A Physical Model of Flow Reconnection to Achieve Ecological Restoration in the Everglades

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2 USGS science for a changing world

3 National Park Service

4 University of Hawaii

5 FIU Florida International University Miami's public research university

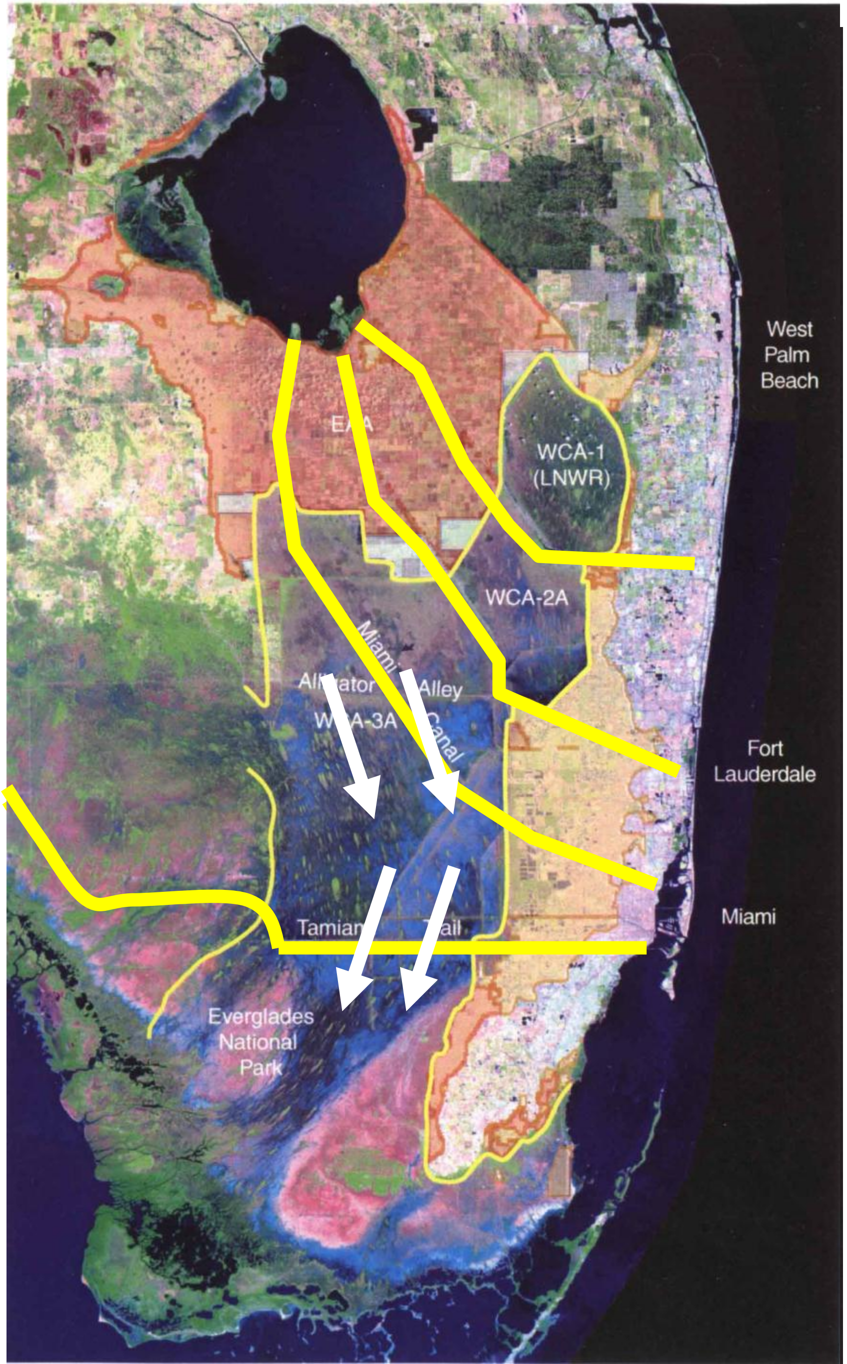
6 FCE LTER

7 US Army Corps of Engineers

1 South Florida Water Management District

International Wetlands Conference (INTECOL)
June 3-8, 2012

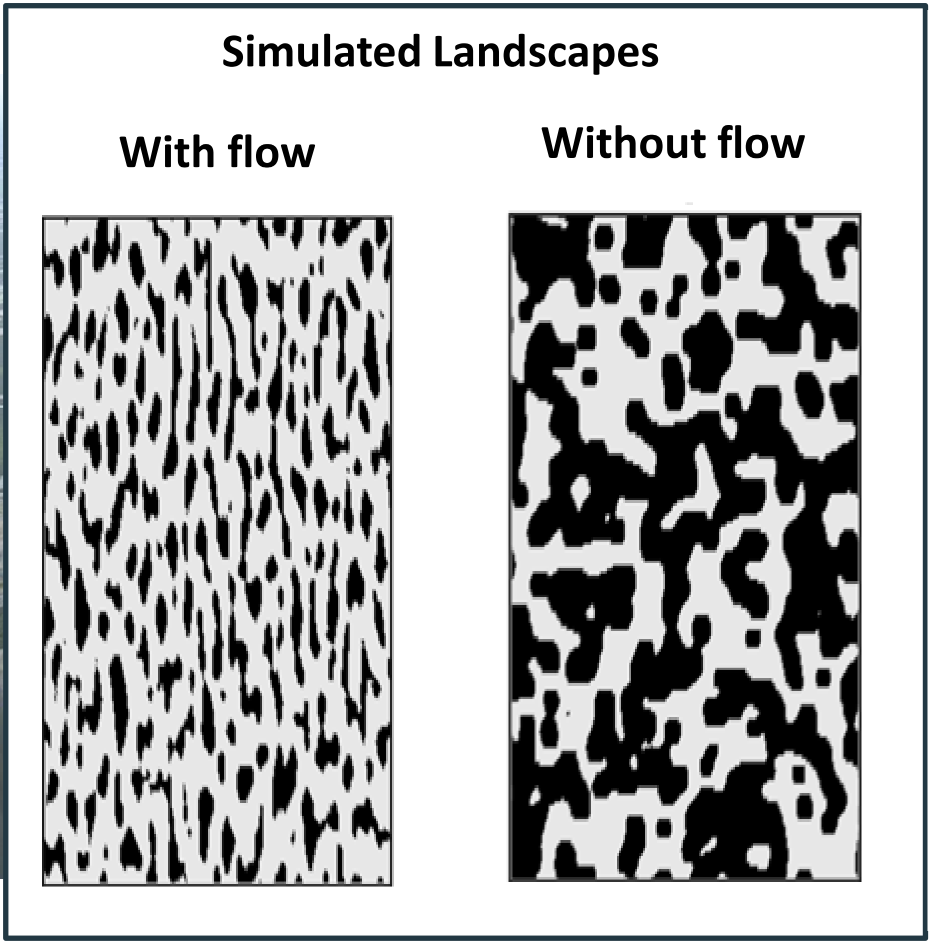
sfwmd.gov



A brief history of the Everglades, water management, and restoration

- late 1800s to 1910
  early canals & levees
- ca. 1930
  Tamiami Trail completed
  more canals & levees
- 1950s – 1970s
  Water Conservation Areas
- today …
  Comprehensive Everglades
  Restoration Plan (CERP)

