The Utility of High Frequency Nutrient Monitoring in Post-Auditing of Nonpoint Source Load Estimating Models

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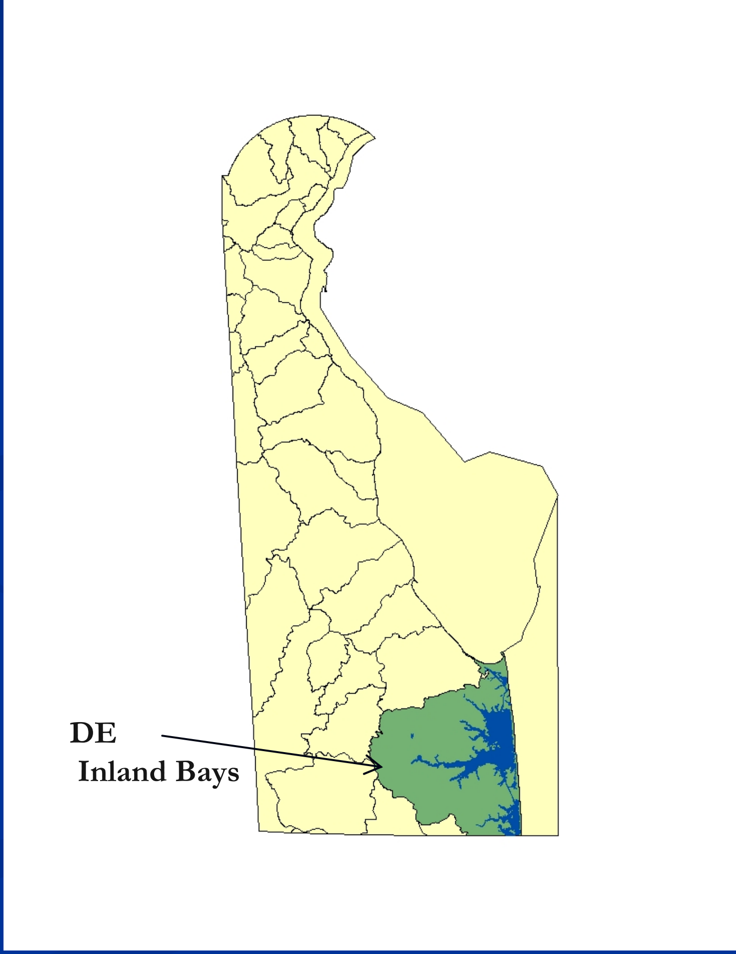
Presentation Outline

- Background information
- Installation of a Water Quality Data Analyzer (Greenspan, Aqualab®)
- Brief review of monitoring results
- Comparison of annual nutrient loads calculated using monitoring data with three nonpoint source load estimating models
- Closing remarks

Background

- DE Inland Bays Watershed has a drainage area of about 310 miles^2 (32 miles^2 of water)
- Waters of Inland Bays are impaired because of high nutrients and low dissolved oxygen
- A Total Maximum Daily Load (TMDL) was established in 1998 (and verified in 2005)
- The TMDL calls for:
  - Elimination of all point sources of nutrients
  - Reduction of nonpoint sources nutrients load by 40 to 85 percent



Background

- The cost of implementing TMDL: $200M in 10 years.
- While the TMDL is being implemented, DNREC looked for new technologies to accurately and cost effectively monitor nutrient loads and track progress
- Greenspan Aqualab Water Quality Analyzer we selected
- Aqualab was deployed in 2004 at the outflow of Millsboro Pond, the largest source of fresh water to the Inland Bays

GREENSPAN ANALYTICAL

Greenspan Aqualab®

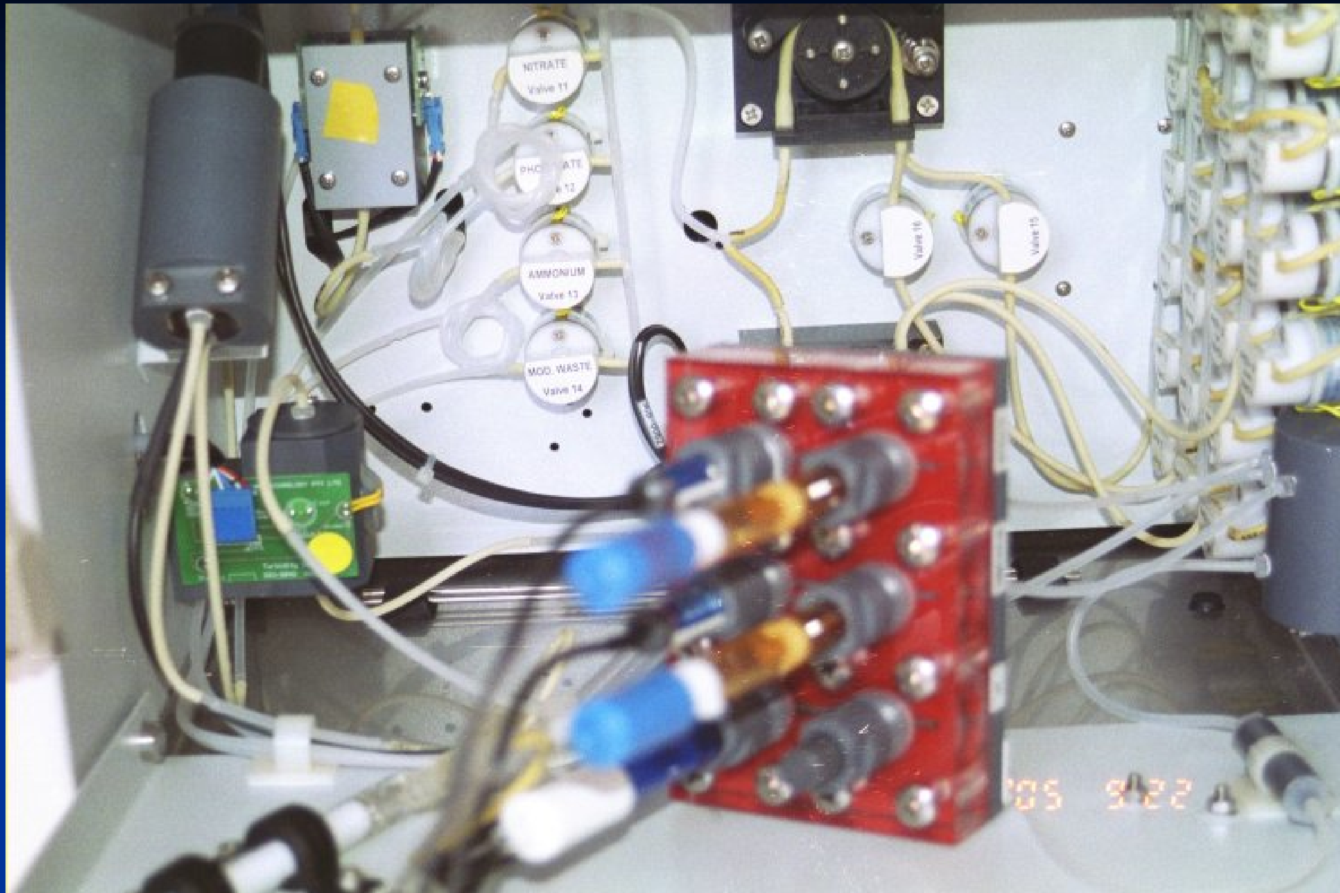
- Is a self-contained automated water quality analyzer
- It measures dissolved oxygen, pH, conductivity, temperature, turbidity, nitrate, ammonium, and phosphate at high frequency (up to every hour)
- It is programmed, controlled, and operated remotely

