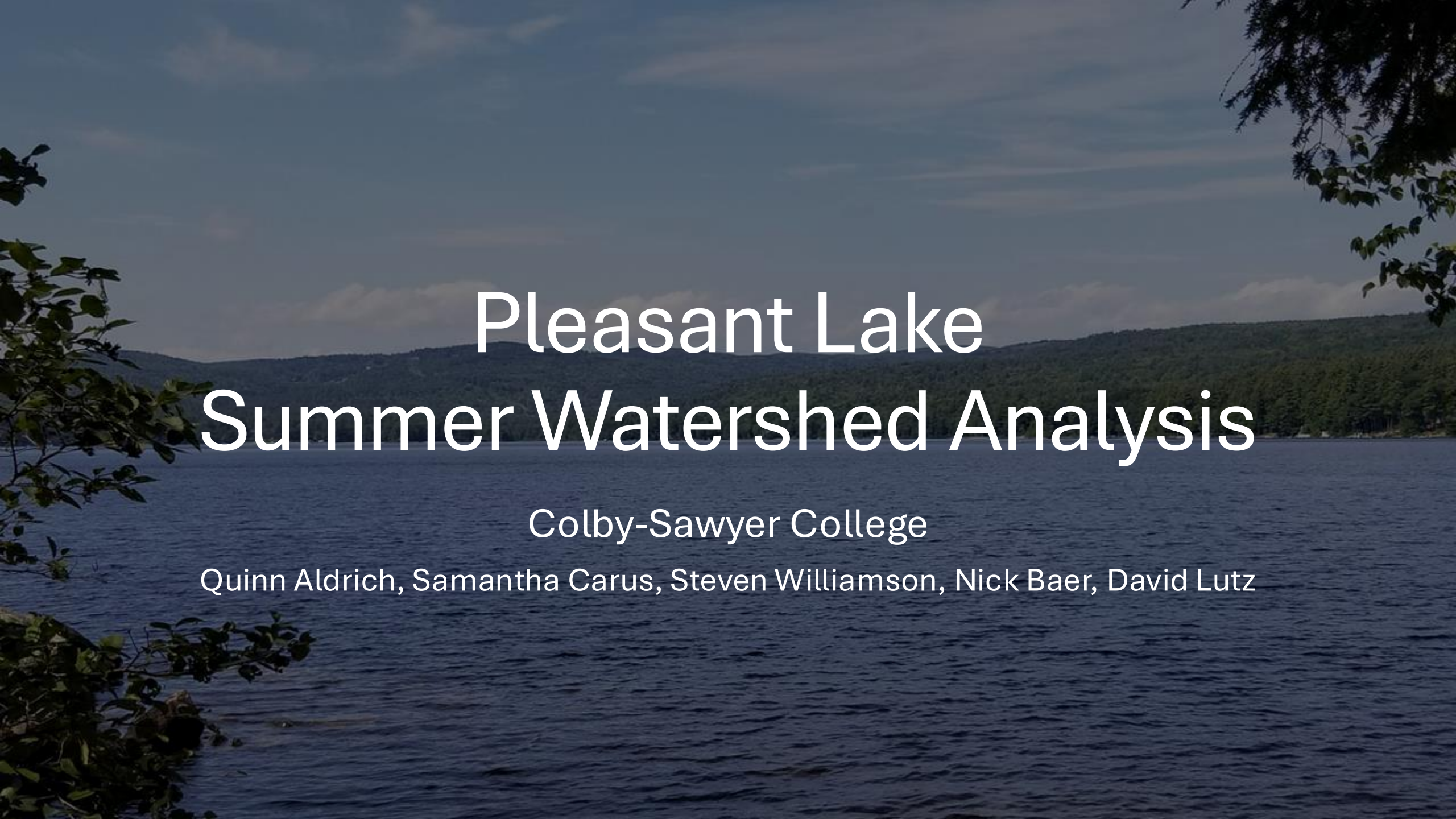


Pleasant Lake Summer Watershed Analysis

Colby-Sawyer College

Quinn Aldrich, Samantha Carus, Steven Williamson, Nick Baer, David Lutz

Who We Are

- Quinn Aldrich – Senior Environmental Science Major, Chemistry Minor

Who We Are

- Sam Carus- Senior Environmental Science, Biology Minor

Introduction: Key Findings of Community Based Project Data

September-April
750 samples
22 sample days

- Defined seasonal dynamics of tributaries
- Identified tributaries of concern
- Highlighted importance of storm events and snowmelt

Introduction: Key Findings of Community Based Project Data

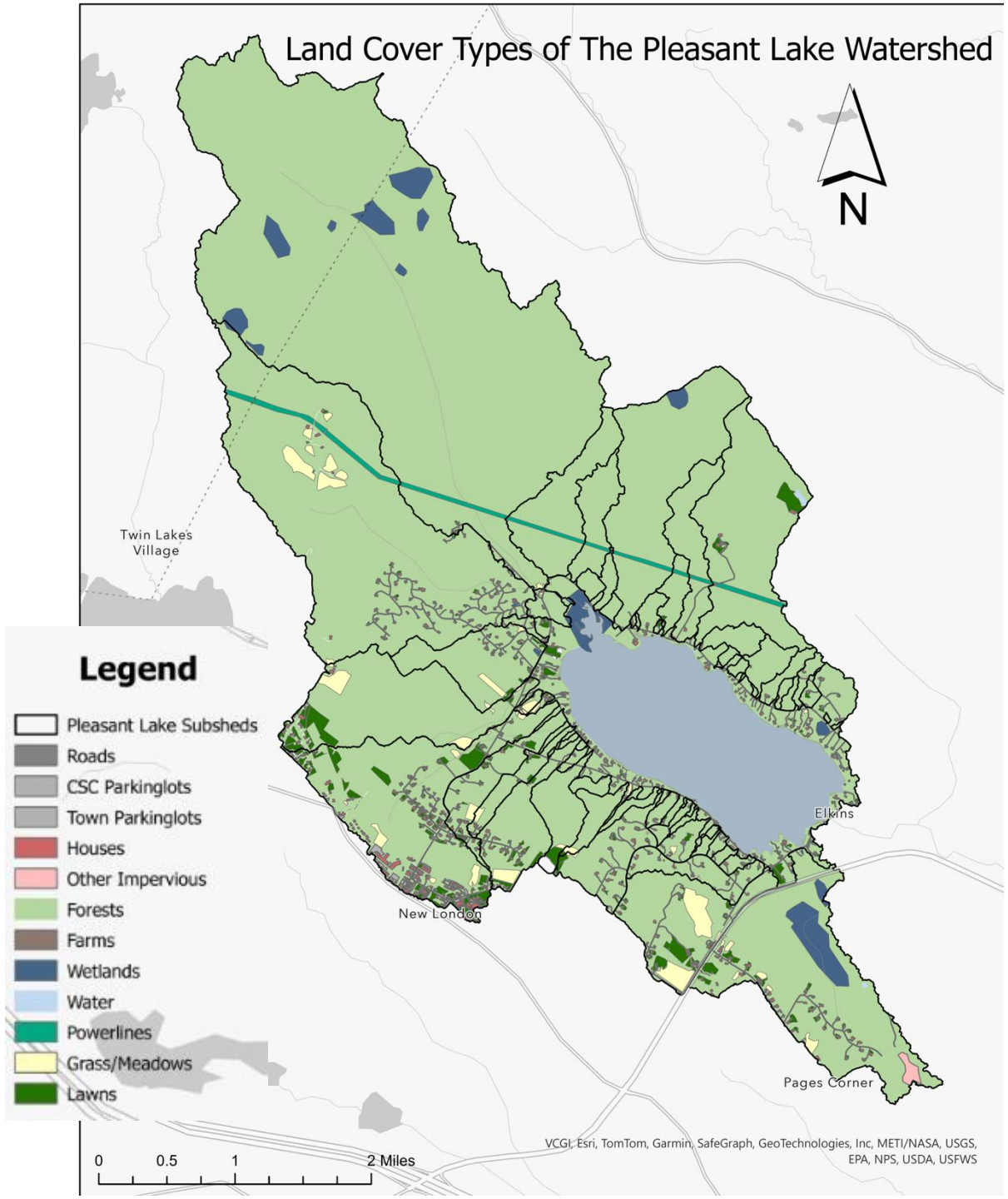
- Defined seasonal dynamics of tributaries
- Identified tributaries of concern
- Highlighted importance of storm events and snowmelt

↑ Loading of Phosphorus and Chloride

↑ Phosphorus Concentration

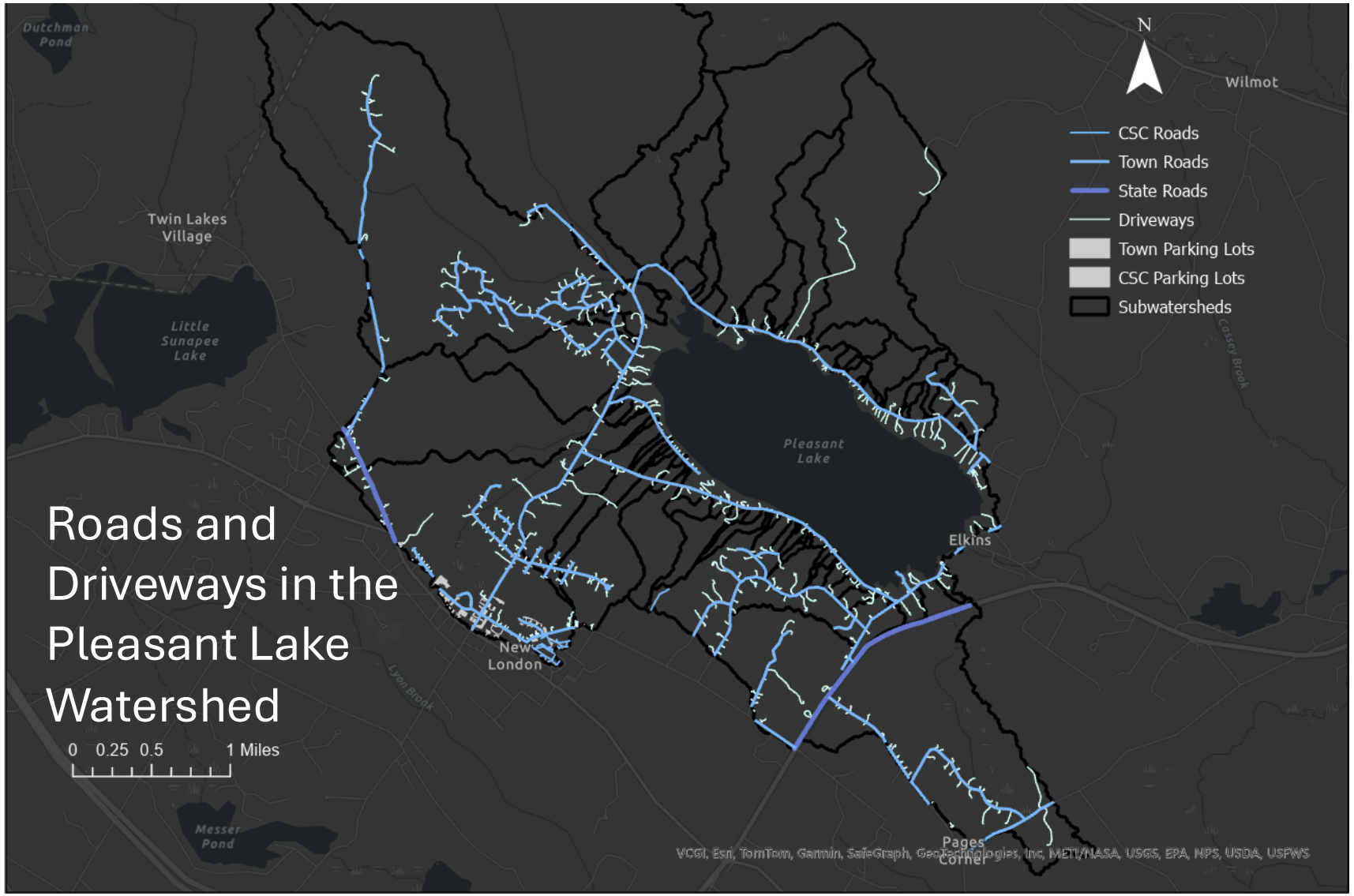
↑ Turbidity

↓ Chloride Concentration



Human Development and Impervious Surfaces

Phosphorus Concentrations



State road salt application

Higher Salt Application

Higher Chloride Concentrations

Objectives of Additional Sampling

Continued Monitoring

Growing season biogeochemical assessment

Capture summer rainstorm events

Comparative Analysis

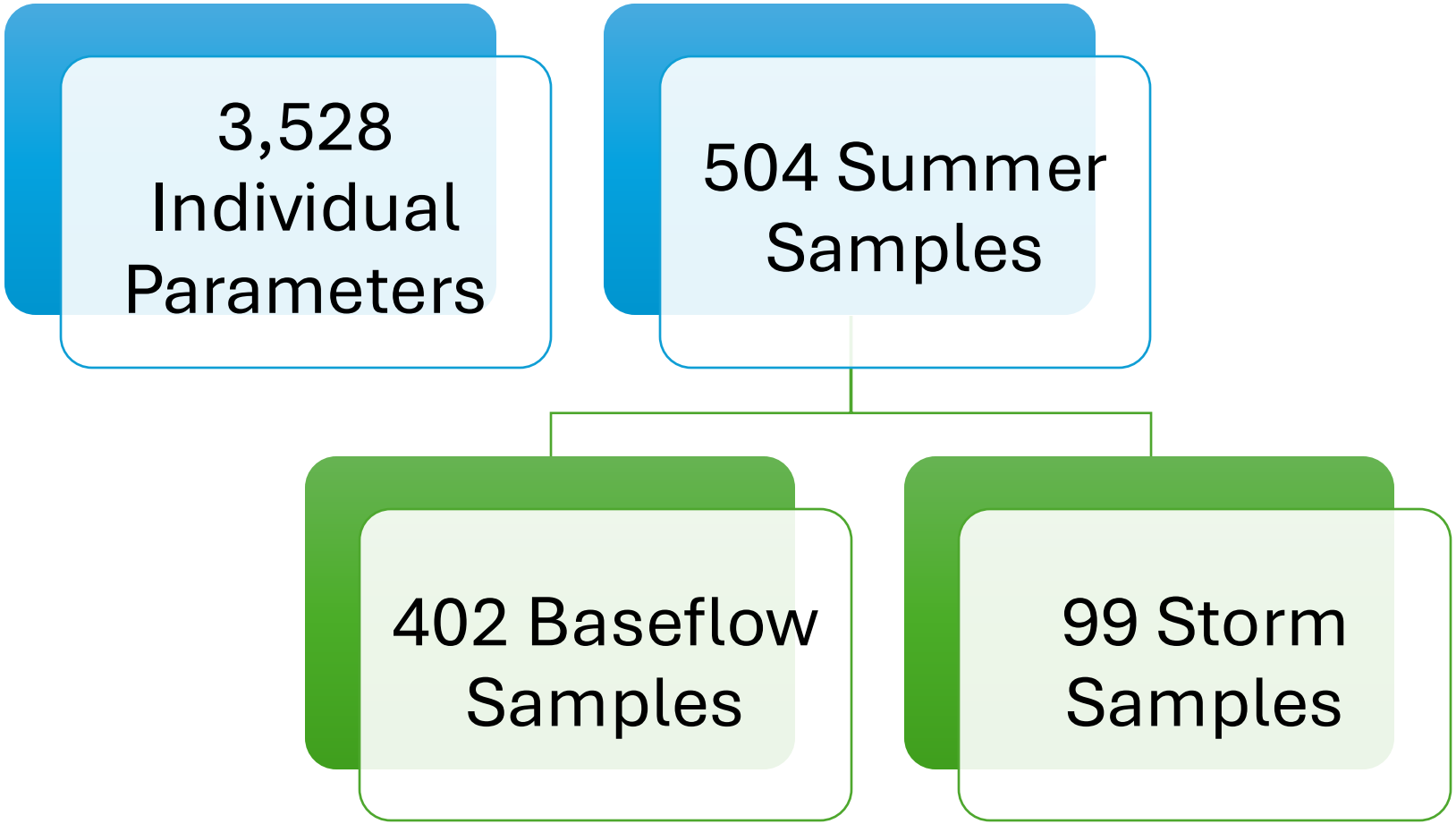
Compare tributary data with 2024 VLAP data

Compare loading across seasons

Identify factors that influence differences in concentrations

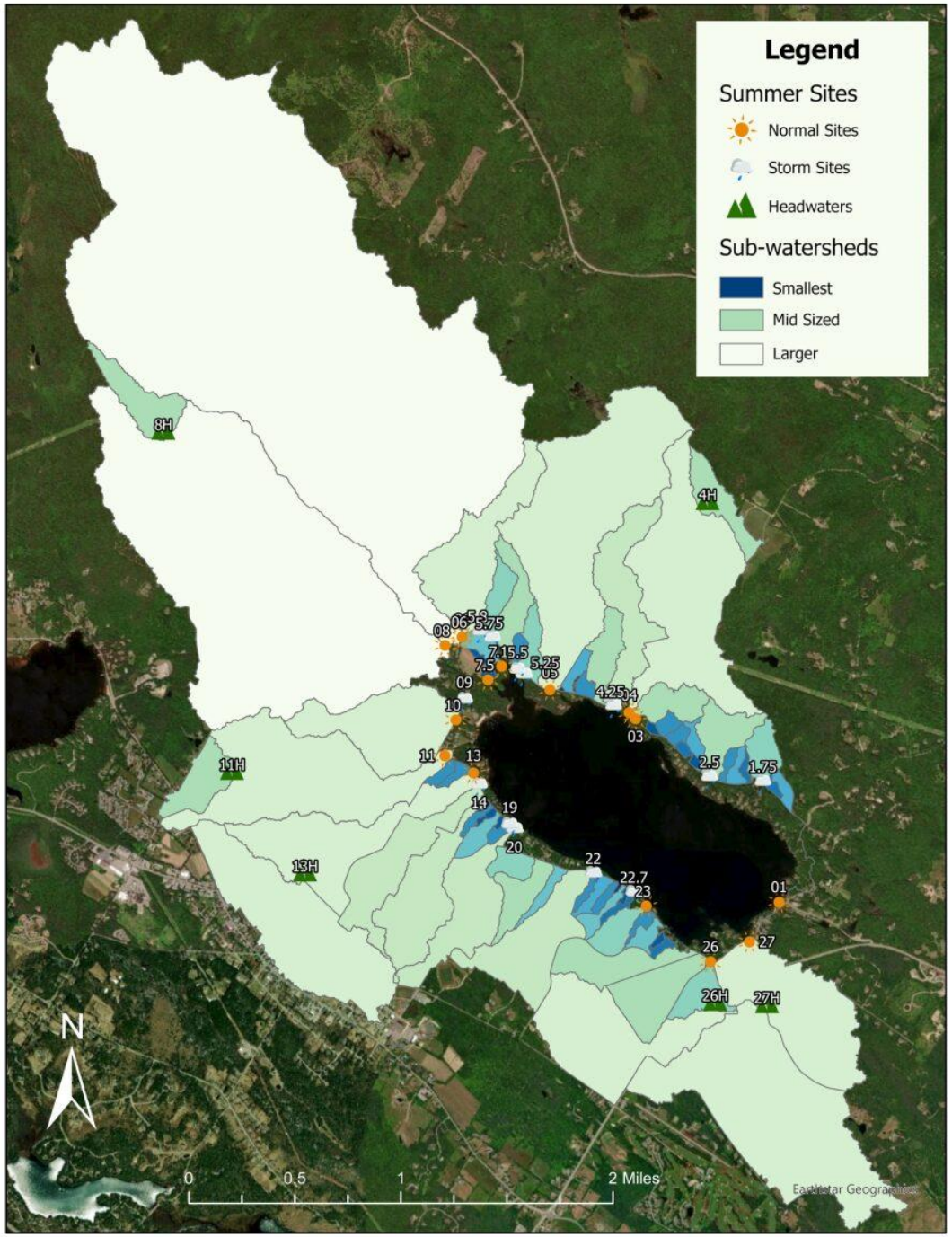
Cyanobacteria bloom at Elkin's Beach 6/19

