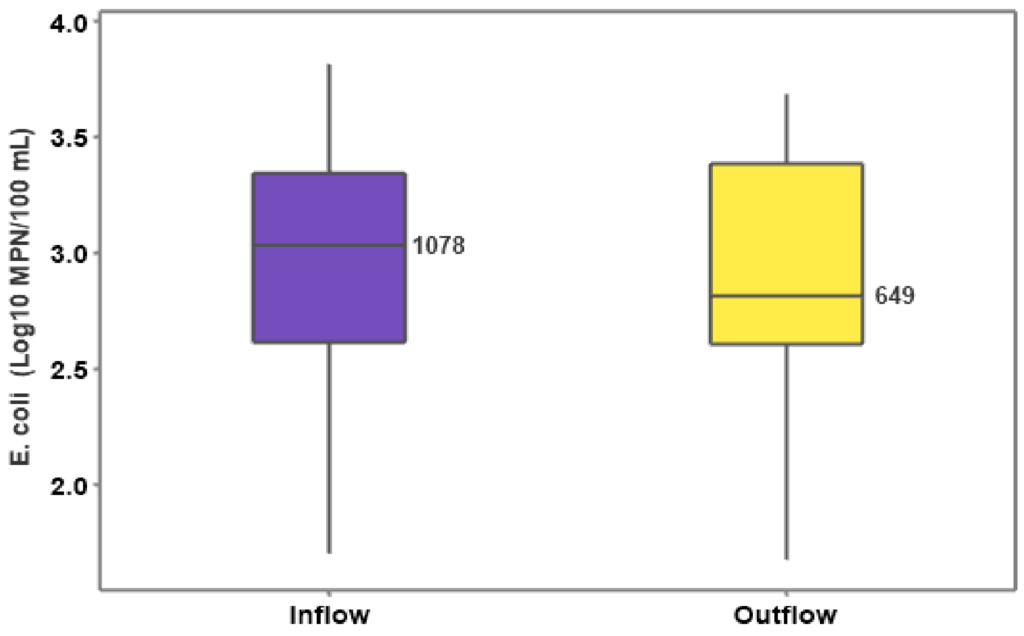
Results (Flow Dynamics)

- Outflow lower than inflow during 69% of sampling events
- Overall difference in outflow and inflow significant ($p = 0.014$)
- Flow greater during the cooler months of fall and winter
- Outflow and inflow not significantly different during cooler months but are sig different during warmer months
  - Evapotranspiration



