NORTH CAROLINA
Nothing Compares

NMEB Conference

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Raleigh, NC

Evaluating Water Quality Before and After Stream Restoration

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Need and Justification

- Water quality improvement is often stated as a goal in mitigation. **Bernhardt et al., (2005)**

- Historically it has not been measured sufficiently to support those goals. **Palmer et al., (2007)**

- Many investigators questioned the functional value and efficacy of restoration for pollutant attenuation absent watershed controls **Walsh et al., 2005; Bernhardt and Palmer, 2007; Craig et al., 2008; Selvakumar et al., 2010**

- The last decade has shown a range of results and promise but understanding of scale and efficacy of specific practices is still lacking. (**Palmer et al. (2014**); **Lammers and Bledsoe (2017)**; **Newcomer Johnsen et al., (2016))**

DMS Resources

1. DMS has a large inventory of projects from 2 decades of mitigation.

2. Opportunity for long term observation and monitoring.

3. Tied to a robust watershed planning approach.

DMS Study Objectives

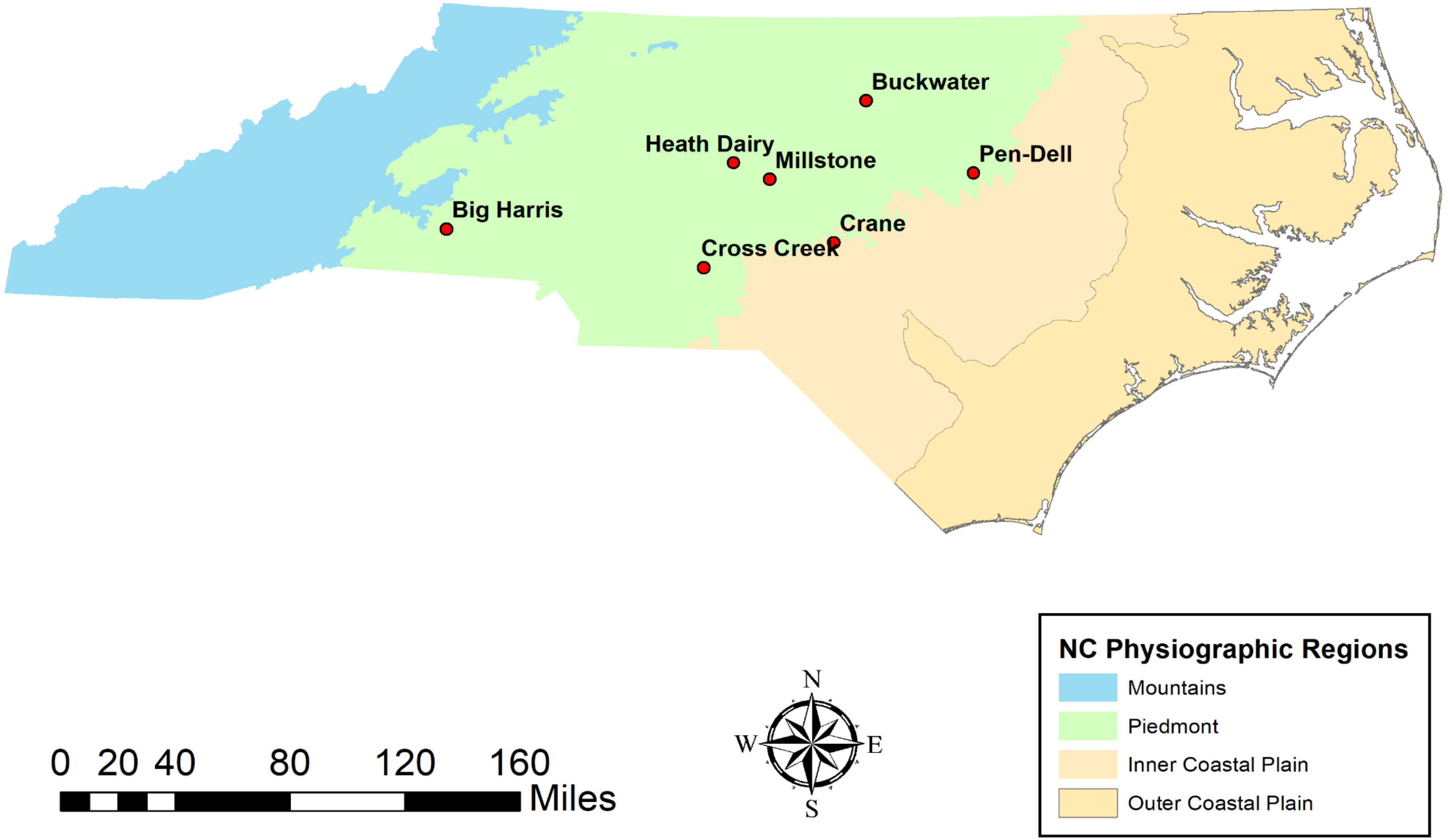
1. Provide case examples of water quality response to restoration.
   (Todays presentation is focused on one such case example deliberately selected with a condition of high signal to noise)

