# Characterization and Remediation of Acid Forming Dredge Materials

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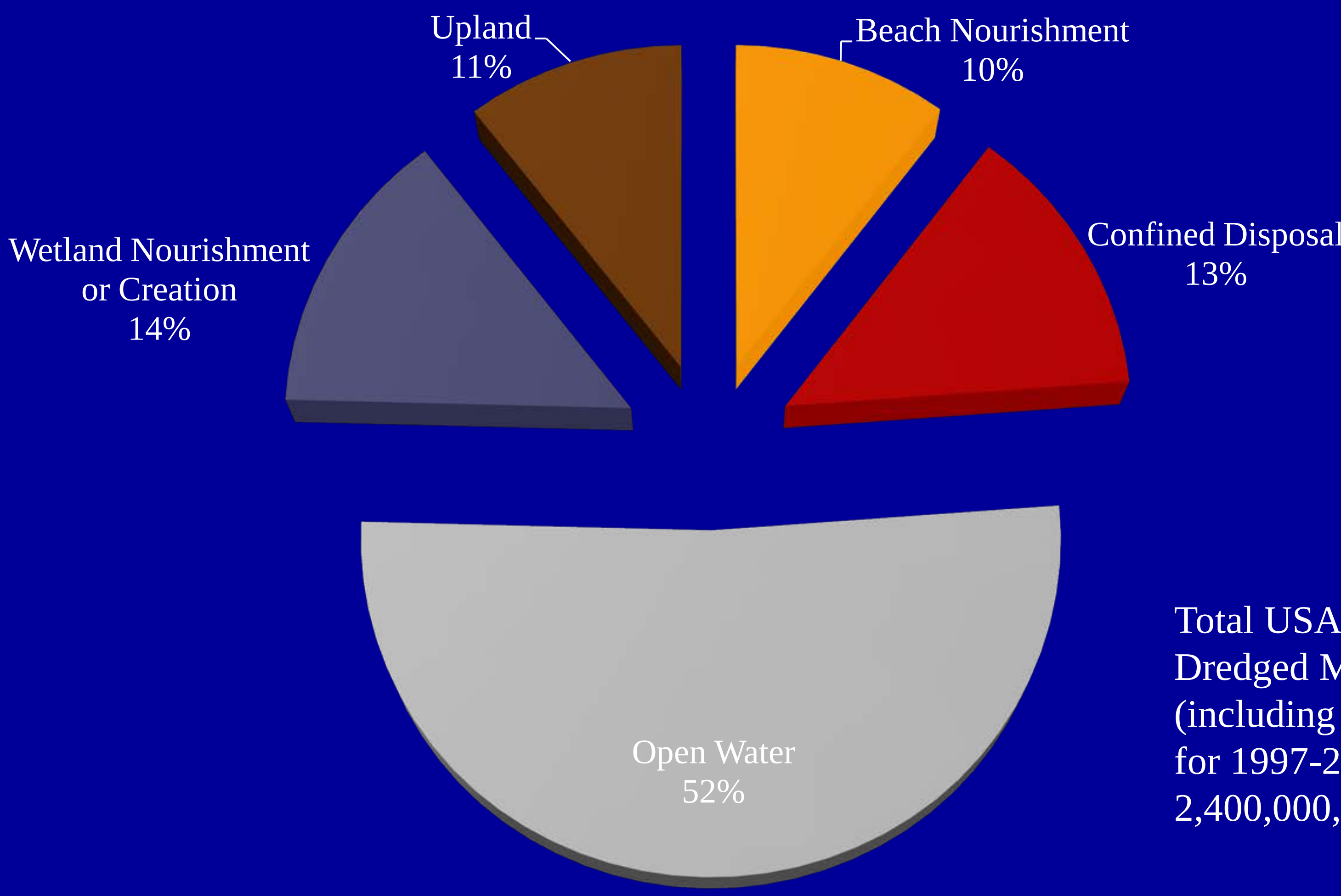
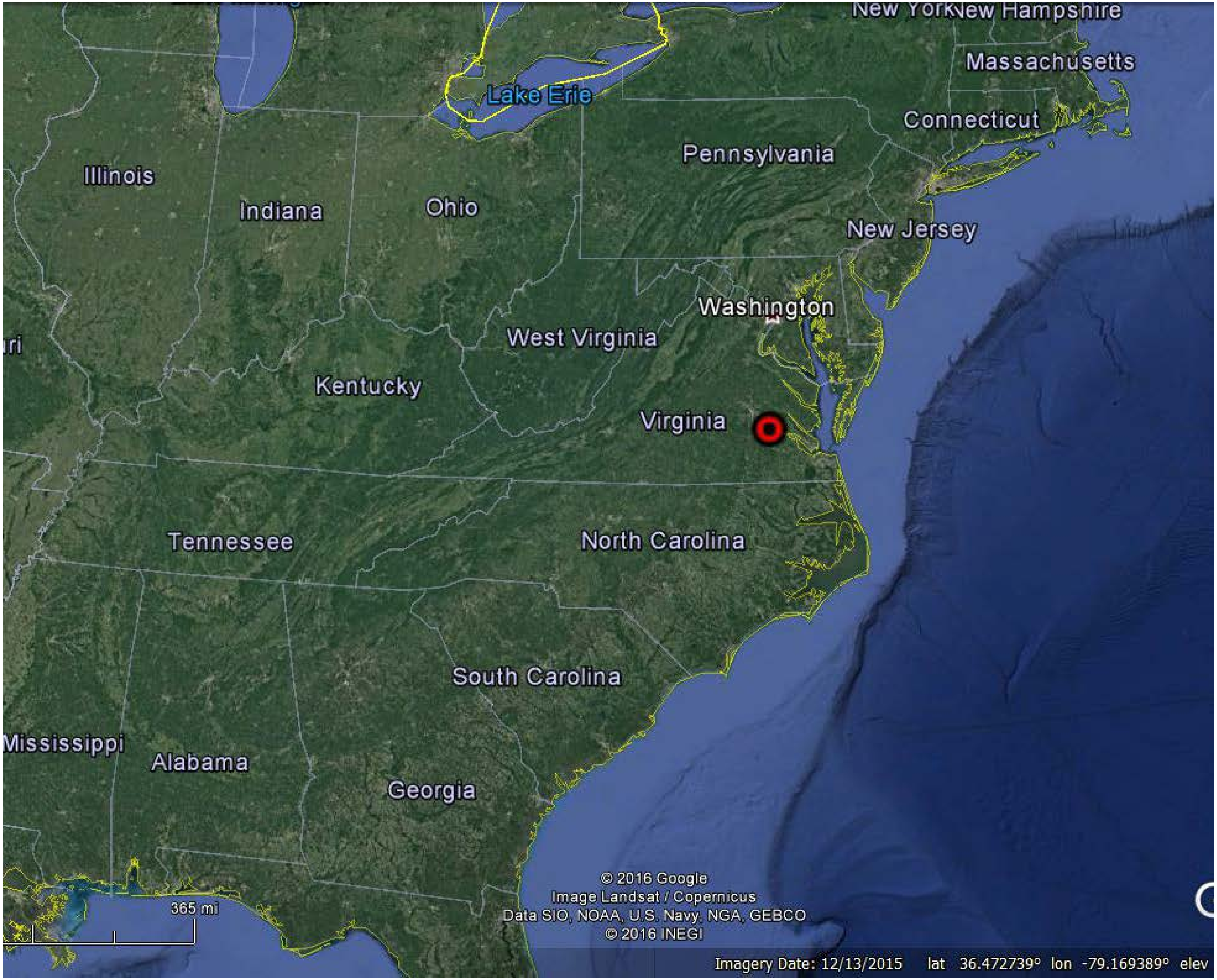
# Dredged Material Placement Alternatives 1997-2010