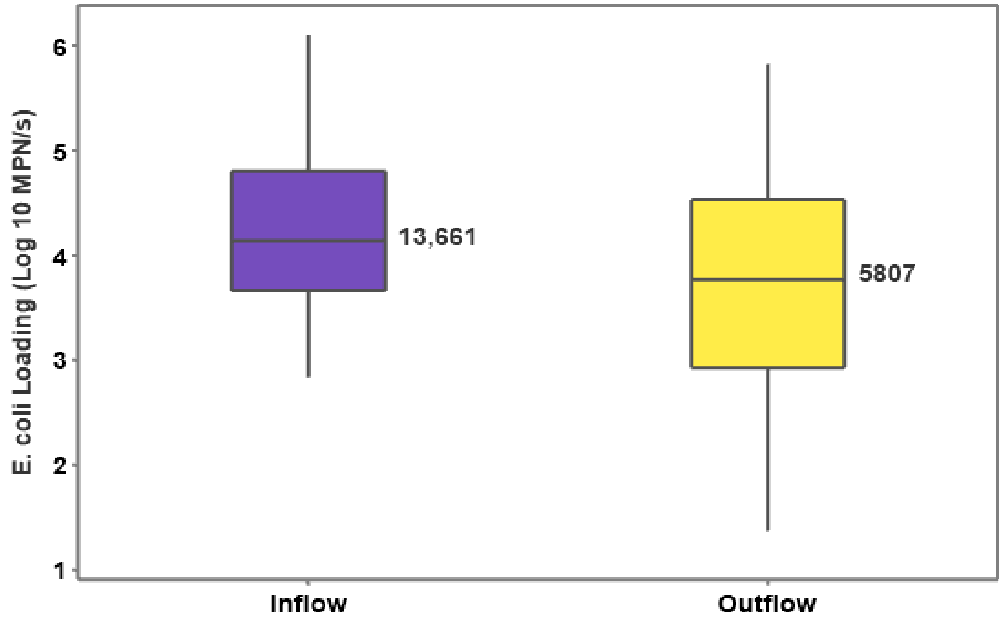






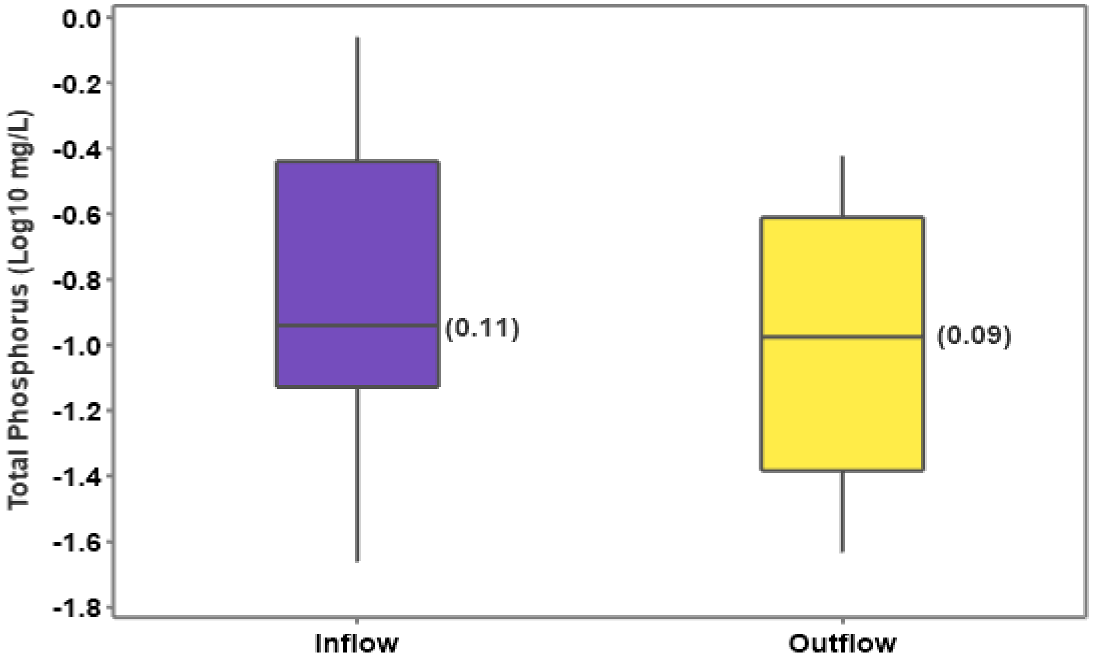
Results (*E. coli* Treatment)

- 40% Reduction in *E. coli* concentrations
- Differences not significant ($p > 0.05$)
- Outflow concentrations of *E. coli* exceeded STV of 410 MPN/100 mL during 76% of sampling events
- Outflow geometric mean of *E. coli* (719 MPN/100 mL) exceeded EPA standard (126 MPN/100 mL)

