ICPRB Participation in Phase 6 Watershed Model Development

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Interstate Commission on the Potomac River Basin

Chesapeake Bay Program Modeling Workgroup Meeting

December 11, 2013

Background

- Maryland Department of the Environment is supporting ICPRB participation in Phase 6 development
- MDE-ICPRB partnership in Phase 5:
  - ICPRB participation in early Phase 5 calibration effort
  - Periodic review of Phase 5 development
  - ICPRB assisted in development of local sediment TMDL methodology (based on P5)
  - ICPRB developed nutrient local TMDLs for MDE based on Phase 5 Model

MDE Interests in Phase 6 Watershed Model

- MDE is interested in improving the performance of the Watershed Model at calibration stations upstream of Fall Line
  - Improvements in simulation at a local scale would help improve acceptance of TMDL allocations by stakeholders
  - Provide sounder basis for local nutrient and sediment TMDLs and consistent baseline for environmental management

Objectives

- Regional Factors
  - Incorporate regional factors into land use loading targets or mitigate their negative impacts
- Use WQ Calibration Data to Inform PQUAL Parameters
- Improve River Calibration Load Targets
  - Establish load targets for Western Shore, Eastern Shore, and Lower Potomac
  - Investigate how Chain Bridge phosphorus loads are related to loads in subwatersheds
  - Compare load targets with SPARROW

Objectives (cont.)

- Make River Calibration Methodology Sensitive to Flow Regime
- Incorporate Local Information into Model Calibration Targets
  - Local monitoring data
  - Results of finer scale simulation models
  - MS4 monitoring data
  - Soil tests

Using Water Quality Calibration Data to Help Set PQUAL Parameters

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This work is a still exploratory. It presents a “PROOF OF CONCEPT” that

1. An analysis of water quality data can help set PQUAL parameters

2. This use of water quality data can take over the at least some of the roles of Regional Factors in the Phase 6 Watershed Model

TOPICS

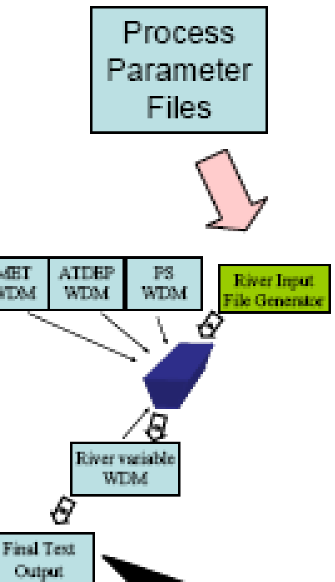
- Brief Review of How Targets and Regional Factors are set
- PQUAL parameters
- Analysis of Water Quality Calibration Data
- Linking analysis of water quality data to land segments
- How to use WQ analysis to help set PQUAL parameters

Land Segment Targets and Regional Factors

- Land Segment Nutrient Targets
  - TN and TP targets based on literature review, nutrient inputs
  - Split into separate targets for baseflow, surface flow
- Regional Factors
  - Multiplicative factors applied to land segment loads to calculate edge-of-stream loads
  - Set in WQ calibration to improve agreement between model and ESTIMATOR loads/key WQ stations

lested Optimization

River Calibration

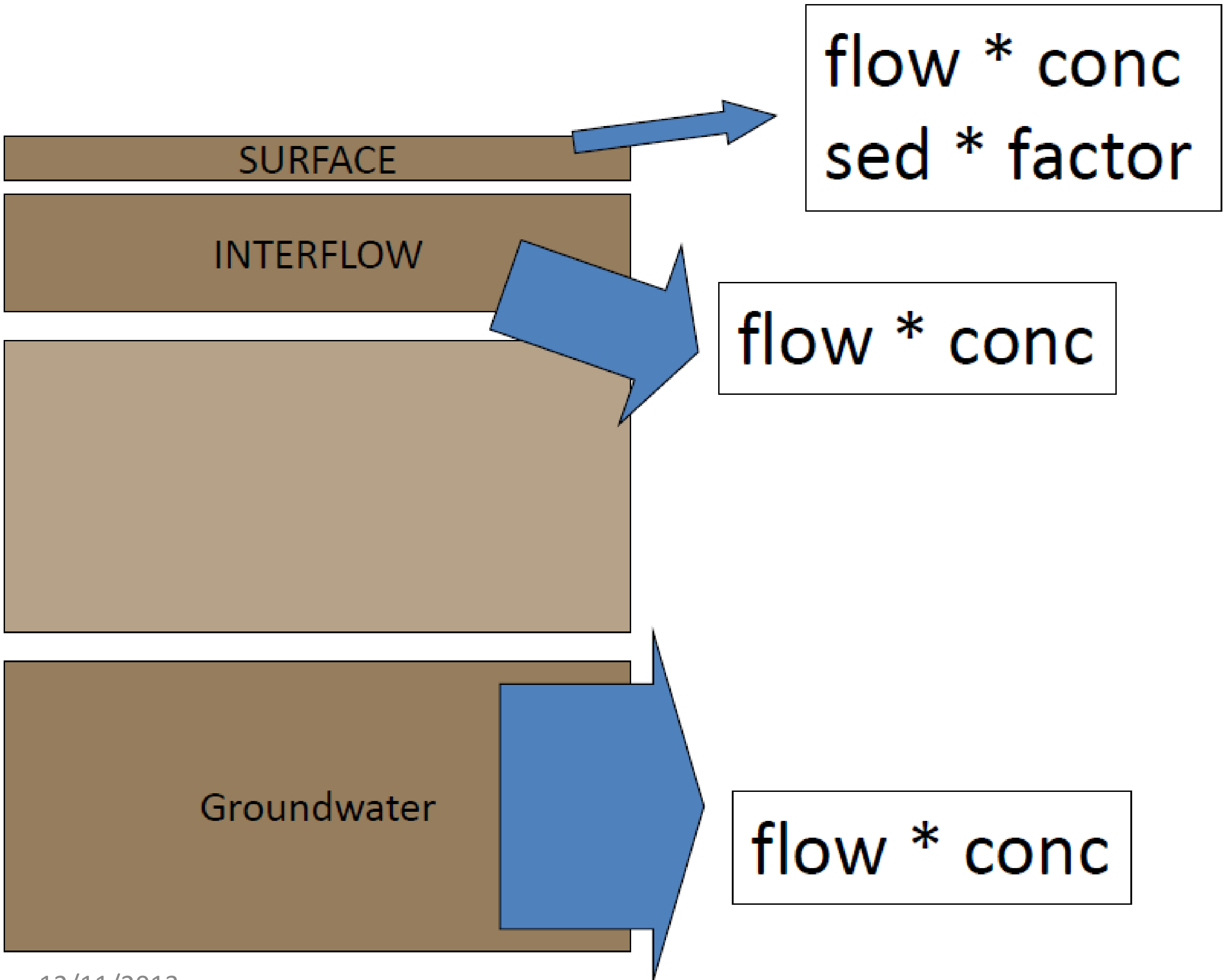


- Assume the sensitivity of the simulation to each parameter
- Determine an appropriate adjustment direction for each parameter
- Take a small step in that direction

- Calculate necessary EOS to unbias the calibration
- Adjust EOS by that amount

PQUAL loading model

G. Shenk 7/23/13



PQUAL MODULE

- Parameters of PQUAL are concentrations associated with baseflow, interflow, surface runoff, and eroded sediment
- Parameters can be set on a monthly (seasonal) basis
- How can we set PQUAL parameters?
  - Targets for basflow loads
  - Simulated flow (baseflow, etc.) from PWATER
  - Concentration parameter = target/ simulated flow

