

Quantifying the Water Quality Benefits of a Restored Tidal Stream Using Intensive Nitrate and Flow Monitoring

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Introduction

- In a joint effort between NCSU, the NC Ecosystem Enhancement Program, and the NC Coastal Federation 14 ha of salt marsh and 1000 m of tidal stream were restored (Figure 1) at North River Farms (Figure 2) in 2005 and 2006
- Goals for the salt marsh and tidal stream restoration:
 - Restore habitat
 - Reduce nutrient loads reaching the North River
 - Provide design guidance for future salt marsh restoration projects in coastal North Carolina

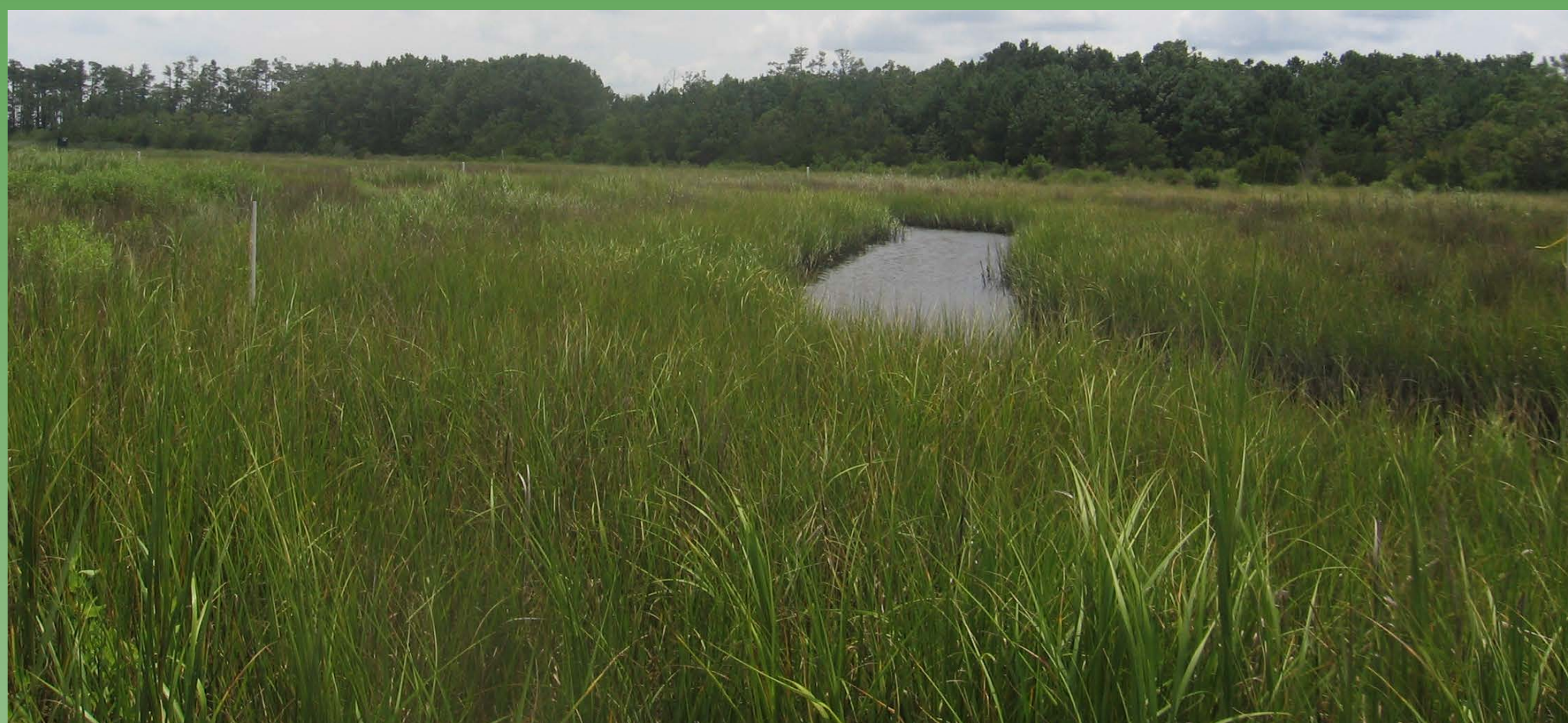


Figure 1. The restored salt marsh and stream three years after construction and planting were completed.