2. Gain understanding of the scale under which change detection is feasible.
   (Gradient of signal to noise)

3. Understanding the efficacy of different practices.

4. Understanding the time frames of improvement and their sustainability.

DMS WQ Study Sites

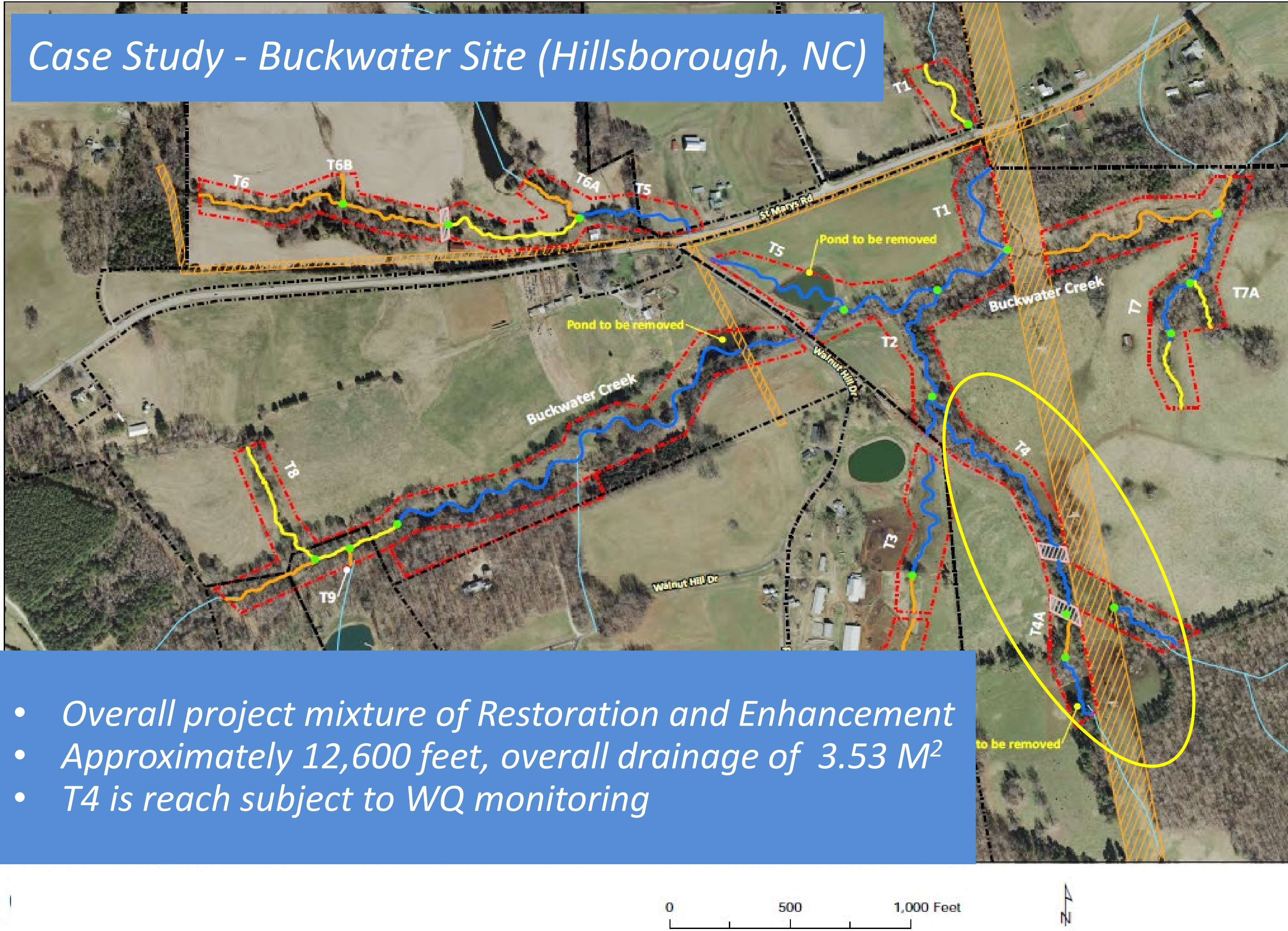


DMS WQ Study Sites

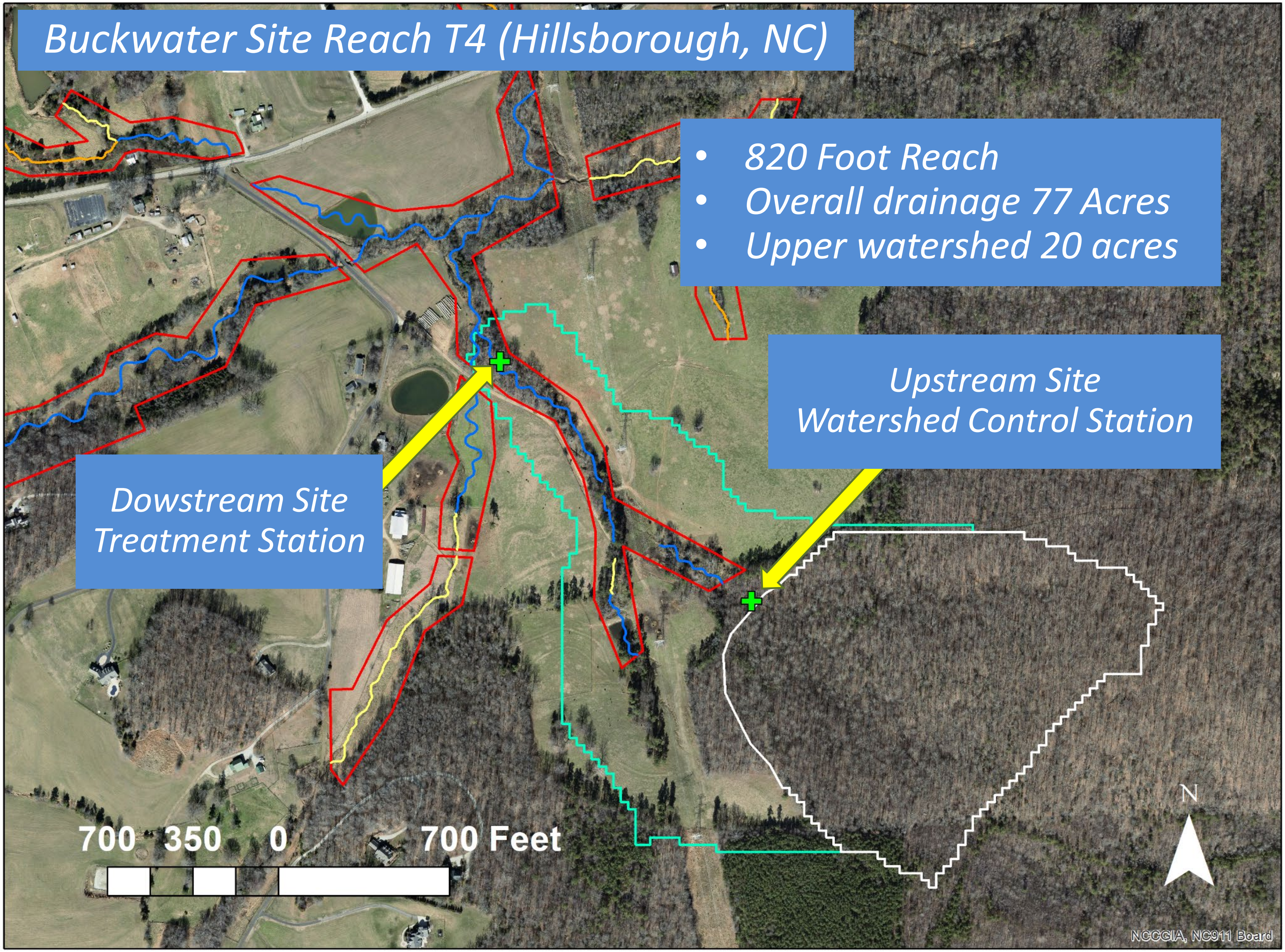
Project	# Reaches	Param	Years Pre	Years Post
Heath Dairy	2	F,N,S,M	3	1.7
Millstone	2	F,N,S,M	1.3	
Pen Dell	1	F	1	2
Buckwater	1	F,N,S	0.8	1
Big Harris	13	F,N,S,FS,M	5	0.5
Cross Creek	1	F,N,S	1	
Crane Creek	1	F,N,S	0.5	
	Indicates a year or more of post restoration data			