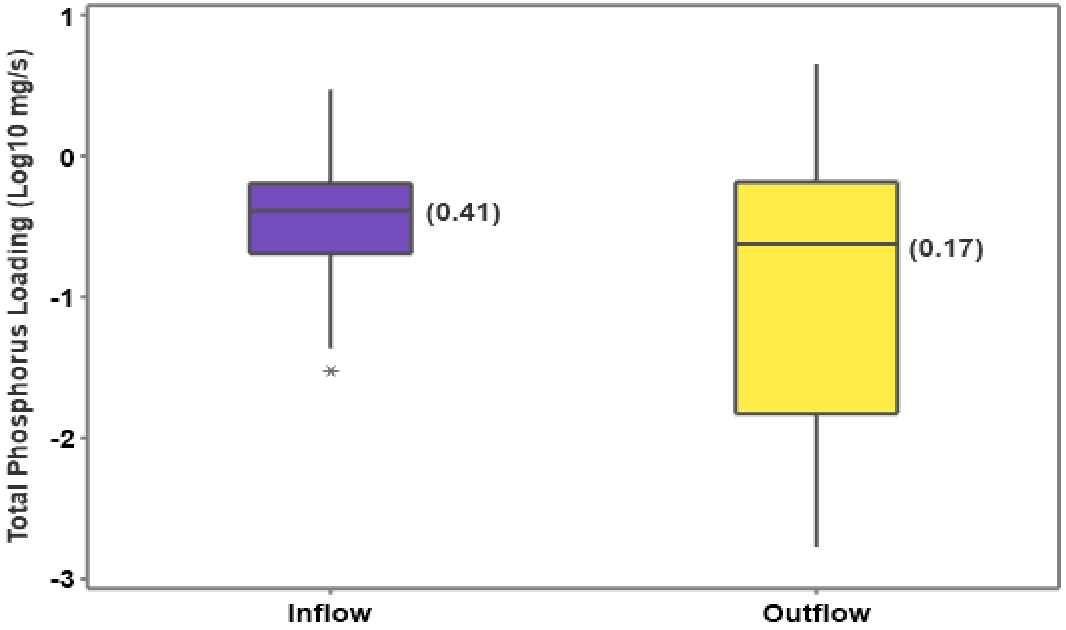


- 57% Reduction in *E. coli* Loading comparing outflow to inflow
- Differences significant ($p = 0.006$)
- Outflow loadings of *E. coli* significantly correlated with inflow loadings ($r = 0.727$; $p < 0.001$)

Results (Phosphorus Treatment)

