Hydrology of Clay Settling Areas and Surrounding Landscapes in the Phosphate Mining District, Peninsular Florida

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Clay Settling Areas (CSAs)

- ~75% of nation's phosphate is mined in Florida
- Ore body is ⅓ clay-sized sediments
- Clay waste disposed of in CSAs, which are above-grade, rectangular reservoirs
- Clay remains saturated for decades
- Cover ~40% of the mined landscape (~50,000 ha. in 1998; ~70,000 ha. at build-out)
- Unknown water-resources consequences

Wetlands on CSAs[1]

- Differential settling and clay-rich deposits create inundated local topographic lows
- Wetlands occupy substantial portions of local topographic lows
- Depressional wetlands predominate
- Floristically simple, with little recruitment of *Taxodium distichum* and *Nyssa aquatica*
- Are they isolated?

[1] *Brown et al. (2010), FIPR Pub. No. 03-149-238*

Hypothesis

Surface and/or subsurface flows connect uplands and wetlands on CSAs and to the surrounding hydrological landscapes.

Ft. Meade CSA A

- Located on the Ft. Meade North Mine in Polk County
- Constructed ~20 years ago
- ~75 hectares in area and ~6 m in height
- Located on unmined land
- Slope trends N-S, slumping toward the SW corner
- Subsidence and collapse have isolated the outfall pipe
- Complex deposits and flow systems….