- Upstream row crop agriculture is a large source of nutrients to the North River
- Reduction of nutrient loads by salt marshes is used to promote restoration
- Quantifying the reduction in nutrient loads is difficult due to complex patterns of flow and nutrient dynamics
- Recently developed technology allows for intensive monitoring of nutrient concentrations

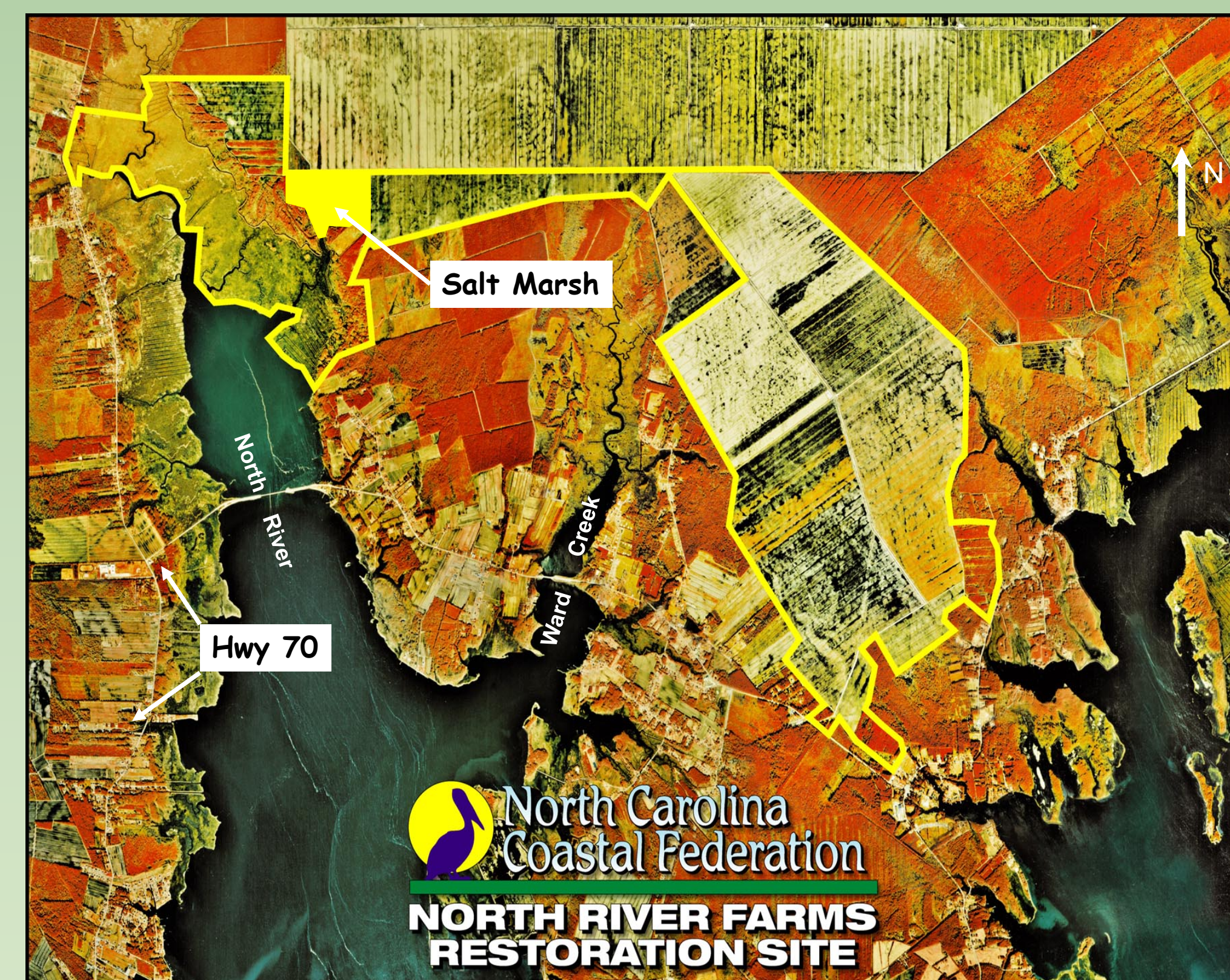


Figure 2. Location of the salt marsh restoration at North River Farms

Research Questions

- Can in-situ UV-Visual spectrophotometers be used to continuously monitor the nitrate ($\text{NO}_3\text{-N}$) concentrations in a tidal stream?
- Does the restored system serve as a source or sink of nitrogen?
- How much nitrogen is removed or released by the system?

Continuous Monitoring Methods

- Monitoring goal: Use continuous flow and $\text{NO}_3\text{-N}$ monitoring to determine the mass of $\text{NO}_3\text{-N}$ entering and leaving the system
- Upstream/downstream monitoring design (Figure 3)
- Equipment used to monitor flow at each station:
 - Doppler velocity meter
 - Wooden trapezoidal flume
 - Pressure transducer water level recorder

