
Wissahickon Creek Watershed TMDLs

Technical Approach and Status

February 9, 2006

Presentation Overview

- TMDL Background and Results (EPA)
- Modeling Approach (Tt)
 - Nutrients
 - Siltation
- TMDLs Addressing Algae Elsewhere in the Region (Tt)
- Recent TMDL Questions (EPA & Tt)

Wissahickon TMDL Background

- EPA established nutrient and sediment TMDLs for the Wissahickon Creek Watershed on 10/09/03
- Wissahickon TMDL revision?

Why Was the TMDL Done?

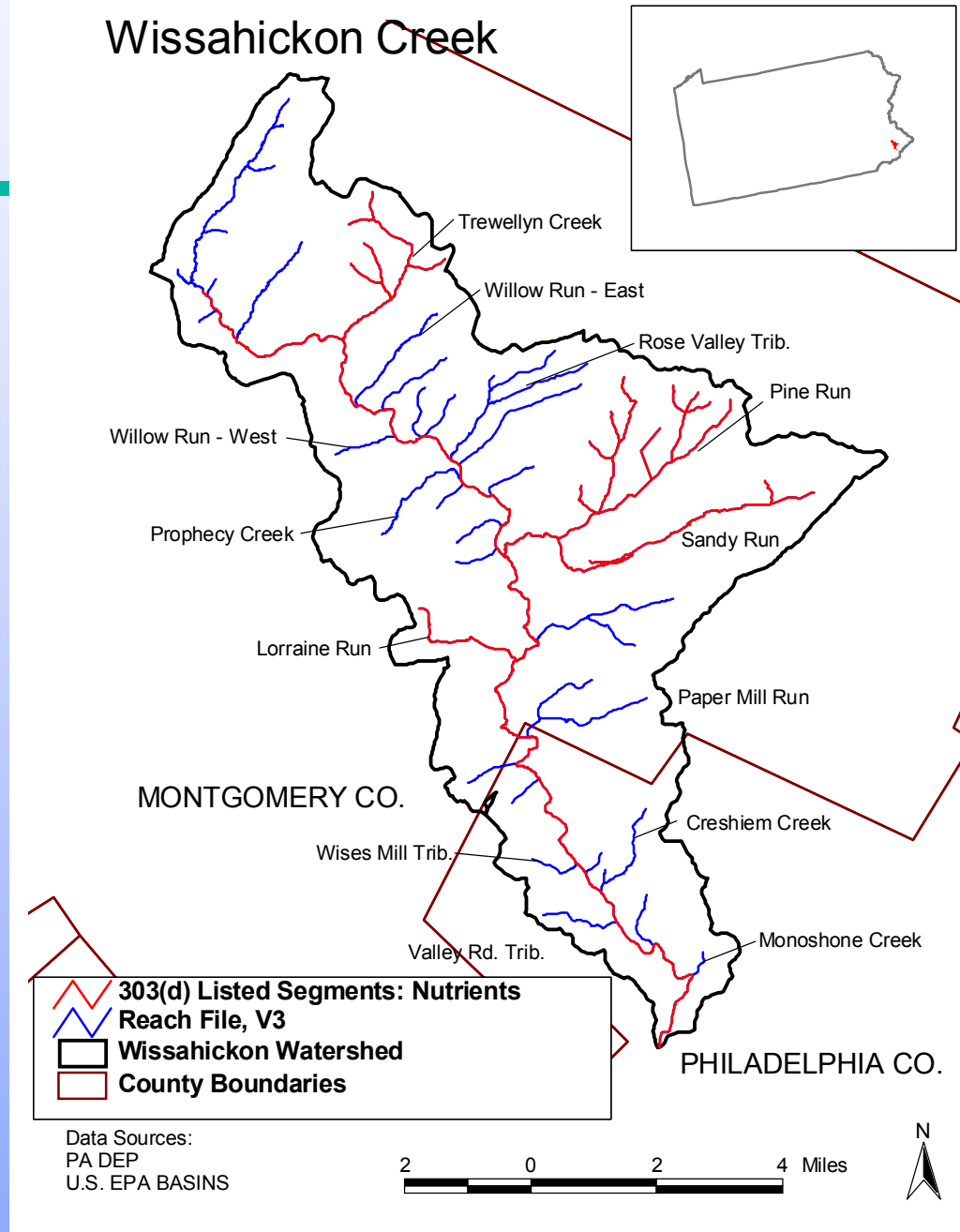
- Results of 1997-1998 PA DEP Unassessed Waters Project
 - Habitat Screening
 - 95% of stations impaired
 - Primary sources were urban runoff/stormwater, municipal point sources, and low baseflow
 - Chemical/Flow Sampling
 - Extremely high nutrient concentrations
 - Point sources contributed majority of baseflow nutrients
 - Macroinvertebrate Sampling
 - Moderately to severely impaired
- Results of 1998 PA DEP Periphyton Study
 - Increased nutrients causes excess periphyton growth
 - Benthic community impacted by excess periphyton biomass

Nutrient Impairments

- Sources of nutrients identified as municipal point source, urban runoff/storm sewer.

Goals:

- Reduce reoccurrence of DO violations
- Reduce nuisance algal growth (periphyton)



Applicable Water Quality Standards

- Numeric nutrient criteria not available
- DO criteria for seasonal trout stocking (PA Code, Title 25, 93.7)
 - Feb. 15 to July 31: DO minimum daily average of 6.0 mg/l, minimum 5.0 mg/l
 - Remainder of year: minimum daily average of 5.0 mg/l, minimum 4.0 mg/l

Results of Nutrient TMDL

Major point source WLAs during critical period:

Table 4-3. WLAs for five major dischargers in the Wissahickon Creek watershed - Trout Stocking (April 1/May 1 to July 31 - see Section 5)

Name	NPDES	CBOD5 (mg/L)	NH3-N (mg/L)	NO3+NO2-N (mg/L)	Ortho-PO4-P ^B (mg/L)	TMDL Percent Reduction			
						CBOD5 ^A	NH3-N ^A	NO3+NO2-N ^B	Ortho-PO4-P ^B
North Wales Boro	PA0022586	3.00	0.50	15.16	1.41	70.0%	80.0%	0.0%	70.0%
Upper Gwynedd Township	PA0023256	5.00	0.74	20.08	1.82	50.0%	59.0%	0.0%	49.0%
Ambler Boro	PA0026603	10.00	1.50	30.52	4.68	0.0%	0.0%	0.0%	0.0%
Arlington Township	PA0026867	7.50	0.72	30.27	1.85	25.0%	64.0%	0.0%	60.0%
Upper Dublin Township	PA0029441	12.77	2.25	36.71	1.45	14.9%	10.0%	0.0%	36.9%