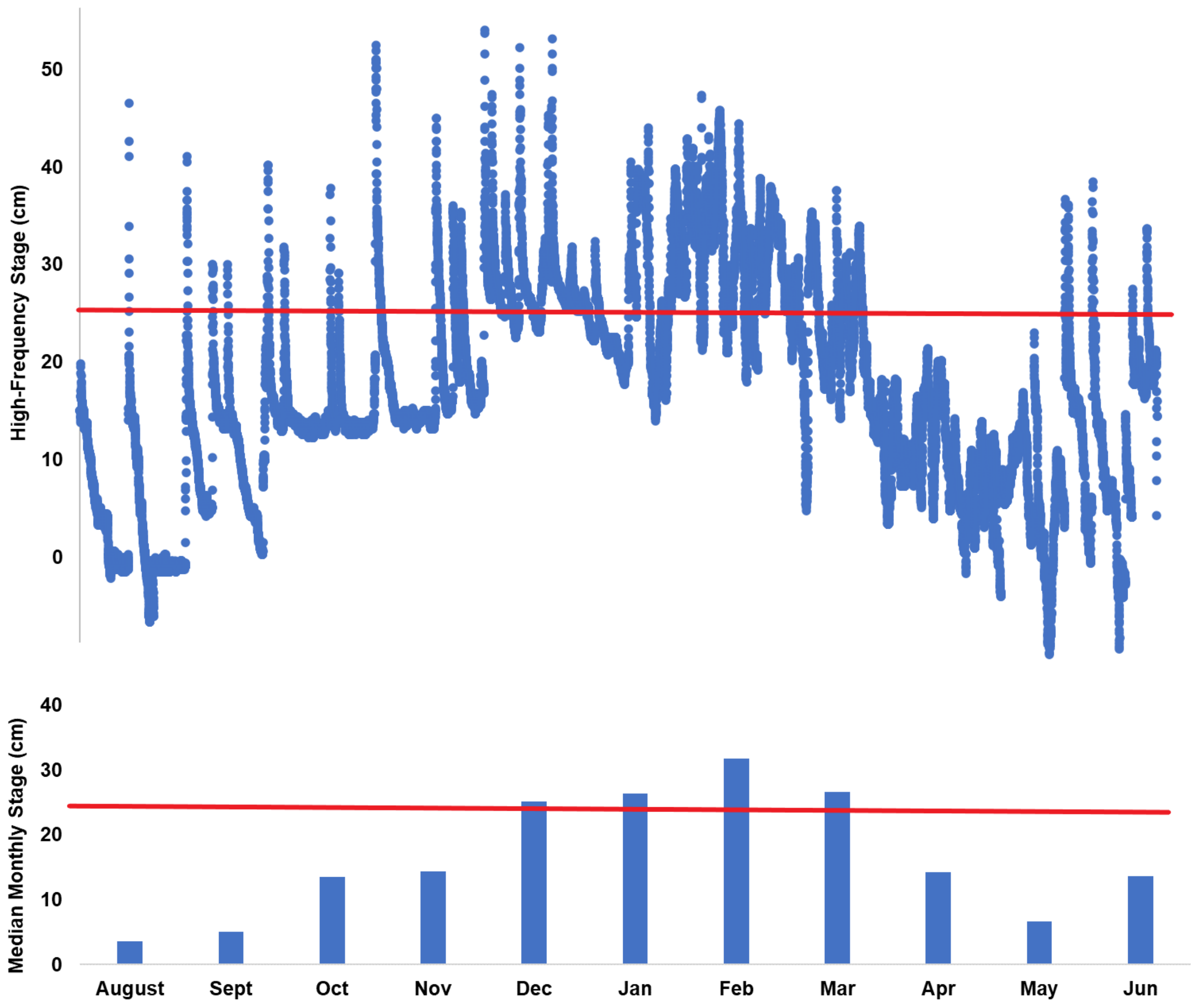


- 18% Reduction in TP concentration
- During 63% of sampling events outflow concentrations of TP were lower than inflow concentrations
- Differences not significant (p = 0.233)



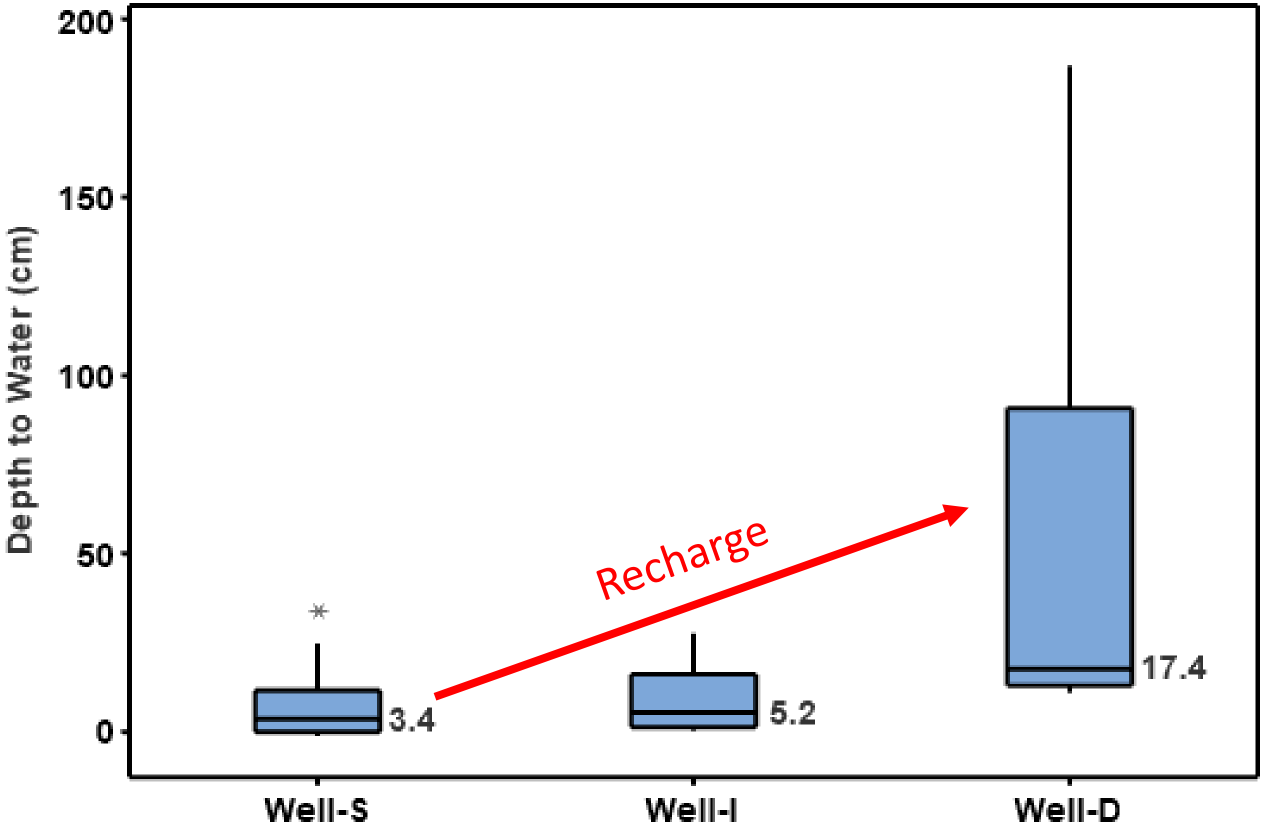
- 59% Reduction in TP Loading
- During 81% of sampling events outflow loadings of TP were lower than inflow loadings
- Differences significant (p = 0.011) between outflow and inflow TP loadings
- TP treatment efficiency was inversely correlated with influent TP loading (r = -0.656; p = 0.006)