Total Summer Sampling Effort



Additional Contributions from Summer Efforts

- Sampling/analysis at tributary headwaters
- Summer thunderstorm impact (pre/post storm)
- Focus on consistently flowing Summer sites
- E-Coli sampling @ baseflow sites (8/19)
- In-lake sediment coring @ VLAP sites (7/25)
- Same-day VLAP and tributary sampling comparison
- Headwater sampling of significant sites



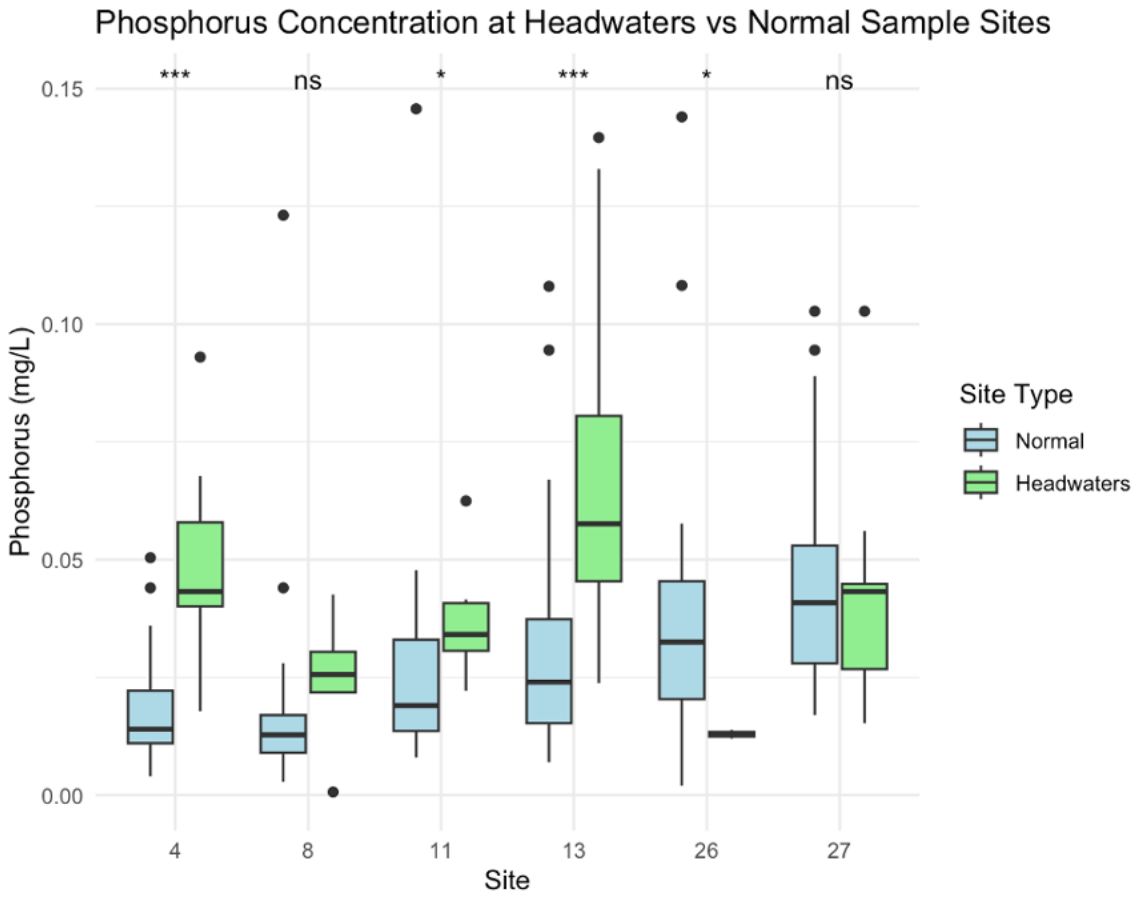
Headwater Analysis:

Provided insights into phosphorus concentrations at upstream vs. regular tributary sites

Headwaters were first Identified key headwaters using GIS-based sub-watershed delineation

Samples were collected at headwaters and downstream sites for comparison for a paired analysis

Headwater Sampling: Phosphorus



Phosphorus concentrations at tributary headwaters and their corresponding routine sampling site are shown. Wilcox test significance between groups p values: ns = no significance. 0.05 0.01** 0.001*** <0.001****

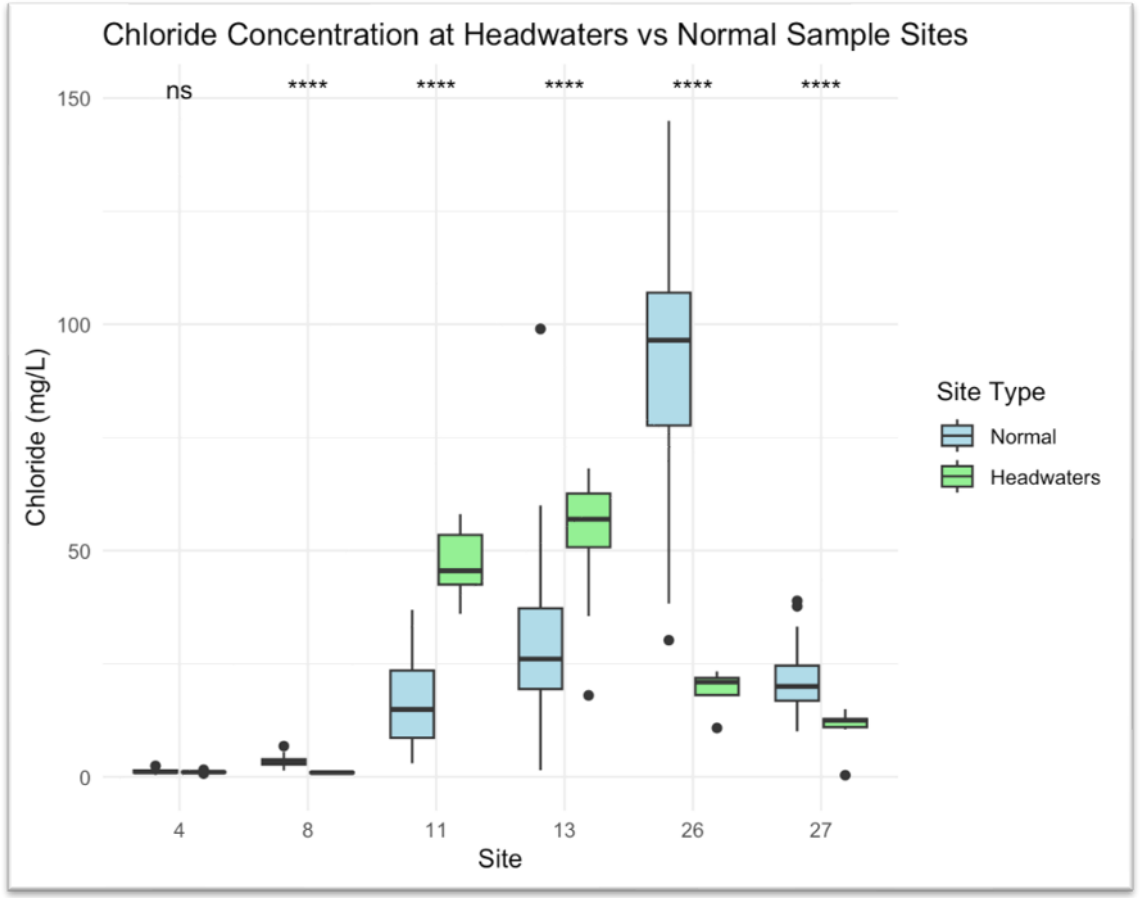
Three sites with significantly higher phosphorus concentration at headwaters

- Stream flowing next to Winship's house (Site 4)
- White Brook (site 11)
- Little Brook (site 13)

One site with significantly lower concentrations at headwaters

- Elkins/Bunker (Site 26)

Headwater Sampling: Chloride



Chloride concentrations for tributary headwaters and their corresponding routine sampling sites are shown. Wilcox test significance between groups p values: ns = no significance. 0.05 0.01** 0.001*** <0.001****

Two sites with significantly higher chloride concentration at Headwaters

- White Brook (Site 11)
- Little Brook (site 13)

One site with lower chloride concentrations at headwaters

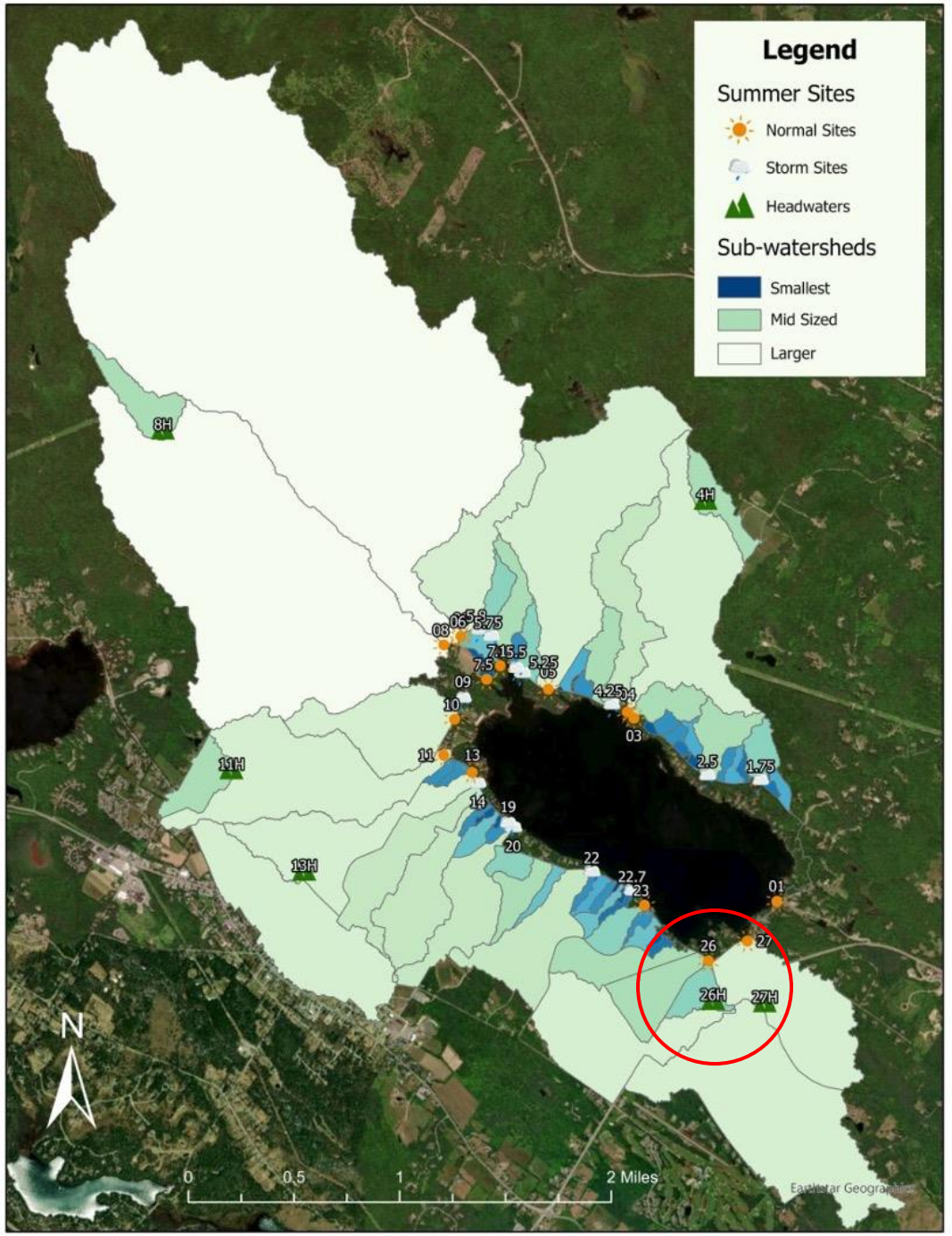
- Site 26 (Elkins/Bunker)

Summary of Headwater Analysis

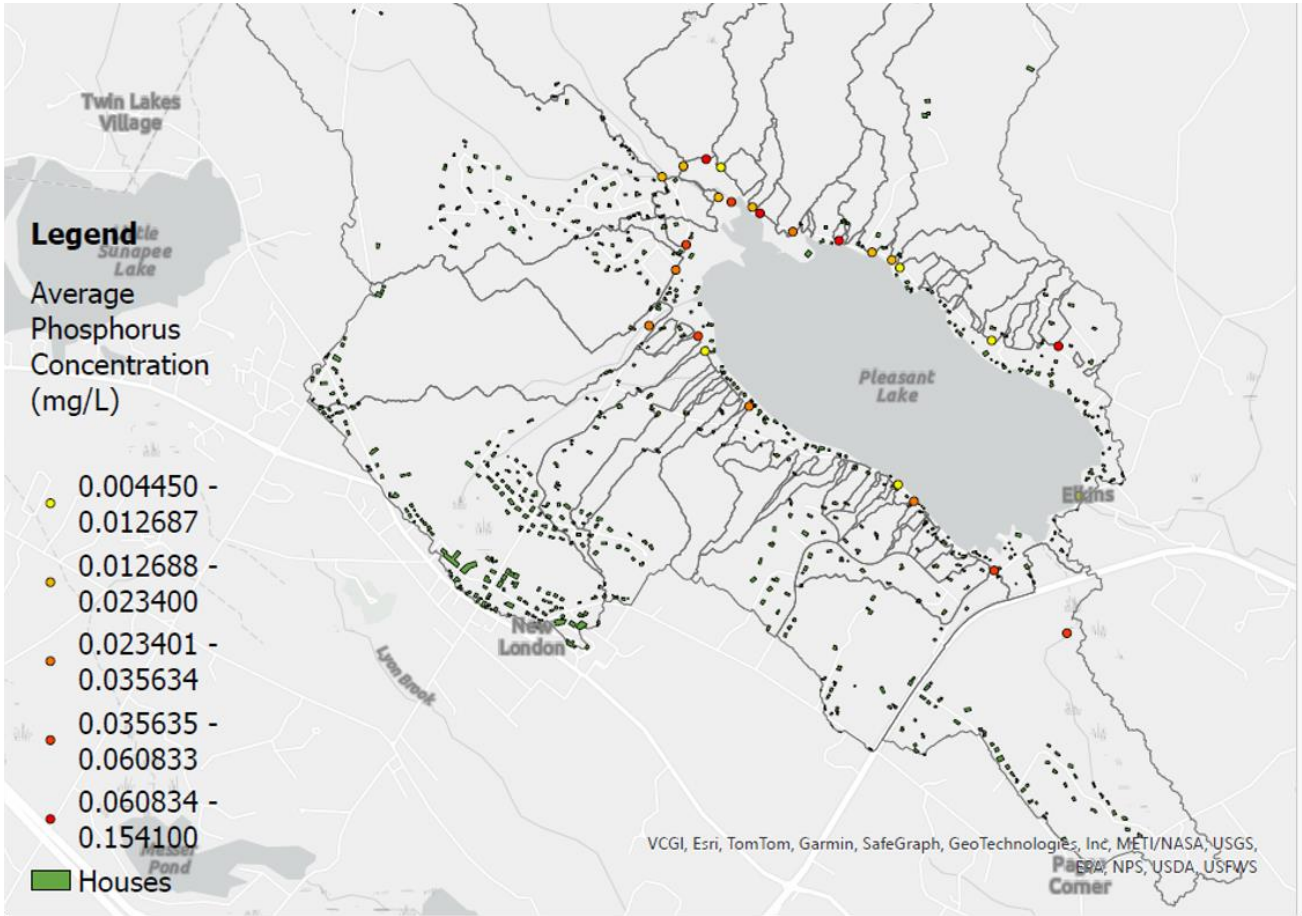
Concentrations were generally **higher** at headwater sites.