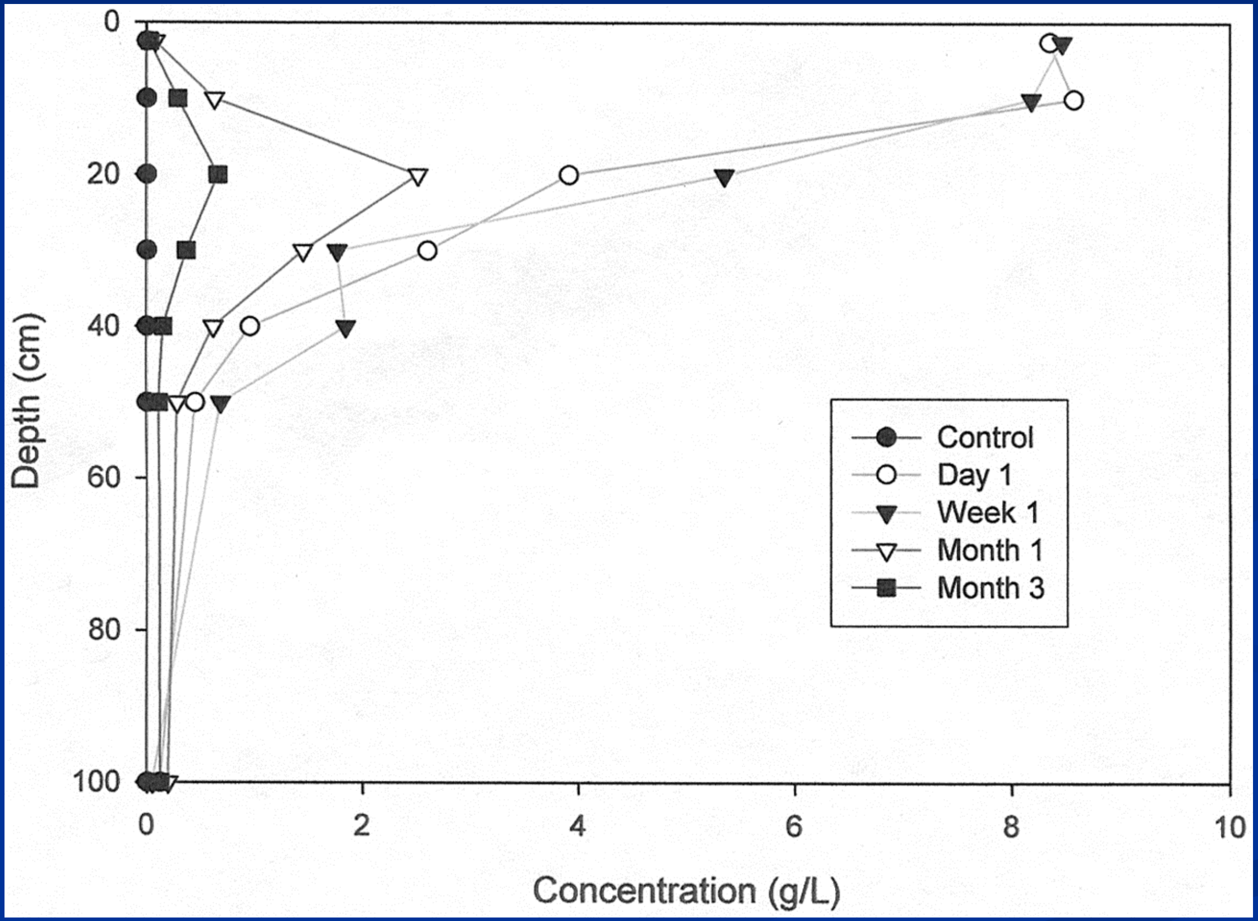
CSA Deposits

Well-developed, subangular-blocky, clay-rich surface layer with desiccation cracks and other macropores ~0.5 m in depth

Massive, clay-rich sublayer saturated below ~1.0-2.5 m ($K_{sat} = 10^{-5}$-10^{-7} m/d)

