Ensuring Soil Quality and Function in Wetland Creation and Restoration Efforts

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and many more from many places!

CSES Crop & Soil Environmental Sciences

VirginiaTech 1872 VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

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Hydric Soils and Wetland Creation

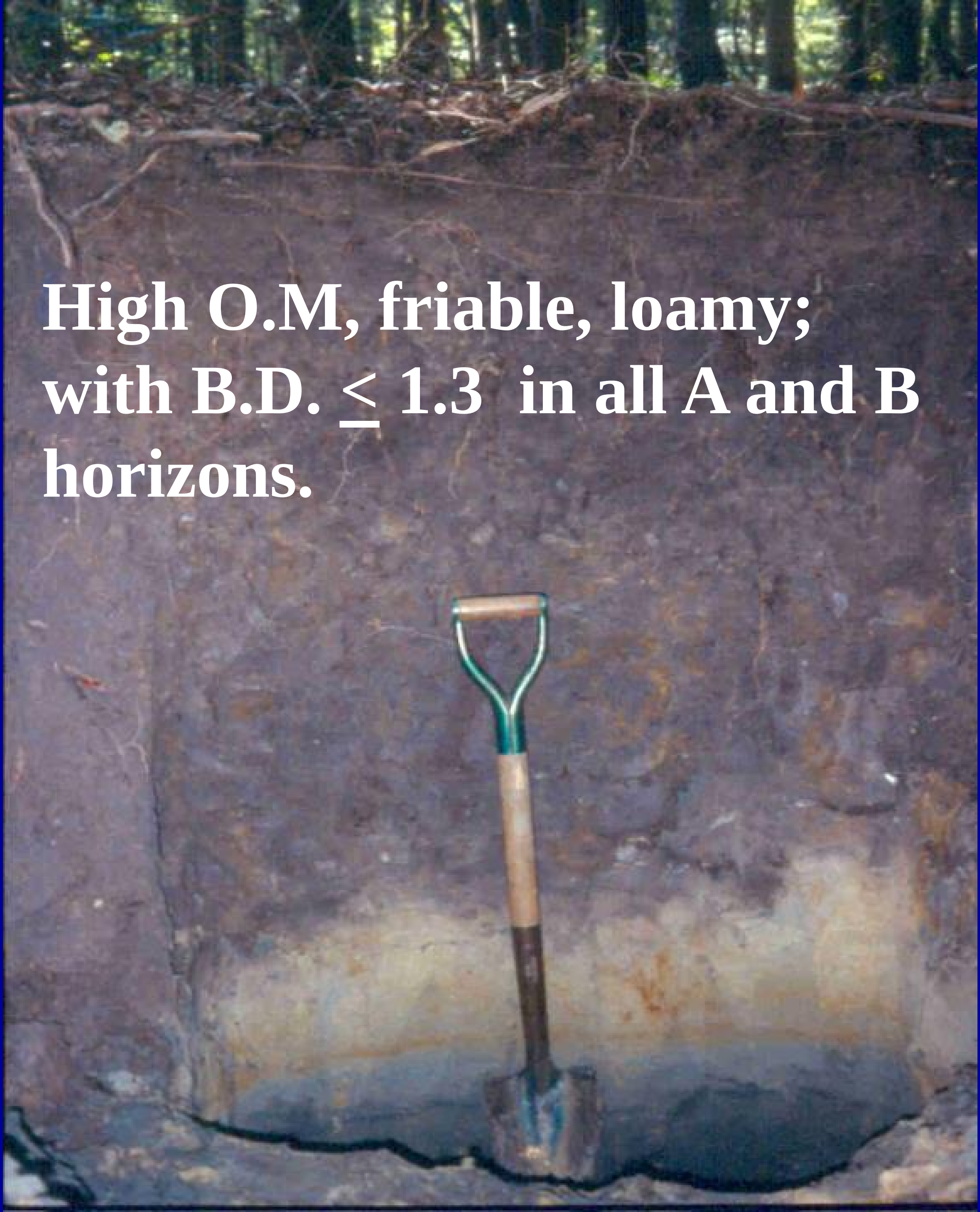
- **The definition of a hydric soil is:** ***a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.*** **https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/hydric/?cid=nrcs142p2_053961**

- ***Presumably,*** **hydric soils** ***are developing*** **in wetland creation and restoration sites and are providing or supplementing numerous functions, including:**
  - **N removal via denitrification and plant uptake**
  - **P removal via sedimentation, plant uptake, etc.**
  - **C sequestration via net OM accumulation**
  - **Habitat provision for wetland flora, fauna, microbes, etc.**
  - **This *necessarily* involve driving soil redox low enough to favor wetland obligates, etc. vs. upland species that want to invade.**

High OM wetland soil at Sandy Bottom Nature Park in Hampton, VA.

The A horizon here is over 30 cm thick. The annual hydroperiod of this soil fluctuates approximately 1.5 m!

This is a mineral flat landscape.



Native hydric soil (Roanoke series) in a Carolina Bay (closed depression) landform. Very high clay, dense in Btg, and acidic.