F – Fecal; N – Nutrients; S – Total Suspended Solids;
M–Macrobenthos FS – Fish

Case Study - Buckwater Site (Hillsborough, NC)



- *Overall project mixture of Restoration and Enhancement*
- *Approximately 12,600 feet, overall drainage of 3.53 M^2*
- *T4 is reach subject to WQ monitoring*


Buckwater Site Reach T4 (Hillsborough, NC)
820 Foot Reach
Overall drainage 77 Acres
Upper watershed 20 acres
Upstream Site
Watershed Control Station
Dowstream Site
Treatment Station
700 350 0 700 Feet
N
NCCGIA, NC911 Board

Buckwater Reach T4 Stressors

- The main lateral stressor to the reach was livestock.
- Eutrophied pond draining to reach.
- Reach was incised (floodplain disconnection).
- Watershed above upper station completely forested.
- This is a low watershed noise case example.

Buckwater Reach T Stressors

Buckwater Reach T4 Stressors

Buckwater Reach T4 Stressors

Station Setup and Methods

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Using ISCO Auto Samplers:

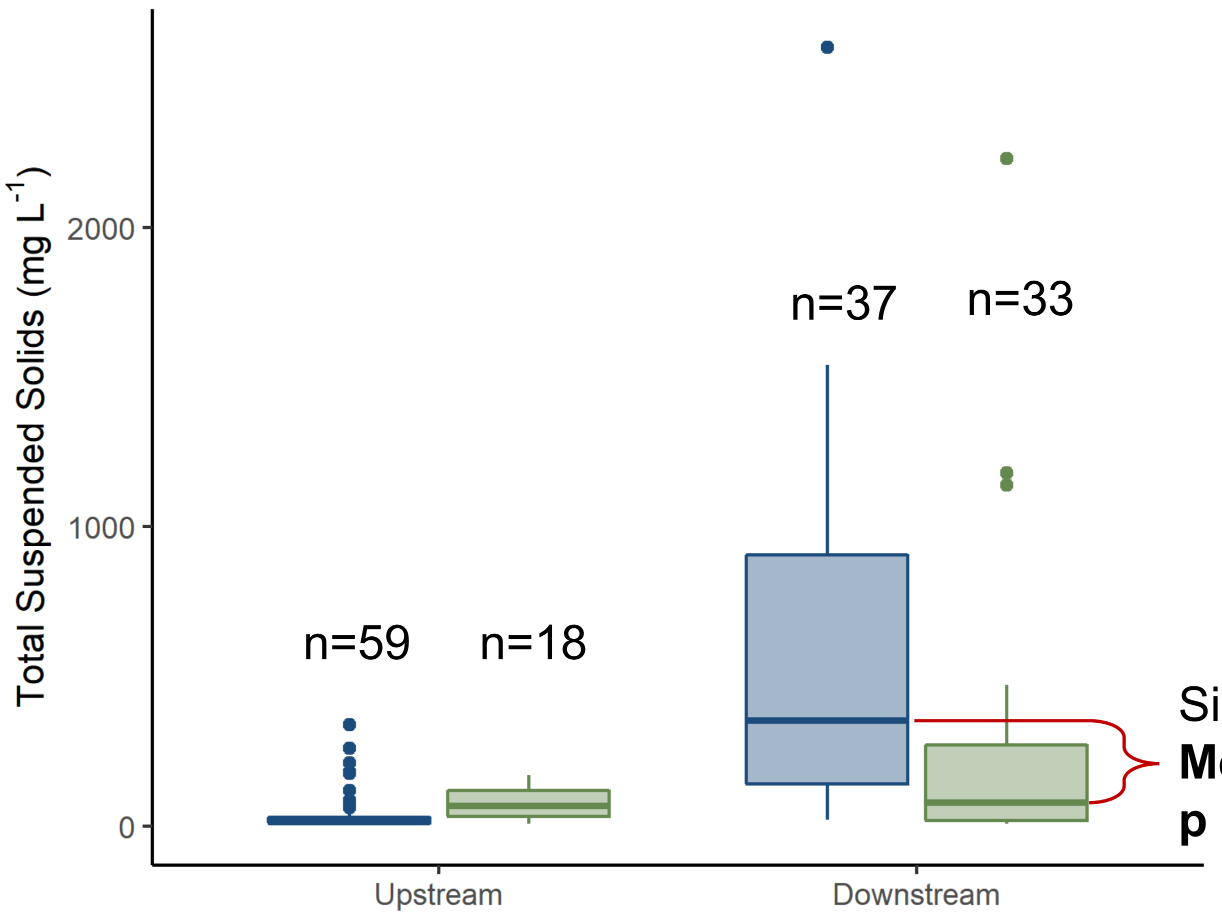
- Records stage measurements in 15 min increments.

- Calculates discharge based on rating curve. Discharge calculated via weir equations or dilution gauging.

- Water samples pulled as flow composite sample in base or storm flow conditions.