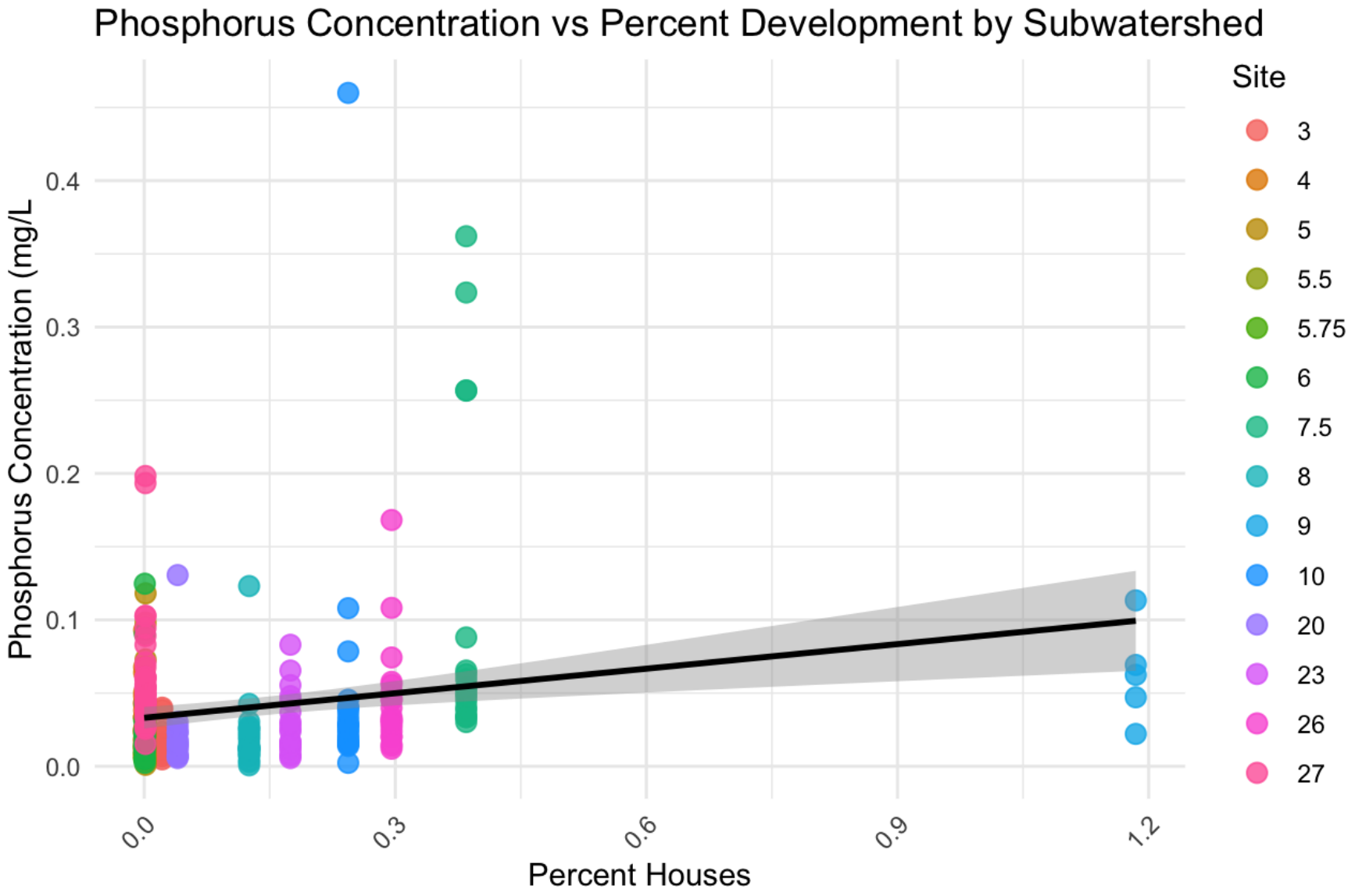
Site 26 Headwaters

(Esther Currier Wildlife Management Area) had **lower** concentrations than tributary samples. (Intersection of Elkins and Bunker road)



Impact of Housing Density on Phosphorus Concentrations in Sub-Watersheds





Linear regression model of phosphorus concentration versus percent houses:
Intercept: 0.0331, p-value: 0.0006, residual Standard Error: 0.05087, R-squared: 0.0445, F-statistic: 12.06

Headwater Sampling: Phosphorus

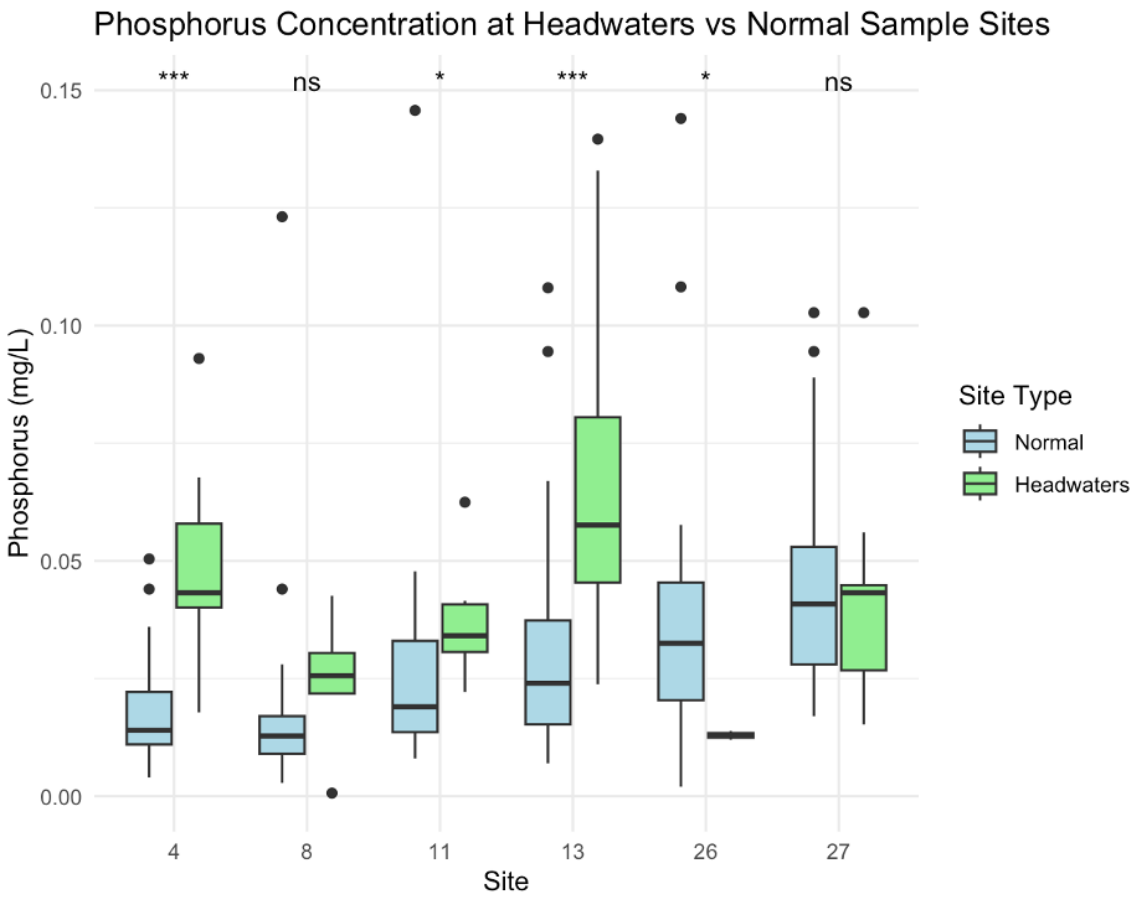


Figure 5: Phosphorus concentrations at tributary headwaters and their corresponding routine sampling site are shown. Wilcox test significance between groups p values: ns = no significance. 0.05 0.01** 0.001*** <0.001****

Significantly Higher Phosphorus Concentration at Headwater Site

- Stream flowing next to Winship's house (Site 4)
- White Brook (site 11)
- Little Brook (site 13)

Significantly lower concentrations at headwater

Site 26 (Elkins/Bunker)

Headwater sampling: Chloride

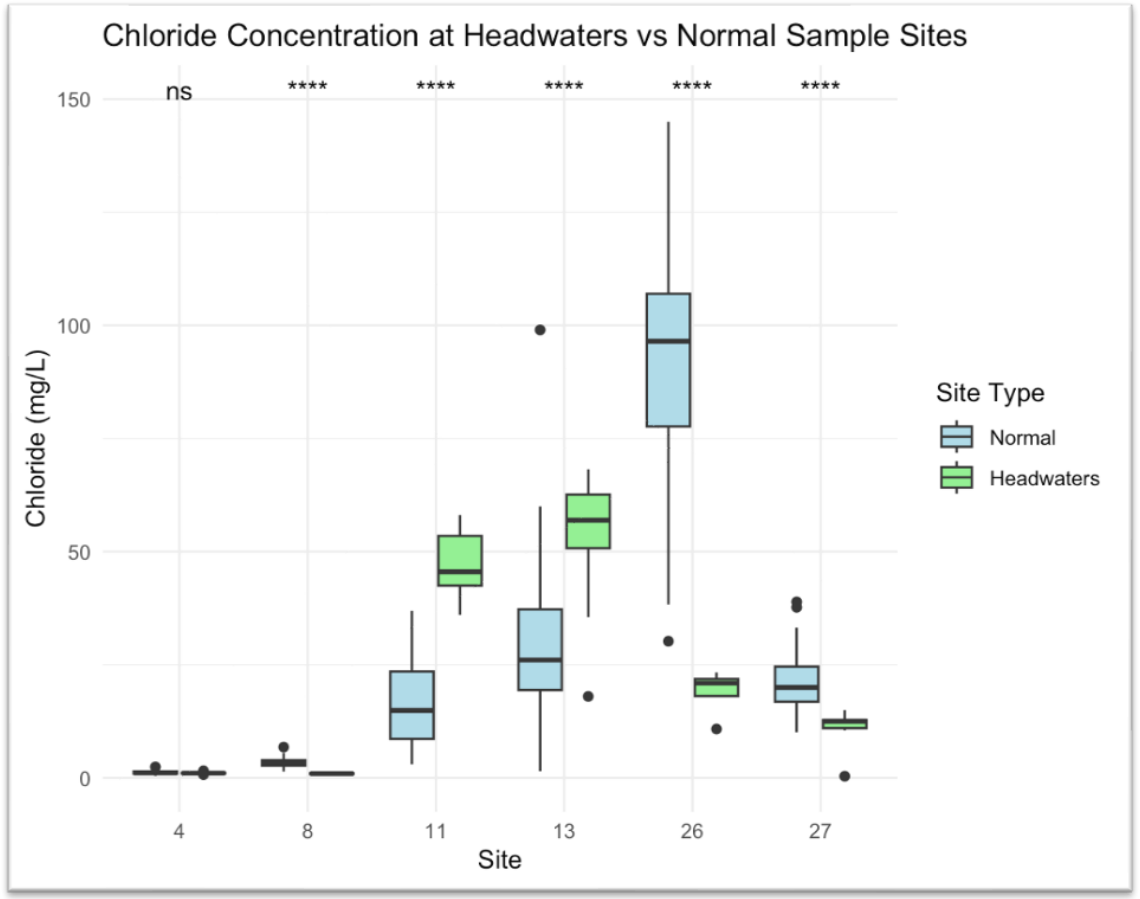


Figure 4: Chloride concentrations for tributary headwaters and their corresponding routine sampling sites are shown. Wilcox test significance between groups p values: ns = no significance. 0.05 0.01** 0.001*** <0.001****

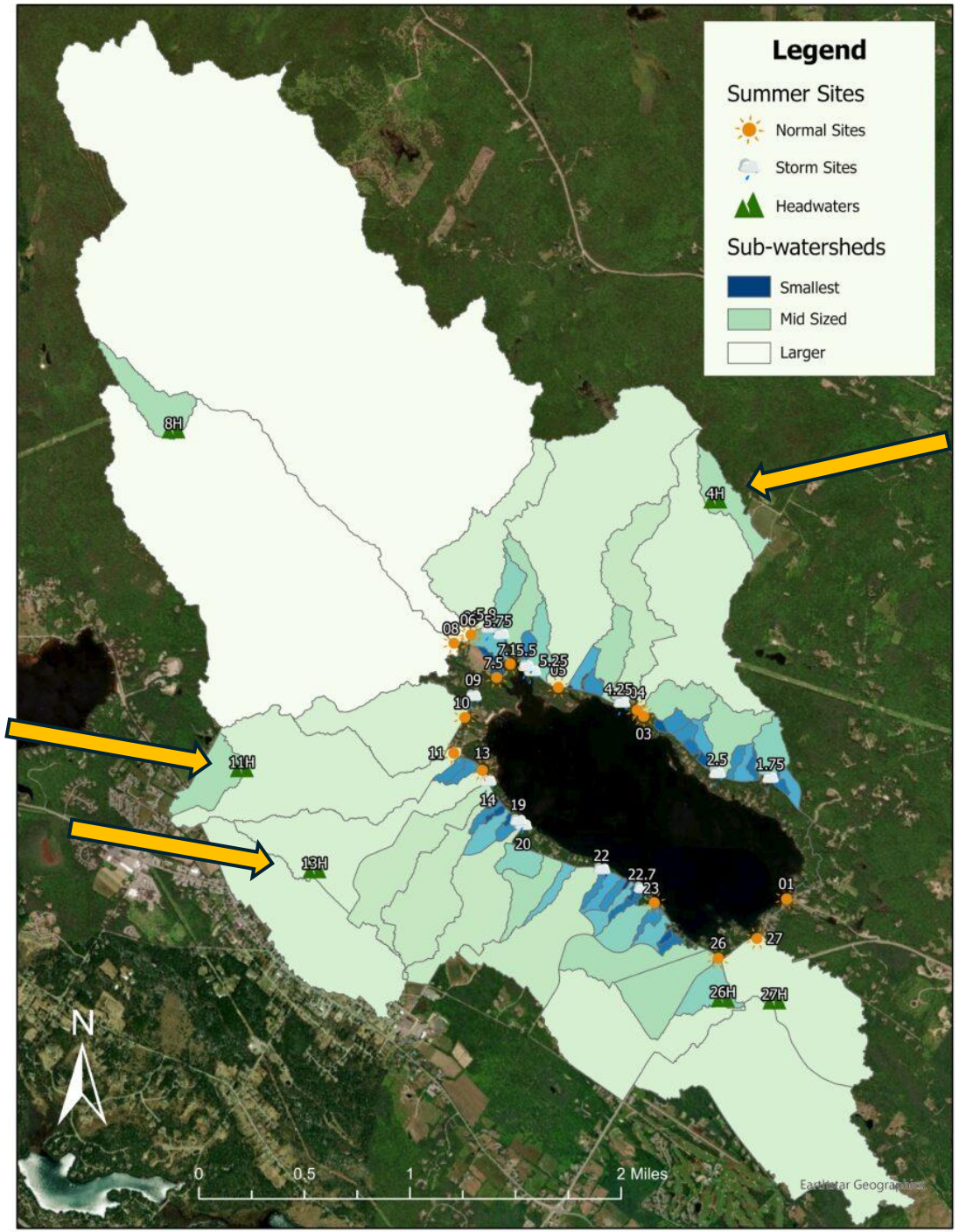
Higher Chloride Concentration at Headwater Site

White Brook (Site 11)
Little Brook (site 13)

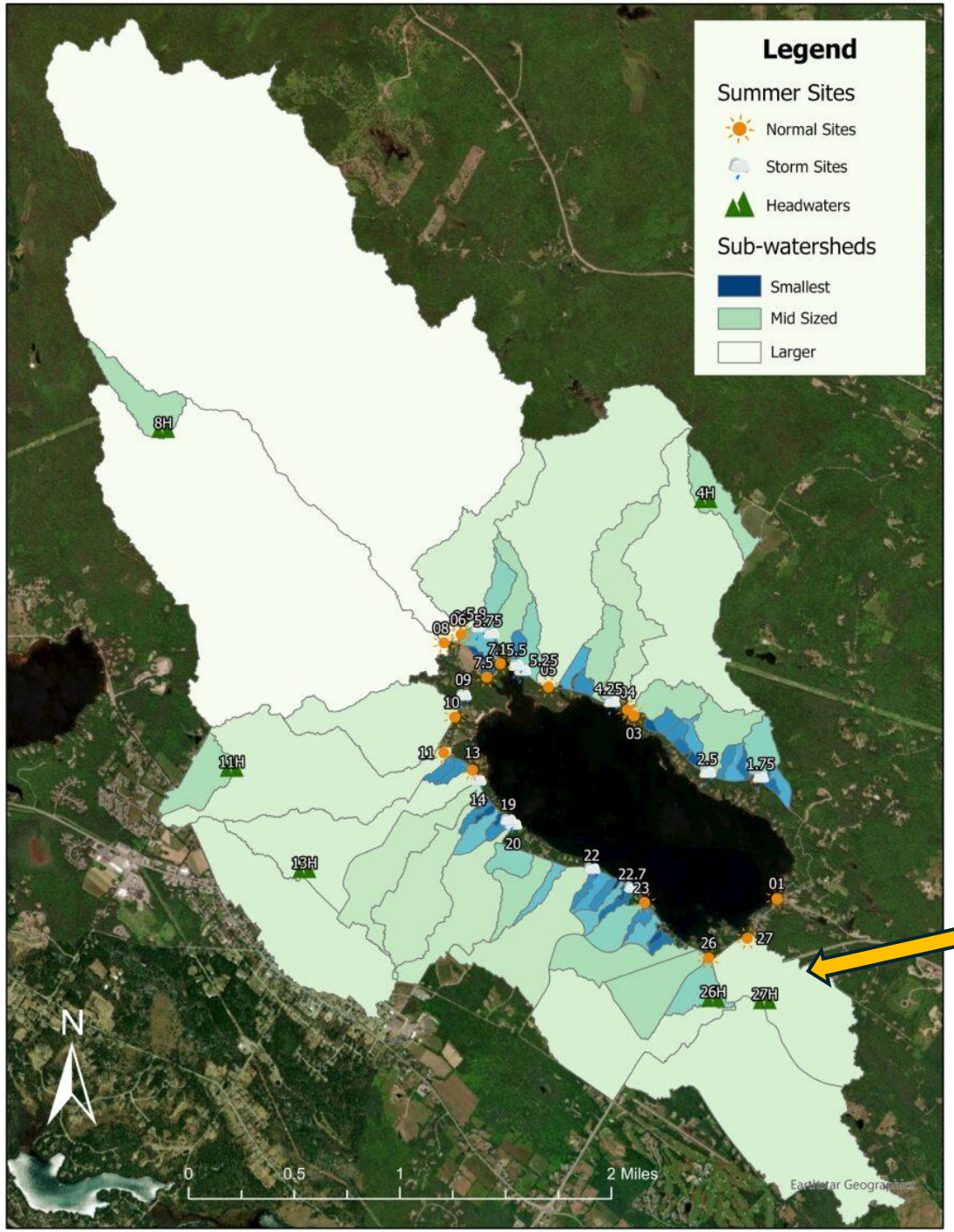
Lower Chloride Concentrations at Headwater Site

Site 26 (Elkins/Bunker)