A - Calculated from NPDES permit limit

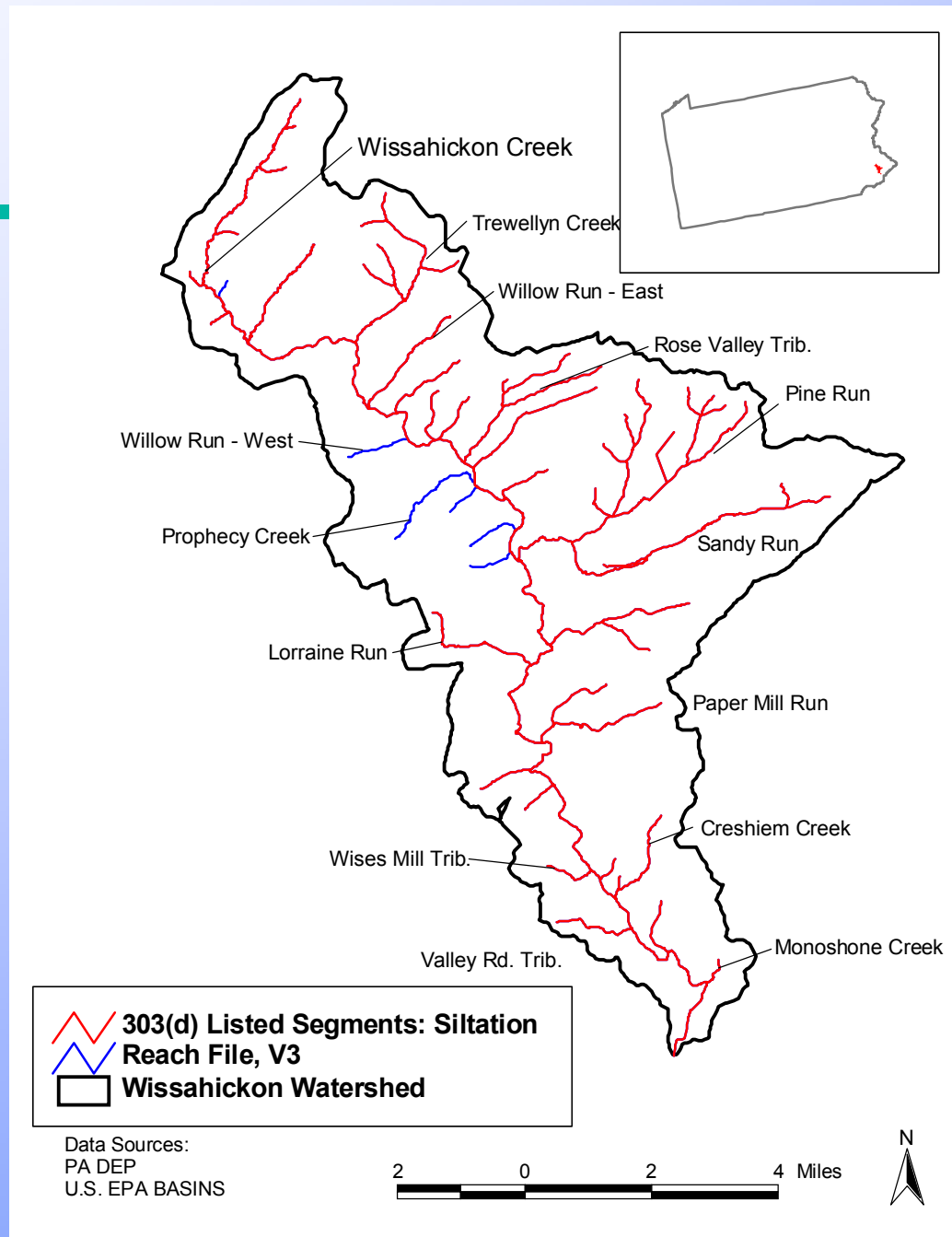
B - Calculated from average of summer 2002 monitoring. If allocations exceeded average of 2002, 0.0 % is reported.

Table 4-3b. WLAs for all facilities discharging nutrients to Wissahickon Creek watershed in pounds per/day - Trout Stocking (April/May1 to July 31 - see Section 5)

Name	NPDES	CBOD5 (lbs/day)	NH3-N (lbs/day)	NO3+NO2-N (lbs/day)	Ortho PO4-P (lbs/day)
Upper Dublin Township	PA002944 1	116.74	20.572	335.664	13.266
Abington Township	PA002686 7	243.979	23.433	984.961	60.291
Valley Green Corporate Center	PA005307 4	0.703	0.139	1.320	0.220
SFU	PA005763 1	0.042	0.010	0.021	0.002
Murray SRSTP	PA005321 0	0.042	0.002	0.004	0.002
SFU	PA005101 2	0.034	0.010	0.027	0.002
North Wales Boro	PA002258 6	20.828	3.470	105.160	9.771
Upper Gwynedd Township	PA002323 6	237.196	35.010	952.753	96.408
SFU	PA005757 6	0.059	0.018	0.006	0.003
Merck & Co. Inc.	PA005353 8	0.763	0.015	0.031	0.042
Ambler Borough Water Department	PA005251 5	0.763	0.015	0.031	0.040
PA Historical & Museum Commission	PA005338 7	0.212	0.169	0.255	0.004
SFU	PA005457 7	0.059	0.018	0.033	0.002
Ambler Boro	PA002660 3	543.402	81.466	1,637.753	254.221

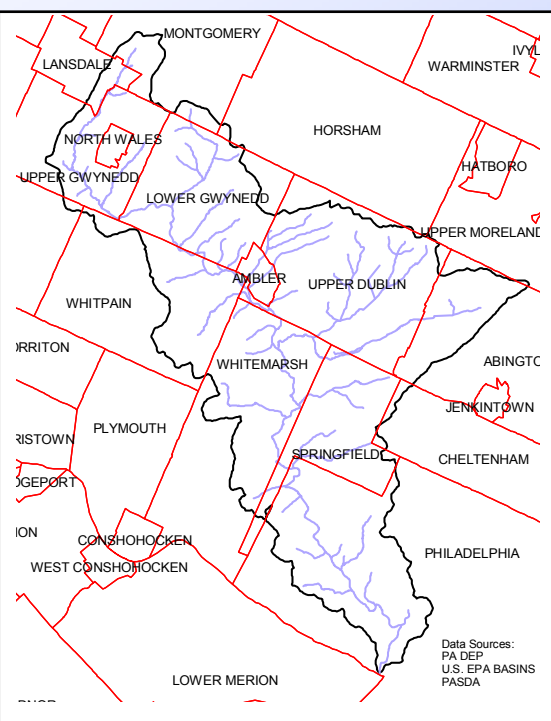
Sediment Impairments

- Source identified as urban runoff/storm sewer, habitat modification
- No water quality criteria available for siltation TMDL endpoint
- Endpoint determined through reference watershed approach



Results of Sediment TMDL

- Summary of sediment WLAs for streambank erosion and overland load by municipality (MS4)



Municipality	Existing Load from Streambank Erosion (lbs/yr)	Streambank Erosion WLA (lbs/yr)	Percent Reduction for Streambank Erosion	Existing Overland Load (lbs/yr)	Overland Load WLA (lbs/yr)	Percent Reduction for Overland Load (lbs/yr)	TOTAL WLA (lbs/yr)
Abington	121,604.48	41,116.77	0.68	362,538.56	87,798.68	0.76	128,913.40
Ambler	17,974.49	9,346.73	0.48	75,008.50	32,843.24	0.56	42,189.97
Cheltenham	1,758.29	1,512.13	0.14	20,549.46	4,449.00	0.78	5,961.13
Horsham	2,611.24	1,267.20	0.51	5,764.44	2,288.51	0.60	3,555.71
Lansdale	10,032.37	5,216.83	0.48	60,295.96	47,115.59	0.22	52,332.43
Lower	168,245.82	87,487.83	0.48	575,510.64	349,872.50	0.39	437,360.30
Montgomery	25,443.78	13,230.77	0.48	135,560.26	97,897.57	0.28	111,128.30
North Wales	8,414.77	4,375.68	0.48	50,070.60	37,955.87	0.24	42,331.55
Philadelphia	133,827.01	115,091.23	0.14	1,413,863.47	265,770.10	0.81	380,861.30
Springfield	51,241.03	38,361.29	0.25	700,517.47	151,803.80	0.78	190,165.00
Upper Dublin	350,903.91	131,125.58	0.63	906,098.66	333,482.10	0.63	464,607.60
Upper	73,016.96	37,968.82	0.48	695,874.85	512,615.60	0.26	550,584.30
Upper	1,108.17	366.85	0.67	1,303.29	494.72	0.62	861.57
Whitemarsh	79,221.96	51,034.76	0.36	479,266.95	188,497.70	0.61	239,532.40
Whitpain	105,137.80	55,148.05	0.48	357,776.46	236,125.20	0.34	291,273.30
Worcester	1,423.06	739.99	0.48	10,644.84	9,610.08	0.10	10,350.07

Extensive Public Participation Effort

- Numerous public meetings conducted throughout all stages of TMDL process.
- Multiple draft documents shared with the public for review and input.
- Public was encouraged to participate in data collection efforts and to review the proposed TMDL methodology upfront.
- Public provided unique opportunity to suggest model updates and modeling scenarios.