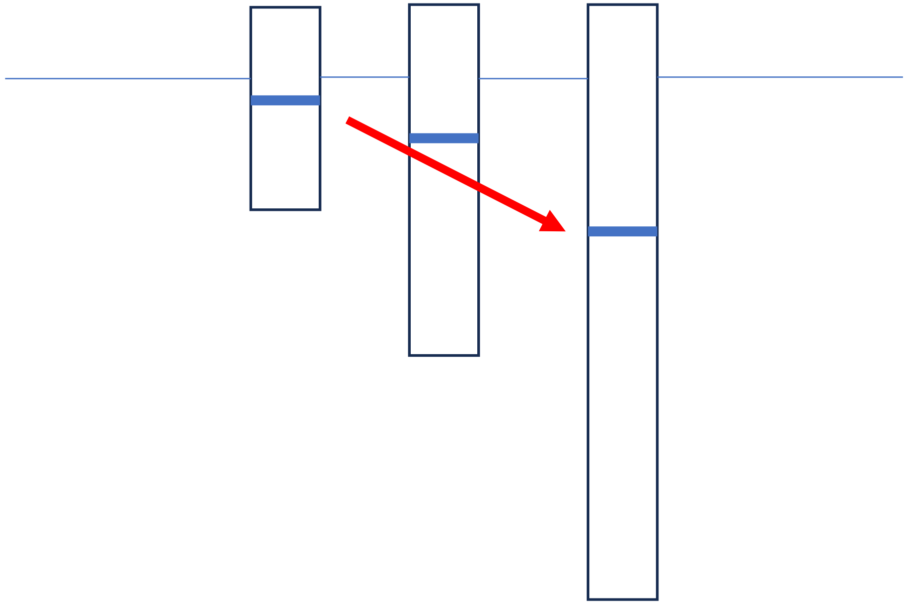
Hydrology Influence on Treatment



Load reductions were best when the inflow water level (stage) was under 24 cm. During the winter months (Dec to March) there was lower residence time of water in the wetland and less treatment

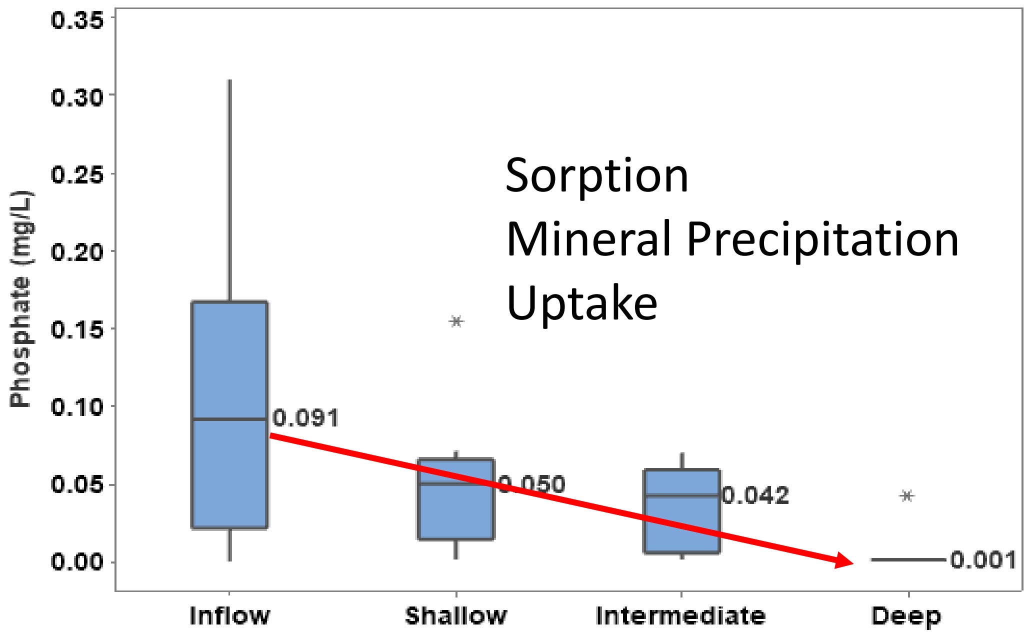
Results (Groundwater Hydrology)