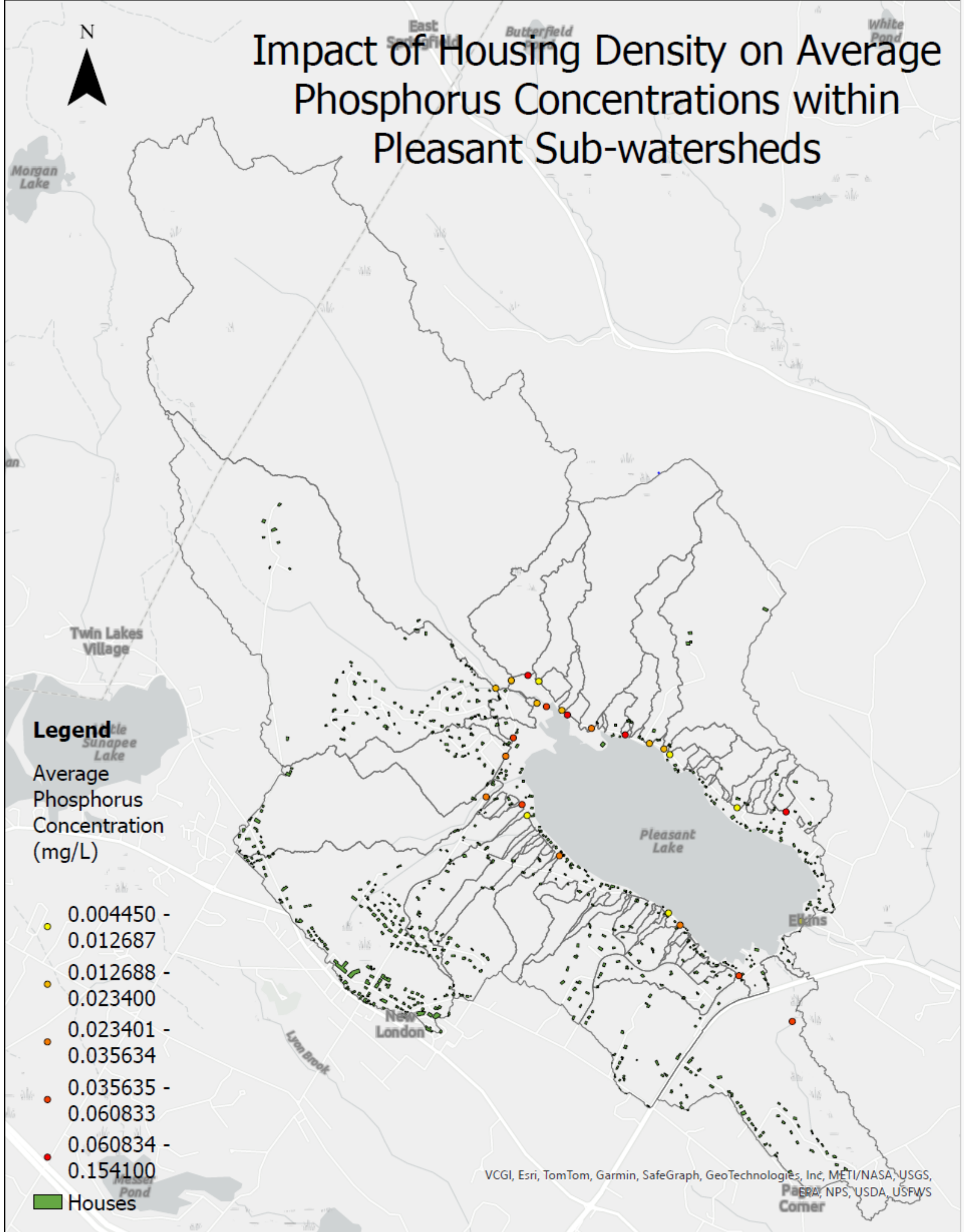
Little and White Brook Headwaters: Significantly higher Phosphorus and Chloride



Site 4 Headwaters: Significantly higher Phosphorus and Chloride



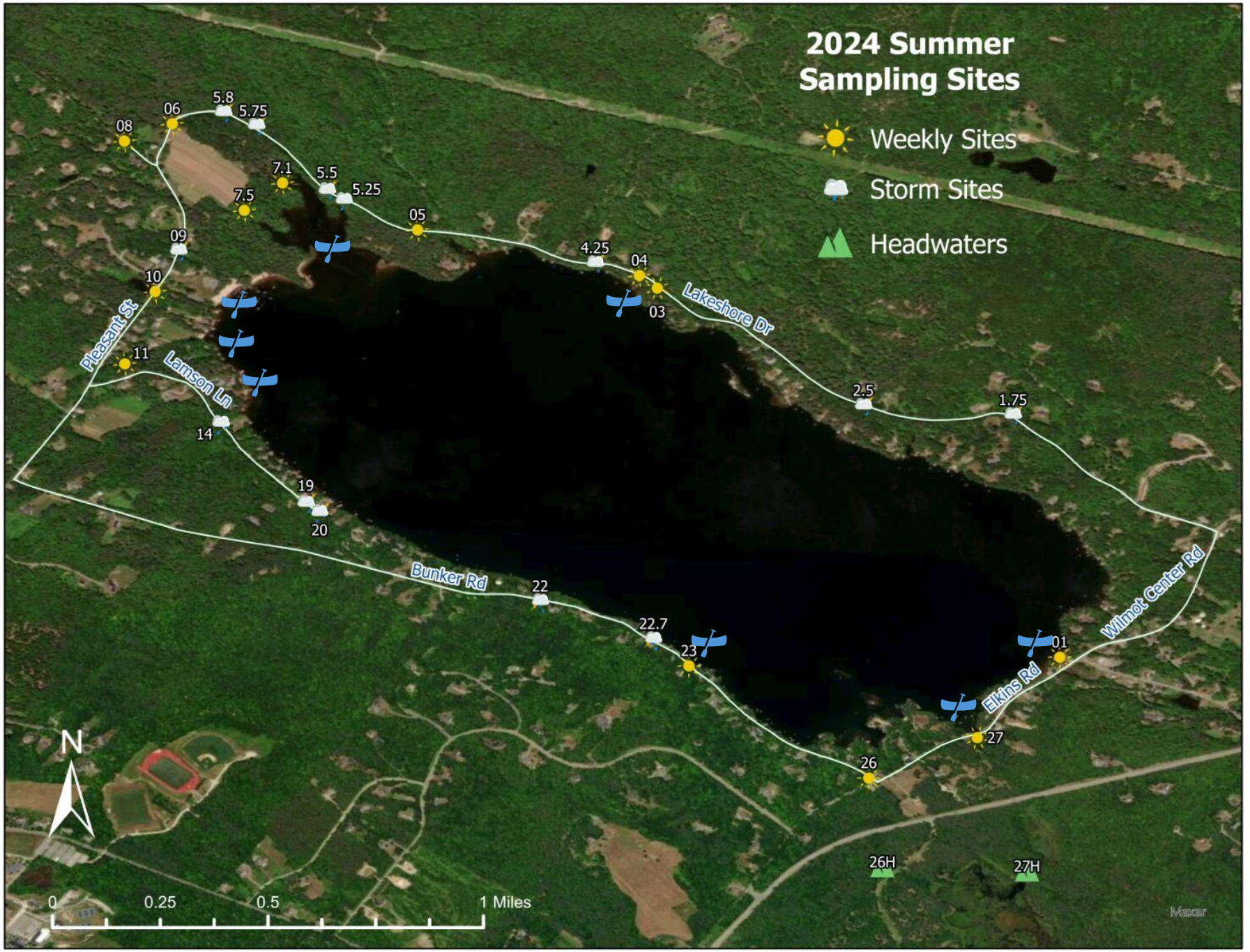
Fire pond and Elkins/Bunkers Headwaters had significantly lower Chloride concentrations

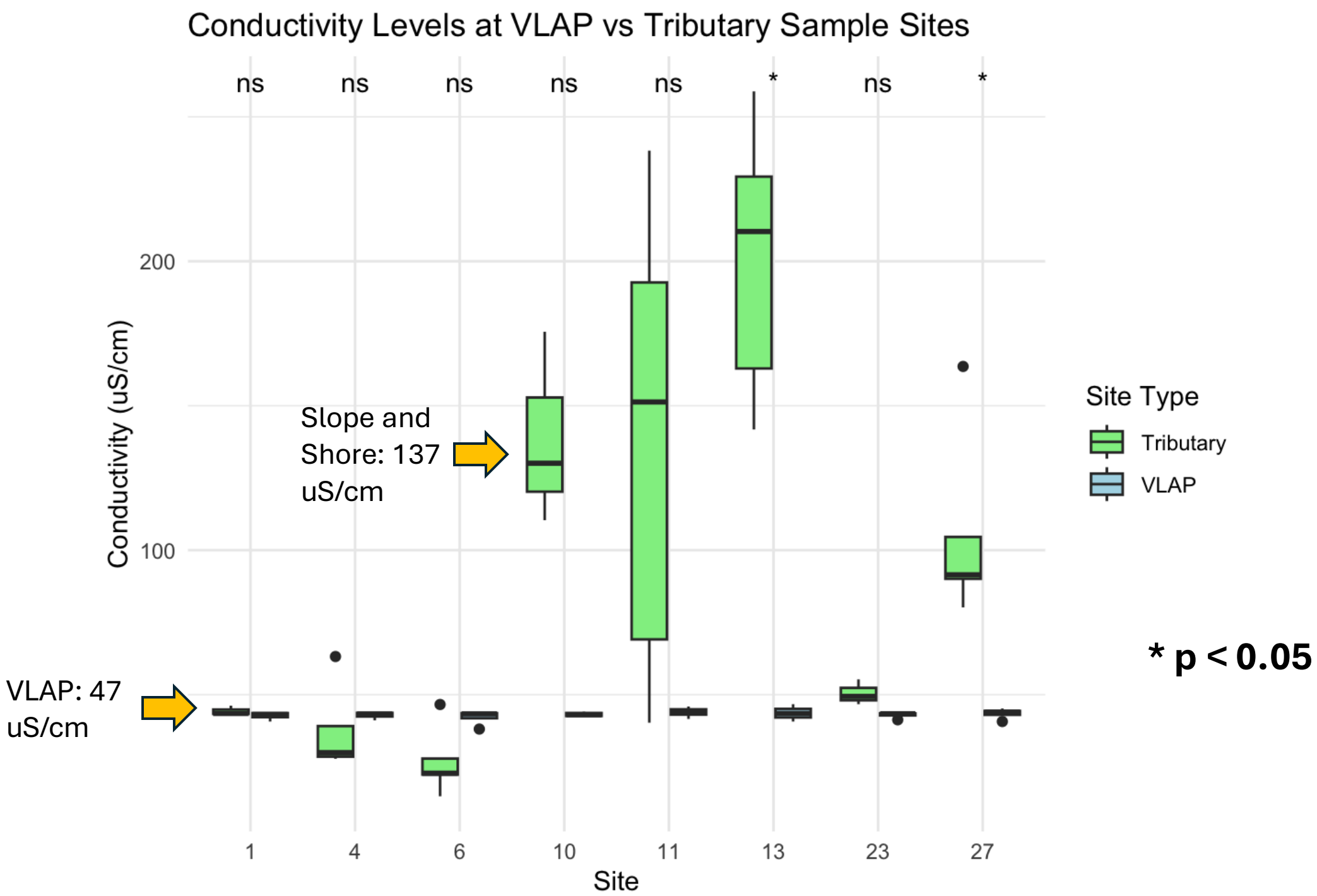

Impact of Housing Density on Average Phosphorus Concentrations within Pleasant Sub-watersheds
N
Morgan Lake
Twin Lakes Village
Pleasant Lake
New London
Elkins
Lyon Brook
Legend
Average Phosphorus Concentration (mg/L)
0.004450 - 0.012687
0.012688 - 0.023400
0.023401 - 0.035634
0.035635 - 0.060833
0.060834 - 0.154100
Houses
VCGI, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS

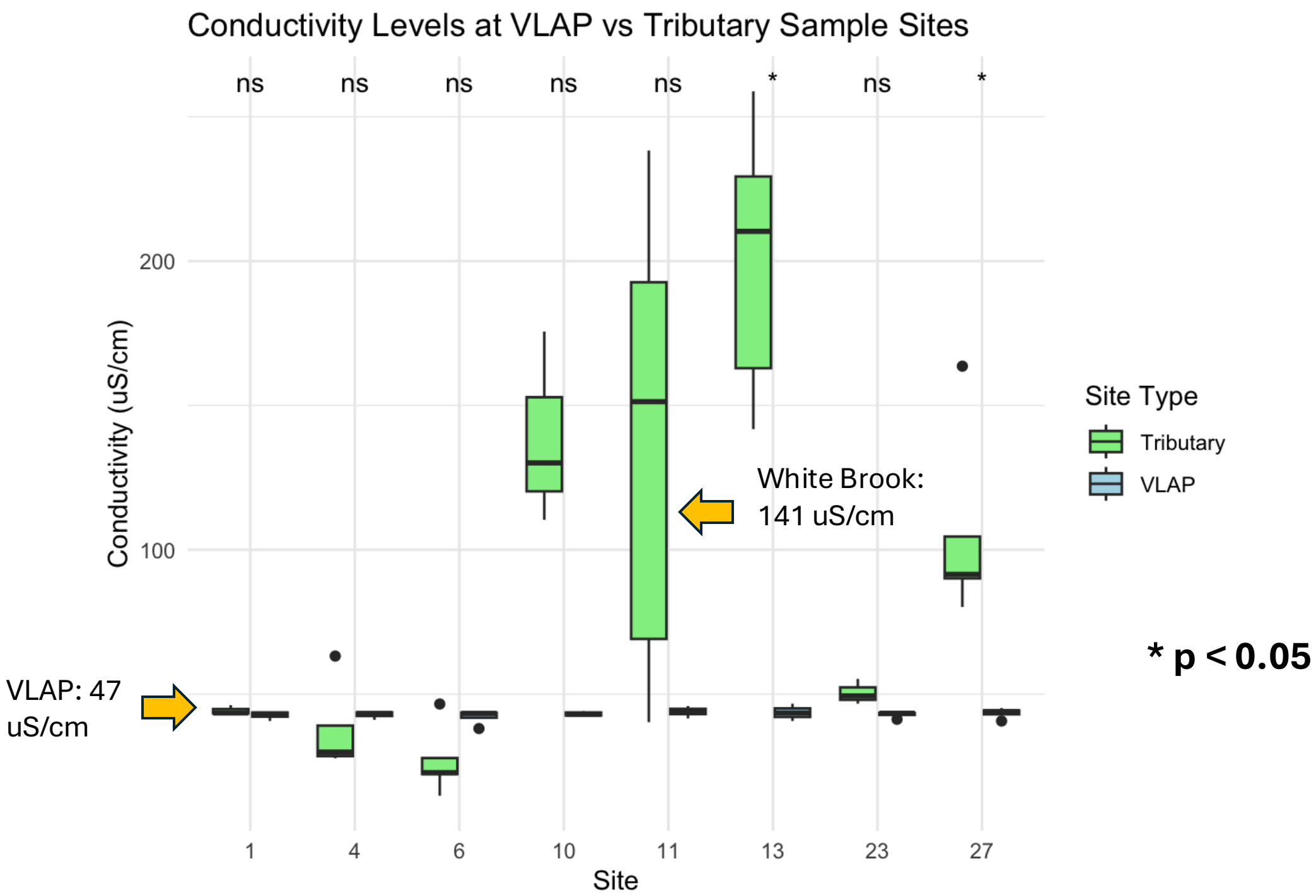
VLAP vs Our Sites

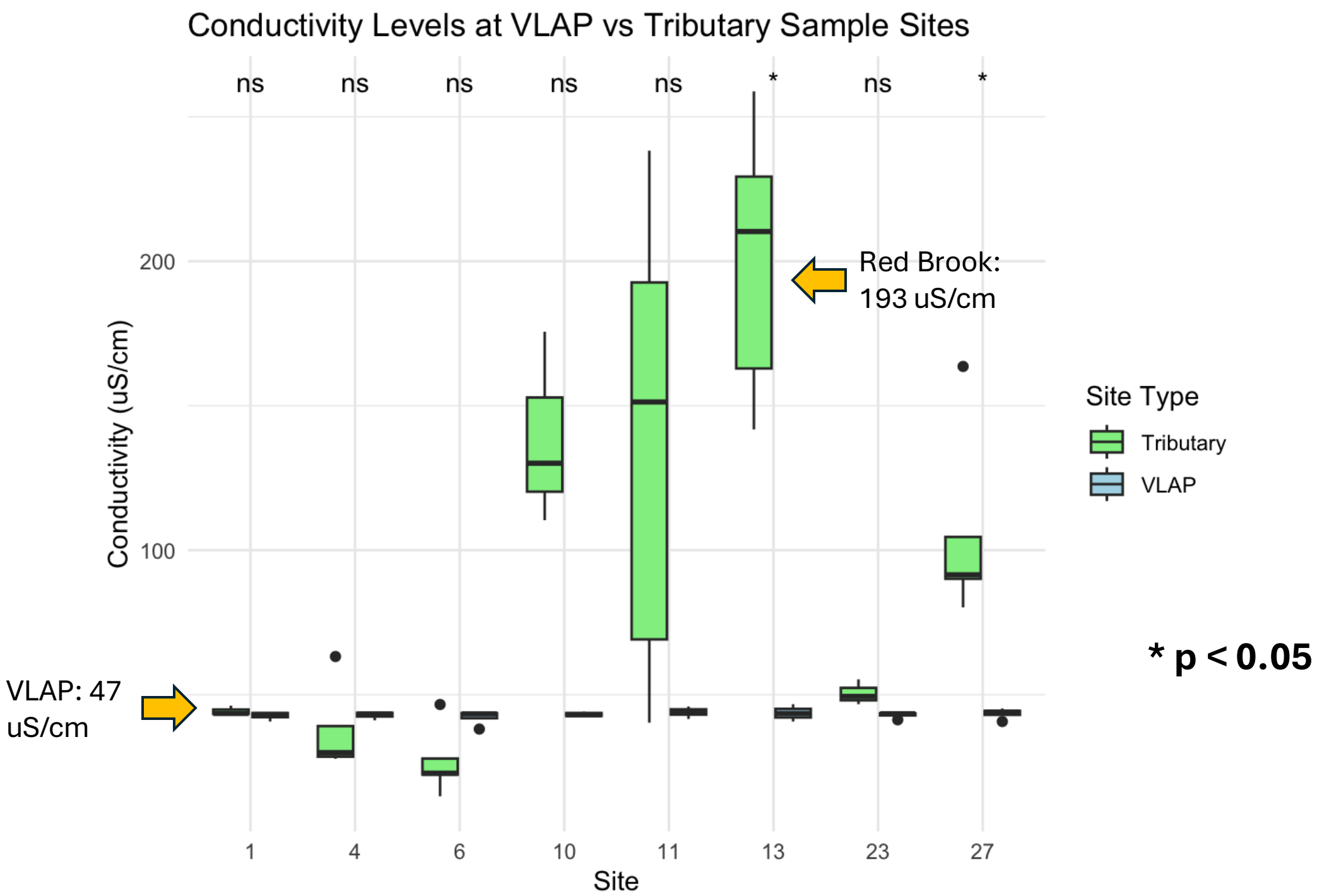
VLAP Site

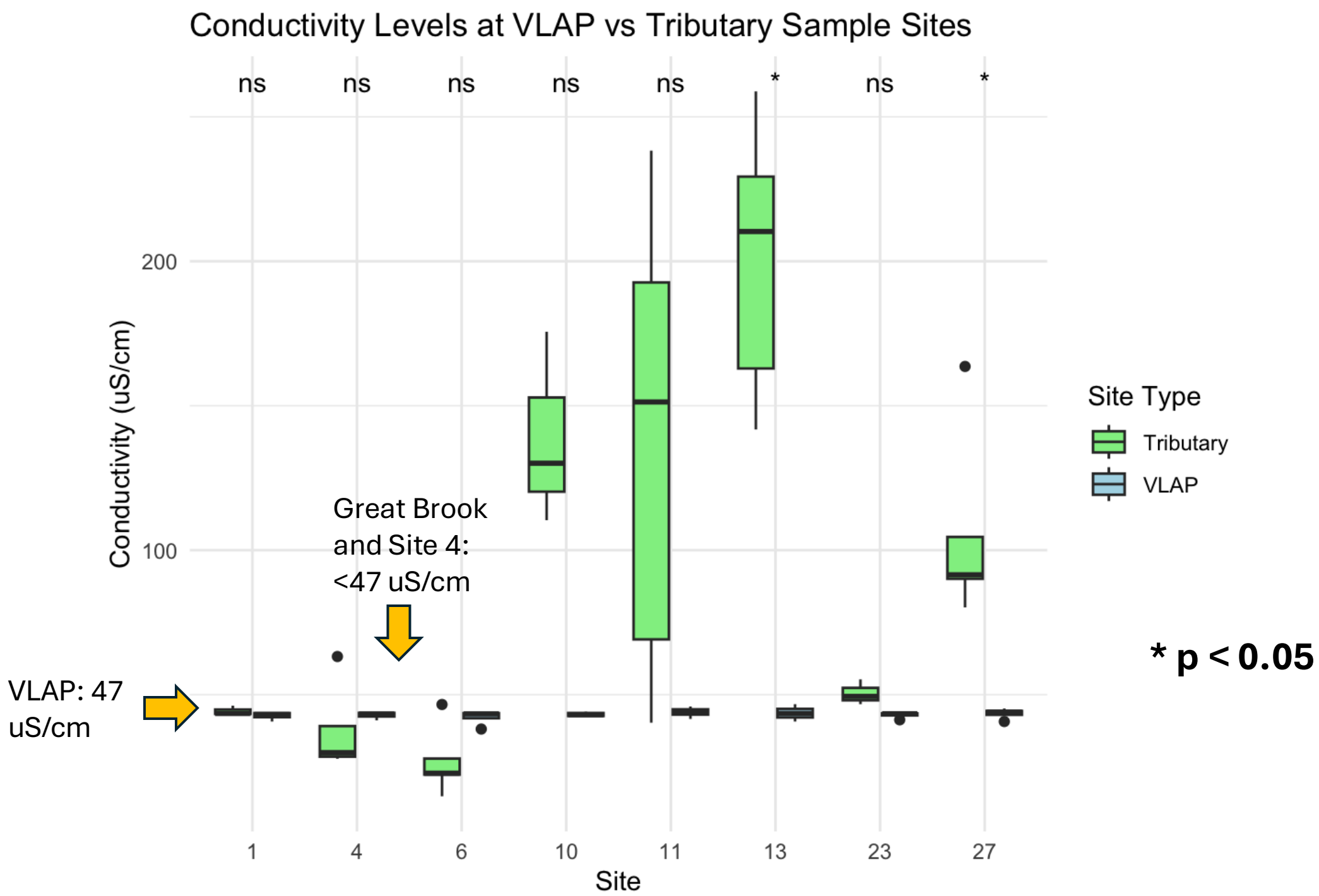
- June 11th
- July 9th
- August 13th

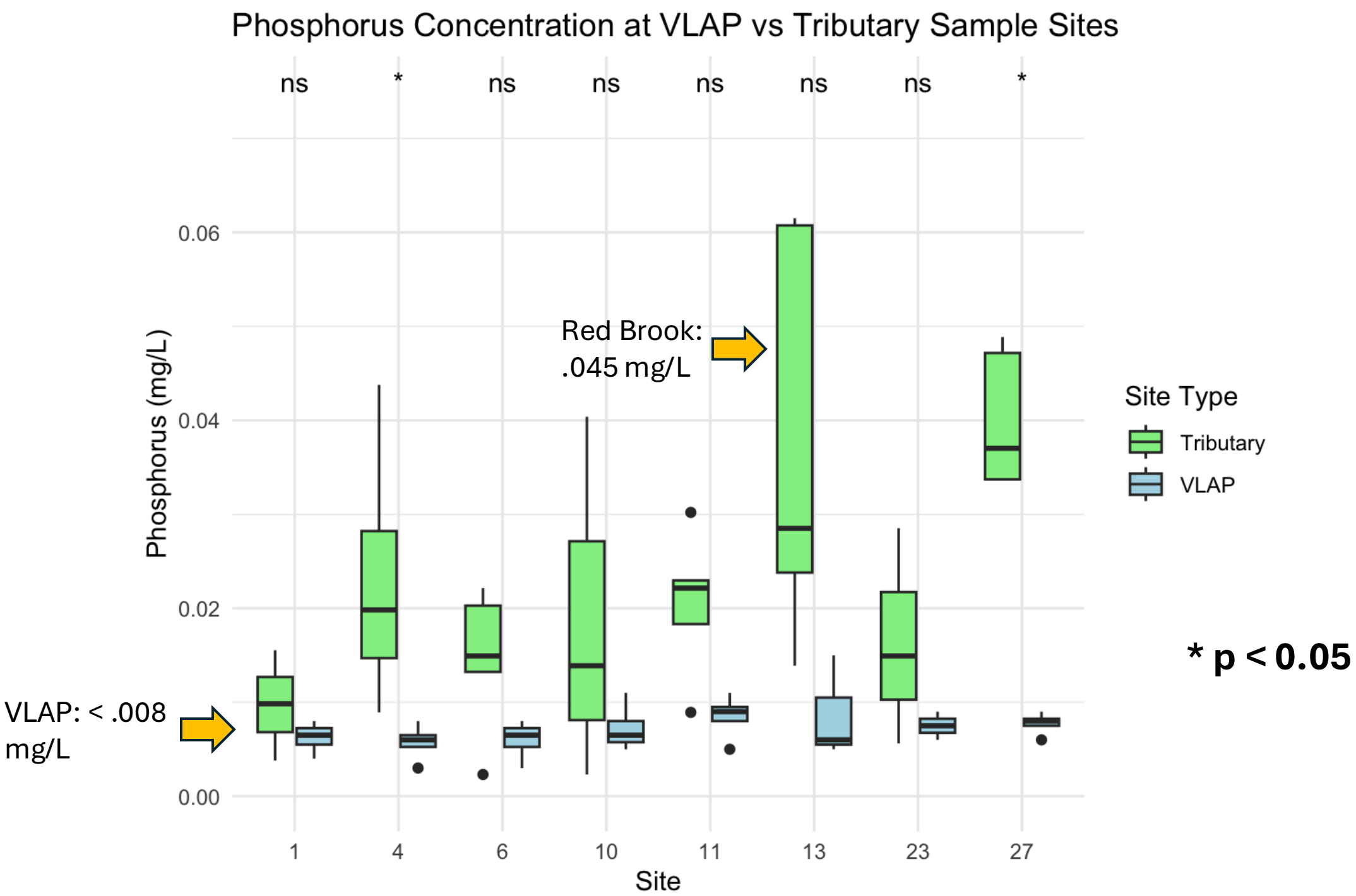


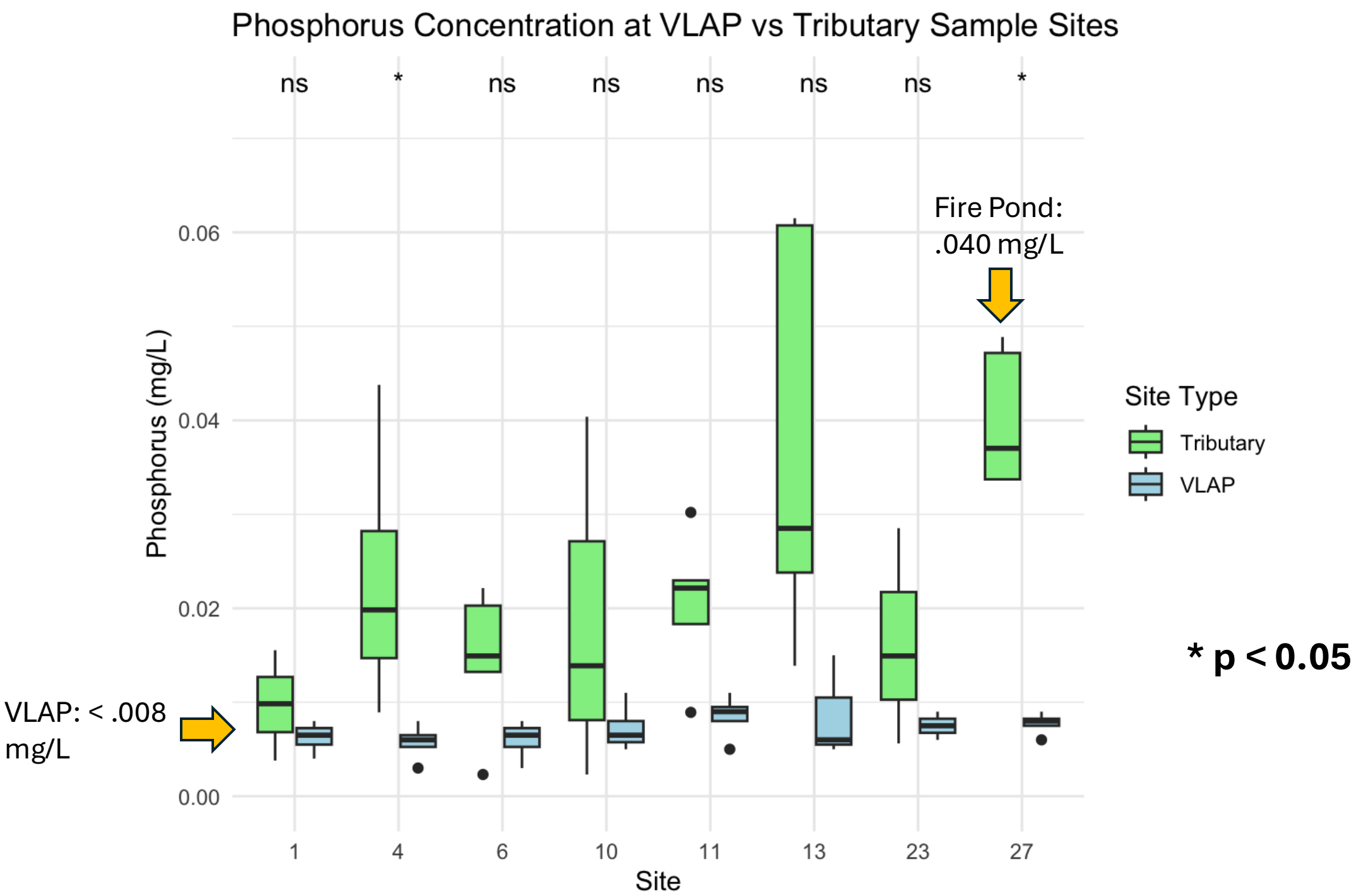

Conductivity Levels at VLAP vs Tributary Sample Sites
ns
ns
ns
ns
ns
*
ns
*
200
100
Conductivity (uS/cm)
Slope and Shore: 137 uS/cm
VLAP: 47 uS/cm
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05

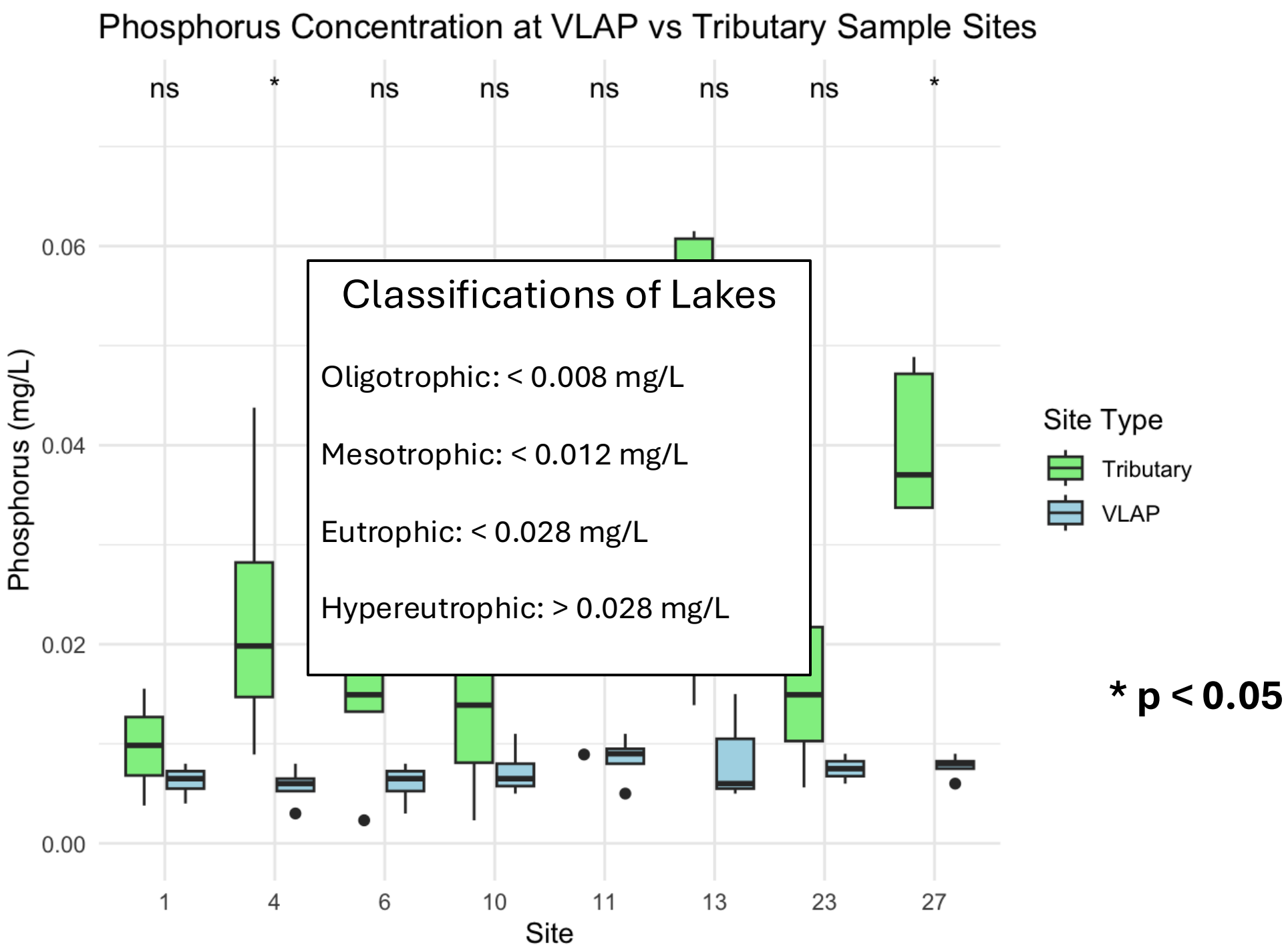

Conductivity Levels at VLAP vs Tributary Sample Sites
ns
ns
ns
ns
ns
*
ns
*
200
100
Conductivity (uS/cm)
White Brook:
141 uS/cm
VLAP: 47
uS/cm
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05

