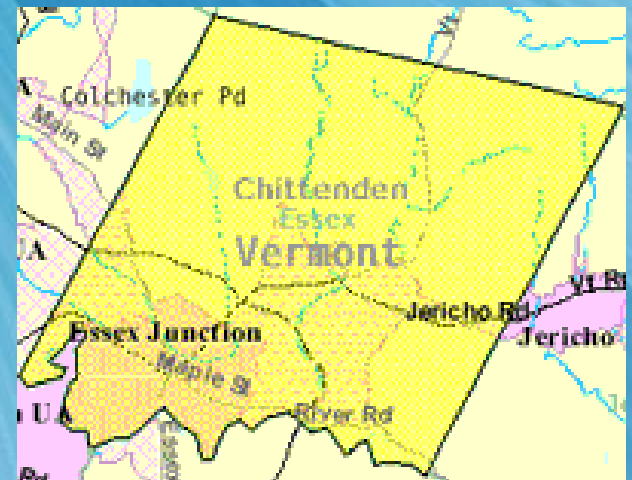
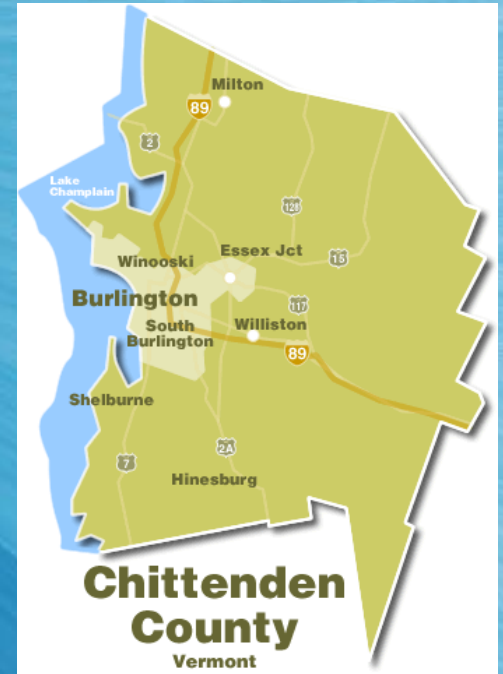
A photograph of a person standing inside a large, dark, corrugated metal culvert pipe that is partially submerged in a stream. The person is wearing a plaid shirt, shorts, and a hat. The stream water is murky and greenish-brown. The surrounding area is densely vegetated with various green plants and trees. The text is overlaid on the image in white with a black outline.

Sediment, Nutrient and Salt Pollution of Essex, Vermont, Streams

Ashley Wright and Suzanne Levine
Essex Waterways Association
and the University of Vermont

About Essex

- ◆ Second most populated Town in Vermont
 - ◆ Includes Essex Junction
 - ◆ Numerous suburbs
- ◆ Continued development encouraged by Town policies/spending
- ◆ Serious stormwater issues, no riparian buffer ordinance



The Essex Waterways Association

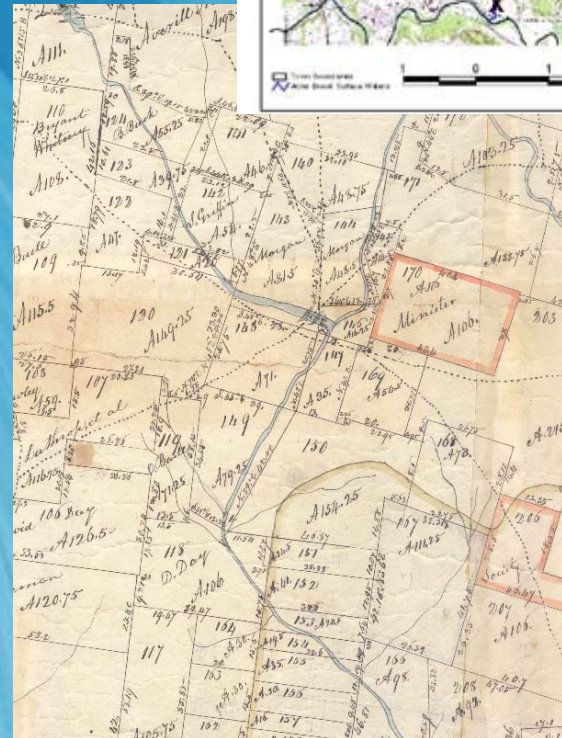
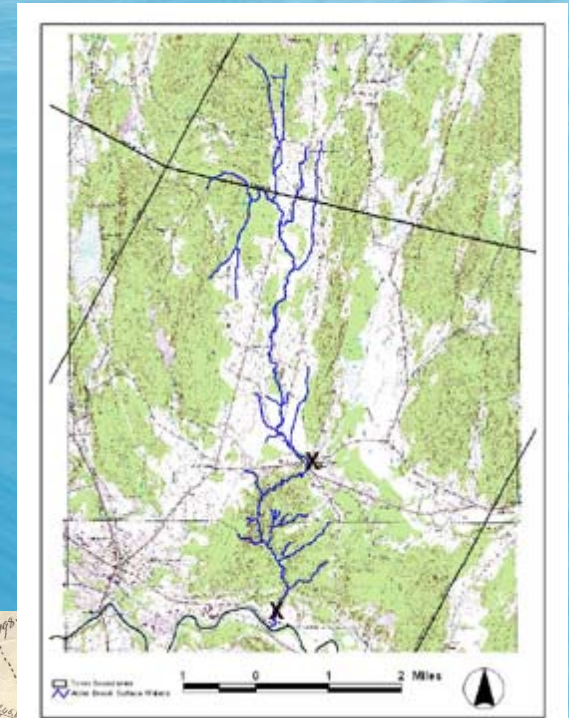
- ◆ Citizens group incorporated December 2005
- ◆ Mission: augment Town and State stewardship of streams and lakes through
 - ◆ Water quality monitoring
 - ◆ Geomorphic assessment
 - ◆ Restoration projects
 - ◆ Education
- ◆ LaRosa Partnership Grant in summer 2006

LaRosa project goals

- ◆ Gather data on water quality in three of Essex's five streams at multiple flow levels over an entire summer
 - ◆ DEC sampling focuses on high flow
 - ◆ Stream biology may be most sensitive to low-flow conditions
- ◆ Assess impact of urban-suburban landscape on pollutant levels
- ◆ Estimate flux of pollutants moving downstream

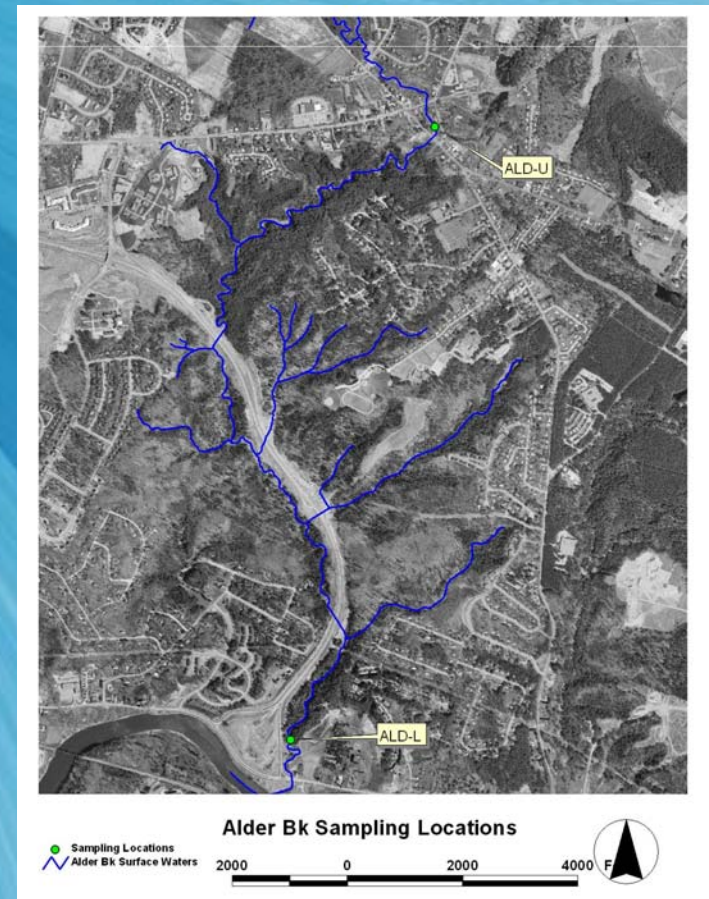
Alder Brook

- ◆ Tributary of Winooski River, once a tributary of the Browns
 - ◆ Diverted into sandy ravines by freshet of 1830, resulting in massive erosion for ~120 years
- ◆ Steeper gradient than other streams
- ◆ Substantial groundwater flow through sands



Alder Brook

- ◆ Erosion in lower reaches rejuvenated by building of Circumferential highway and neighborhood development
- ◆ Upper reaches largely agricultural but under development
- ◆ Classified as an “attainment” stream based on biology



Alder Brook



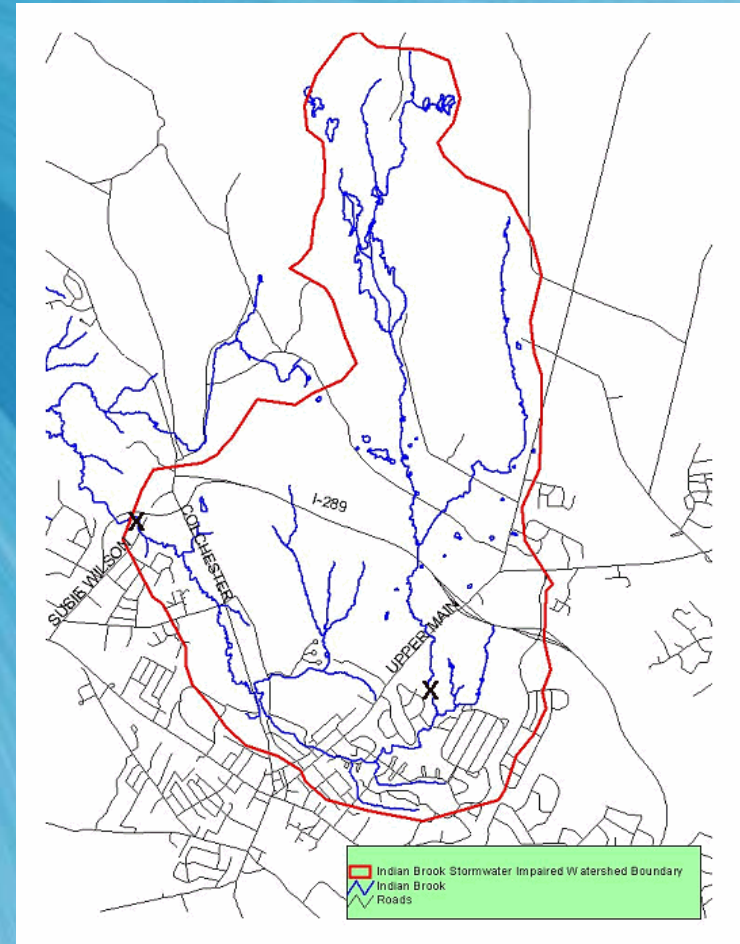
Upper



Lower

Indian Brook

- ◆ Initially passes through forest & low-density residential
- ◆ Then through Essex Junction & the Susie Wilson bypass area
 - ◆ Street drainage directed into stream through pipes
- ◆ Circumferential highway passes over twice
- ◆ Impaired