Using Observed Concentrations to Set PQUAL Parameters

- Simple paradigm: Suppose you are using HSPF with PQUAL to simulate
  - Small watershed
  - Single land use
  - Single river reach
  - Monitoring station at watershed outlet
- Set PQUAL baseflow concentration parameter = average observed concentration in baseflow

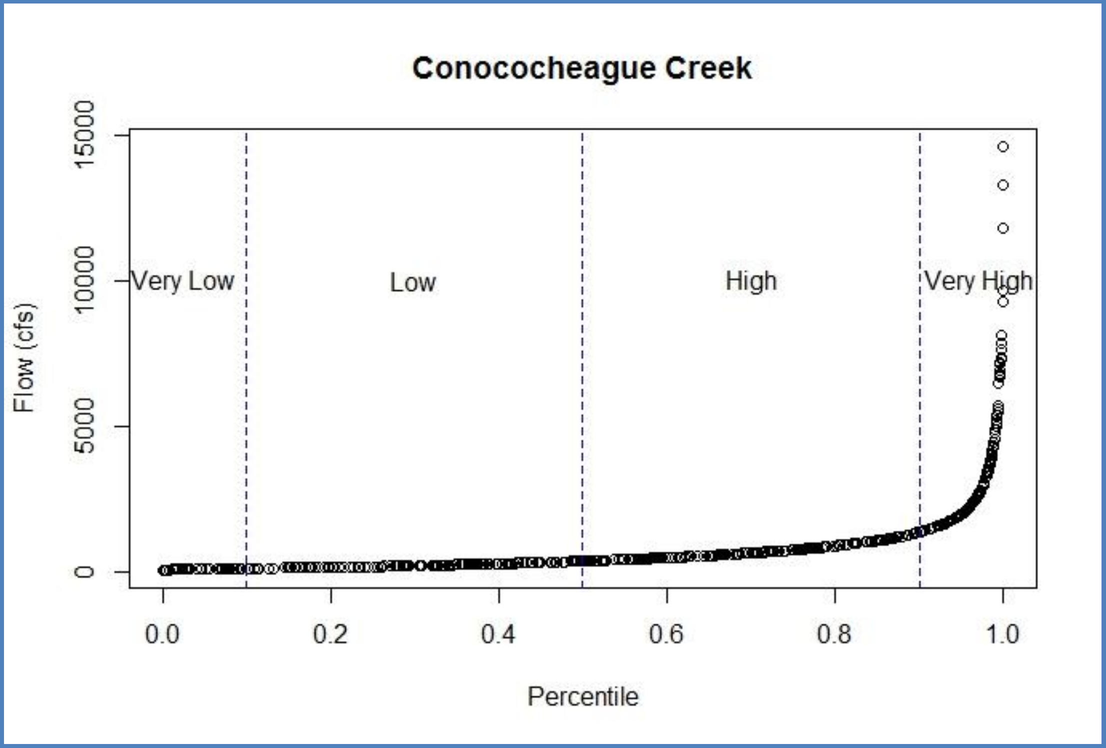
Challenges to Using Observed Data to Inform PQUAL Parameters in Watershed Model

- Multiple land uses
- Nested watersheds in river network
- Not a one-to-relation between land segments and monitoring stations: multiple land segments contribute/impact multiple monitoring locations

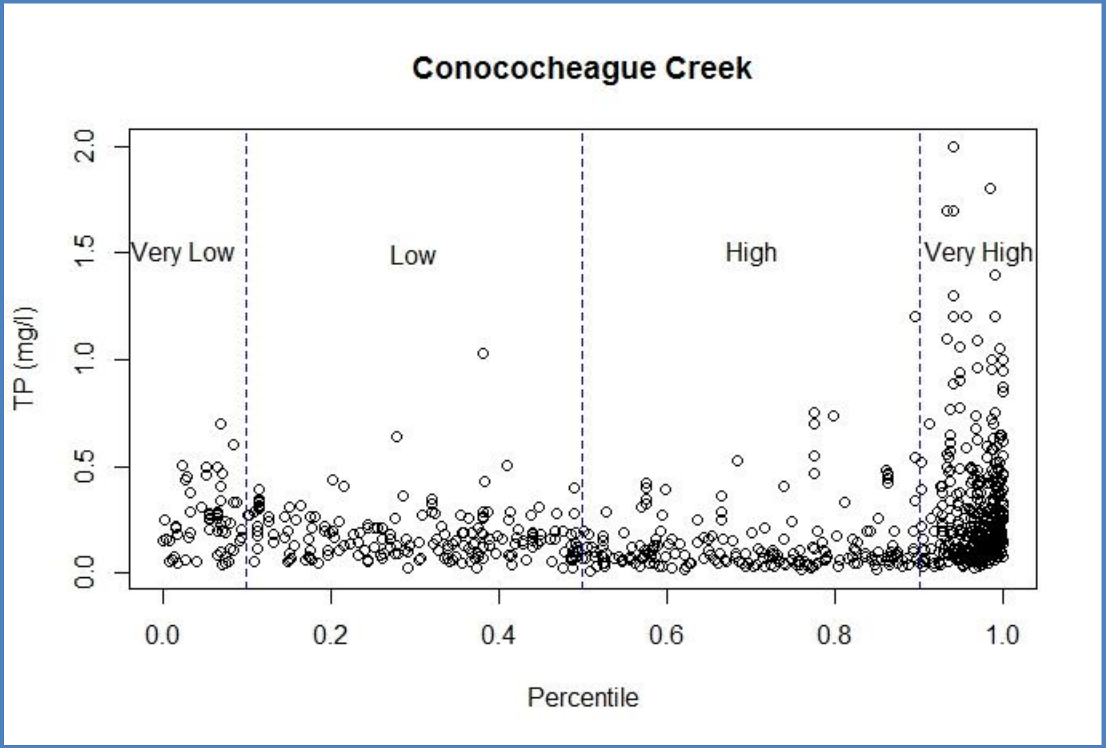
Analysis of Water Quality Calibration Data

Constituents	TN, TP, NO3, PO4
Seasons	• Spring (Mar-May) • Summer (Jun-Aug) • Fall (Sep-Nov) • Winter (Dec-Feb)
Flow Regime (percentile)	• Very low (<10%) • Low (10-50%) • High (50-90%) • Very High (>90%) • Ambient (10-90%)
WQ Statistics	average, maximum, 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles

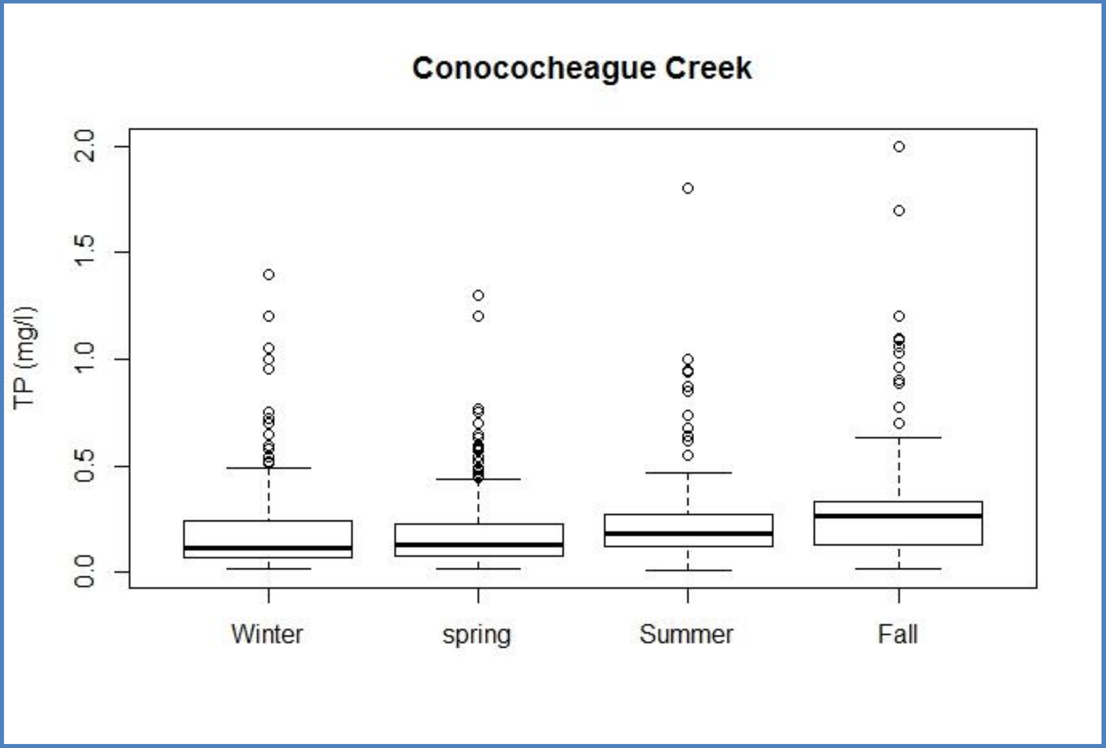
Flow Percentiles and Flow Regime



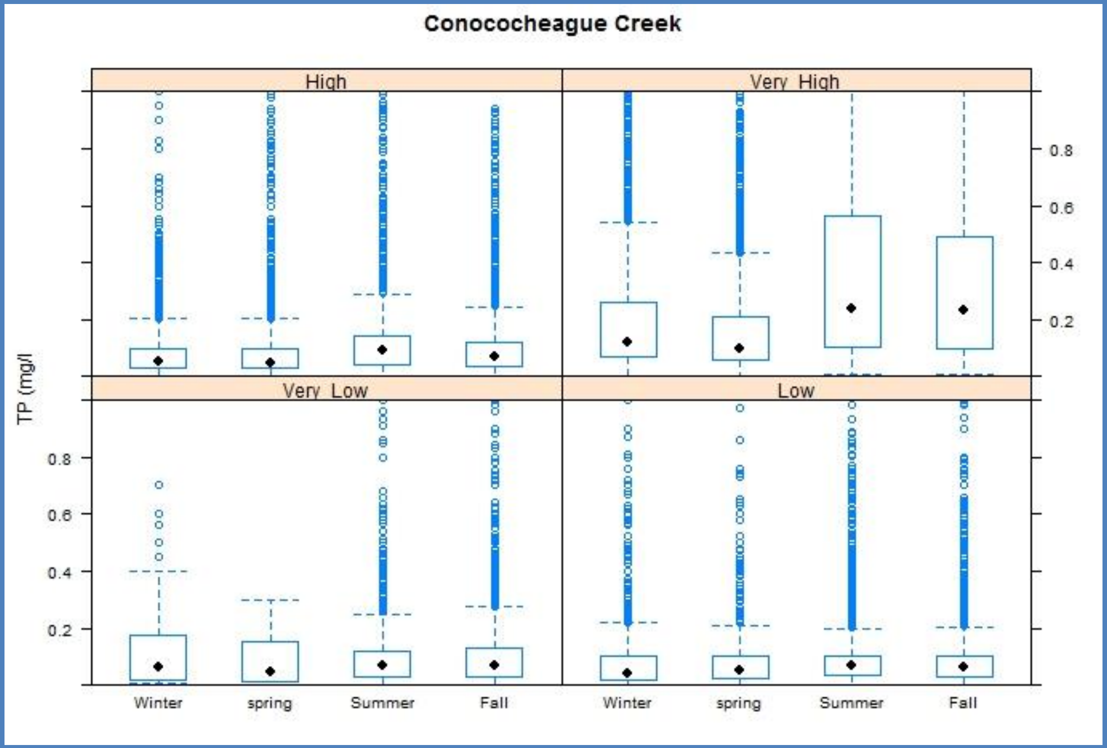
Flow Regime and WQ Concentration



Seasonality of WQ Concentrations



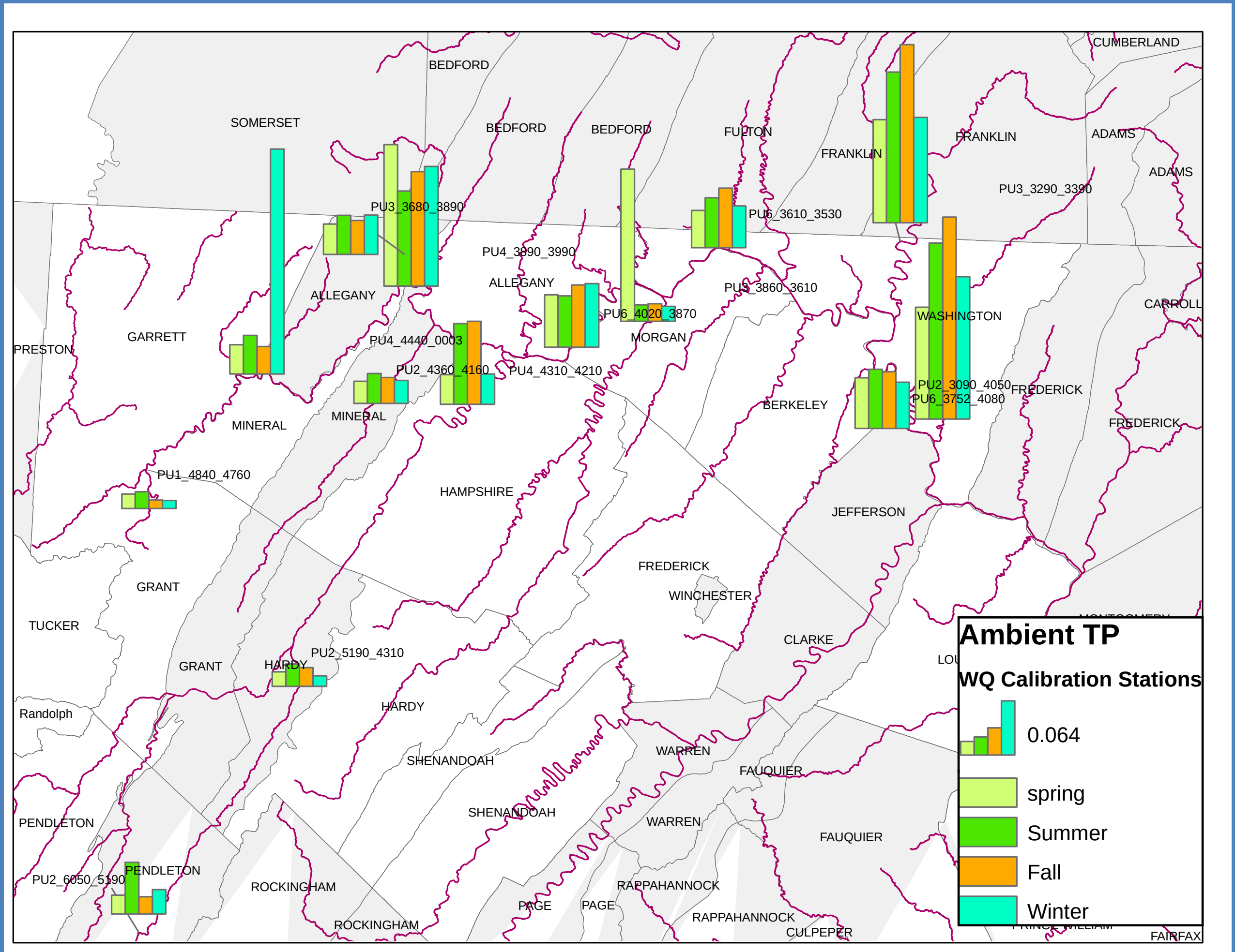
WQ Concentrations by Flow Regime and Season