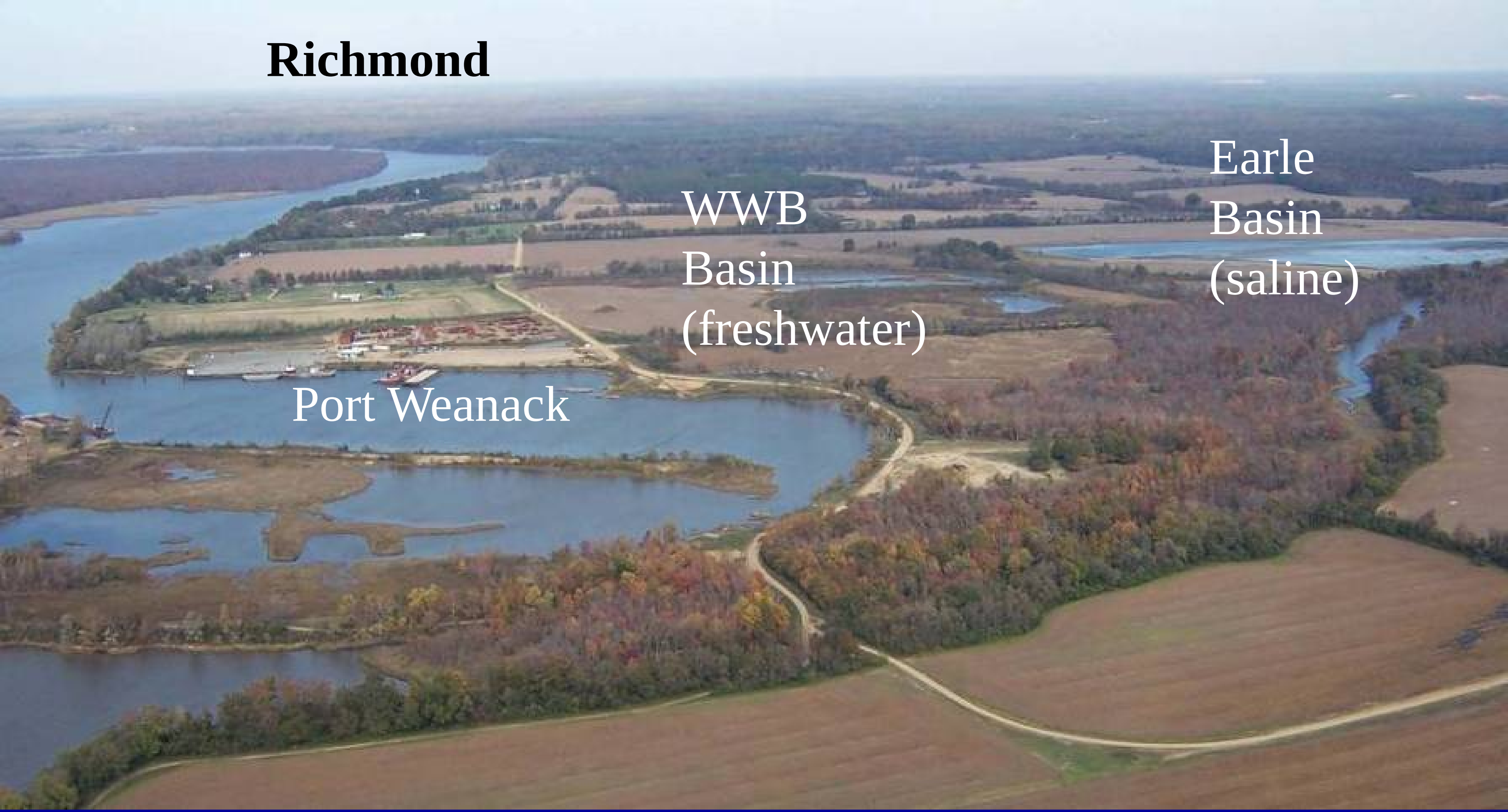



Total USACE Dredged Materials (including contracts) for 1997-2010: 2,400,000,000 $m^3$

**> 200 million $m^3$ annually in USA**

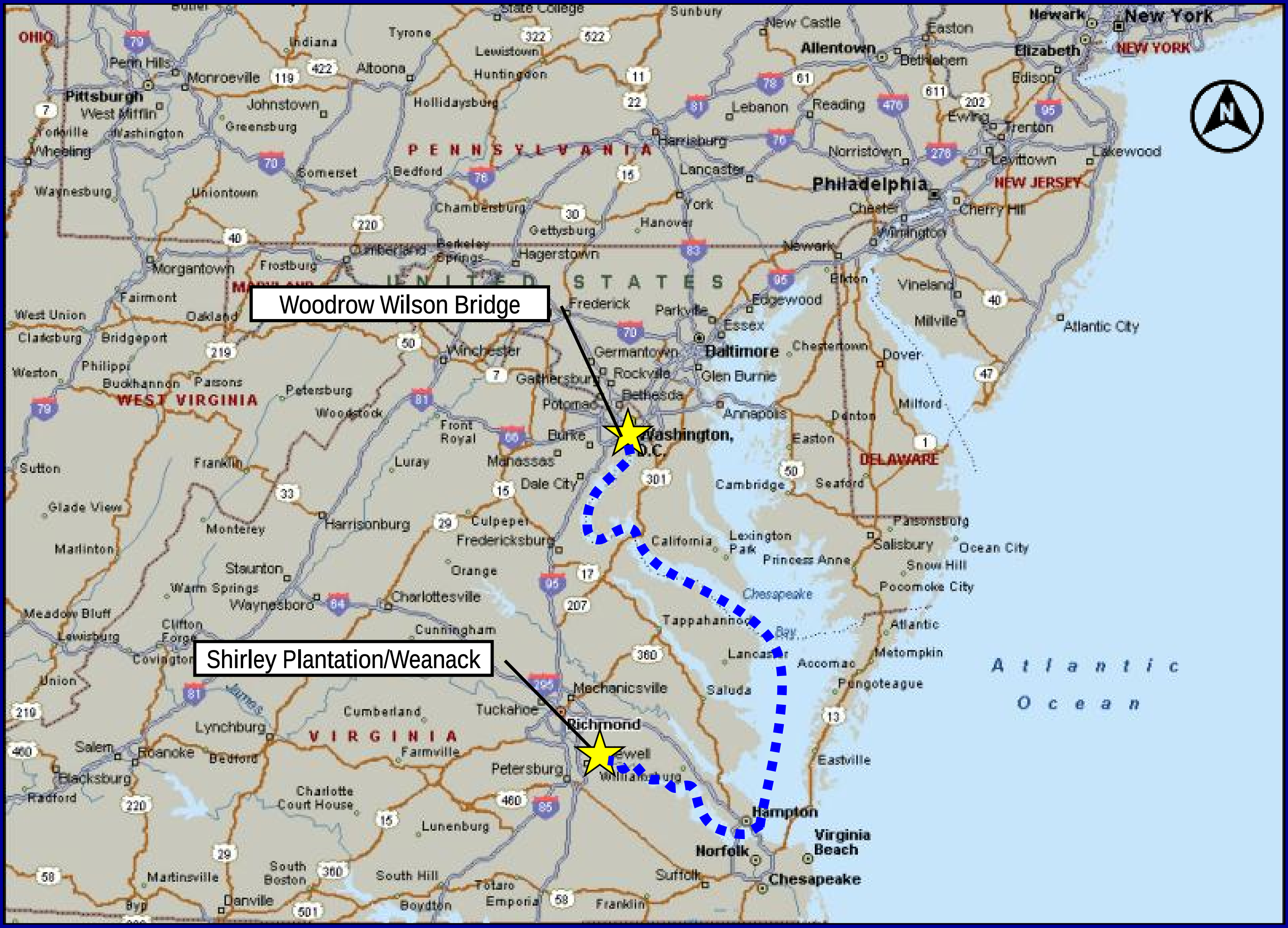


New York
New Hampshire
Massachusetts
Connecticut
Lake Erie
Pennsylvania
New Jersey
Illinois
Indiana
Ohio
Washington
West Virginia
Kentucky
Virginia
Tennessee
North Carolina
South Carolina
Mississippi
Alabama
Georgia
365 mi
© 2016 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2016 INEGI
Imagery Date: 12/13/2015 lat 36.472739° lon -79.169389° elev




**Overview of dredge spoil utilization areas on Weanack Land LLP property adjacent to Shirley Plantation. The dredge spoils (> 750,000 $m^3$ to date) are transported by barge to the port facility shown in the middle of the photograph. The owner (Charles Carter; Weanack Land LLP) *converts them to agricultural uses*.**