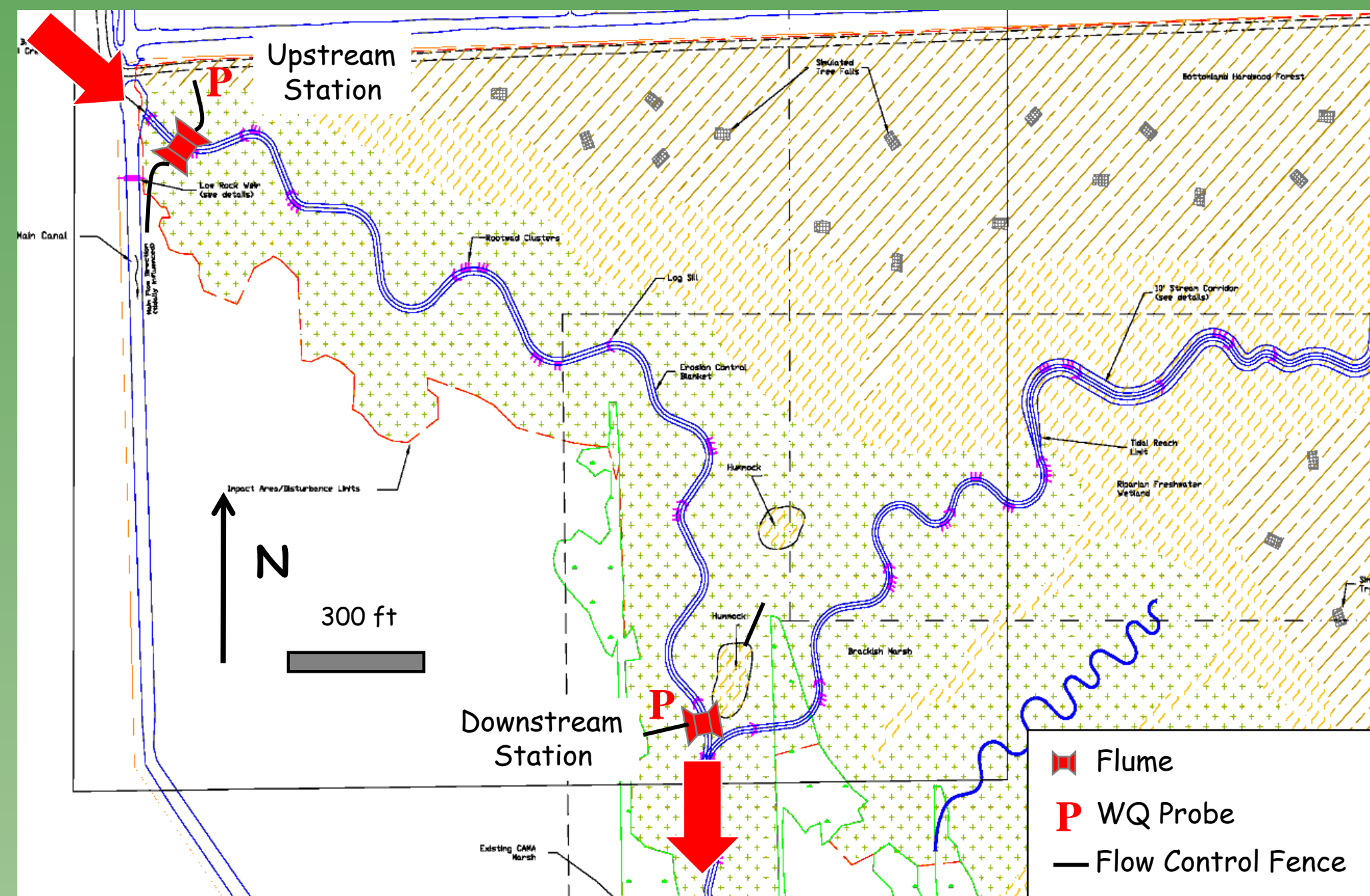


Figure 3. Design plan for the restored salt marsh and the upstream/downstream monitoring.

- UV-visual spectrophotometer (Figure 4) measures absorbance of water from the UV to visual range
- $\text{NO}_3\text{-N}$ concentrations are calculated from the absorbance
- $\text{NO}_3\text{-N}$ concentrations from probes are calibrated to laboratory values



Figure 4. UV-Visual spectrophotometer in the restored tidal stream in March 2011.