Aqualab Sampling

- Sampling starts at pre-programmed times. Sampling pump works for about 7 minutes to purge and flush the entire sampling lines. Then, a small sample is collected and sent to analytical module for analysis
- The instrument operates automatically and independently until an instrumental fault is detected resulting in system shutdown:
  - Leakage
  - Exhaustion of reagents
  - Exhaustion of memory
  - Accumulation of waste

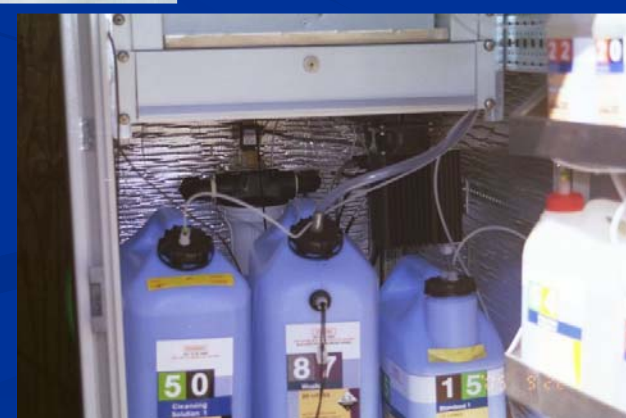
Aqualab Analytical Methods

- Nitrate and ammonium: Ion specific electrodes
- Phosphate: Spectrophotometry
- Turbidity: Nephelometry
- Dissolved oxygen, pH, conductivity, and temperature: Electrical sensors
- Internal standardization (by event or daily)