# Woodrow Wilson Bridge (2001 – 2004; 450,000 $m^3$)



Plantation House
Woodrow Basin
Port Weanack
MPA + LPS Plots
Earle Basin
Image: 2,130m E-W

**Woodrow Wilson Bridge Dredge Soil**


| Horizon + depth | pH | PPA[1] | S | NP[2] | SC[3] |
|---|---|---|---|---|---|
| cm | | | % | % | dS/m |
| ^Ap 0 – 5<br>^Bw1 5 – 60 | 7.49 | 0.00 | 0.03 | 0.95 | 0.62 |
| ^Bw2 60 – 140 | 7.69 | 0.00 | 0.03 | 1.4 | 0.41 |
| ^C 140 – 160 | 7.87 | 0.00 | 0.07 | 1.4 | 0.94 |

[1]PPA - peroxide potential acidity; [2]NP = neutralization potential; [3]SC – specific conductivity

4 year old soil in Baltimore Harbor dredged materials with *sulfuric horizon* to 30 cm with pH 3.3 formed from *sulfidic materials* at base of profile with pH about 7.0. Photo from Del Fanning.

# Weanack/VT Testing Program

- Tested > 30 candidate dredge materials in past 10 years from mid-Atlantic region.

- We use both EPA/WV acid-base accounting (ABA) and hydrogen peroxide oxidation (PPA) methods.

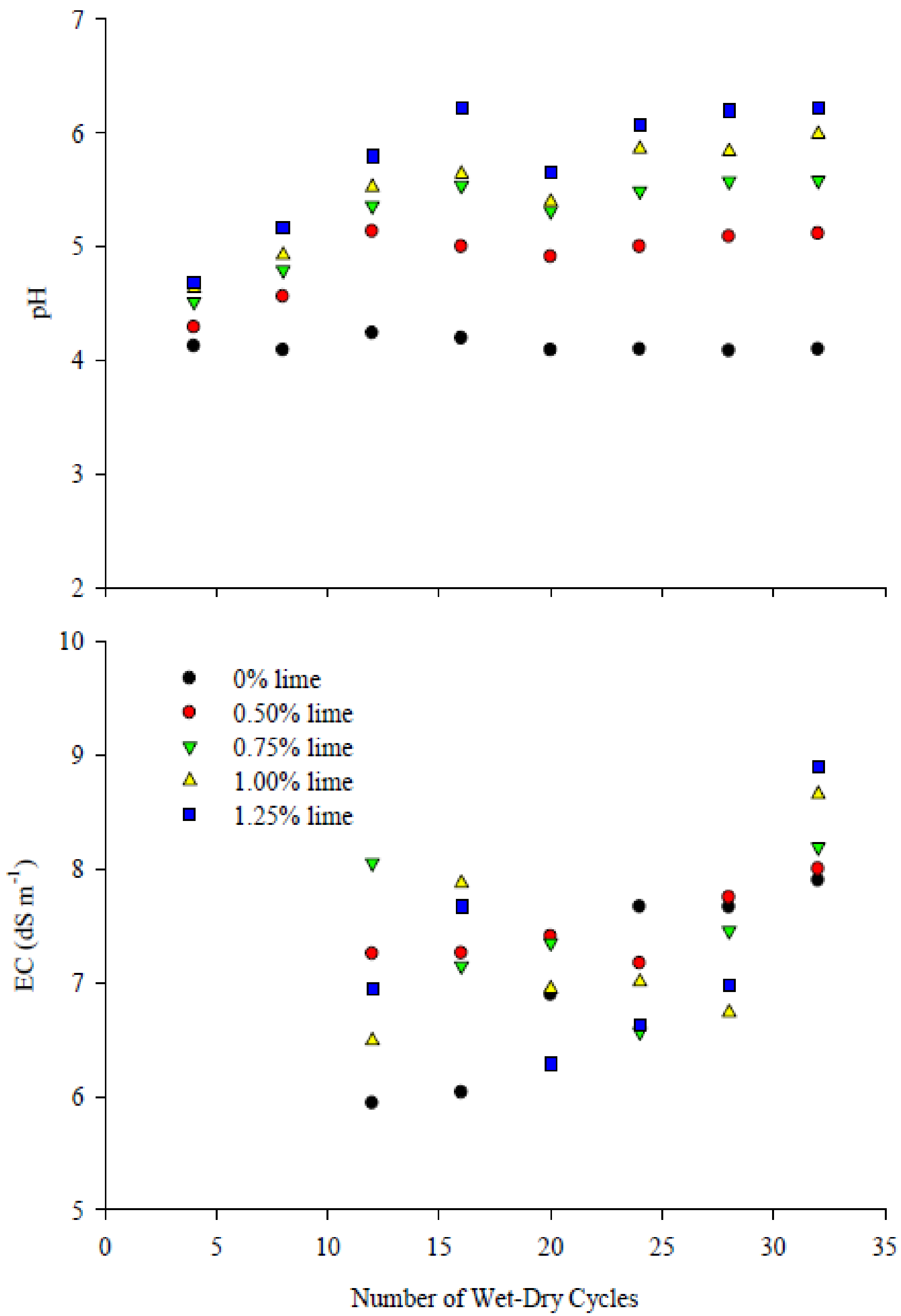
- > 50% of saline source materials have net lime requirement of over 10 Mg per 1000 Mg material of CCE lime. We automatically exclude all > 15 Mg / 1000 Mg net acid and we bulk lime all > 5 Mg / 1000 net acid.

# Maryland Port Administration – MPA Cox Creek Facility

- 1.31 % Total-S (did not fractionate S)
- 7.l3 % CCE (mainly sand- and silt-sized shell fragments)
- -10 Mg / 1000 Mg $H_2O_2$ Potential Acidity (PPA)
- Thus, by typical acid-base-accounting, this material would have an NNP of ~ +30 Mg / 1000 Mg, but PPA predicted it to be net acid-forming.
- Material had "other limitations" not discussed today that would have potentially limited agricultural uses.

Figs. from Wick et al. 2011 ASMR Proc.