Modeling Approach

- 2 different approaches for nutrients and sediment
 - Nutrients
 - Receiving water model
 - Steady-state (low flow) conditions
 - Siltation
 - Watershed model
 - Reference approach

Nutrients

Modeling Approach

- WASP model
- Configured for nutrients, periphyton, and DO
- Full calibration of all components, including periphyton biomass
- TMDL analysis:
 - TMDL endpoint based on in-stream DO criteria for Trout Stocking (TS) and Warm Water Fishes (WWF)
 - Over 50 scenarios analyzed different nutrient reduction scenarios and their impact on periphyton and DO
 - Scenarios led to conclusion that BOD and periphyton were both key contributors to DO
 - WLAs developed for NH₃-N, NO₃+NO₂-N, ortho PO₄-P, and CBOD₅

Nutrients

Modeling Approach

Low-flow WASP (Water Quality Analysis Simulation Program)

- Steady-state model for simulation of critical conditions (low flow)
 - EFDC hydrodynamic model
 - Modified version of WASP to simulate periphyton growth processes
- Processes linking nutrients and DO
 - Periphyton growth processes
 - Considered additional impacts on DO due to BOD and SOD
- Nonpoint sources on a case-by-case basis (e.g., golf courses, sediments behind dams)
 - Results of summer 2002 water quality monitoring showed little impact from nonpoint sources
- Point sources

Nutrients

Changes to Modeling System

In response to public comments and concerns, the following modifications were made to the modeling framework

- **Periphyton Routine**
 - Spatial variation of temperature and impacts on periphyton
 - Spatial variation of solar radiation and impacts on periphyton
 - Spatial variation of substrate availability and impacts on periphyton
- **Diurnal DO simulation (growth of phytoplankton and periphyton only during daylight)**
- **User-defined reaeration formula**

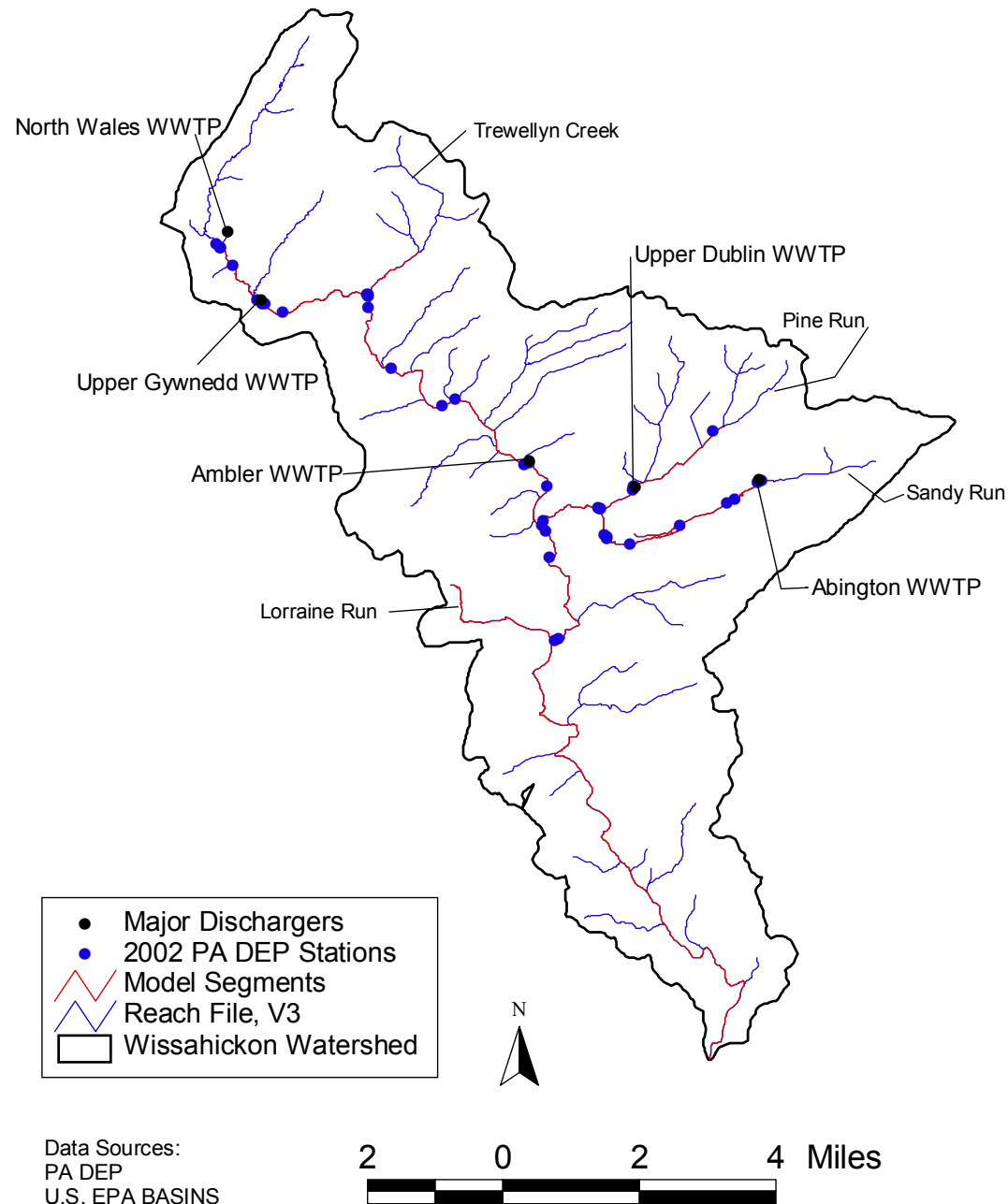
Data Supporting Modeling Effort

- Point Source Data
- Streamflow Data
 - USGS Stations
 - PADEP 2002 measurements
 - Streamflow estimates
 - Time of travel dye study
- 2002 Instream Water Quality Data
 - Potential non-point sources
 - Impacts of low level dams
 - Upstream/downstream/effluent sampling
 - Intermediate station sampling
 - Diurnal DO

Nutrients

Model Extent

- Extent includes portions of all 303(d) listed waters, major point sources, and positions of water quality monitoring stations