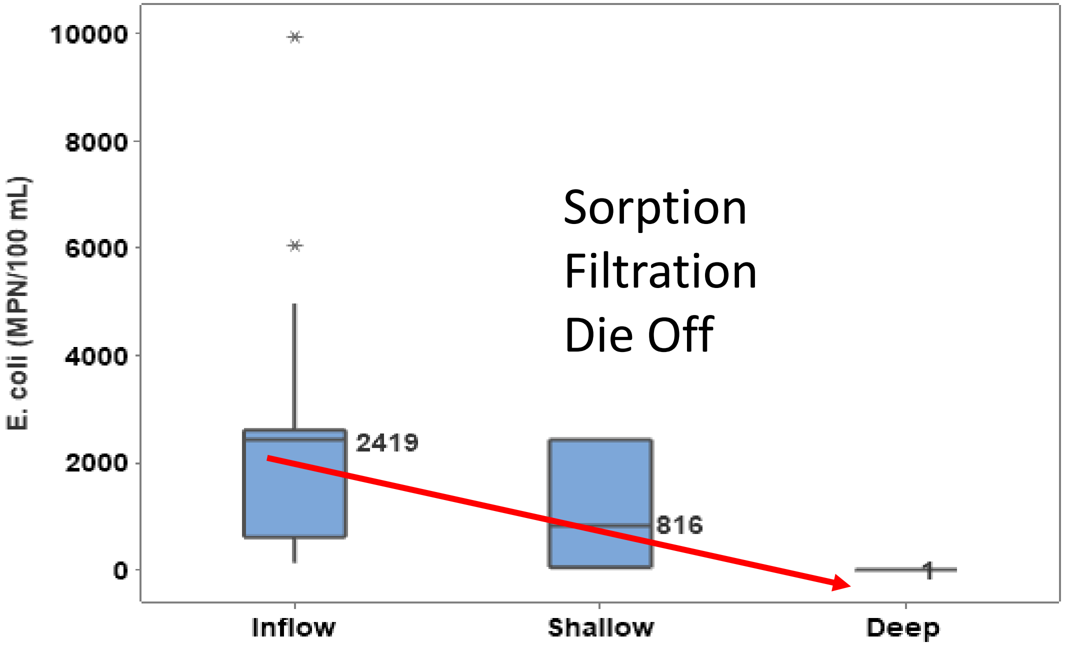




Inflow to the wetland was pooling, infiltrating, and percolating to water table and migrating to Lick Creek

Results (Groundwater Quality)





