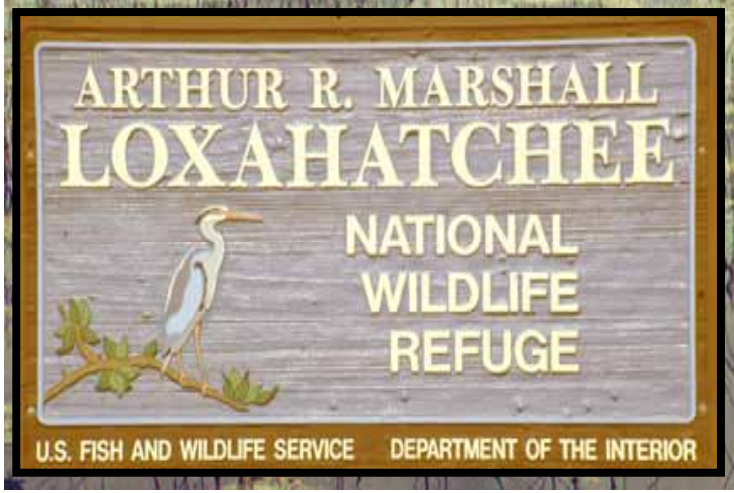
Adaptive management in a learning environment

A case study of hydrology & water quality in the A.R.M. Loxahatchee National Wildlife Refuge



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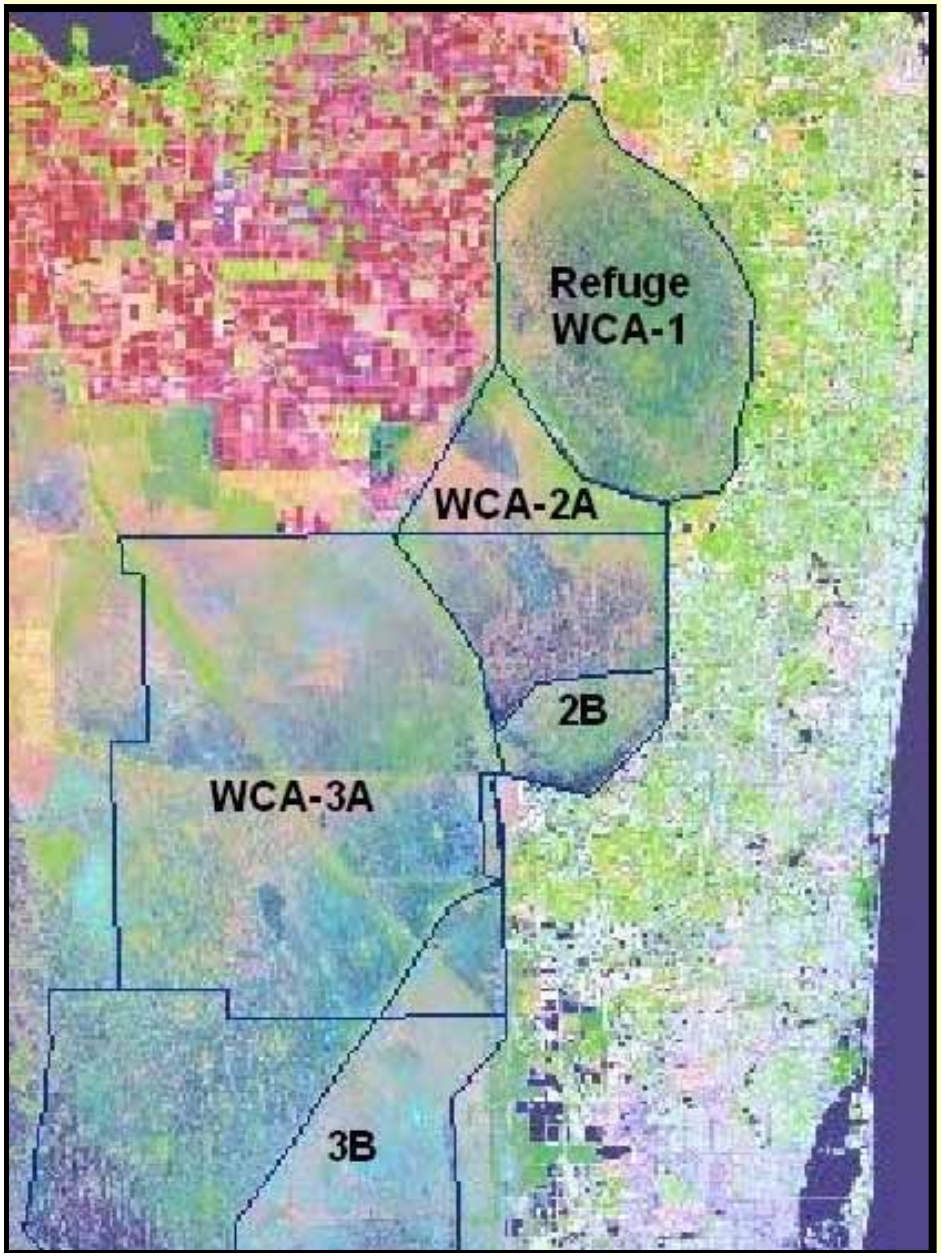
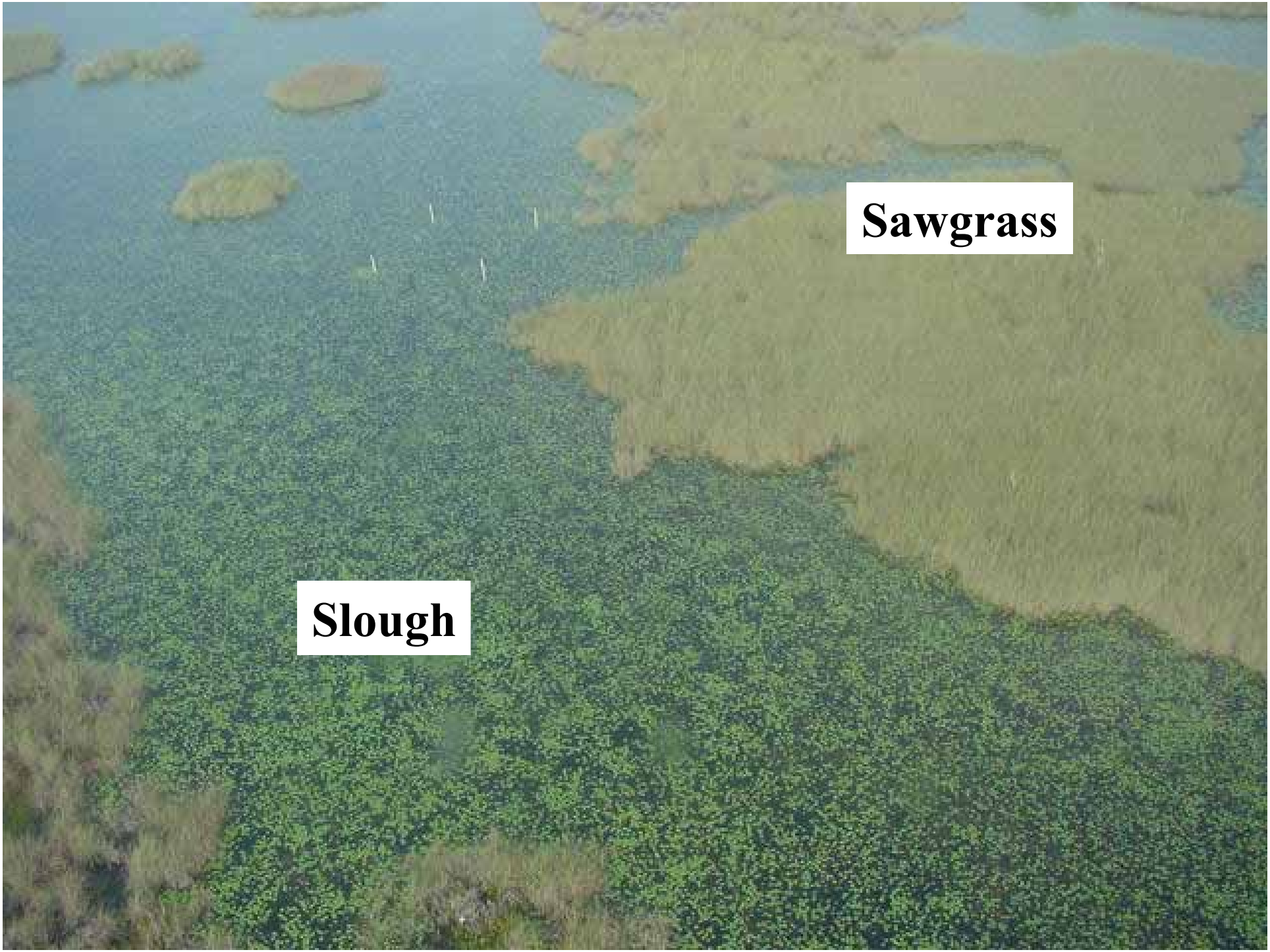
Some Tenets of Adaptive Management