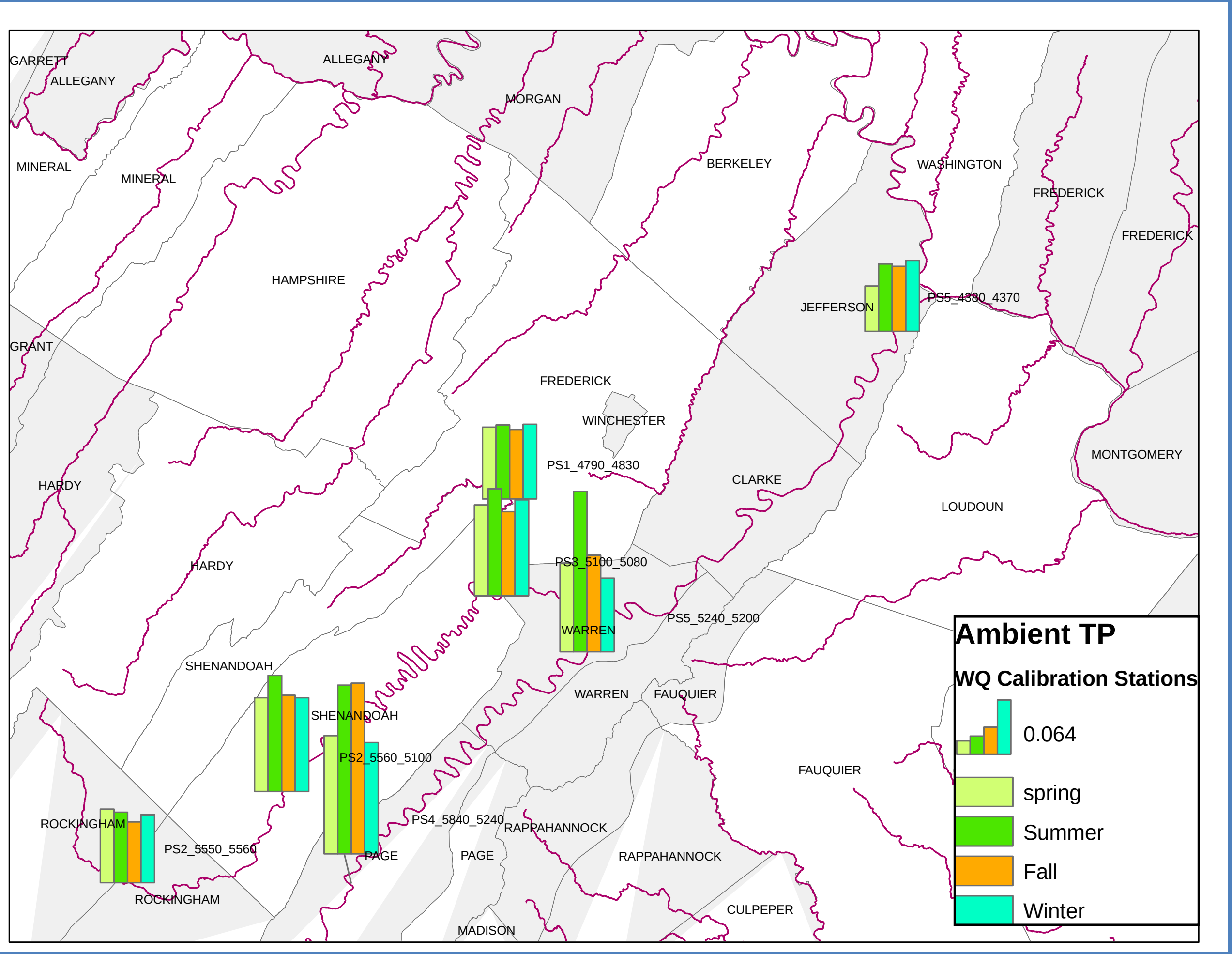
Geographic Analysis

- Graph bar plot of seasonal mean concentrations on map by major/minor basin
- Look for patterns of seasonal rankings, changes in concentration with watershed size
- Ambient (10-90% flow percentile) and Storm (>90^{th} flow percentile)
- (Statistics are highly correlated, so just looked at mean)