Flow – a critical piece of the restoration puzzle



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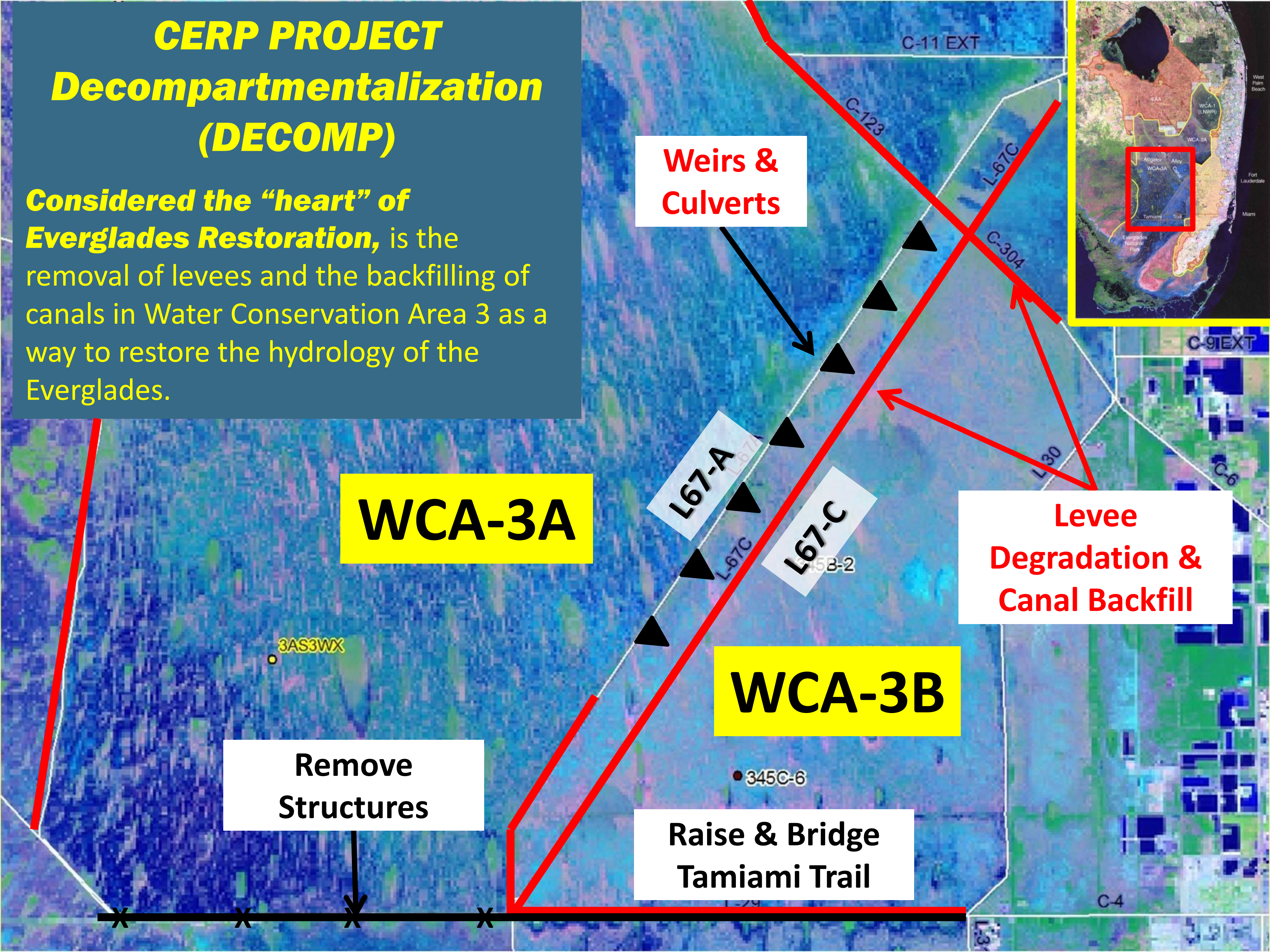
CERP PROJECT Decompartmentalization (DECOMP)

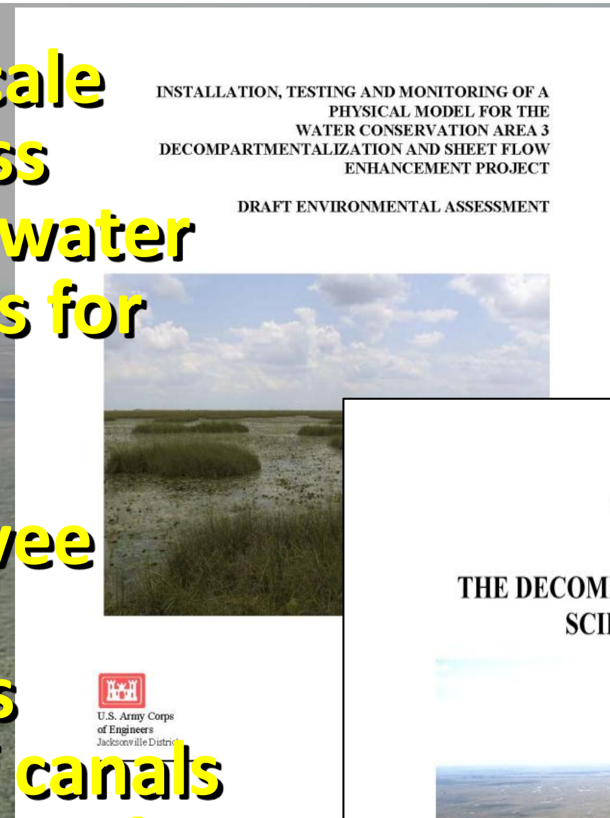
Considered the "heart" of Everglades Restoration, is the removal of levees and the backfilling of canals in Water Conservation Area 3 as a way to restore the hydrology of the Everglades.



Uncertainties of Decompartmentalization: The DECOMP Physical Model (DPM)

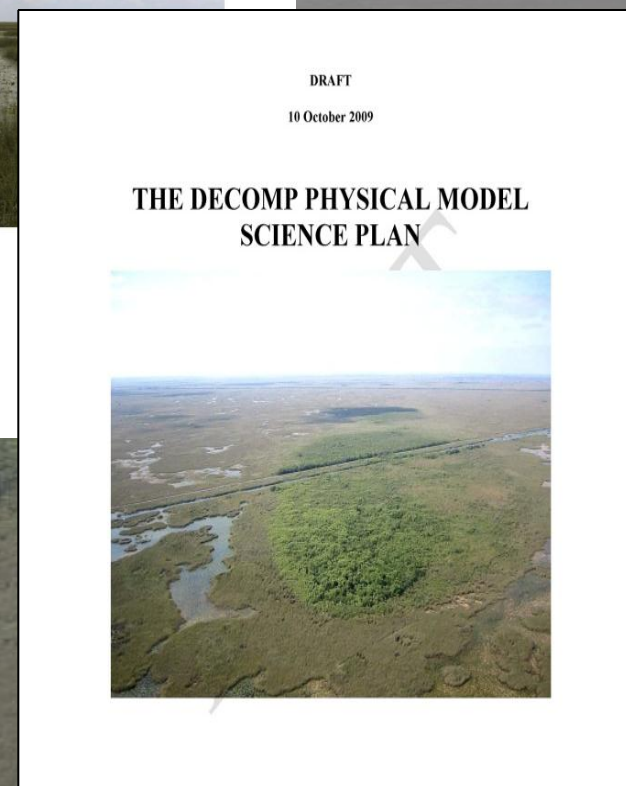
The DPM is a landscape-scale field experiment to address scientific, hydrologic, and water management uncertainties for DECOMP

1. Ecological effects of levee modifications
2. Effects of partial versus complete backfilling of canals
3. Quantification of the benefits of sheetflow
4. Calibration of hydrologic models


INSTALLATION, TESTING AND MONITORING OF A PHYSICAL MODEL FOR THE WATER CONSERVATION AREA 3 DECOMPARTMENTALIZATION AND SHEET FLOW ENHANCEMENT PROJECT