Indian Brook



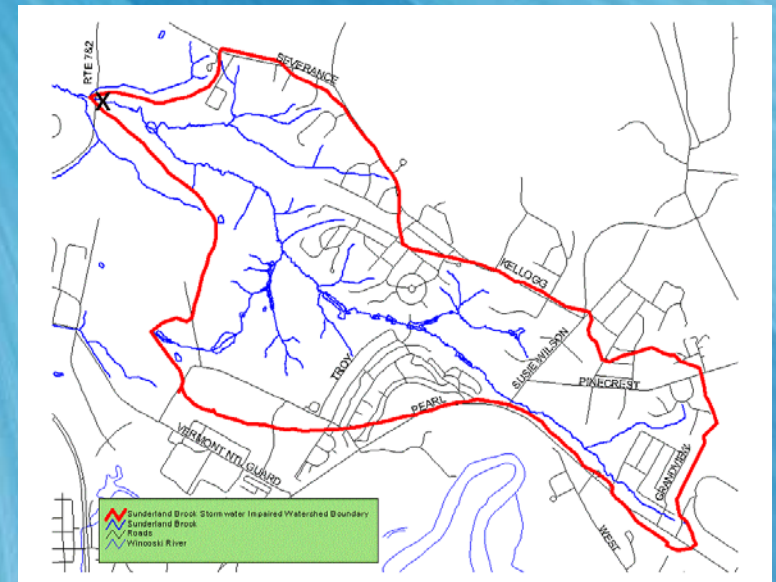
Upper



Lower

Sunderland Brook

- ◆ Arises in urban landscape
 - ◆ Highest pavement coverage of streams
- ◆ Then flows through forest and beaver dams (Fort Ethan Allen) before reaching EWA sampling site at Hwy 7
- ◆ Lowest gradient stream



Experimental Design

- ◆ Sampled before and after urban/suburban areas in Indian and Alder Brooks
- ◆ Put downstream sites at gauging stations to permit estimation of mass transport
- ◆ Sampled biweekly, June-September
- ◆ Sampled Alder Brook before, during and after a September storm (1.36 in of rainfall)

Methods: Sampling

- ◆ Collected samples for total P, total N, Cl, total suspended solids
 - ◆ Followed LaRosa protocol using pre-cleaned bottles
 - ◆ Sampled mid-stream, mid-depth
 - ◆ Pre-filtered chloride samples
 - ◆ Samples brought to Waterbury within 24 h



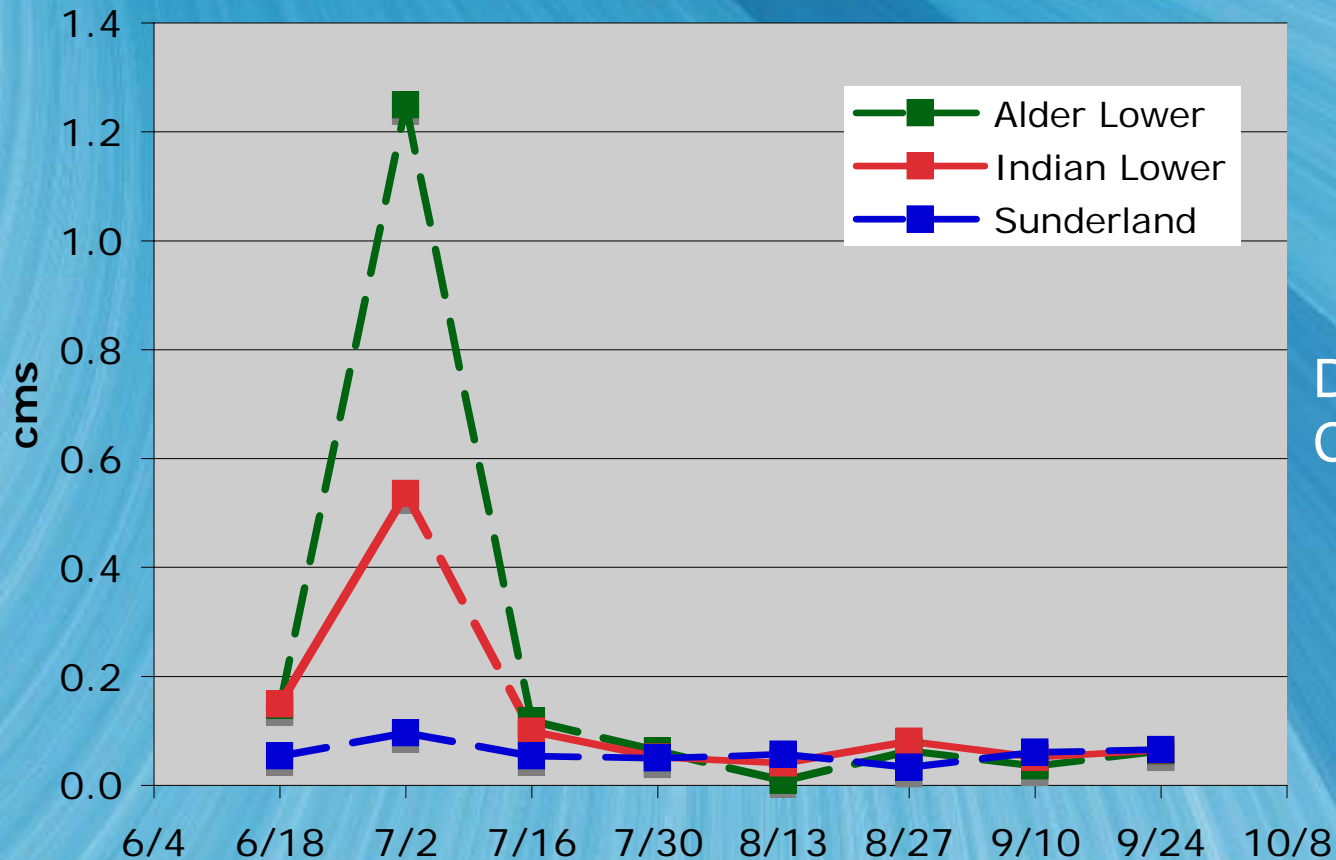
In-situ Measurements

- ◆ Turbidity, specific conductance, pH, dissolved oxygen and temperature measured with a Hydrolab



Stream Discharge during Sampling

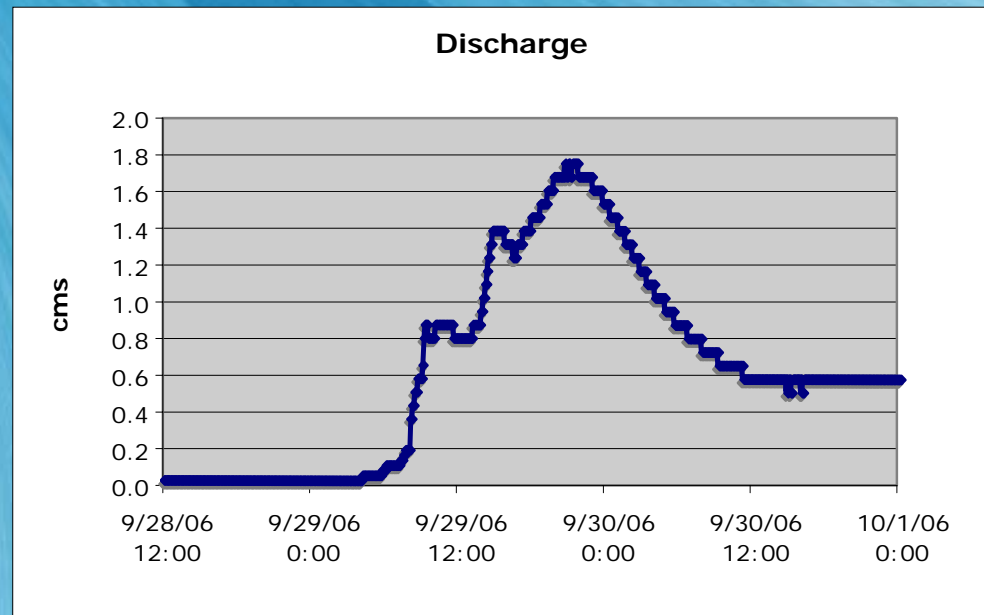
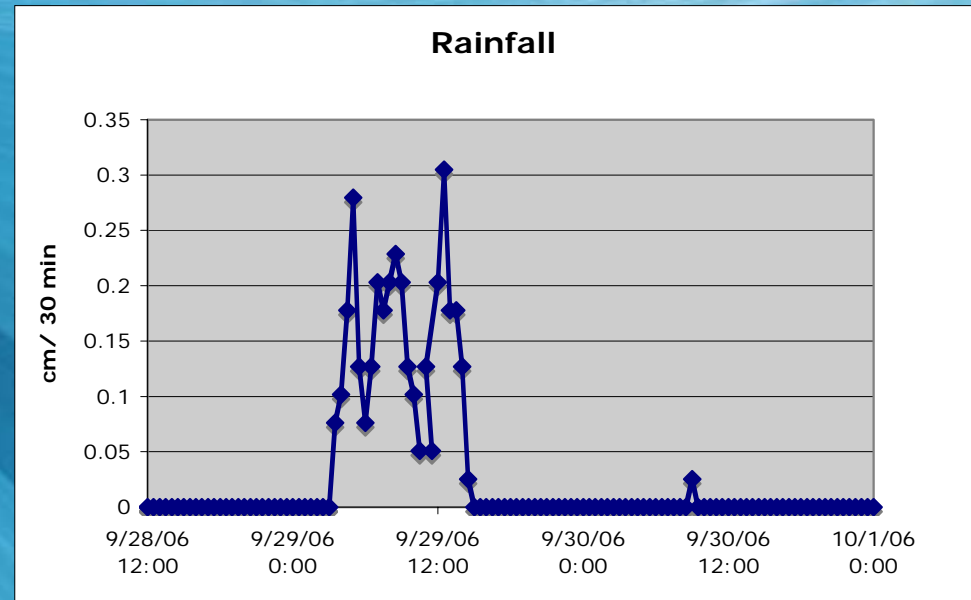
- ♦ Sampled mostly at low flow; one high flow event
- ♦ Alder most, Sunderland least flashy