Ambient Mean TP
Upper Potomac



Ambient Mean TP Shenandoah



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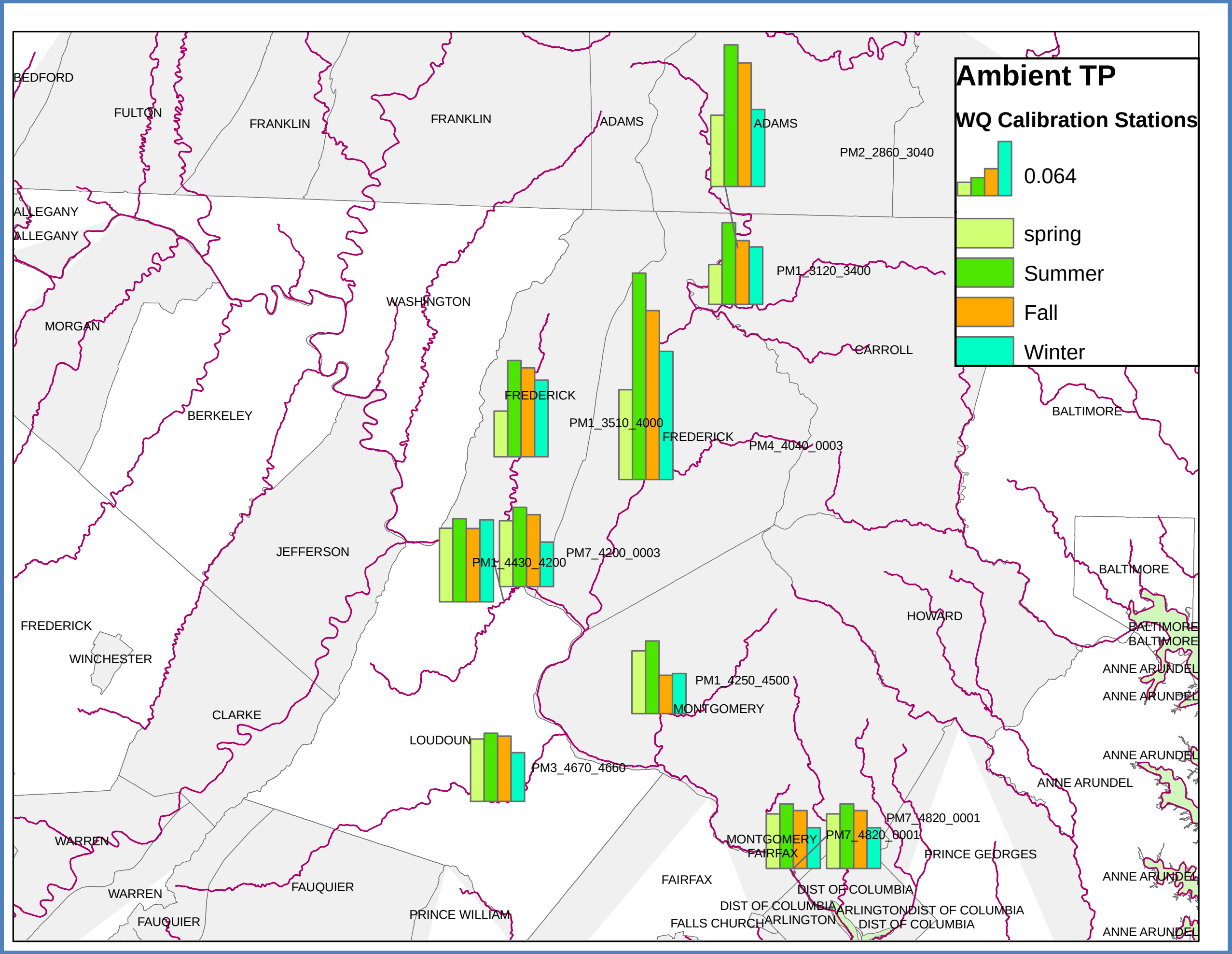
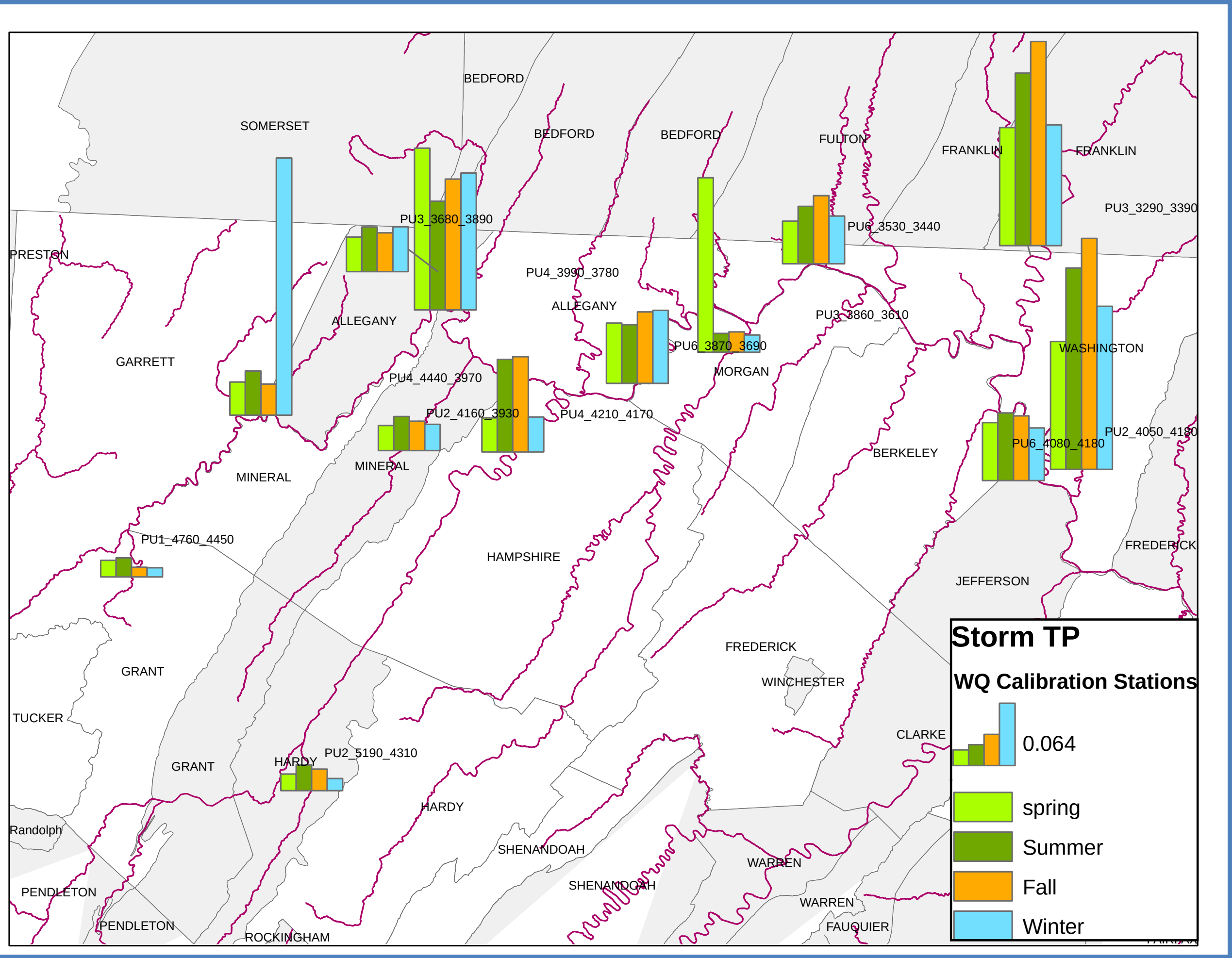
Ambient Mean TP
Middle Potomac



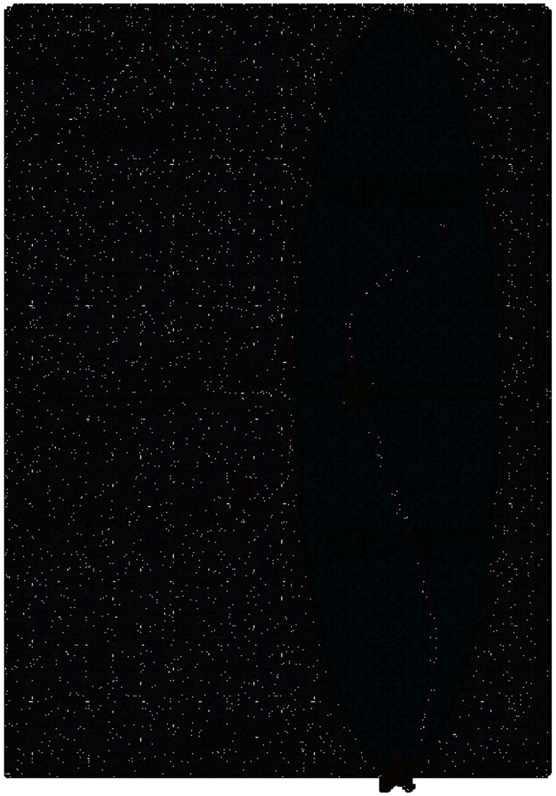
Storm Mean TP
Upper Potomac



Link WQ Calibration Stations to Land Segments through Importance

- Watershed Model already has a method for linking land segments to calibration stations in hydrology calibration: Importance
- Importance
  - What fraction of calibration station's watershed is contributed by land segment
  - Measures influence of land segment on station
- Calculate concentration for each land segment as average of seasonal station concentrations weighed by importance