DRAFT ENVIRONMENTAL ASSESSMENT

U.S. Army Corps of Engineers Jacksonville District

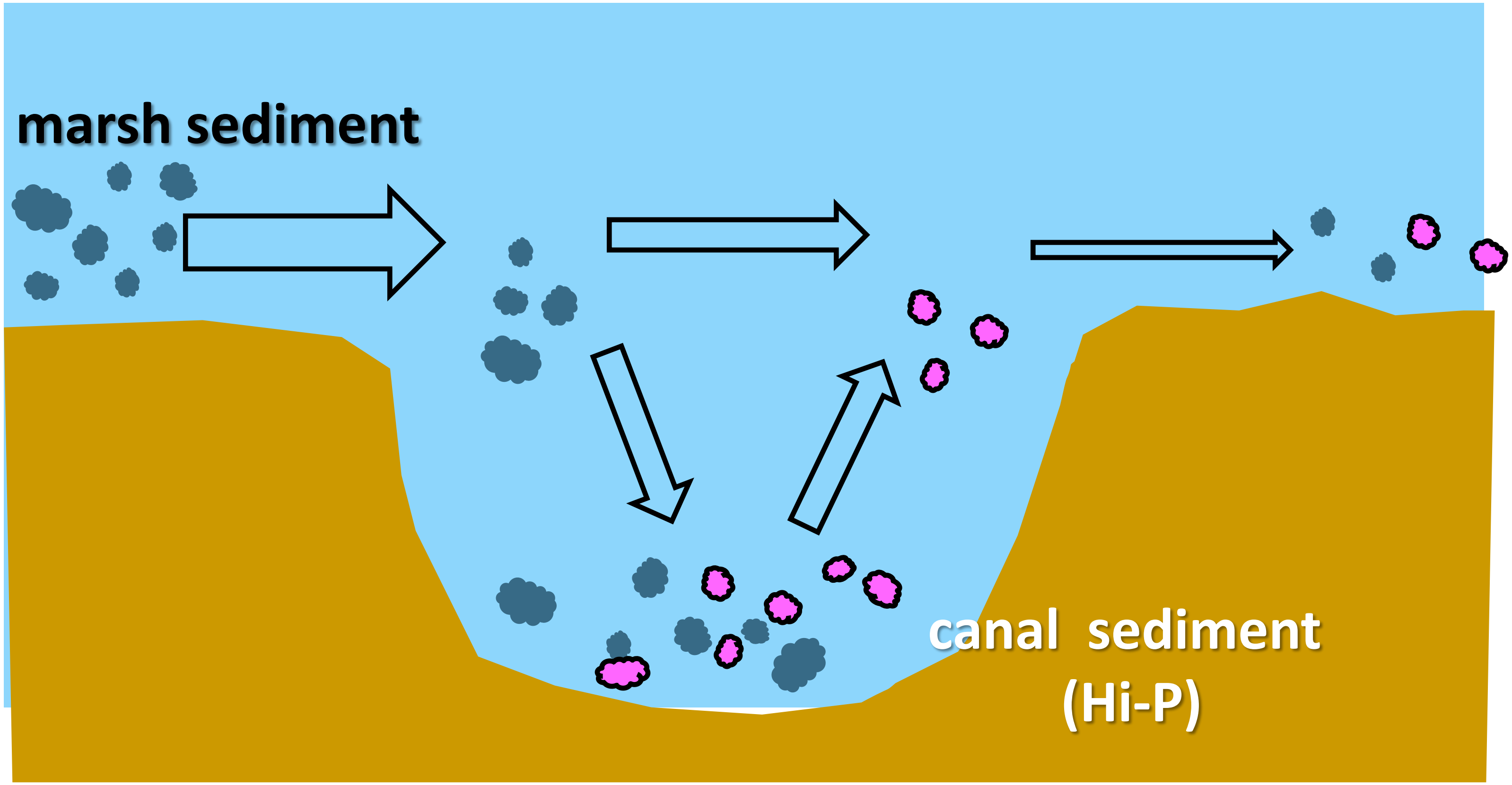

DRAFT

10 October 2009

THE DECOMP PHYSICAL MODEL SCIENCE PLAN

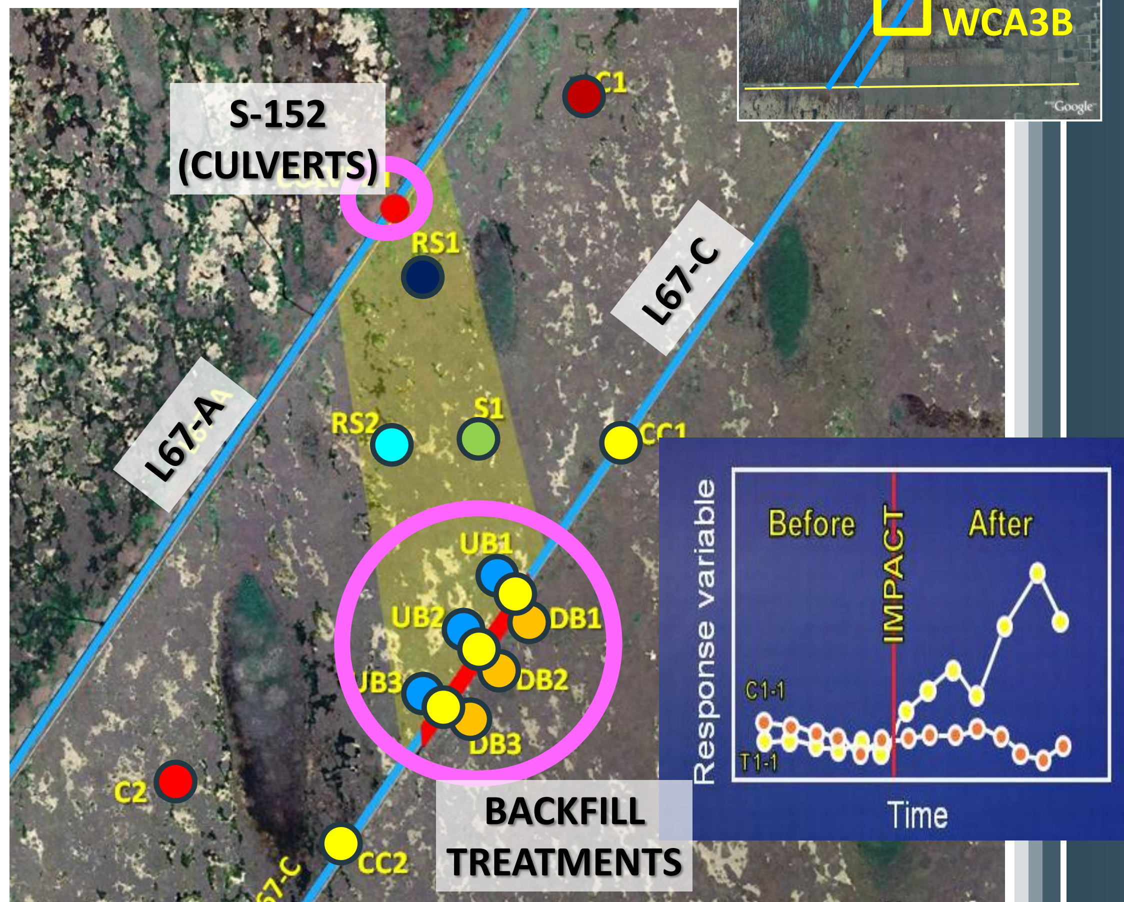
Canal Backfill Hypothesis cluster

Do canal backfill treatments shut down sediment transport?
Do canal backfill treatments alter downstream nutrient loading?
Do canal backfill treatments differ in terms of habitat quality?



The Decomp Physical Model: experimental design

- **Construction**
  - L67A: Eight 6-ft gated culverts
  - L67C: 3000-ft gap and 3 canal-backfill treatments
- **BACI design**
  - 11 marsh sites
  - 5 canal sites
  - Before-, Impact- sampling
- **S-152 Operational constraints**
  - Flooding in WCA3B
  - Water quality in L67A
  - Operational window (OW) i
    November-December

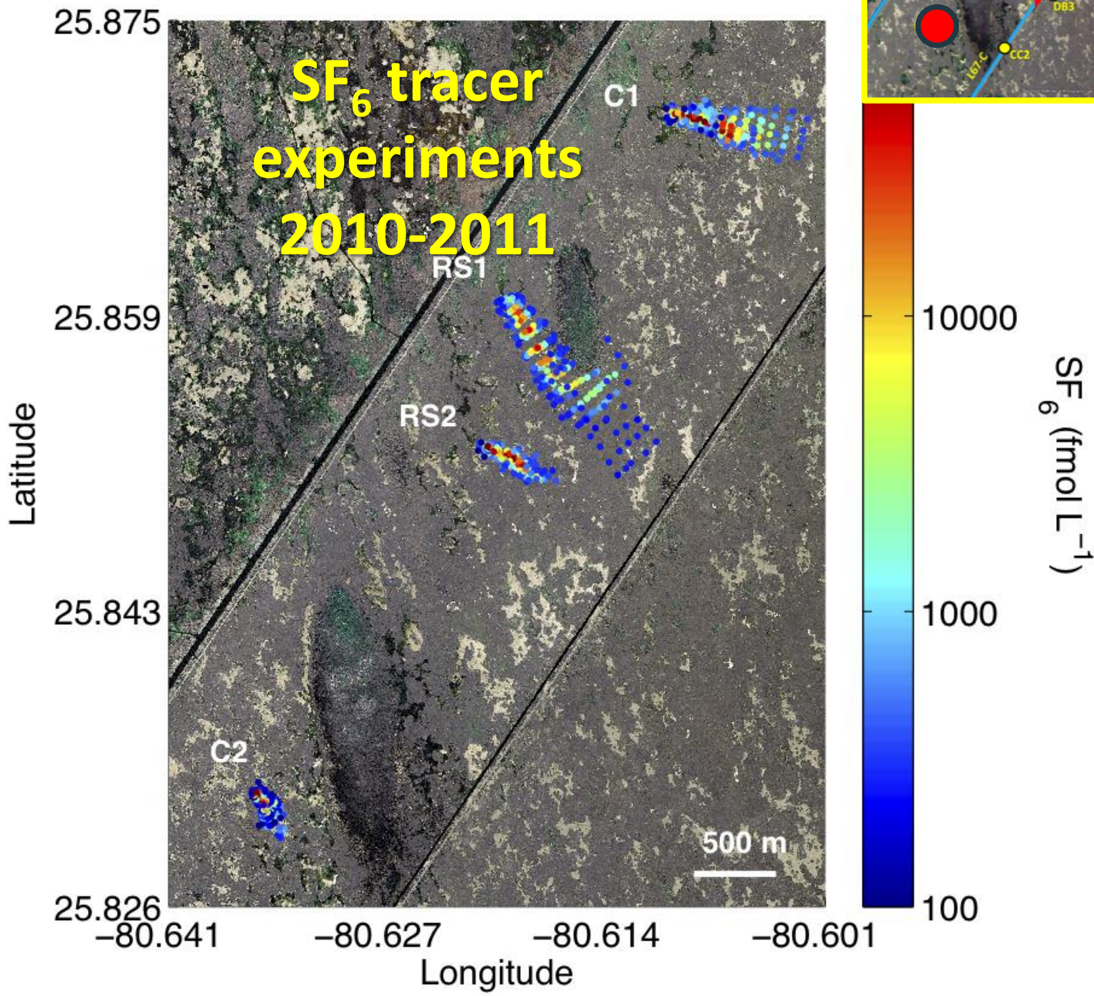


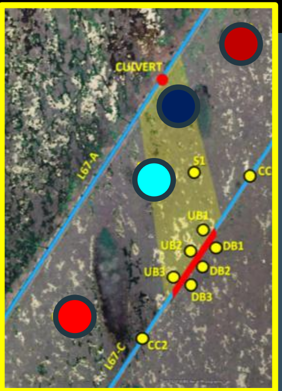
Hydrology, Physical Transport, and Biological Measurements