Vertical Tracer Test

Vertical Tracer Test Results

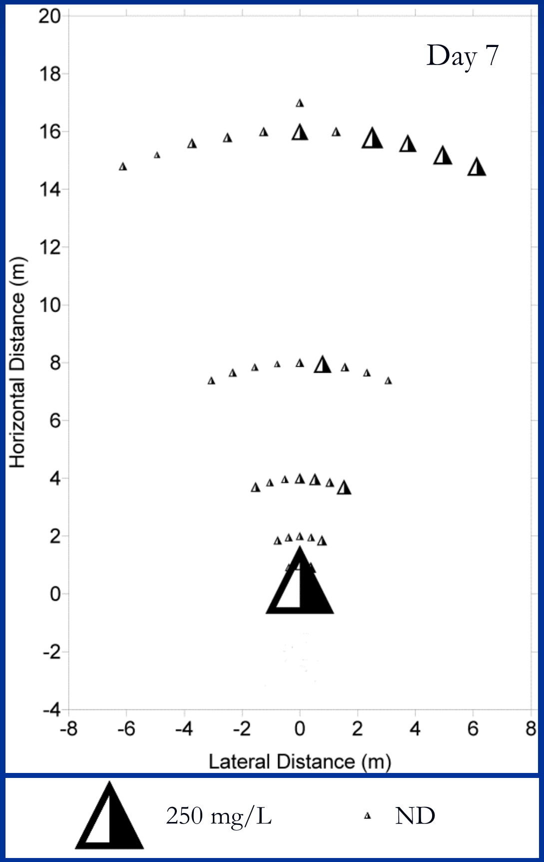


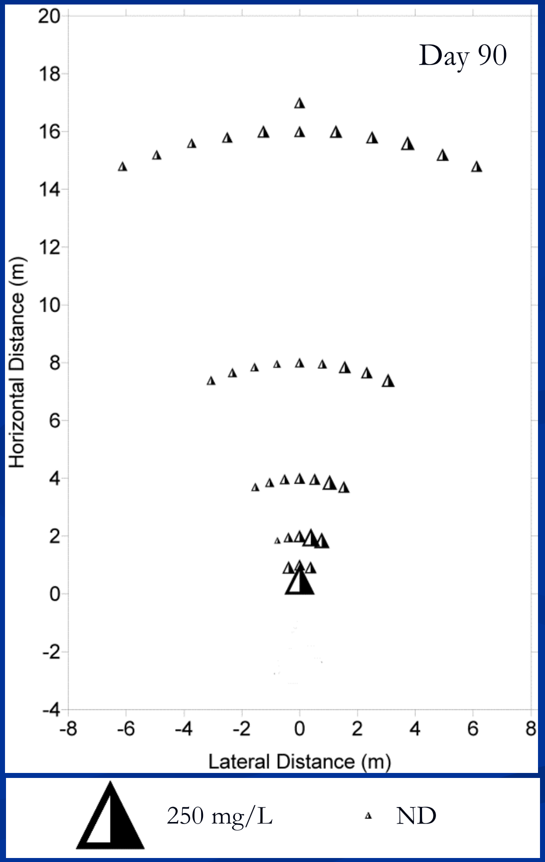
Horizontal Tracer Test

Horizontal Tracer Test

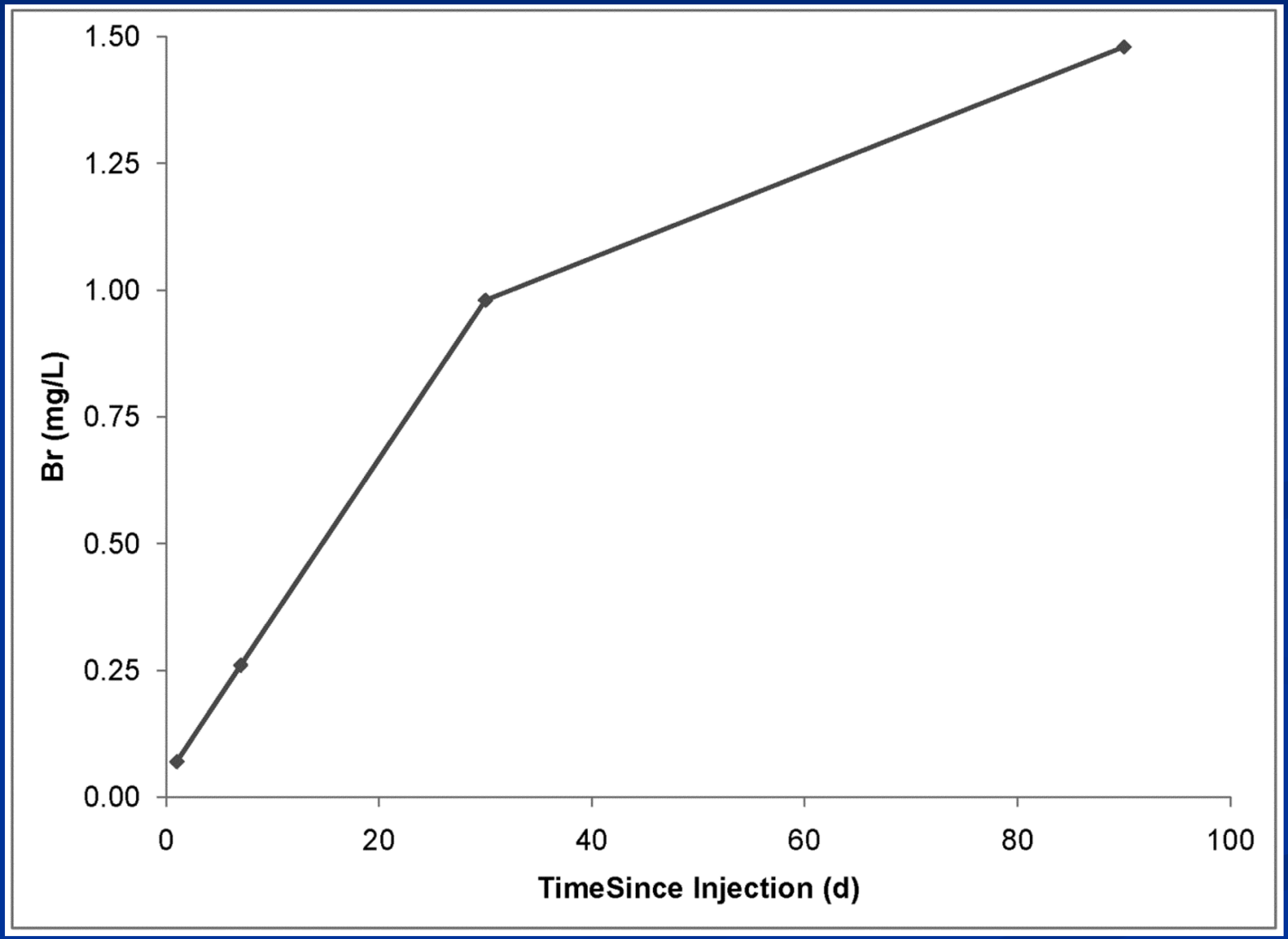
Total Time = 12 minutes!!