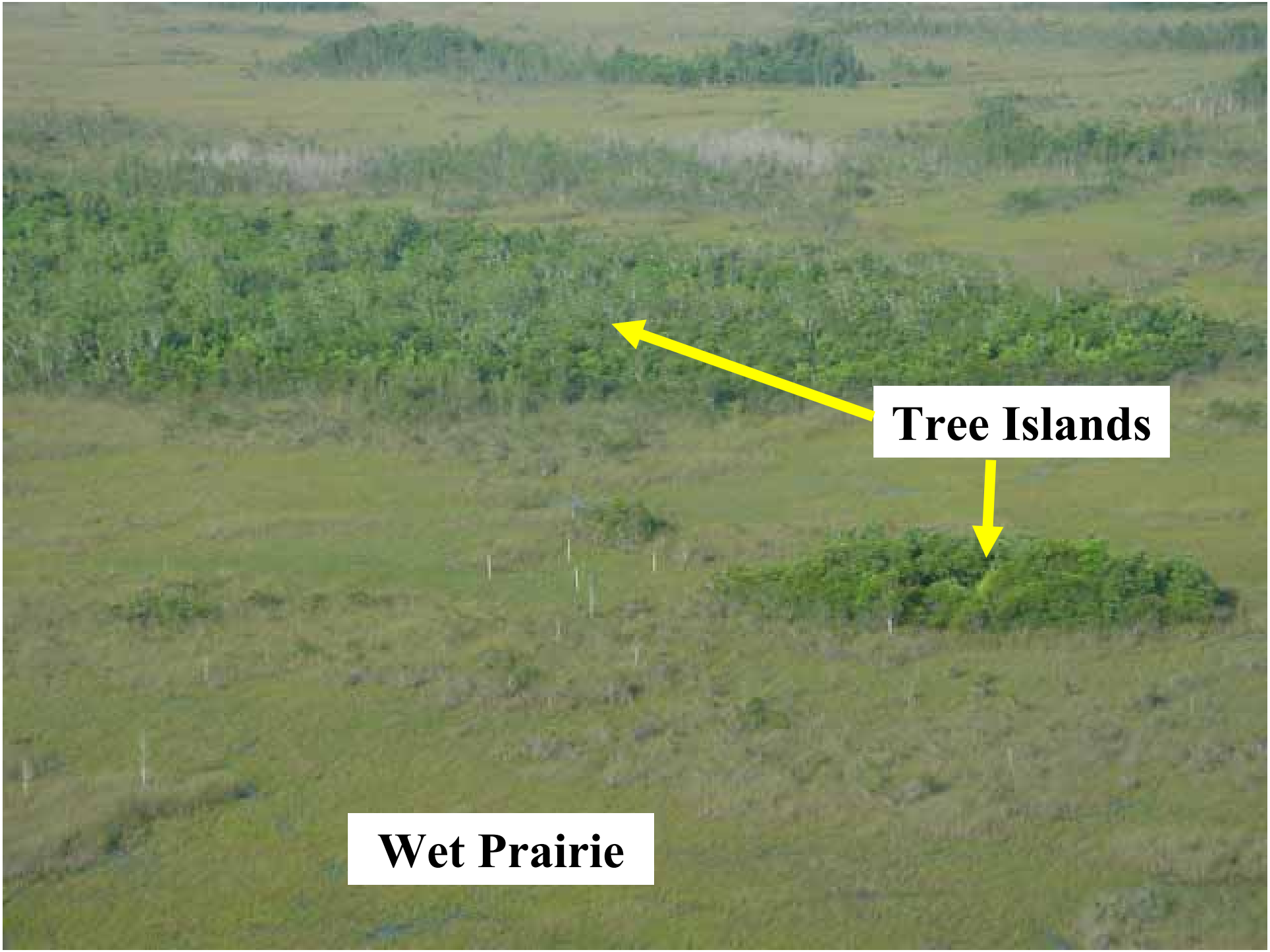
- **Learning happens**
- **Learning incorporated into decision processes**
- **Learning can increase management flexibility**
- **Directed knowledge can be used for assessing potential consequences & risks of decisions**
- **Combination of focused monitoring, modeling & experimentation leads to successful AM**