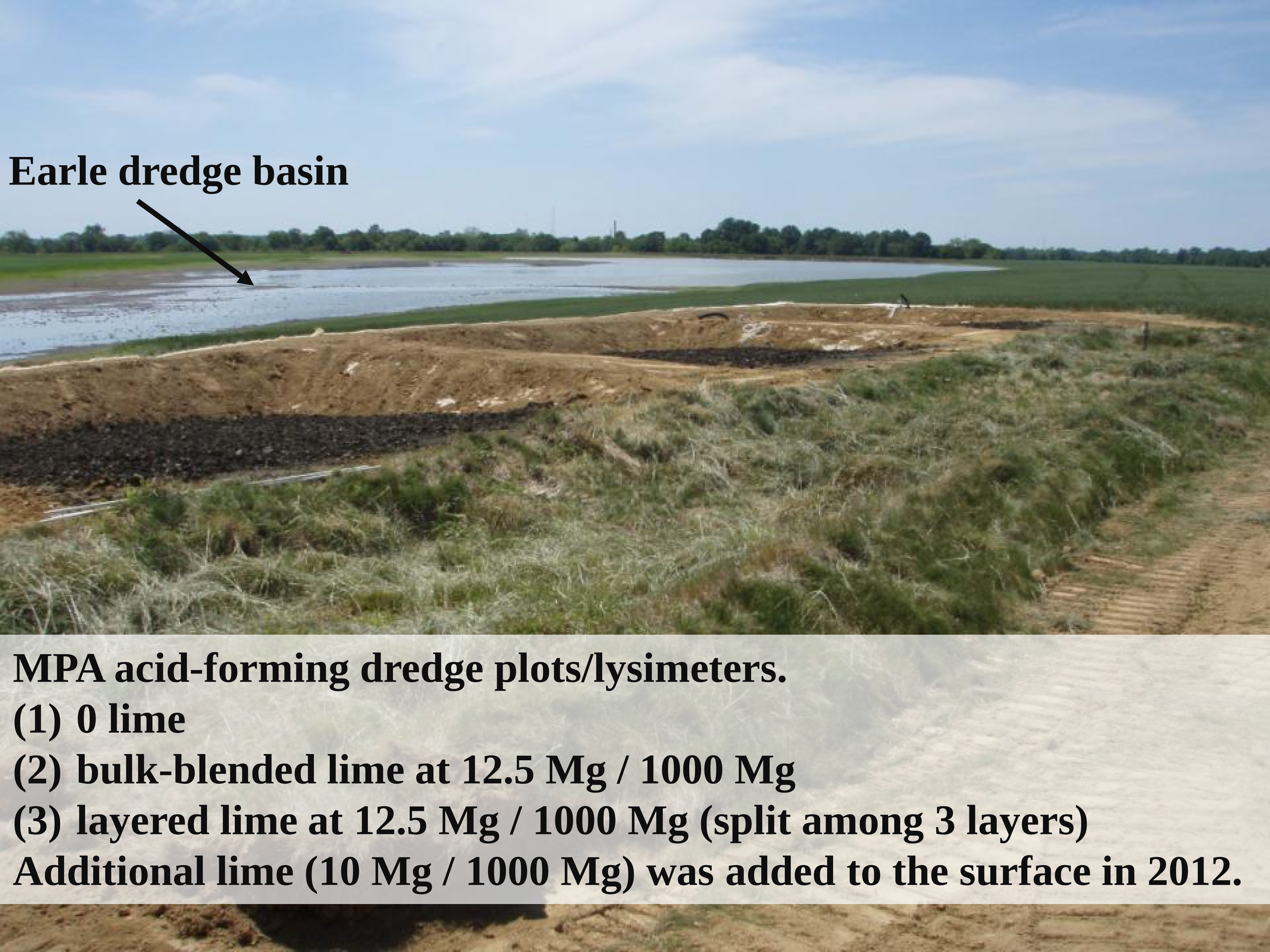
Figure 1. Maryland Port Administration Cox Creek Facility dredge material being placed at Port Tobacco, Shirley Plantation, Charles City, VA, in November of 2009. The materials were immediately covered with a tarp to limit rainfall additions and oxidation.




**Effect of lime rate on pH and EC over 35 Wet-dry incubation cycles in the lab. 1.0 x = 10 Mg / 1000 Mg CCE.**

**Lab pH was never < 4.0, but never > 6.2, even at 1.25x PPA lime addition rate.**

**EC of saturated paste kept on increasing!**




**MPA acid-forming dredge plots/lysimeters.**
**(1) 0 lime**
**(2) bulk-blended lime at 12.5 Mg / 1000 Mg**
**(3) layered lime at 12.5 Mg / 1000 Mg (split among 3 layers)**
**Additional lime (10 Mg / 1000 Mg) was added to the surface in 2012.**

# Zero-tension lysimeters collecting @ ~ 90 cm.

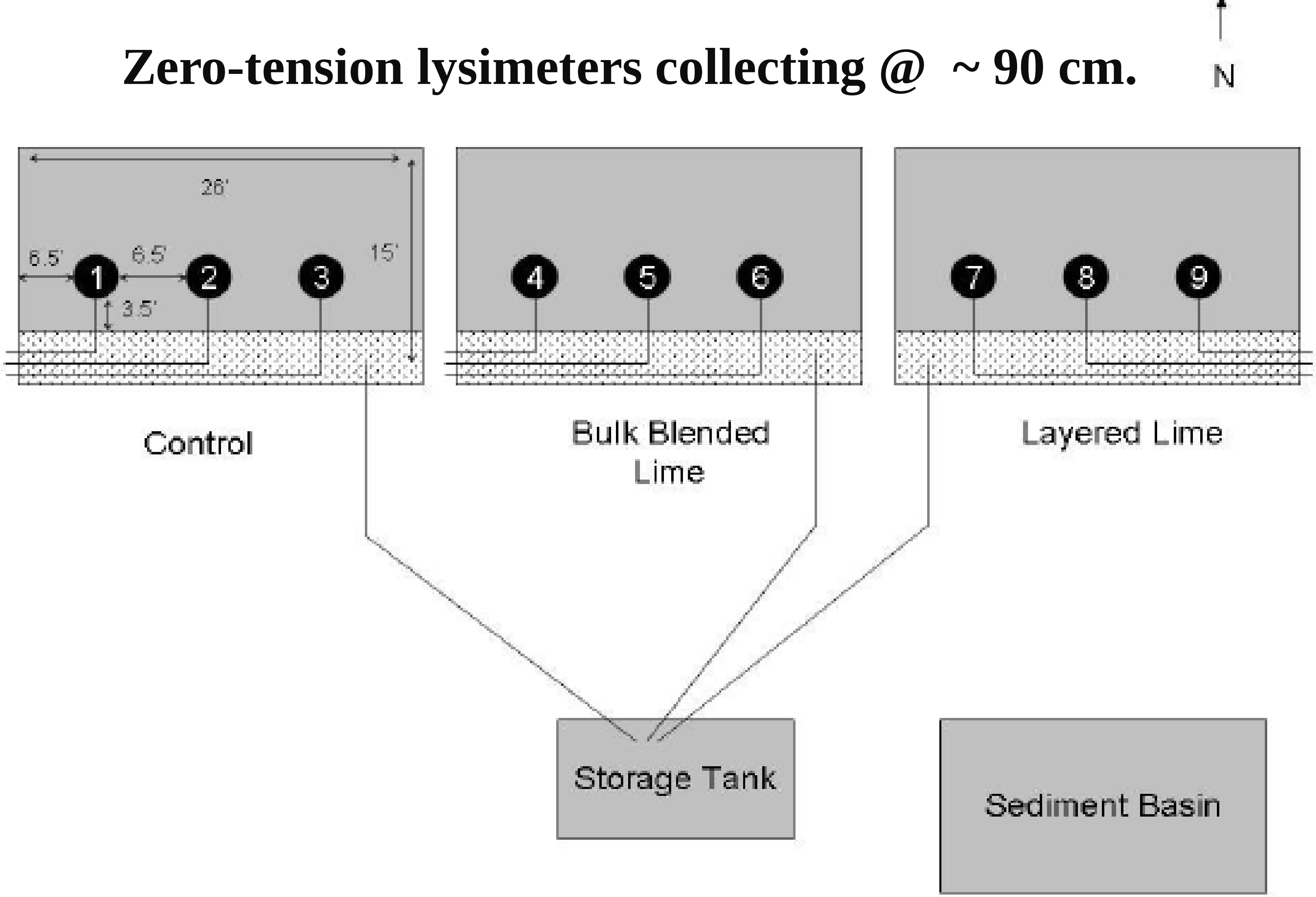



Figure 2. Schematic diagram for lysimeter locations within each treated (control, bulk blended lime and layered lime) cell at the Maryland Port Administration Cox Creek dredge material study, Shirley Plantation, Charles City, VA.

