LimnoTech

Water Environment | Scientists Engineers

Fox River Implementation Plan Project Meeting – Modeling Approach

Fox River Study Group

April 24, 2014

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Meeting Goal:

- Discuss recommended modeling plan for FRIP development and achieve consensus on major elements of plan, so modeling can proceed.

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Specific Objectives for Today:

- Reach consensus on the approach for using QUAL2K in establishing annual load targets for the FRIP.
- Reach consensus on method of calculating tributary load reductions for the FRIP.
- Answer other outstanding questions on the recommended modeling approach (or make a plan to get them answered).

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Discussion Topics:

- General Overview of Recommended Approach
- Water Quality Modeling with QUAL2K
  - LimnoTech recommended approach
    - Seasonality
    - Dealing with summer P flux
- Calculation of NPS Load Reductions
  - Alternatives
  - Recommended approach
- Other Questions
- Next steps

General Overview
Of Recommended Modeling
Approach

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General Modeling Process:

1. Use QUAL2K to determine the combinations of load reduction and (potentially) dam removal necessary to attain WQS.
2. Baseline upstream flows/loads and WWTP flows/loads are determined from data, without models.
3. Dam removal simulated in QUAL2K.
4. Baseline tributary flows/loads are determined from HSPF models.

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General Modeling Process (cont'd):

5. Modify baseline tributary loads from HSPF
   – Baseline loads reduced to see what it would take to achieve target tributary load reductions defined by QUAL2K, assess feasibility.
   – Two options, discussed in detail later.
6. Iterate to evaluate alternatives

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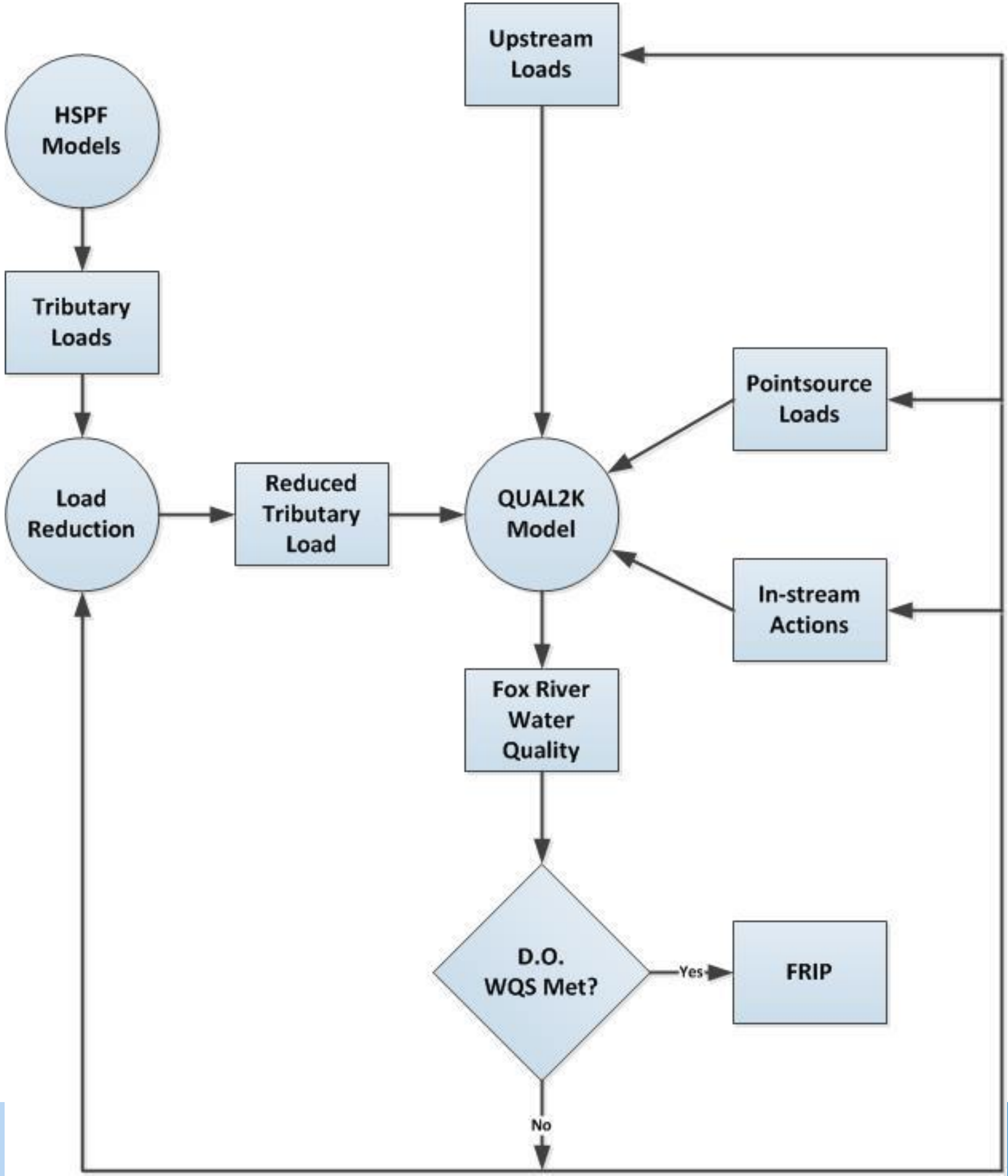

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Questions/Discussion

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Water Quality Modeling with QUAL2K

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What's Driving DO Depletion in the River?

- Excessive phosphorus (P) in water column promotes algal growth; algae die and settle to bed of river; decay lowers oxygen (SOD).
- Phosphorus in the water column settles to bed of river; some P reenters water column from sediments (P flux), worsened by low DO.
  - Sediment P flux causes more algal growth.
  - The cycle continues.