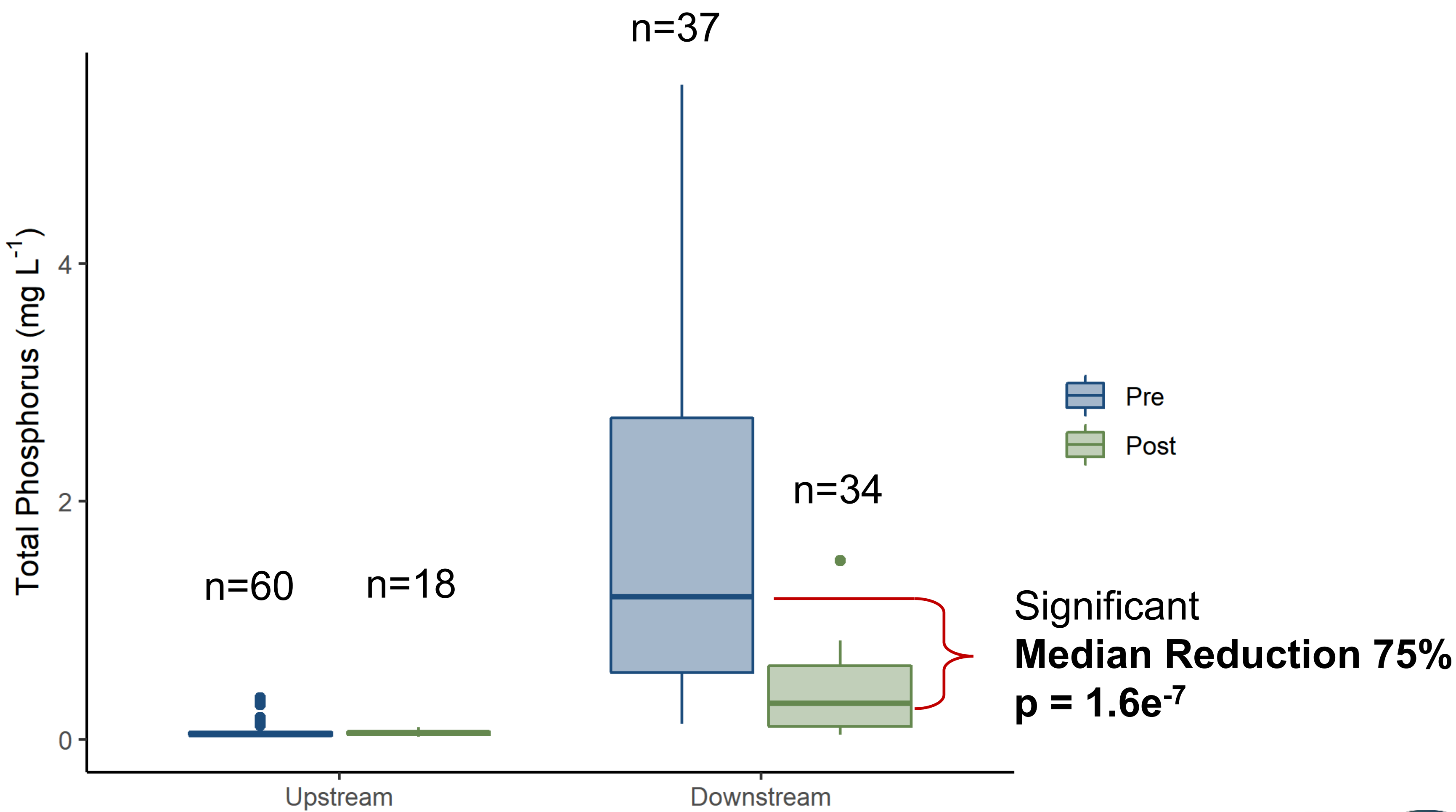
- Integrated precipitation gauge.