Data from M.
Curling, UVM

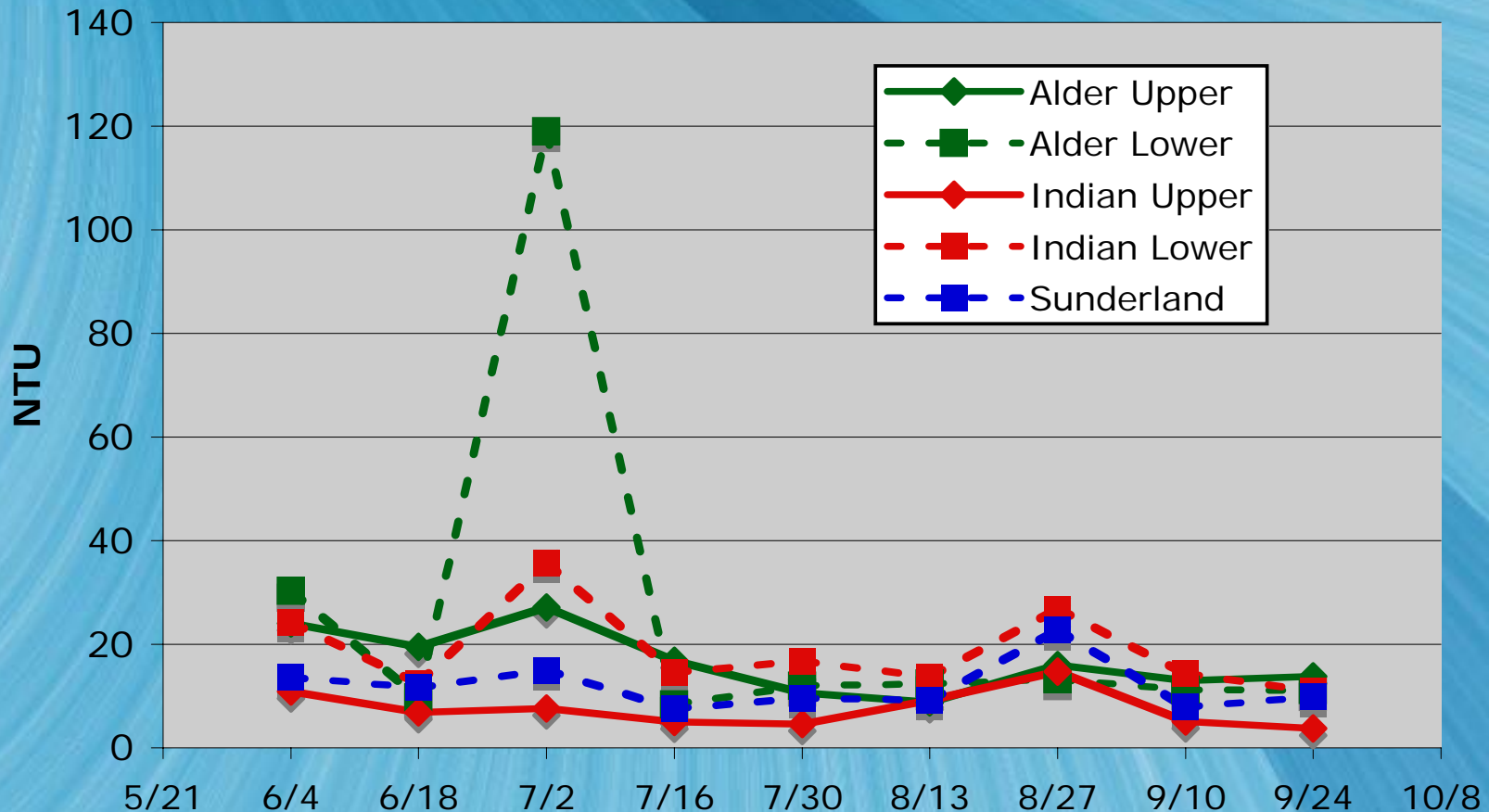
Storm Hydrology

- ◆ Three downpours reflected as pulses in stream flow, but with ~6 h delay
 - ◆ Represents mode runoff travel time
- ◆ Post-storm plateau ~10X pre-storm baseline
 - ◆ Groundwater recharge



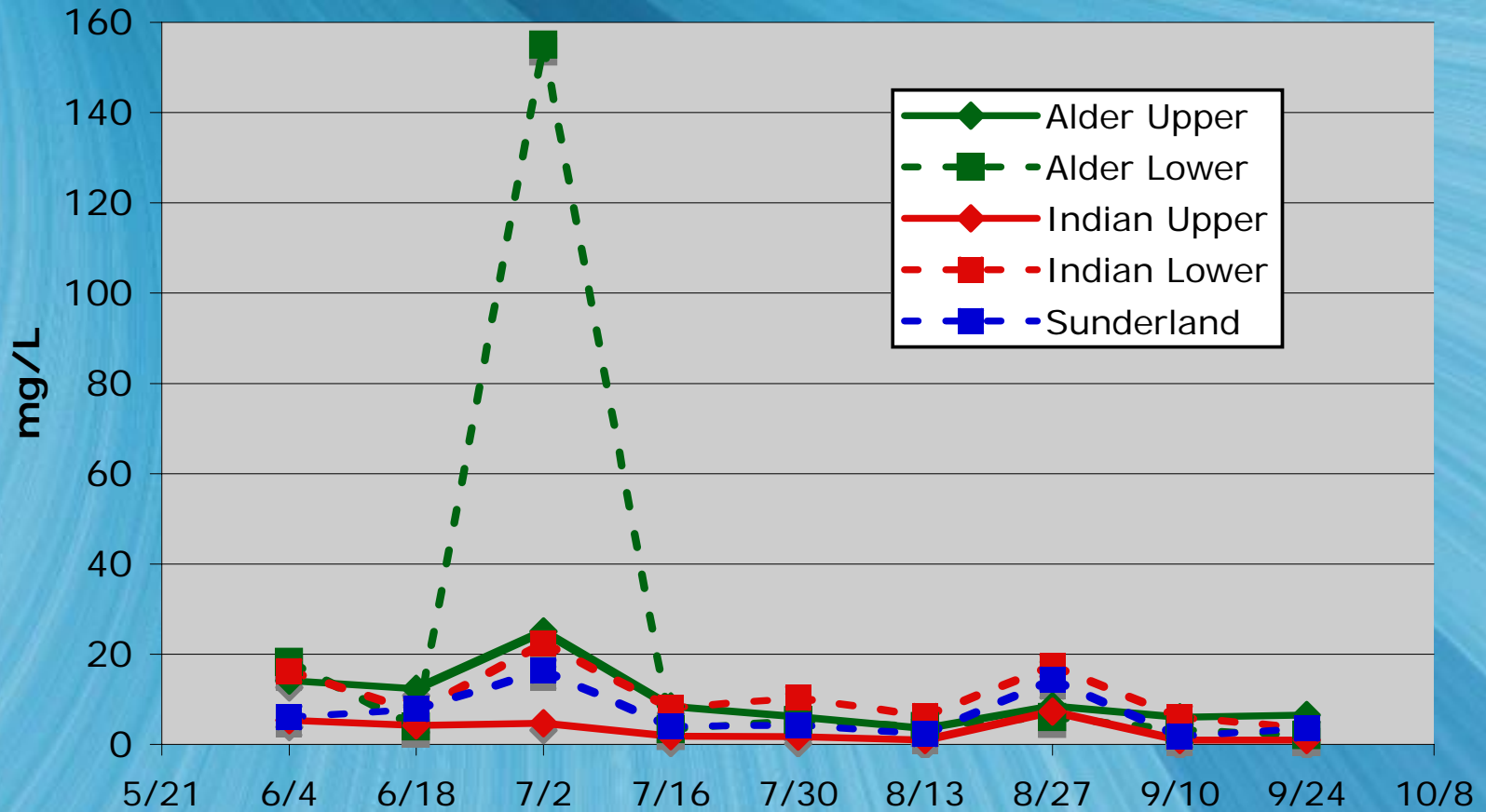
Biweekly Turbidity

- ◆ Values frequently above standard recommended to avoid biological impacts, 10 NTU
- ◆ Extremely high in Lower Alder at high flow