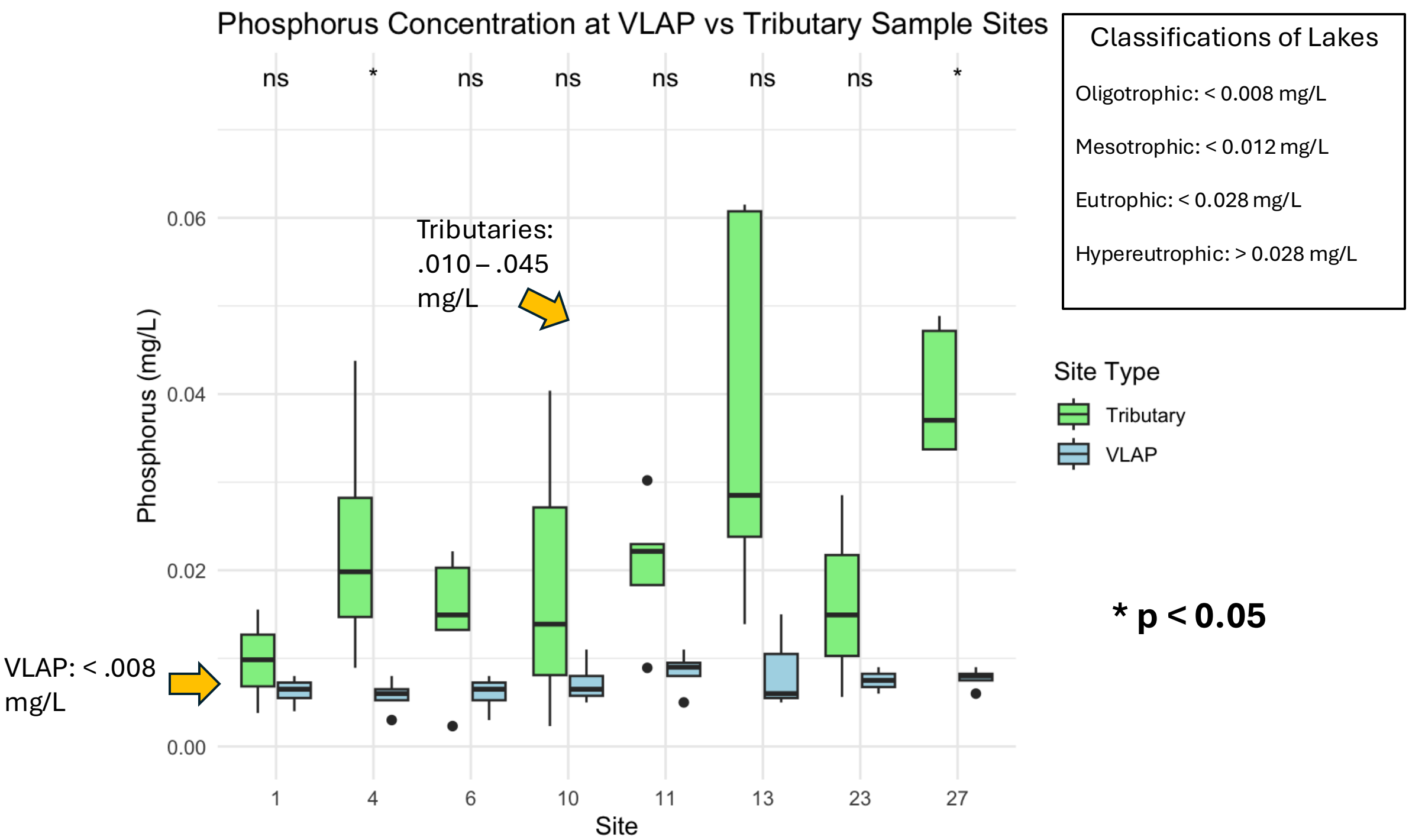

Conductivity Levels at VLAP vs Tributary Sample Sites
ns
ns
ns
ns
ns
*
ns
*
200
100
Conductivity (uS/cm)
Red Brook:
193 uS/cm
VLAP: 47
uS/cm
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05


Conductivity Levels at VLAP vs Tributary Sample Sites
ns
ns
ns
ns
ns
*
ns
*
200
100
Conductivity (uS/cm)
Great Brook and Site 4: <47 uS/cm
VLAP: 47 uS/cm
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05


Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
0.06
0.04
0.02
0.00
Phosphorus (mg/L)
Red Brook:
.045 mg/L
VLAP: < .008
mg/L
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05


Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
Fire Pond:
.040 mg/L
VLAP: < .008
mg/L
Phosphorus (mg/L)
0.06
0.04
0.02
0.00
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
* p < 0.05


Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
0.06
0.04
0.02
0.00
Phosphorus (mg/L)
1
4
6
10
11
13
23
27
Site
Classifications of Lakes
Oligotrophic: < 0.008 mg/L
Mesotrophic: < 0.012 mg/L
Eutrophic: < 0.028 mg/L
Hypereutrophic: > 0.028 mg/L
Site Type
Tributary
VLAP
* p < 0.05


Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
Tributaries:
.010 – .045
mg/L
VLAP: < .008
mg/L
Phosphorus (mg/L)
0.06
0.04
0.02
0.00
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
Classifications of Lakes
Oligotrophic: < 0.008 mg/L
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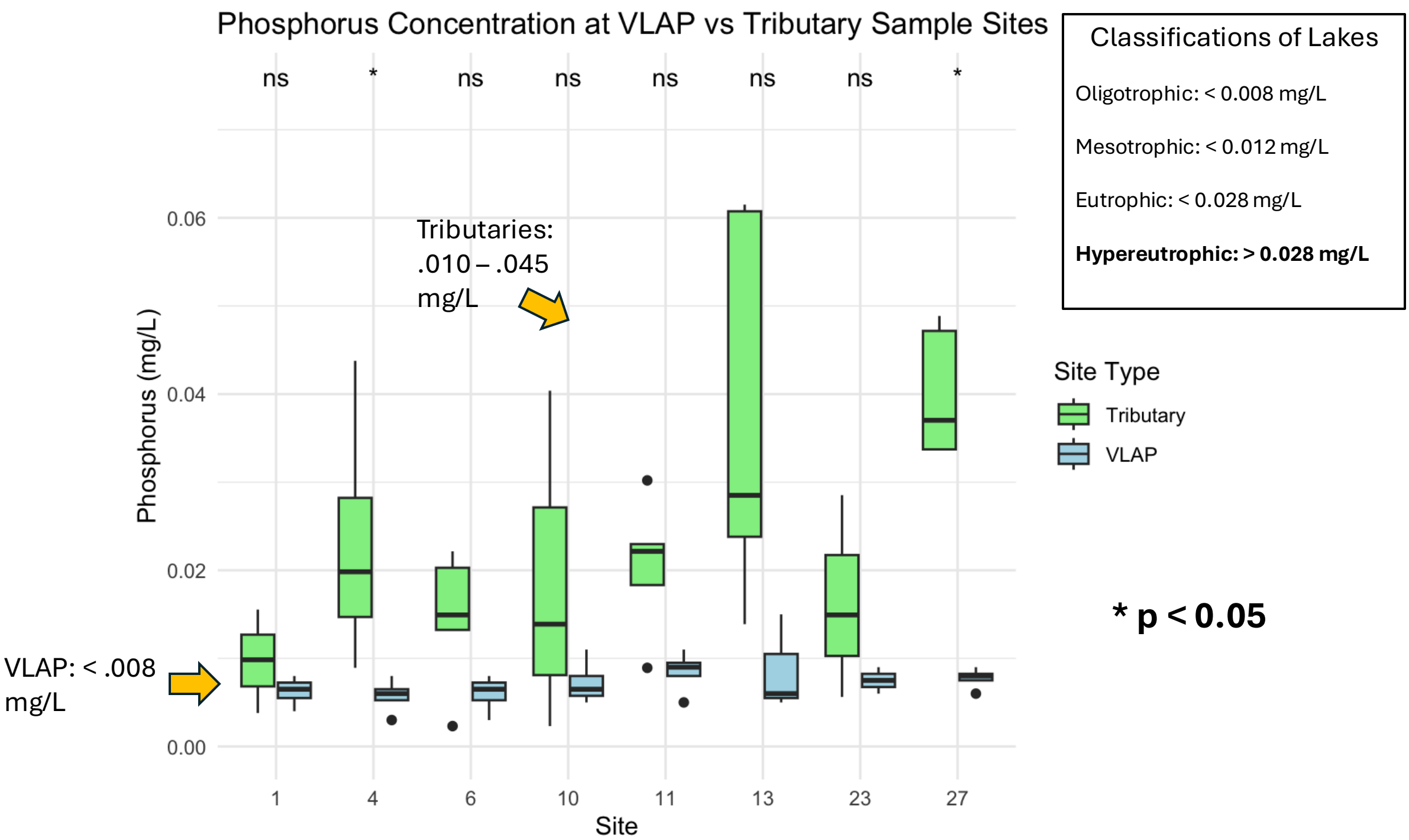
Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
0.06
0.04
0.02
0.00
Phosphorus (mg/L)
Tributaries:
.010 – .045
mg/L
VLAP: < .008
mg/L
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
Classifications of Lakes
Oligotrophic: < 0.008 mg/L
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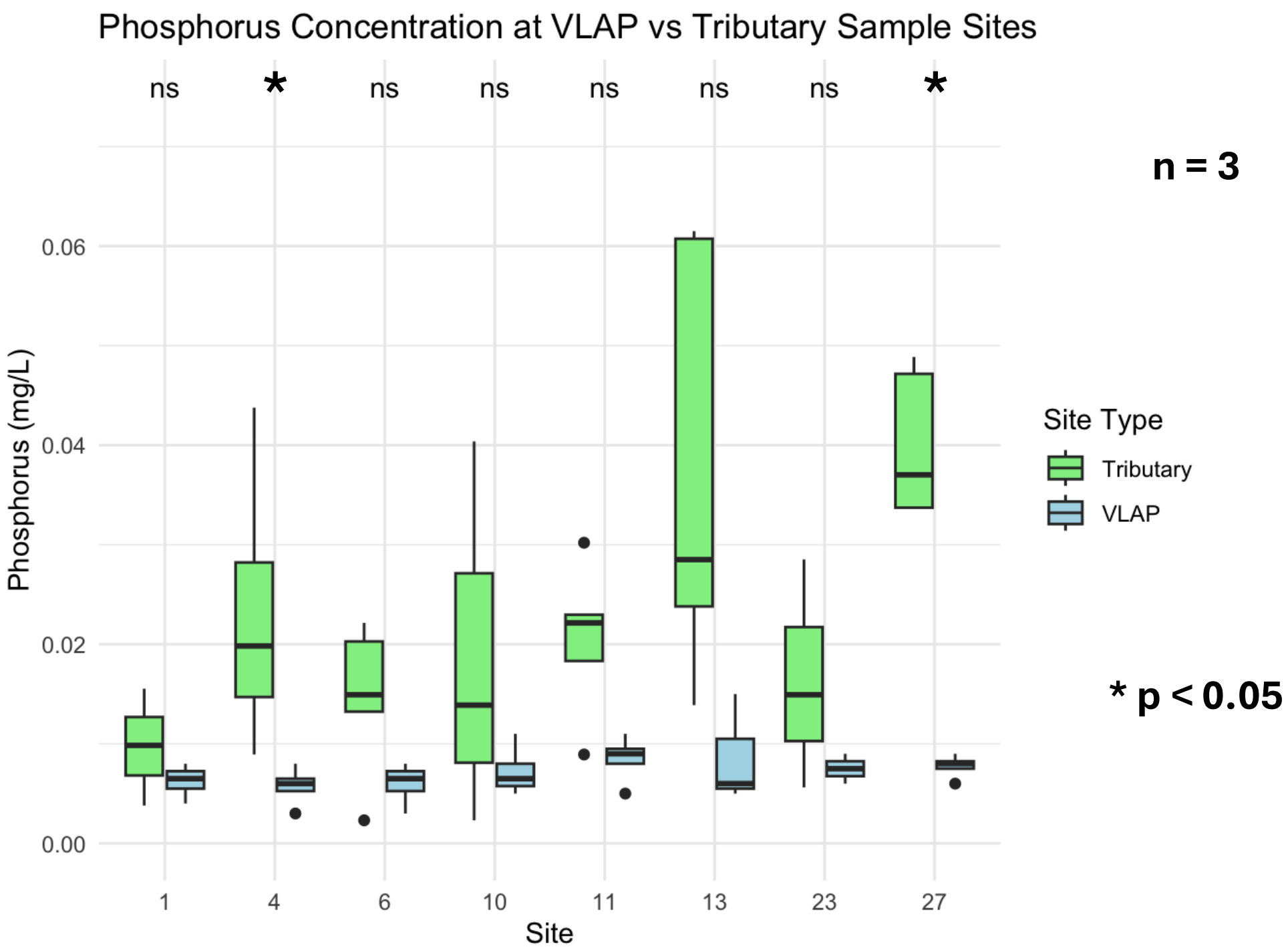
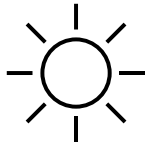
Hypereutrophic: > 0.028 mg/L
* p < 0.05


Phosphorus Concentration at VLAP vs Tributary Sample Sites
ns
*
ns
ns
ns
ns
ns
*
0.06
0.04
0.02
0.00
Phosphorus (mg/L)
1
4
6
10
11
13
23
27
Site
Site Type
Tributary
VLAP
n = 3
* p < 0.05

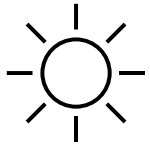
Impact of Summer Thunderstorms on Phosphorus – June 20th



Site	Before Storm	After Storm
Great Brook	30 ug/L	91 ug/L
Little Brook	13 ug/L	123 ug/L
White Brook	23 ug/L	146 ug/L
Red Brook	35 ug/L	108 ug/L
Bunker/Elkins	45 ug/L	168 ug/L
Fire Pond	83 ug/L	198 ug/L

0.4 in / 1hr!

Impact of Summer Thunderstorms on Phosphorus – June 20th



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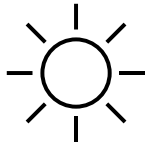
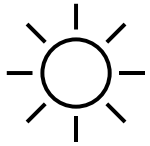
Impact of Summer Thunderstorms on Phosphorus – June 20th



Site	Before Storm	After Storm
Great Brook	30 ug/L	91 ug/L
★ Little Brook	**13** ug/L	**123** ug/L
White Brook	23 ug/L	146 ug/L
Red Brook	35 ug/L	108 ug/L
Bunker/Elkins	45 ug/L	168 ug/L
Fire Pond	83 ug/L	198 ug/L

10x Higher!

Impact of Summer Thunderstorms on Phosphorus – June 20th



Site	[illegible]	After Storm
Great Brook		91 ug/L
Little Brook		123 ug/L
White Brook		146 ug/L
Red Brook		108 ug/L
Bunker/Elkins		168 ug/L
Fire Pond	83 ug/L	**198** ug/L

Classifications of Lakes

Oligotrophic: < 8 ug/L

Mesotrophic: < 12 ug/L

Eutrophic: < 28 ug/L

Hypereutrophic: > 28 ug/L

Storm Events Drive Summer Phosphorus Loading

Site	Grams P in Hour	Grams P in Day
Fire Pond (Pre Storm)	5.8	139.2
Fire Pond (Storm)	211.4	5074.3
Little Brook (Pre Storm)	0.032	1.92

Discharge

Sediments

Storm Events Drive Summer Phosphorus Loading

Site	**Grams P in Hour**	**Grams P in Day**
Fire Pond (Pre Storm)	5.8	139.2
Fire Pond (Storm)	211.4	5074.3
Little Brook (Pre Storm)	0.032	1.92

Storm Events Drive Summer Phosphorus Loading

Site	Grams P in Hour	Grams P in Day
Fire Pond (Pre Storm)	5.8	139.2
Fire Pond (Storm)	**211.4**	5074.3
Little Brook (Pre Storm)	0.032	1.92

Storm Events Drive Summer Phosphorus Loading

Site	Grams P in Hour	Grams P in Day
Fire Pond (Pre Storm)	5.8	**139.2**
Fire Pond (Storm)	211.4	5074.3
Little Brook (Pre Storm)	0.032	1.92

A 1-hour storm brings in almost twice as much phosphorus as a day of baseflow for the Fire Pond

Storm Events Drive Summer Phosphorus Loading

Site	Grams P in Hour	Grams P in Day
Fire Pond (Pre Storm)	5.8	139.2
Fire Pond (Storm)	211.4	5074.3
Little Brook (Pre Storm)	0.032	**1.92**

