# Lower Yakima River Eutrophication Study: Year Three Update

## Presentation to Yakima Basin Science and Management Conference

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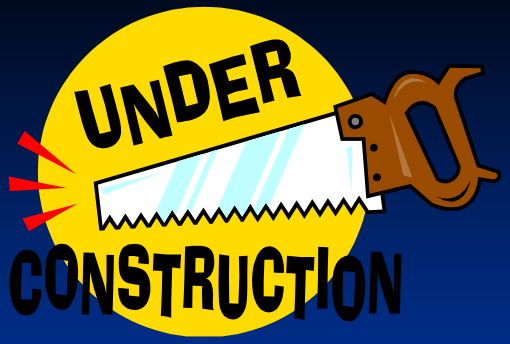
# Outline

- Study partners, objectives
- 2004 & 2005 recap
- 2006 highlights
  - Rooted aquatic plant biomass
  - Relationship between algae and nutrients
- 2007 questions

# Study Partners, Objectives

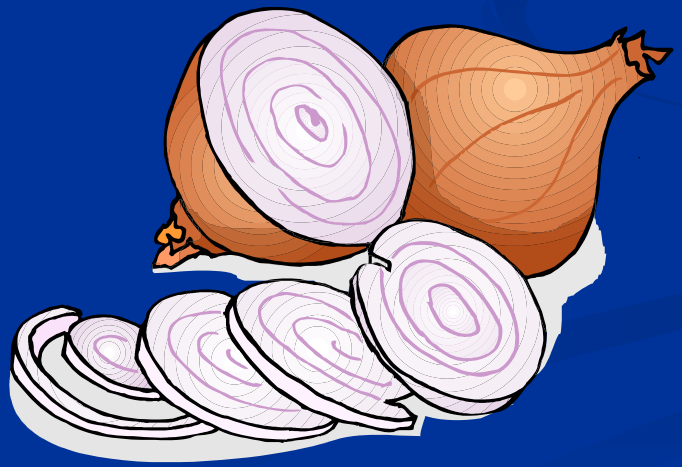
- 3-way partnership: U.S. Geological Survey, South Yakima Conservation District, and Benton Conservation District.
  - Multi-agency support: U.S. Bureau of Reclamation, EPA, USDA Agricultural Research Service, Yakama Nation, Dept. of Ecology, Washington State University, Yakima Joint Board, Roza Irrigation District, Sunnyside Valley Irrigation District, etc.
- 5-year study, objectives include:
  - Characterize pH and dissolved oxygen (DO) conditions, nutrient concentrations, type of substrate, and aquatic plant and algal communities.
  - Assess relationships between nutrient concentrations, plant growth, substrate, stream flow, pH, and DO for the conditions observed.
- Why? Wanted to learn reason for sudden increase in plant growth, was it causing problems, and what could we do about it. Because excess aquatic plants/algae can cause:
  - low DO due to nighttime plant respiration and
  - high pH due to daytime photosynthesis.

# Work in Progress

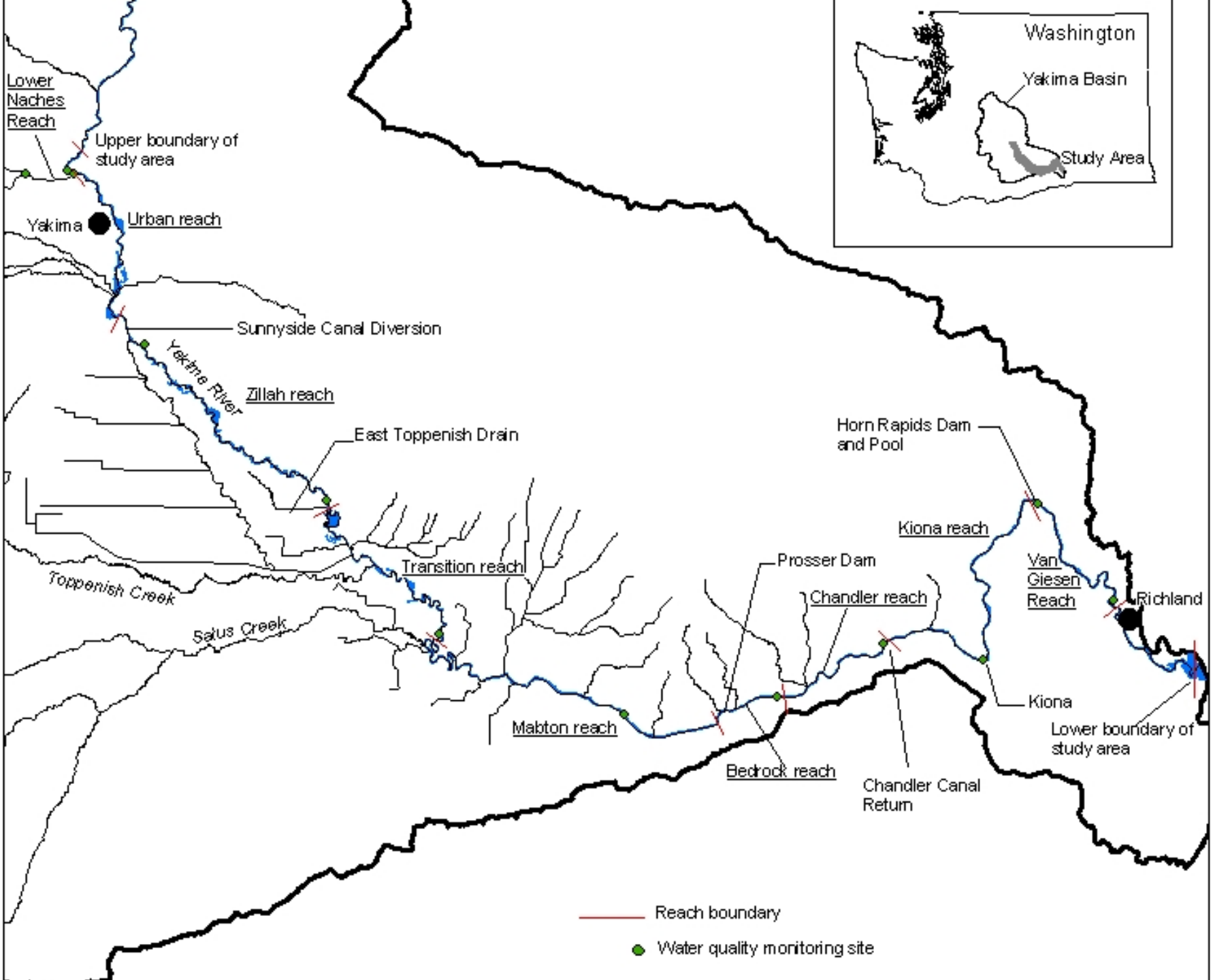



Caveat:

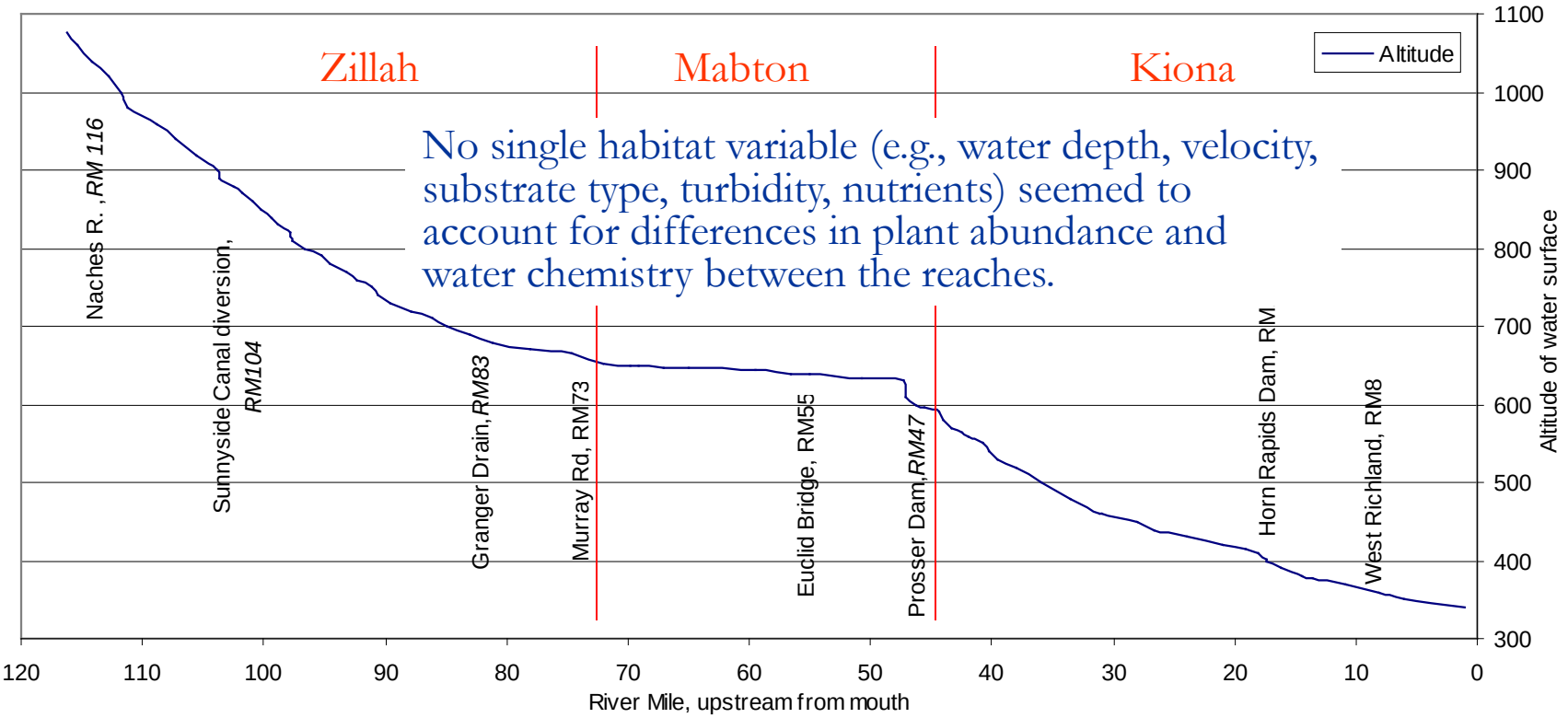
My understanding of nutrient-related processes occurring in the Yakima River has completely changed after each year of this study. I fully expect it to change again after this year.



*Like layers of an onion…*


Washington
Yakima Basin
Study Area
Lower Naches Reach
Upper boundary of study area
Yakima
Urban reach
Sunnyside Canal Diversion
Yakima River
Zillah reach
East Toppenish Drain
Horn Rapids Dam and Pool
Kiona reach
Transition reach
Prosser Dam
Van Giesen Reach
Richland
Toppenish Creek
Chandler reach
Salus Creek
Kiona
Mabton reach
Lower boundary of study area
Bedrock reach
Chandler Canal Return
Reach boundary
Water quality monitoring site

# 2004 Results from 10 Reaches: Three Very Different River Segments




| *Segment* | *Zillah* | *Mabton* | *Kiona* |
|---|---|---|---|
| *Aquatic plants* | Moderate (dense patches) | Sparse to moderate | High |
| *Algae* | Abundant | Phytoplankton? | Abundant |
| *DO & pH* | Moderate DO, severe pH | Moderate | Severe |
| *Nutrient concentrations* | Low | Highest | High |
| *Substrate* | Cobble | Mud | Cobble |
| *Velocity* | Fast | Slow | Moderate to fast |