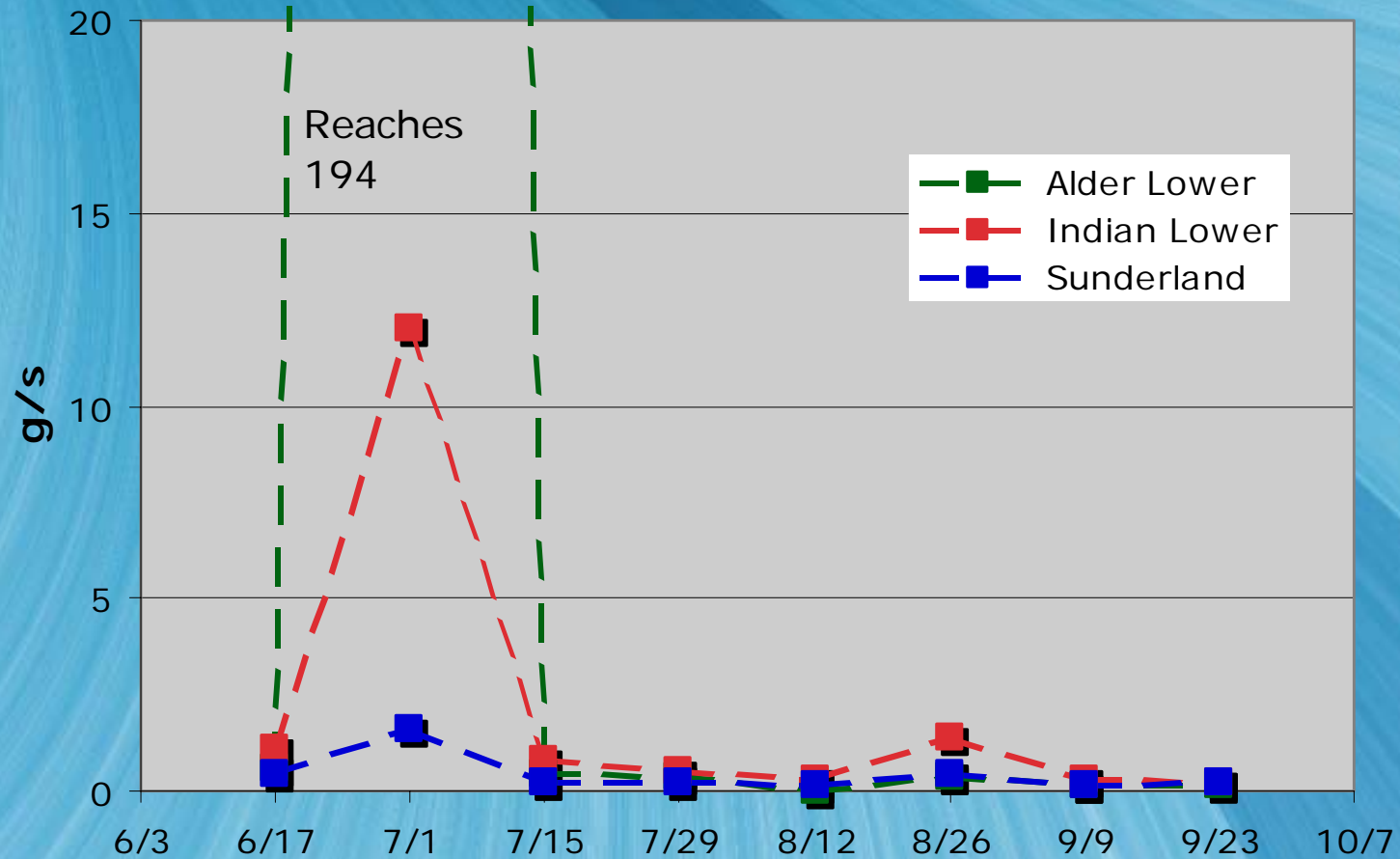


Biweekly TSS

- ◆ Patterns similar to those of turbidity

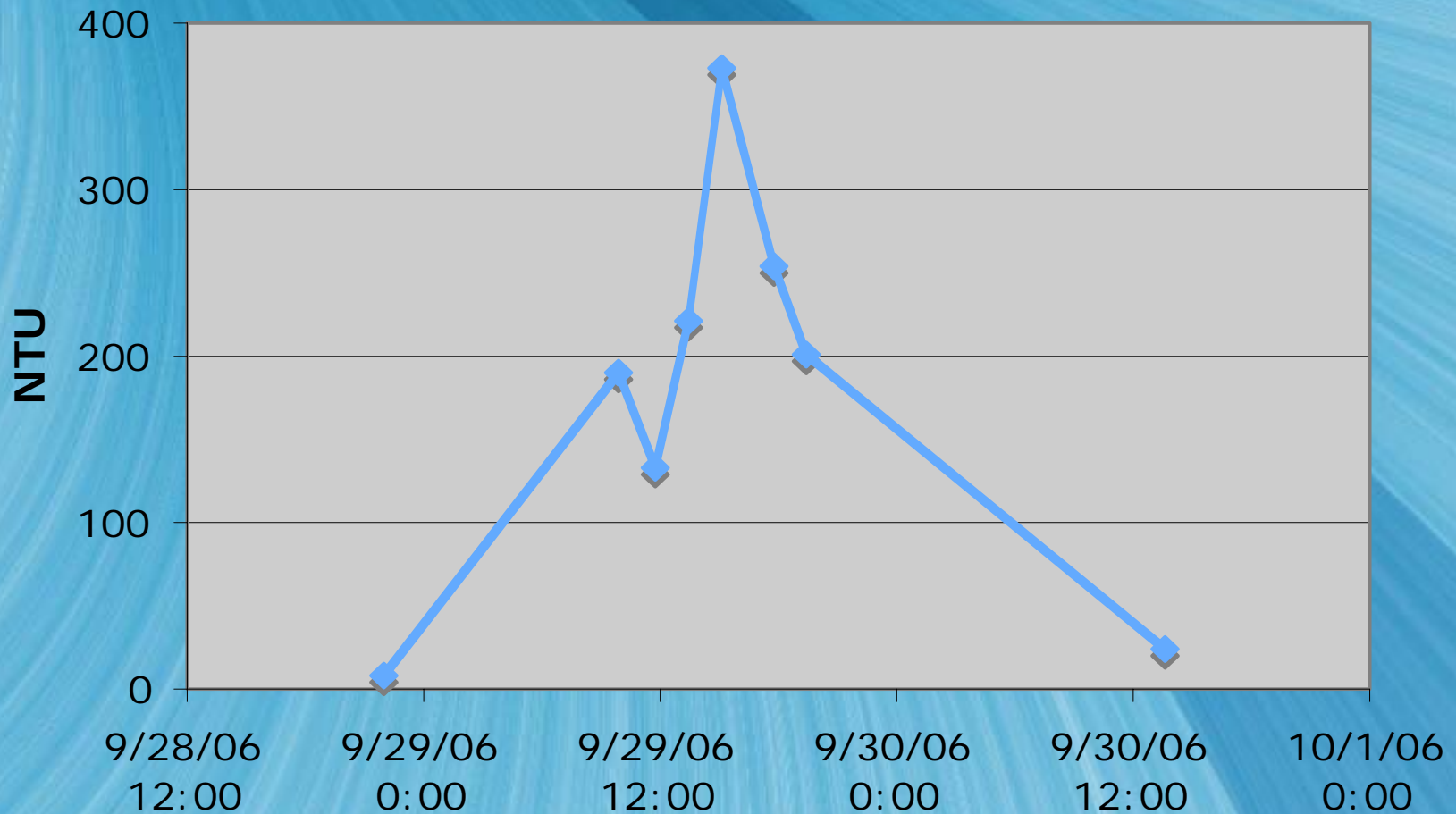


Suspended sediment flux downstream

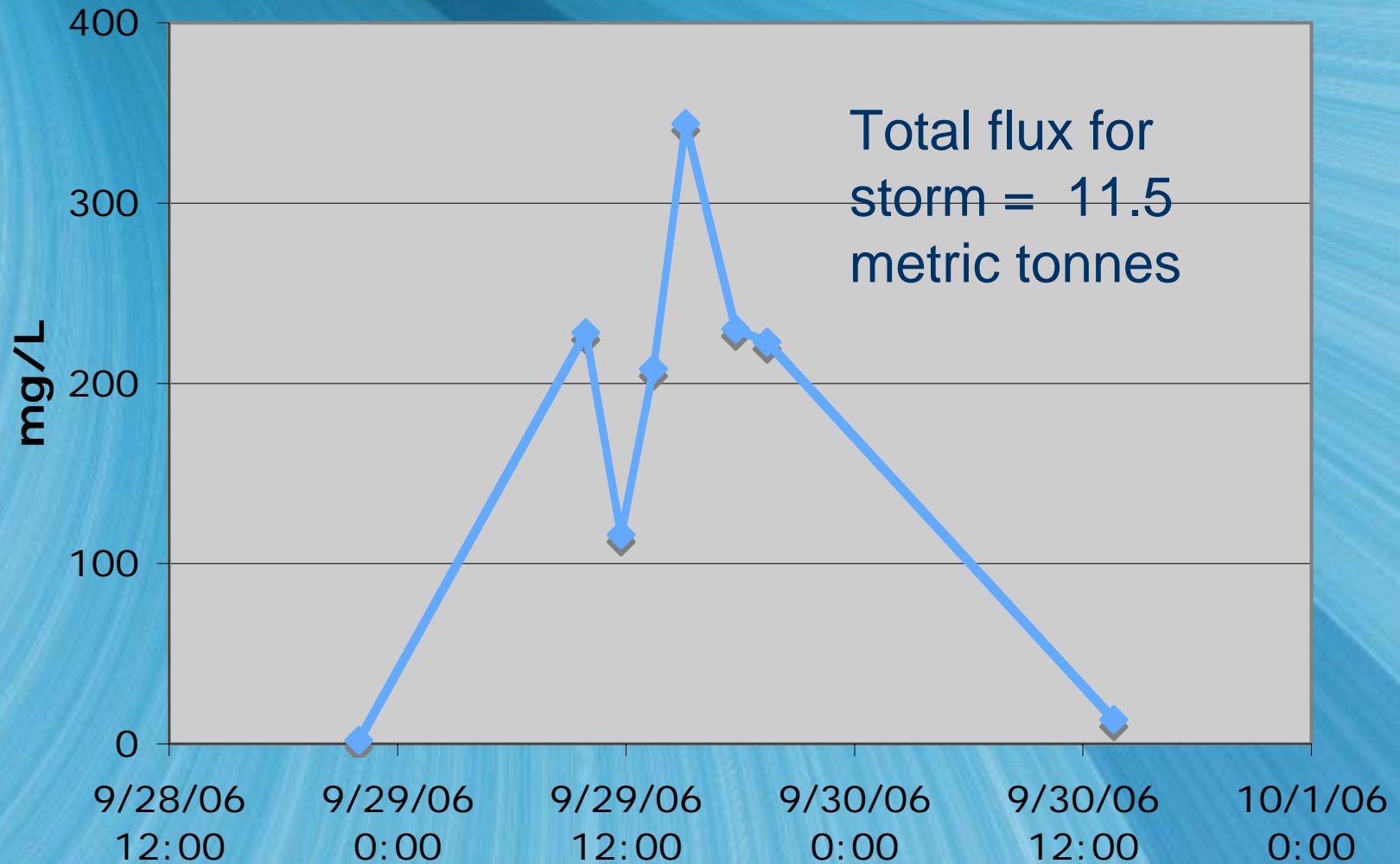


Turbidity in Alder Lower during storm

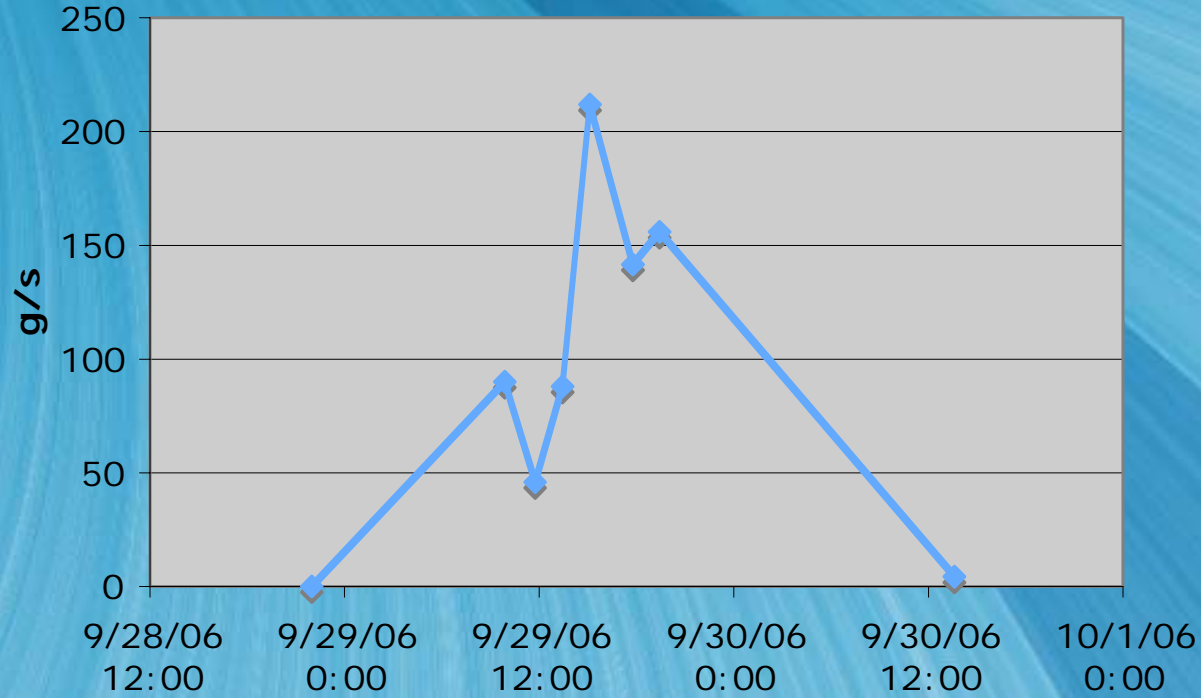
- ◆ NTU > 100 and up to 380 throughout high flow