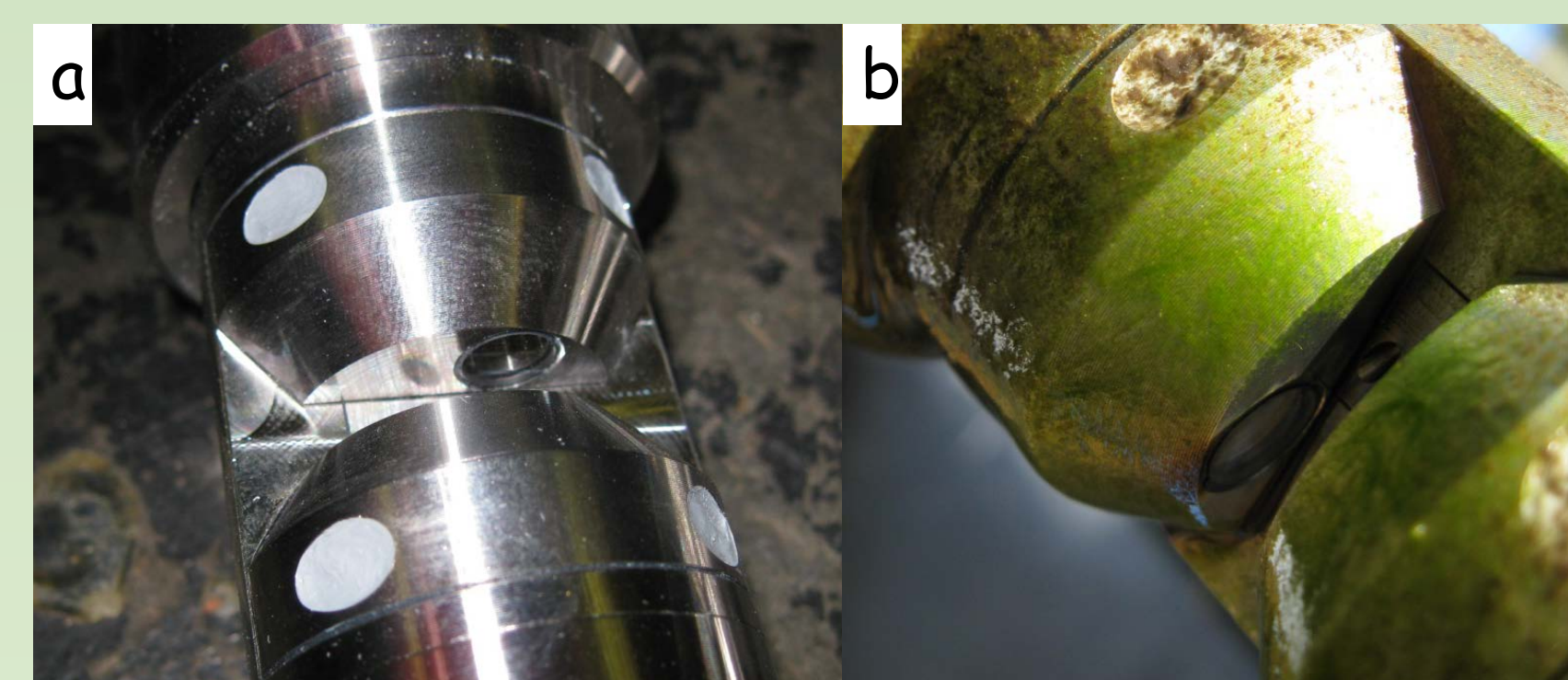


Figure 5. a) Clean spectrophotometer in the lab. b) Spectrophotometer after being submerged in the stream for one week. The slight brown area just to the left of the measurement window is visual evidence of fouling.

Results

UV-Visual Spectrophotometer Evaluation

- Probes initially installed in the tidal stream (Figure 4)
- Fouling greater than expected
- Visually obvious (Figure 5) and seen in sudden concentration drops after cleaning (Figure 6)
- Thought to be caused by Fe and Mn oxide precipitation on measurement windows

