MODELING FOR THE WISSAHICKON WATERSHED TMDL

DATASETS

- EPA formally requested data for Wissahickon in December, 2011
  - Good response- received/acquired data from many sources (PWD, PADEP, USGS, LIMS, DVRPC)
- Wealth of watershed, source data obtained
  - Monitoring data (DMR, in-stream flow/water quality, weather)
  - Watershed characteristics (updated DVRPC landuse, stream cross section data)
  - Nutrient Endpoint Analysis, Wissahickon Nutrient Stressor Verification

PERMITTED FACILITIES

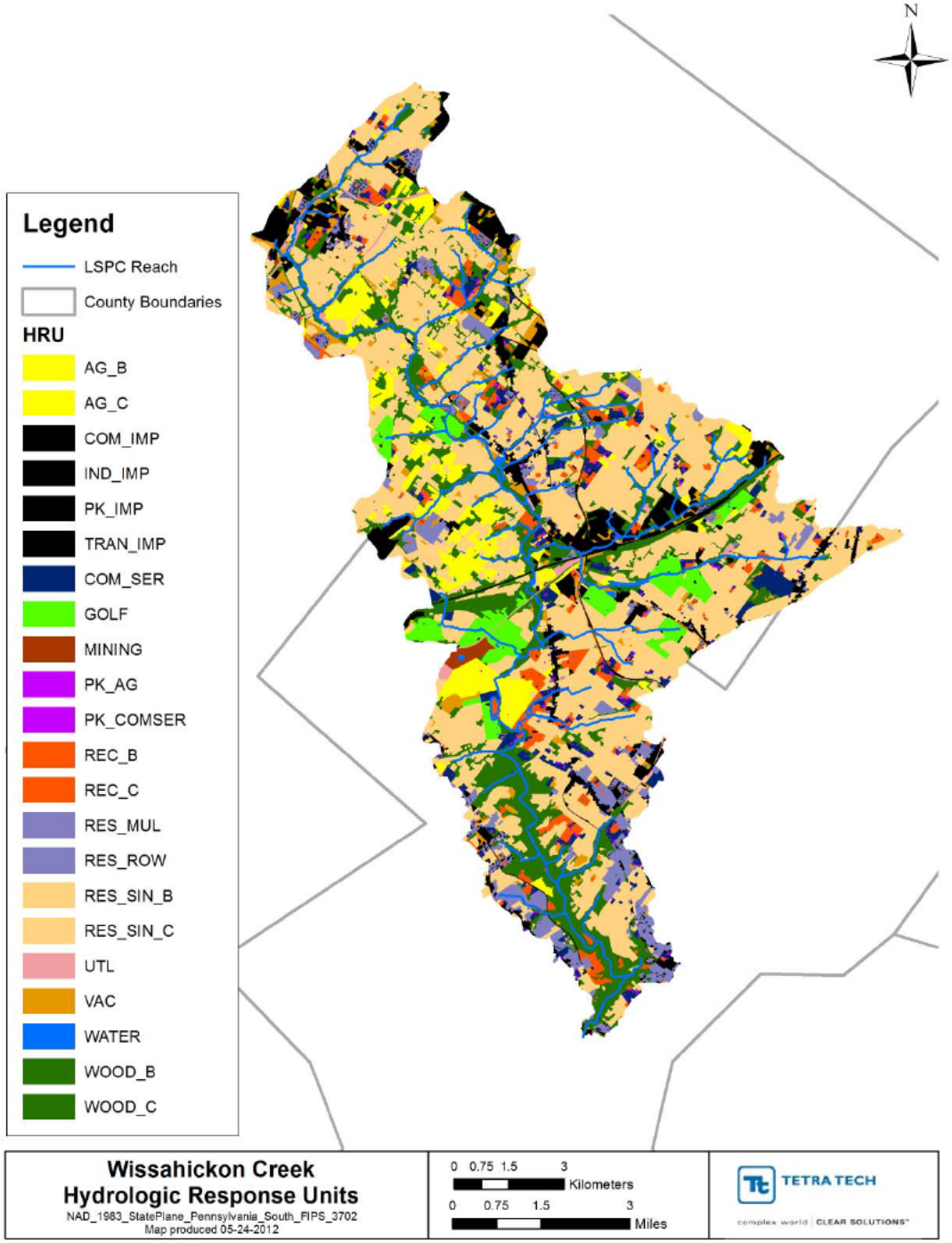
Permit Number	Facility Name
PA0012190	Precision Tube Co
PA0022586	North Wales Water Authority
PA0023256	Upper Gwynedd Twp WWTP
PA0026603	Ambler Boro STP
PA0026867	Abington STP
PA0029441	Upper Dublin WWTP
PA0050865	Gessner Ambler Fac
PA0052515	Ambler Boro WFP
PA0053074	Valley Green Corp Ctr STP
PA0053538	Merck Sharp & Dohme Corp West Point Facility
PA0054712	Philadelphia MS4
PA0055565	Wings Field Preservation Association
PA0057631	David & Marie Sayers
PAG130005	North Wales Boro MS4
PAG130012	Abington Twp MS4
PAG130016	Montgomery Twp MS4
PAG130019	Upper Moreland Twp MS4
PAG130026	Worcester Twp MS4
PAG130031	Upper Gwynedd Twp MS4
PAG130036	Ambler Boro MS4