Drainageway Stabilization

Drainageway Modification

Over 230 m of drainageway modified

Septage Pumping

Pumped 15 septic tanks as part of this project

Septic System Repairs

Unclogged trench & connected effluent pipe to other portion of drainfield

Septic Repair

Installed new septic drainfield
and replaced septic tank

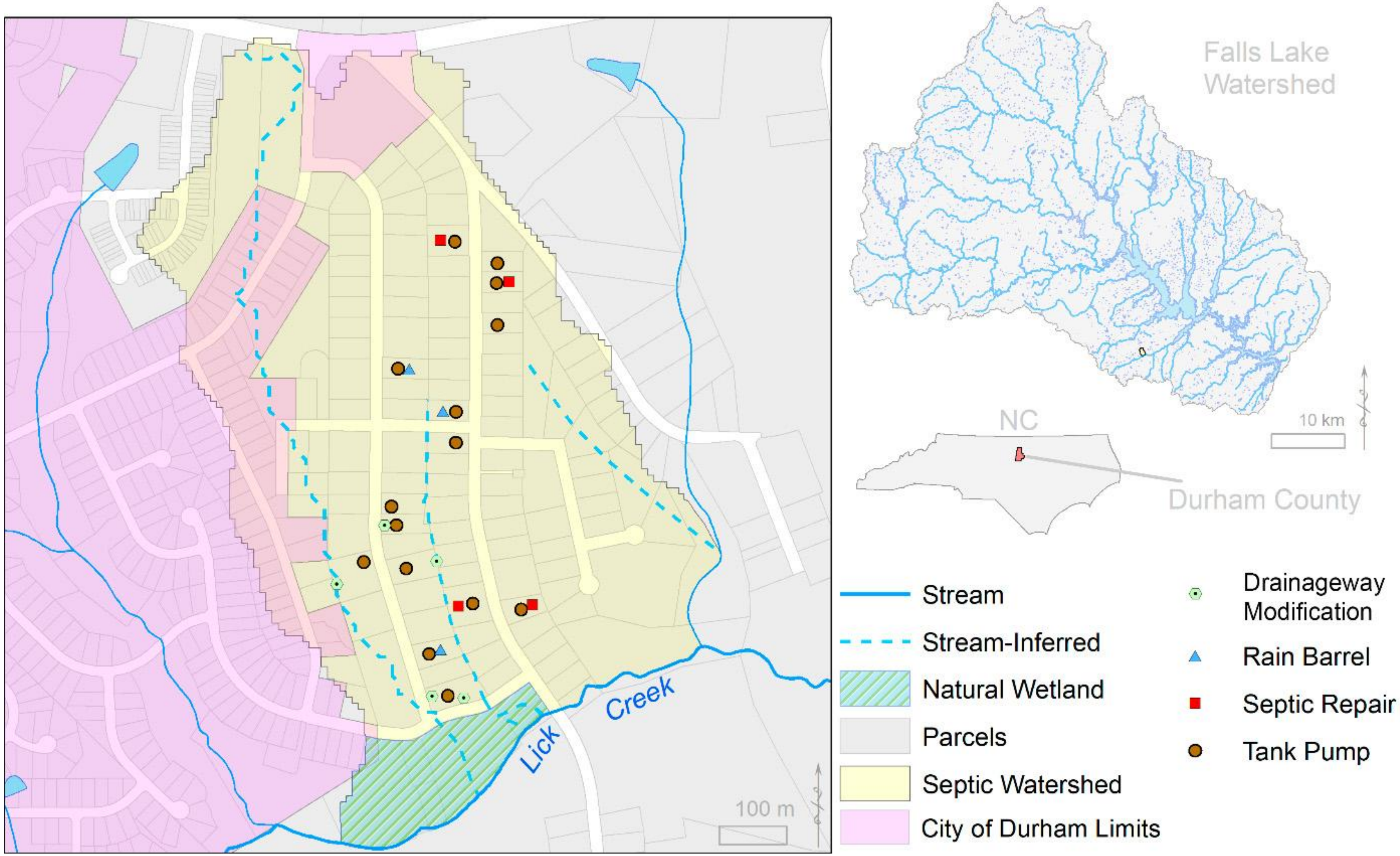
Septic System Repair

Installed new drainfield trenches

Septic System Repair

Replaced cracked septic tank lid

Implementation of Practices in Study Area



Summary

- Wetland lowered exports of TP by 59% and *E. coli* by 57%
- Wetland treatment efficiency linked with hydraulic residence time of water in wetland and inversely correlated with inflow
- Malfunctioning septic systems were contributing to elevated nutrient and bacteria concentrations and loads
- Efforts to slow runoff including modifications of drainageways were implemented
- Efforts to improve performance of septic systems including installation of new drainfield trenches, pumping of septage, replacement of septic tank lids were made
- More work is needed to prevent erosion of wetland outlets (likely hard stabilization) and improve functioning of septic systems

Questions