TSS during Storm

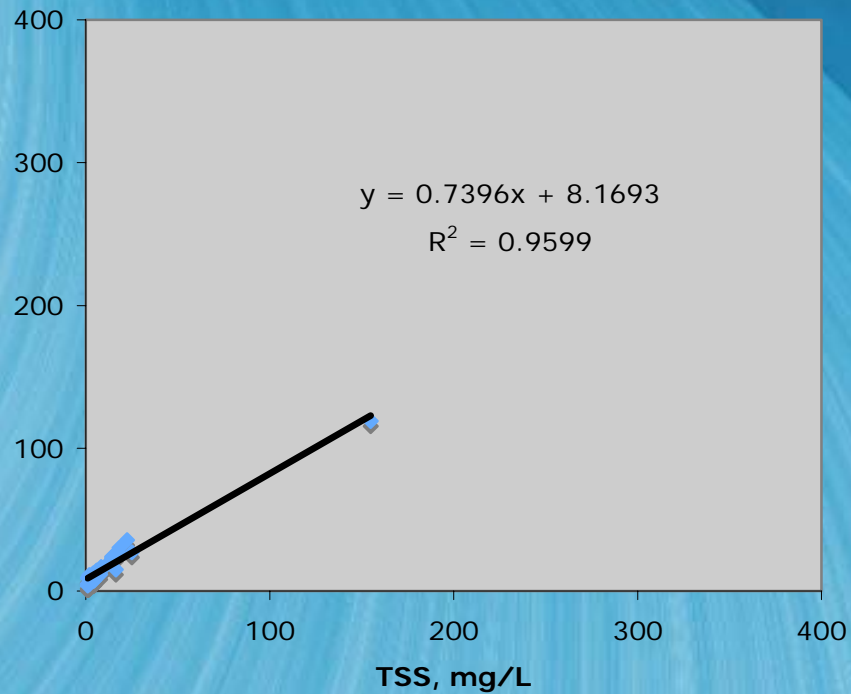


Flux Moving Downstream

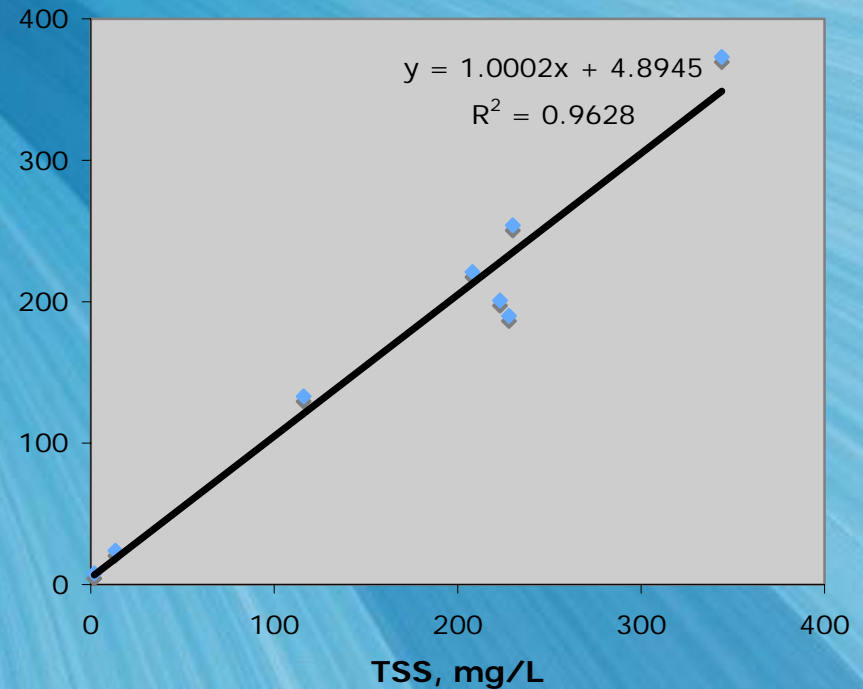


Turbidity-TSS Relationships

Biweekly data

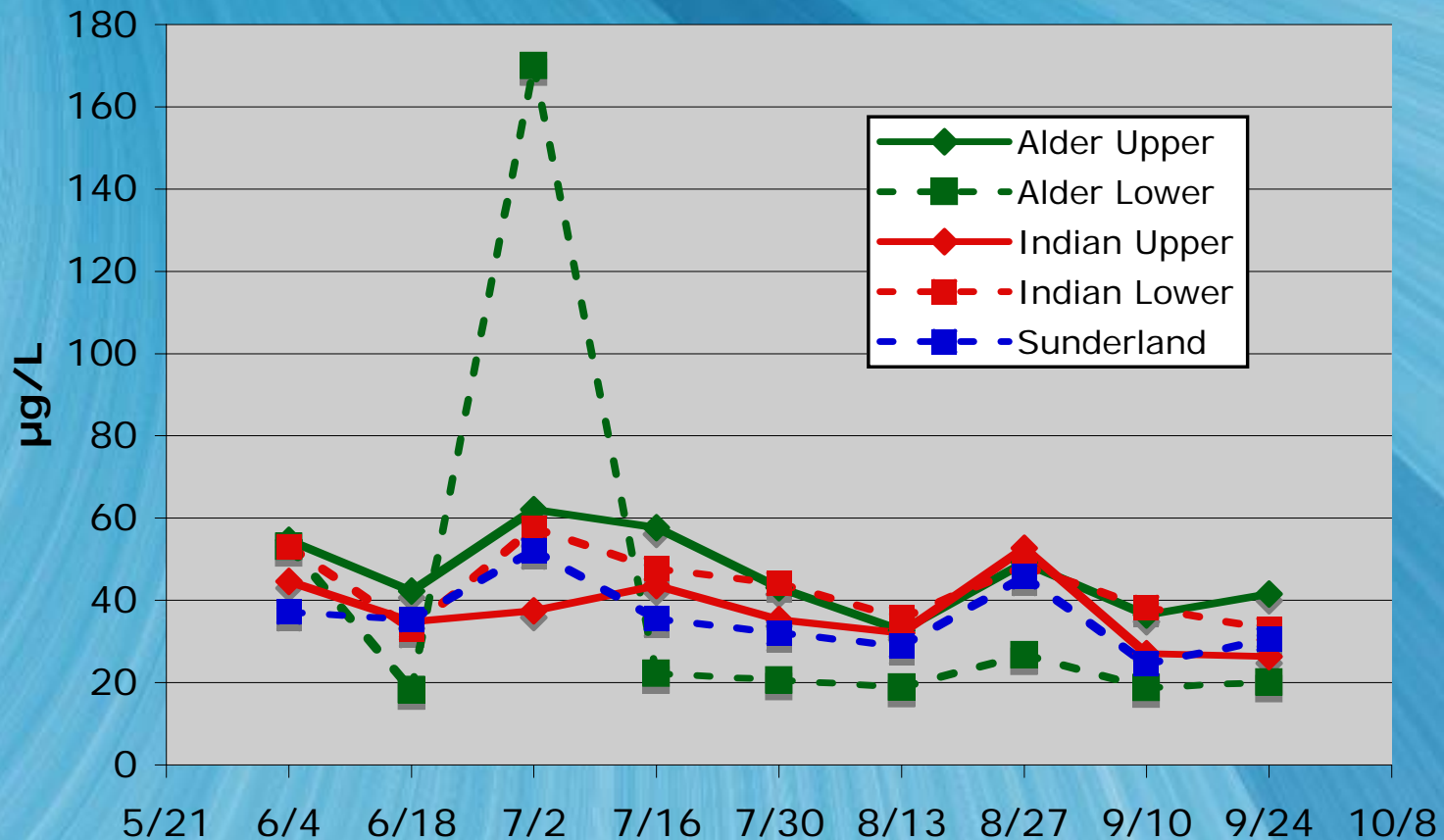


Storm data

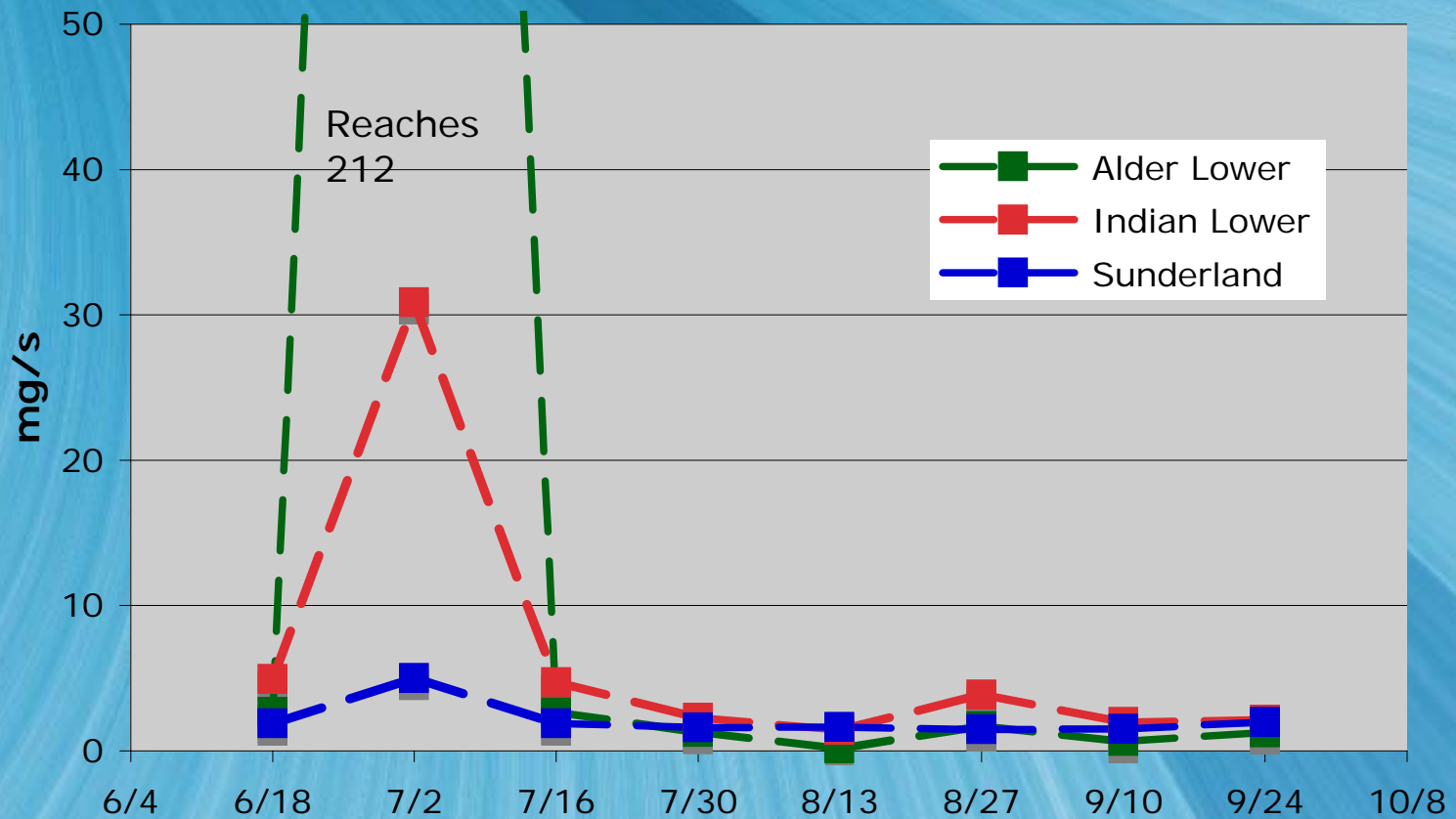


Total Phosphorus: biweekly

- ♦ Consistently $>10 \mu\text{g/L}$ standard for Lake Champlain
- ♦ Extremely high in Alder Lower at high flow