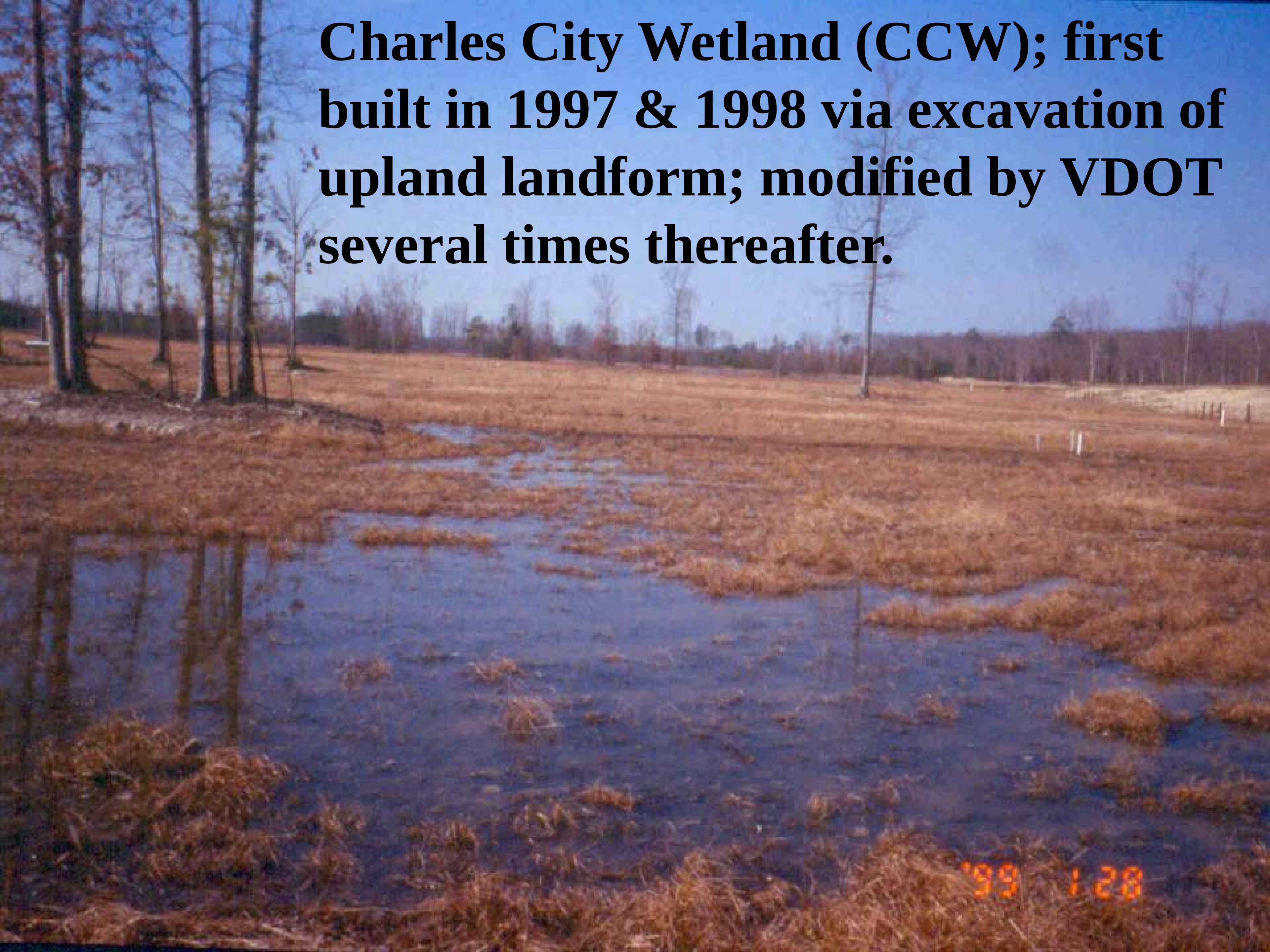
Not all hydric soils are “pretty”!

Spartina sp. tidal marsh vegetation on sound behind barrier island in Maryland.

Sulfidic peaty soil in a tidal marsh (*Sulfihemists*).

Considerable and detailed work on tidal marsh soils has been done by Rabenhorst, Fanning, Stolt and others at the Universities of Maryland and Rhode Island.

Charles City Wetland (CCW); first built in 1997 & 1998 via excavation of upland landform; modified by VDOT several times thereafter.



Surface soil at CCW in 2002 after preliminary "remediation efforts"

Note massive structure in surface breaking to firm plates at about 20 cm.

This directly limits rooting, litter to soil incorporation, subsoil microbial biomass, and therefore redox process and associated development of features!

Common Limitations in Created / Restored Wetland Soils

- Compaction, compaction, compaction!
- Lower soil OM levels than natural sites/soils
- Lack of microtopography
- Degraded soil structure/permeability/rooting
- Higher soil temps when young, leading to higher C loss rates
- Often dissimilar in basic chemical and physical properties than native soils due to cut/fill processes during contstruction