Storm Events Drive Summer Phosphorus Loading

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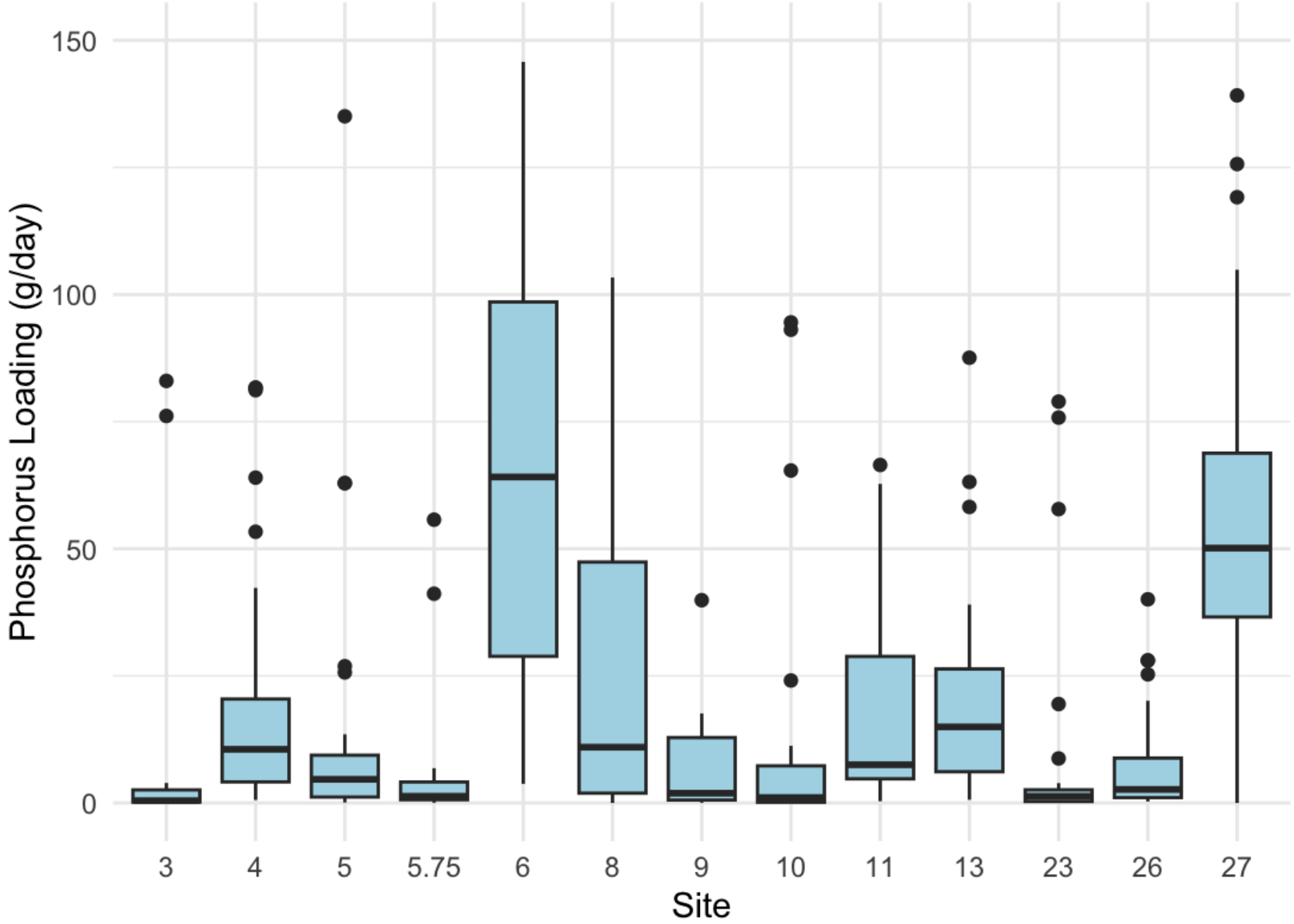
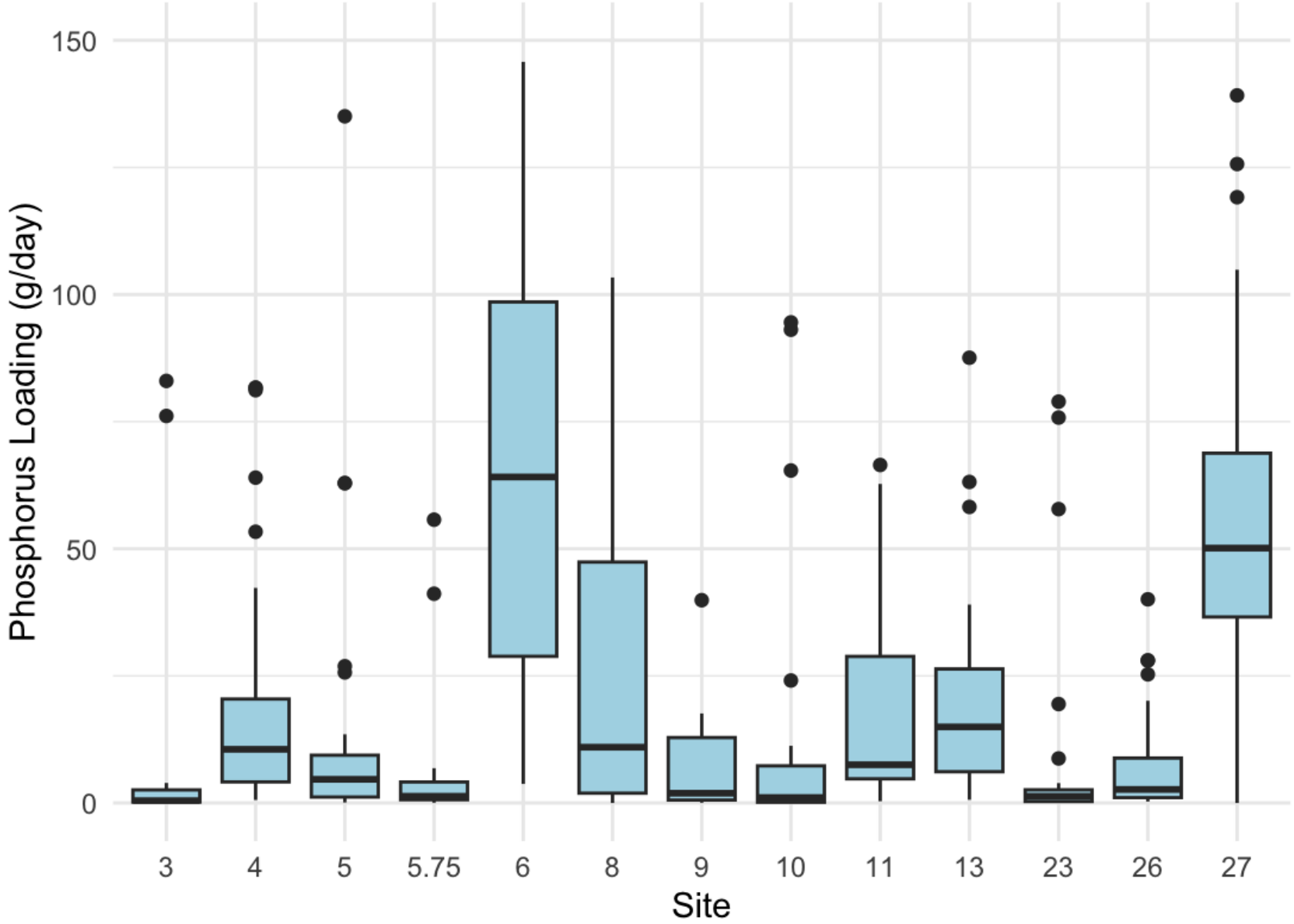
Fire Pond (Pre Storm)	5.8	139.2
Fire Pond (Storm)	211.4	5074.3
Little Brook (Pre Storm)	0.032	**1.92**

The Fire Pond brings in as much phosphorus during a 1-hour storm as Little Brook brings in 110 Baseflow Days

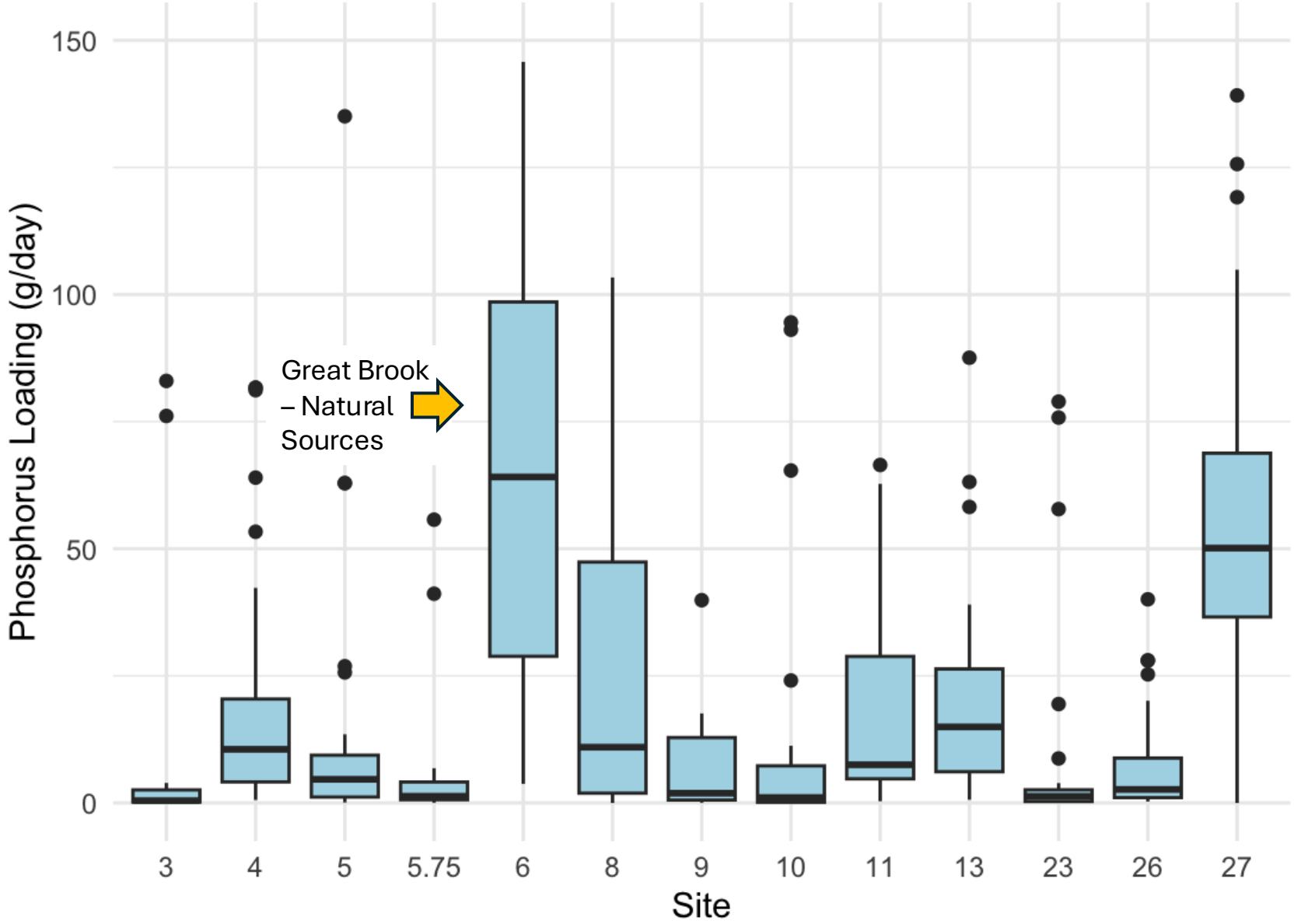
Average Phosphorus Loading Per Day



Sites to Focus Management Efforts on



Average Phosphorus Loading Per Day



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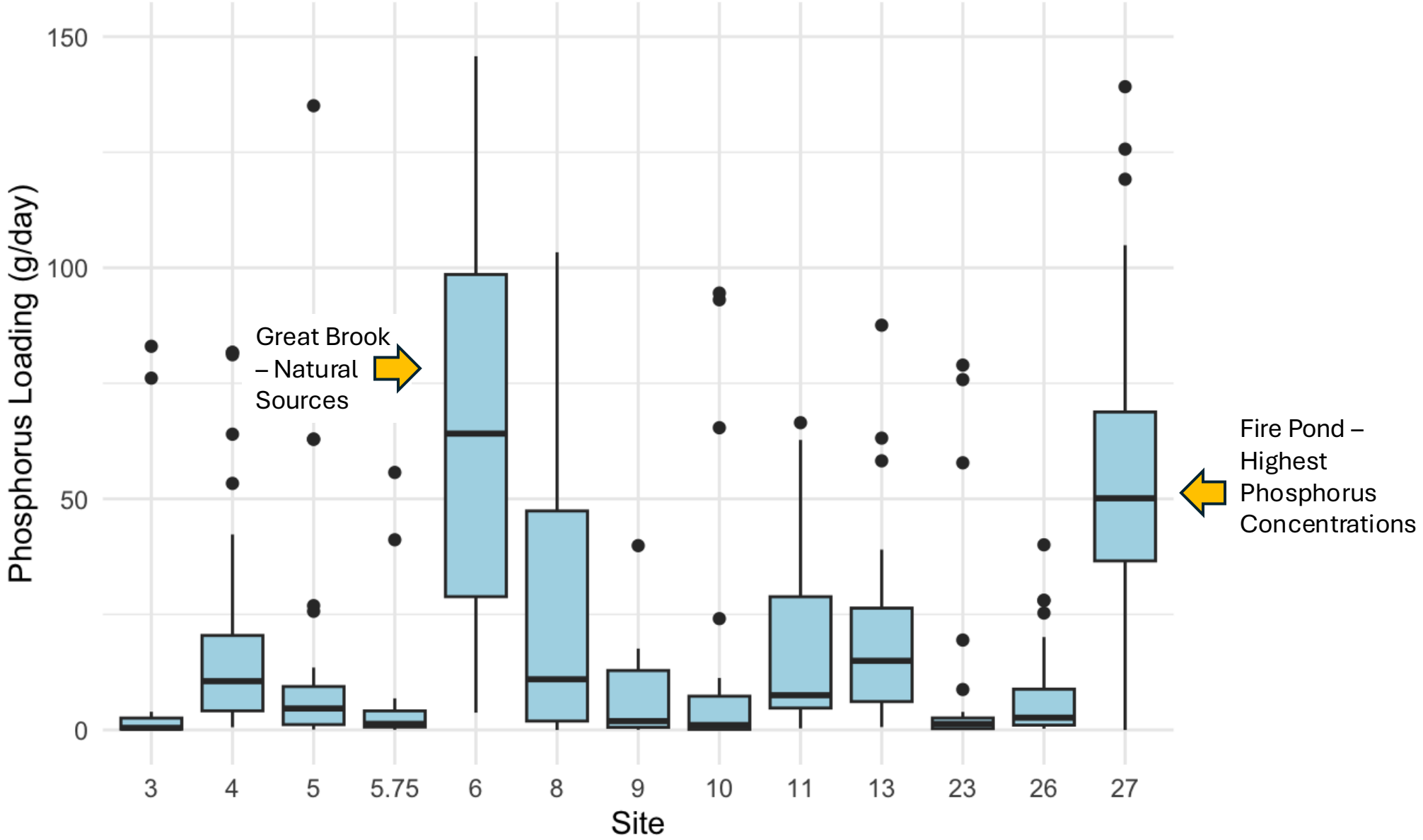
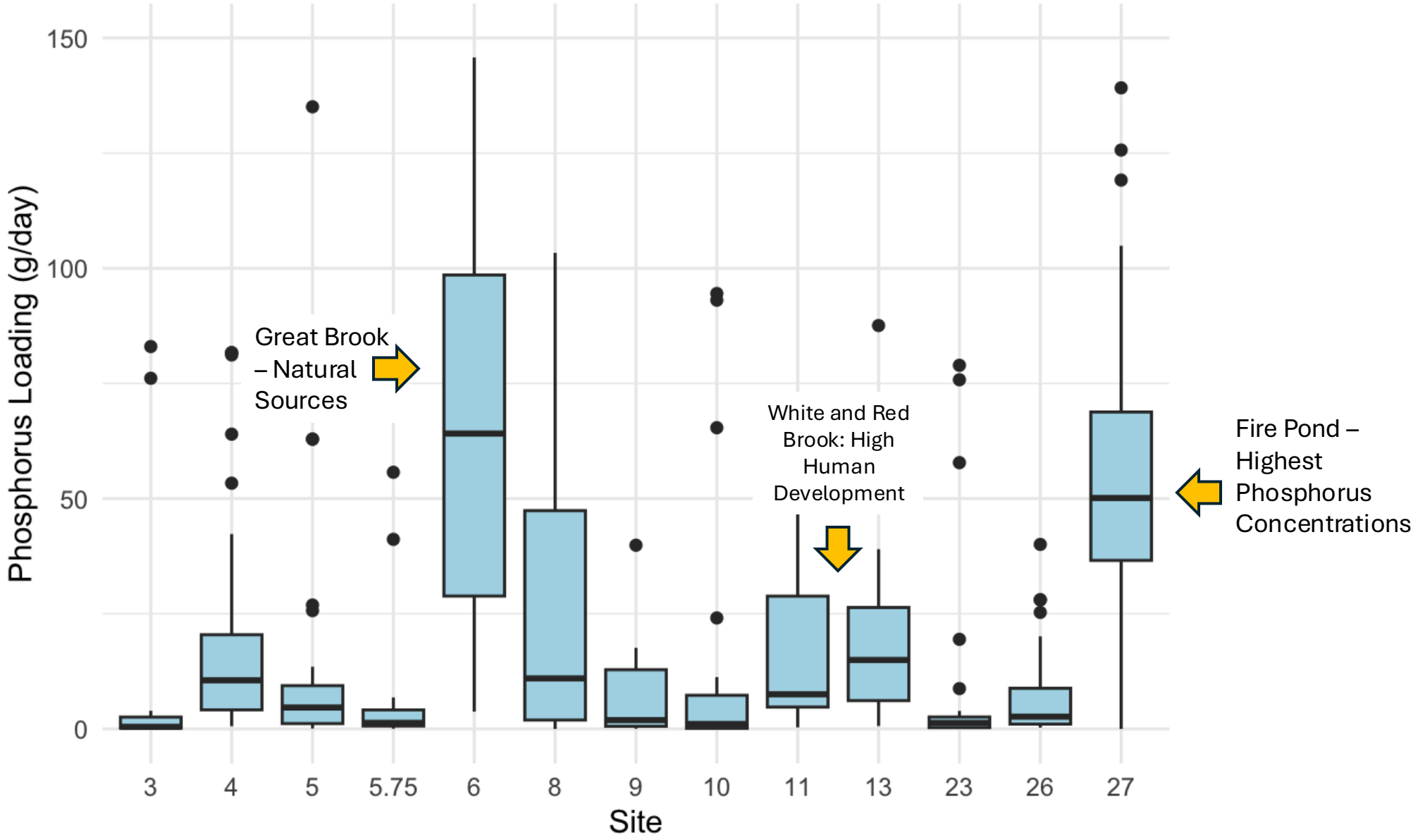
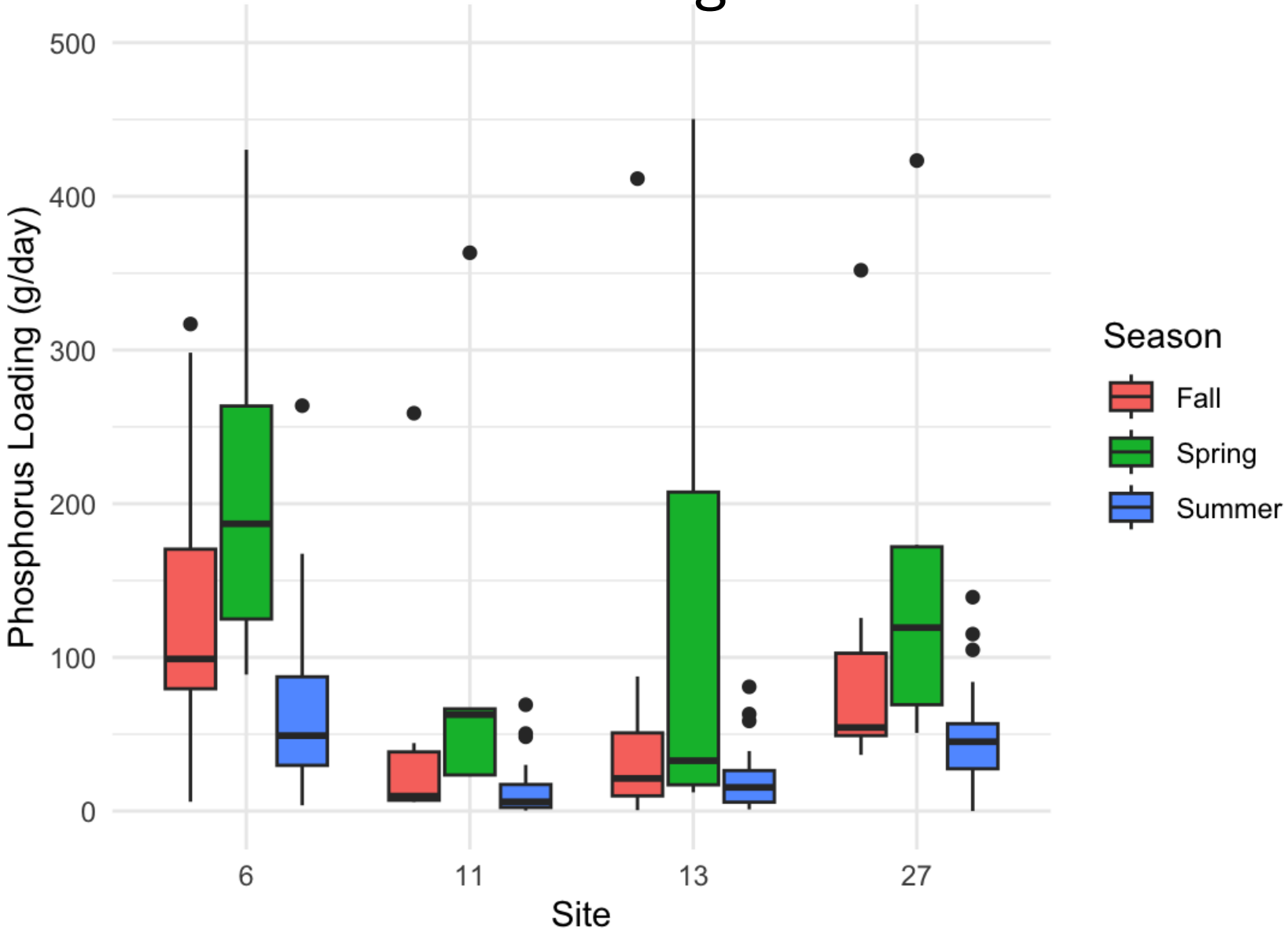


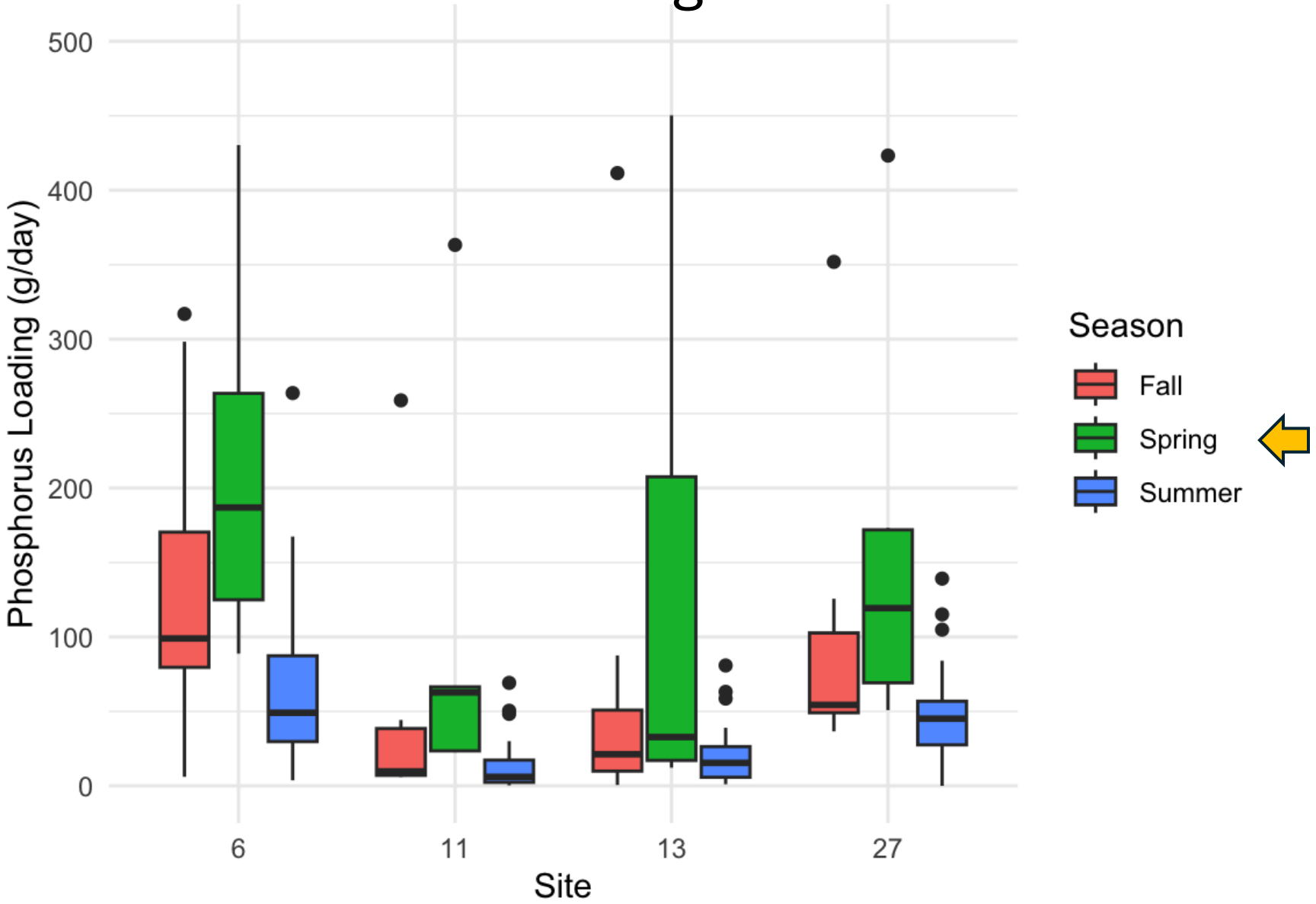
Average Phosphorus Loading Per Day



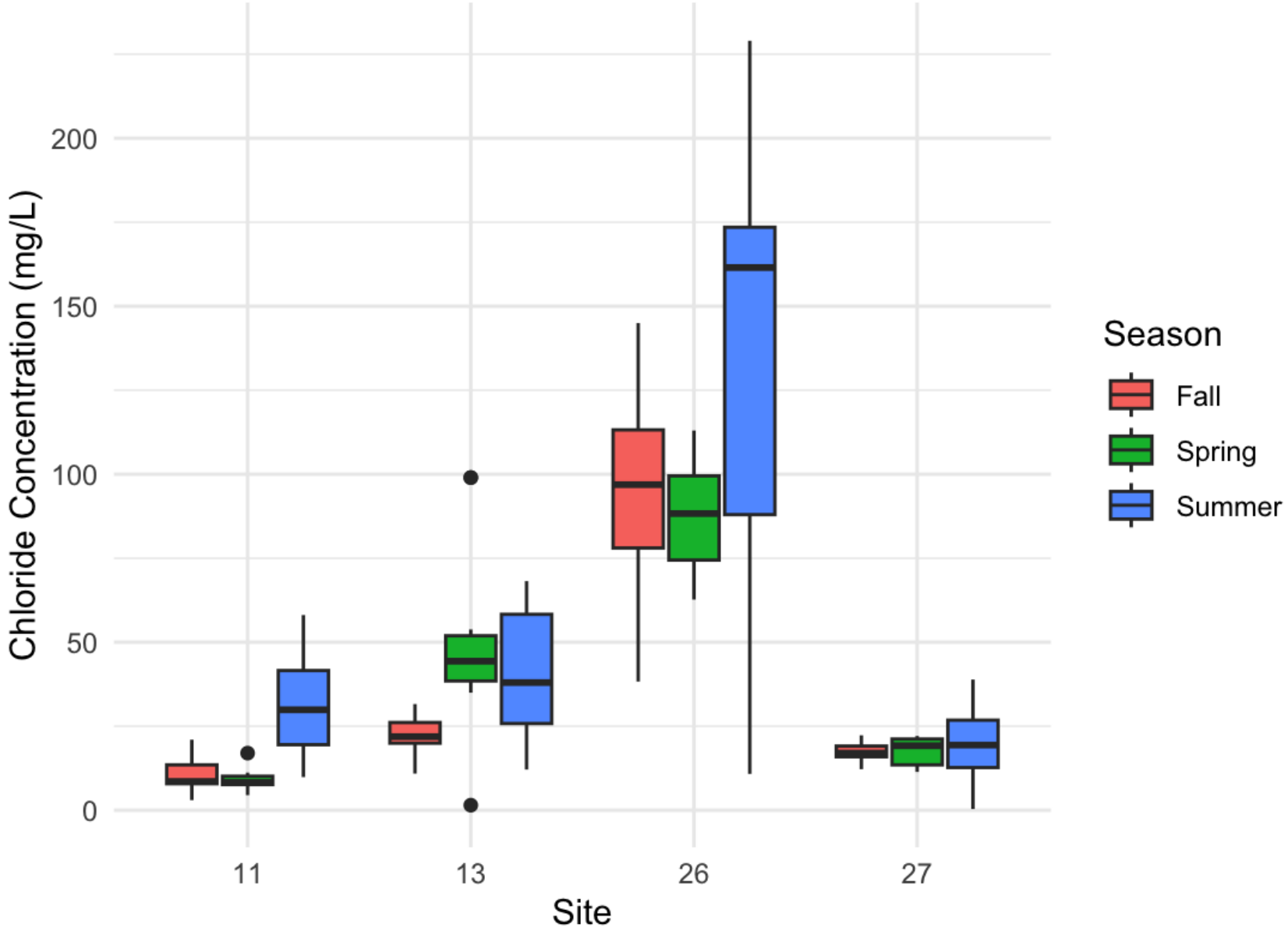
Seasonal Impacts on Phosphorus Loading



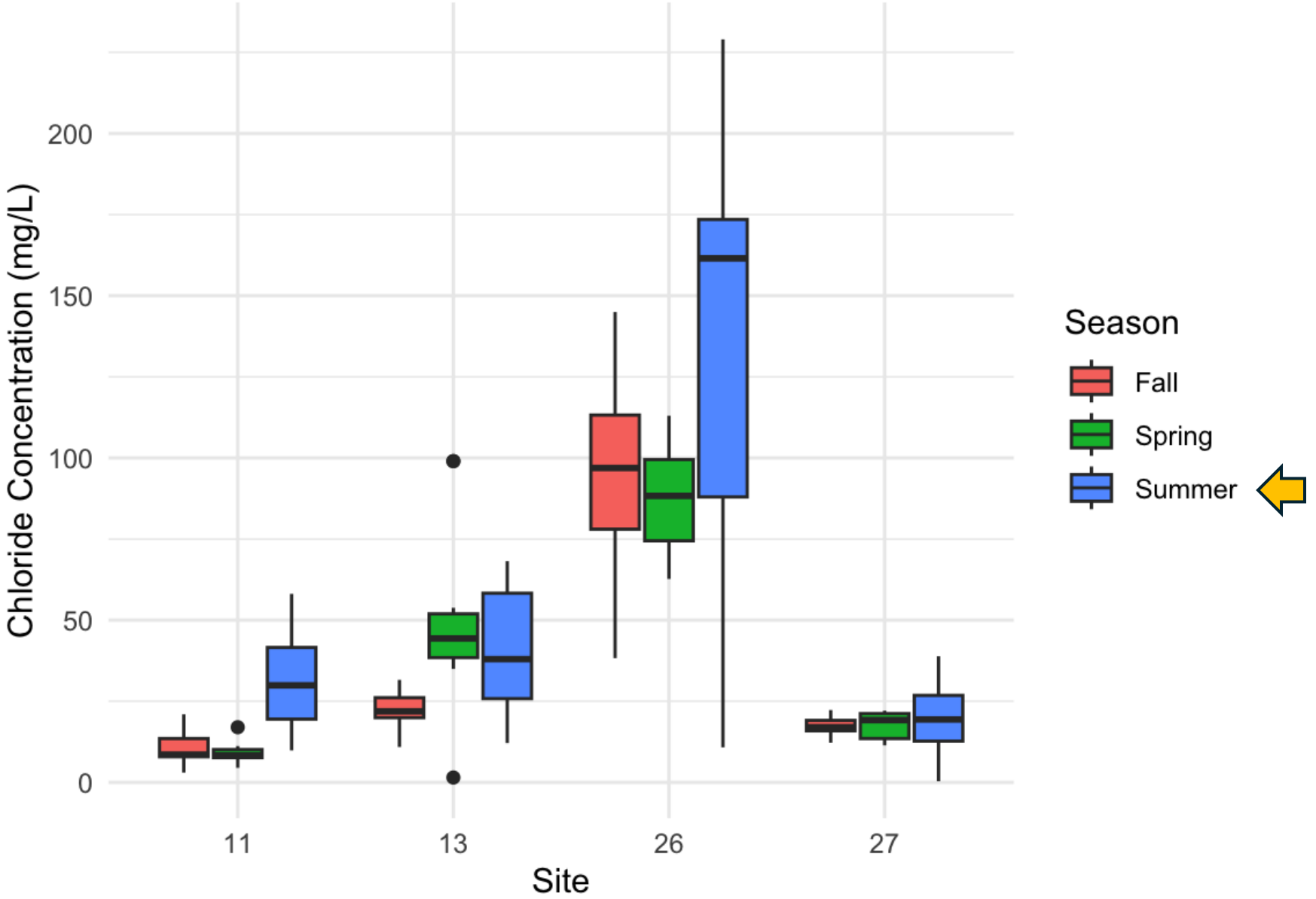
Seasonal Impacts on Phosphorus Loading



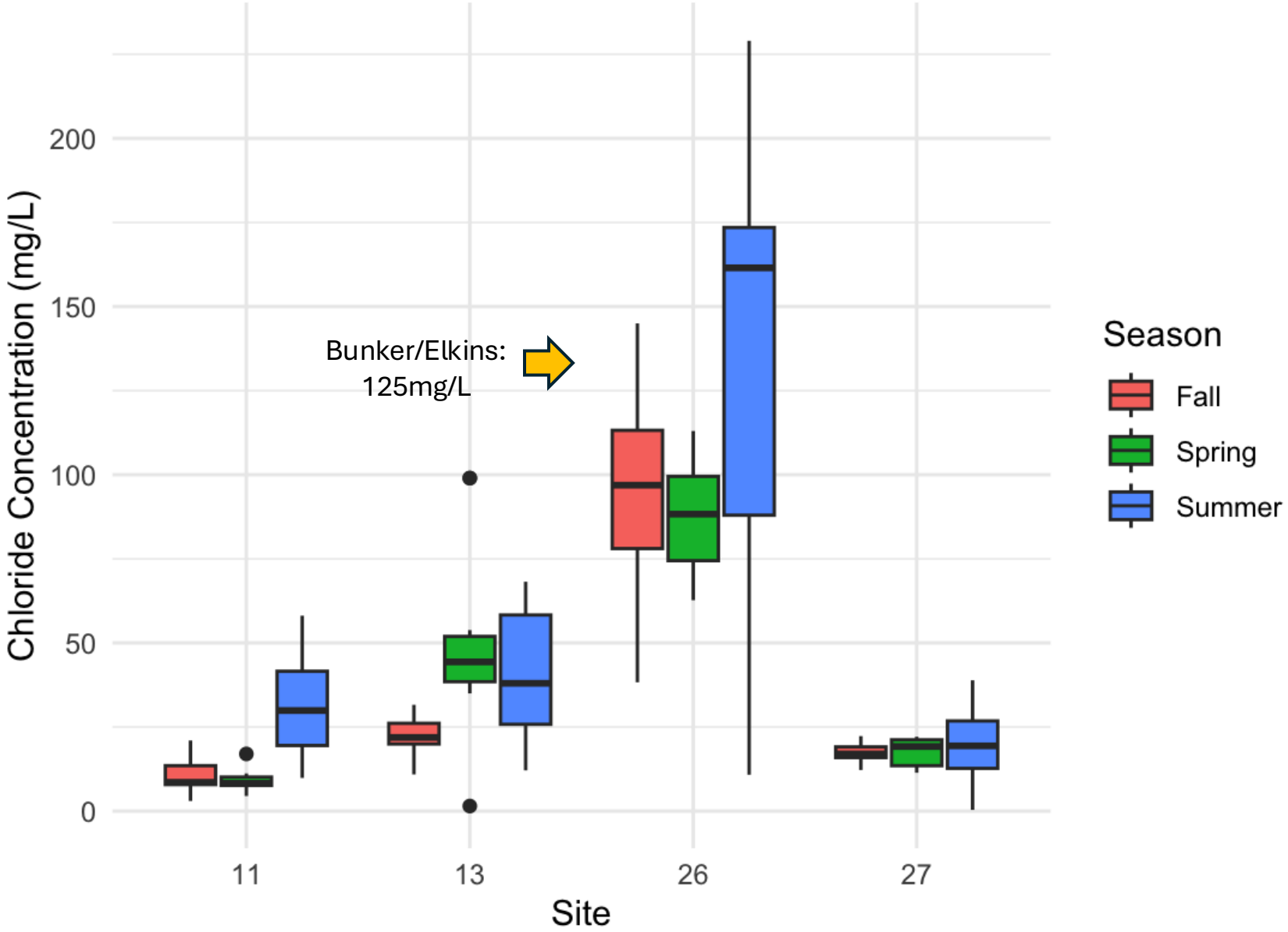
Chloride Stays in the Soil Across Seasons



Chloride Stays in the Soil Across Seasons



Chloride Stays in the Soil Across Seasons



Conclusions

- Site 26 > Headwaters (Phosphorus + Chloride)
- Site 27 > Headwaters (Chloride)
- Housing cover and development -> phosphorus concentrations
- Tributary sampling different than in-lake
- Summer storm events drive phosphorus loading
- Spring flushes of phosphorus
- Chloride stays in the soils and leaches throughout the year

Potential Next Steps

- Future VLAP sampling to include tributaries
- Measuring DO beyond 25m at the deep spot
- Analysis of sediment cores
- E coli testing for septic influence
- Salt Minimization Plan
- Watershed-Based Management Plan

What Can Homeowner's Do?

- Fertilizer Use
- Winter Road Salt Use
- Septic System Maintenance
- Shoreline buffers
- Native Vegetation

LSPA Examples

LSPA Examples

GRANLIDEN PROJECT

SLOWED WATER AND INCORPORATED SEVERAL ELEMENTS TO ALLOW MATERIAL TO SETTLE OR INFILTRATE.

Thank You

Teriko MacConnell

Nick Baer

Dave Lutz

Terri Herman

Town of New London

Bob Harrington

Kimberly Hallquist

Cara Leon

Jim Perkins

New London Archives

Pleasant Lake Protective Association

Pleasant Lake Homeowners

Debra Perkins

NH Department of Environmental Services

Leon Malan

Doug Baxter

Lake Sunapee Protective Association

Elizabeth Harper

John Waage

Tehya Kloster

Craig Williamson

Buster Welch

Janet Kidder

Bebe Casey

Bill Helm

Doug Bent

Jen Esten

John Wilson

Mark Vernon

Colby·Sawyer College

EXPLORE. CONNECT. MAKE A DIFFERENCE.

Appendix

Regular Site	Headwater Site
Winship House	Langenau Forest pond outlet
Little Brook	Powerlines at the top of Morgan Hill
White Brook	Messer Farm Expansion land plot (Ausborn Sargent Property)
Bunker/Elkins	Esther Currier Wildlife Management Area
Fire Pond	Outlet of Esther Currier Wildlife Management Area

Appendix