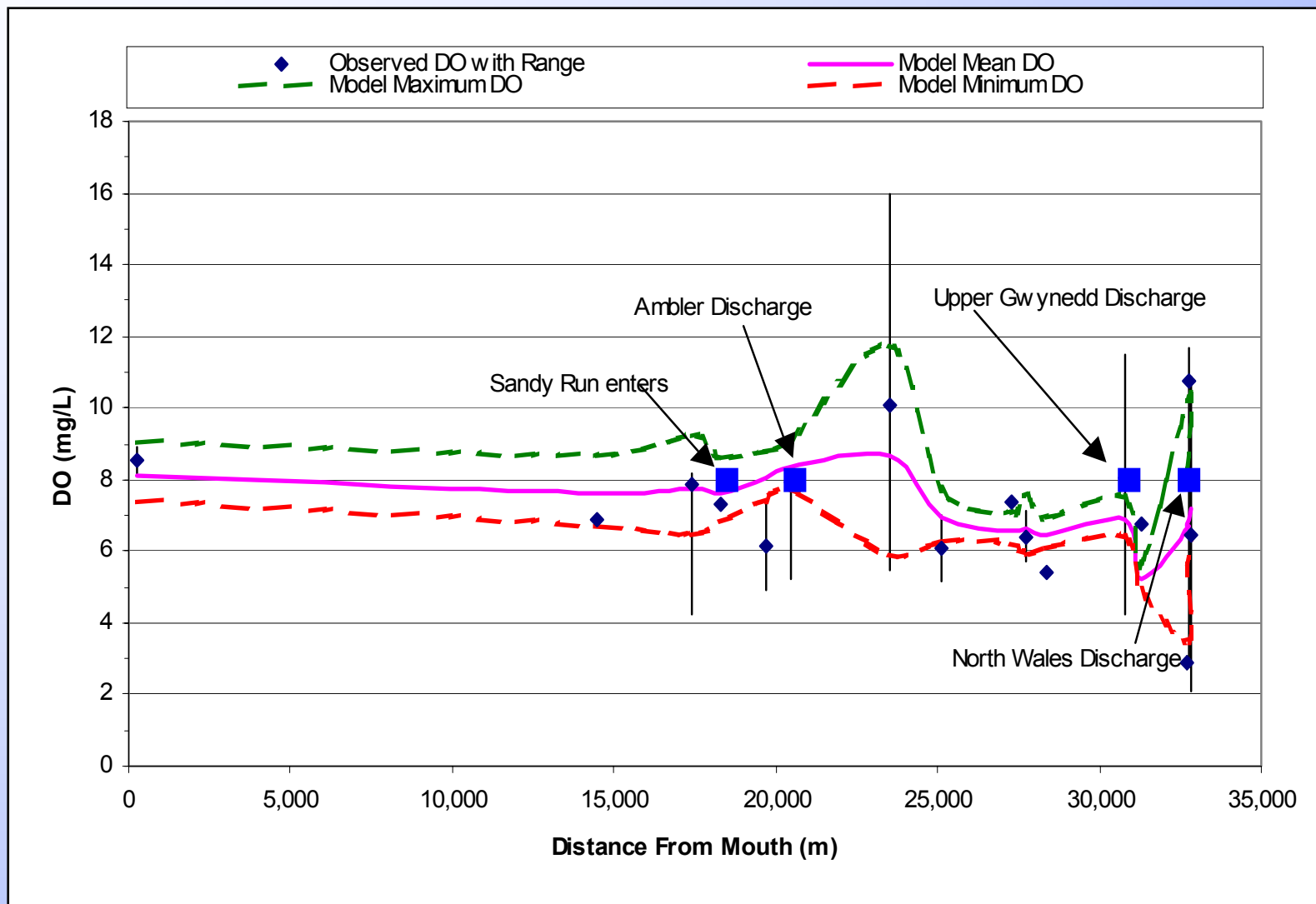
Nutrients

Model Testing/Calibration

- **Hydrodynamic model (EFDC)**
 - PA DEP summer 2002 time-of-travel study
 - PA DEP 2002 temperature data
- **Water quality model (WASP)**
 - PA DEP summer 2002 in-stream water quality data
 - DO
 - Nutrients (NH₄-N, NO₂/NO₃-N, PO₄-P)
 - 1998 periphyton data

Nutrients

DO Calibration



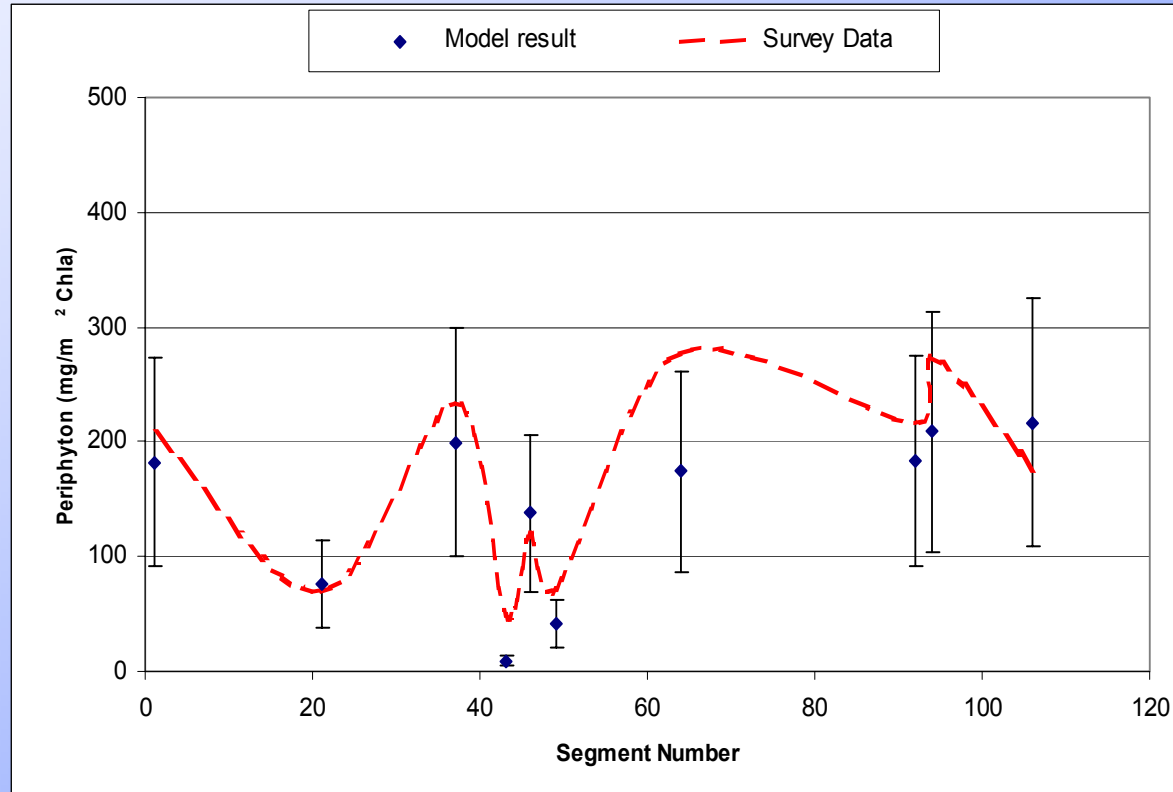
Nutrients

Periphyton Biomass Comparison

Periphyton

Comparison

- 1998 periphyton biomass data
- Relative distribution of biomass assumed consistent for summer 2002