Buckwater T4 – Total Suspended Solids

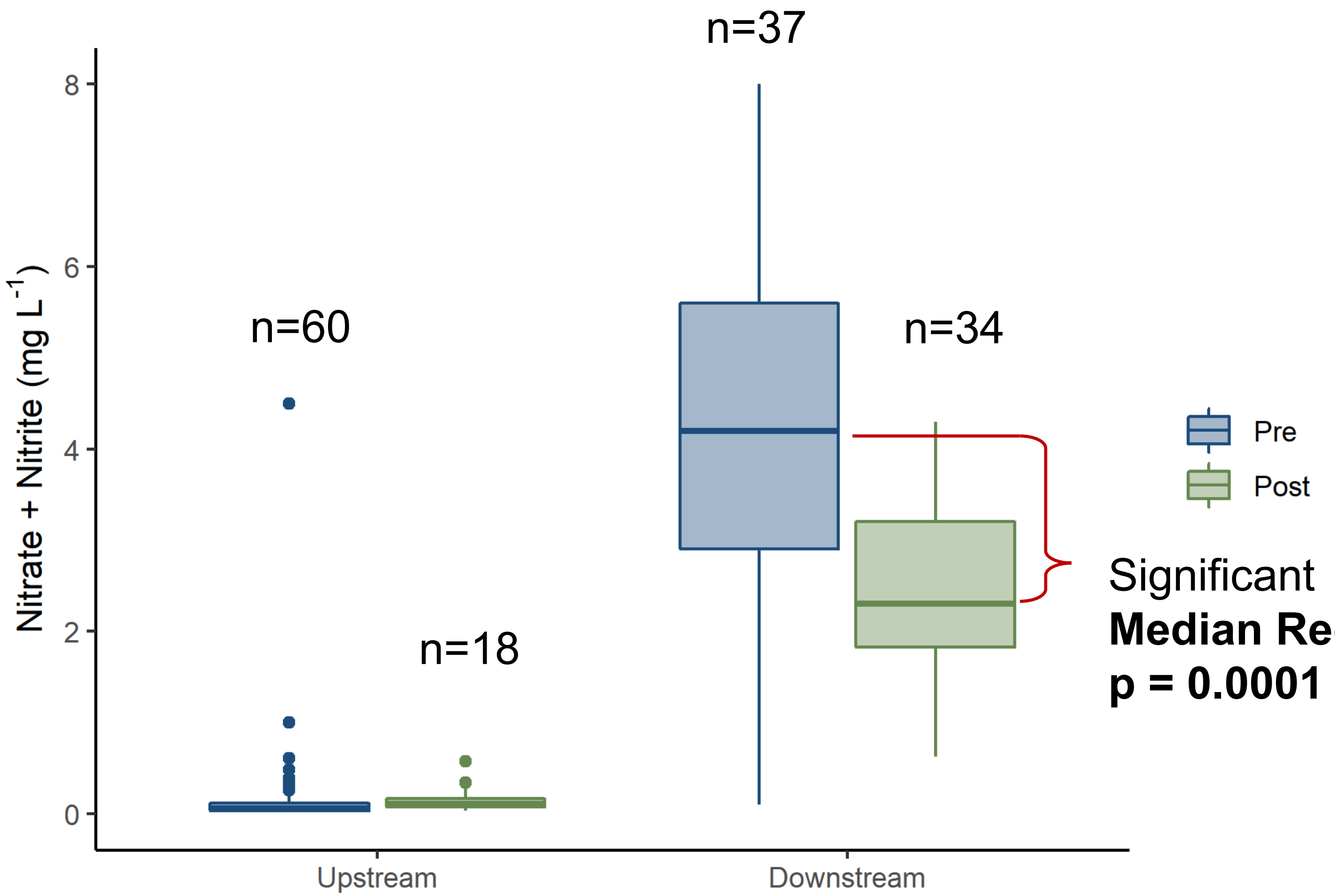


Significant
Median Reduction of 78%
p = 9.6e^{-5}

Buckwater –Total Phosphorus