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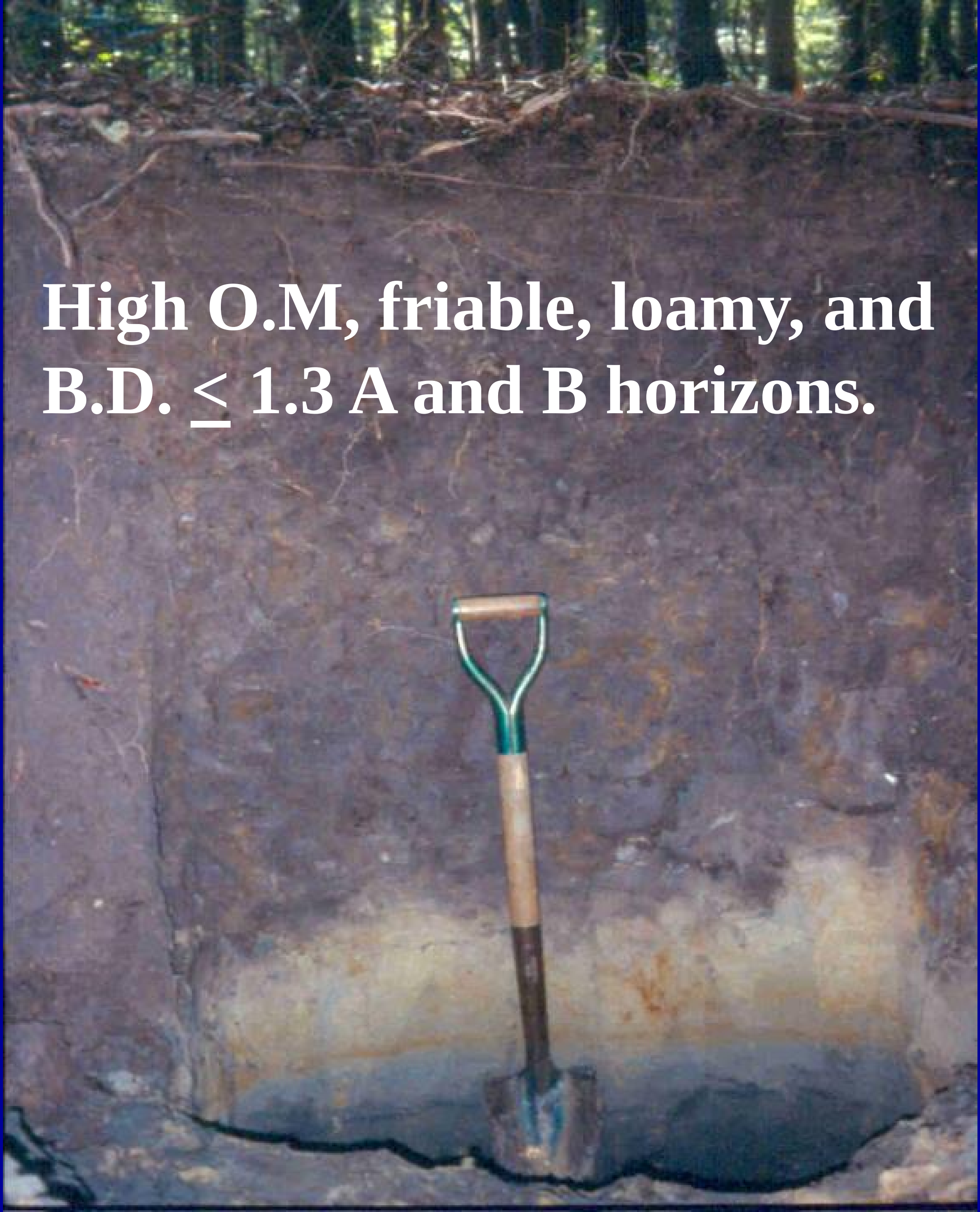
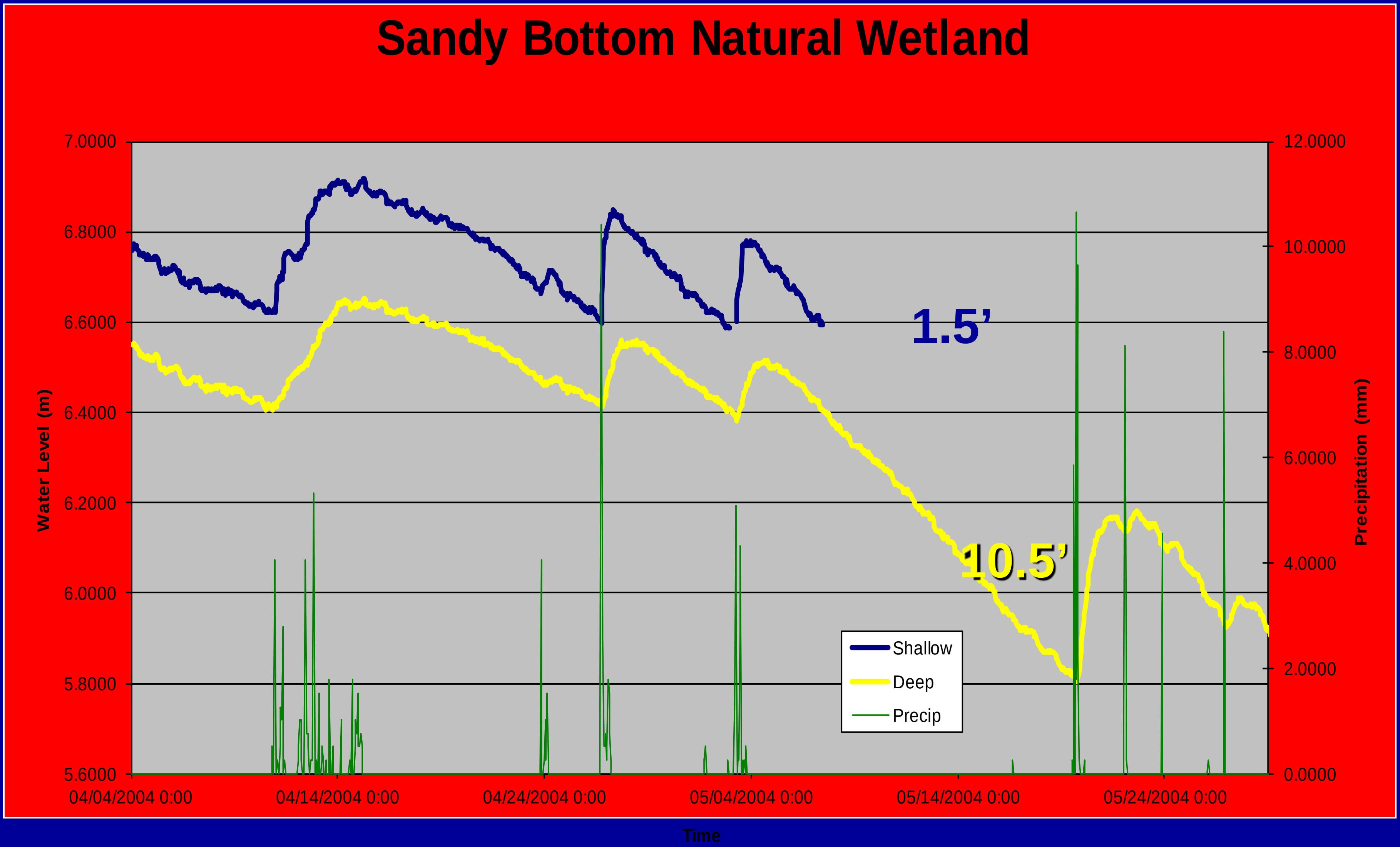
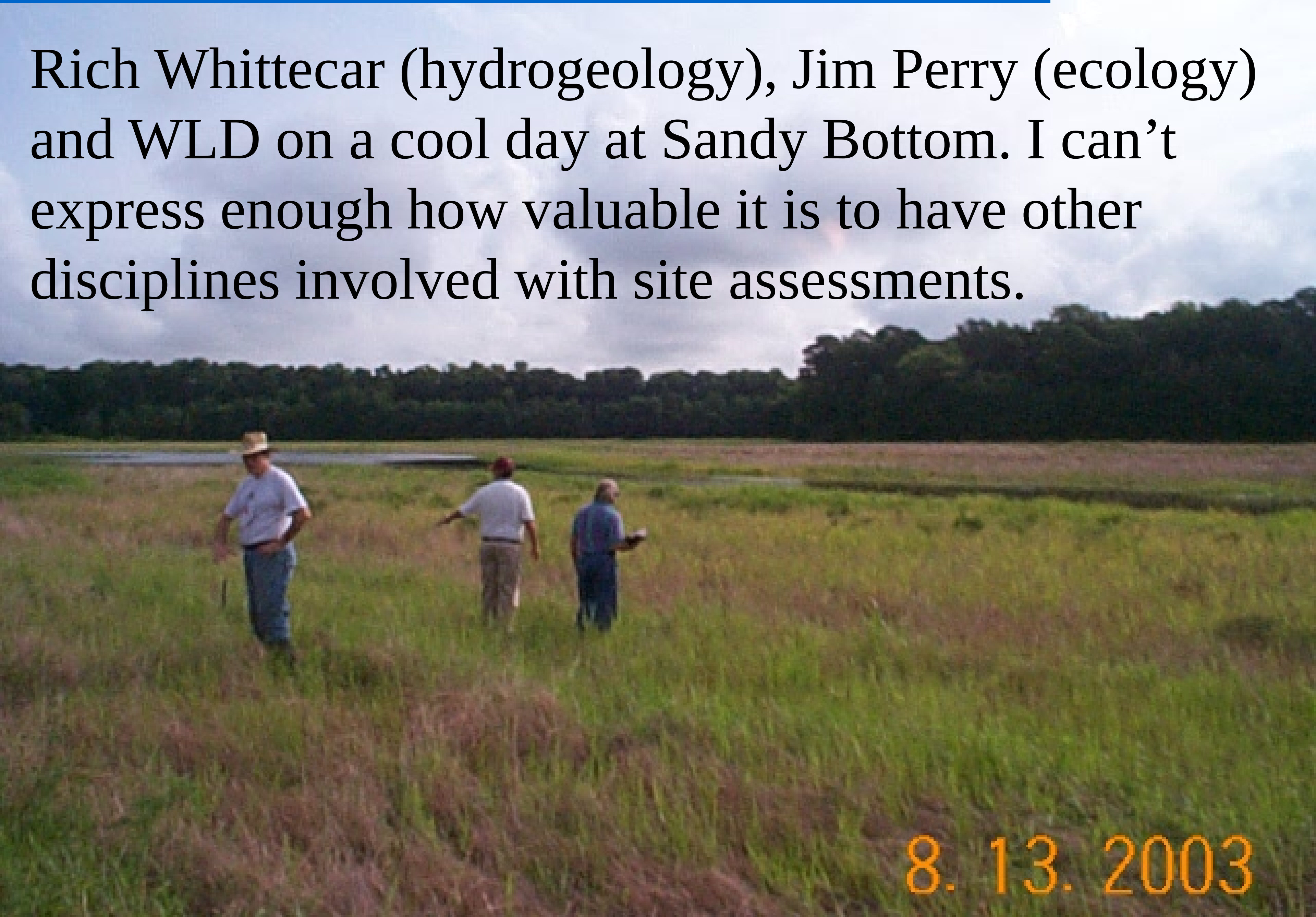