Nutrients

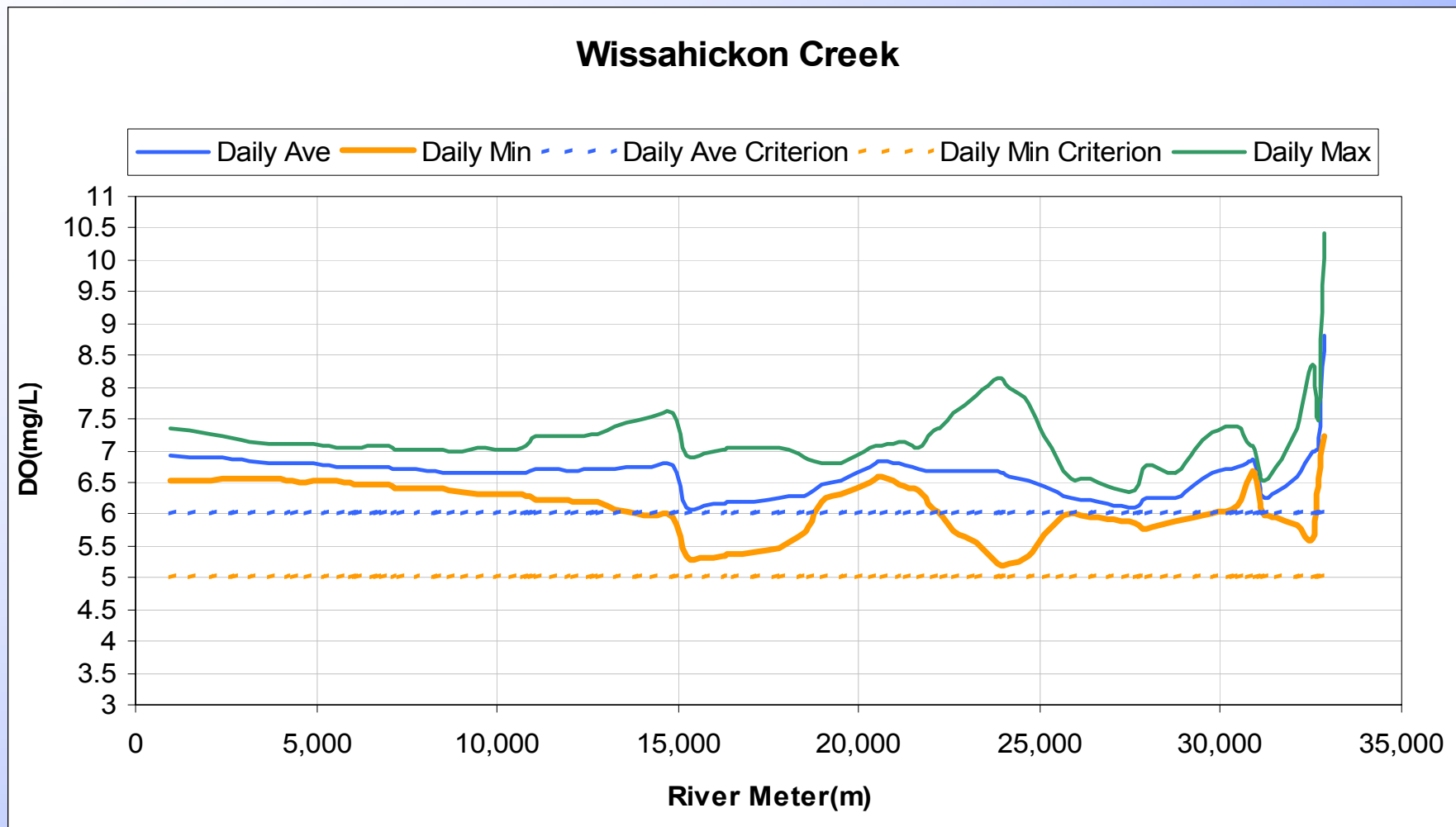
TMDL Development

Model Configuration of Critical Conditions

- Modeling system configured to critical conditions
 - 7Q10 background flows
 - Discharge design flows
- TMDL endpoint based on in-stream DO criteria for Trout Stocking (TS) and Warm Water Fishes (WWF)
- Over 50 scenarios analyzed different nutrient reduction scenarios and their impact on periphyton and DO
- WLAs developed for NH₃-N, NO₃+NO₂-N, ortho PO₄-P, and CBOD₅

Nutrients

DO – Comparison to WQ Standards



Siltation

Modeling Approach

Reference Watershed Approach

- No numeric instream criteria for siltation in PA
- Reference watershed used to set endpoints for TMDL development
 - Reference watershed is an unimpaired stream with similar characteristics as Wissahickon Creek
 - Objective is to reduce the loading rate of sediment in the impaired stream segment to a level equivalent to or slightly lower than the loading rate in the unimpaired reference stream
- AVGWLF model developed for both the Wissahickon Creek and reference watersheds for comparison of siltation loads
 - Overland load from storm runoff
 - Streambank erosion

Siltation TMDL

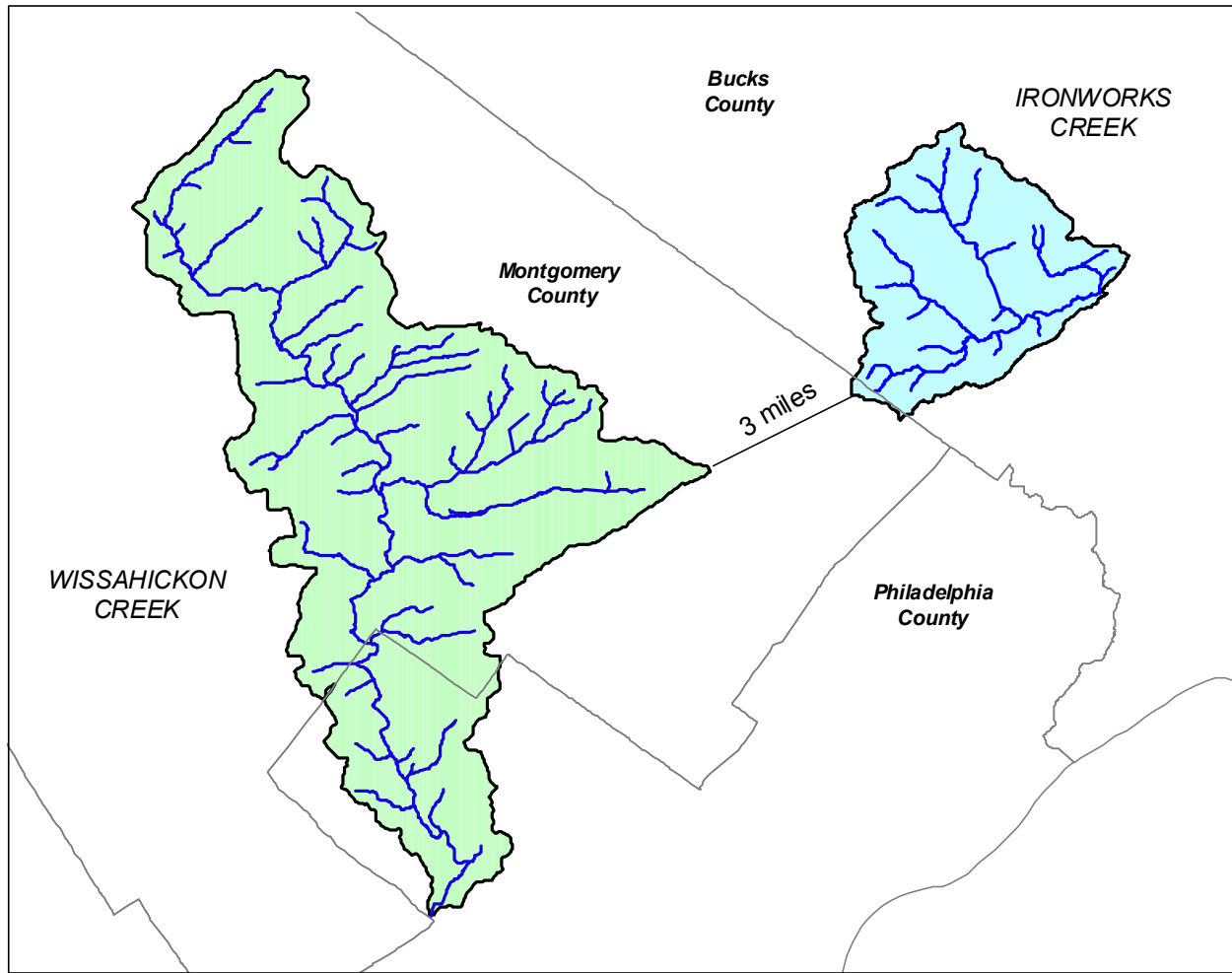
Reference Watershed Selection

- Goal: Identify similar, unimpaired watersheds to be used to develop siltation TMDL endpoints.
- Data used:

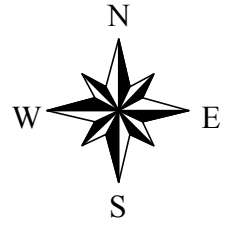
Ecoregion coverages	Land use distribution
Topography	Watershed size
Soils	Point source inventory
Surface Geology	
- Initial reference station list based on RBP assessment and ecoregion location. Areas within an Ecoregion share the same habitat features (i.e. topography, vegetation, climate)