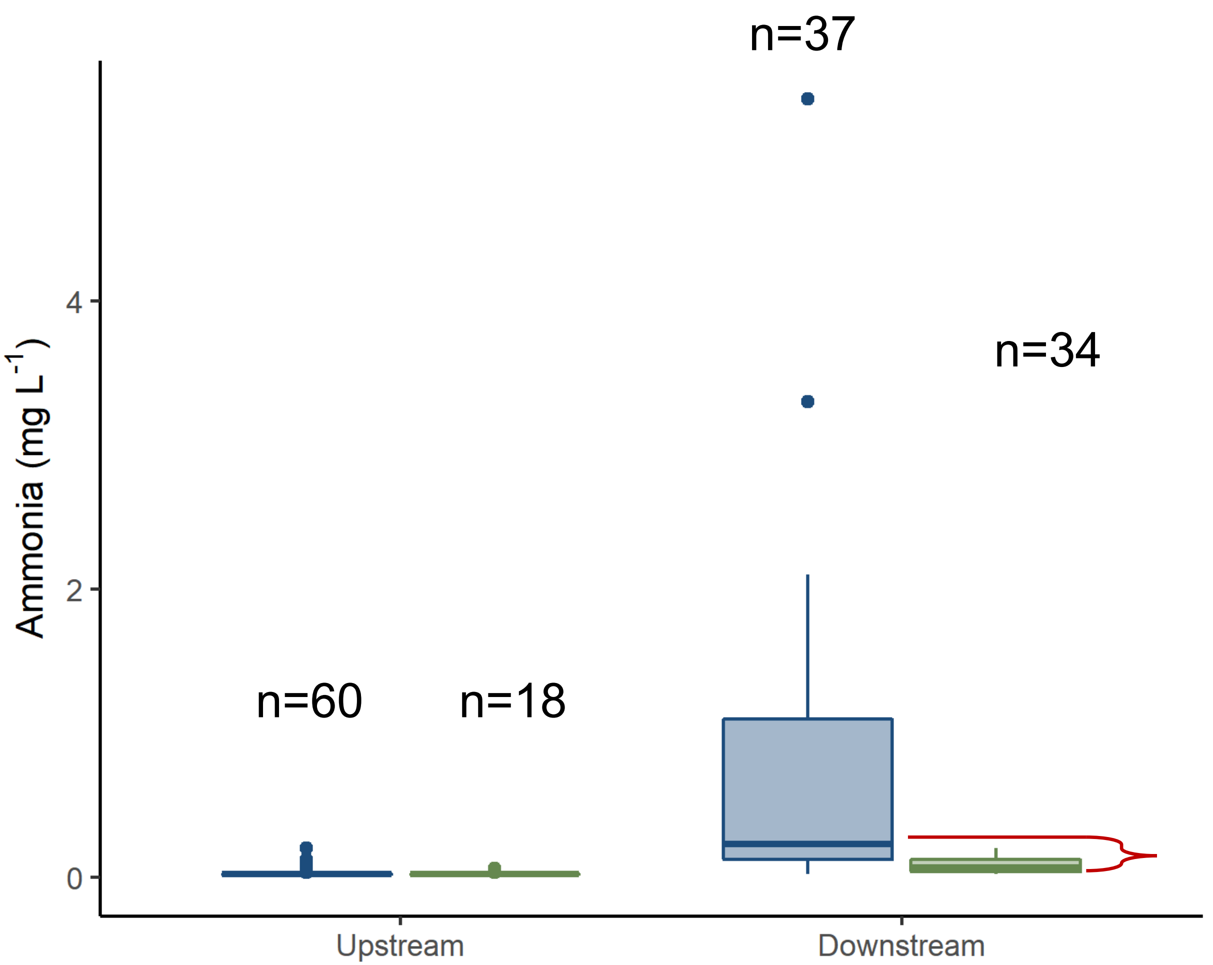


Buckwater - Nitrate & Nitrite



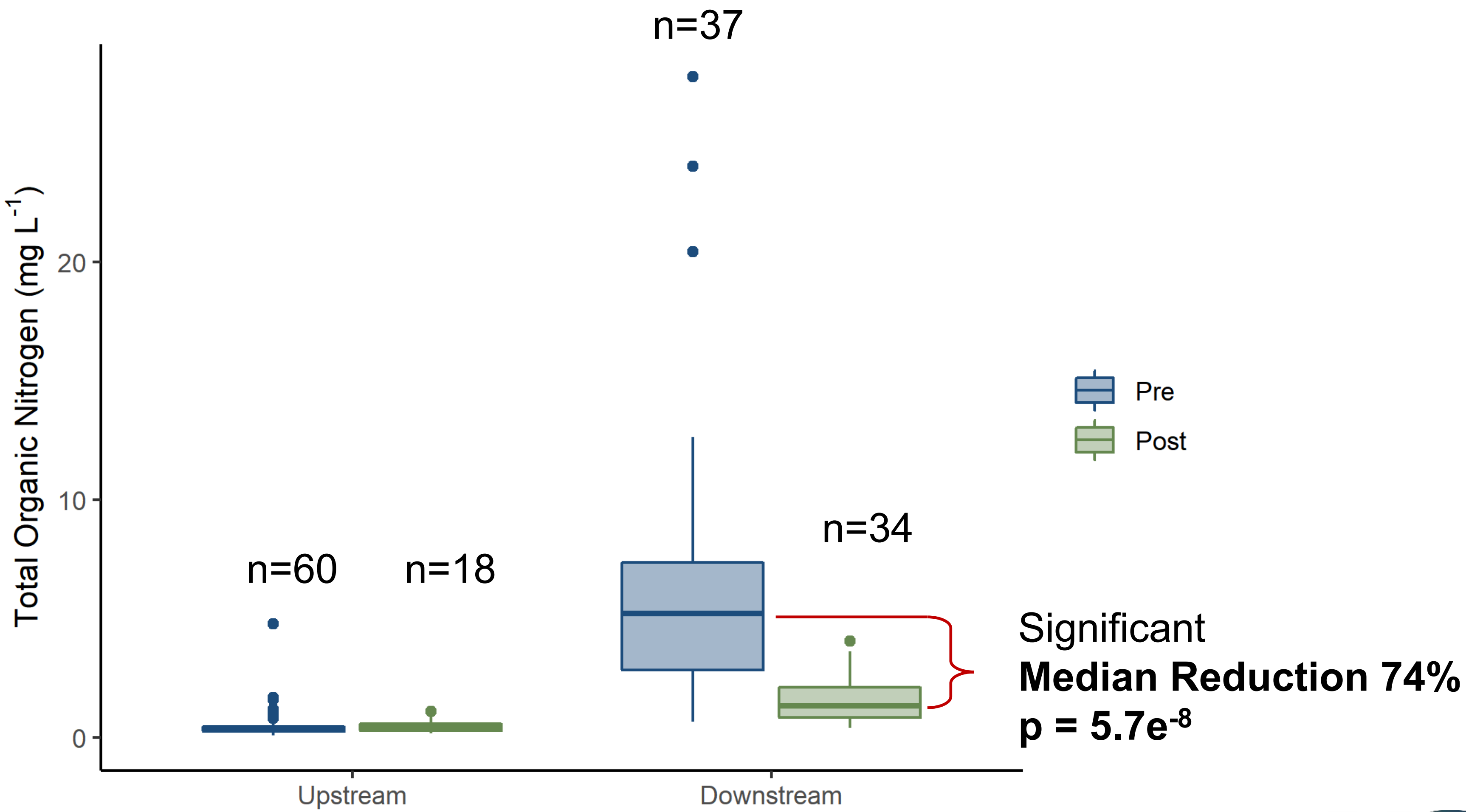
Significant
Median Reduction 45%
p = 0.0001