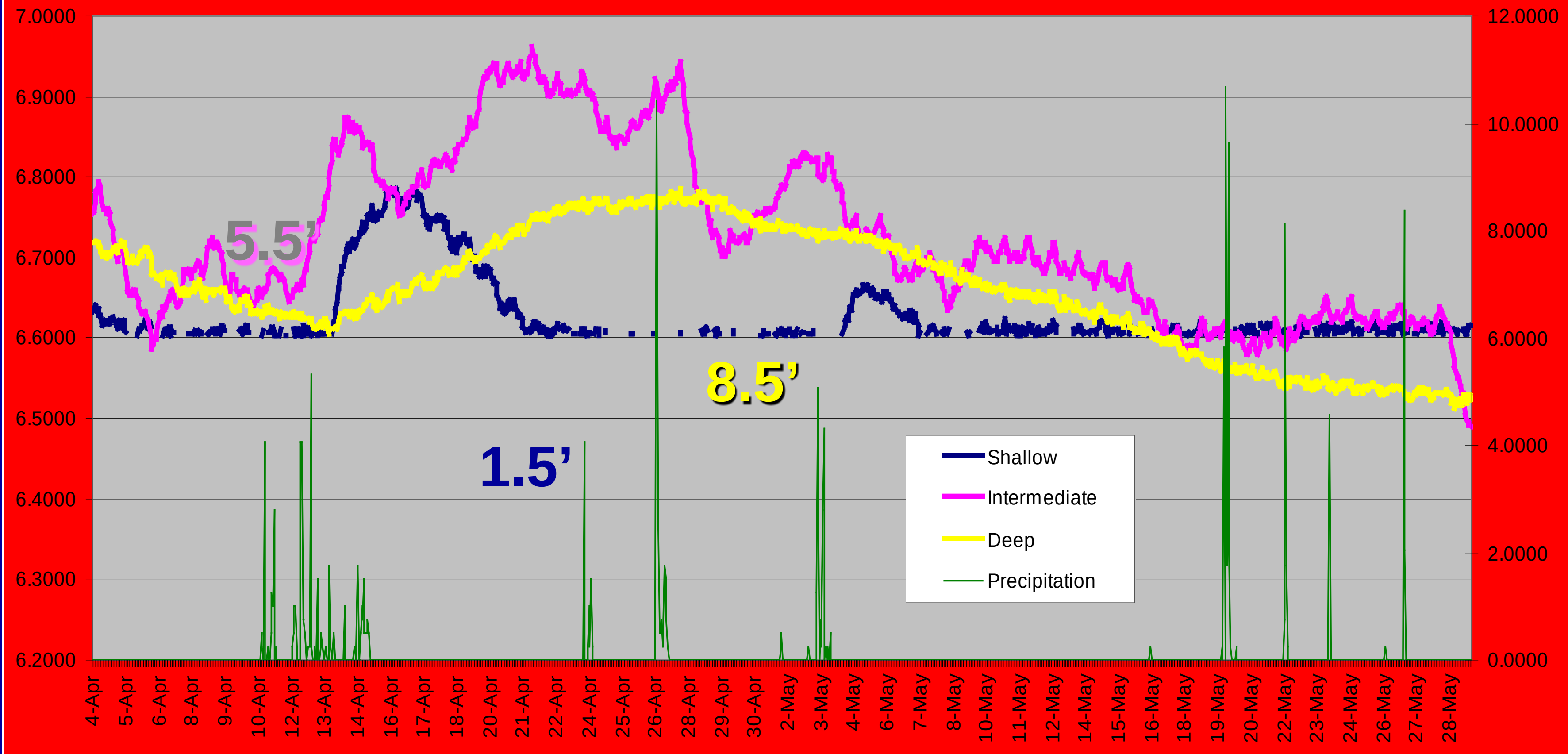
Shows that the two levels being measured are clearly “connected”. Note falling head with depth; indicative of GW recharge locally. Data from DesPres & Whittecar and DesPres M.S. thesis.