Siltation TMDL

Reference Watershed – Ironworks Creek



- County Boundaries
- Streams reaches
- Wissahickon
- Ironworks Creek



Siltation

Comparison of Wissahickon Creek to Ironworks Creek

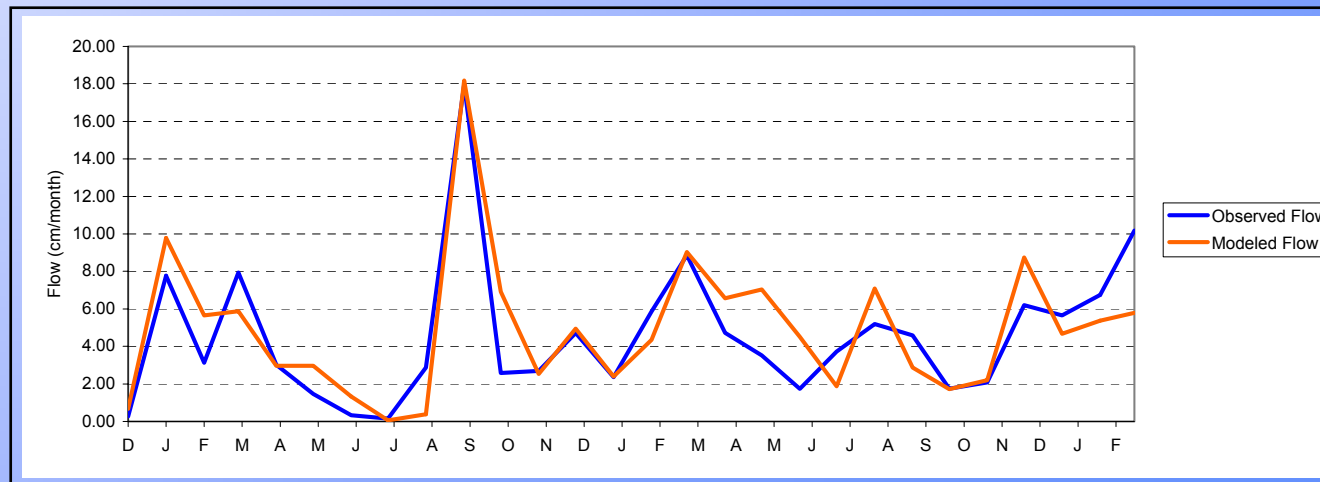
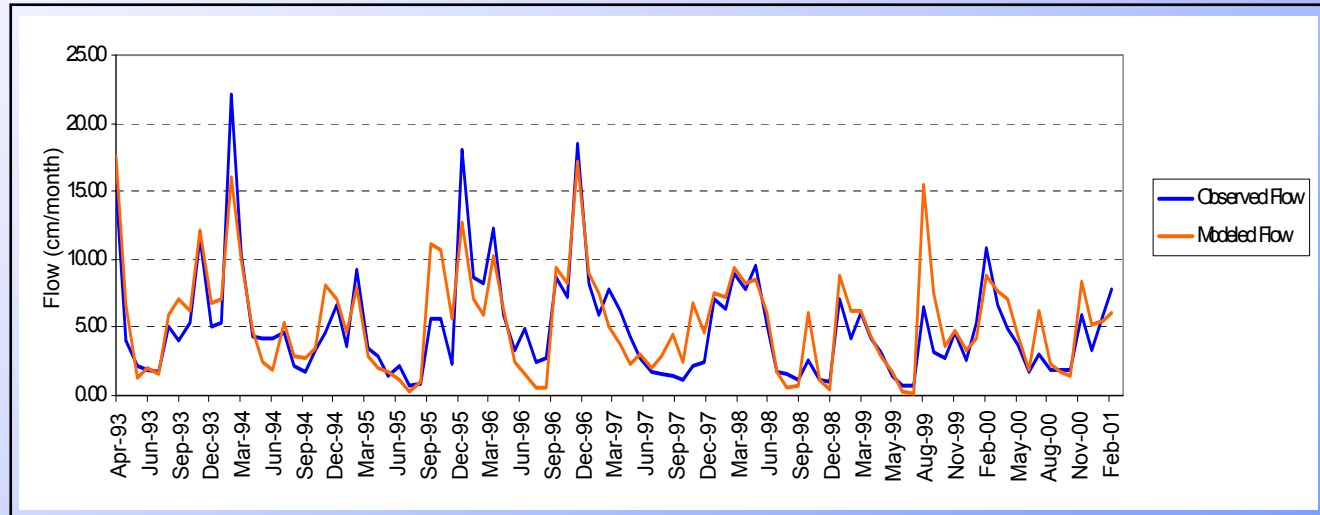
- Good match between most categories that impact siltation
 - Landuse is key
 - Soils and ecoregion also critical
 - Point sources are insignificant loads

Stream	Wissahickon Creek	Ironworks Creek
Watershed Type	Impaired Watershed	Reference Watershed
Watershed Size (acres)	40,928	11,114
Geologic Province	Piedmont	Piedmont
Dominant Rock Types	Sandstone/ Metamorphic-Igneous/ Shale/ Carbonate	Sandstone/ Metamorphic-Igneous
Dominant Soils	C & B	C & B
Ecoregions	Triassic Lowlands Piedmont Uplands Piedmont Limestone Dolomite Lowlands	Triassic Lowlands Piedmont Uplands
Percent Slope of Watershed	0.25%	0.63%
Point Sources	14	0
Percent Urban	43%	44%
Percent Forested	40%	31%
Landuse Types:	% Landuse	% Landuse
Low Intensity Development	34.10%	39.80%
High Intensity Development	8.50%	4.20%
Hay/Pasture	7.10%	11.70%
Cropland	8.90%	10.90%
Conifer Forest	2.40%	1.80%
Mixed Forest	10.20%	10.30%
Deciduous Forest	28.00%	19.60%
Quarry	0.30%	0.00%
Coal Mine	0.02%	0.00%
Transitional	0.40%	0.10%

Siltation

Hydrology Calibration

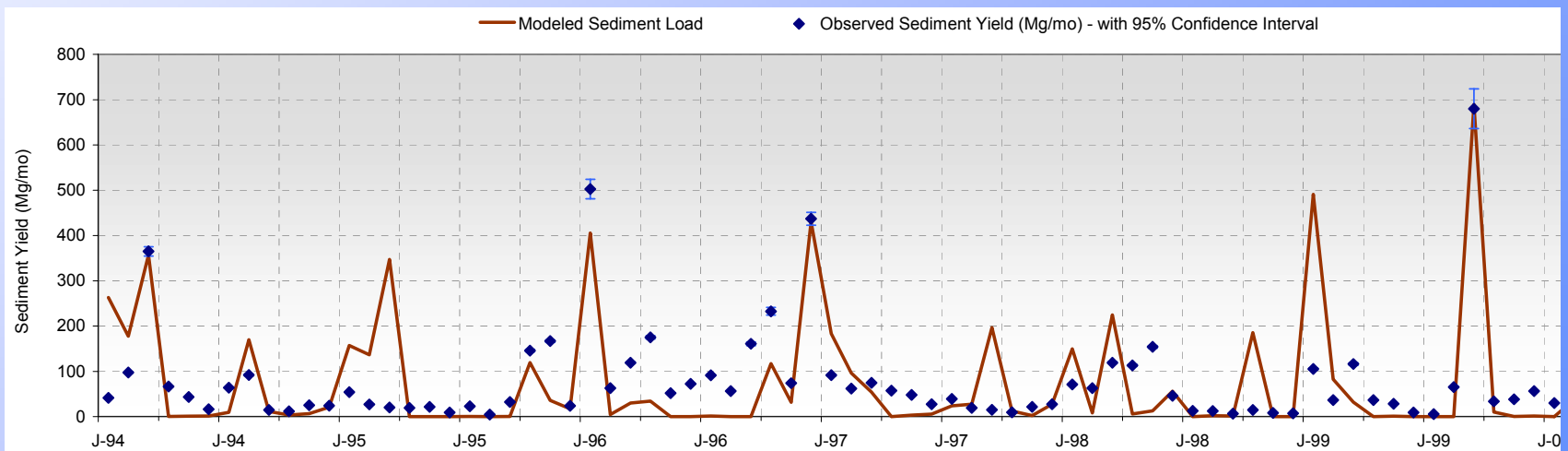
- Monthly hydrology calibration performed on both the Wissahickon and reference watersheds