# 2005 Highlights

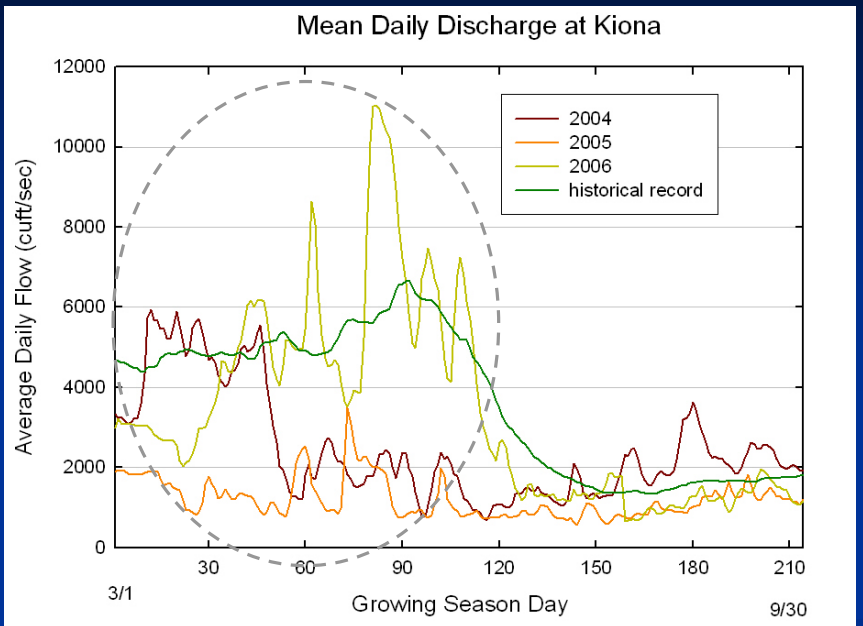
**Begin to quantify relationships: study 1 reach from each segment**

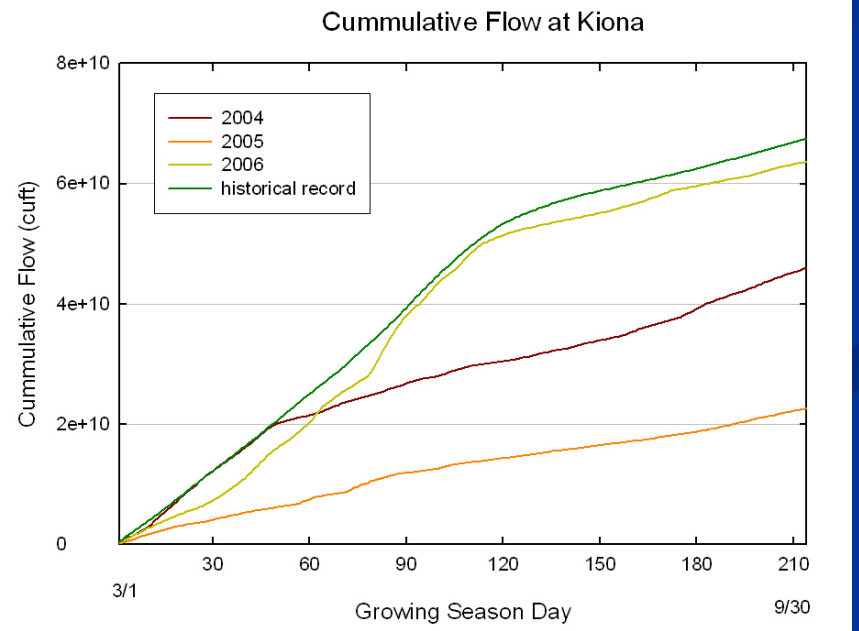
| | Reach | | |
|---|---|---|---|
| ***Variable*** | ***Zillah*** | ***Mabton*** | ***Kiona*** |
| *Productivity* | **50-100x lower than Kiona reach** | **Not yet estimated** | **50-100x higher than Zillah reach** |
| *Biomass (median)* | **0 gm/m2** | **0 gm/m2** | **1020 gm/m2** |
| *DO violations* | **31% of time** | **12% of time** | **34% of time + 1% less than 4 mg/L** |
| *pH violations* | **91% of days** | **78% of days** | **91% of days** |
| *Turbidity (median)* | **2 FNU** | **8 FNU** | **1 FNU** |

- Water quality: similar results to 04 but much stronger data set (continuous data at 3 sites from March to Oct):
  - Very poor DO at Kiona (down to 3 mg/L near dawn on a few days);
  - Severe pH at Zillah and Kiona (> 9.5);
  - Least impaired reach was Mabton;
  - Generally low turbidity. Light generally not limiting plant growth.
- Differences in plant biomass did not seem to correspond to differences in DO & pH conditions.
- At end of 2005, my biggest concern: had improved water clarity due to improved irrigation practices irreparably harmed the river? Was excessive water star grass here to stay?

# 2006: Return to Normal Discharge

- 2006: Abundant snowpack resulted in prolonged high flows from mid-March to late June. 2006 normal year, discharge 97% of normal Mar 1 to Jun 30.
- 2005: Very little snow. One short-duration 11,000 cfs peak in Jan. Discharge ~27% of normal Mar 1 to Jun 30.
- ~4e+10 cu ft more cum flow in spring '06 than '05 = ~ 918,274 ac-ft (total capacity of all 5 reservoirs = 1,065,400 ac-ft)




Provisional data, please do not quote or cite.

# 2006

- Kiona reach:  aquatic plants
  - Biomass
  - Dissolved oxygen, pH, and turbidity
- Zillah reach:  algae
  - Biomass, relationship to nutrients

# Kiona Plant Biomass Results

- Median biomass
  - 2005: 1020 gm/m2
  - 2006: 32 gm/m2
- Species present (within samples)
  - 2005: water star grass
  - 2006: water star grass + 1 curly leaf pondweed