- Hydrology (Laurel Larsen, Jud Harvey, David Ho)
  - A network of sites for stage, water depths, flow direction, and velocity
  - Hydraulics of new S-152 culverts (head and tail water stages and cfs)
  - Synoptic mapping of water depth and velocity in conjunction with flow manipulations
  - Vegetation mapping for hydraulic resistance
  - Tracer studies (SF6 tracer and dye)
  - Canal hydraulics
- Physical Transport (Colin Saunders , Sue Newman, Laurel Larsen)
  - Particle transport (Floc tracers, sediment traps, molecular markers)
  - Sediment erosive properties
  - Resuspension and deposition of natural particles
- Biogeochemical & Biological (Sue Newman, Larsen, Joel Trexler)
  - Synoptic mapping of surface water biogeochemistry, and biomass and sediment nutrients
  - Environmental monitoring (dissolved oxygen, pH, temperature, specific conductivity)
  - Fauna characterization (native and exotic) and movement
  - Vegetation structure

Ridge-and-Slough Baseline Conditions: Flow across the landscape

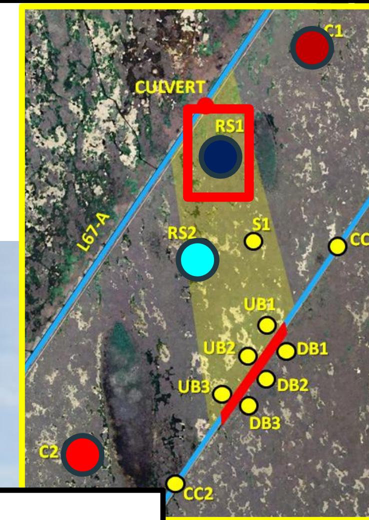
- **SF_6 tracer**
  - Injected at a point source
  - continuous SF_6 analysis
  - 4 days post-injection
- **Findings**
  - Water flows southeast
  - Velocities 0.04 - 0.2 cm s^{-1}
  - Historically, flow was N-S & velocities >2 cm s^{-1}
- (next talk) **David Ho *et al*. Resolving Kilometer-scale Flow Patterns in the Everglades Using SF_6 …**

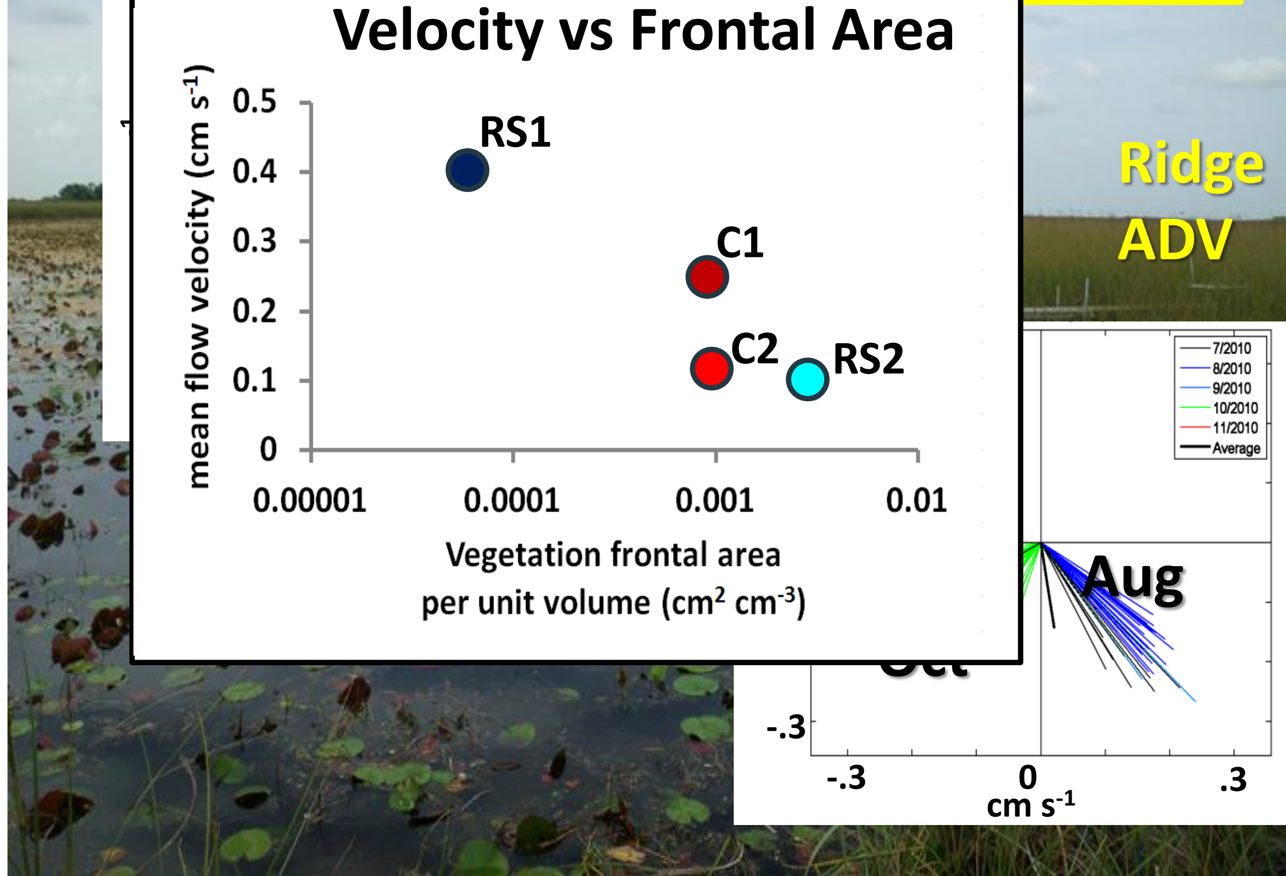




Ridge-and-Slough Baseline Conditions: flow at the local scale

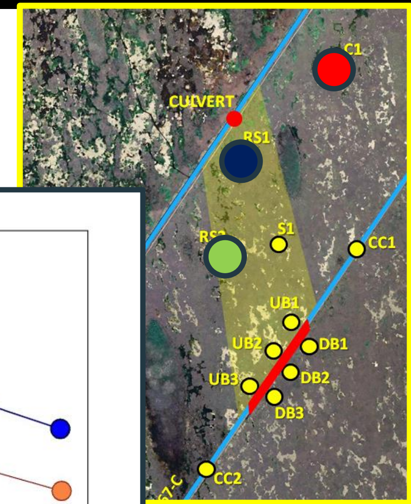
- **Acoustic Doppler Velocimeters**
  - 16 platform ADV locations
  - ridge and slough
  - Depth profiles
  - Seasonal, interannual variation
- **Findings**
  - Range 0.07 to 0.7 cm s^{-1}
  - Slough - follows landscape orientation
  - Ridge - varies more seasonally
  - Vegetation frontal area drives spatial variation in velocity