Permit Number	Facility Name
PAG130038	Lansdale Boro MS4
PAG130054	Cheltenham Twp MS4
PAG130072	Lower Gwynedd Twp MS4
PAG130075	Upper Dublin Twp MS4
PAG130103	Whitemarsh Twp MS4
PAG130130	Springfield Twp MS4
PAG130137	Whitpain Twp MS4
PAG130157	Horsham Twp MS4
PA0054712	Philadelphia MS4
PAG040003	Entwisle SRSTP
PAG040009	Harris SRSTP
PAG050011	BP Amoco Station 1269
PAG050079	Sunoco, Inc.
PAR110049	Moore Products Co.
PAR210024	Allied Concrete & Supply Dresher Plt
PAR230073	McNeil Consumer Healthcare Ft Washington Plt
PAR600075	Poor Boys Used Auto Parts/West
PAR800114	Federal Express Corp Sega
PAR900001	Abington Transfer Station

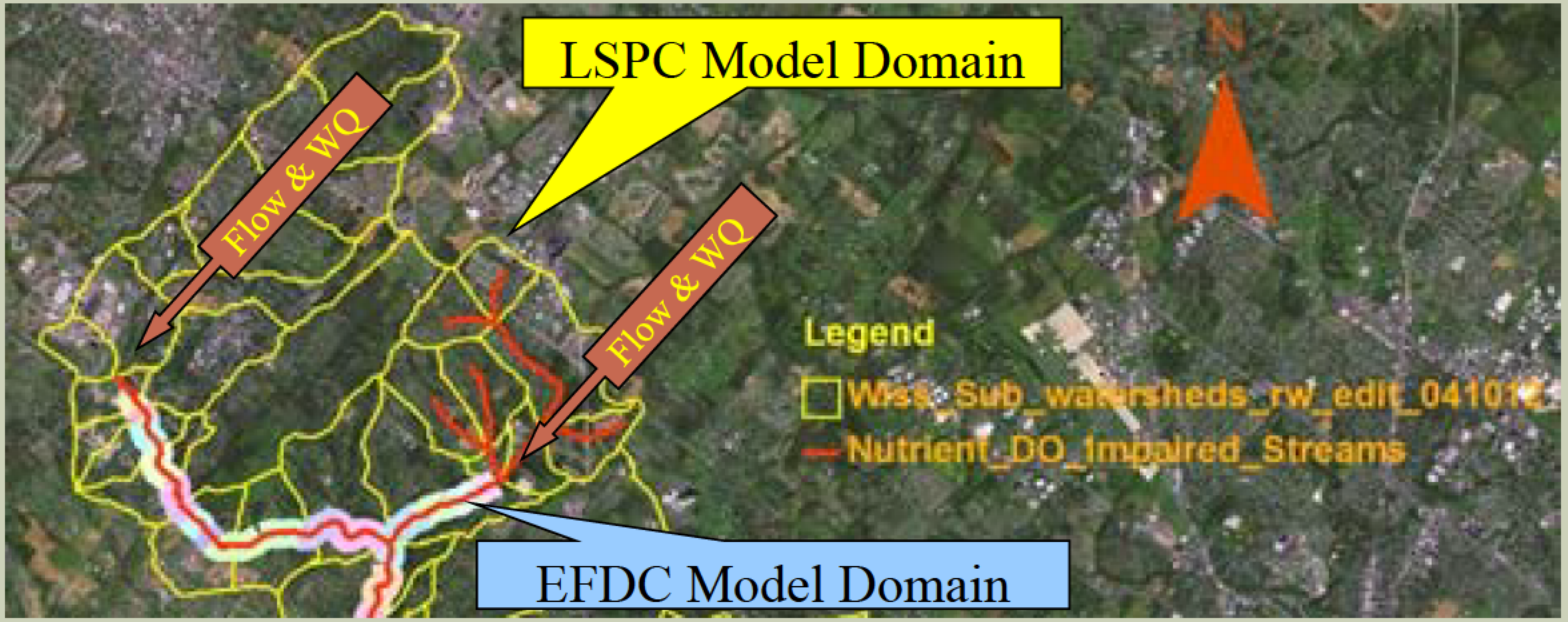
- Five Municipal POTWs
- Three industrial wastewater small facilities
- One Phase I MS4
- Fifteen Phase II MS4s
- Six storm water general permits
- Two storm water individual permit
- Two groundwater cleanup general permits
- One small sewage facility
- Three single residence