Buckwater - Ammonia

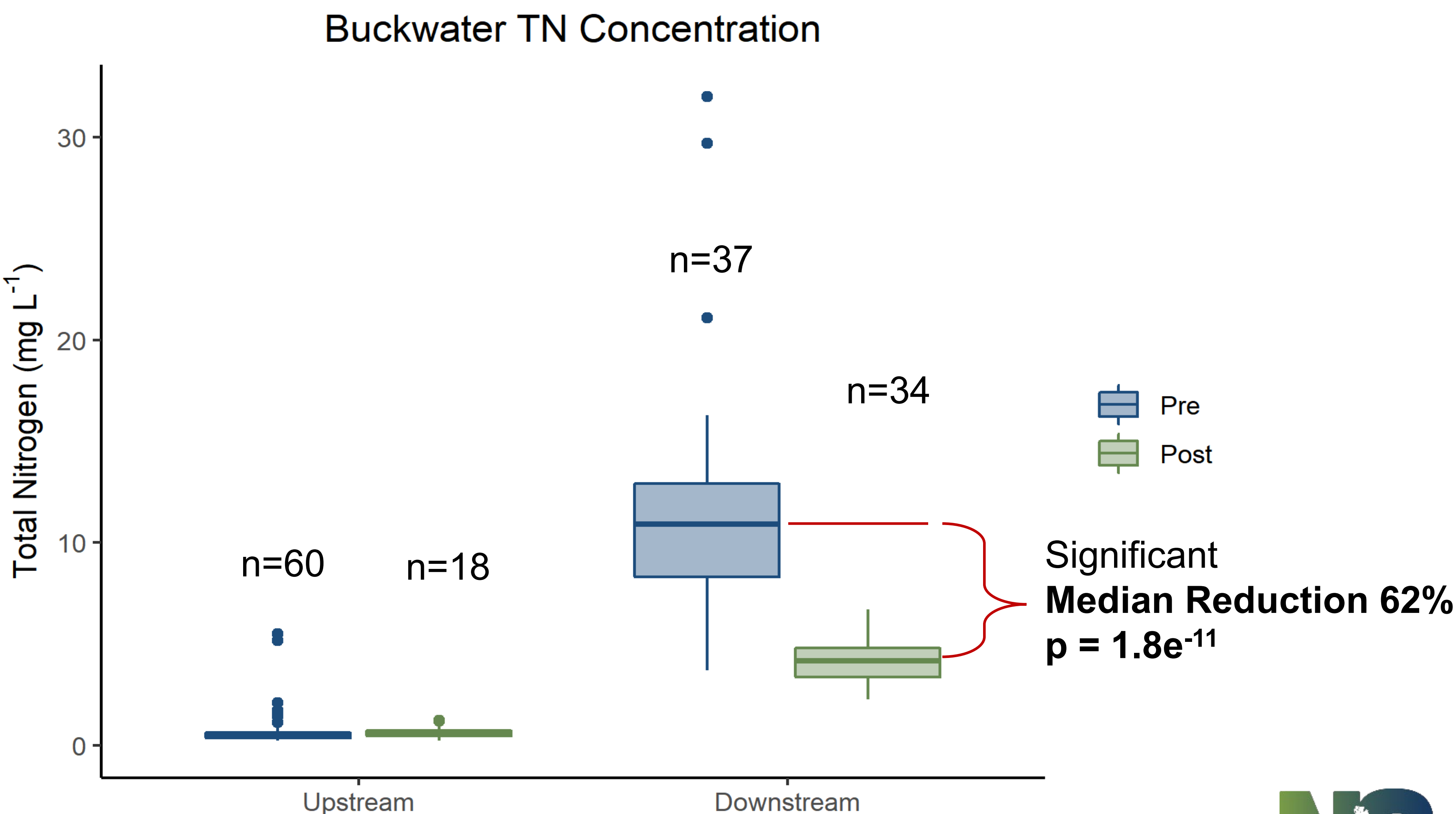


Significant
Median Reduction 72%
p = 1.9e^{-7}

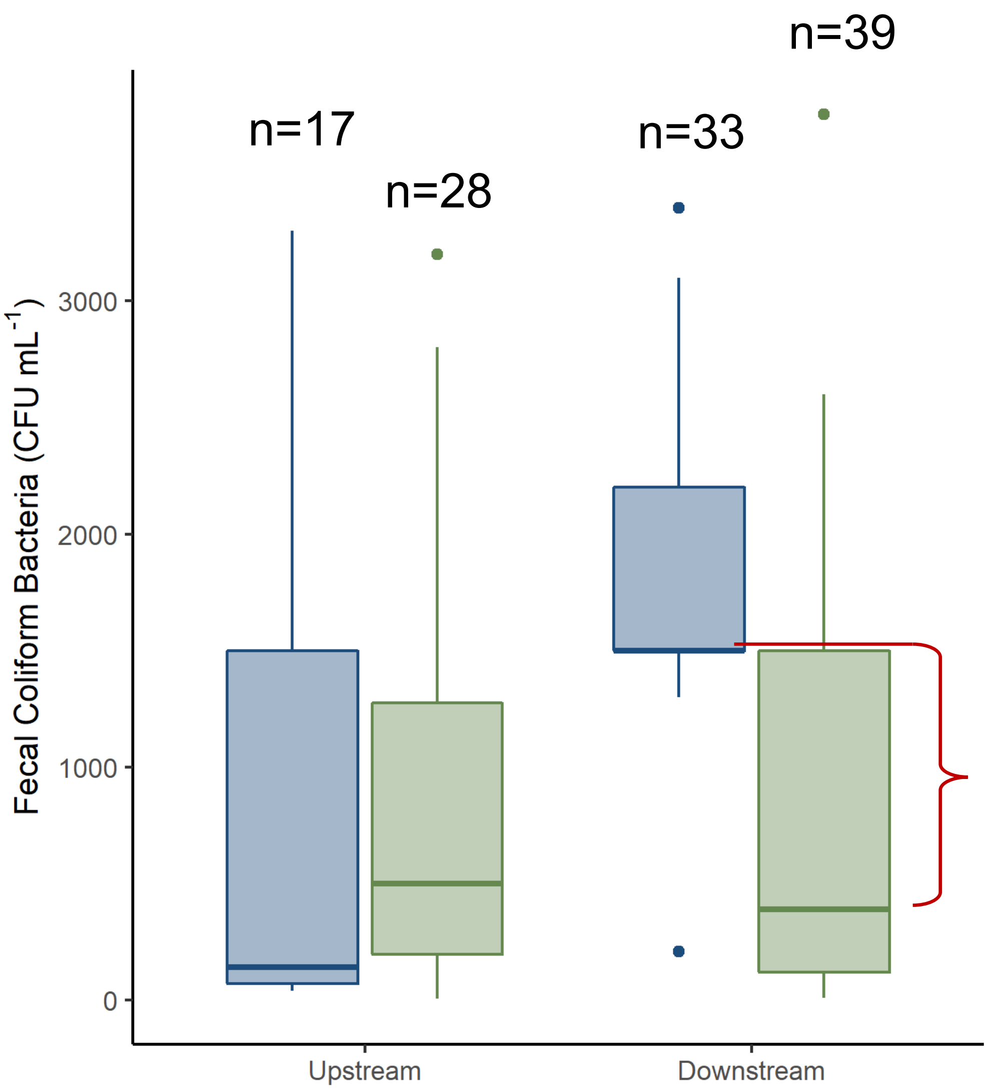
Buckwater - Total Organic Nitrogen



Buckwater – Total Nitrogen



Buckwater – Fecal Coliform (T-4)



- Stations significantly different pre-construction
- Stations similar post-construction

Significant
Median Reduction 74%
p = 8.3e-6

Summation of Buckwater Results Thus Far

- Low watershed noise case study demonstrated:

  62 – 78% reduction in all pollutants pre-post..
  except NO_2/NO_3 (45% reduction).

- Concentrations and reductions were related to livestock removal.

  NO_2/NO_3 reductions still significant but this parameter is more groundwater mediated.

- At this time we cannot attribute the proportion of reductions to the different treatments applied (e.g. cattle removal, channel manipulation, floodplain reconnection).

Looking Ahead

- Include projects with different levels of signal to noise.

- Determine if reductions are sustained or even increase.