# **2016** Soil profile for control; no lime.


20
40

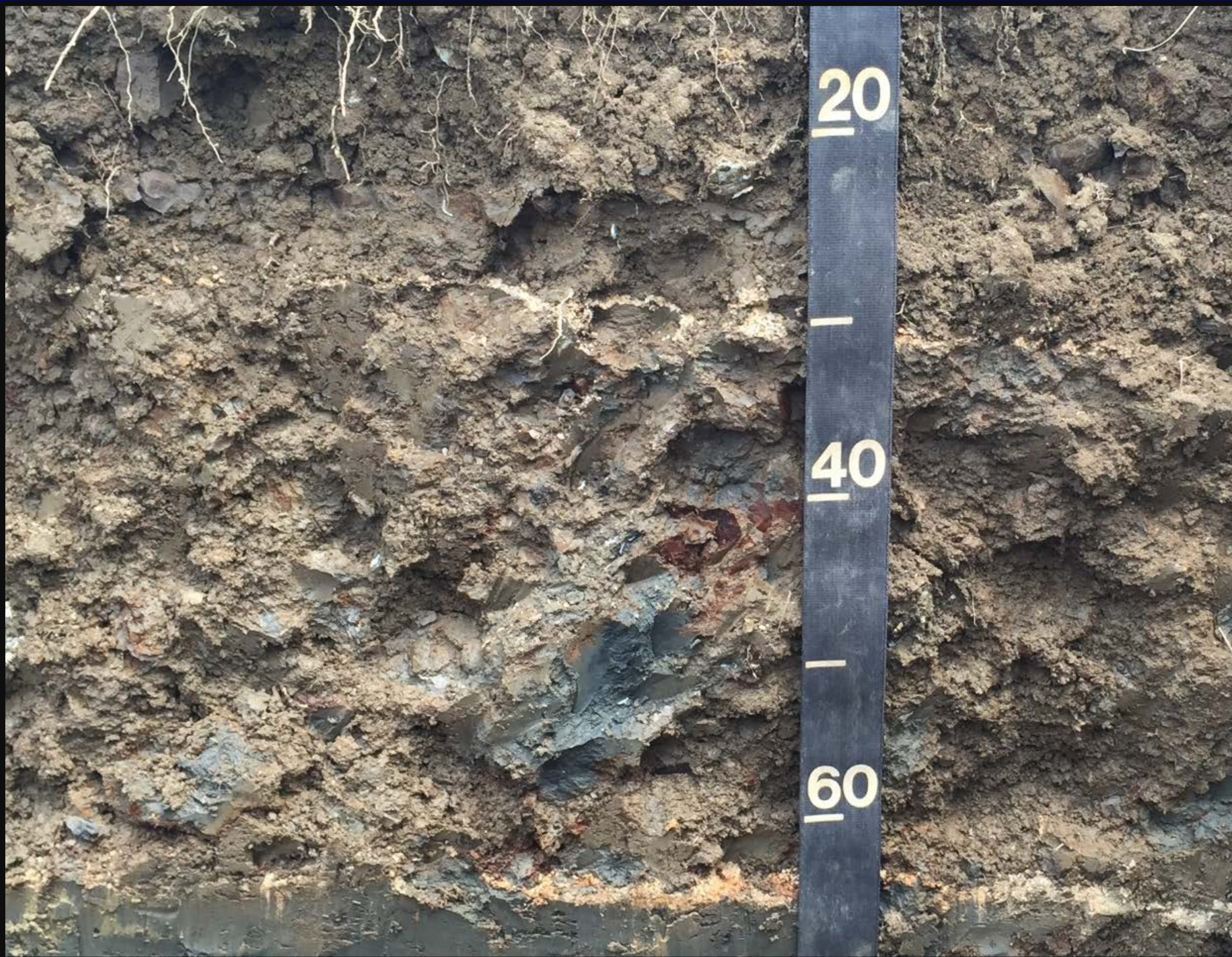

60
80

## NO LIME


| Horizon + depth | pH | PPA[1] | S | NP[2] | SC[3] |
|---|---|---|---|---|---|
| cm | | | % | % | dS/m |
| ^Ap 0 – 7 | 3.82 | 2.43 | 0.60 | 0.16 | 2.97 |
| ^Bj1 7 – 26 | 3.52 | 4.65 | 0.71 | 0.00 | 3.17 |
| ^Bj2 26 – 78 | 3.66 | 6.97 | 0.76 | 0.00 | 3.28 |
| ^Cseu 78 – 95 | 7.92 | 3.52 | 1.21 | 1.21 | 3.47 |

[1]PPA - peroxide potential acidity; [2]NP = neutralization potential; [3]SC – specific conductivity

Soil profile for layered lime. Lime added in 2010 to surface and at -30 and -60 cm in layers without mixing or incorporation. An additional 10 Mg / 1000 Mg was added to the surface in 2012.



20
40
60

# LAYERED LIME


| Horizon + depth | pH | PPA[1] | S | NP[2] | SC[3] |
|---|---|---|---|---|---|
| cm | | | % | % | dS/m |
| ^Ap 0 – 10 | 6.83 | 0.00 | 0.79 | 0.99 | 2.44 |
| ^Bj 10 – 30 | 6.52 | 0.00 | 0.48 | 0.78 | 2.36 |
| ^Cseu 30 – 64 | 4.22 | 4.16 | 0.75 | 0.11 | 2.80 |
| ^Cse 64 – 88 | 4.89 | 9.93 | 1.19 | 0.52 | 4.67 |

[1]PPA - peroxide potential acidity; [2]NP = neutralization potential; [3]SC – specific conductivity