Sandy Bottom Wetland

Rich Whittecar (hydrogeology), Jim Perry (ecology) and WLD on a cool day at Sandy Bottom. I can’t express enough how valuable it is to have other disciplines involved with site assessments.



Sandy Bottom Constructed Wetland

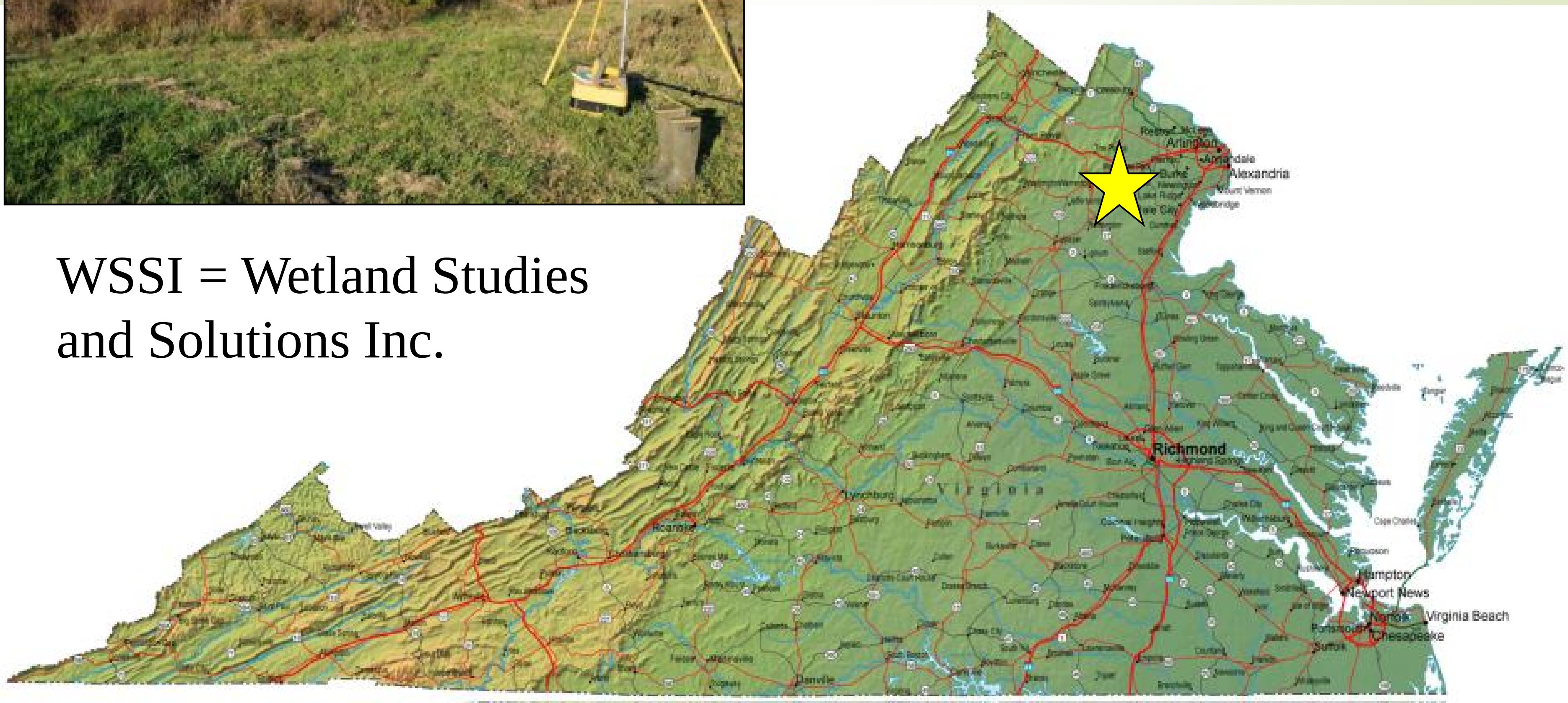


Same site x dates; nested piezometers in created wetland portion.