Horizontal Tracer Test Results – Fan & Receiving Wetland



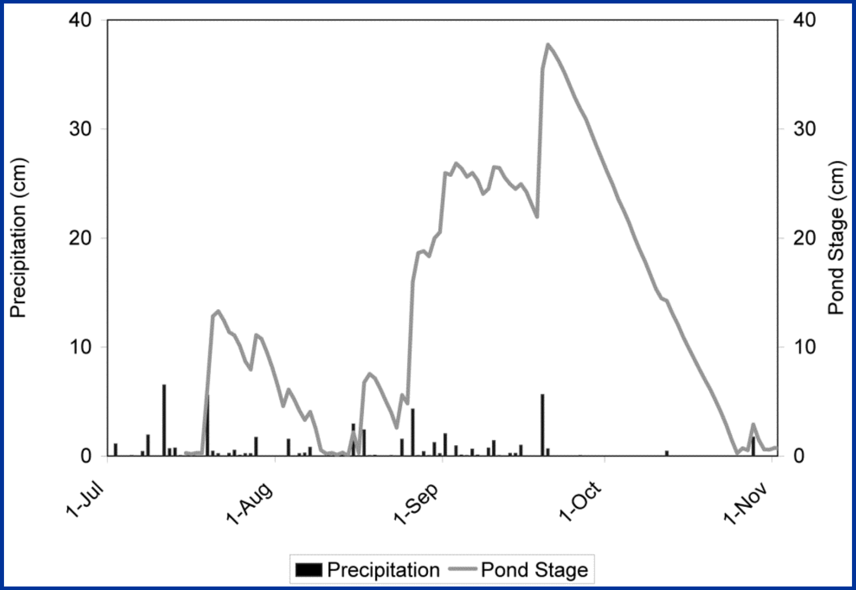


Horizontal Tracer Test Results – Receiving Wetland

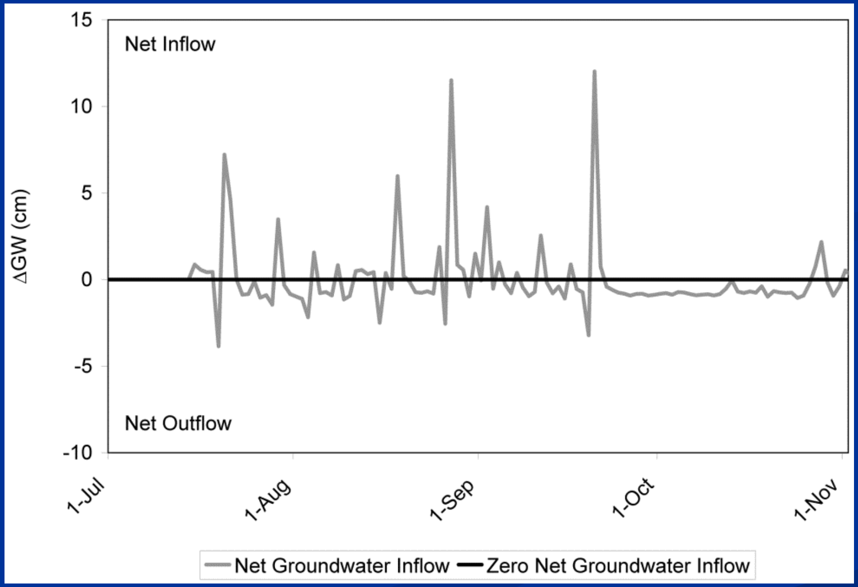


Physical Hydrology of the Receiving Wetland