Link Land to River



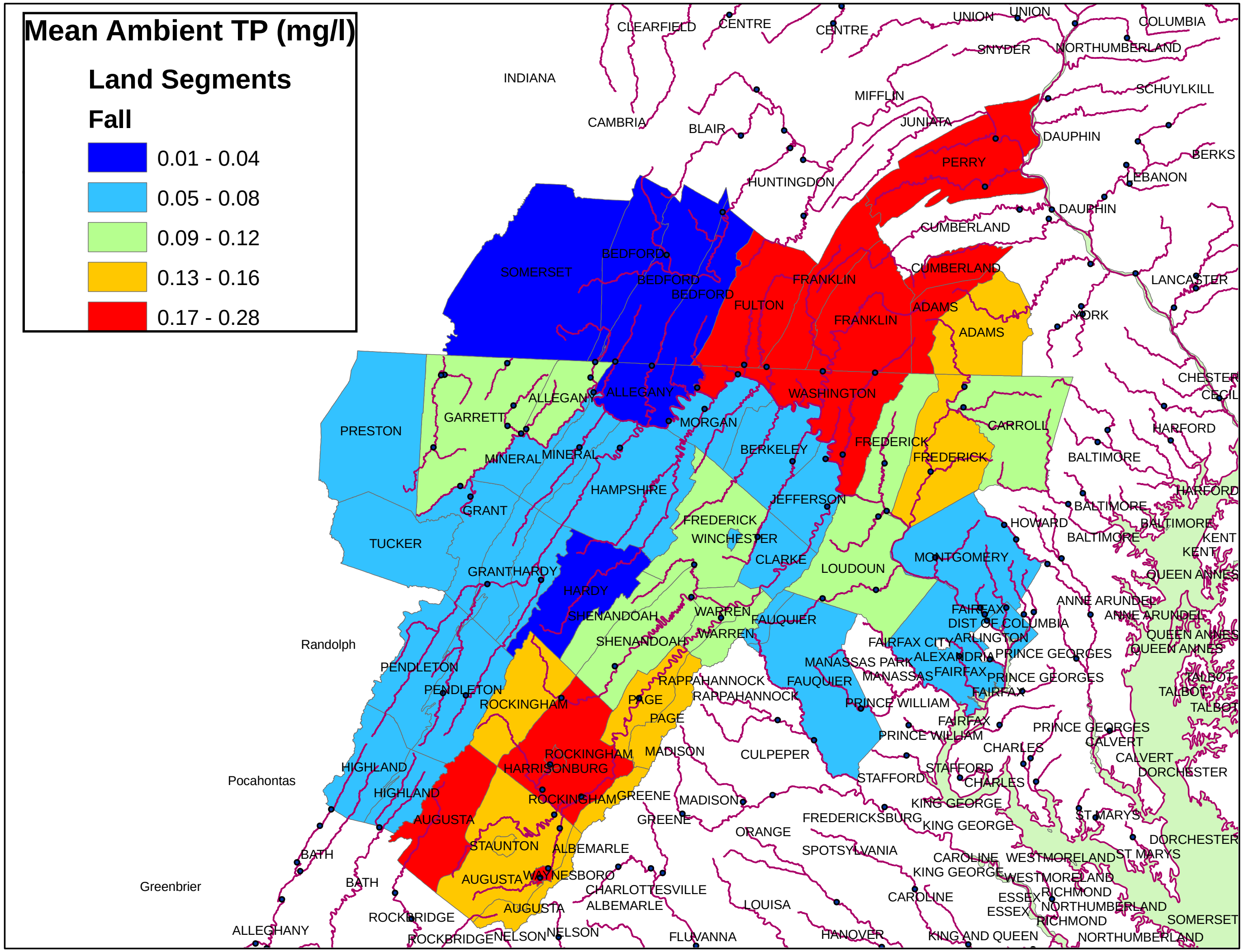
Basis: Percent of basin made up of each Land Segment

Land Segment A is:
100% of station 1
50% of station 2

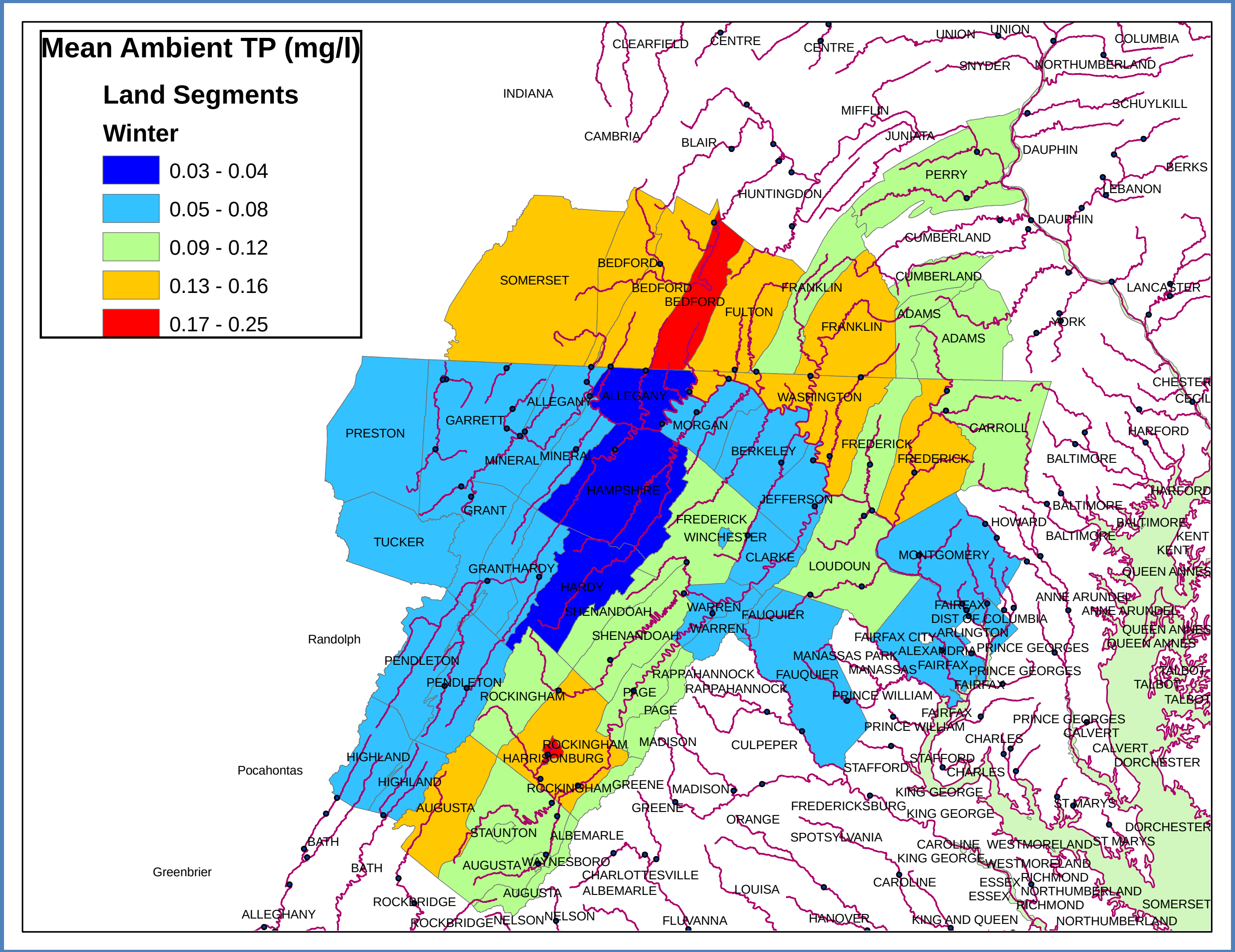
The "importance" ratio is 2:1, so Land Segment A uses 2/3 of the station 1 parameters and 1/3 station2 parameters

Assigned 'orphan' counties to 'siblings'