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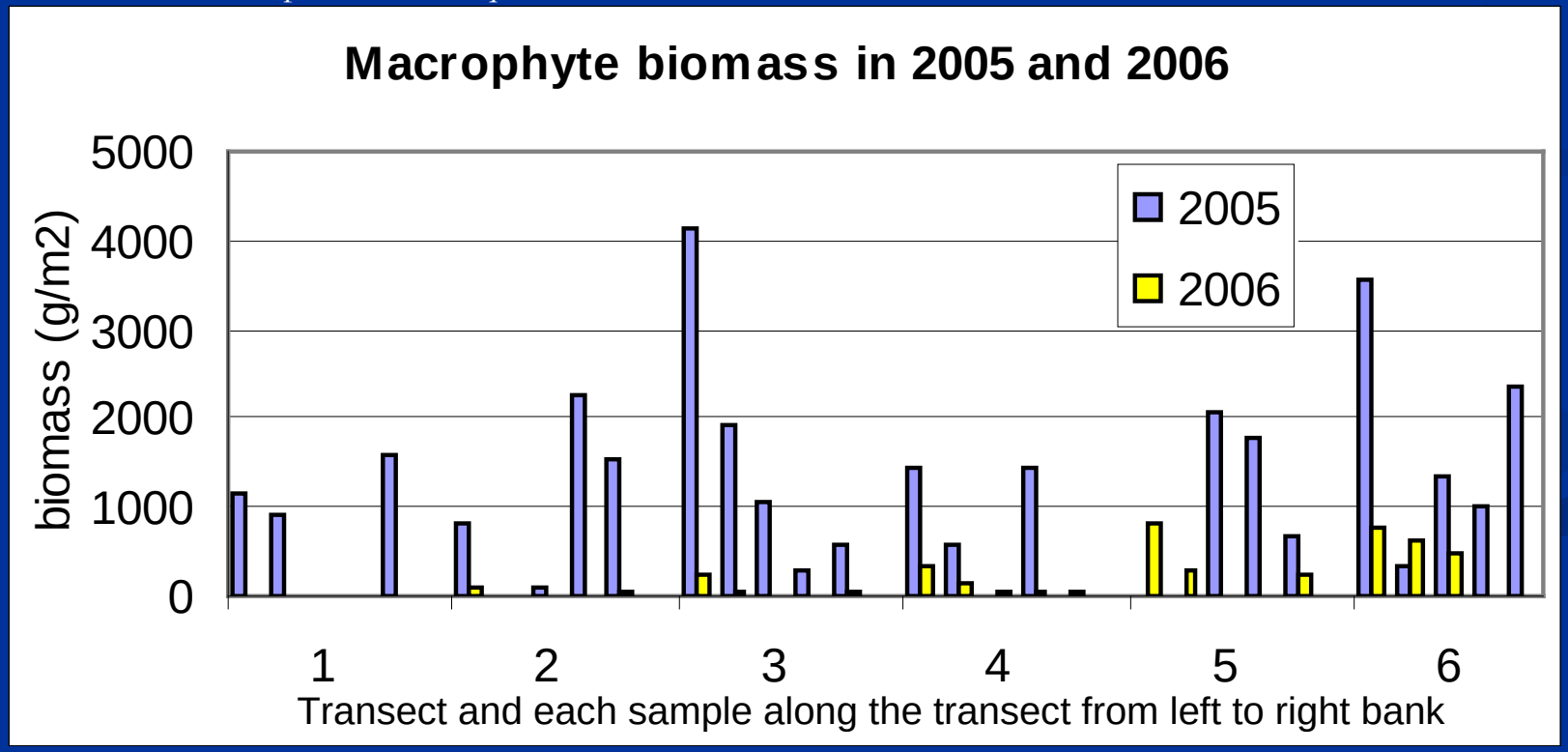
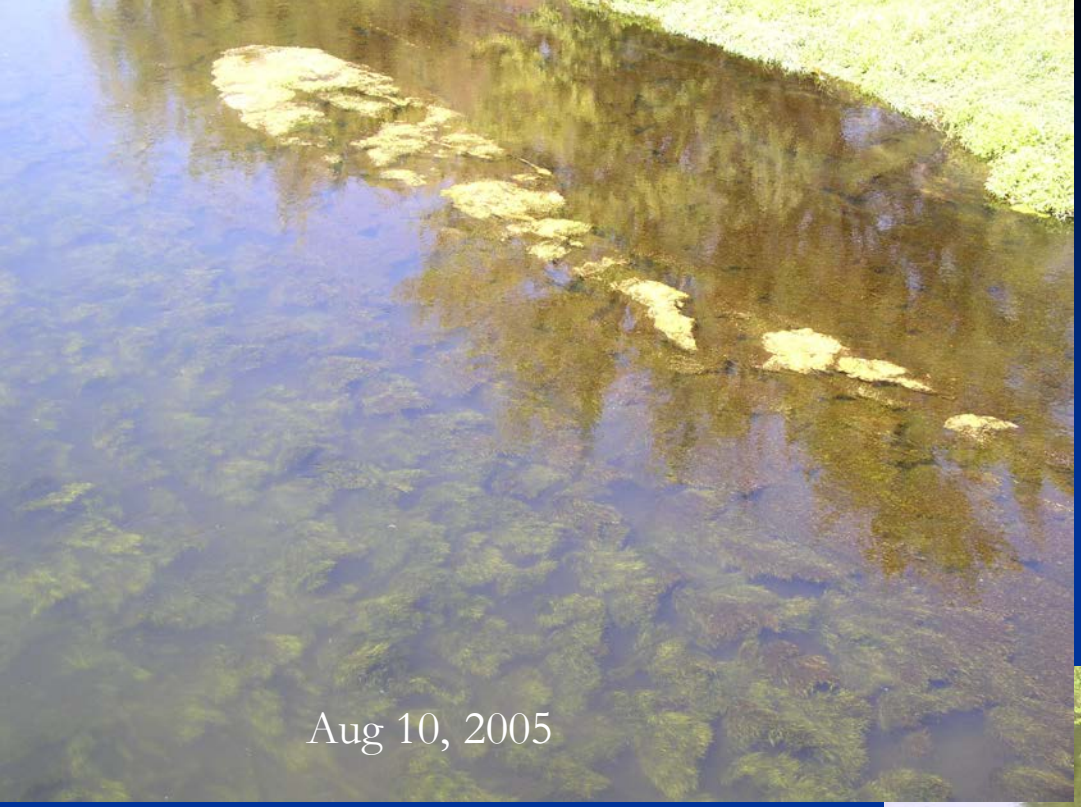