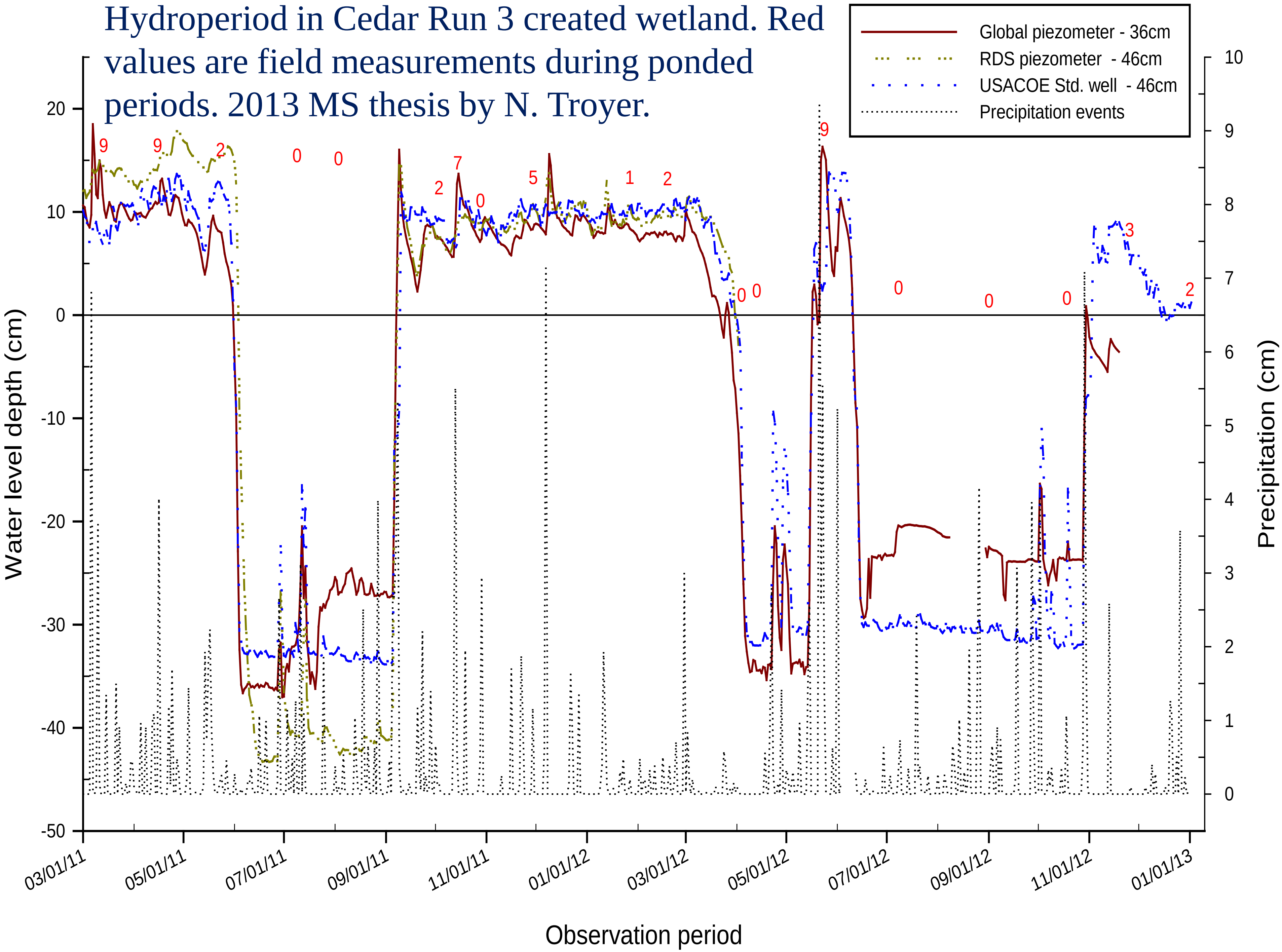
Cedar Run 3 and 4 Wetlands
> 1000 ha created wetlands
in region in Triassic geology

Focus Area of Related VT Projects Sponsored by Piedmont Wetlands Research Program/WSSI. All in N. Virginia Triassic

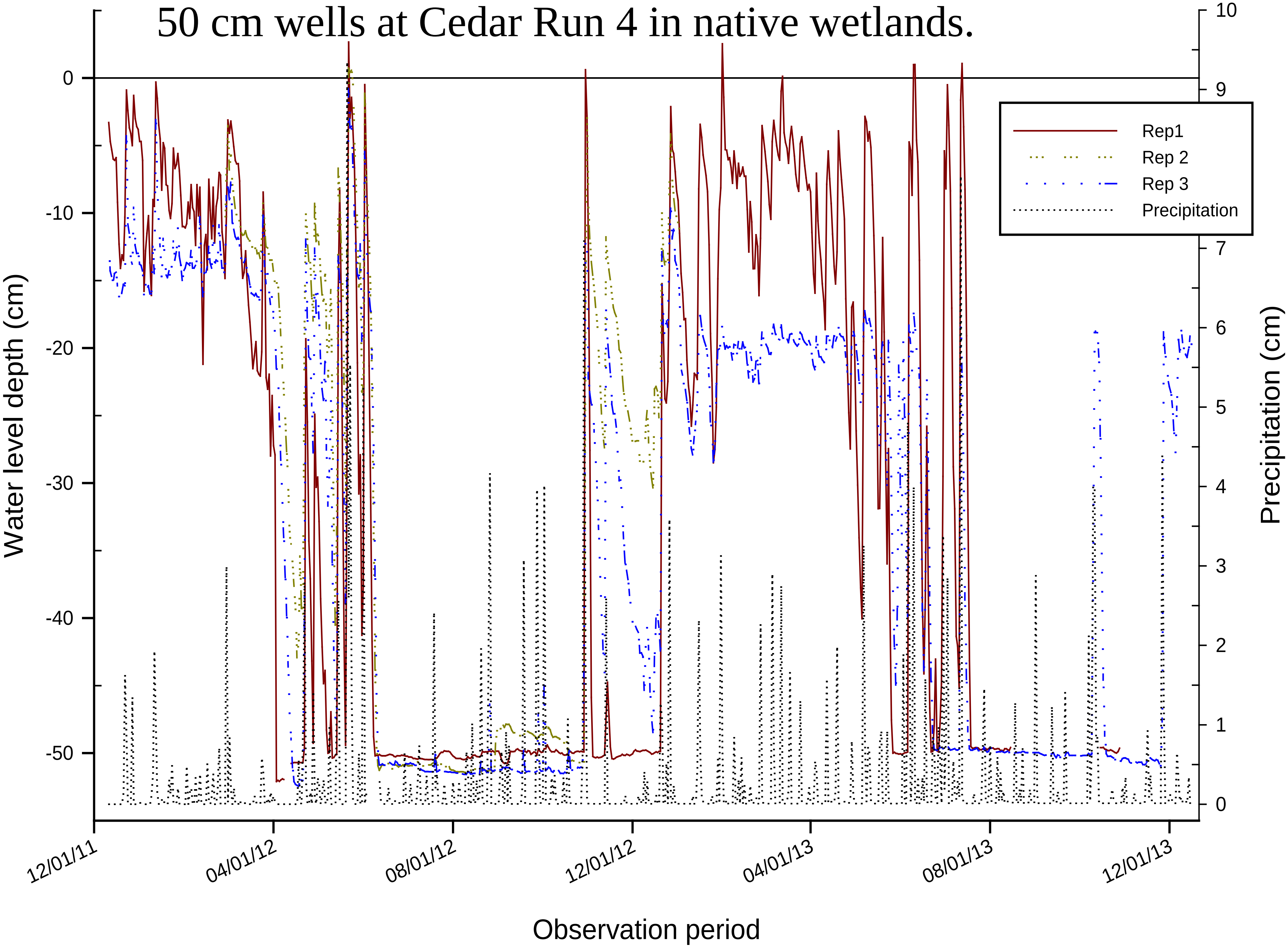
WSSI = Wetland Studies and Solutions Inc.