# Soil profile for bulk-blended lime.


40

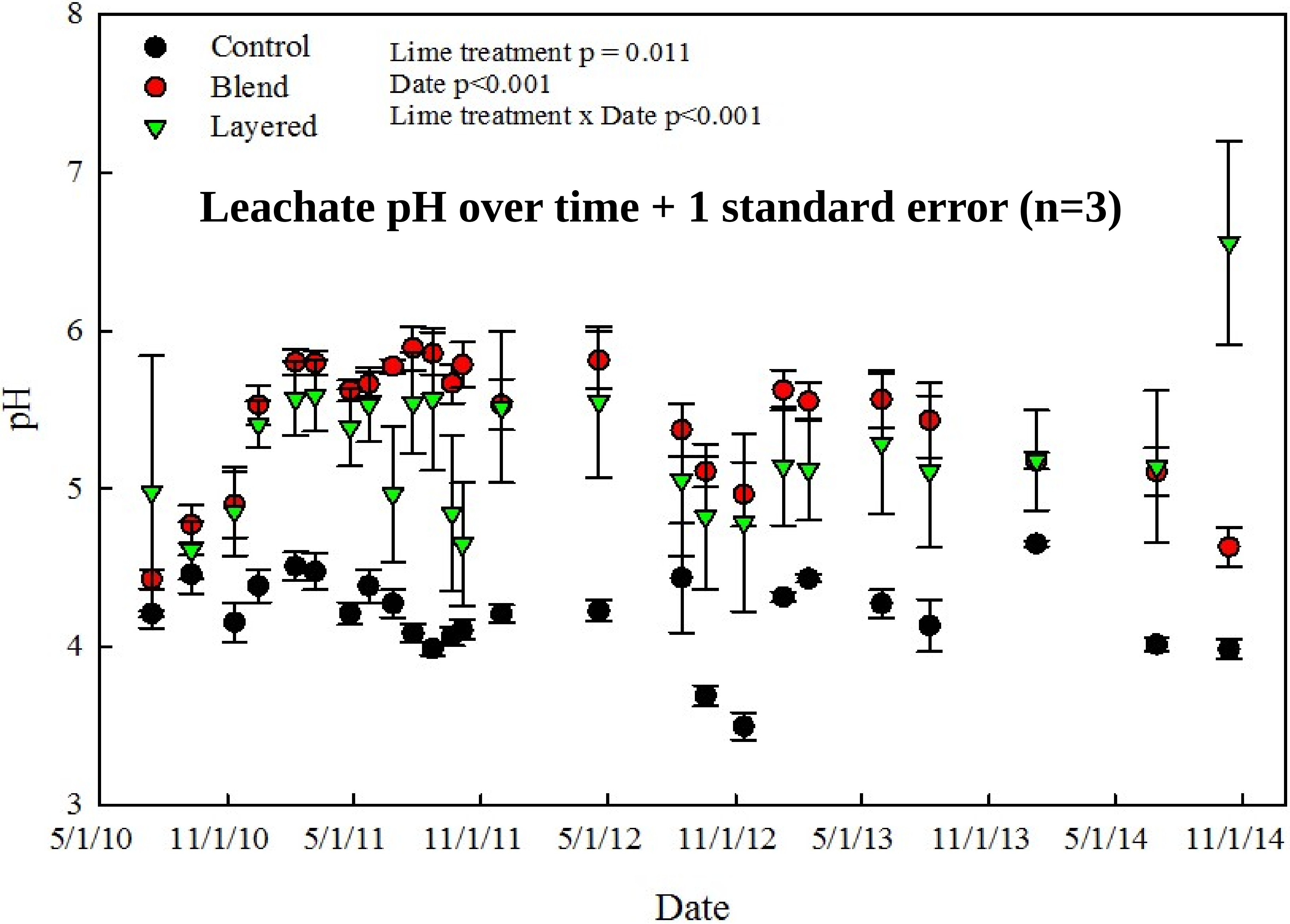
# BULK BLEND LIME

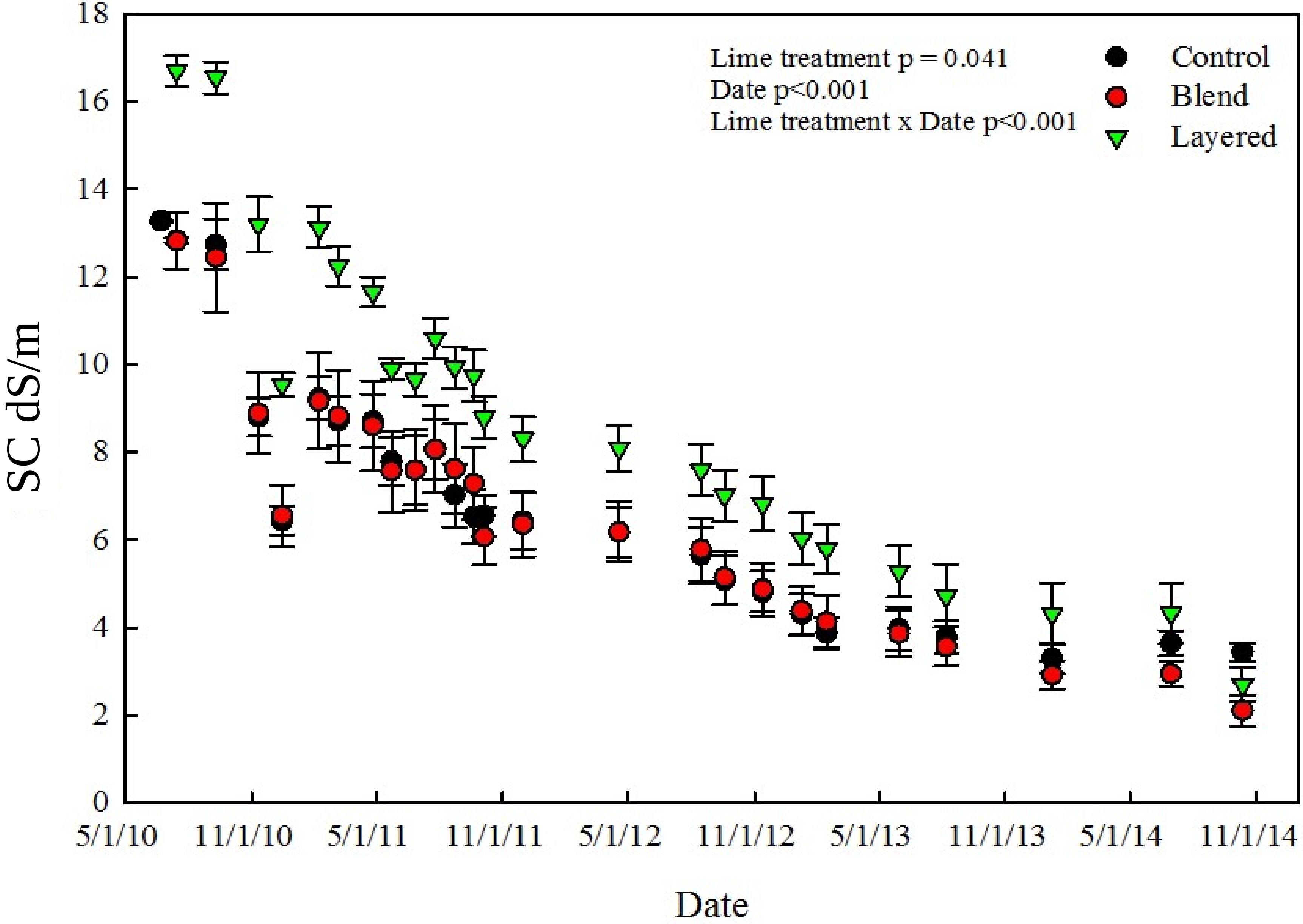

| Horizon + depth | pH | PPA[1] | S | NP[2] | SC[3] |
|---|---|---|---|---|---|
| cm | | | % | % | dS/m |
| ^Ap 0 – 12 | 7.58 | 0.00 | 0.39 | 1.81 | 2.66 |
| ^Cseu 12 – 64 | 4.04 | 2.32 | 0.89 | 0.01 | 2.80 |
| ^C 64 – 88 | 4.67 | 1.39 | 0.72 | 0.47 | 2.86 |

[1]PPA - peroxide potential acidity; [2]NP = neutralization potential; [3]SC – specific conductivity

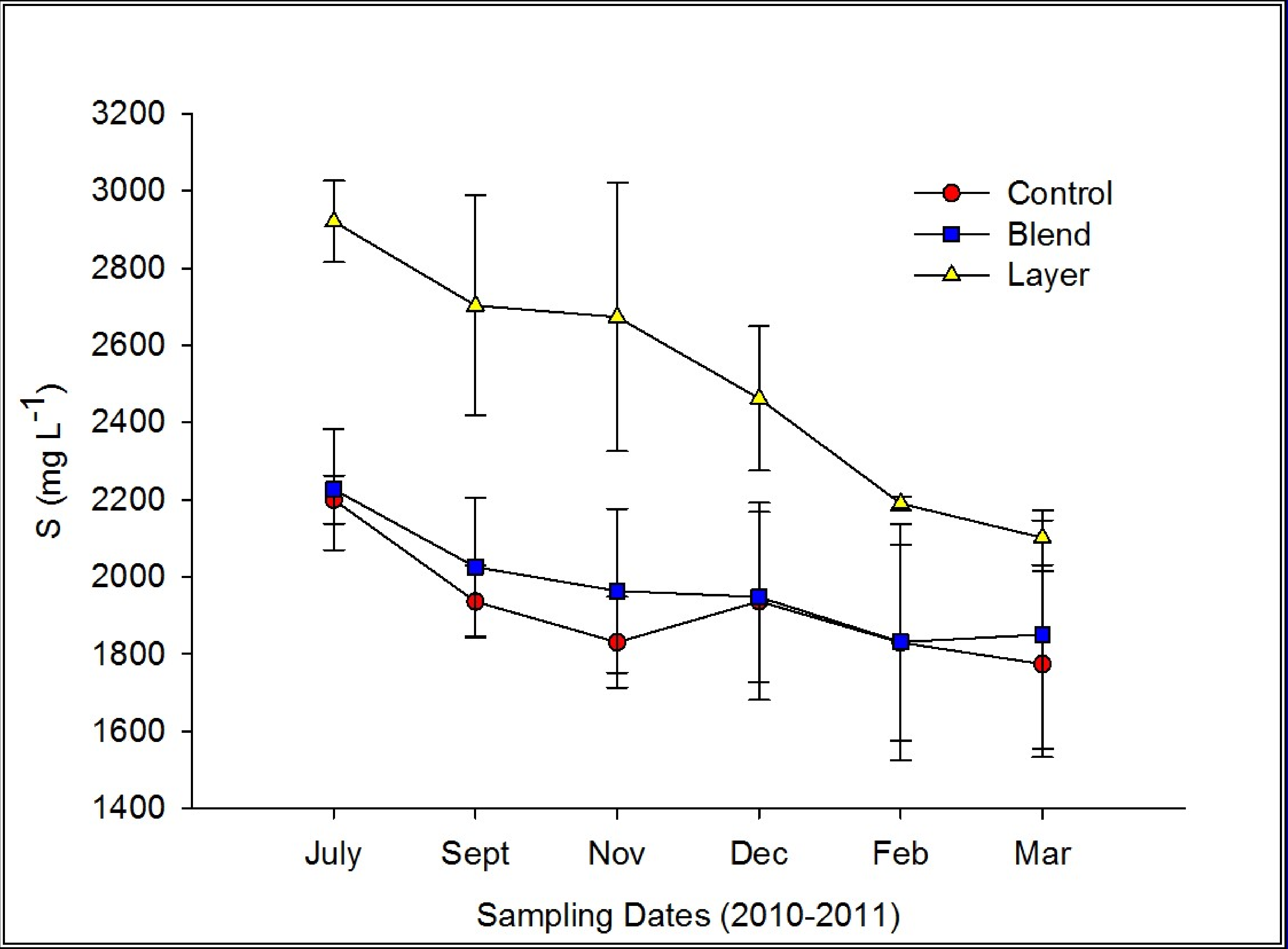
| | DEPTH | CONTROL | LAYERED | BULK BLEND |
|---|---|---|---|---|
| pH | surface | 3.82 | 6.83 | 7.58 |
| | mid | 3.66 | 6.52 – 4.22 | 4.04 |
| | bottom | 7.92 | 4.89 | 4.67 |
| %S | surface | 0.60 | 0.79 | 0.38 |
| | mid | 0.73 | 0.48 – 0.75 | 0.89 |
| | bottom | 1.21 | 1.19 | 0.72 |
| NP | surface | 0.16 | 0.99 | 1.81 |
| | mid | 0.00 | 0.78 – 0 .11 | 0.01 |
| | bottom | 1.21 | 0.52 | 0.47 |