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Determination of Annual Allowable Load

- Initial water quality modeling efforts focused on load reductions necessary to meet water quality standards during critical summer conditions
  - Recognize that greater assimilative capacity exists during other periods of the year
- Implementation Plan designed to assess *annual* load
- Analysis will be conducted to define assimilative capacity during different seasons

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Seasonal Approach to Determine Annual Load:

- Begin with critical season assessment to define:
  - Maximum allowable WWTP loads; and
  - Reduction in annual watershed load
    - Specified via adjustment to sediment phosphorus concentration

  necessary to meet water quality standards
- Conduct seasonal analysis to determine
  - Maximum allowable WWTP loads that will meet WQS for times other than summer critical conditions
- Divide the allowable loading rates defined above into distinct seasonal periods
  - Annual allowable load = sum of seasonal loads

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QUAL2K Analysis of Noncritical Seasons:

- QUAL2K inputs expected to vary by season
  - Upstream Boundary
    - Month-specific 7Q10 flow
    - Observed monthly annual water temperature
  - Wastewater Treatment Plants
    - Begin with existing baseline levels
  - Tributaries
    - Average flows and temperature taken from HSPF results
  - Climate
    - Air and dew point temperatures from local climate stations
    - Length of day provided by the US Naval Observatory for Aurora

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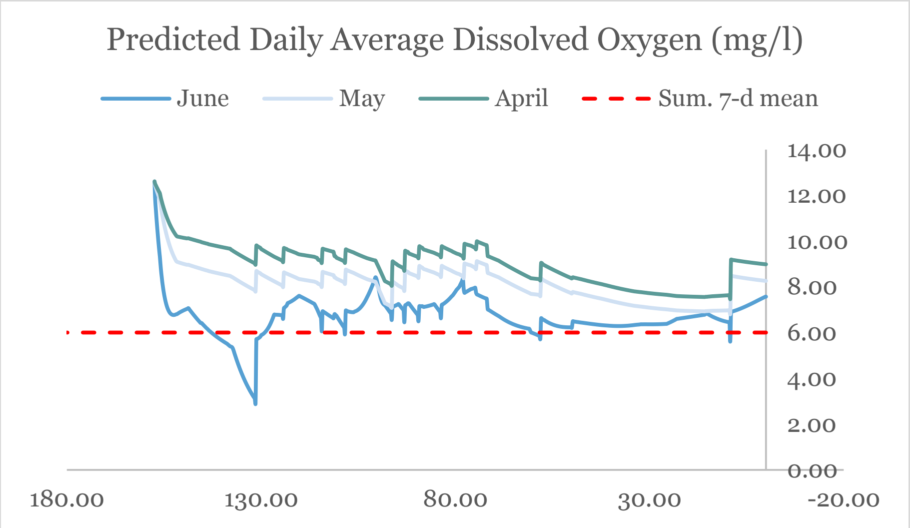
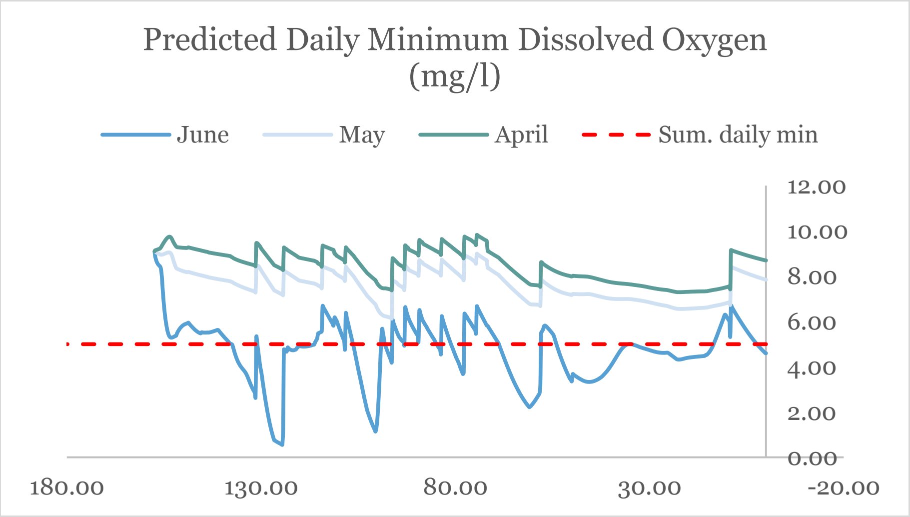
Preliminary Seasonal Results - Spring:

- Violations in June, but not April or May





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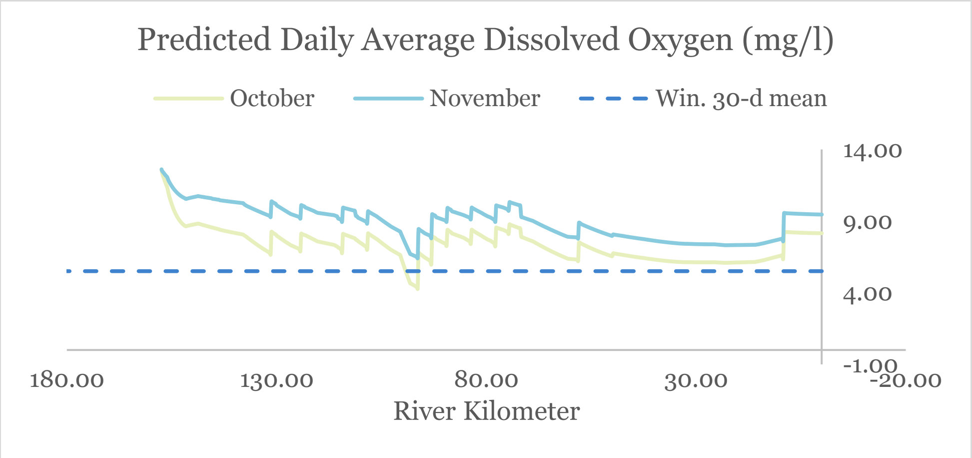
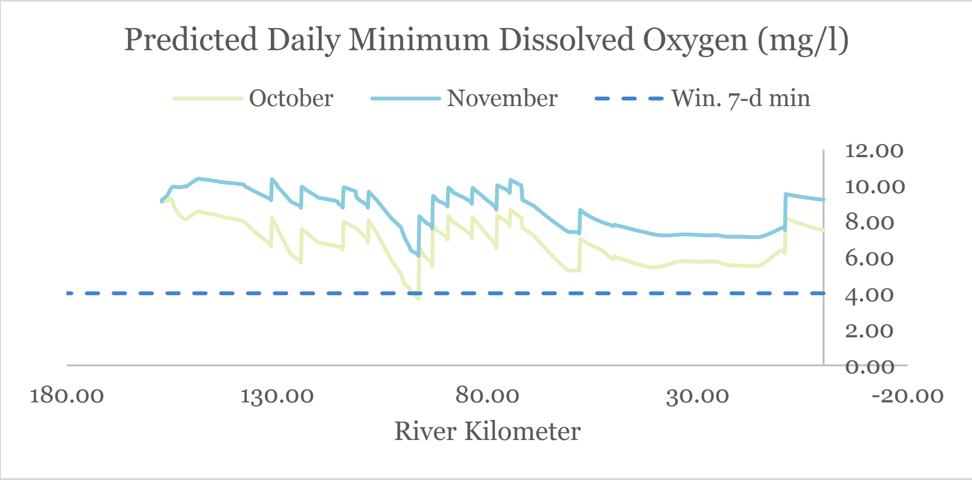
Preliminary Seasonal Results - Fall:

- Violations in October, but not in November





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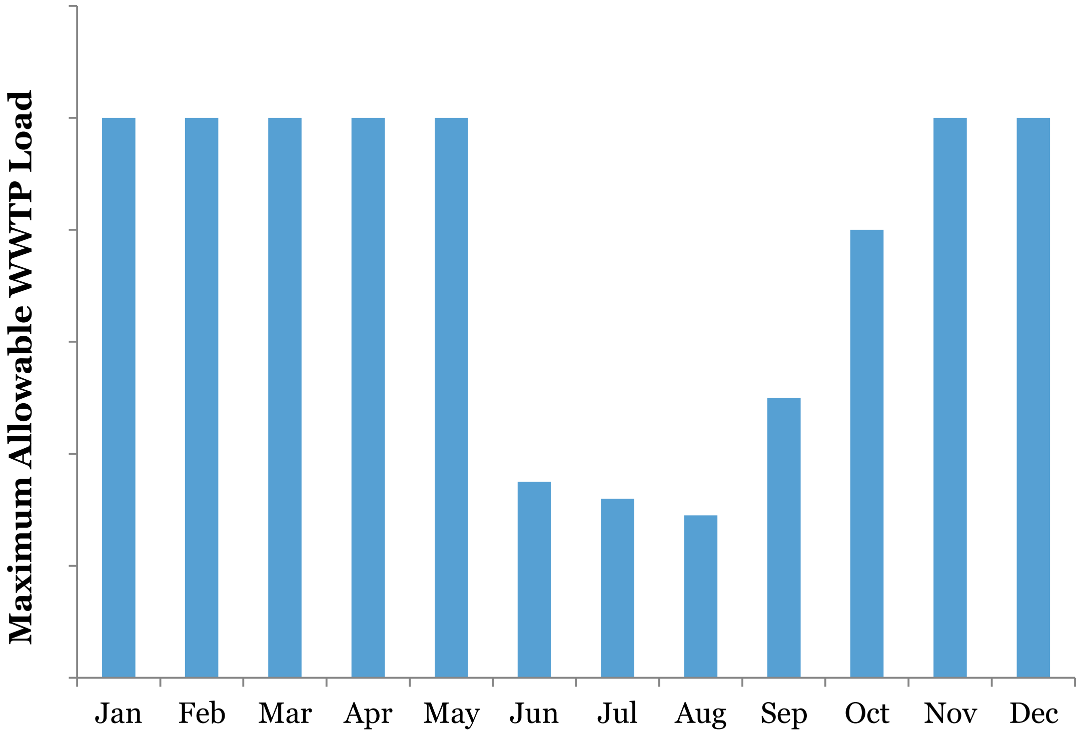
How do we convert monthly results into seasonal permit limits?