Hydroperiod in Cedar Run 3 created wetland. Red values are field measurements during ponded periods. 2013 MS thesis by N. Troyer.



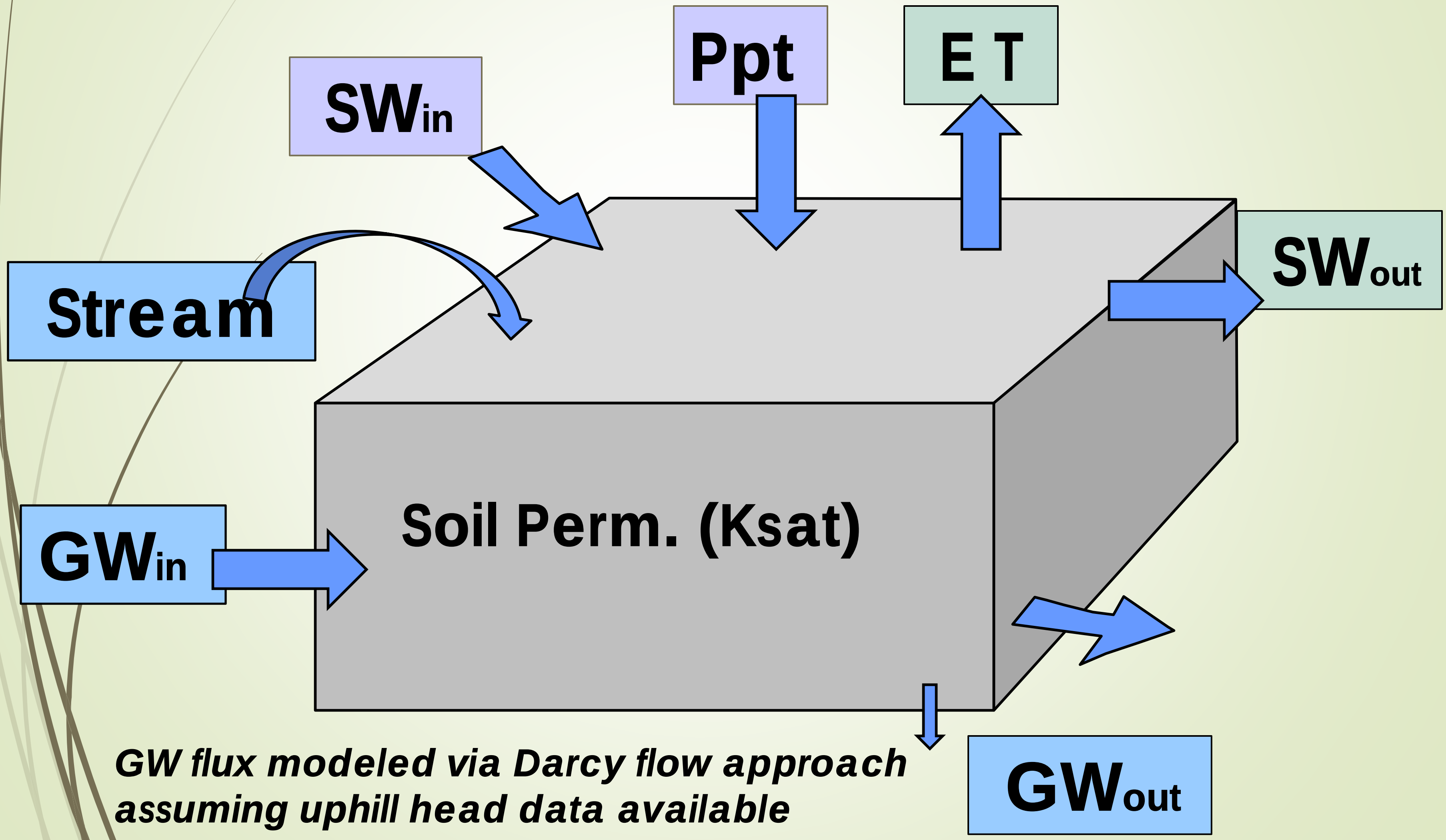
Local landform at Cedar Run 4 location #2. Soils are an intimate mixture of the somewhat poorly drained Rowland Soil Series (*Fine-loamy, mixed, superactive, mesic Fluvaquentic Dystrudepts*) and the poorly drained Bowmansville Soil Series (*Fine-loamy, mixed, active, nonacid, mesic Fluventic Endoaquepts*). Note: Local depressions were not sampled.



50 cm wells at Cedar Run 4 in native wetlands.
Water level depth (cm)
0
-10
-20
-30
-40
-50
Precipitation (cm)
10
9
7
6
5
4
3
2
1
0
Rep1
Rep 2
Rep 3
Precipitation
12/01/11
04/01/12
08/01/12
12/01/12
04/01/13
08/01/13
12/01/13
Observation period

Water Budgeting is Critical!