Analytical
Module

Reagent and
Waste Storage



Aqualab®

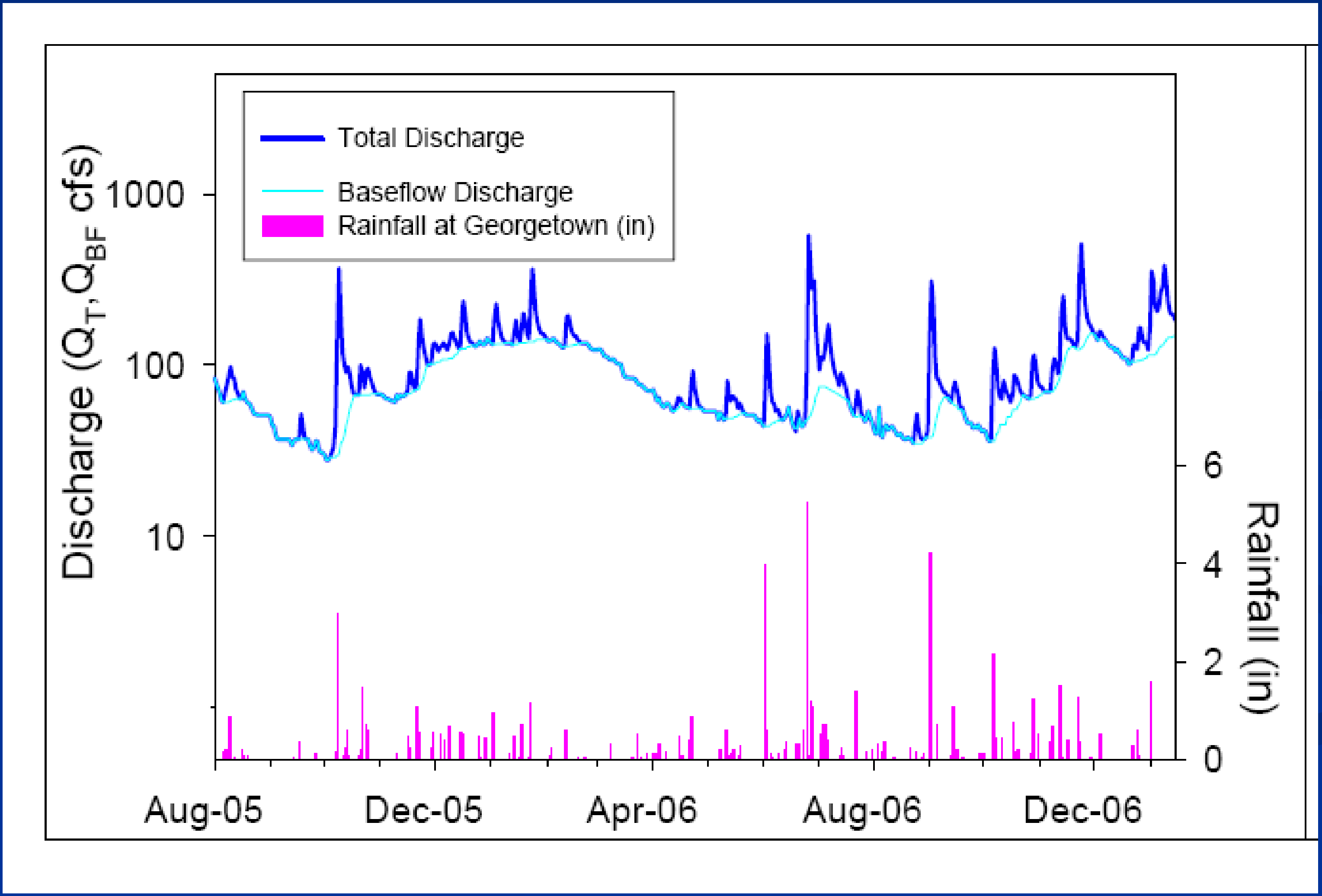
GREENSPAN
ANALYTICAL

Installation

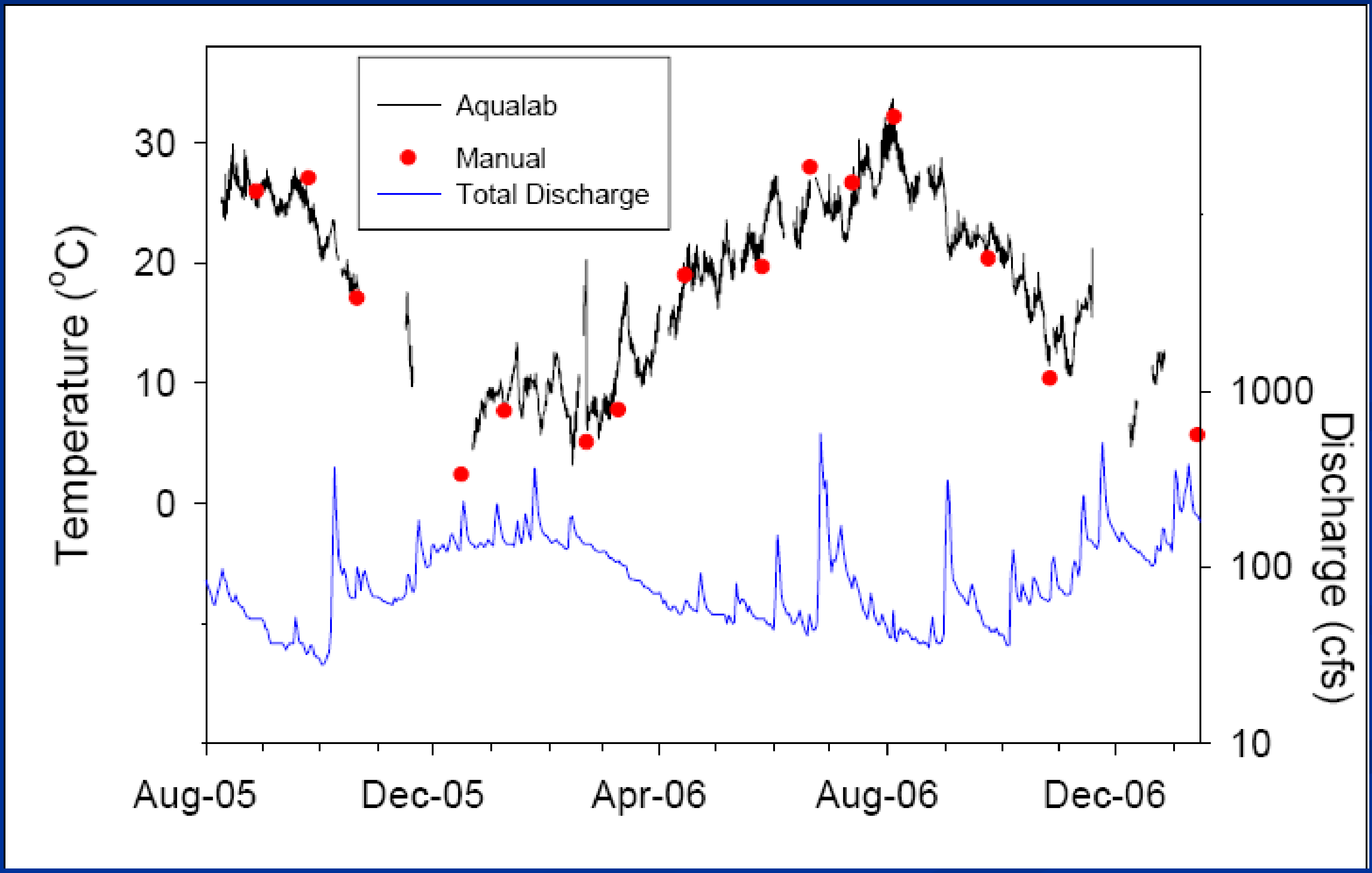
Monitoring Approach

- Temperature, specific conductivity, pH, dissolved oxygen, and turbidity: Hourly
- Nutrients: Every 4 hours
- In addition, baseflow manual sampling is conducted once or twice per month for comparison and quality control
- In general, there is good agreement between manual samples and samples collected by Aqualab