Fall Weighted Baseflow TP Concentration



Winter Weighted Baseflow TP Concentration



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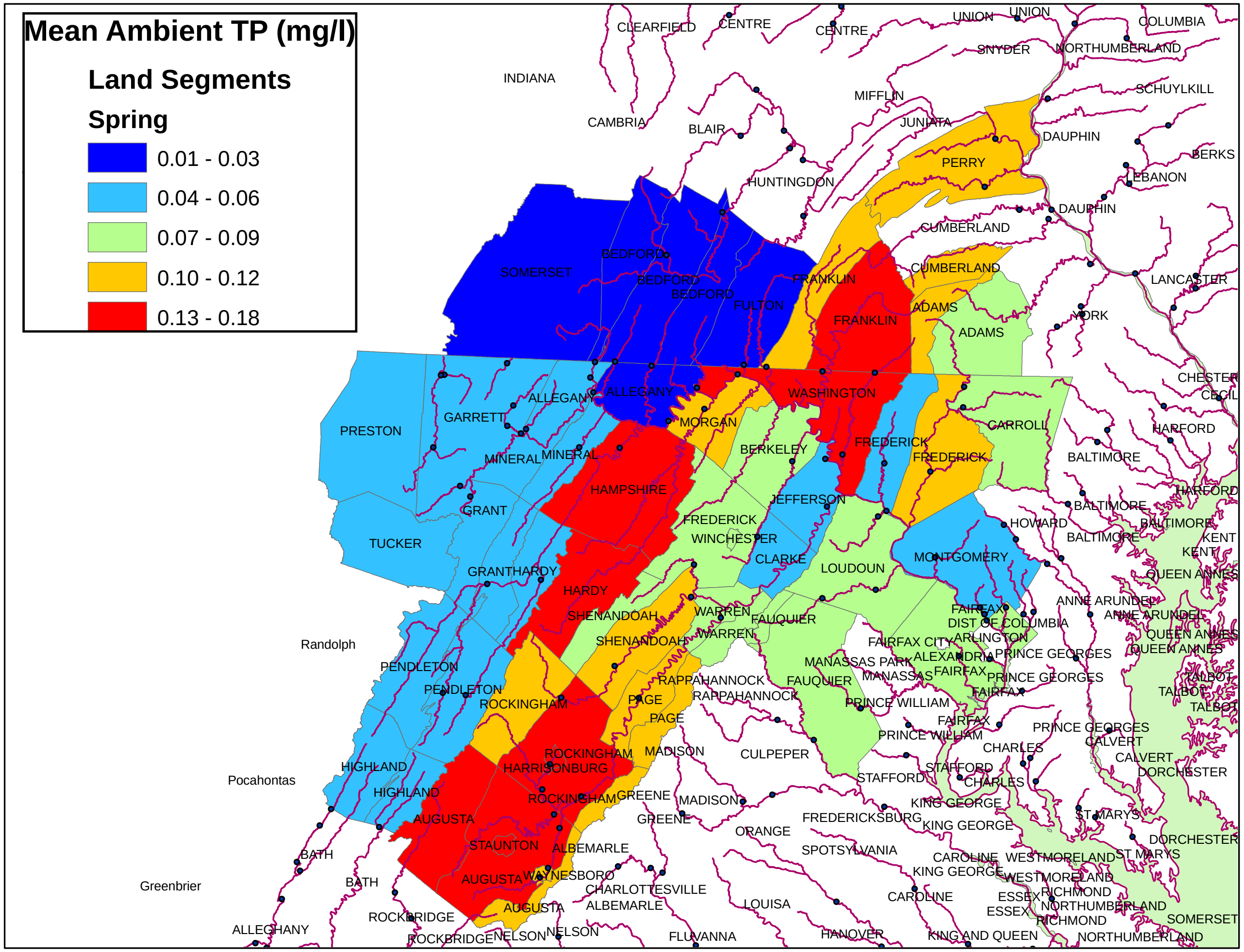
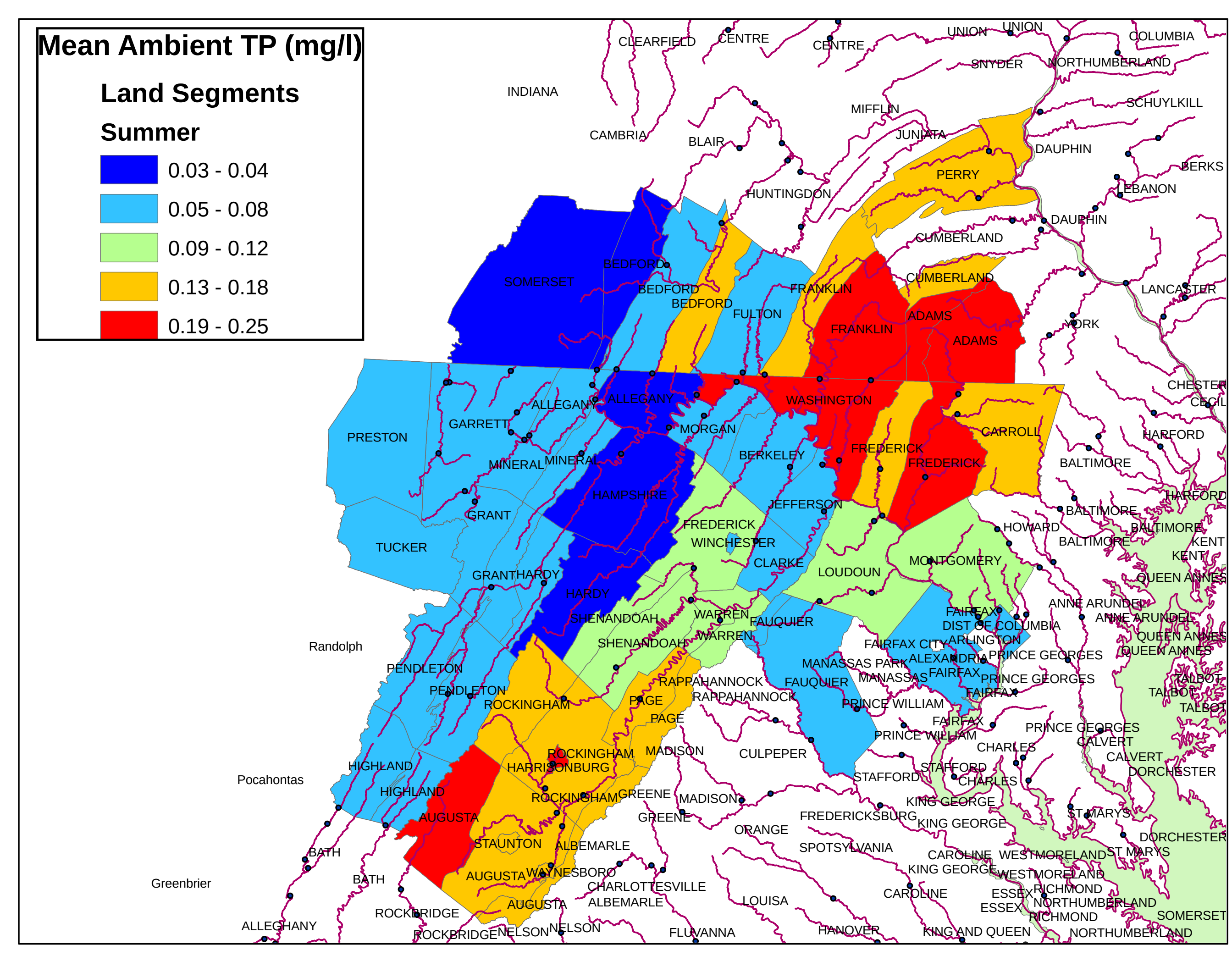
Spring Weighted Baseflow TP Concentration



Summer Weighted Baseflow TP Concentration



Using Weighted Concentrations to Modify LU PQUAL Parameters

- Weighted Seasonal Concentration *Baseflow = Contribution of Land Segment to baseflow load (on seasonal basis)
- Modify initial PQUAL baseflow concentration parameters so anticipated baseflow load matches load based on weighted seasonal concentrations
- Assume same correction factor for each land use

C = observed (seasonal) baseflow concentration (as weighted by station importance)