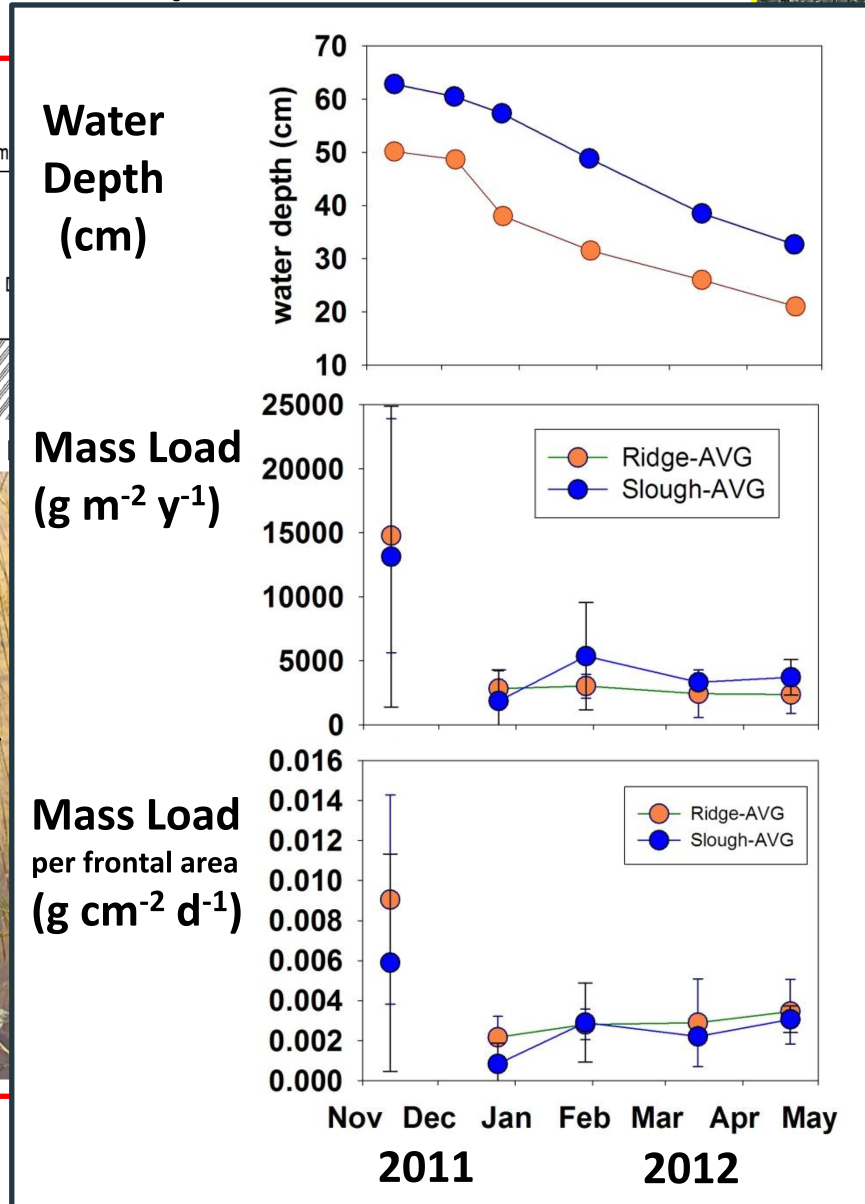




Ridge-and-Slough Baseline Conditions: sediment transport

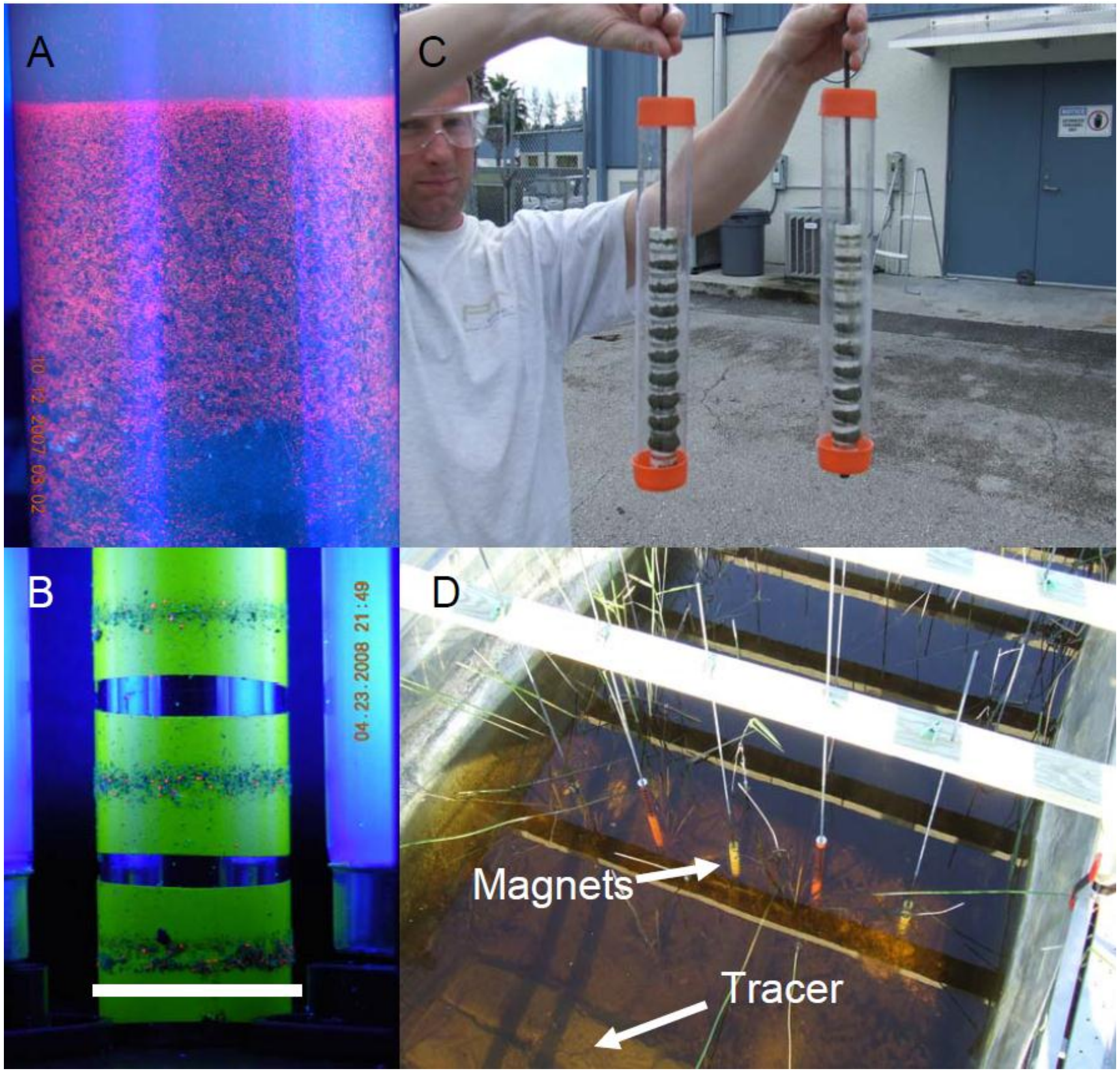
- **Sediment traps**
  - adapted from Phillips et al., 2000 *Hydrol Procs.*
  - C1, RS1, RS2 - ridge & slough
  - parallel to flow, based on measured flow vectors
- **Findings**
  - Load: <100 to 16,000 g m^{-2} y^{-1}
  - highest loading in wet season
  - deepest site (C1) has highest loading during dry-down
  - Slough and ridge loading equal



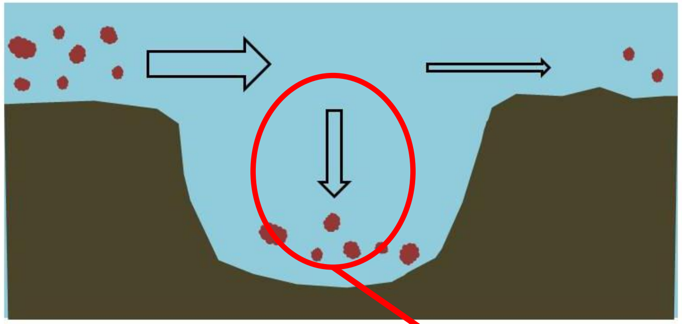


Tracing floc movement with synthetic floc

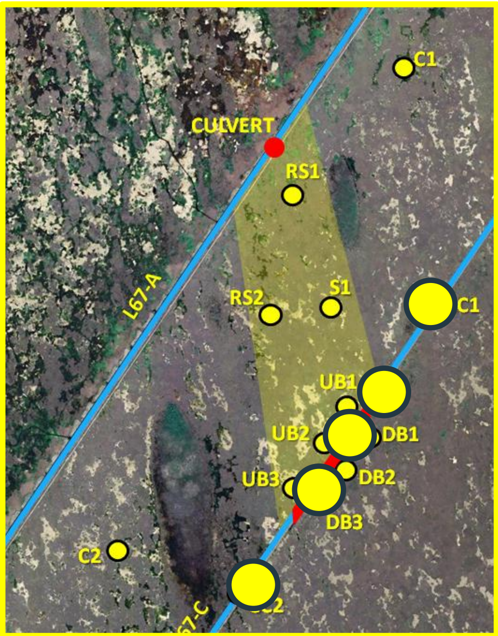
- **Magnetic floc**
  - Physical properties matched to natural Everglades floc
  - 25kg frozen blocks deployed at upstream locations
  - Synoptic surveys
  - Floc collected using 11 Guass magnets
  - UV-fluorescent, different colors to track multiple cohorts