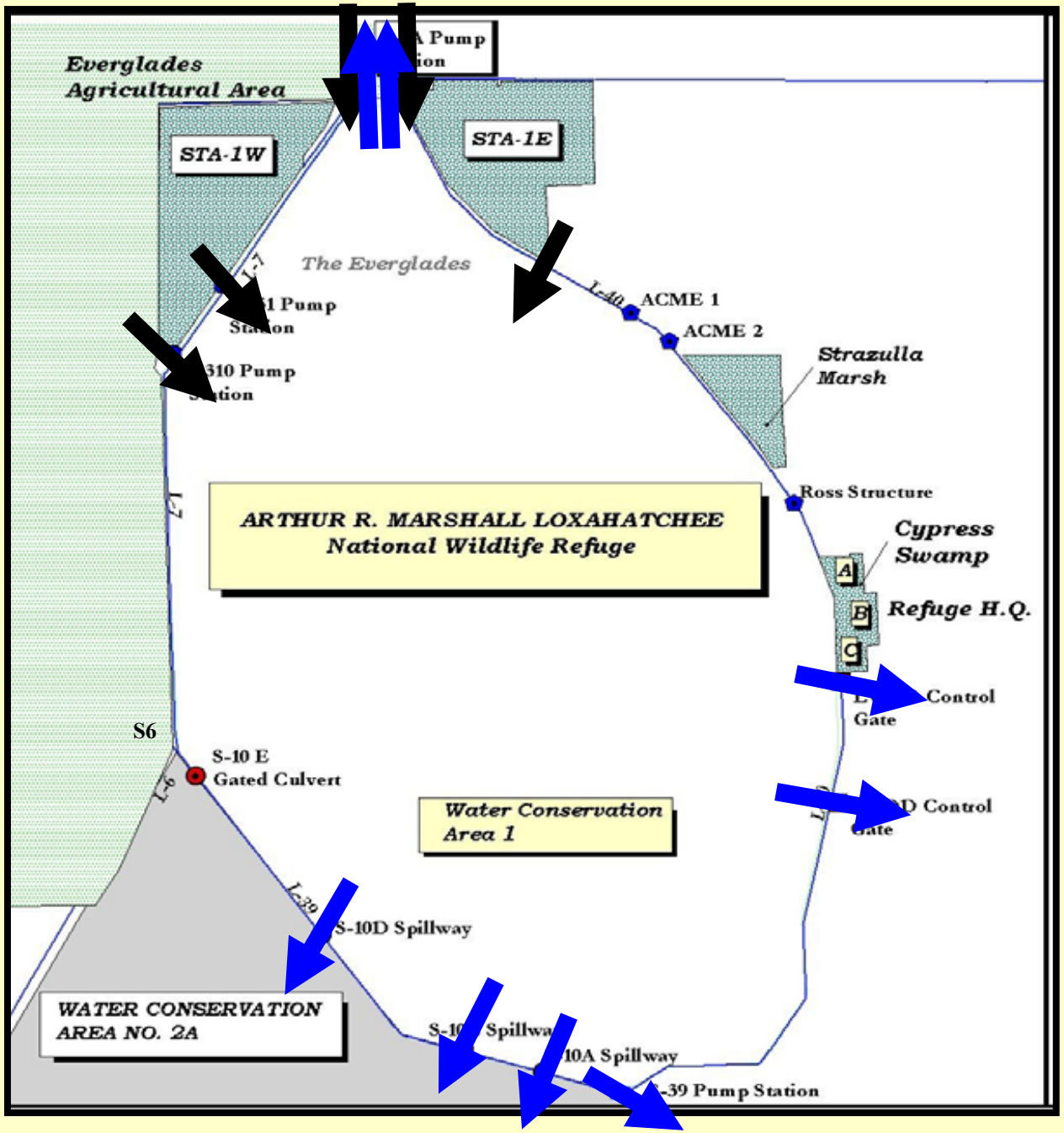
Refuge Background



- Established in 1951
- 144,000 acres
- Purposes:
  - Conservation
  - Water Supply
  - Flood Protection
- Soft-water system
- Historically rainfall-dominant
- Formerly sheet-flow
- Water Regulation Schedule
- Consent Decree for WQ


Sawgrass
Slough


Tree Islands
Wet Prairie



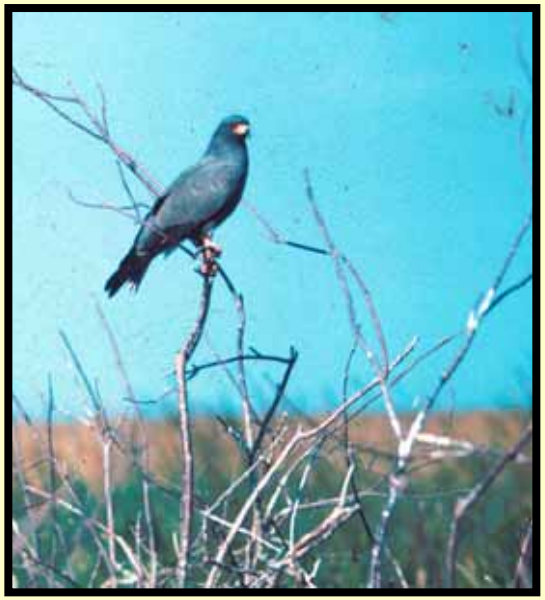
Current Refuge Inflows and Outflows

Current Inflow

Current Outflow

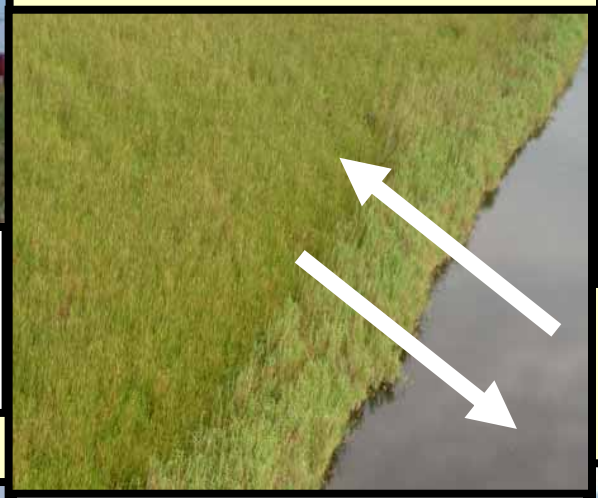
Managing Refuge Resources Involves:

- **Maintaining water quantity & water quality**
- **Identifying water management strategies to maximize ability to achieve desired conditions**



How Does Water Management Influence the Refuge Marsh?