Evidence of Fouling

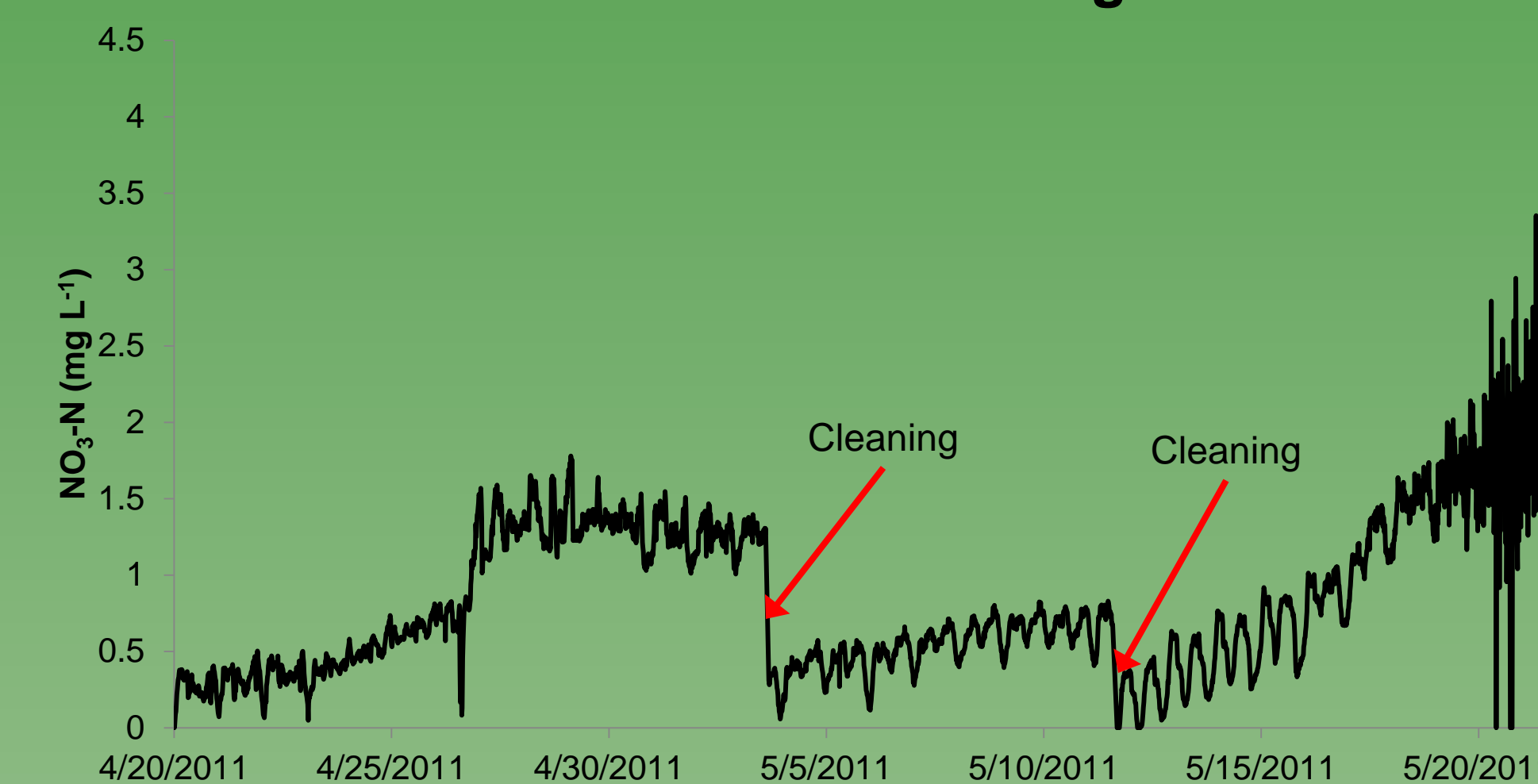


Figure 6. The steady increase in $\text{NO}_3\text{-N}$ concentrations following cleaning is evidence of the severe fouling that occurred with the probes installed in the stream.

- Solution: Remove probe from the stream and pump water to the probe (Figure 7)
- Pumping system sequence:
 - Pump water from the stream to the spectrophotometer
 - Take measurement
 - Drain stream water and purge the system
 - Rinse the measurement windows with pressurized tap water
- Result: Fouling greatly reduced



Figure 7. The downstream monitoring station in July 2011 after the spectrophotometer was removed from the stream.

Short-term Mass Balance

- The mass of $\text{NO}_3\text{-N}$ entering or leaving the salt marsh was calculated every 15 minutes for one week in March 2011
- Normal tidal flux (Figure 8) and storm flow (Figure 9) were observed during this week
- Mass balance result: 2 kg of $\text{NO}_3\text{-N}$ removed in one week