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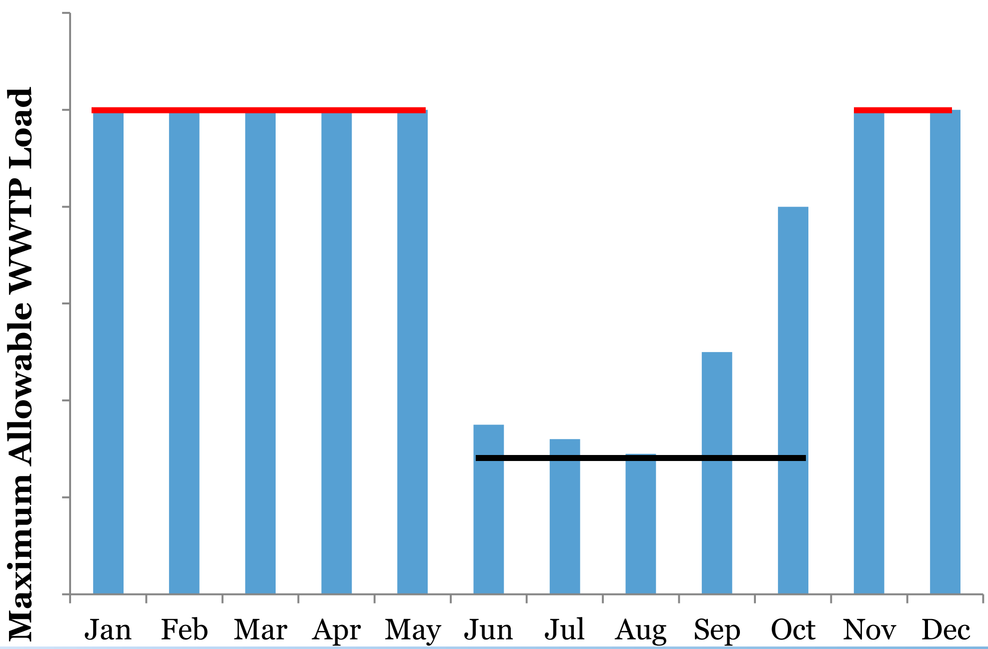
How do we convert monthly results into seasonal permit limits

- Two seasons?

Summer — Off-season



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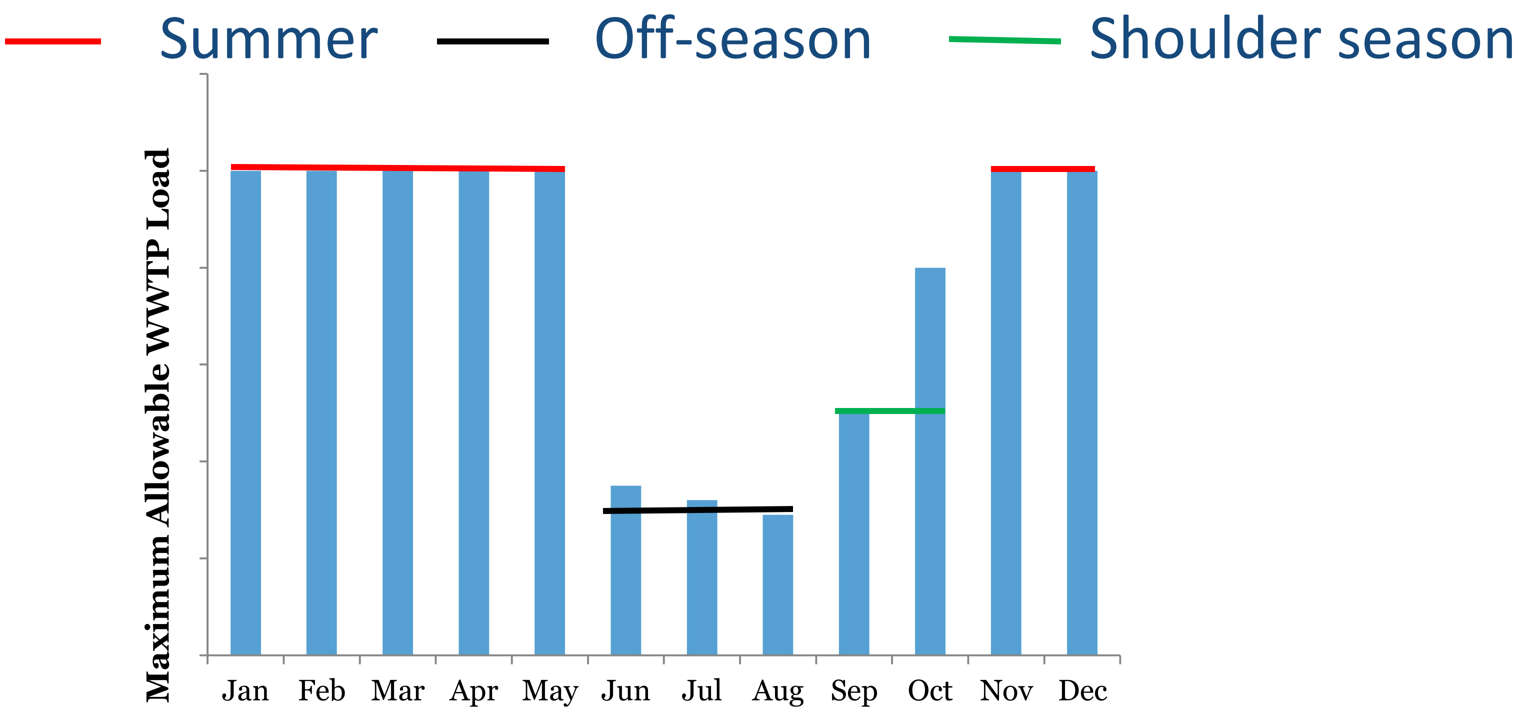
How do we convert monthly results into seasonal permit limits

- Three seasons?