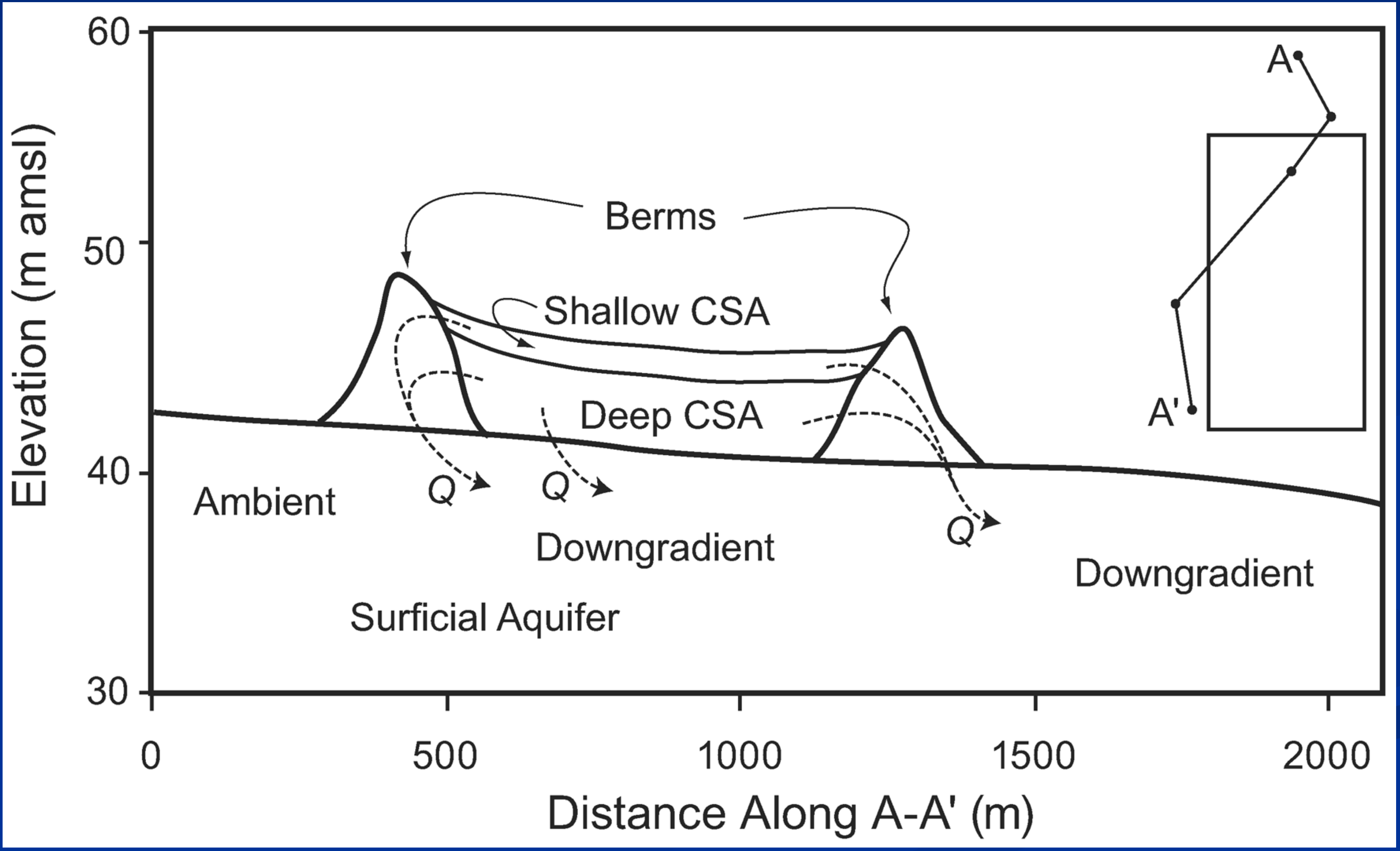
Hyetograph & Hydrograph



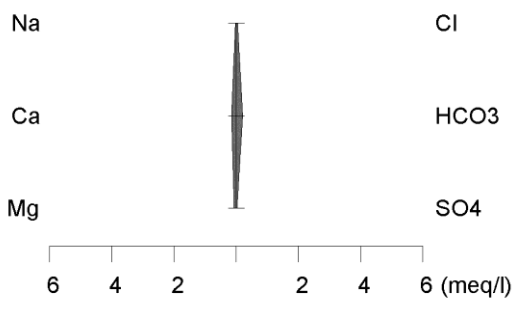
Water Budget Solved for ΔGW



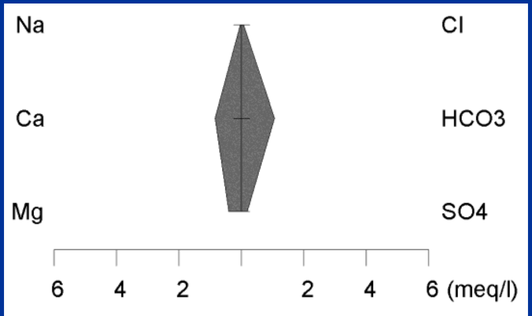
Conceptual Model & Hypothesized Flowpaths