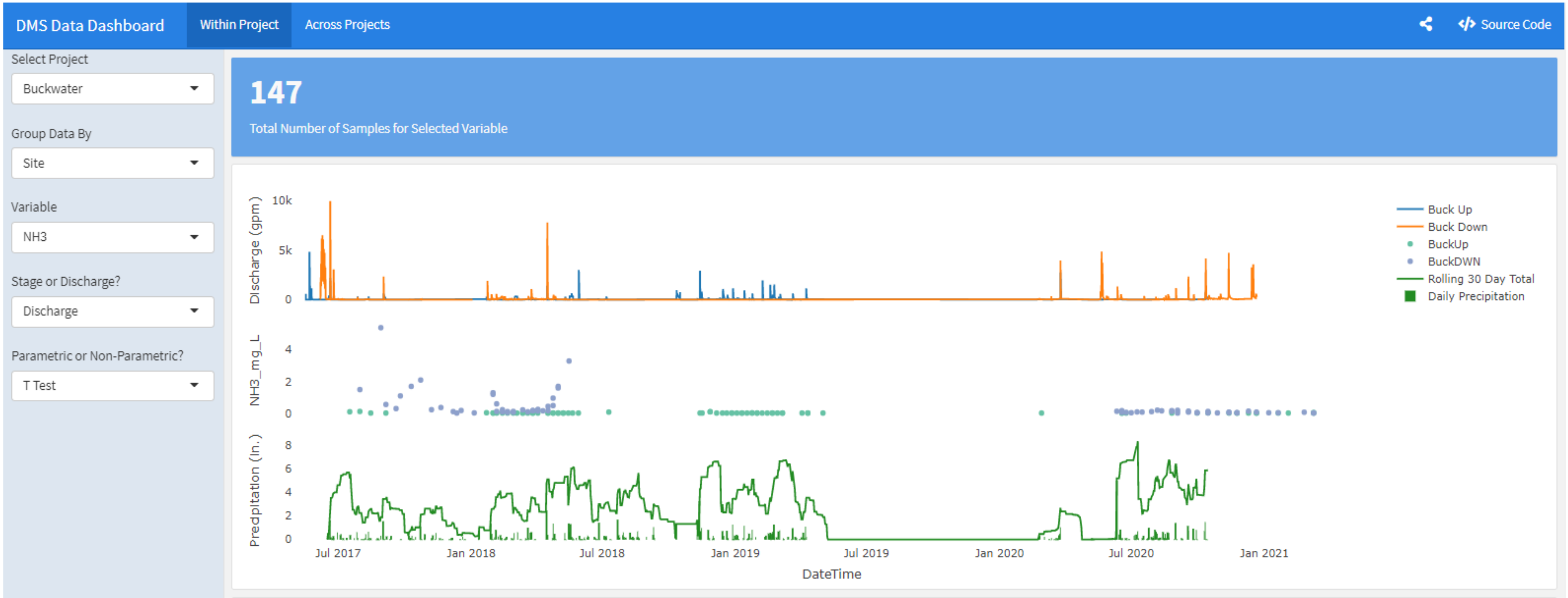
- Examine effects of different restoration treatments? (e.g. livestock removal versus channel modification)

  Example: Millstone Project with NCSU partners.

- Calculate and compare discharge and loads.

- Analyze change in hydrologic residence times.

DMS Data Sharing Resources – Web Dashboard



DMS Data Sharing Resources – Web Dashboard

DMS Data Dashboard | Within Project | Across Projects | Source Code

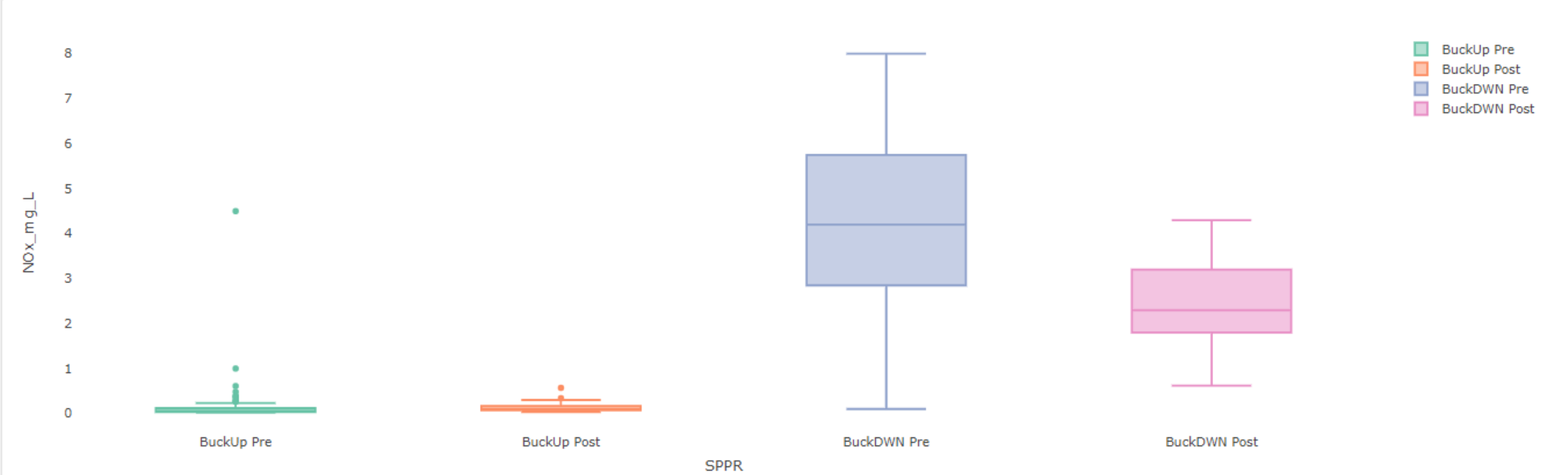
Select Project: Buckwater

Group Data By: Site + Pre and Post Restoration

Variable: NOx

Stage or Discharge?: Discharge

Parametric or Non-Parametric?: T Test



Show 10 entries

Search:

	Variable	Group A	Group B	n Group A	n Group B	Test Statistic	DF	P Values
1	NOx_mg_L	BuckDWN Post	BuckDWN Pre	32	37	-4.65064596110617	51.7312504006054	0.0000233
2	NOx_mg_L	BuckDWN Post	BuckUp Post	32	18	13.4367537175331	33.2618718341732	5.41e-15
3	NOx_mg_L	BuckDWN Post	BuckUp Pre	32	61	12.187028679179	44.4147221157828	9.2e-16
4	NOx_mg_L	BuckDWN Pre	BuckUp Post	37	18	11.7875733057548	36.6314159636725	5e-14
5	NOx_mg_L	BuckDWN Pre	BuckUp Pre	37	61	11.4238341719509	39.6327776882484	4.13e-14
6	NOx_mg_L	BuckUp Post	BuckUp Pre	18	61	-0.549104642492704	73.6810755750711	0.585

Showing 1 to 6 of 6 entries

Acknowledgements

- DMS Management

- Academic Partners

  NCSU Bio and Ag Engineering (Dan Line, Jamie Blackwell)

  Heath Dairy and Millstone

  WCU (Dr. Jerry Miller)

  Big Harris Project

- Mitigation Provider Partners

  Land and Water Solutions (Pen Dell)

  Restoration Systems (Crane Creek)

  Wildlands Engineering (Buckwater, Cross Creek, Big Harris)

Citations

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