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Sediment Flux Considerations

- QUAL2K model of the Fox River is a steady-state model of summer low flow conditions
  – Not structured to directly consider water quality benefits that may occur in response to pollutant load reduction in other portions of the year.
- Potentially an issue if lags exist between loads and responses
  – Sediments have a longer response time to changes in load than the water column

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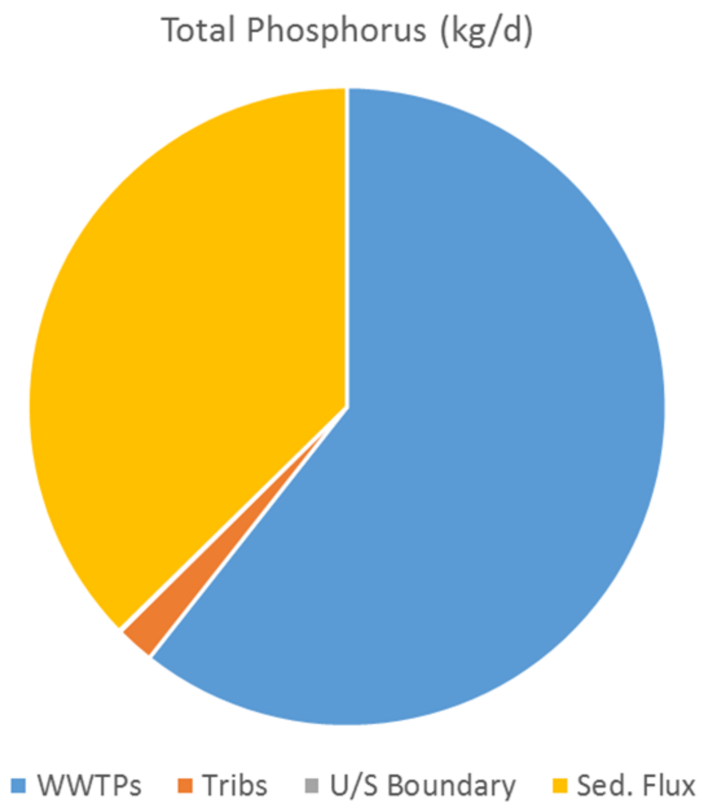
Why Care About Sediment P Flux?

- Under summer critical low flow conditions, sediment is a major P source (37%).
- Need to determine if/how to reflect loads from non-summer season into QUAL2K sediment routines



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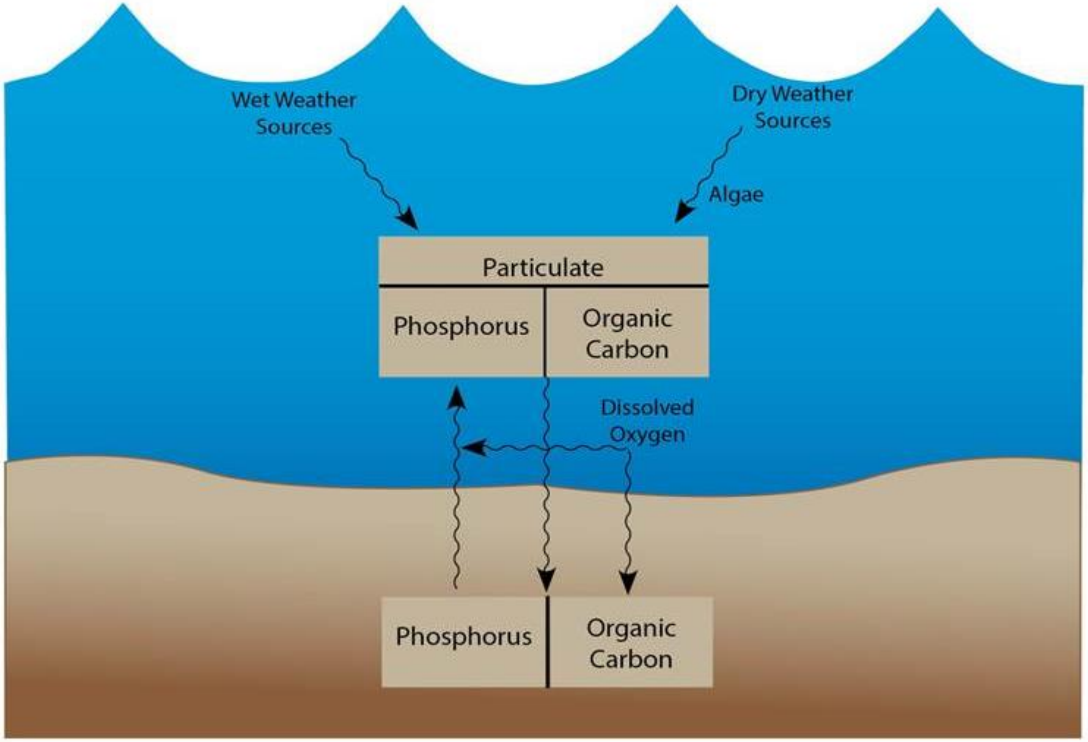
QUAL2K Predictions of Sediment Flux:

Key processes

- Particulate material settles to bottom
- Organic carbon in bottom sediments consumes oxygen
- Reduced oxygen concentrations facilitate release of phosphorus