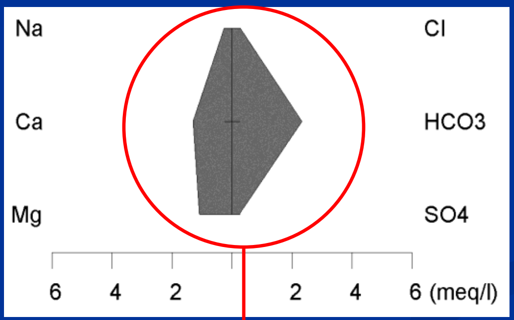
Chemical Signatures of Water



Rainfall

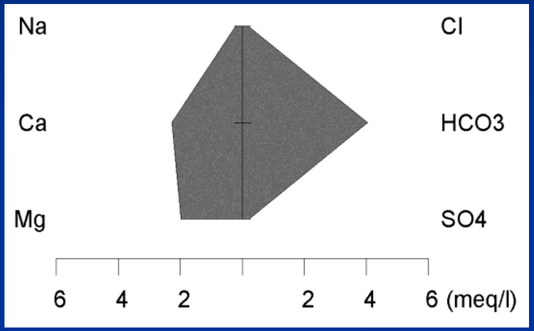


Ambient

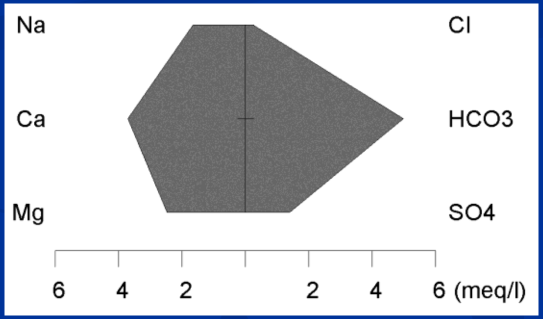


Downgradient

Is downgradient water a mix of rainfall/ambient water and shallow/deep CSA water?