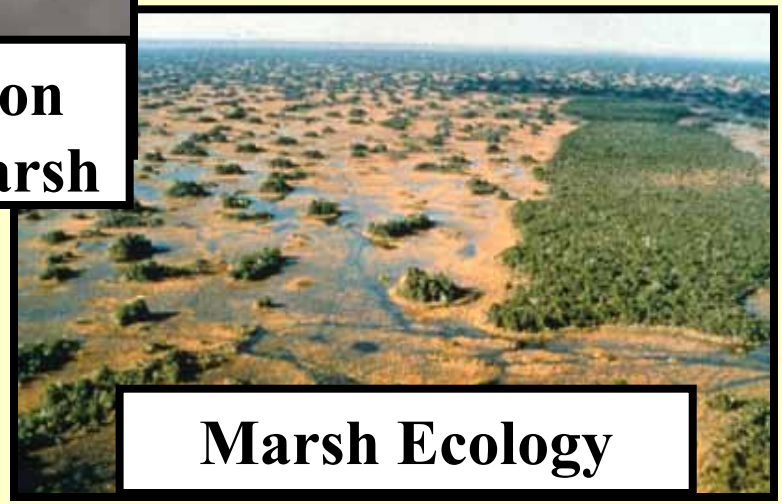
Water Management Operations



Water Intrusion Canal ←→ Marsh

Water Quality and Hydrology in Marsh

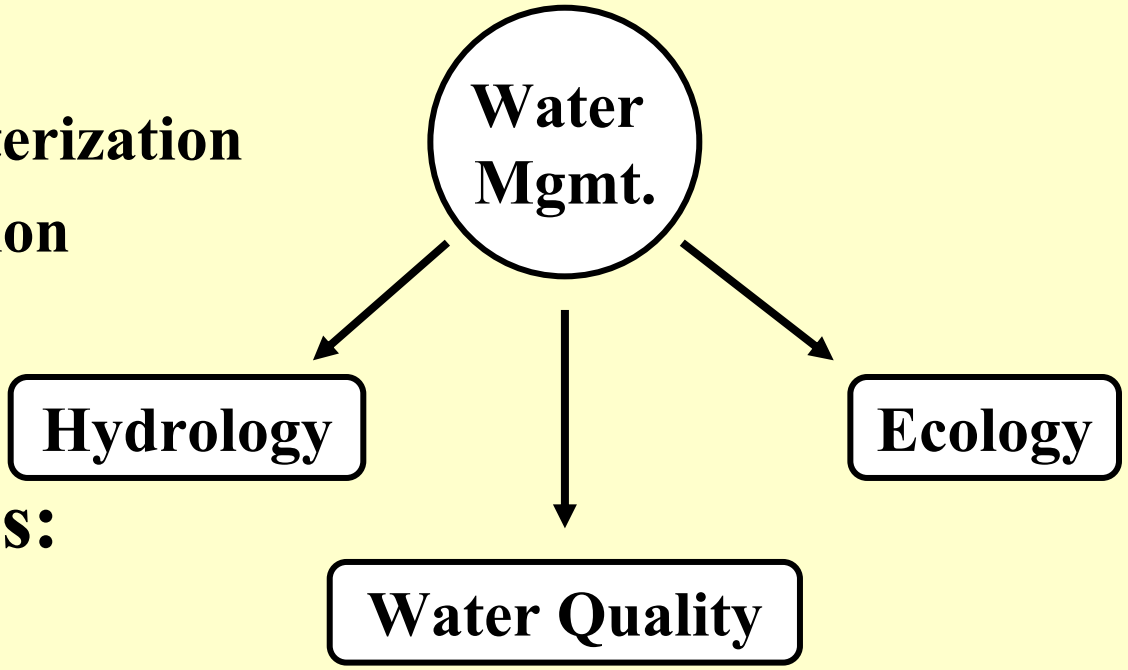
Canal Flow and Stage



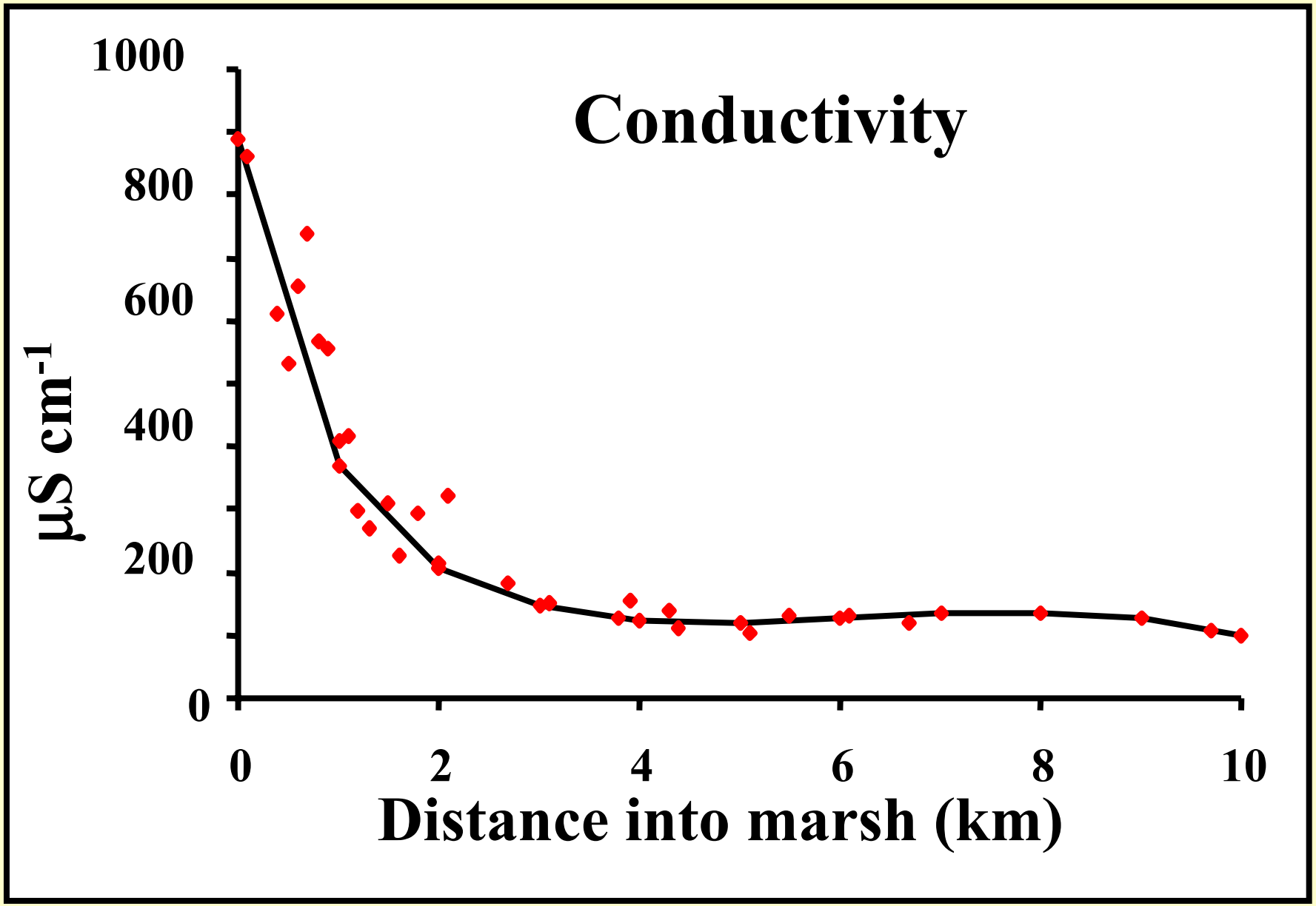
Marsh Ecology

Refuge's Enhanced Water Quality Monitoring & Modeling Program

- **Field activities:**
  - Marsh WQ characterization
  - Canal water intrusion
  - Ecological effects
- **Modeling exercises:**
  - Water budget
  - Hydrodynamic
  - Water quality