From Kiona bridge



Aug 10, 2005

Aug 21, 2006

June 30, 2005

July 2, 2006

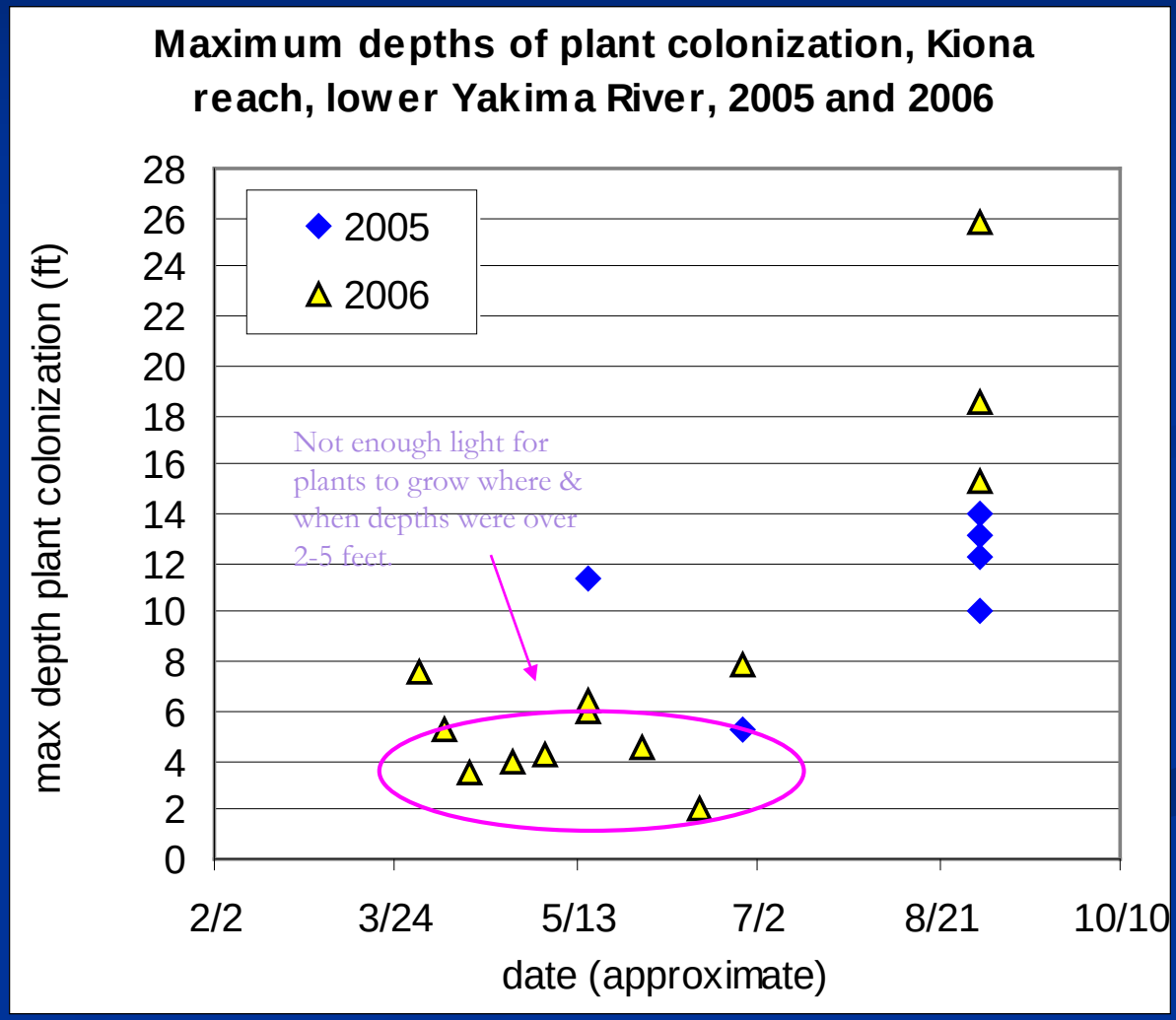
# Why Did Sustained Flows Decrease Biomass?

- Decreased light availability. From Mar 1 to Jun 30:
  - Increased turbidity. Median turbidity 1 FNU in 2005 and 16 FNU in 2006.
  - Increased depth. Median daily mean gage height at Kiona was 3.7 ft in 2005 and 6.1 ft in 2006.
- Increased velocity (personal observation; no data yet).
- Excellent timing? In one study in Michigan, water star grass began growing when water temperature exceeded 8°C. At Kiona, temperatures began to consistently exceed 8°C in early March 2005 and mid-March 2006.

# Decreased Maximum Depth of Plant Colonization

Based on measurements of photosynthetically-active radiation in the river at varying depths, the median maximum depth of plant colonization were:

- 2005: 12 feet
- 2006: 6 feet

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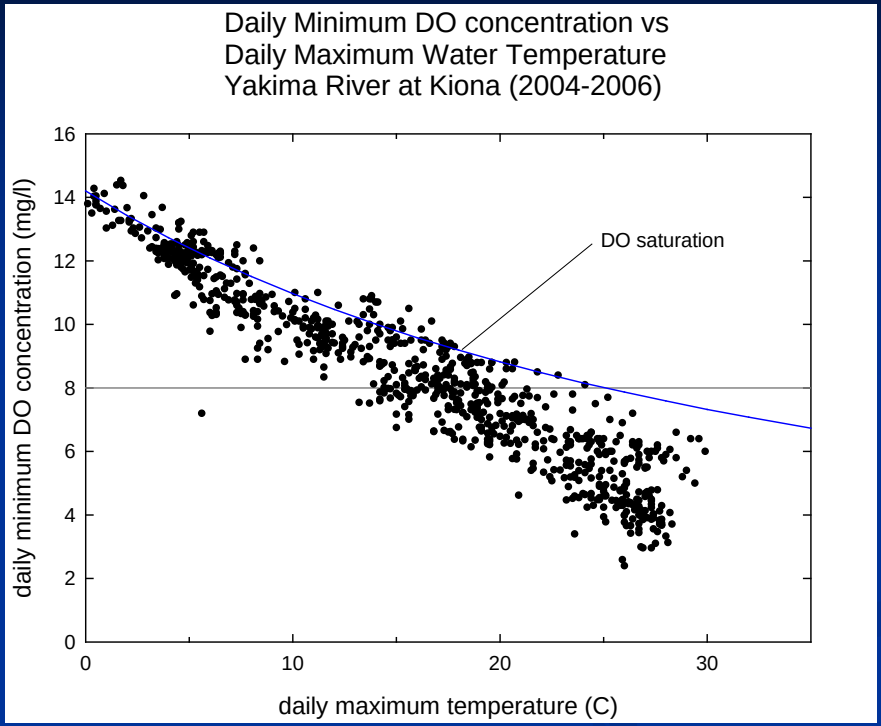
# Results of Decreased Plants

- Increased water velocity, decreased depth.
- Increased turbidity.
- Decreased habitat for epiphytic algae.
- Improved DO and pH conditions, but still not in compliance.

# What Variable Best Explains Variability in Minimum Dissolved Oxygen?

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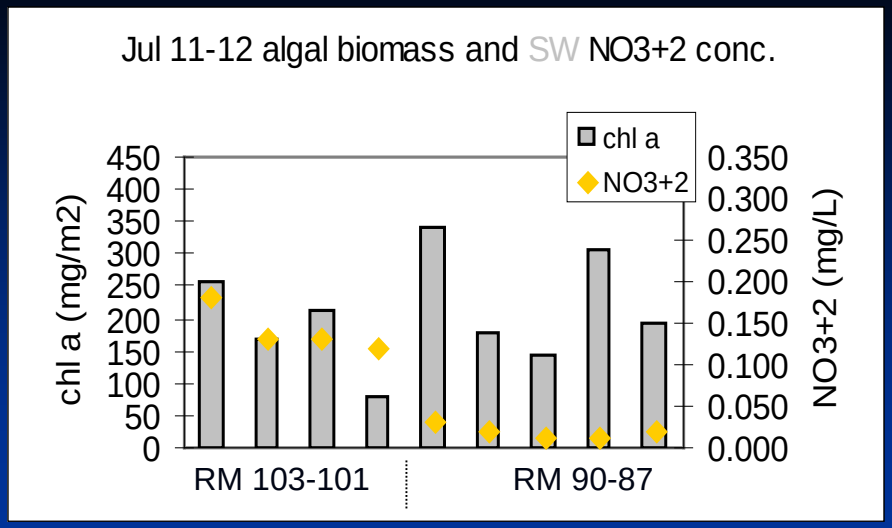
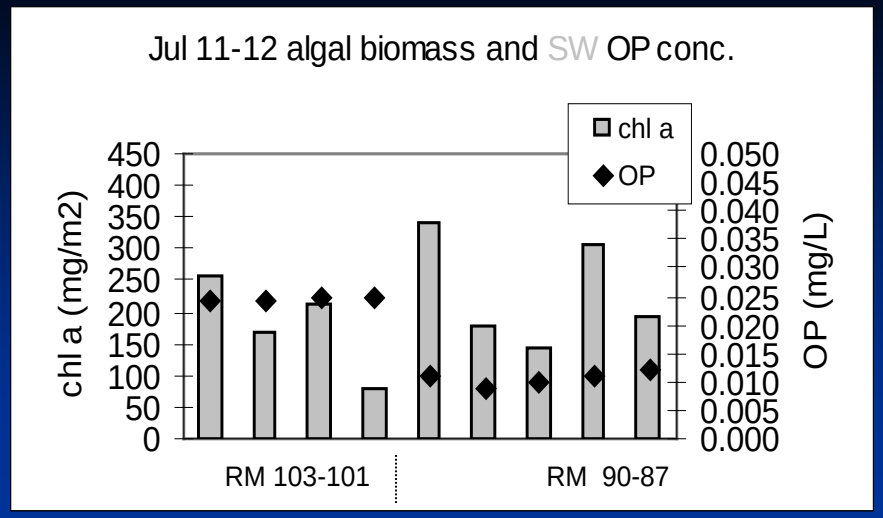
- Low DO concentrations
  - Not just due to decreased solubility at higher temperatures (see chart above).
  - Multiple linear regression: variability in temperature best relates to variability in minimum DO concentrations. Possible explanation: warmer water → faster growth?
  - Low DO a result of chemistry + biology.
- What can we do about temperature in the Kiona reach?

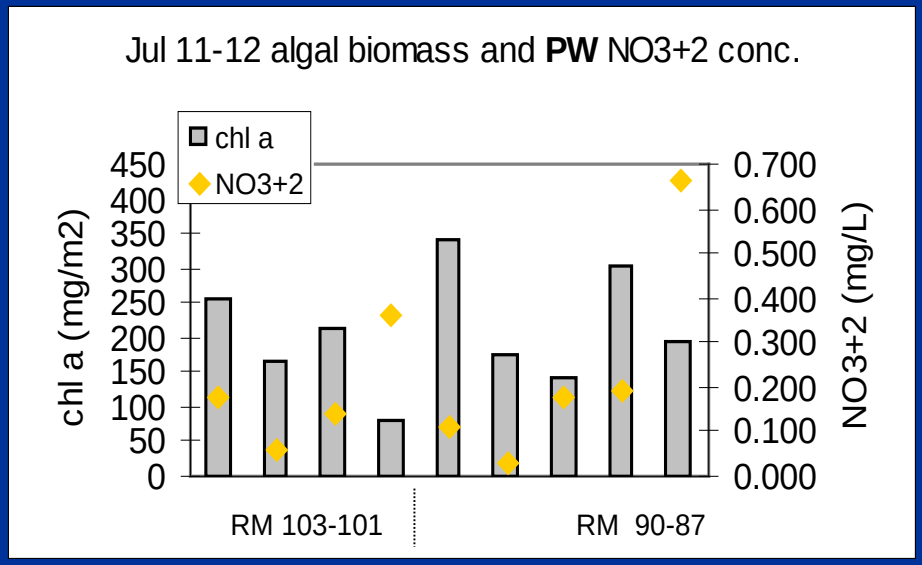
# Zillah Reach Algae

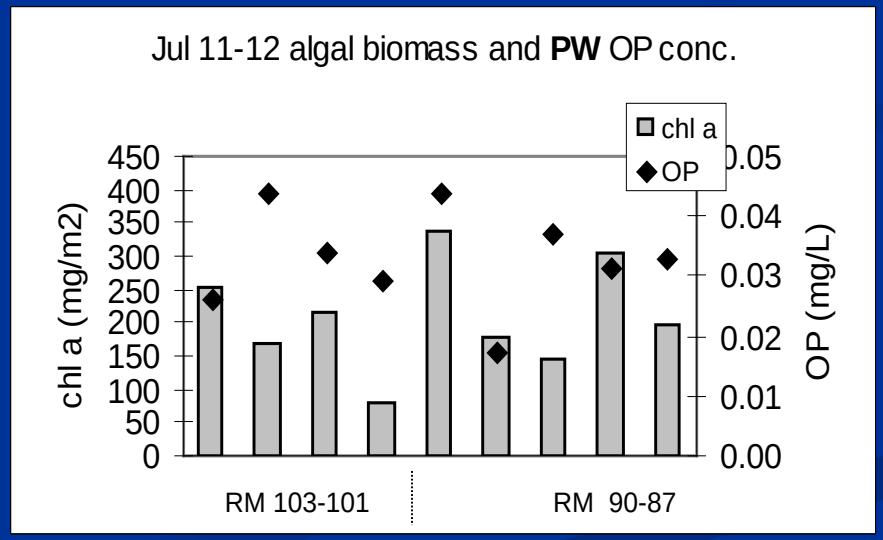
Hypothesis: Nutrient concentrations at the bottom of the reach might be low enough to limit algal growth because so much of the nutrients have been taken up by algae throughout the rest of the reach.



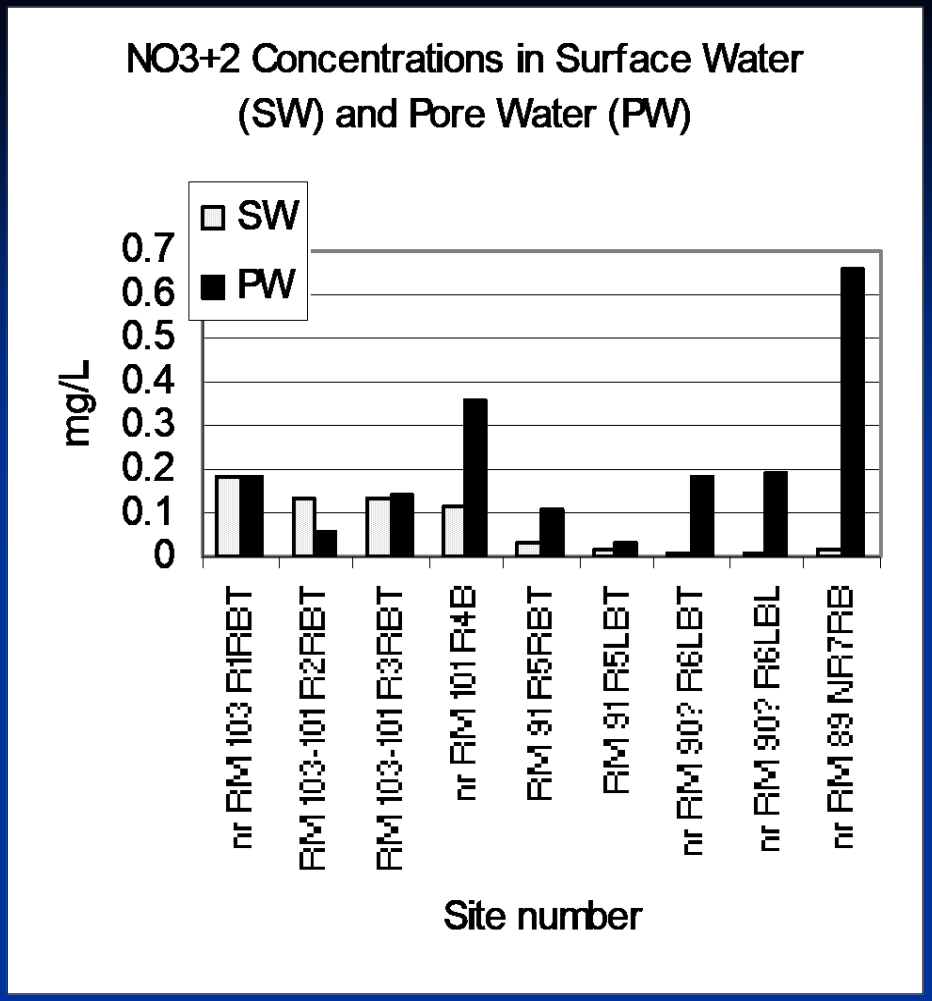




*Zillah reach has nuisance levels of algae and fails state DO and pH standards yet meets EPA's recommendations for streams in Ecoregion 3 for TN < 0.38 mg/L but not for TP < 0.022 mg/L.*

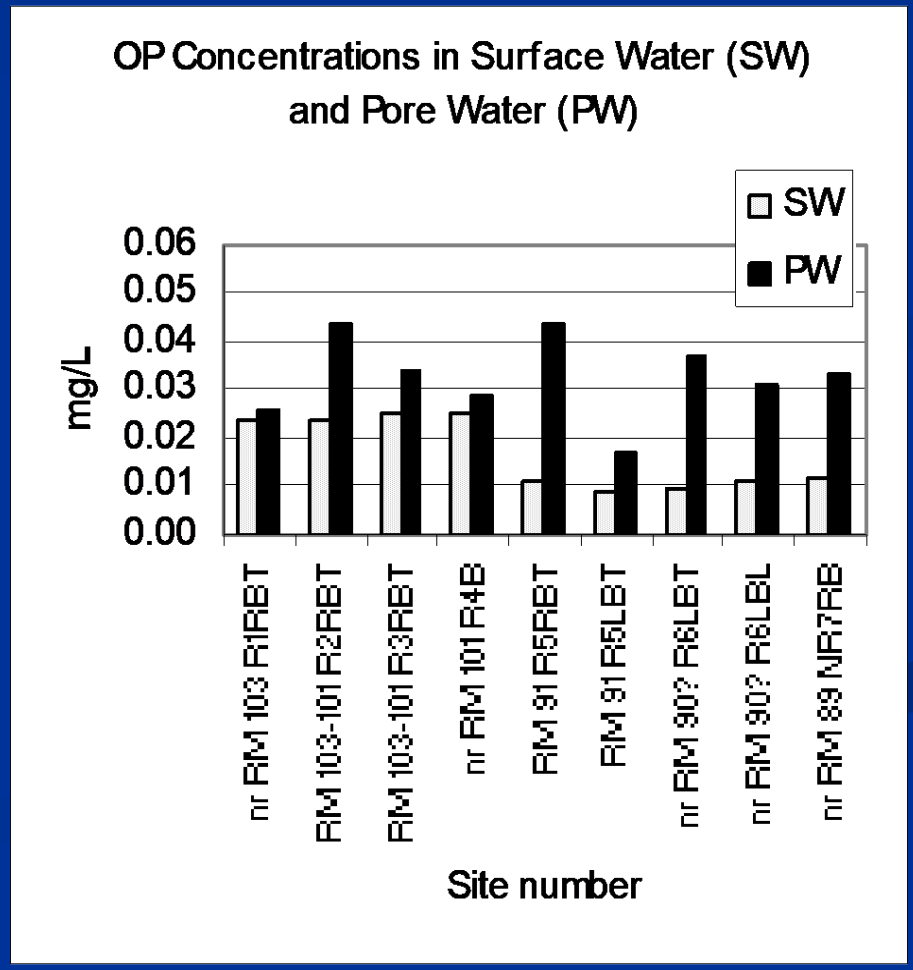



Dissimilar patterns between algal biomass and nutrient concentrations (in surface water & porewater). Lower nutrient concentrations did not correspond to less algae.




Nutrient concentrations usually higher in porewater than surface water. So? In gaining reaches, algae could obtain all the nutrients they need from hyporheic water regardless of surface water concentrations.

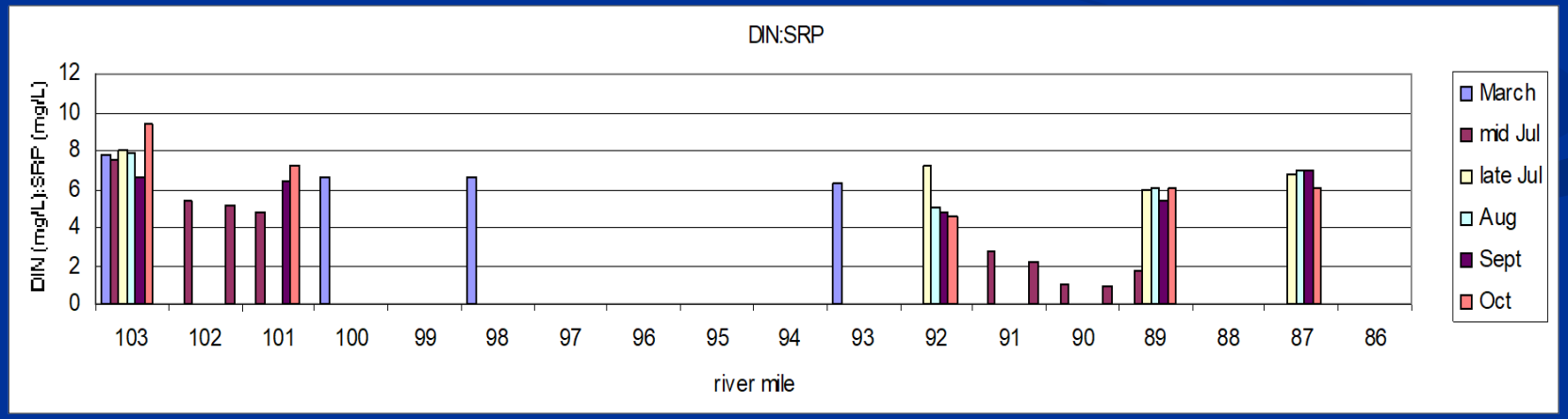


# Is N or P Limiting?

- Dr. Richard Kiesling, USGS National Research Program. We deployed periphytometers twice for 2-week deployments in late July and late September. Results? Neither N or P was limiting.

- Nutrient concentrations from throughout the reach and throughout the season suggest nitrogen is closer to limiting than phosphorus because the ratio of dissolved inorganic nitrogen (nitrate+ammonia) to soluble reactive phosphorus (orthoP) was < 7 at most sites.

*Periphytometer, Oct 06, RM 92.*



# Conclusions

- Abundant water star grass & algae in the Kiona reach resulted in DO concentrations and pH levels of concern in 2004 and 2005. In 2006, water star grass biomass was significantly reduced thanks to runoff from an abundant snowpack. While DO and pH conditions improved, they still did not meet state standards.
- Relationship between algae and nutrients in the Zillah reach were more complex than anticipated.
  - There was no relationship between nutrient concentrations and algal biomass, even at fairly low nutrient concentrations.
  - Nutrient concentrations in porewater were generally higher than in surface water.
  - Nitrogen may be the nutrient closest to limiting concentrations.

# 2007 Intended Scope of Work

| Question | Method |
|---|---|
| Is there a relationship between nutrient concentrations, algal accrual rates, and DO/pH conditions over a wide range of nutrient concentrations? | Deploy periphytometers in the Zillah and Kiona reaches of the Yakima River and the lower Naches River. |
| How do water quality conditions at Kiona compared in 2007 against the previous 3 years? | Maintain continuous monitor at Kiona through end of September. |
| How does the river's productivity in 2007 compare to 2005, with much less aquatic plant biomass in 2007 than in 2005? | Conduct 2-station productivity analyses for 3 two-week periods in the Kiona reach. |
| Could differences in substrate stability help account for differences in aquatic plant abundance between the reaches? | Ask the Bureau of Reclamation for results from their hydrodynamic model of the Yakima River. |
| Where does water star grass in the Kiona reach obtain its nutrients from? (Lit review says river bed not water column but data specific to Yakima River would be nice.) | Obtain water and plant tissue samples for N15 analysis. |

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**Questions?**