Nitrate Flux and Stream Flow During a Normal Day

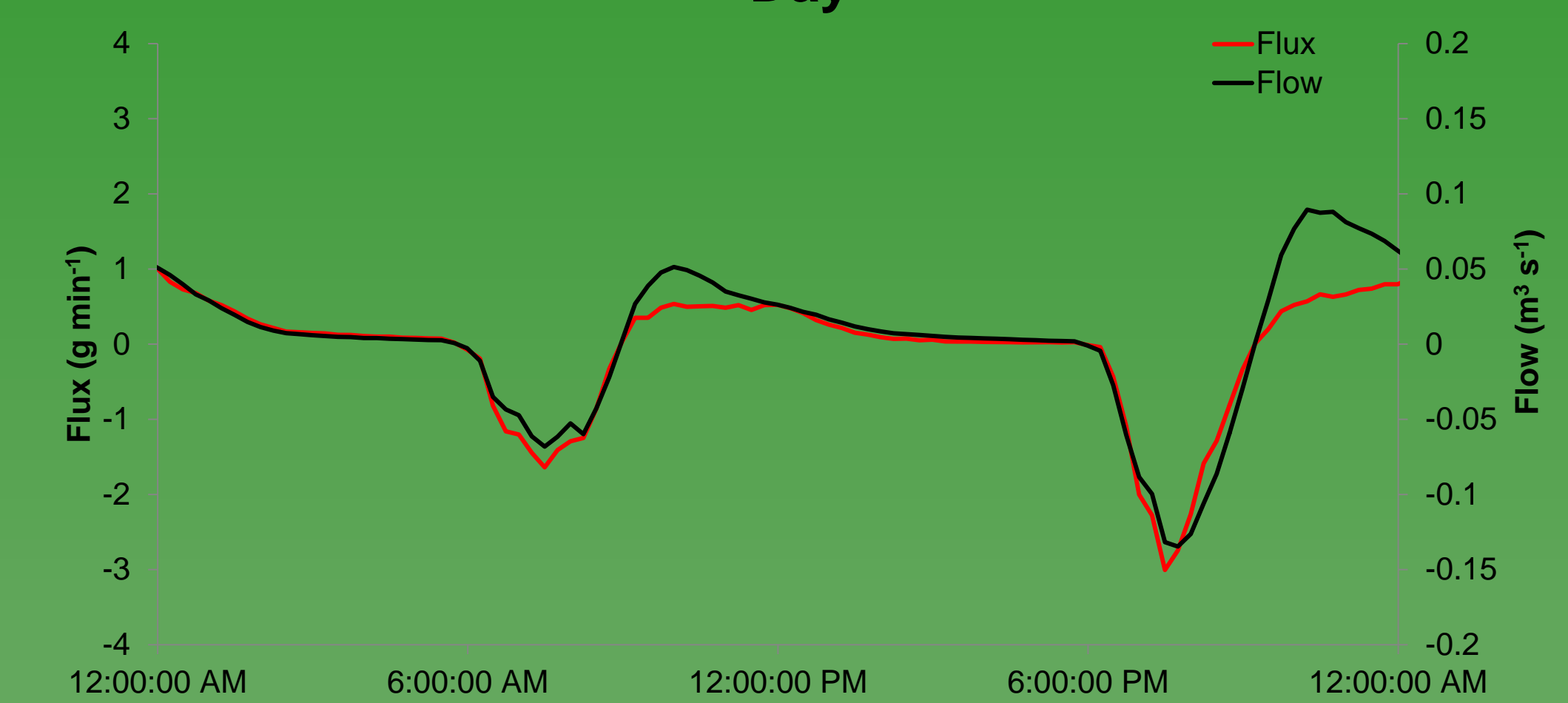


Figure 8. The stream flow and flux of $\text{NO}_3\text{-N}$ for March 3, 2011 at the downstream station. Note: positive flow/flux is going out to the estuary and negative flow/flux is coming into the marsh.

- Approximately 21 mm (0.8") of rain fell on March 6, 2011
- Storm flow (Figure 9):
 - Shown as a reduction in magnitude of negative flow as the tide is rising instead of a large peak in the hydrograph
 - The peak in $\text{NO}_3\text{-N}$ flux is caused by a spike in the $\text{NO}_3\text{-N}$ concentration.
 - The source of $\text{NO}_3\text{-N}$ is likely the upstream agricultural production.