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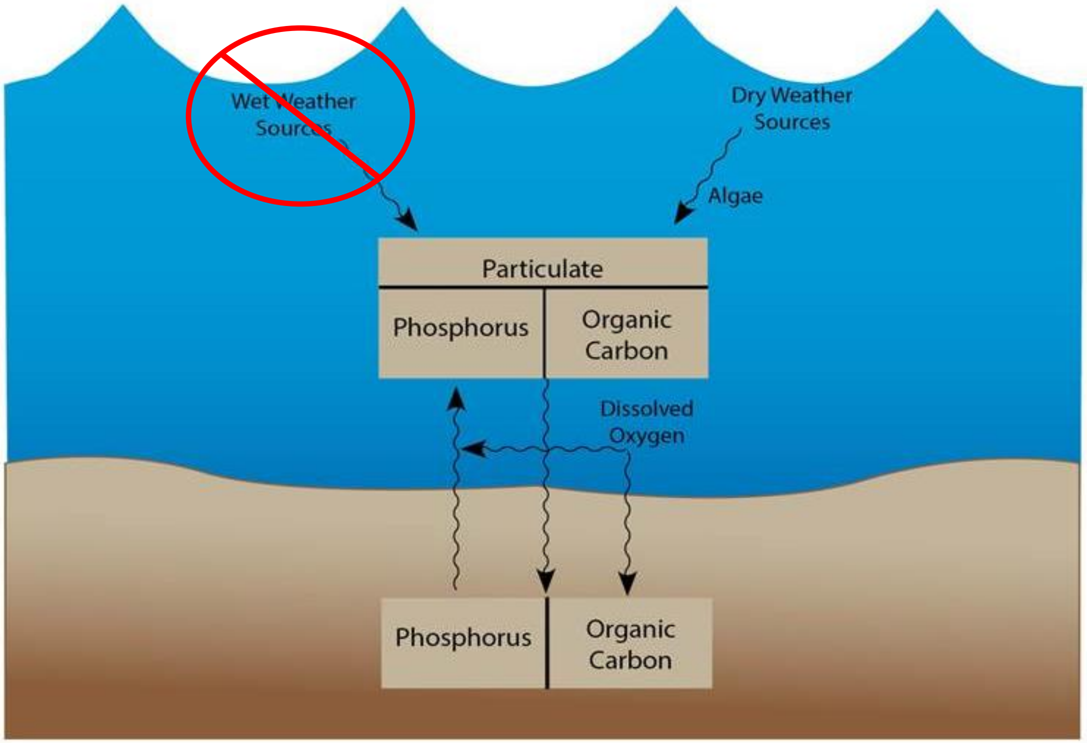
QUAL2K, as structured, assumes that sediment concentrations are controlled by dry weather sources

- Appropriateness of this assumption depends on the response time



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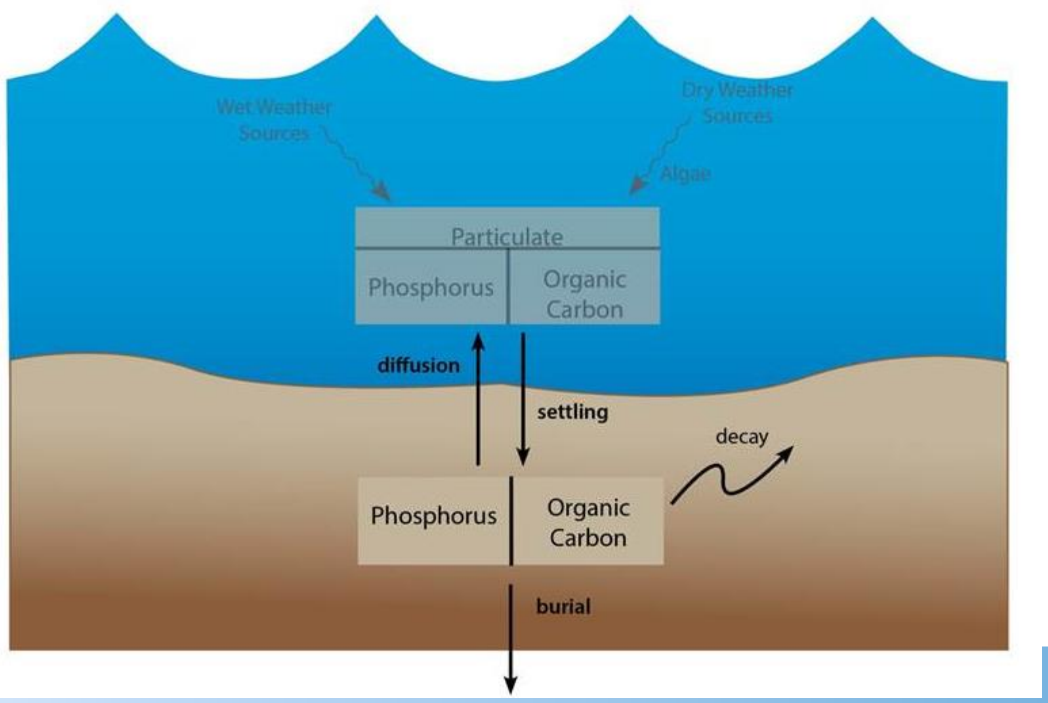
Response times can be estimated by examining the scientific literature of sediment modeling

- Change in sediment concentration = Settling load – diffusion – burial - decay



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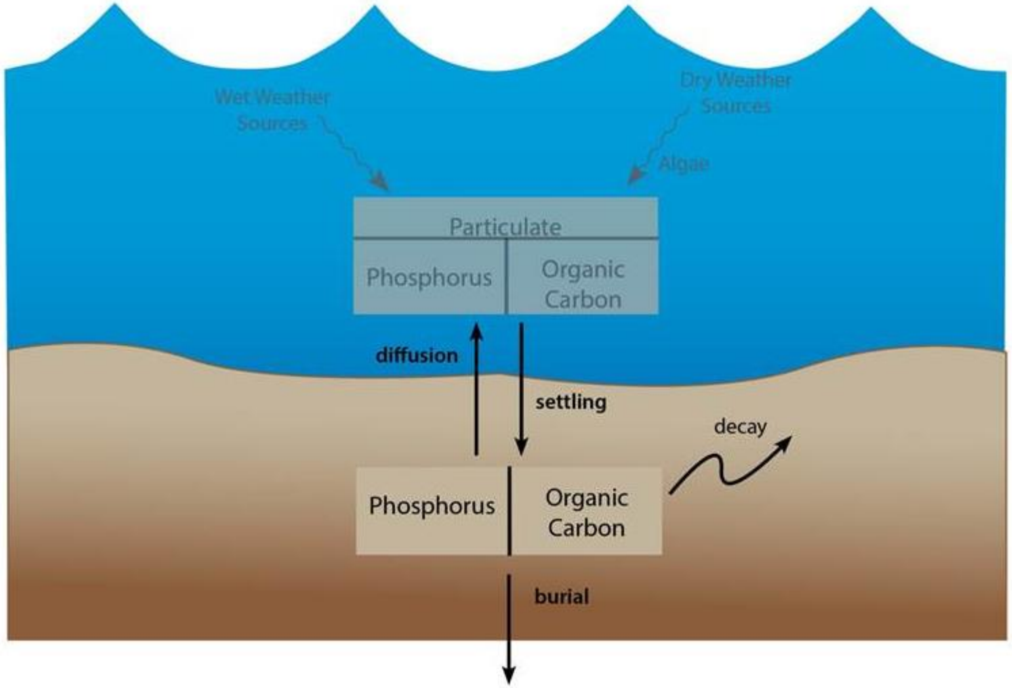
Time Frame of Sediment Response to Changing Loads