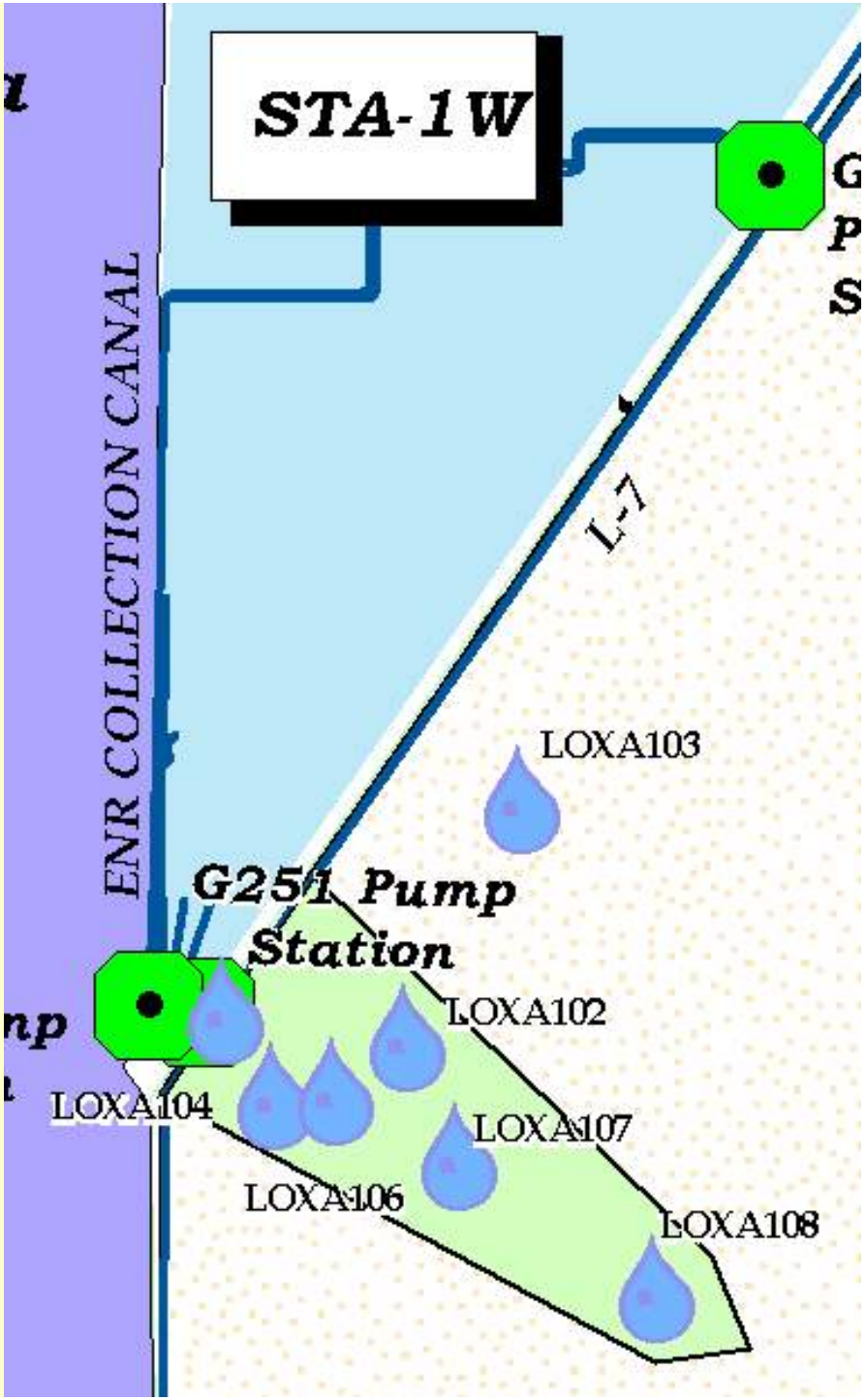


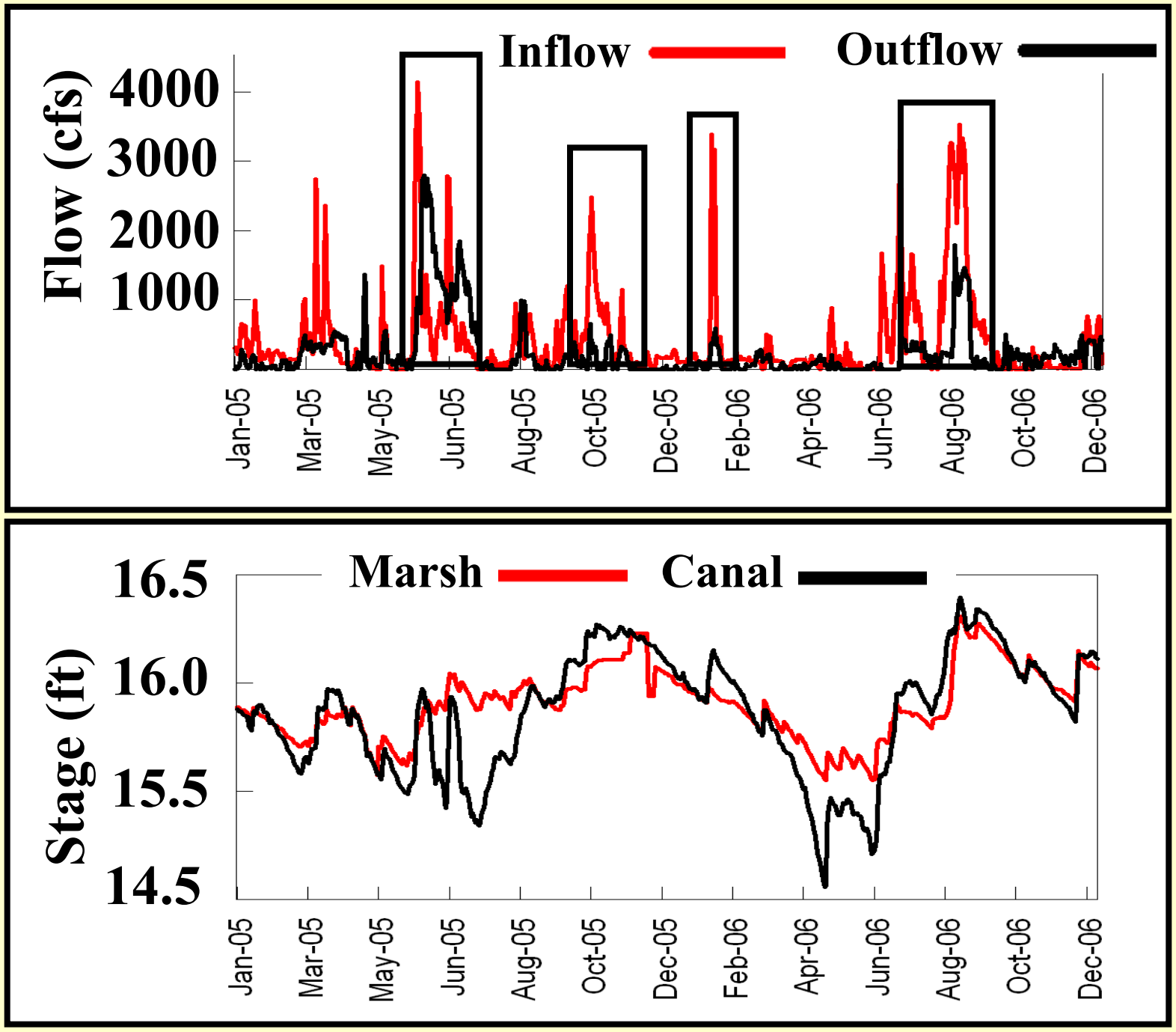
Water Quality Gradients in the Refuge

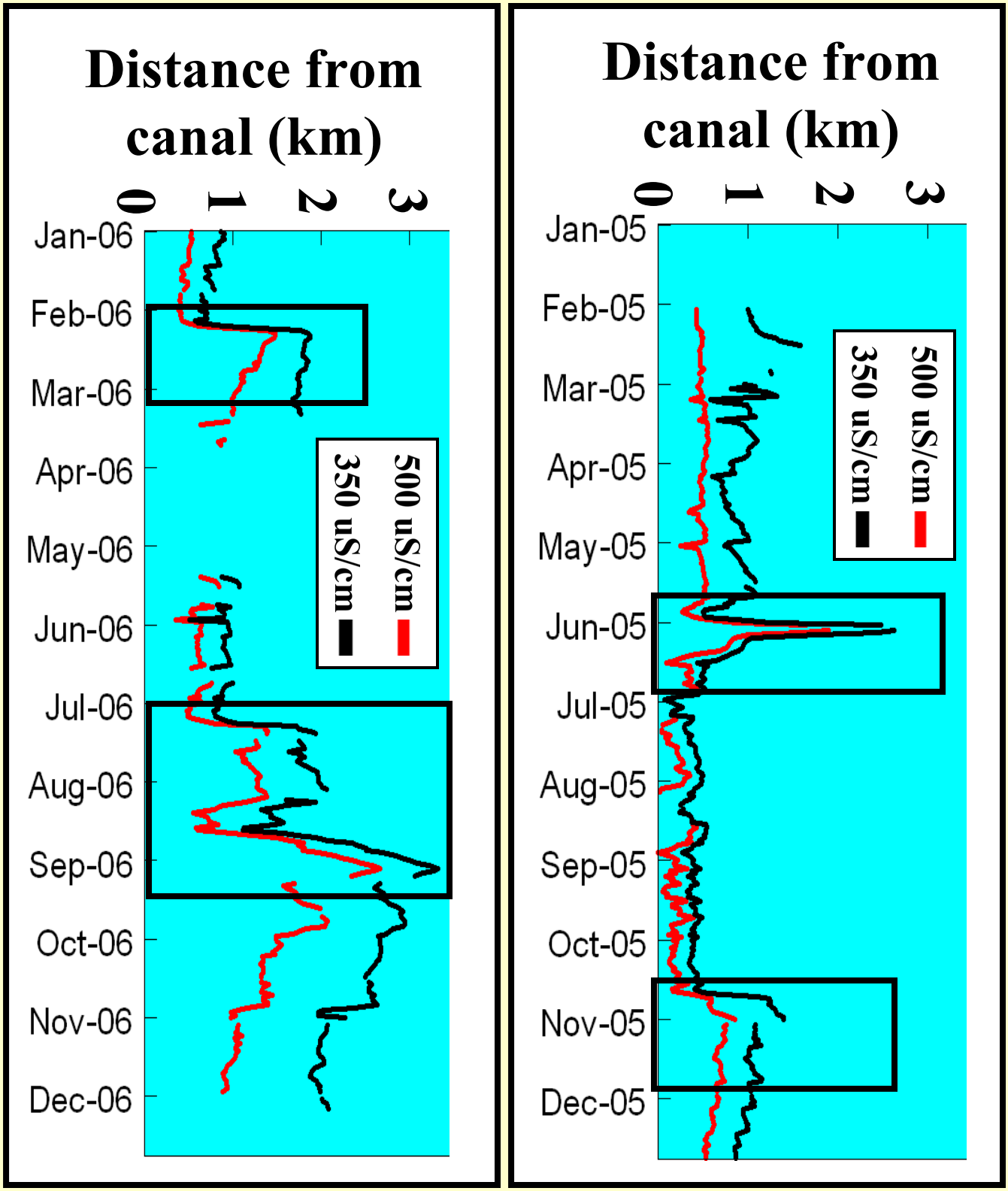


Canal Water Intrusion

- Conductivity transects used to track canal water penetration into the marsh
- Conductivity sondes recording hourly along gradient transects throughout the marsh

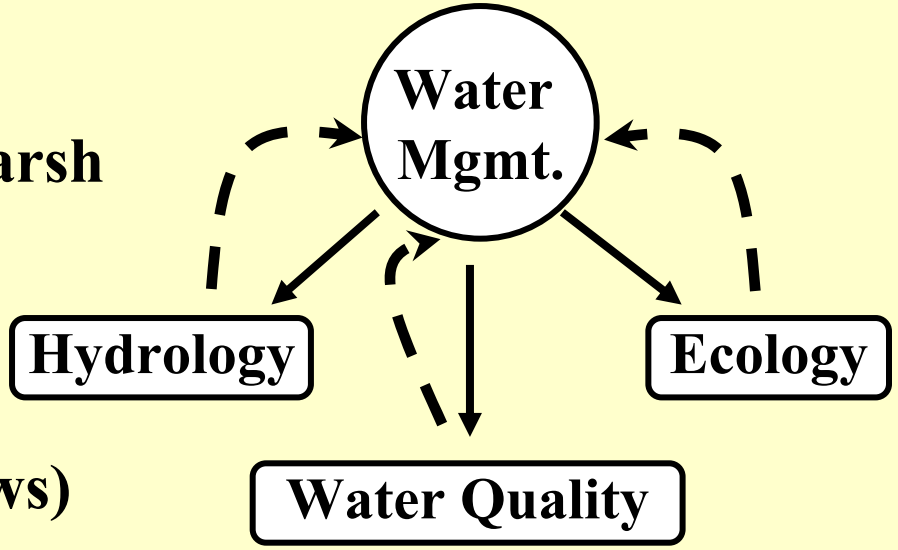



Inflow
Outflow
Flow (cfs)
4000
3000
2000
1000
Jan-05
Mar-05
May-05
Jun-05
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06
Marsh
Canal
Stage (ft)
16.5
16.0
15.5
14.5
Jan-05
Mar-05
May-05
Jun-05
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06


Distance from canal (km)
0
1
2
3
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
350 uS/cm
500 uS/cm
Distance from canal (km)
0
1
2
3
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
350 uS/cm
500 uS/cm

Learning & Resource Management

- **Pumped inflow should be of short duration when canal and marsh stages are similar**
- **Inflow can be higher when marsh stages are greater than 0.5 ft higher than canal stages**
- **Inflow should cease (or have comparable or greater outflows) when canal stages are greater than 0.25 ft higher than marsh stages**
- **If greater volume or duration of inflows are needed, maintain high outflows**