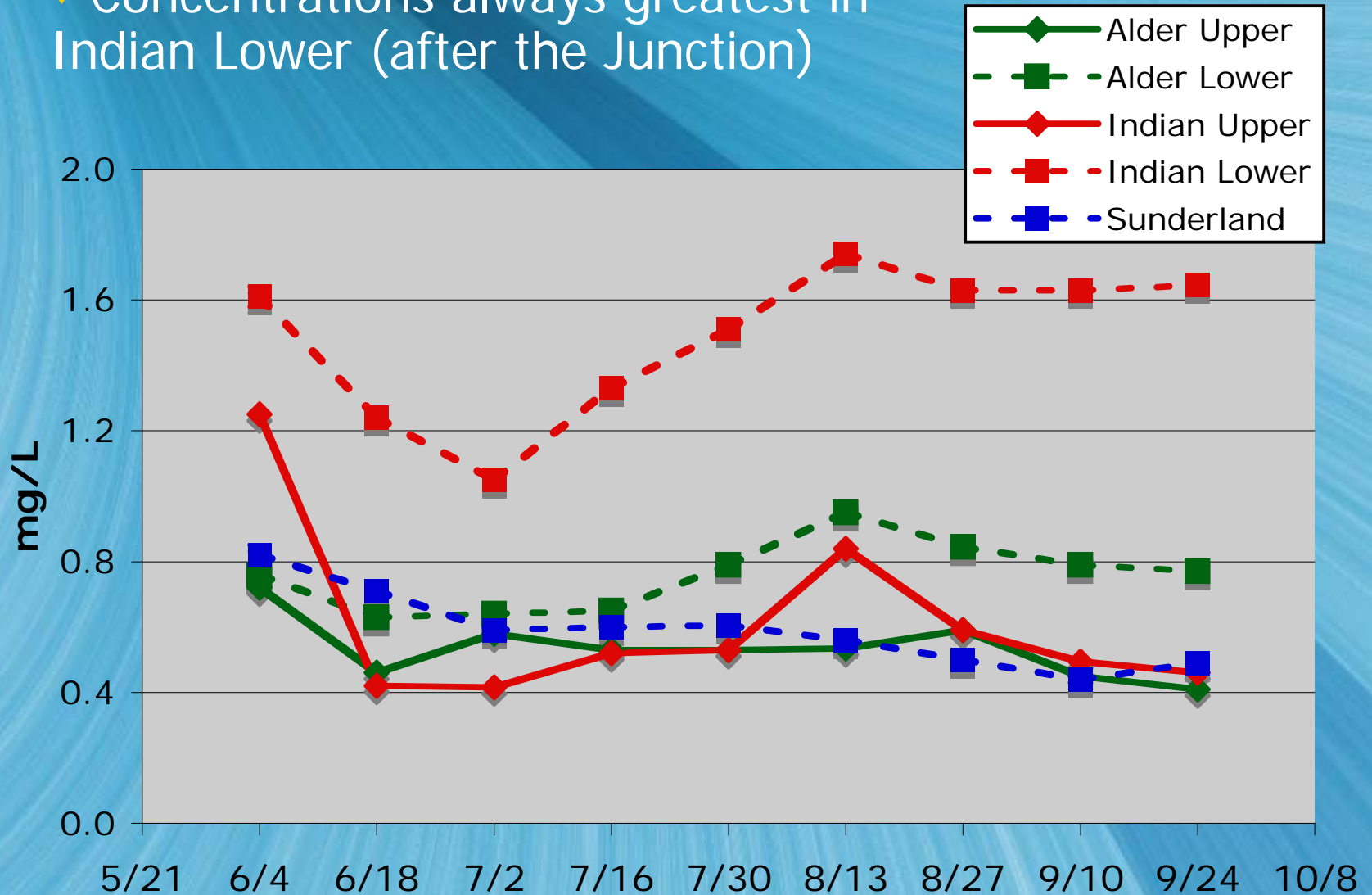


P flux moving downstream



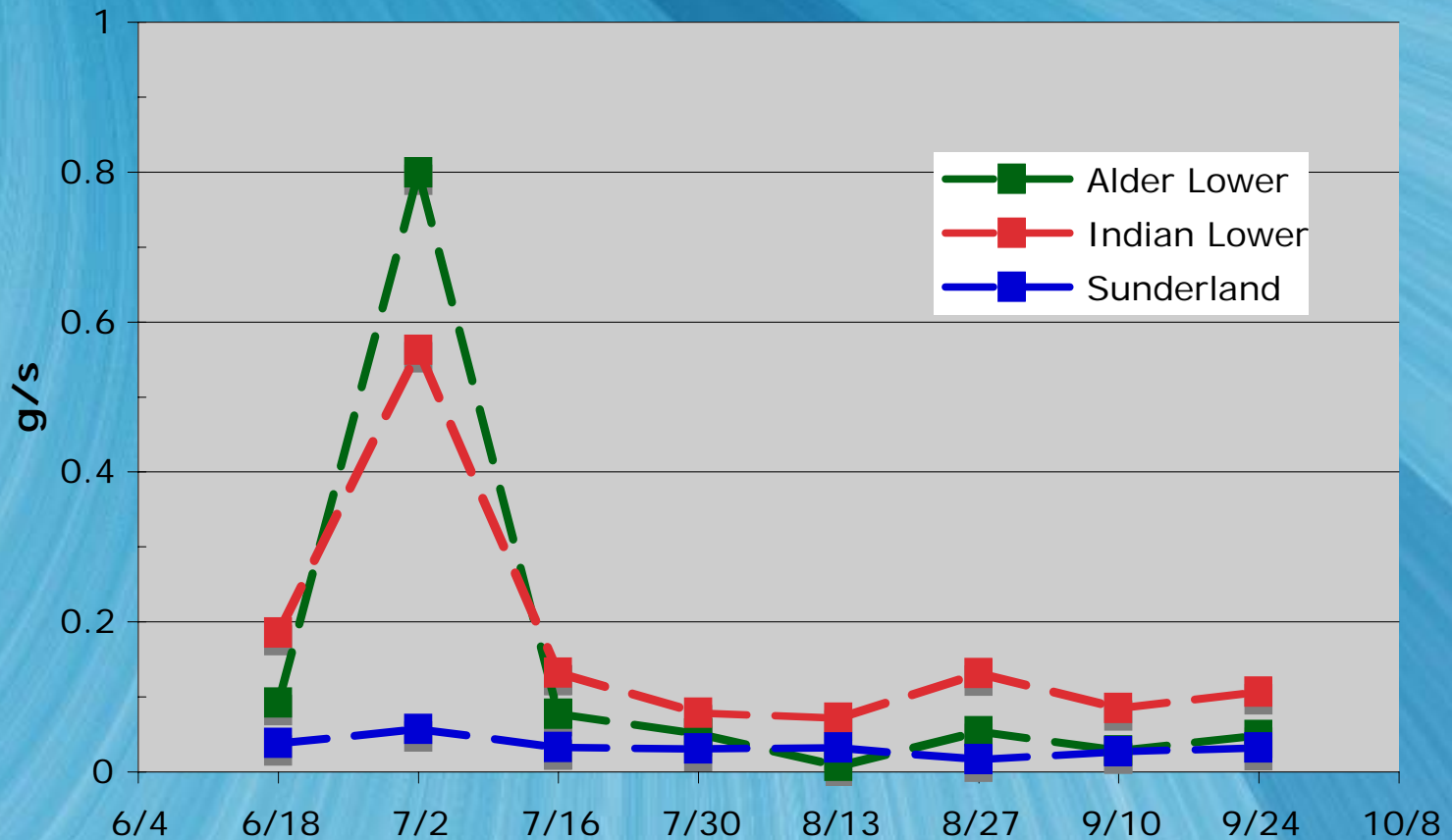
Total Nitrogen: biweekly

- ◆ Concentrations always greatest in Indian Lower (after the Junction)



N flux moving downstream

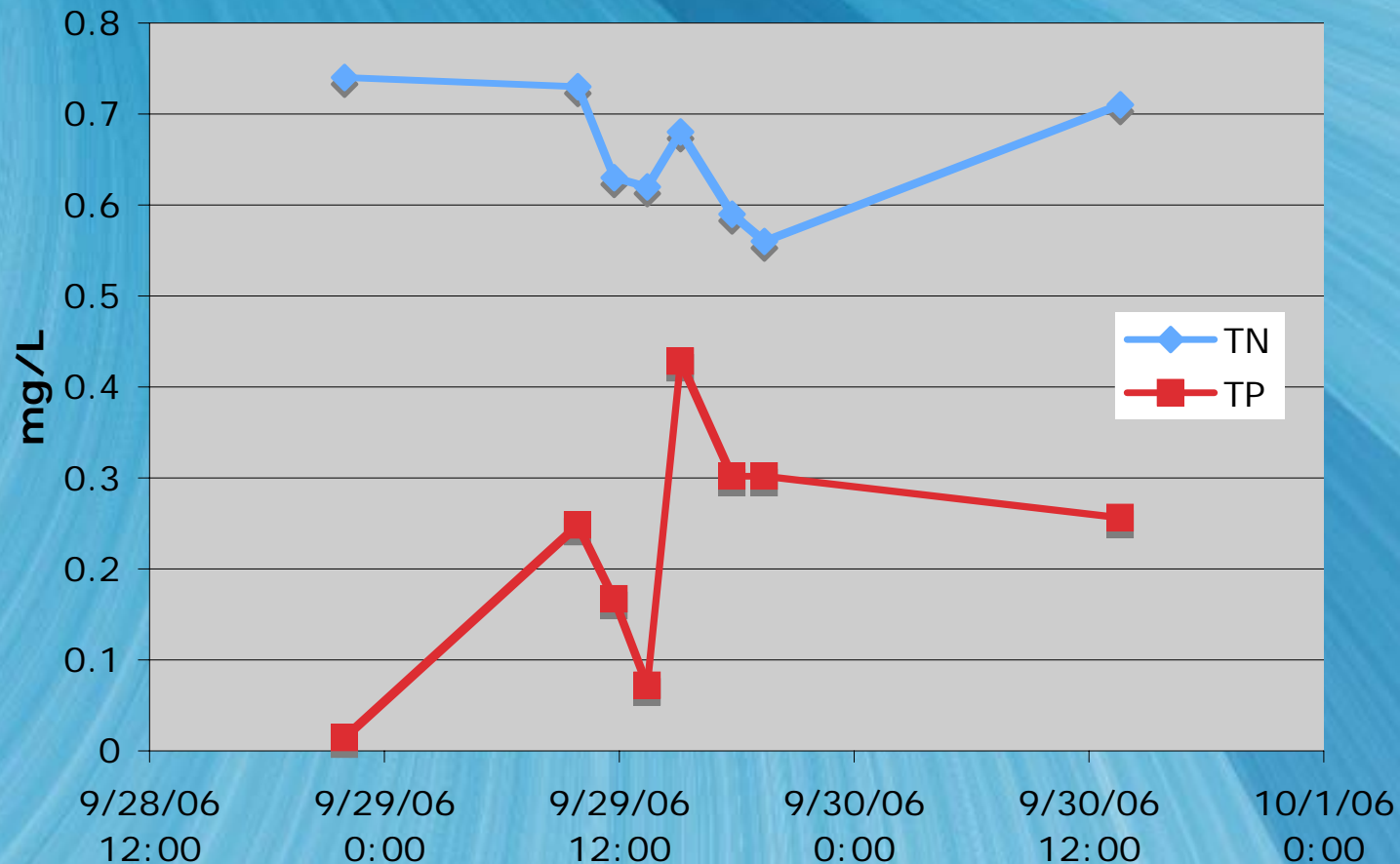
Greater for Alder than Indian at high flow due to higher discharge