Siltation

Water Quality Calibration

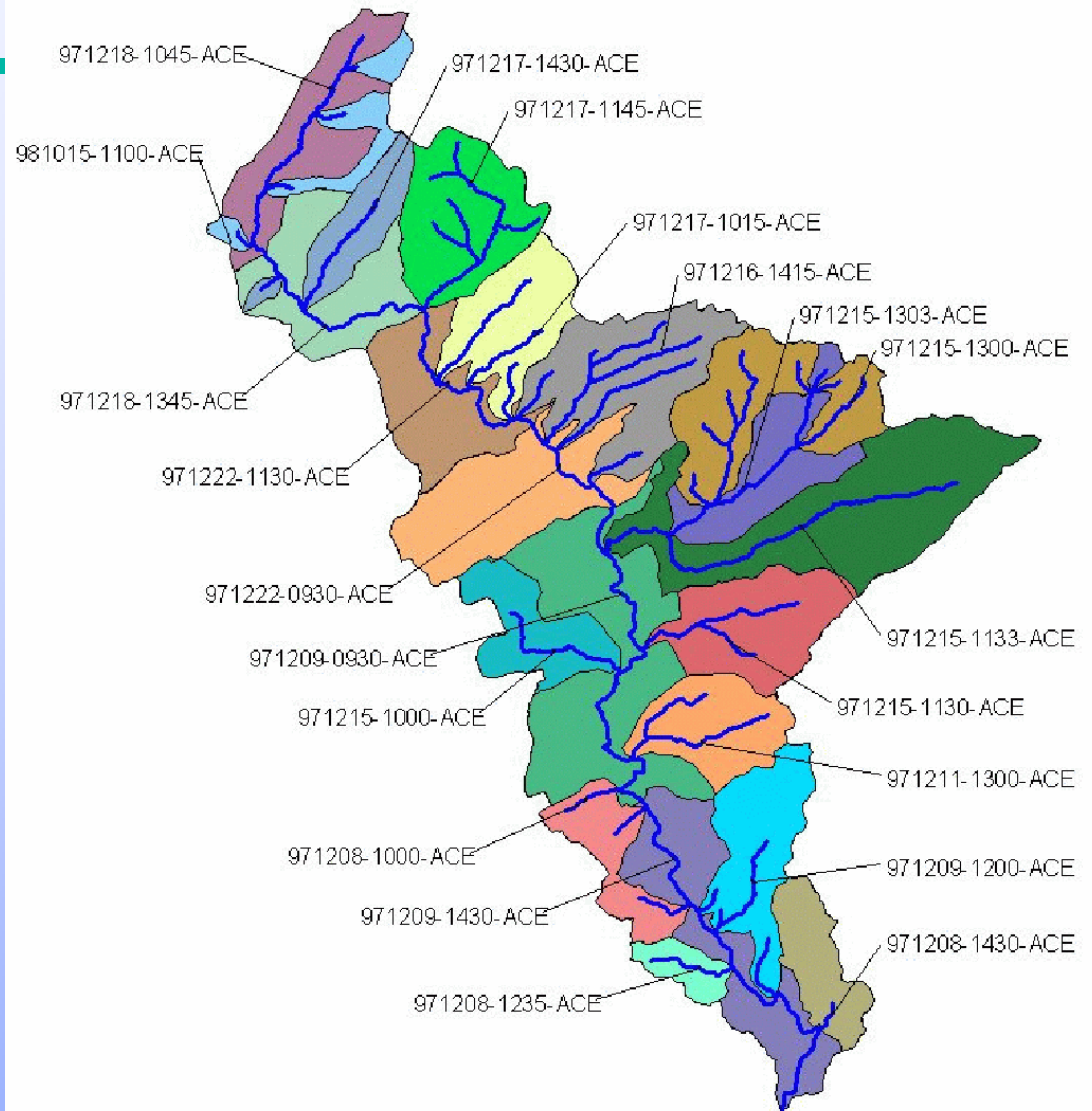
- Calibration less of issue due to empirical aspect of model
- “Validation” of model using water quality data at mouth of Wissahickon Creek (USGS gage 01474000 & WQN0115)
- Validation limited due to limited water quality data for storm flows
- Monthly sediment loads validated



Siltation

TMDL Calculation

- Wissahickon Creek watershed was divided into subwatersheds for each 303(d) listed stream segment
- TMDLs were calculated for each stream segment
- TMDL components:
 - LAs to upstream loads
 - WLAs to dischargers and stormwater permits (MS4s)
 - 10% margin of safety



Siltation

MS4 Permits

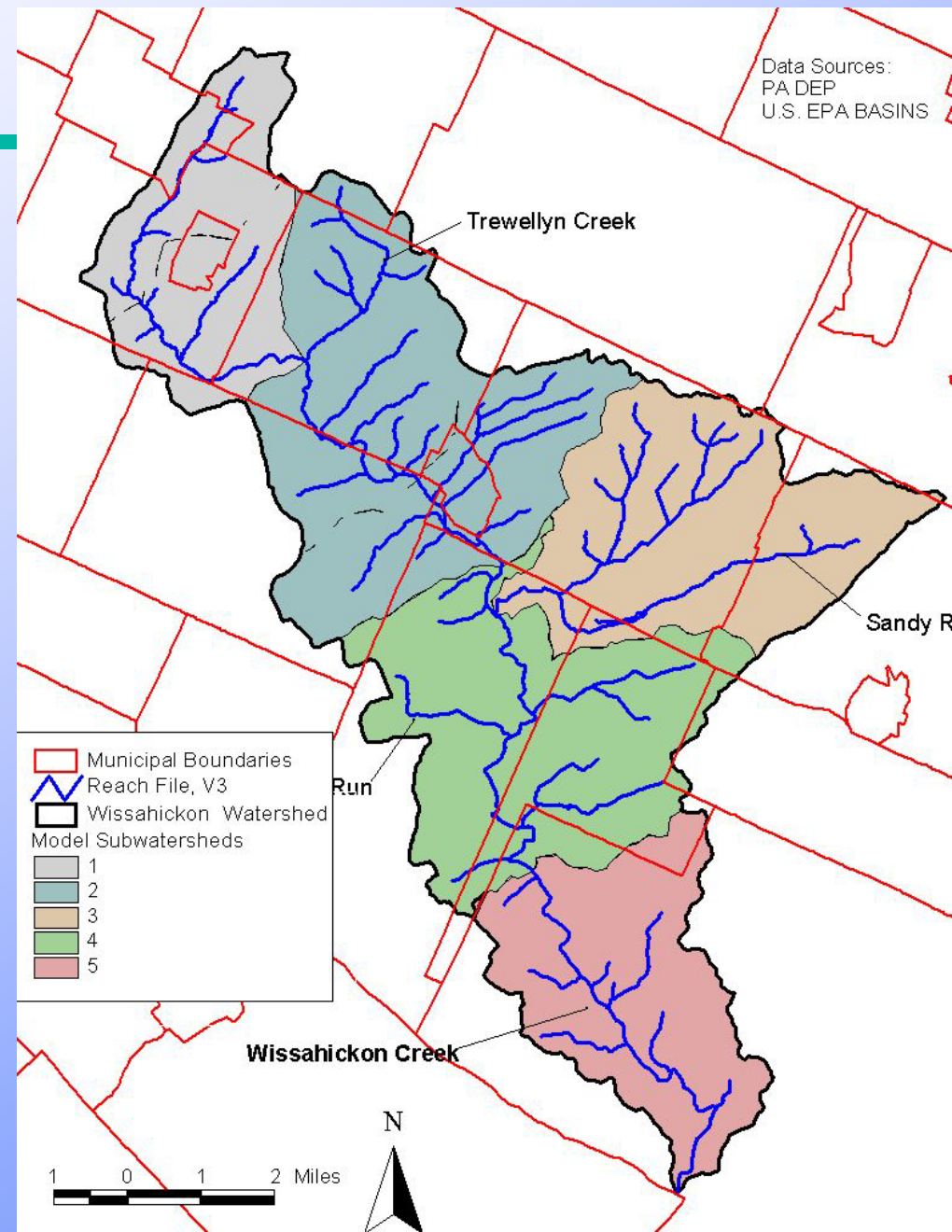
- MS4s require WLAs
- WLAs were calculated for each municipality (MS4)
- WLAs include:
 - Overland load from runoff
 - Streambank erosion