Response time dictated by the rate of the loss terms

- Diffusion
  - 0.00003 to 0.0004 /day
- Burial
  - 0.00001 to 0.0001 /day
- Decay
  - 0 for phosphorus
  - 0.035/day for carbon



Response times

- Phosphorus = 3.8 years, responds to annual loads
- Organic carbon = 20 days, responds to summer load

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Options for Allowing QUAL2K to Consider Wet Weather Loading:

- Three options identified
  - Option 1: Adjust model inputs for prescribed sediment flux
  - Option 2: Adjust model inputs for percent bottom coverage
  - Option 3: Modify the model code
- Option 1: Prescribed Sediment Flux
  - QUAL2K developers recognized that sediments respond to loads that occur prior to summer low flow
    - Provided the capability for user to assign portion of the sediment flux caused by pre-summer sources
  - This option negates the ability of the model to consider the feedback between phosphorus flux and oxygen
    - **Unacceptable**

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Options for Allowing QUAL2K to Consider Wet Weather Loading:

- Option 2: Adjust Model Inputs for Percent Bottom Coverage
  - We had previously identified a model input related to "percent bottom coverage" as a means for adjusting sediment flux to reflect watershed load reductions
  - Investigation into the model code indicated that this input also affects settling in the water column
    - **Unacceptable**
- Option 3: Modify the model code
  - Ultimately concluded that the only means to accurately reflect off-season load reductions is to make a change to the QUAL2K model code

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Options for Allowing QUAL2K to Consider Wet Weather Loading:

- Option 3: Modify the model code (cont'd)
  - Sediment phosphorus flux in QUAL2K is described by the following equation

    $P\ flux = SOD_{computed} \div Dissolved\ Oxygen \times (P_{sediment} - P_{water})$

  - We propose to add a single coefficient to reflect the reduction in annual phosphorus load to the sediments

    $P\ flux = SOD_{computed} \div Dissolved\ Oxygen \times (\mathbf{a} \times P_{sediment} - P_{water})$

    where a = annual reduction factor

  - Biggest assumption of this approach is that annual phosphorus load to sediments is proportional to annual load to the river

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Questions/Discussion

Calculation of Tributary Load Reductions

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Calculation of NPS Load Reductions to:

1. Test feasibility of meeting load reduction target determined using QUAL2K.
2. Evaluate alternative approaches for meeting load reduction target determined using QUAL2K ('what if' scenarios) .

NOTE: FRIP will not identify specific actions to be taken to meet load reduction targets; may provide examples.

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Two Alternatives:

1. Run HSPF models to test each iteration of NPS control alternatives.
2. Use spreadsheet tool to reduce baseline loads calculated by HSPF.

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First Alternative – Use HSPF

Procedure for calculating load reduction in each tributary using HSPF:

1. Start with HSPF-calculated baseline NPS loads
2. Specify pre-determined load reduction (%) for each pollutant in each affected land use category
3. Specify percentage of each land use to be treated within tributary
4. Run HSPF
5. Export results, tabulate reduced loads in spreadsheet, compare to baseline

Crop change (crop to non-crop, soy to corn, etc.) could be implemented the same way or as land use changes in model.

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Second Alternative – Use Spreadsheet Tool

Procedure for calculating load reduction in each tributary using spreadsheet tool:

Start with HSPF-calculated baseline NPS loads

↓

Specify pre-determined load reduction (%) for each pollutant in each affected land use category

↓

Specify percentage of each land use to be treated within tributary

↓

Spreadsheet tool calculates load reduction, compare to baseline

All control measures would be calculated using tool

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Second Alternative – Use Spreadsheet Tool

Summary

FOX RIVER LOAD REDUCTION TOOL - Summary

Subwatershed	Scenario (kg P/yr)	Change	Base (kg P/yr)
01 Buck Creek	42.4		42.4
02 Indian Creek	177.5		177.5
03 Little Indian Creek	88.8		88.8
04 Brumbach Creek	11.9		11.9
05 Mission Creek	15.5		15.5
06 Somonauk Creek	81.4		81.4
07 Roods Creek	16.2		16.2
08 Clear Creek	6.6		6.6
09 Hollenback Creek	13.8		13.8
10 Little Rock Creek	75.1		75.1
11 Big Rock Creek	118.7		118.7
12 Rob Roy Creek	20.8		20.8
13 Blackberry Creek	63.3	10.2	73.5
14 Morgan Creek	19.7		19.7
15 Waubonsie Creek	30.0		30.0
16 Indian Creek	13.8		13.8
17 Mill Creek	31.2		31.2
18 Ferson Creek	54.0		54.0
19 Norton Creek	11.7		11.7
20 Brewster Creek	16.2		16.2
21 Poplar Creek	43.4		43.4
22 Tyler Creek	40.5		40.5
23 Jelkes Creek	6.8		6.8
24 Crystal Lake Outlet	25.9		25.9
25 Spring Creek	26.5		26.5
26 Flint Creek	36.3		36.3
27 Tower Lake Outlet	5.8		5.8
28 Silver Lake Outlet	1.9		1.9
29 Unnamed Tributary	6.6		6.6
30 Sleepy Hollow	15.5		15.5
31 Cotton Creek	20.5		20.5
32 Fox Upper Mainstem	85.8		85.8
33 Fox Lower Mainstem	171.9		171.9
Watershed Total	**1,396**	-10	1,406