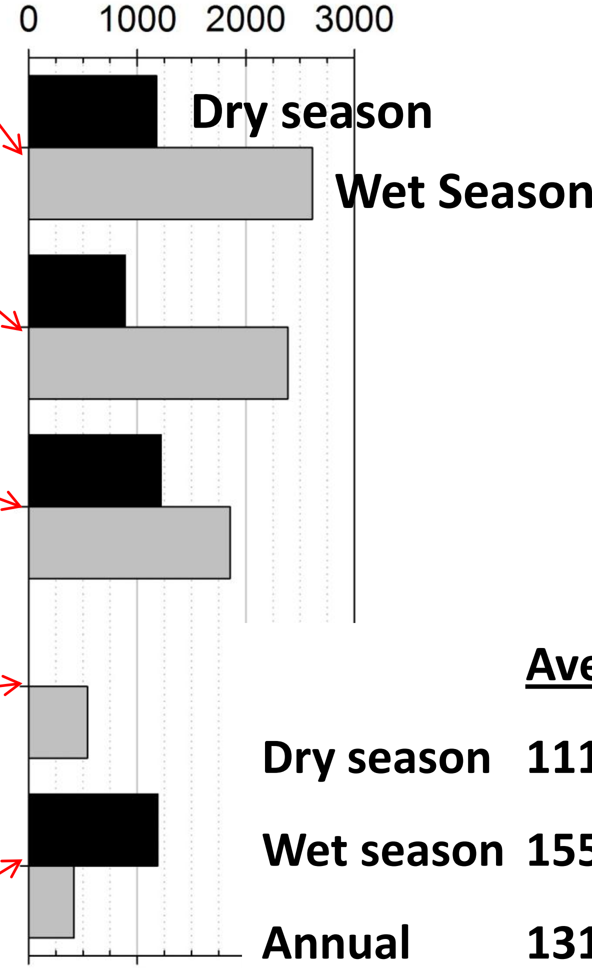
Baseline conditions in the canal: sediment accumulation



- **Vertical sediment traps**
  - 4”-dia PVC (len:inlet >5)
  - Anchored to bottom, kept upright with floats
  - 3-6 week deployments
- **Post processing**
  - Sieve, retain <1-mm
  - Dry wt to determine mass accumulation



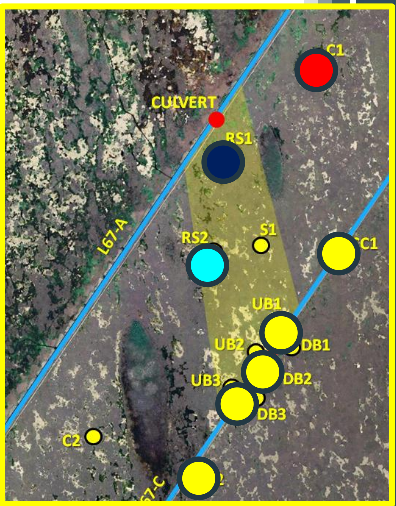
Vertical Accumulation ($g\ m^{-2}\ y^{-1}$)



	Average ± SD
Dry season	1119±155
Wet season	1553±1025
Annual	1312±225
Literature *	1000-2000

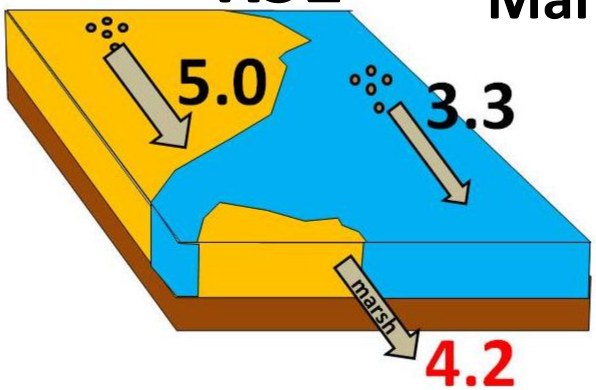
* Merkel & Hickey-Vargas 2000 *Water, Air and Soil Pollution* 122: 327-349

Sediment Budget: Marsh to Canal

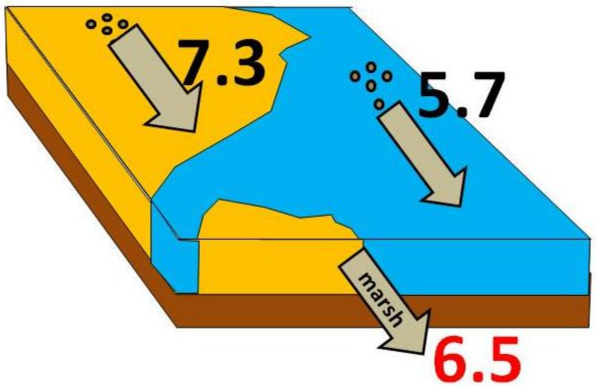


Marsh - Mass Transport (kg m^{-2} y^{-1})

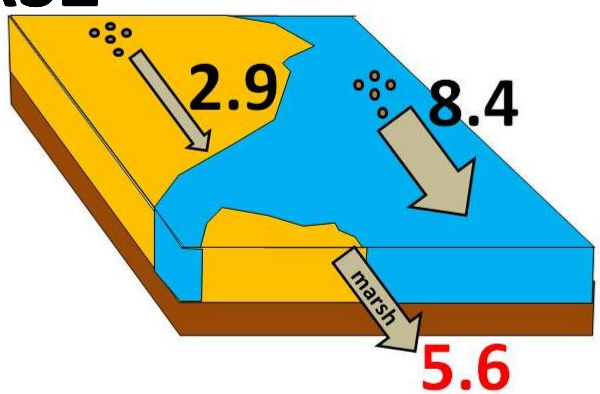
RS1



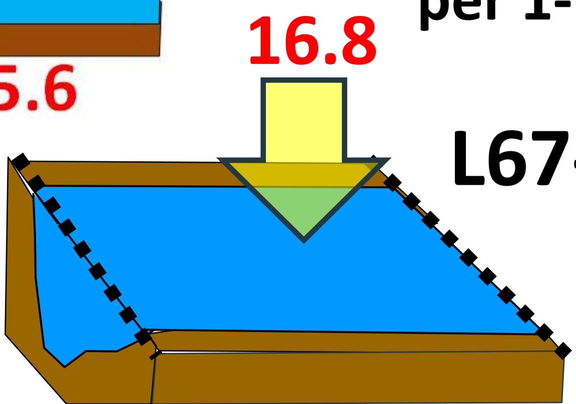
C1



RS2



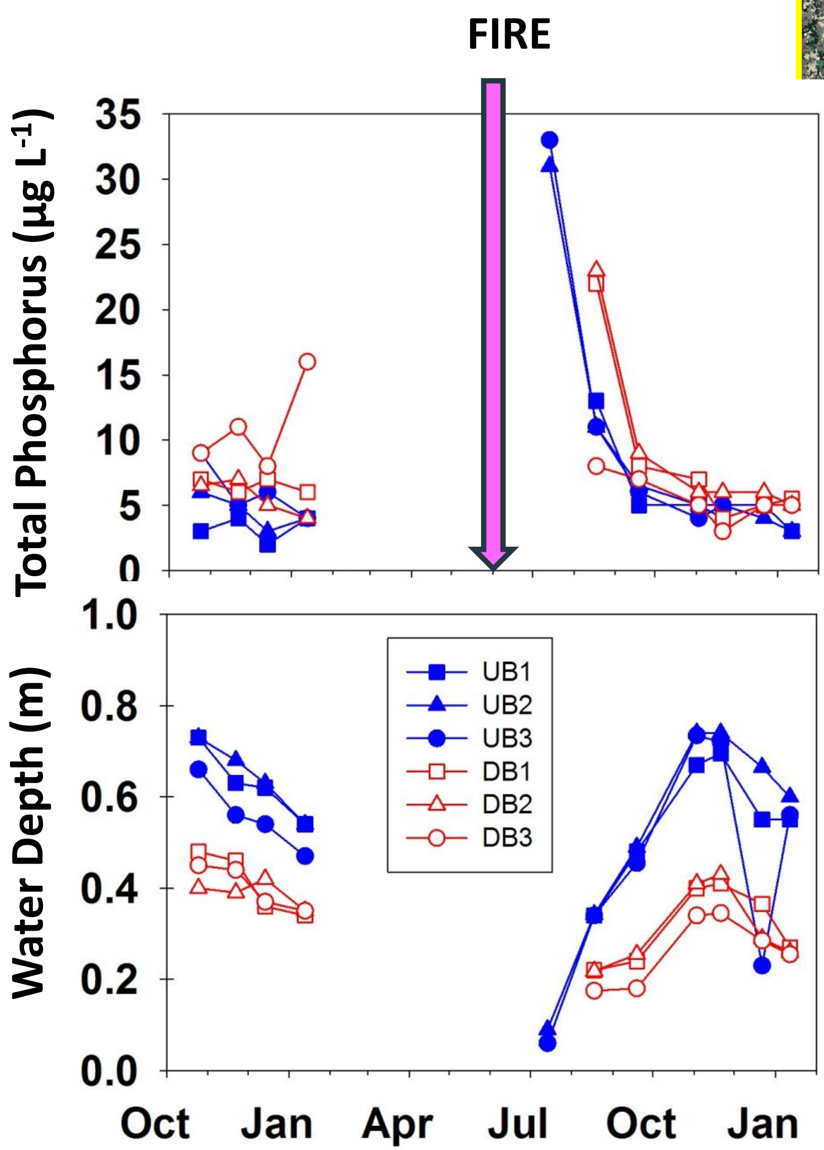
Canal – Mass Accumulation per 1-m wide "Ribbon" (kg m^{-1} y^{-1})

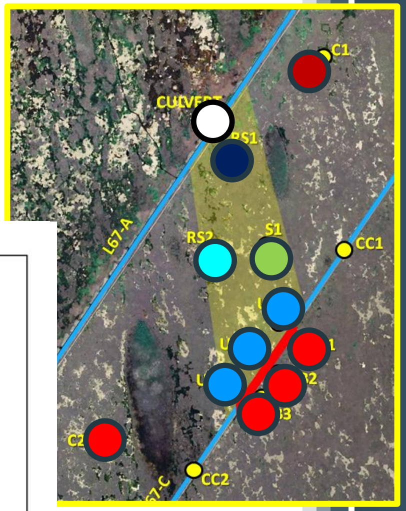


L67-C

Baseline Conditions: Water Quality

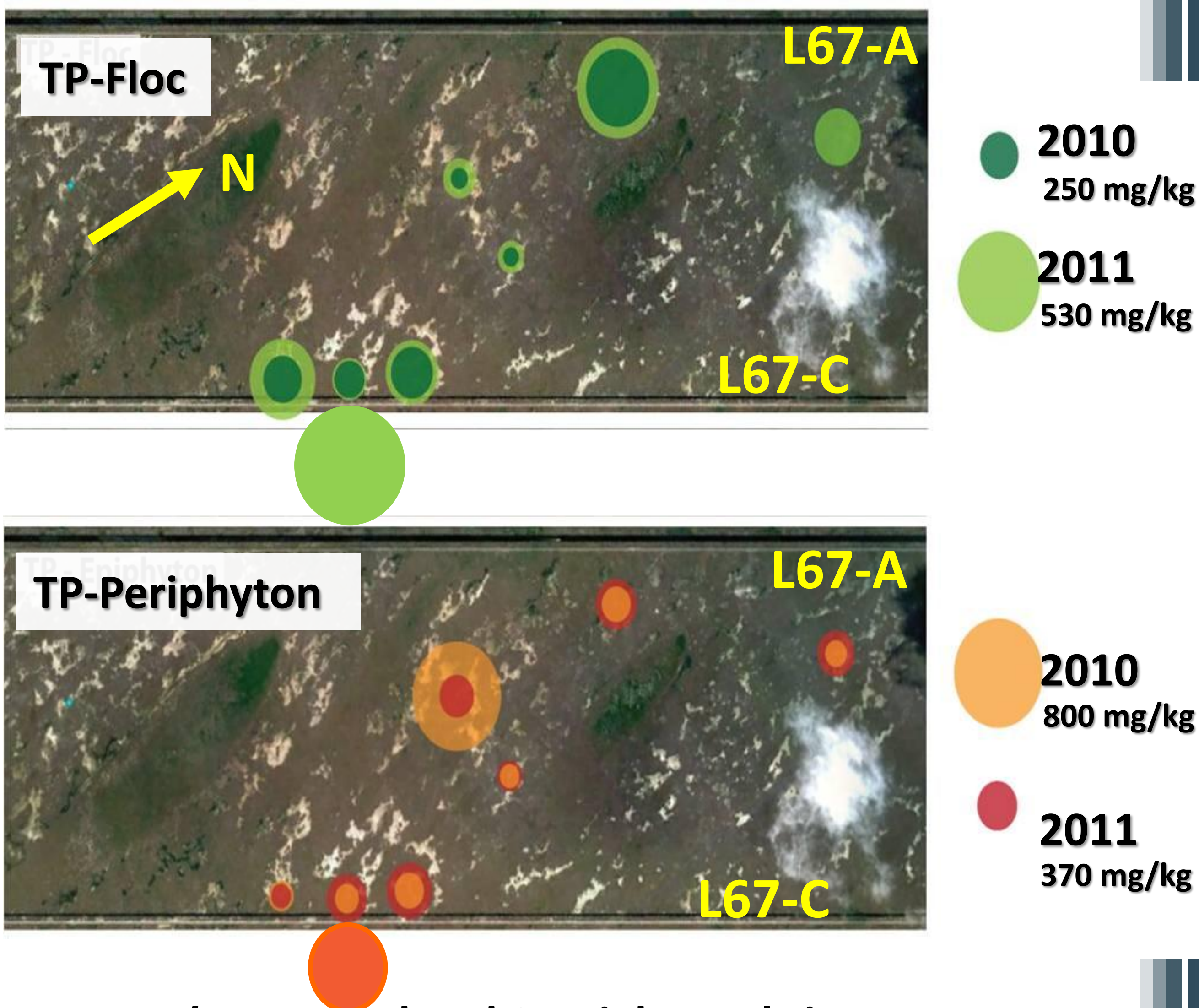
- **Water quality**
  - TP, TN, fine particulates, DOC, SUVA/refractory
- **Findings**
  - TP varies with water depth
  - More variation during re-wetting
  - Higher TP downstream of canal/levee





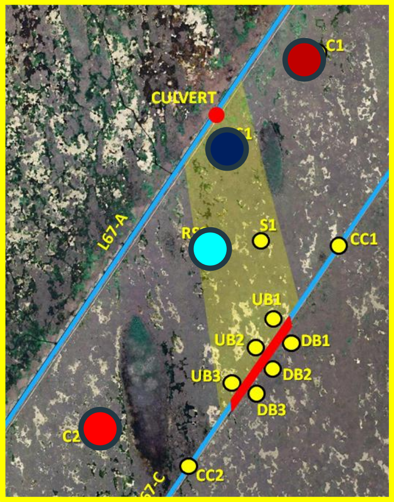
Baseline Conditions: Nutrient Sources

- **Floc, periphyton**
  - TP, TN, TC, SO4, Microbial-C, Aromatics
- **Findings**
  - Higher TP in 2011
  - Higher Floc-TP near canals
- **Coming up ...**
  - Spatial survey of benthic floc & soil

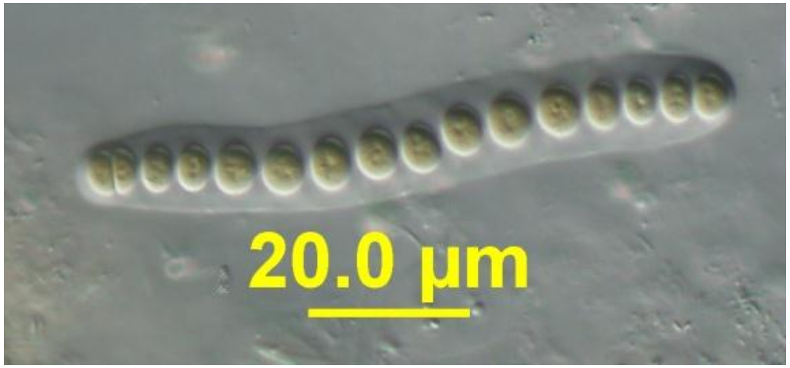


(poster) **Laurel Larsen *et al*. Temporal and Spatial Trends in Mobile Organic Sediment in a Free- Flowing Everglades**

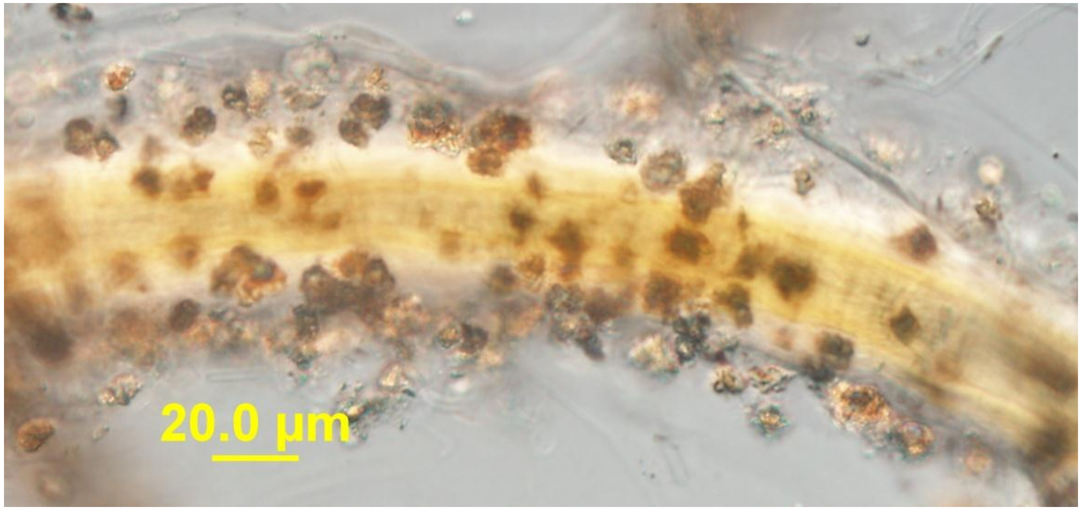
Algal taxonomy of floc



- **Algal taxonomy**
  - algal epiphyton & periphyton
  - C1, C2, RS1, RS2
- **Barry Rosen** "Cyanobacteria Species from Florida Everglades Floc" (Wednesday)