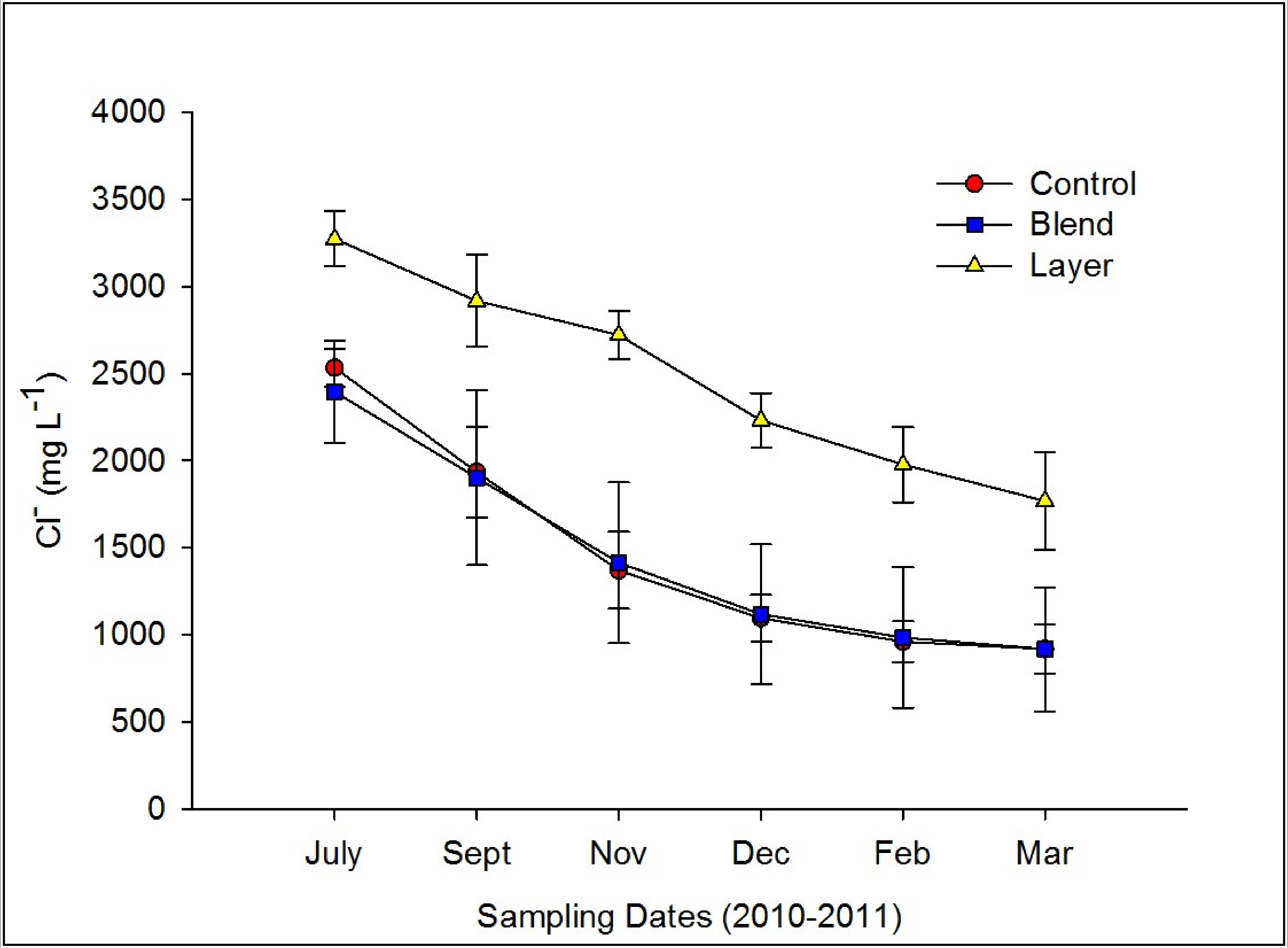
# Figs. From Koropchak et al. 2015 - JEQ



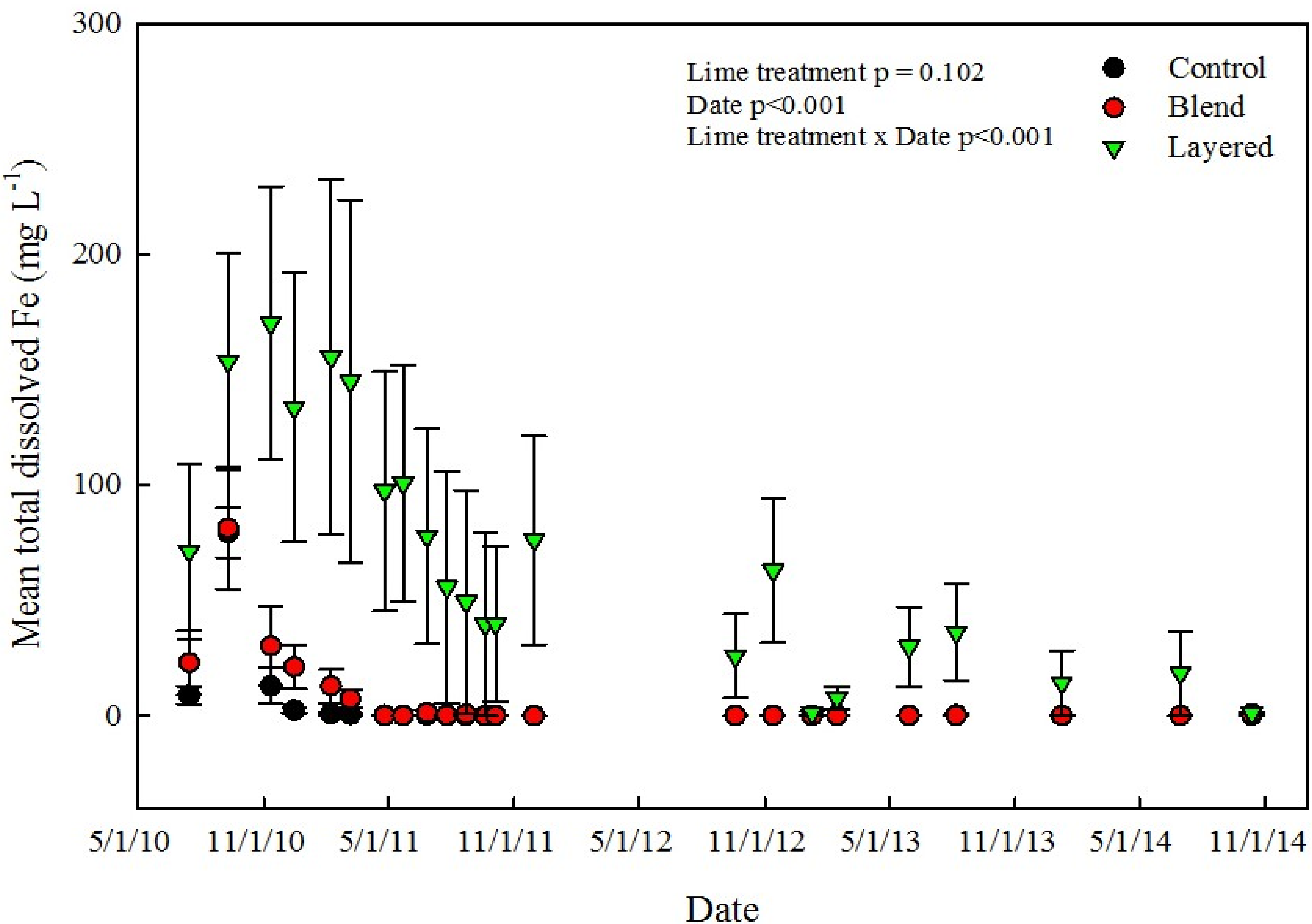


SC dS/m
Date
Lime treatment p = 0.041
Date p<0.001
Lime treatment x Date p<0.001
Control
Blend
Layered
0
2
4
6
8
10
12
14
16
18
5/1/10
11/1/10
5/1/11
11/1/11
5/1/12
11/1/12
5/1/13
11/1/13
5/1/14
11/1/14