Nitrate Flux and Stream Flow During and Following a Rain Event

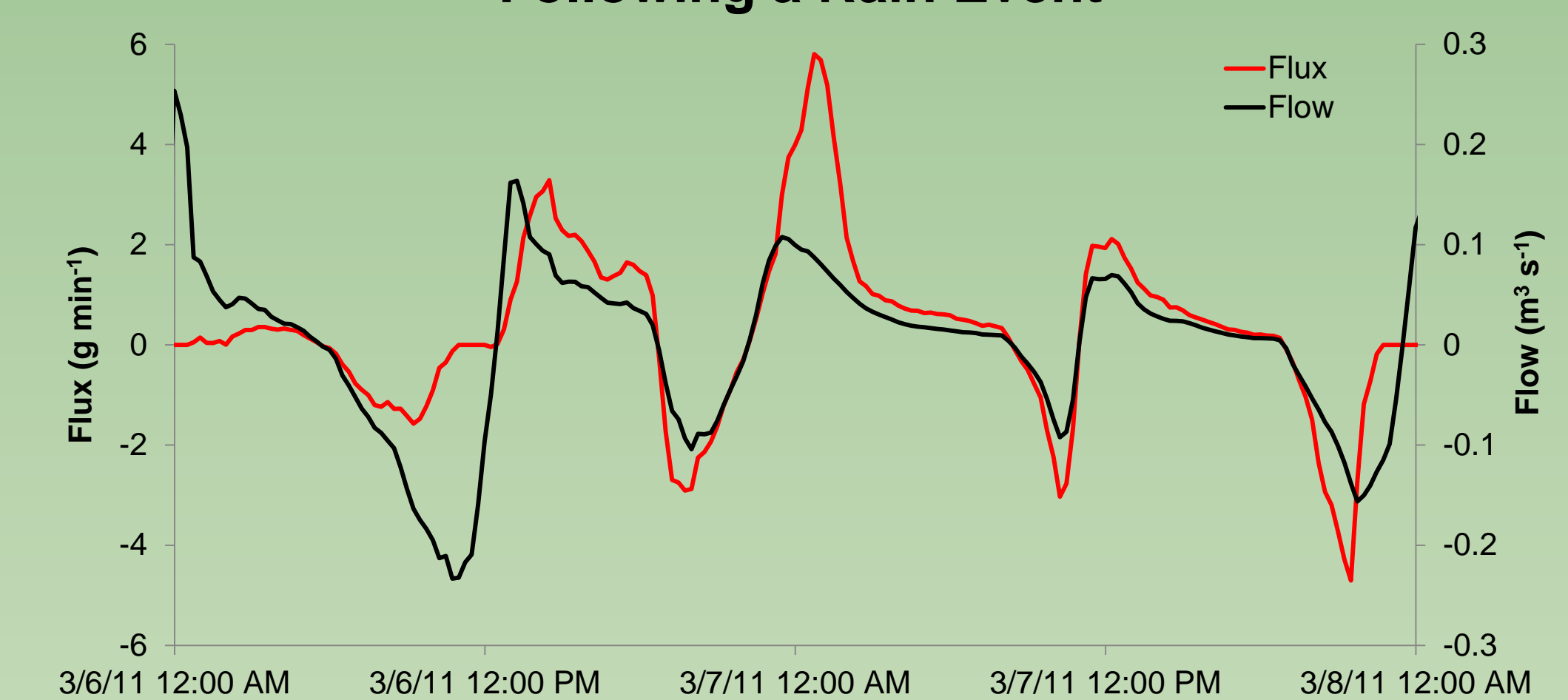


Figure 9. The stream flow and $\text{NO}_3\text{-N}$ flux for March 6-7, 2011.

Summary

- The primary difficulty of using UV-Visual spectrophotometers in a tidal stream is instrument fouling.
- Fouling can be reduced by minimizing the time the probe is exposed to the stream water.
- The probes provide a method of capturing important $\text{NO}_3\text{-N}$ flux events, such as storms, that are often missed in other sampling schemes.
- During one week of data collection 2 kg of $\text{NO}_3\text{-N}$ were retained in the restored marsh and tidal stream.
- Long-term mass balances will be developed now that the fouling has been reduced.

Research Funded by:

