Phosphorus Forms and Fate in the Lower Fox River Watershed

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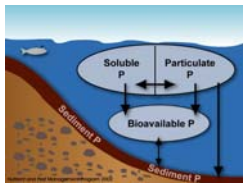
THE LOWER FOX RIVER watershed monitoring program

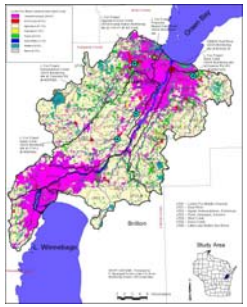
Study Overview and Background

- The effectiveness of some phosphorus reductions strategies such as grass filter strips and detention basins may depend on whether phosphorus is in the dissolved or particulate phase as it leaves the source area.
- Dissolved phosphorus (DP) is the phosphorus that passes through a 0.45 um filter when a water sample is filtered. Total P is comprised of DP + particulate P. Ortho-P (PO_4) is the dominant form of DP.
- Understanding the form in which P leaves source areas and is transported by streams is critical for predicting the fate of P using computer simulation models.
- This study (Phase 3) was initiated to answer questions related to P forms in runoff by tracking the ratio between DP and total phosphorus from farm, to channel/ditch, and to stream using targeted sampling throughout the flow path.

Background

- Early modeling efforts in the Fox-Wolf Basin (NEWWT modeling with SWRRB,;1993) assumed 10 to 30% of TP in dissolved form from ag. source areas and only 11% in Lower Fox Basin.
- Fox-Wolf Basin 2000 (1999-2002) monitored tributaries to assess/validate SWAT model predictions. Found that proportion of dissolved P assumed in models not supported by data.
- Further analysis of existing datasets was initiated in PHASE 1 and PHASE 2.





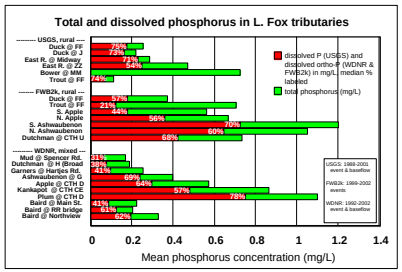
Land Use in the Lower Fox River Watershed

Samples from Apple Creek tribs, May 2004

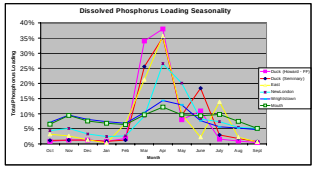
Apple Creek trib: May 23, 2004
Source Area site #3 downstream

PHASE 1: CONCENTRATION Analysis – Dissolved to Total Phosphorus Ratios in Lower Fox Streams

Large fraction of phosphorus is dissolved in streams. Fraction generally lower in urban areas.



***PHASE 1 CONCLUSION**: Conduct PHASE 2 to determine whether phosphorus loads follow same trend as concentrations.*



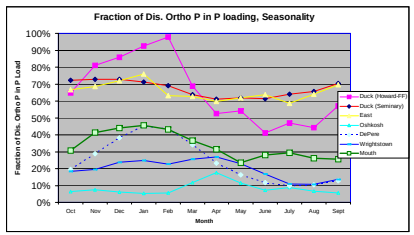
Seasonality in dissolved phosphorus loading is similar to total phosphorus loading

PHASE 2: Phosphorus and Sediment LOADS in Fox-Wolf Basin; Dale Robertson, USGS - Wisconsin

- ***USGS: Constituent Transport Model utilized to Calculate Loads***
  - ***Calibration Period 1985-1999 (some exceptions)***
  - ***Computation Period 1988-99 (a few to 2002)***

PHASE 2 CONCLUSIONS:

- ***In general, dissolved P makes up large percent of phosphorus loading in smaller streams (50-74%).***
- ***Dissolved P fraction highest in fall and winter months.***
- ***Largest total & dissolved P load in March & April for streams in L. Fox Subbasin – very seasonal trend***
- ***What does this mean for effectiveness of BMPs (best management practices) for phosphorus control?***



- DP fraction of total P loading generally high, especially in small streams.
- Dissolved fraction highest in fall and winter months.

PHASE 3: Phosphorus Forms at Different Spatial Scales
UW-Green Bay, Lower Fox River Monitoring Program

Primary Goal - Water Quality and Load Monitoring:
Better understand the form of phosphorus present so we can predict impact of phosphorus reduction strategies within Lower Fox River Sub-basin by comparing dissolved phosphorus and total phosphorus at different scales throughout a watershed.

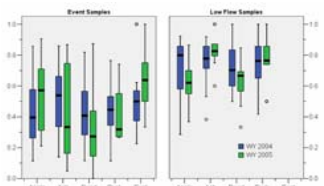
OBJECTIVES

1) Primary study area is Apple Creek watershed. Sampling sites located in streams draining primarily rural land uses.
   - Event grab sampling in < 2 sq. km source area watersheds.
   - Compare to USGS continuous monitoring sites.
2) Measure concentration and proportion of Dissolved P (DP) to Total P (TP) in streams at multiple spatial scales.
3) Track DP, TP, TSS along flow path (source vs integrators; upstream vs downstream).
4) Relate results to watershed characteristics (soils, management, topography) and previous studies.
5) Apply SNAP-Plus, derive P-Index & compare to WQ.
6) Evaluate models (P-Index, SWAT).

METHODS

- Grab samples from 11 Source Area (0.2 to 2.1 km²) and 4 integrator sites (12 to 85 km²) during Runoff Events, at or near peak flow.
  - Targeted uniform precip events; tape-down measurements taken for relative discharge.
- Source area sites selected in quasi-random basis (agricultural landuse; suitable discharge, area not too large).
- Primary Integrator site: downstream main stem USGS Site: Continuous discharge & automated samples at CTH U (117 km²); other 4 LFRWMP stations also used for analysis.
- TSS, total P, dissolved P analysis at Green Bay MSD lab.
- Samples collected during 5 runoff events (March to June, 2004), plus 1 in 2005, and 1 complete event in Jan 2006.
- Utilize Nutrient Management Plans with soil-test P data as input to SNAP-Plus.

Five Lower Fox Primary Tribs: Dissolved P:TP Ratio (2004-05)

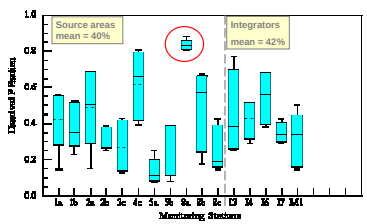


55% Dissolved P (overall mean & median fraction)

median DP = 0.22 mg/L

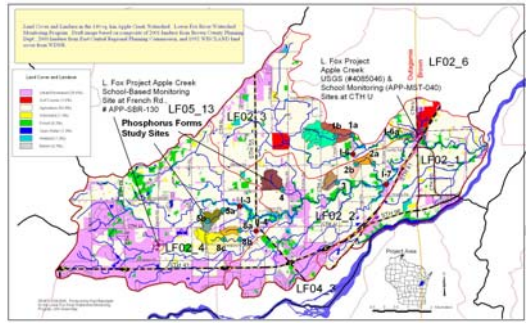
median TP = 0.46 mg/L

Apple Creek P-Form Study: Dissolved Phosphorus Fraction in 2004



- Source areas similar to integrator sites
- Site 8a significantly higher than all except 4 (TUKEY MCP)

Apple Creek Study Area: Sampling sites and sub-watershed boundaries of source areas shown below (I- denotes larger integrator sites, e.g., I-6)



Apple Creek Tributaries: Dissolved Phosphorus (2004 events only)

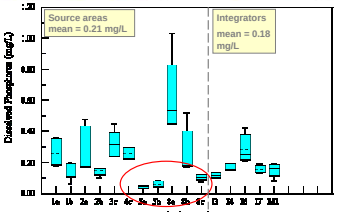
1) Source areas similar to integrator sites

2) Source areas Stat. Analysis (cluster 5a,b, 8c):

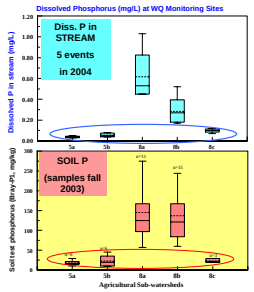
site 5a < all sites except 5b

5b < all except 5a & 8c

(p<0.05 TUKEY MCP)



Apple Creek sub-watershed stations



ABOVE: Soil-test P results (Bray-P1 ppm):

Soils within sub-watersheds 5a, 5b, 8c are *significantly lower* than 8a or 8b (p<0.01, TUKEY MCP)

Dissolved P > in Stream (mg/L)

closely matches

Soil test P > in drainage area (mg/L Bray-P1)

PRELIMINARY CONCLUSIONS

- Dissolved P fraction fairly high at main stem sites (40-60%). Coincides with earlier findings in Lower Fox.
- EVENT Dissolved P fraction at source area sites (0.2 to 2.1 km²) similar to integrator sites (12 to 85 km²) and main stem site (117 km²) → no obvious net concentration change observed.
- SIGNIFICANT differences in Dissolved P from source areas ($p < 0.0001$).
- In-stream DP closely parallels Soil-test P (Bray-P1), where data available.
  - available soil-P implicated as major source of stream DP.
- Source area sites with low dissolved P had low DP/TP ratio, still relatively high TP (although may be reduced some).
  - Implications for effectiveness of BMP's.
- Preliminary P-Index application/assessment:
  - areas evaluated so far: WQ measurements generally reflect relative P-Index values for TP, DP, and PP.