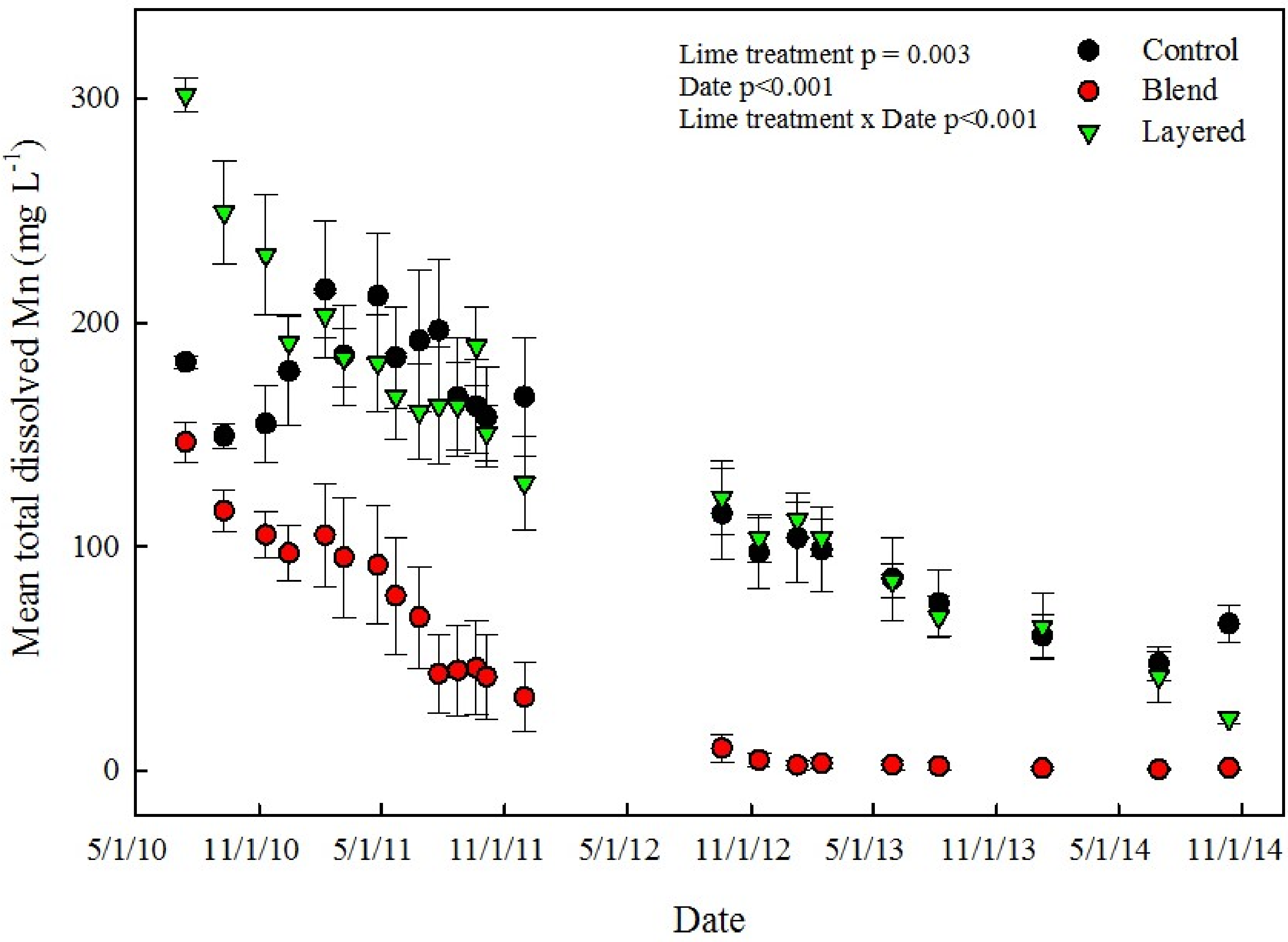

3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
S (mg L-1)
Control
Blend
Layer
July
Sept
Nov
Dec
Feb
Mar
Sampling Dates (2010-2011)



4000
3500
3000
2500
2000
1500
1000
500
0
Cl⁻ (mg L⁻¹)
Control
Blend
Layer
July
Sept
Nov
Dec
Feb
Mar
Sampling Dates (2010-2011)



Mean total dissolved Fe (mg L$^{-1}$)
300
200
100
0
Lime treatment p = 0.102
Date p<0.001
Lime treatment x Date p<0.001
Control
Blend
Layered
5/1/10
11/1/10
5/1/11
11/1/11
5/1/12
11/1/12
5/1/13
11/1/13
5/1/14
11/1/14
Date



Lime treatment p = 0.003
Date p<0.001
Lime treatment x Date p<0.001
Control
Blend
Layered
Mean total dissolved Mn (mg L-1)
300
200
100
0
5/1/10
11/1/10
5/1/11
11/1/11
5/1/12
11/1/12
5/1/13
11/1/13
5/1/14
11/1/14
Date

# Vegetation Response

**The plots were seeded (Fall of 2010) to *Eragrostis curvula* (weeping lovegrass), *Festuca arundinacea* "bronson" (tall fescue), *Festuca brevipila* "stonehenge" (hard fescue), *Lotus corniculatus* "norecen" (birdsfoot trefoil), *Lespedeza cuneata* (Korean lespedeza), and *Secale cereale* (cereal rye).**

**This initial seeding attempt and a subsequent effort in the fall of 2011 both failed to produce > 20% cover on any of the plots. Another lime (@ 10 Mg ha$^{-1}$) dose was added to the surface of the two lime treatments in spring of 2012 and those plots finally supported ~70% mixed vegetative cover by the fall of 2013.**

**The control plots remained barren through late 2014, but by the summer of 2015 had begun to support a limited cover (~15%) of plants like weeping lovegrass invading from adjacent plots.**


July 2010
7/2010
75 ft
1994
Imagery Date: 7/3/2010
April 2011
4/2011
Image © 2016 Commonwealth of Virginia
75 ft
1994
Imagery Date: 1/31/2011
Oct 2012
10/2012
75 ft
1994
Imagery Date: 10/21/2012
Oct 2014
10/2014
1994
2016
75 ft
1994
Imagery Date: 10/8/2014

# CONCLUSIONS

**Collectively, our experience with managing these materials in an upland environment indicates they will be limited by our ability to accurately predict liming needs and by their local ground- and surface water impacts.**

**For this material (MPA saline dredge) the PPA technique for estimating potential acidity was superior to a more conventional acid-base-accounting technique based on Total-S and CCE determinations. However, neither adequately predicted the nature of the acid release over time.**

# CONCLUSIONS

**The exact nature of the phytotoxicity was not directly determined, but we assume that is was due to a combination of (a) very high levels of soluble salts the first two seasons combined with (b) high soil heat levels due to the black color of the exposed surface materials.**

**Overall results continue to support excluding materials > 10 Mg /1000 Mg net potential acidity.**


**We deeply appreciate the support of**
**Charles Carter (Shirley/Weanack)**
**Chee Saunders (Marshall Miller/Cardno)**
**Rich Whittecar (Old Dominion University)**
**in these efforts over time.**