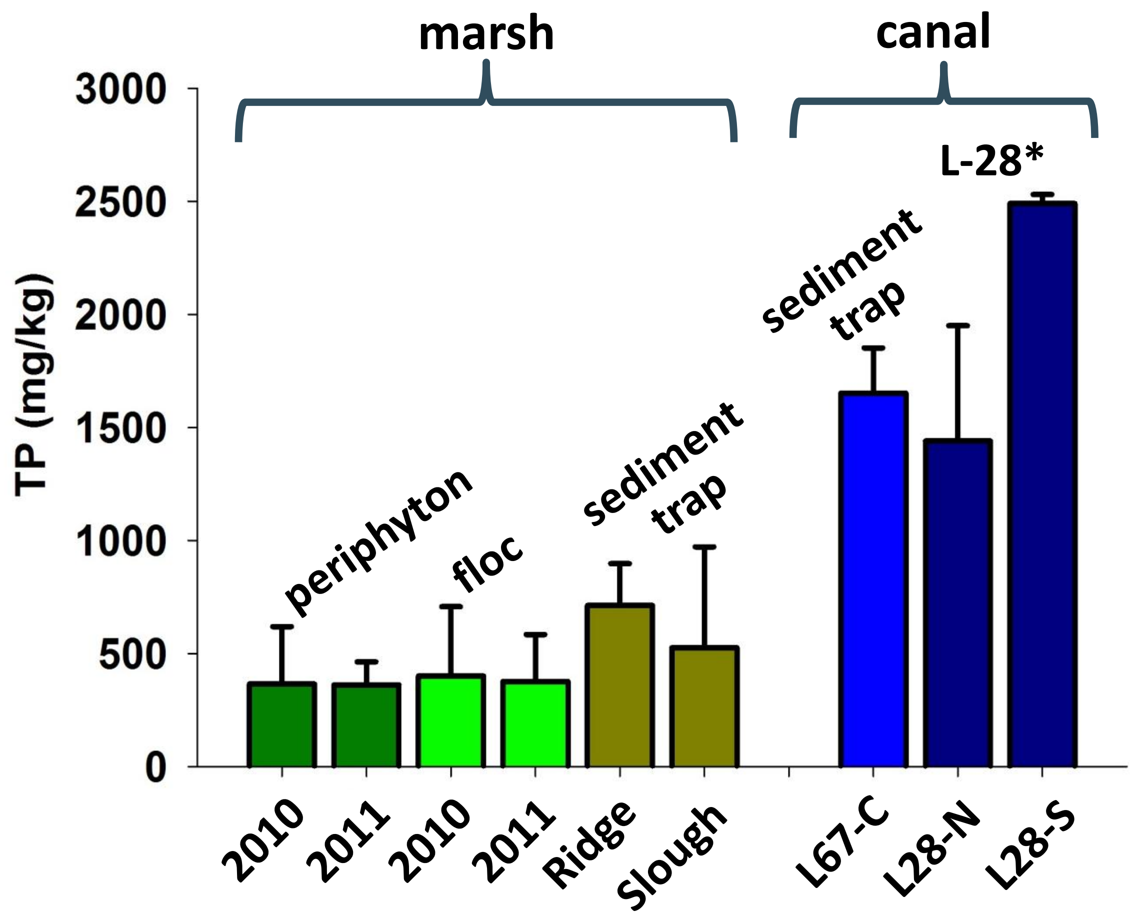
Johanesbaptistia pellucida



Scytonema filament crystals

Sediment Phosphorus and Sources: marsh vs canal

- Phosphorus content highest in canal sediments
- Suggests canal accumulating a local source of sediment
- Canals a potential source of P



*Merkel & Hickey-Vargas 2000. *Water, Air, and Soil Pollution*

Baseline Conditions: Fish communities

Hypotheses

- High flow will change habitat use, seasonal movement of fish
- Backfill treatments will alter fish predator-prey dynamics in canal

Data collection

- (throw traps, drift fences) quantify large, small fish in marshes near and far from canals
- (sonar, electrofishing) to quantify fish in canals and document behavior (schooling, predatory interactions)
- Radio tracking bass and bowfin to document habitat use and movements in canal and marsh

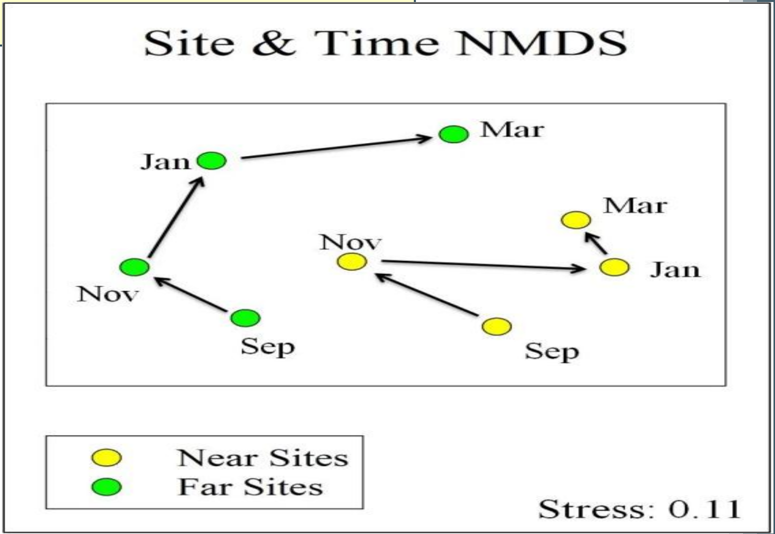
Baseline results

- Small and large fish species composition and density vary as a function of canal proximity
- Large and small fish move into the canal in the dry season; small fish form schools as antipredator behavior

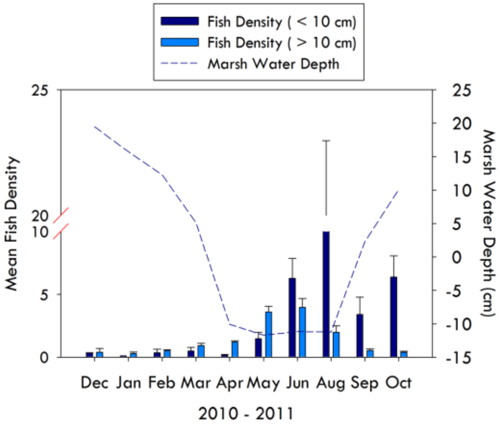
Michael Bush – poster 257, Wed, session 2

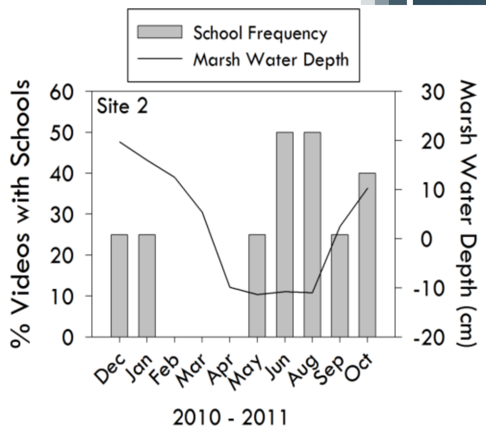
Ann Hijuelos – oral presentation, Wed 4:40PM

Fish species composition in marsh is consistently different near and far from L76C



Large and small fish move into the L67C in the dry season. Small fish form school when predators become abundant





Baseline conditions in the no-flow state

- **Flow does not follow historic landscape directionality**
  - velocities are higher in sloughs, more variable in sawgrass
  - ... generally too low to entrain floc
  - ... driven by vegetation (spatially) and surface slopes (temporally)
- **Sediment transport the same in ridges and sloughs**
  - ... too low to account for accumulation in canals
- **Water [P] and sediment TP higher near canal**
  - connectivity between canal and near-canal marshes
- **Fish populations near-canal are distinct from marsh populations**
  - except during dry season

Countdown to The Main Event...

- **May 2012 - Construction starts**
- **Sept 2012 – Check stage, water-TP triggers for S-152**
- **November 2012 - Construction complete**
- **December 2012 – *Flow Baby Flow***

Acknowledgements...

Eric Cline, Robert Shuford, Tamela Kinsey, Richard Walker, Kristin Wheeler, Michael Manna, Fabiola Santamaria, Michelle Blaha, Ed Clark, Paul Linton, Shi Xue, Pamela Lehr, Pete Rawlik, Mark Shafer, Vince Sandoval, Megan Jacoby, Jeff Woods, Mark Dickman, Mark Zucker, Lori Miller, Andy Loschaivo, Steve Baisden, Pamela Tellis, Jed Redwine, Ernest Marks, Ingar Hansen, Deinna Nicholson, Paul Julian, Mike Ross, Pablo Ruiz, Jay Sah, Michael Bush, Ann Hijuelos, ...

USACE, USGS, ENP, USFWS, FDEP, SFWMD
Univ. Hawaii, Florida International University, ...

QUESTIONS?

A Physical Model of Flow Reconnection to Achieve Ecological Restoration in the Everglades

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