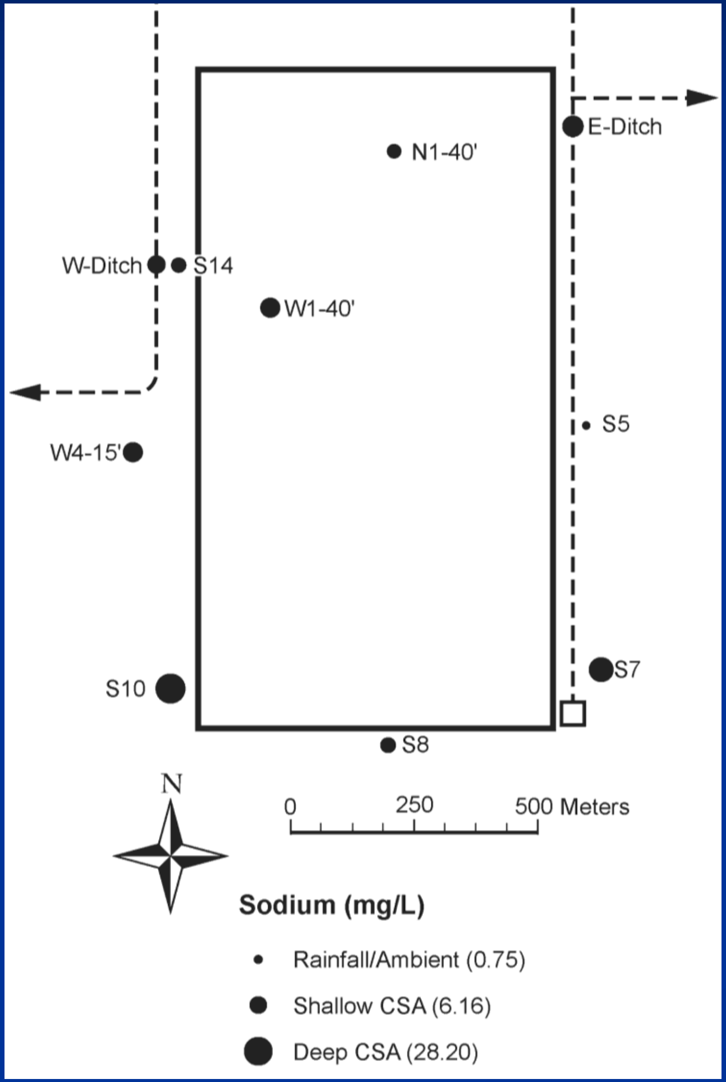
Shallow CSA

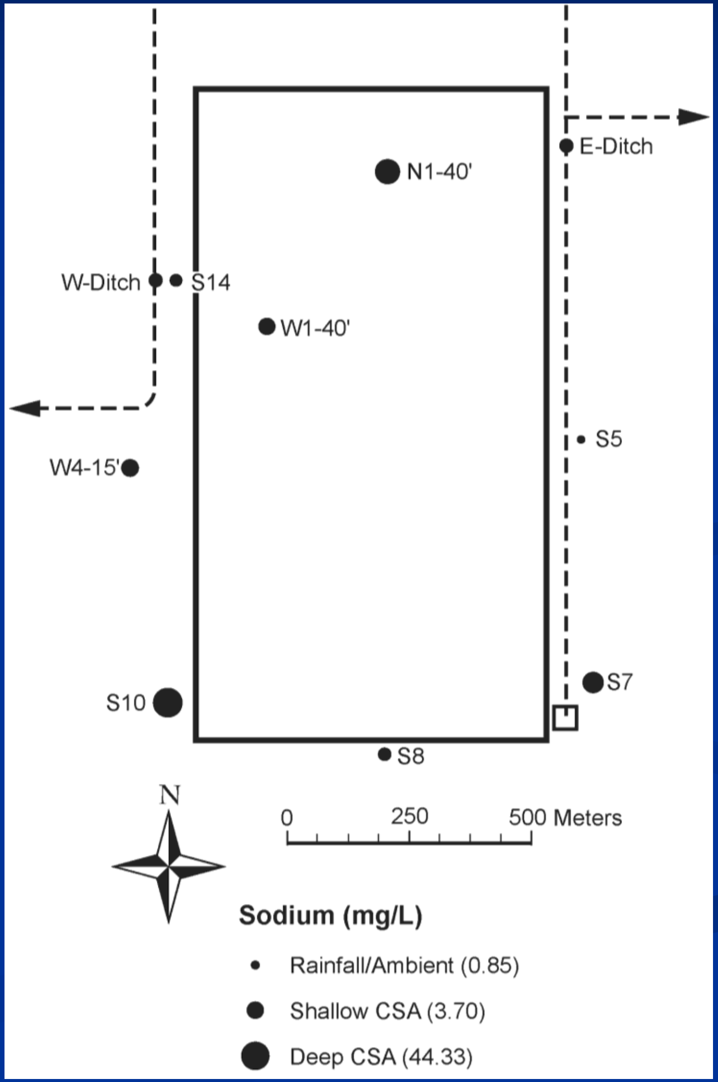


Deep CSA

Natural Tracer Results

Dry Season





Wet Season

Mass-Balance Mixing Model

$$Na_{DG} = f_{RA}Na_{RA} + f_{SCSA}Na_{SCSA} + f_{DCSA}Na_{DCSA}$$

$$f_{RA} + f_{SCSA} + f_{DCSA} = 1$$

where

Na = sodium concentration

f = fractions

RA = rainfall/ambient water

$SCSA$ = shallow CSA water

$DCSA$ = deep CSA water

Two equations with three unknowns, so the solution is mathematically indeterminate and we can only get a range of plausible solutions.

Mass-Balance Mixing Model Results – Downgradient Water Samples

	Rainfall/Ambient Water	Shallow CSA Water	Deep CSA Water
Dry Season	0.23-0.89	0.01-0.71	0.07-0.20
Wet Season	0.17-0.85	0.06-0.74	0.09-0.13

90% of the samples required at least some shallow and/or deep CSA water in all plausible solutions!!

Conclusions

- The CSA supports two flow systems.
  - Upper layer supports rapid, preferential flow through desiccation cracks and other macropores
  - Lower layer supports slow, saturated flow through low-permeability clay matrix (e.g., $K = 10^{-5}$-10^{-7} m/d)
- Wetlands are hydrologically connected on CSAs and to the surrounding hydrological landscapes through surface and/or subsurface flows.
  - Both shallow and deep CSA source waters contribute to downgradient waters.

Thank You!

Questions?

Not My Job