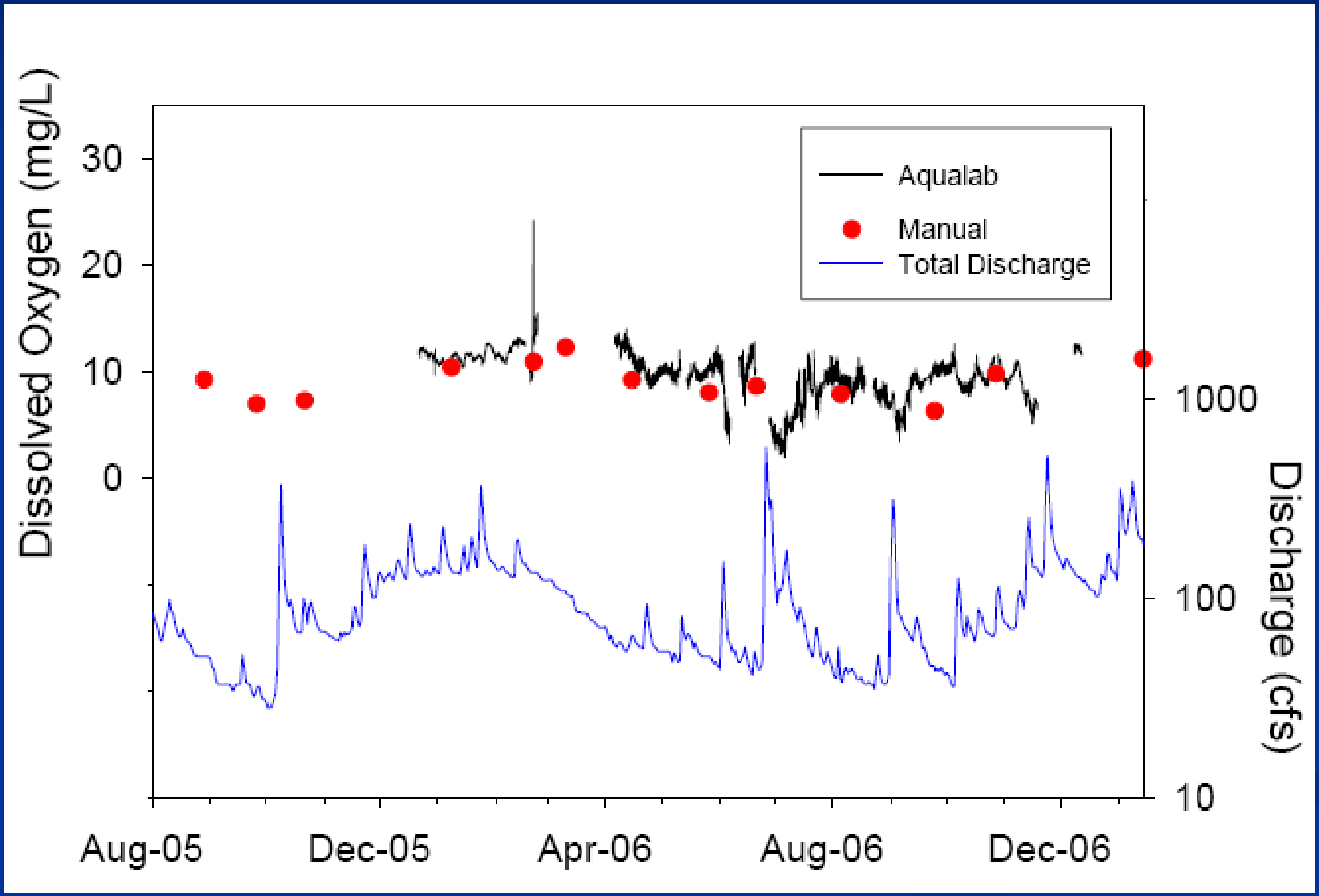
Stream Flow and Rainfall



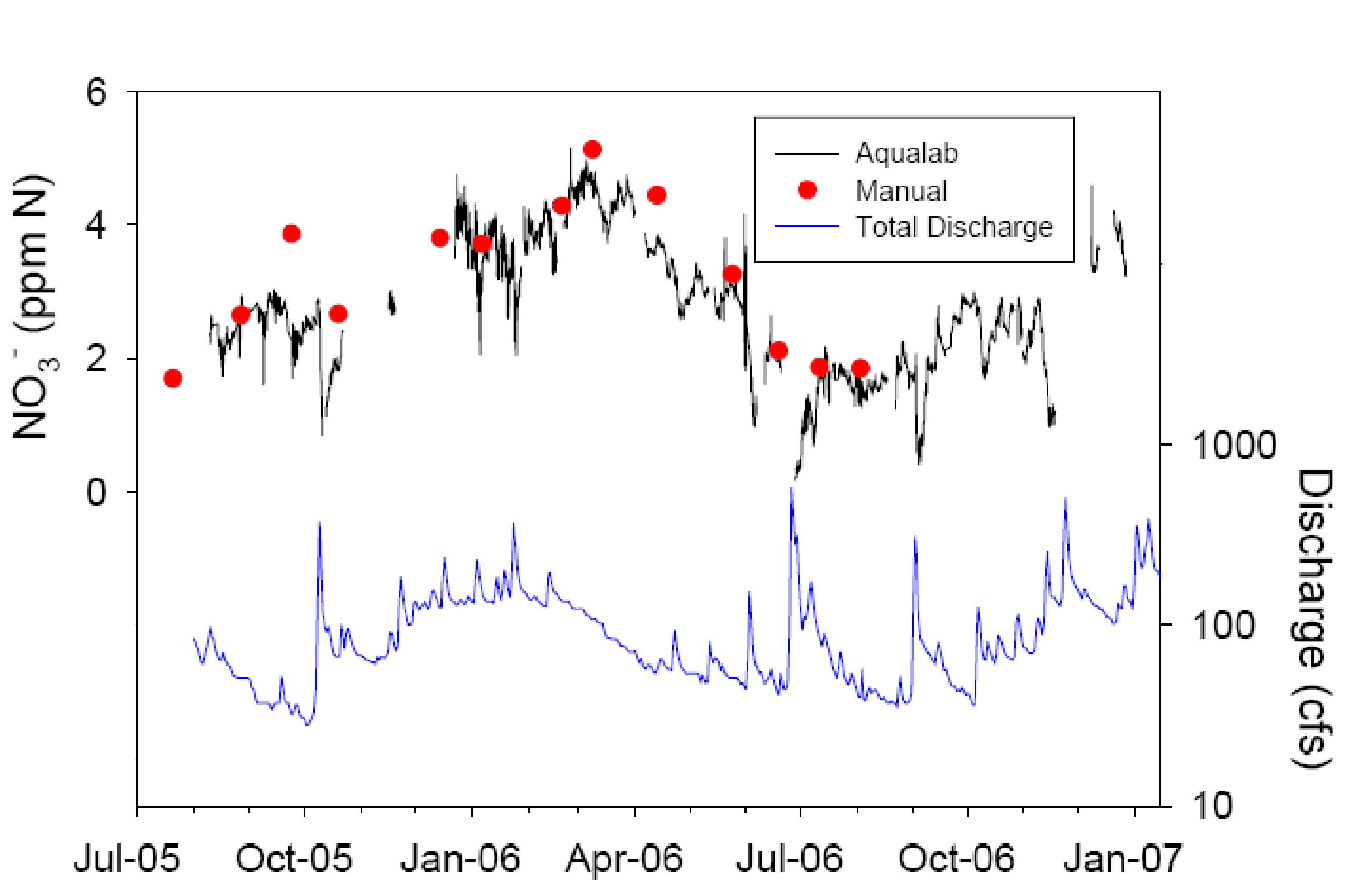
Comparison of Aqualab and Grab Samples for Temperature