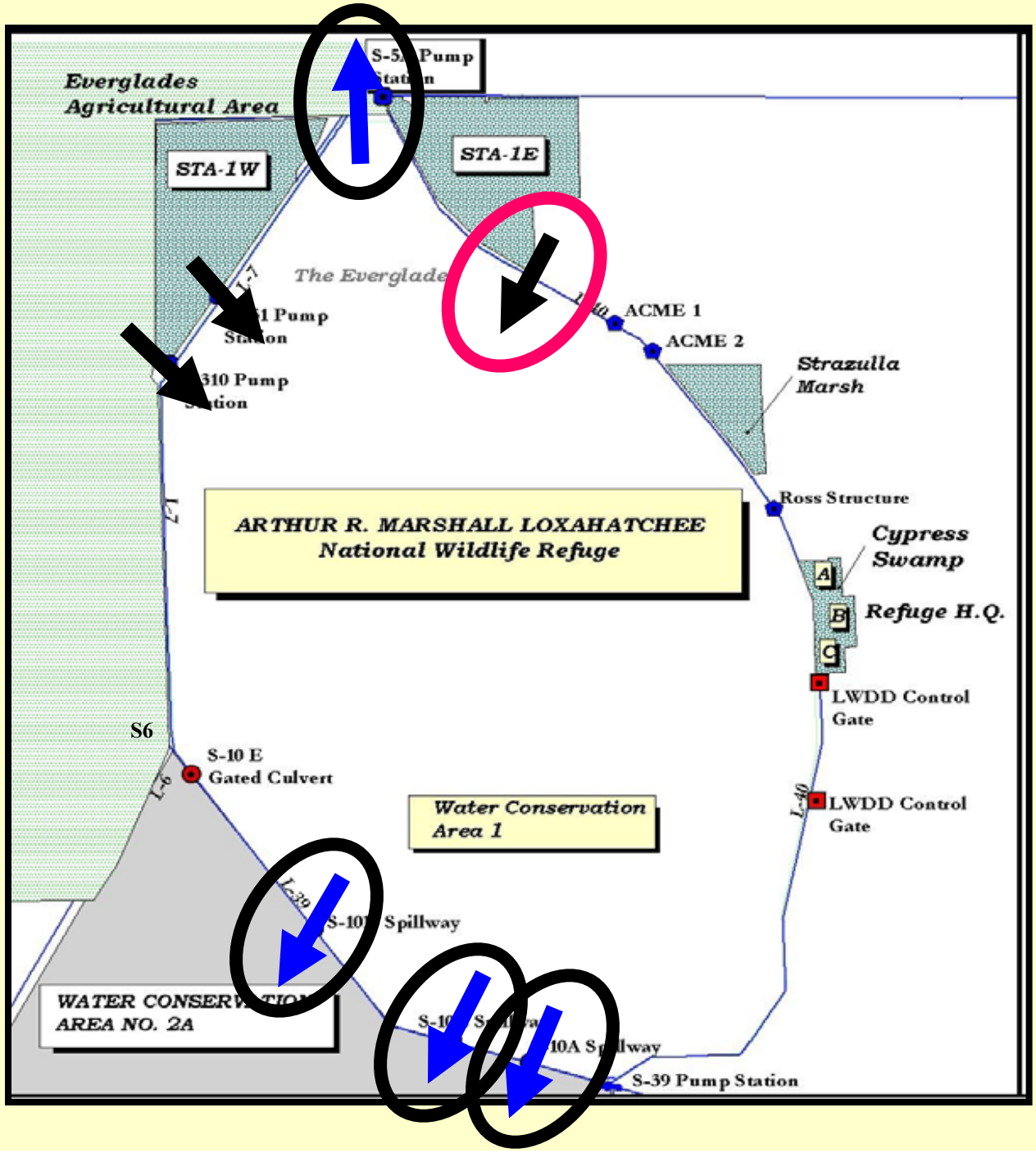


☆Adaptive Management ☆ in a Learning Environment

Utilizing Knowledge for Management Decision Within an AM Framework

Case Study Scenario: (February, 2008)

- **STA-1E discharges usually limited to < 550 cfs**
- **Rapid increase in water entering STA-1E (rain, inflows)**
- **Possible resource management questions:**
  - **What are options for minimizing impacts?**
  - **What is likely outcome based on learned knowledge?**
  - **What can be done to learn from the event?**
  - **Is risk acceptable enough to receive additional discharges from STA-1E?**



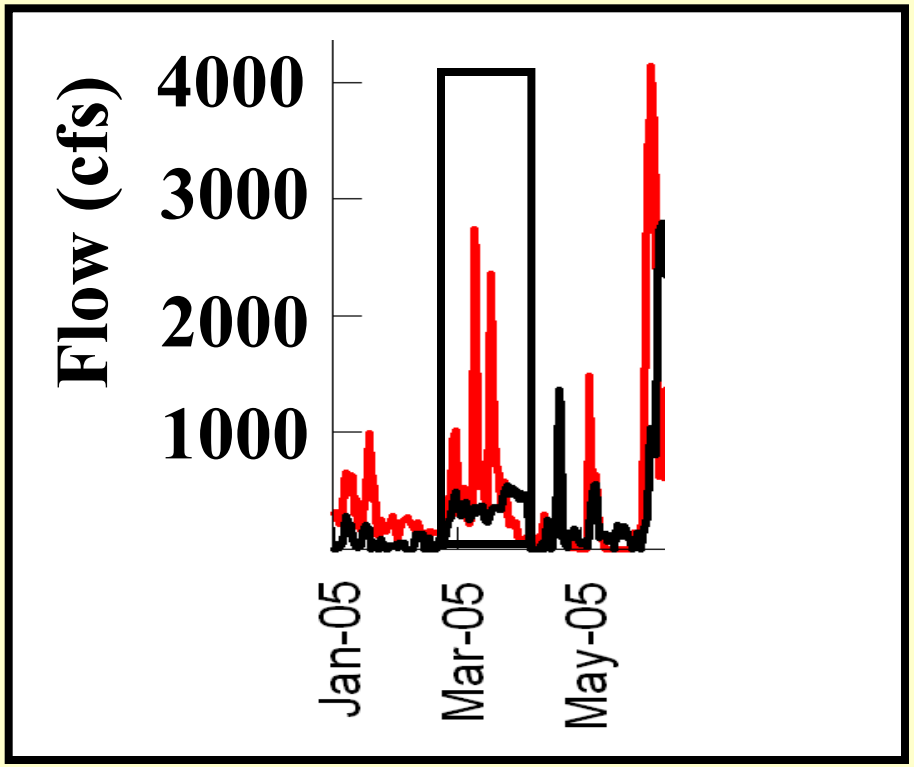
Proposed Increased Inflows

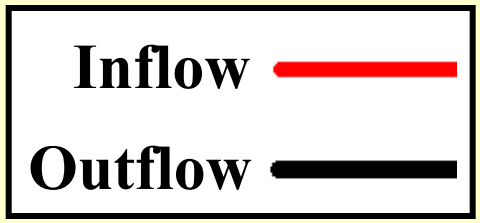
Previous Conclusion:

"If greater volume or duration of inflows are needed, maintain high outflows."