One option is Wetbud, which is a design tool for wetland creation



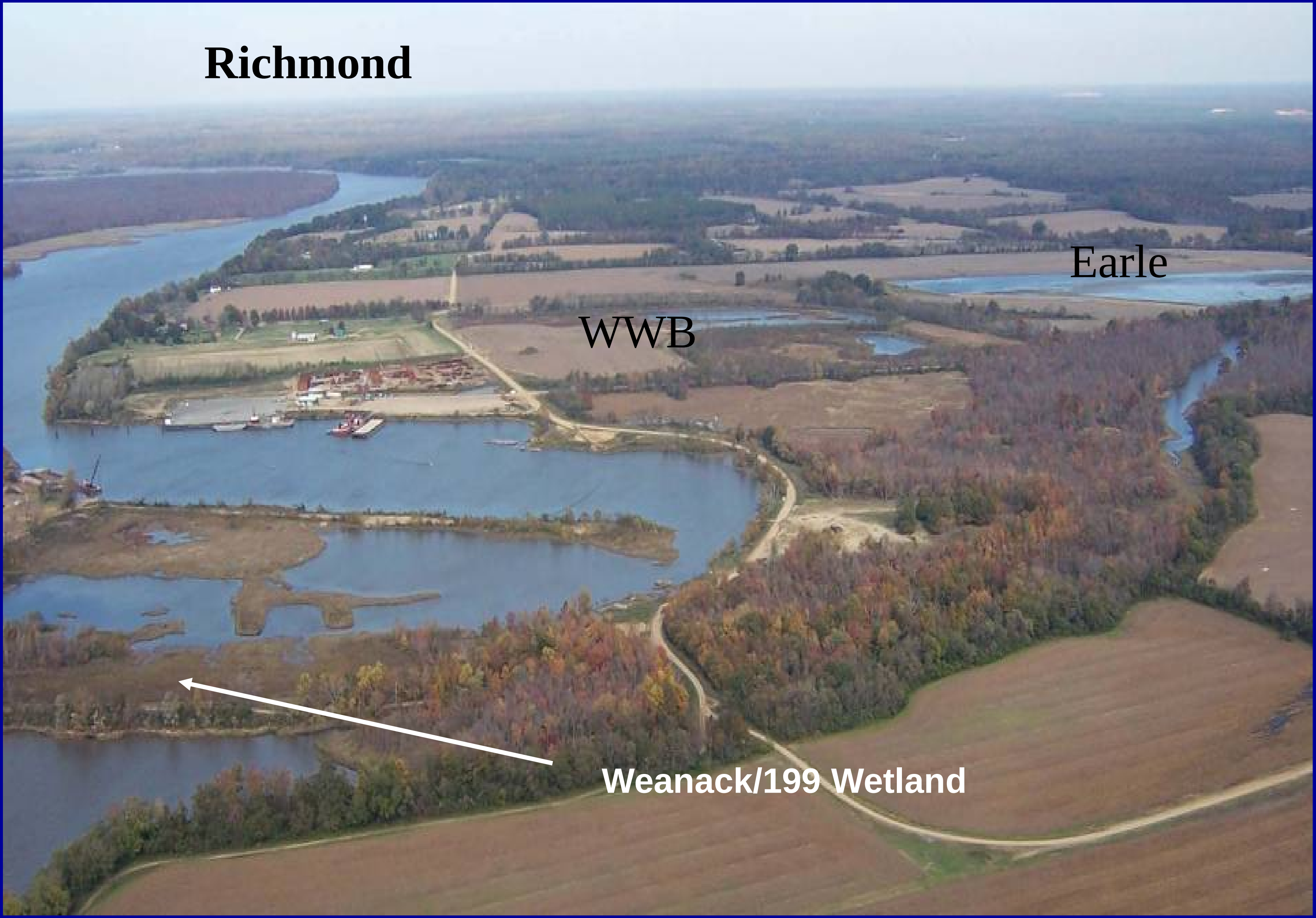
GW flux modeled via Darcy flow approach assuming uphill head data available

Site for Charles City Wetland (CCW) OM Loading rate experiment, first built in 1997 & 1998; modified by VDOT several times thereafter. How do we determine “soil success’?

Effects of Compost amendment on pedogenesis after 3 years

0 Mg/ha rate; Relict redox only **56 Mg/ha (25 T/ac; < 2.5% OM)**

Long term effect of original compost loading (112 Mg/ha – 50 T/ac) at CCW dry experiment – Summer 2015.



Richmond
Earle
WWB
Weanack/199 Wetland

Experimental area graded and flagged. Note uniform brown and oxidized sediment colors across the site.

Experimental area after hummock installation and application of topsoil. Picture shot 3 hours after adjacent high tide.

Distinct redox concentrations and depletions (F3; depleted matrix) formed in replaced upland topsoil within three years. Also note distinct band of concentrations at topsoil/sand contact.

Photo from 2009 of high compost addition treatment vs. original soil from berm. Soils in the creation site were evaluated for color and were similar.

Image of control plot soil (sand; fertilizer only) taken 11/8/15 – 10 years old. Note significant accumulation of OM in surface and low chroma below.

Detailed study by Emily Ott (PhD student) & John Galbraith is ongoing.

Bald cypress in pit (left) vs. mound (right).
Note other woody stems invading.

Avoid sulfidic materials at all costs! Mattaponi Wetland; bare ground in rear was pH 3.1 as is the wetland floor when it dries down in the summer. Around 25% of VDOT Coastal Plain sites hit sulfidic materials which will then require high liming rates, etc.

So, how do I determine "hydric soil success"?

- Learn how to accurately and completely describe soil morphology, particularly redox features!
- Carefully describe soil morphology (a) before any site disturbance and then (b) immediately after final creation/restoration. Quantify/count redox feature abundance; don't simply place them into classes (e.g. few vs. many).
- At a pre-determined interval (e.g. 1, 3 and 5 yr?), conduct follow-up soil descriptions on "mini-pits" excavated to 30 cm+ and carefully quantify color, redox feature abundance, etc.
- If the soil is "moving in the right direction", you should be able to detect and quantify (a) development of lower overall chroma and (b) increased redox concentrations, pore linings, or other features.