Dissolved Oxygen

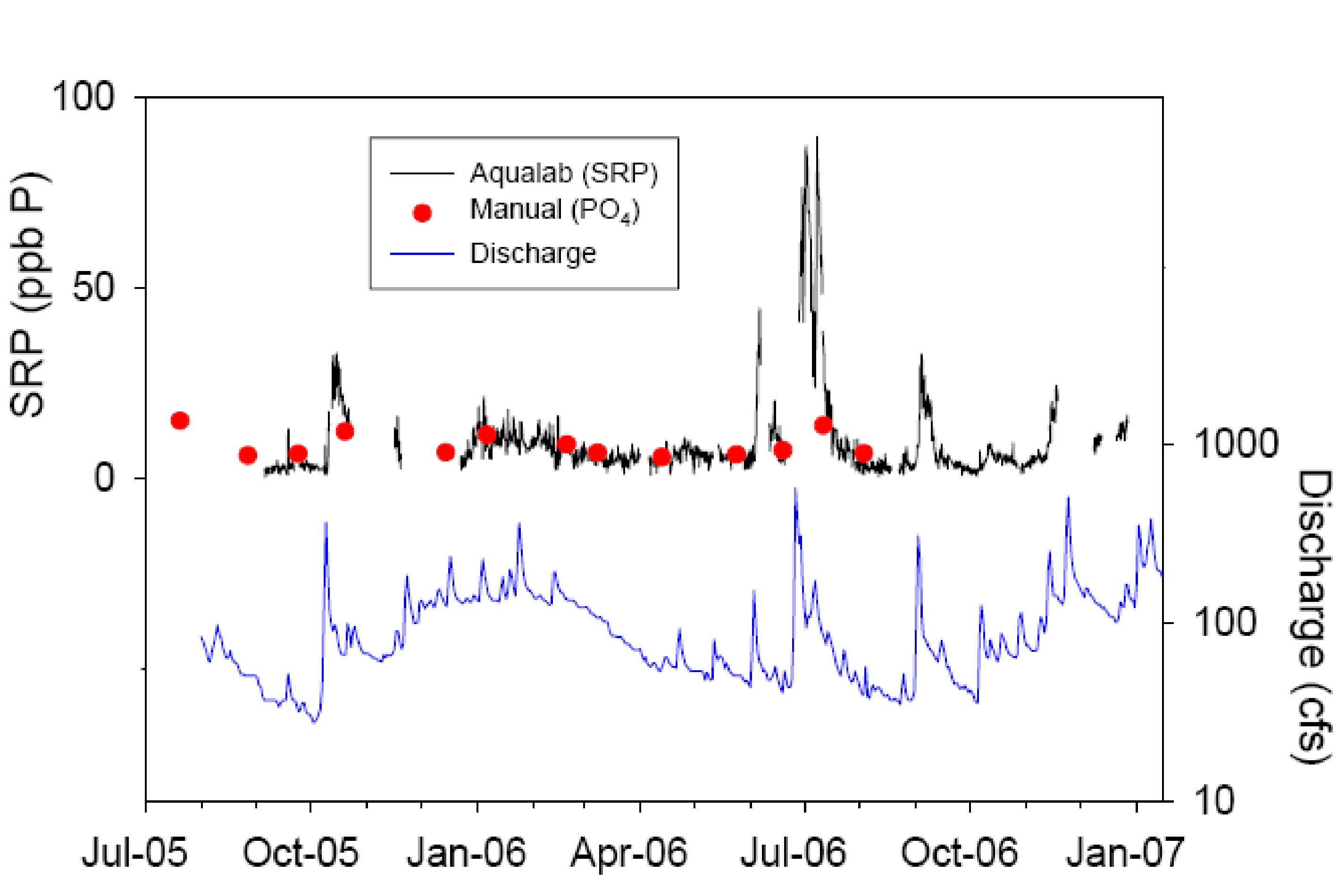


Nitrate (NO_3)