TP and TN in Alder during storm

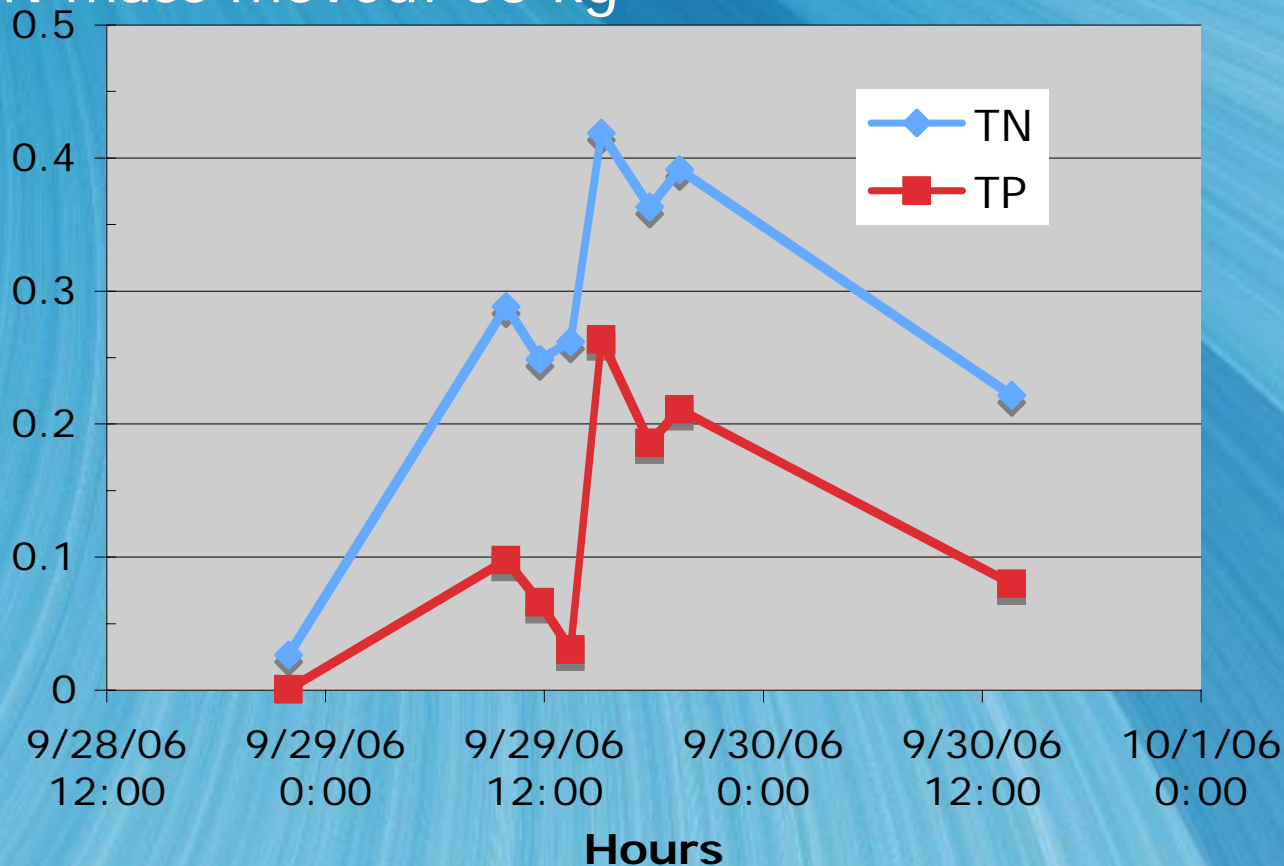
- ◆ TP follows sediment peak

TN decreases during storm indicating that it largely DIN, but also shows peak with maximum sediment transport



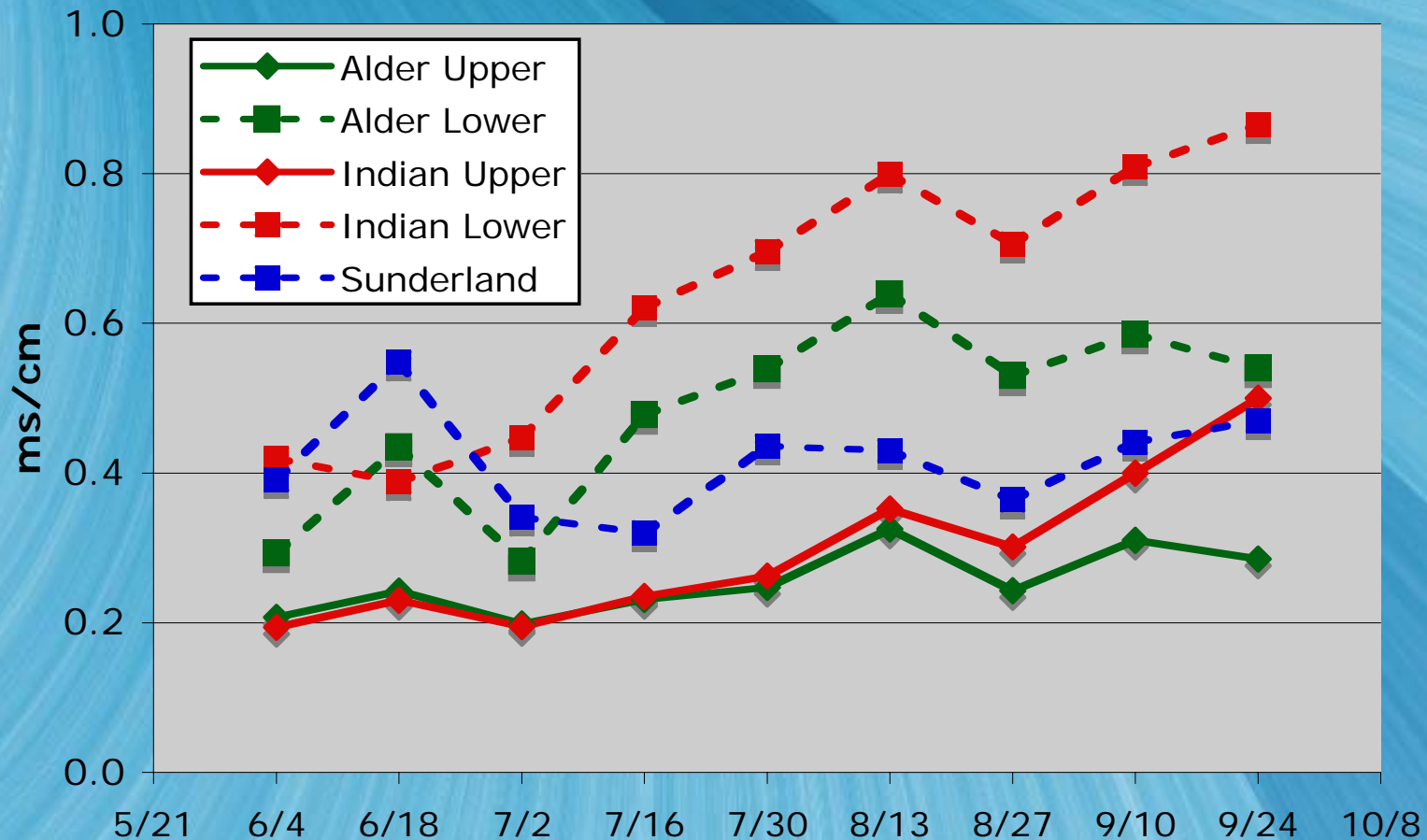
P and N Transport during Storm

- ◆ Total P mass moved through site during the monitored period: 16.7 kg
- ◆ Total N mass moved: 33 kg



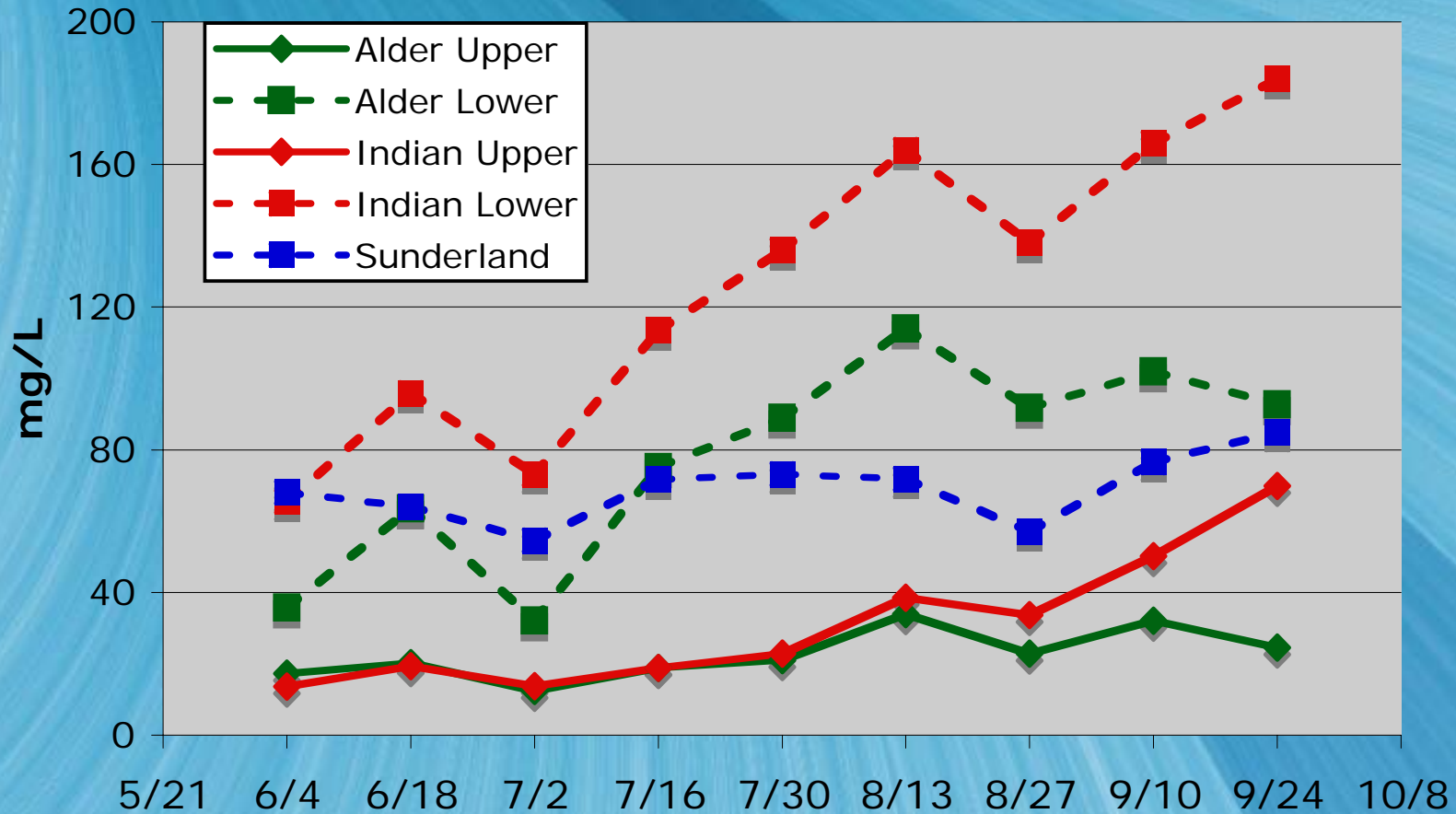
Salt: Biweekly specific conductance

- ◆ Conductance increases in passing through urban areas, although it is summer & no salting is occurring



Biweekly chloride

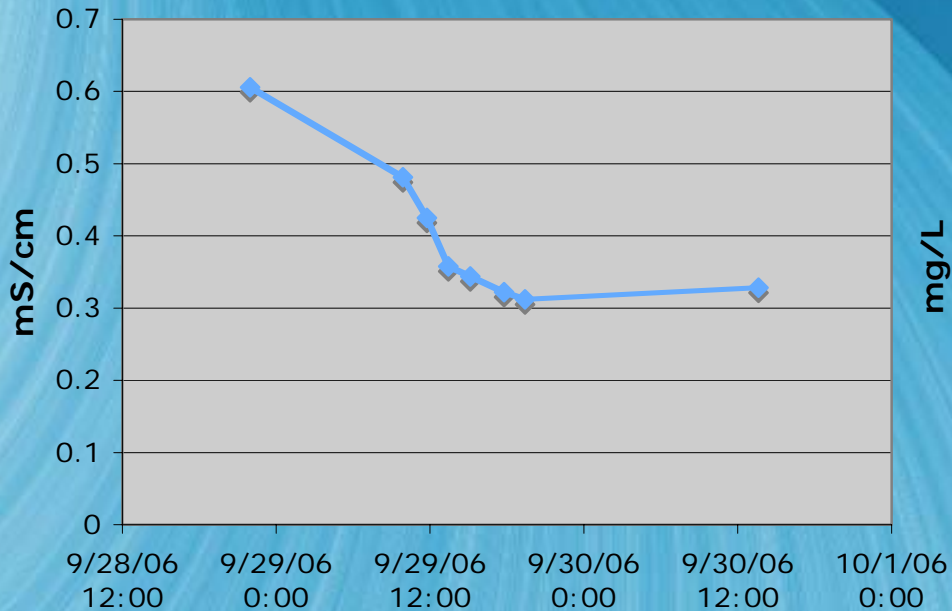
- ◆ Same pattern; Indian Brook greatest concentrations
- ◆ 250 mg/L unofficial biological effects level