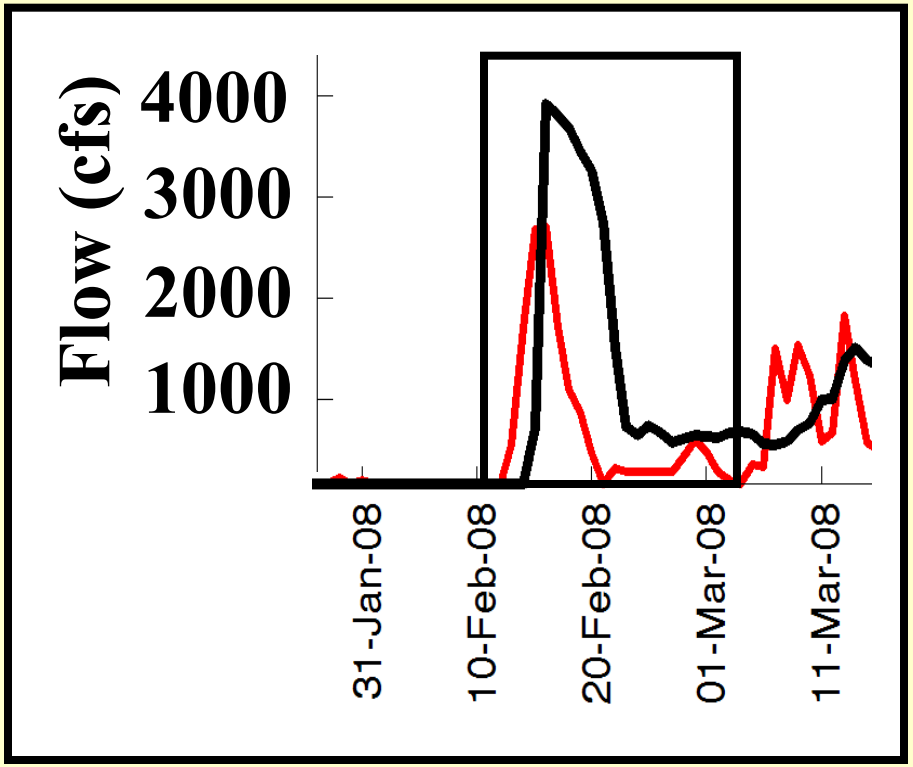
Timing/ Extent Outflows

Learning from AM experiment

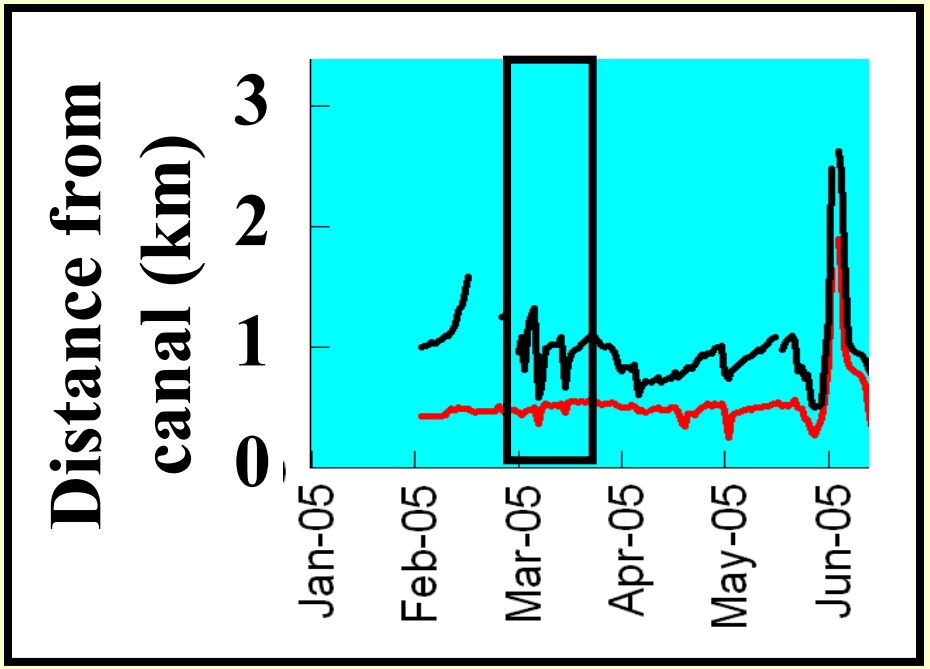




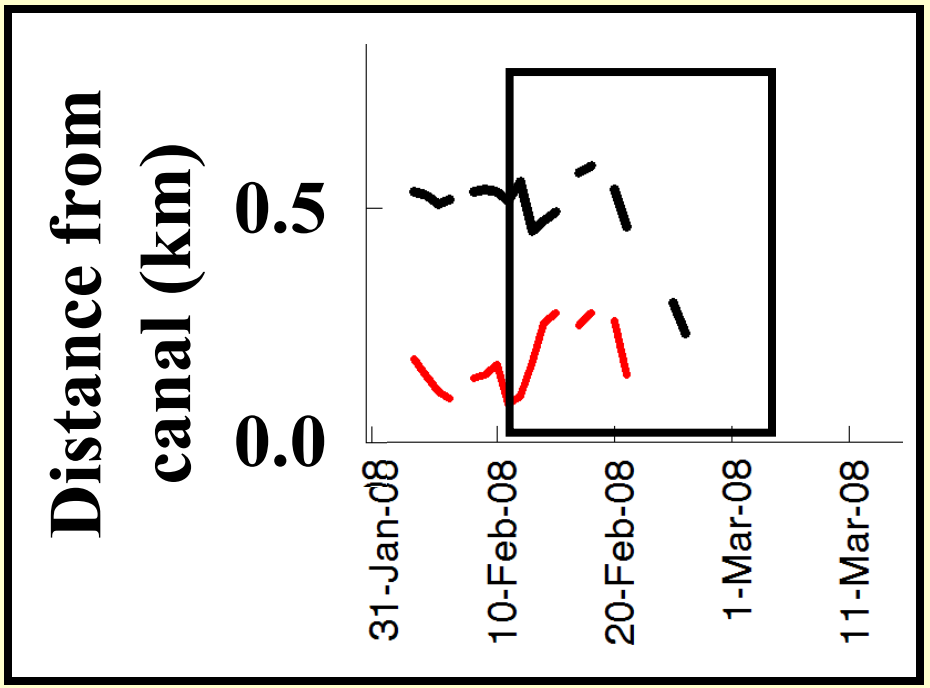
Mar. 2005	Feb. 2008
High Inflows	High Inflows
Low Outflows	High Outflows



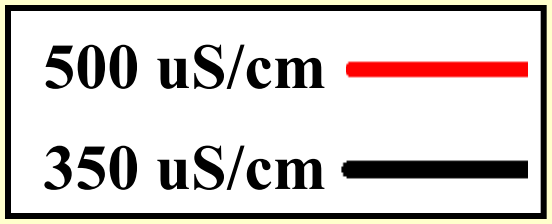
Learning from AM experiment



Mar. 2005	Feb. 2008
High Intrusion	Moderate Intrusion
0.5 – 1.25 km	0.25 – 0.6 km



Intrusion by STA-1E



Science for Resource Management

Information	Then	Now
• Structure Operations	Available	Available
• Canal & Marsh Stage	Available	Available
• Tracking Canal Water Movement		Transects at inflows
• Water Quality in Marsh	14 stations	> 52 stations
• Modeling	Limited	More extensive
• Ecological Effects	Limited	More extensive
• Management Recommendations	Present	Continued to be refined

Key Messages

- **Science-based approach fosters expert knowledge**
- **Directed knowledge plays integral role in better assessing consequences & risks**
- **Resource management flexibility can be increased**
- **Increased flexibility provides additional opportunities for learning**

Thank You & Questions

Snail kite chicks – July, 2008

Photo: Ed Bullington

Oliver Ray Baranski – July, 2008