Editor

FOX RIVER LOAD REDUCTION TOOL - Subwatershed Editor

BBC2: Blackberry Creek

Update Summary | Reset Windows

	BMP Enrollment	Removal Efficiency	Mass Removed	Baseline (kg P/yr)	Acres
Total	**41%**	**34%**	**10.2**	**73.5**	**47,070**
Land Use					
Corn (COR)	54%	28%	2.5		10,597
Soy (SOY)	83%	42%	5.4		9,864
Urban - high density (UHD)	28%	44%	0.4		1,929
Urban - low/medium density (UMD)	**45%**	**27%**	**1.9**		**10,051**
Urban - Open space (UOS)	15%	22%	0.1		1,045
Forest (FOR)	n/a				2,204
Rural Grassland	n/a				10,257
Surface water (SWA)	n/a				871
Wetlands (SWM)	n/a				252

Urban - low/medium density (UMD) BMPs:

	BMP Enrollment	Removal Efficiency	Mass Removed	Notes or comments
Dry detention basin	*10%*	*50%*	0.8	*Notes or comments*
Wet detention basin				
Bioretention	*20%*	*10%*	0.3	
Constructed wetland				
Infiltration basin				
Permeable pavement	*10%*	*40%*	0.6	
Green roof	*5%*	*25%*	0.2	
Other - describe				

Scenario 01 Title *Illustrative Blackberry Creek application*

Description

Mass loading estimates are purely illustrative values based on an arbitrary unit area load of 1 kg/sq mi/year

Load ... | Save ... | Image ...

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Second Alternative – Use Spreadsheet Tool

- Process transparency – inputs are visible
- Communication enhancement – can be used in meetings
- Ease of use – don't need to be a modeler
- Future utility – may be useful after the FRIP is completed

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Questions/Discussion

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Next Steps

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Process:

Phase 1: Refine WQ Targets

Task 1: Kick-off workshop with FRSG

Task 2: Assess and define water quality targets

Task 3. Review model and recommend adjustments if needed

Phase 2: Develop Load Reduction Alternatives

Task 4. Second workshop with FRSG

Task 5. Model revised loading scenarios

Task 6. Develop alternatives to attain water quality goals

Phase 3: Prepare Watershed Implementation Plan

Task 7. Third workshop with FRSG

Task 8. Prepare Draft WIP

Phase 4: Finalize Watershed Implementation Plan

Task 9. Fourth workshop with FRSG

Task 10. Prepare Final WIP

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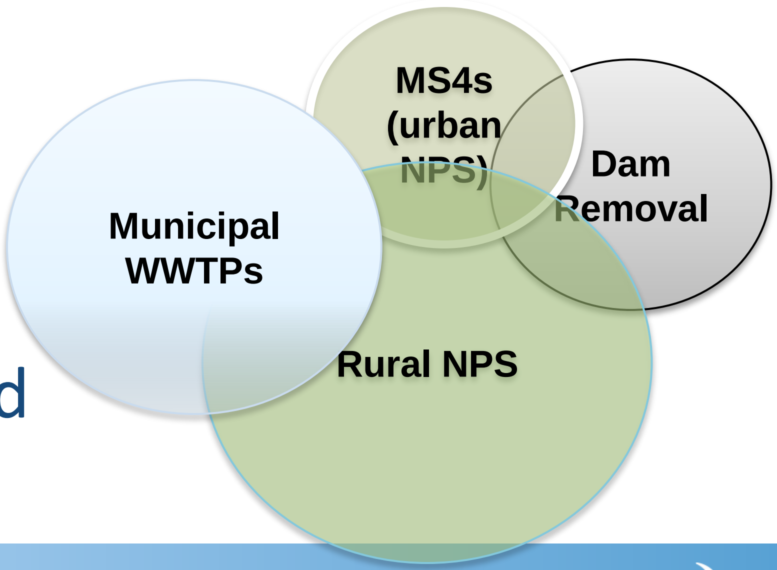
Task 5: Model revised loading scenarios:

- Use QUAL2K water quality model:
  - Adjust load sources one at a time
  - Dozens of different scenarios planned.
  - Scenarios originally described in SOW, but some variations may be made as a result of recent progress.

Fox River Implementation Plan: First Workshop

Task 6: Develop alternatives to attain water quality goals:

- Develop control measure alternatives:
  - Current and future watershed & source characteristics will help us identify control measures.
  - The system data and models will help identify the most effective actions.
  - Prioritize control actions, find the right mix.



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Schedule:

Task No.	Task	2013		2014												2015					
		Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
1	Kick-off meeting		■																		
2	Assess and define water quality targets		■	■																	
3	Review model and recommend adjustments (if needed)		■	■																	
4	First workshop with FRSG				■																
5	Model revised loading scenarios					■	■	■													
6	Develop alternatives to attain water quality goals						■	■	■	■	■	■									
7	Second workshop with FRSG												■								
8	Prepare Draft WIP													■	■	■	■				
9	Third workshop with FRSG																	■			
10	Prepare Final WIP																		■	■	

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Questions?