C_{oi} = original baseflow concentration parameter for LU_i

C_{ri} = revised baseflow concentration parameter for LU_i

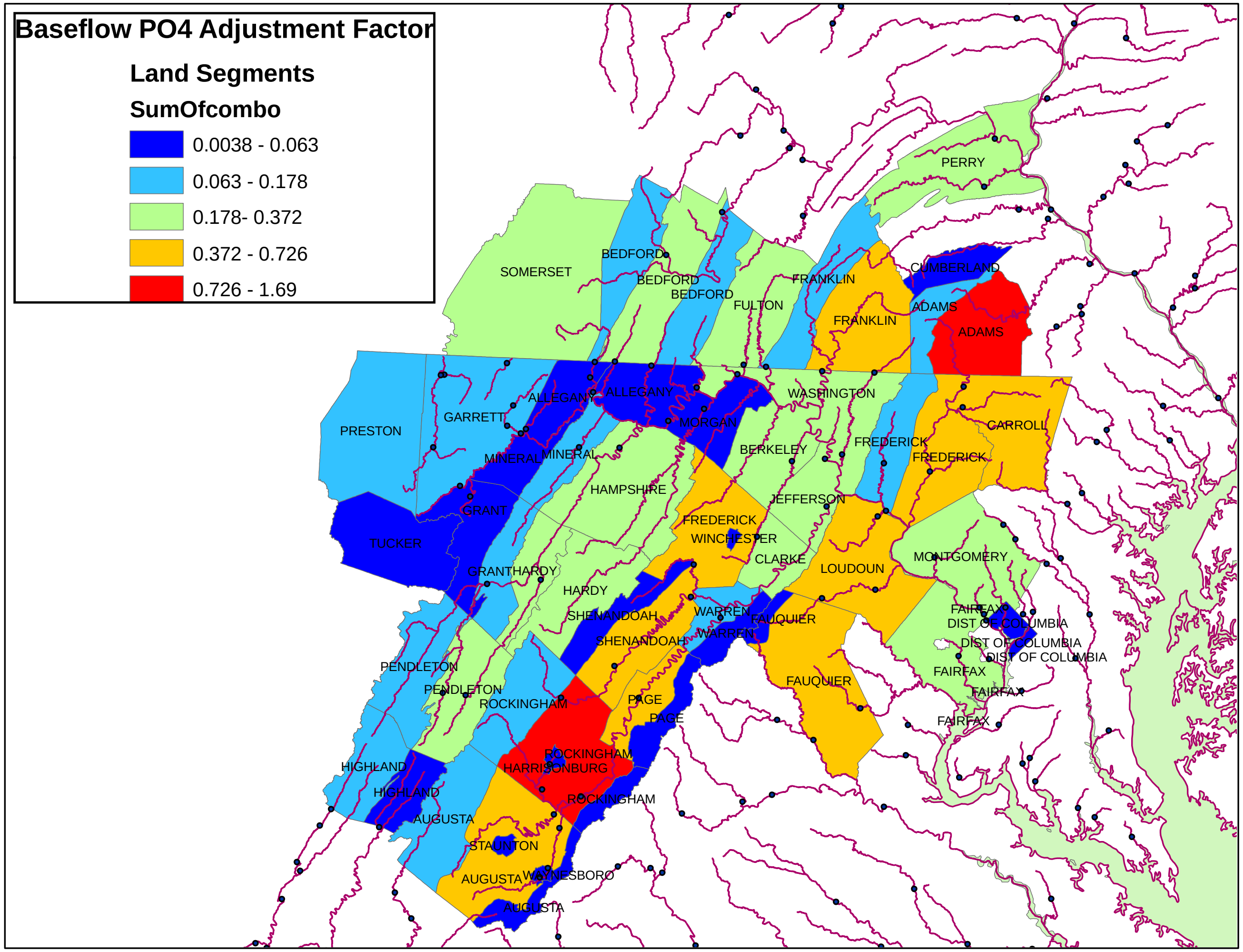
A_i = area of LU_i

B_i =baseflow volume from LU_i

a = Correction factor

Basic Assumption:	$\mathrm{C} * \sum \mathrm{A_i} * \mathrm{B_i} = \mathrm{a} * \sum \mathrm{C_{oi}} * \mathrm{A_i} * \mathrm{B_i}$
Solving for a:	$a = C * \frac{\sum A_i * B_i}{\sum C_{oi} * A_i * B_i}$
Assume B_i 's same, to simplify:	$a = C * \frac{\sum A_i}{\sum C_{oi} * A_i}$

(Test) Adjustment Factor for PO4



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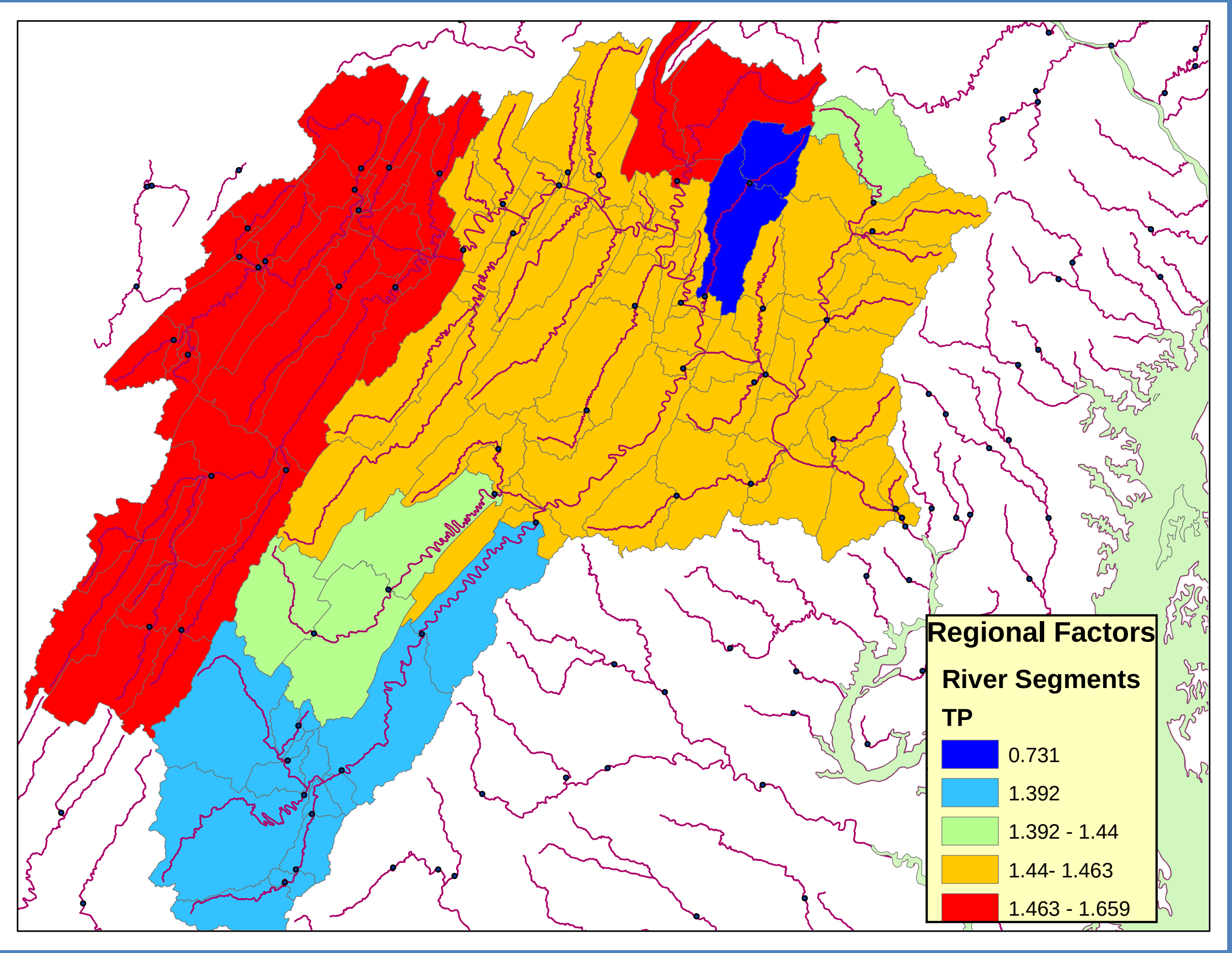
P532 TP Regional Factors



Advantages over Regional Factors

- Targeted use of WQ data to modify land segment loads
- Modifications can be applied to land simulation targets outside of river calibration

Issues

- Which statistics to use
- Alternative methods of weighing land uses
- Can method be applied to other PQUAL parameters (interflow)
- Take into account point source influence
- ???

Contact Information

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