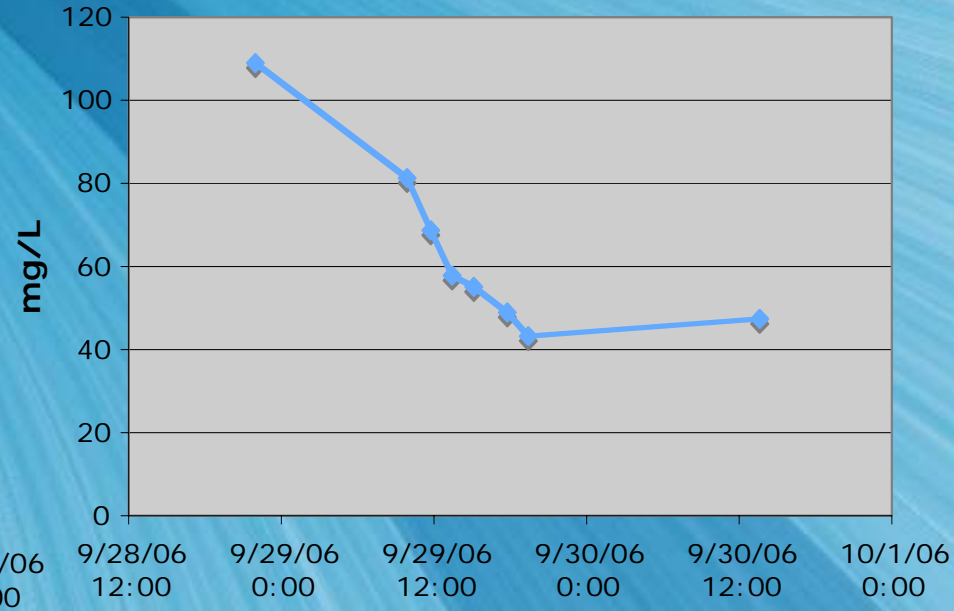
Salt indicators in Alder during storm

- ♦ Lack of full recovery after high flow indicates source being depleted

Specific conductance

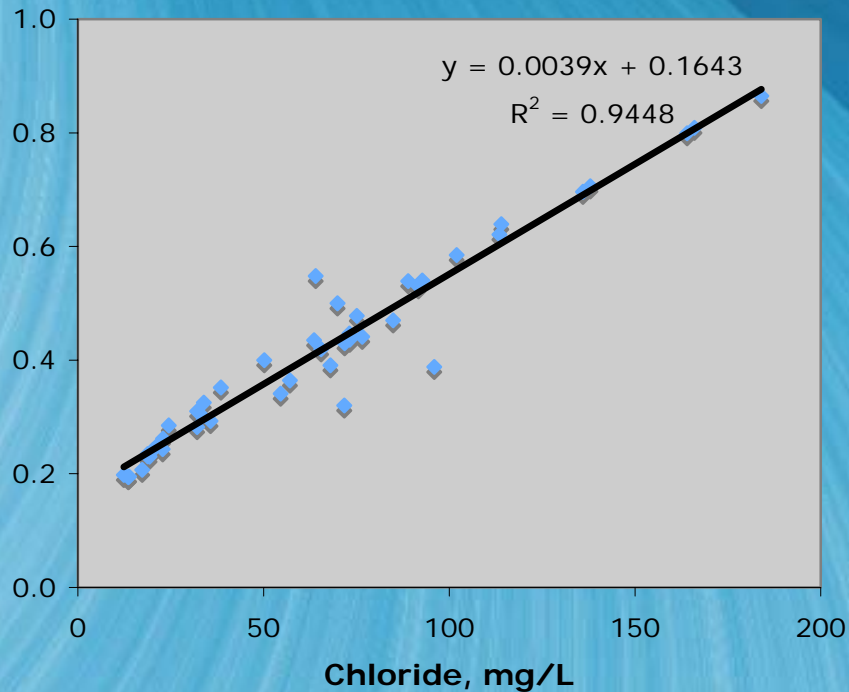


Chloride

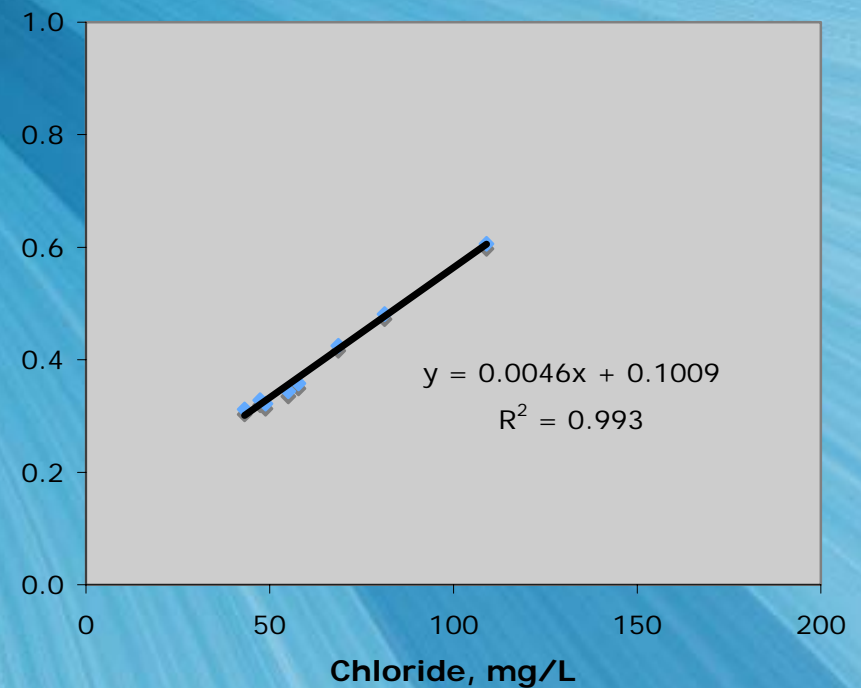


Conductance-chloride Relationships

Biweekly data



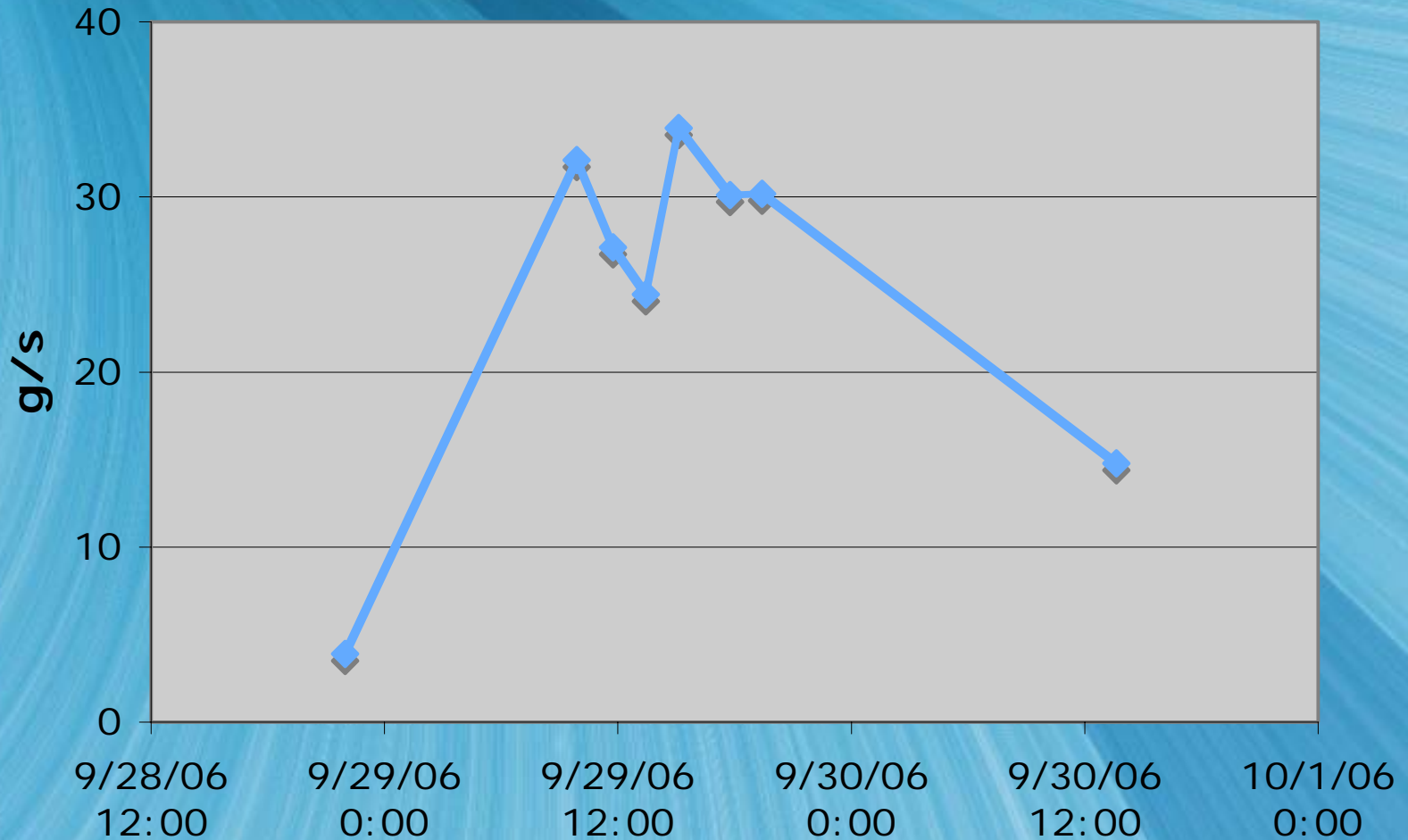
Storm data



Indicates dominant salts are NaCl and CaCl

Downstream Cl flux during storm

- ◆ 3.3 metric tonnes total!



Conclusions

- ◆ All three streams are polluted with P
- ◆ N also is an issue in Indian Brook
- ◆ Chloride concentrations are surprisingly high for summer
 - ◆ Levels are likely to be greater in winter and spring, suggesting a serious pollution threat for stream organisms

Conclusions

- ◆ Alder Brook is a greater transporter of pollutants than Indian and Sunderland at high flow due to its flashy nature
 - ◆ Mass balance throughout the year should be done to determine whether storm-related transport is important enough that the stream should be treated as “impaired”
- ◆ Sunderland Brook has lower levels of many pollutants despite having the greatest urban watershed coverage
 - ◆ Impact of beaver ponds in cleansing the stream should be assessed