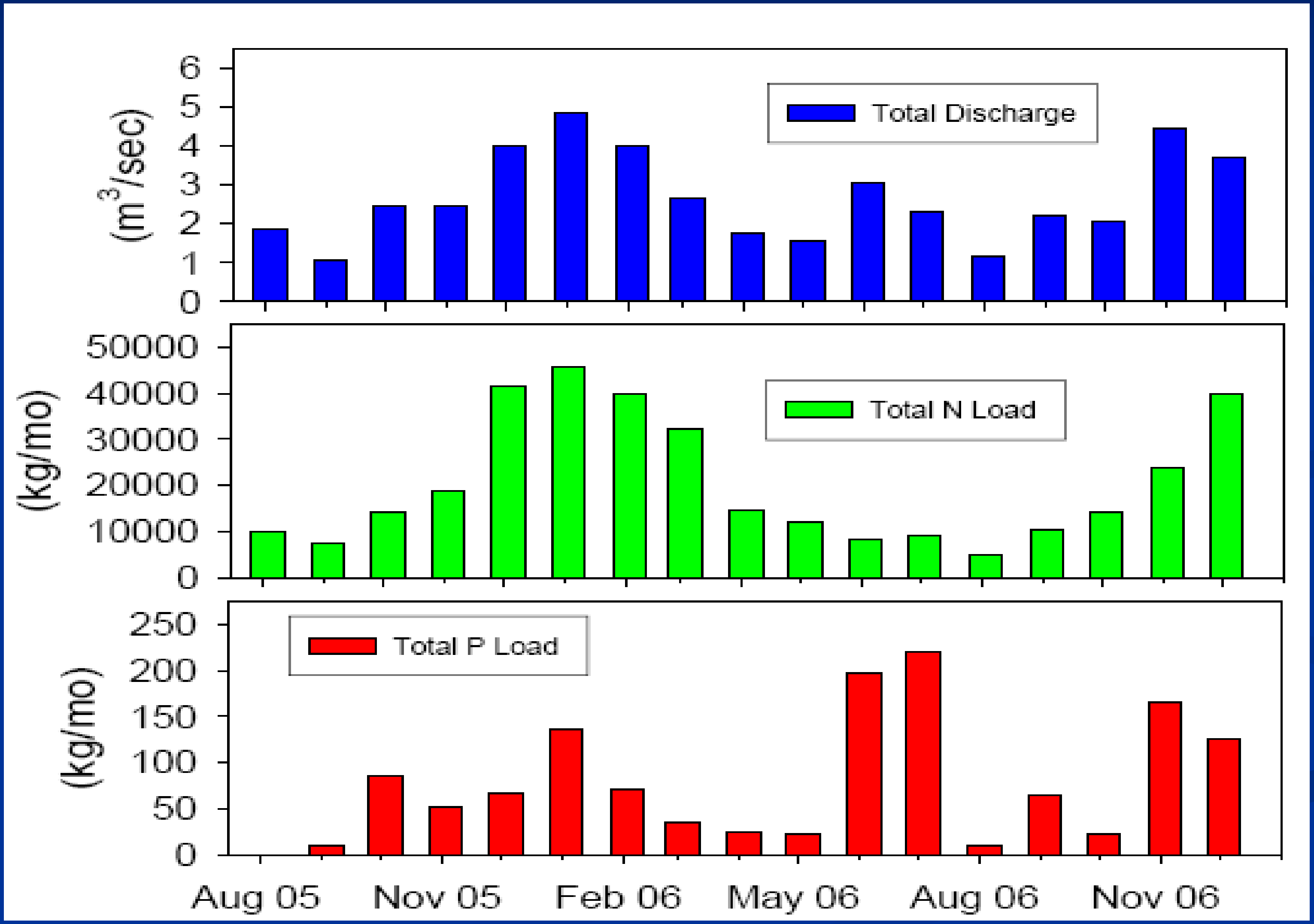


Aqualab
Manual
Total Discharge
NO3- (ppm N)
Discharge (cfs)
6
4
2
0
1000
100
10
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

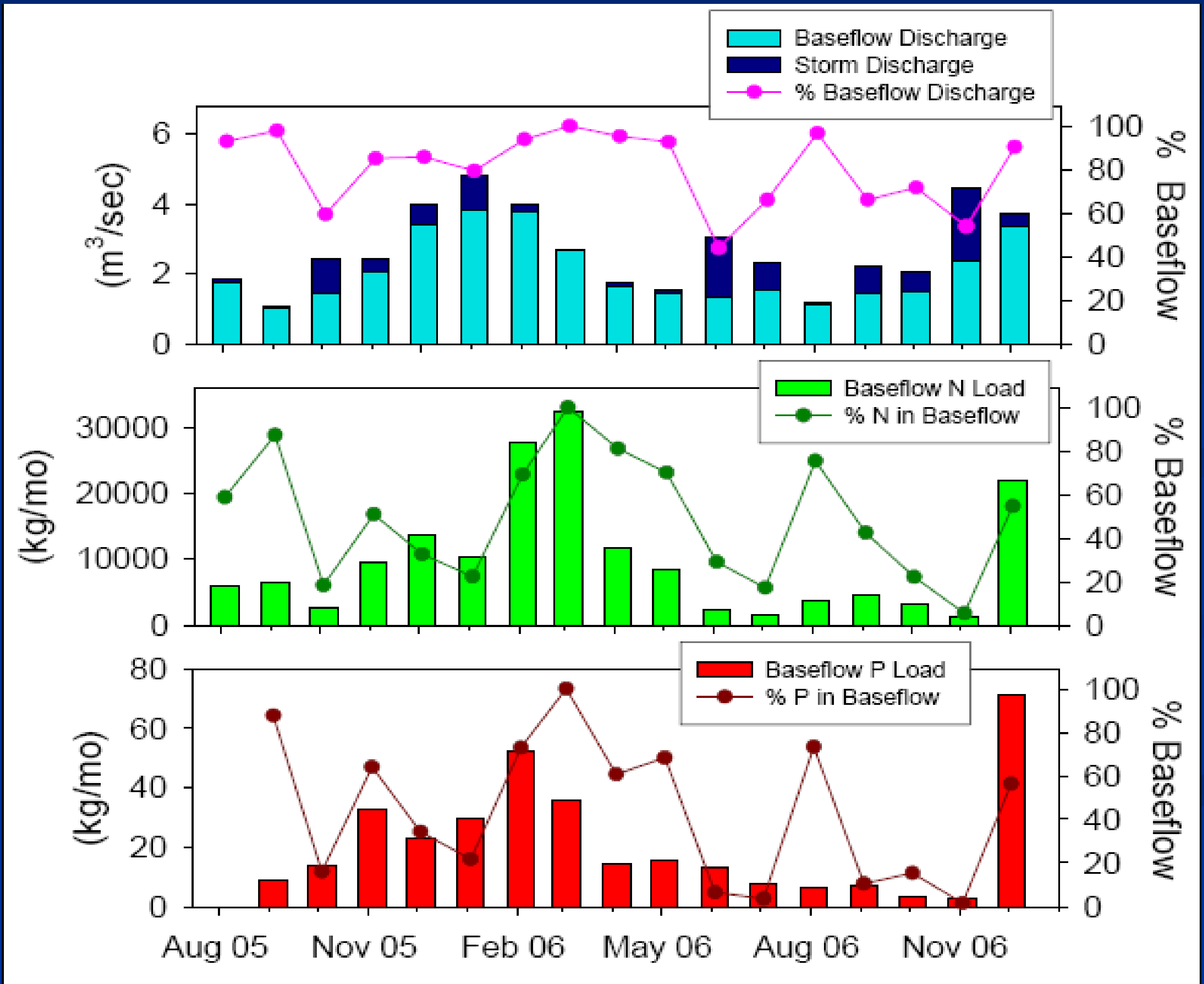
Orthophosphate (PO_4)