Siltation

Allocation of Streambank Erosion

- Streambank erosion determined for each model subwatershed using empirical method in AVGWLF
- WLAs distributed among MS4s
 - Distributed based on total area of each MS4 within each subwatershed
 - WLAs reported for each impaired stream segment



Other TMDLs Addressing Algae in the Region

- Other TMDLs developed to address excessive algae growth
- Wissahickon was developed to address nutrient impairment – DO was selected as TMDL endpoint
- Modeling approach slightly different for the TMDLs
- Comparison of Wissahickon and Skippack nutrient TMDLs follows...

Skippack Approach

- QUAL2K
- Configured for nutrients, periphyton, and DO
- No calibration against observed periphyton biomass
- TMDL focused on TP reduction
 - dynamic linkage between phosphorus and periphyton was not used for scenario analysis and TMDL determination
 - 0.24 mg/L TP target - assumed appropriate level for depressing periphyton growth
 - model predicted periphyton above the threshold of nuisance periphyton for TMDL allocation (periphyton chlorophyll-a 50 mg/m² to 100 mg/m², PA State report)

Modeling Coefficients

- Differences
 - CBOD
 - Nitrification
 - Denitrification
 - Hydrolysis rate for organic phosphorus
- Similarities
 - Phytoplankton growth and respiration rates
 - Hydrolysis rate for organic nitrogen
- Differences in Periphyton Representation

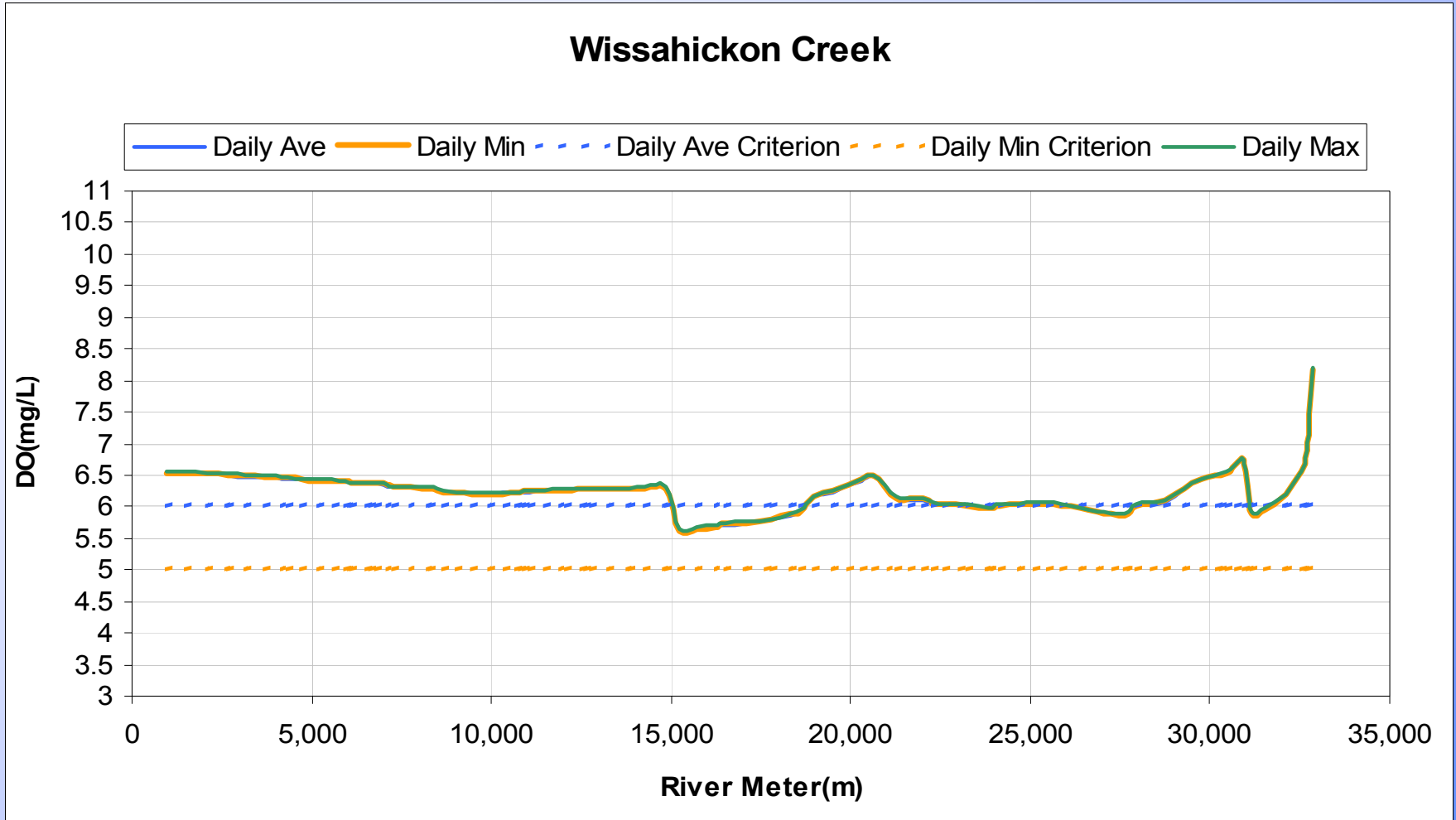
Periphyton Coefficients

- Periphyton growth rates for the two models cannot be compared because different formulations are used.
- For the Skippack Model, the half saturation coefficients for N and P were set to 250 ug N/L and 50 ug P/L, respectively.
- In the Wissahickon Model, the half saturation coefficient for P was set to 5.0 ug/L (based on range of 1.0 to 5.0 ug/L in Thomann & Mueller)

Periphyton Sensitivity Runs for Wissahickon Model

- Ran model with half saturation coefficient (for P) of 125 ug/L instead of 5 ug/L
 - Periphyton more sensitive to reductions in P
 - Makes it more difficult to achieve the daily average DO criteria
 - Daily minimum DO criteria can be readily met
- Ran model with periphyton off
 - No diurnal DO fluctuation
 - Daily average DO criteria is not met at all locations
 - CBOD and SOD still impacting DO

Periphyton Off



Summary

- **Wissahickon Model**
 - addresses nutrient-DO-periphyton relationships
 - was calibrated for nutrients, DO, and periphyton
 - TMDL was developed for DO criteria (and explicitly considers periphyton and nutrient limitations)
- **Skippack Model**
 - did not focus on DO impact
 - was not calibrated for periphyton
 - periphyton simulation was not used to guide TMDL development; only addressed TP concentration for TMDL
 - difference in model parameter coefficients