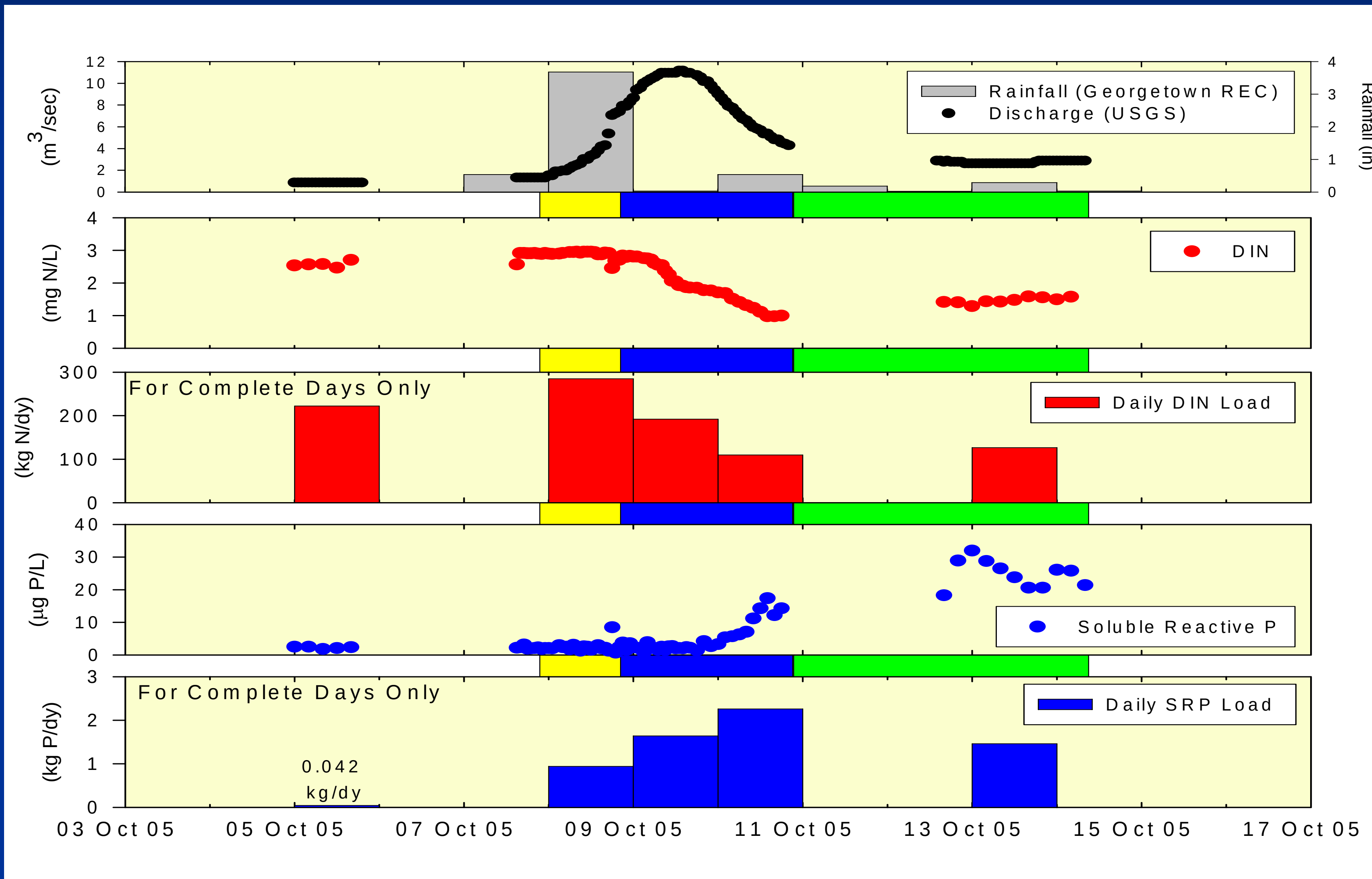
Monthly Discharge and Nutrient Loads



Monthly Discharge and Nutrient Loads



Nutrient Concentration and Loads During Storm Events



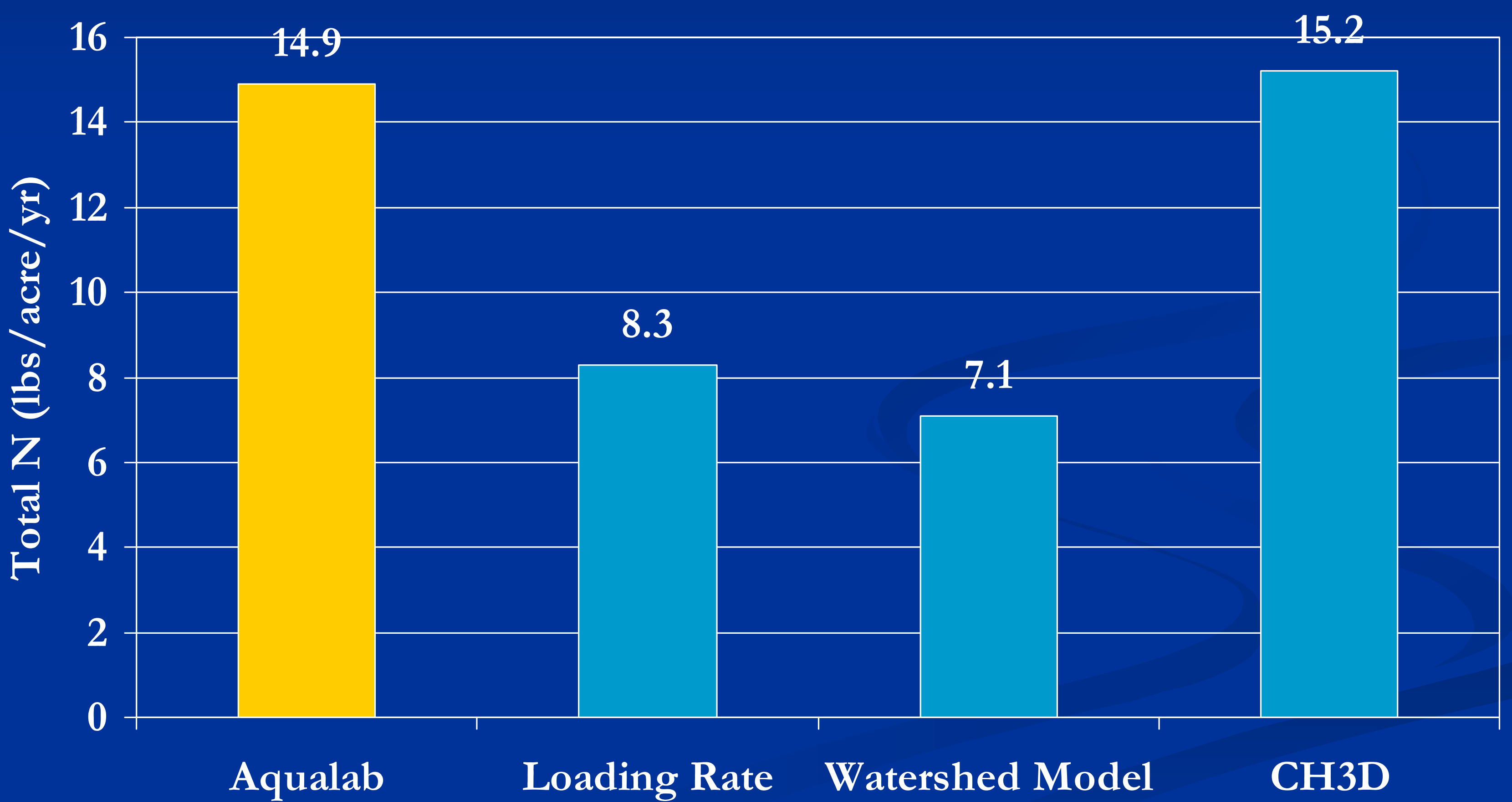
Calculating Annual Nutrient Loads

- Monitoring results for calendar year 2006 was considered
- Annual average flow: 98.4 cfs
- This is about 60 percentile of long-term annual average flow, classifying it as a "normal" year.
- Daily nutrient loads are calculated by multiplying average daily flow and average daily concentration
- Annual nutrients load:
  - Total N = 14.9 lbs/acre/yr
  - Total P = 0.1 lbs/acre/yr

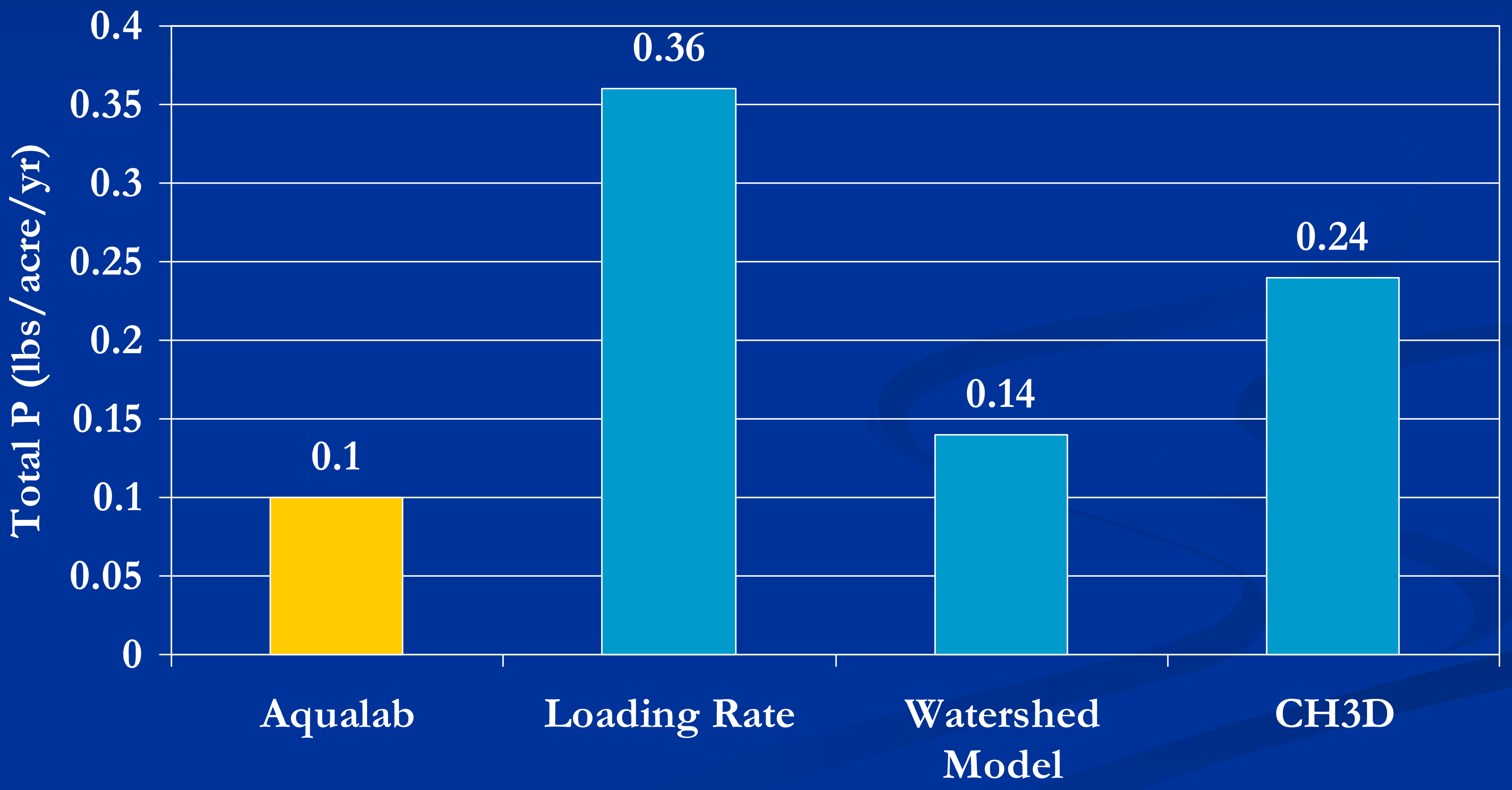
Previous Estimates of Annual Nutrient Loads

- During past several years, DNREC had used the following methods to estimate annual nutrient loads for the Inland Bays watershed:
  - Loading Rate Method
  - Watershed Model (HSPF Model)
  - Water Quality Model (US Army Corps of Engineer's CH3D-CE-QUAL Model)

Comparison of Estimated Annual Loads with Monitoring Results for Nitrogen



Comparison of Estimated Annual Loads with Monitoring Results for Phosphorus



Summary

- Total N:
  - The load estimating methods had produced reasonable results (all estimates were within $\pm$ 0.5 standard deviation of measured load)
  - The relative difference between modeled and monitored results were from -53% (for the CH3D model) to +2% (for the HSPF Model)
- Total P:
  - The load estimating models over-predicted phosphorus load with relative differences ranging from +52% (for the HSPF model) to 281% (for the loading rate method)
  - Overestimation of phosphorus load by models is probably due to the function of Millsboro Pond, which traps sediment and suspended particles

Concluding Remarks

- Installation of Aqualab Data Analyzer has allowed DNREC to collect cost-effective, high quality, and high frequency data
- Collected data has been valuable in accurate estimation of nutrient loads and in tracking progress toward achieving TMDL targets
- Collected data has provided ability to post-audit load estimating tools and make necessary adjustments, if necessary

Thank You!

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