DIFFUSE SOURCES

- Landuse/landcover (all under MS4 jurisdiction)
  - Golf courses
  - Stormwater
  - Agriculture
  - Forested
- Septic Systems



LINKED MODELING SYSTEM CONCEPT



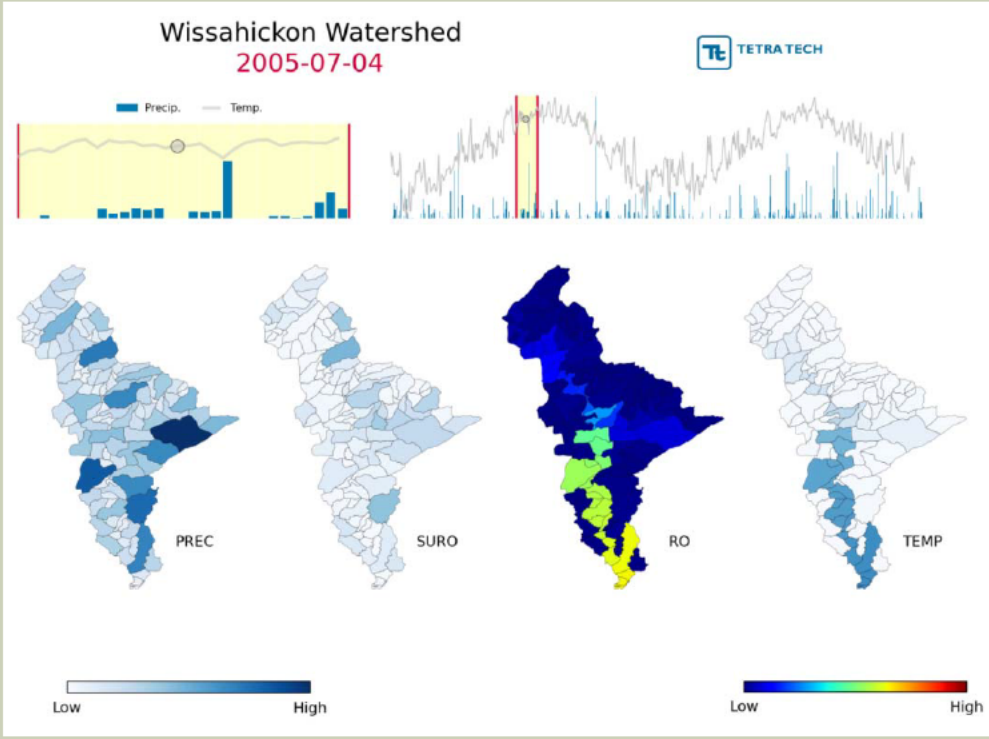
- LSPC represents contributions from the land surface and smaller tributaries
- Volumes and loads estimated by LSPC are delivered to EFDC
- EFDC simulates hydrodynamics and water quality based on LSPC inputs and weather data input

LSPC WATERSHED MODEL

ADVANTAGES OF DYNAMIC MODELING

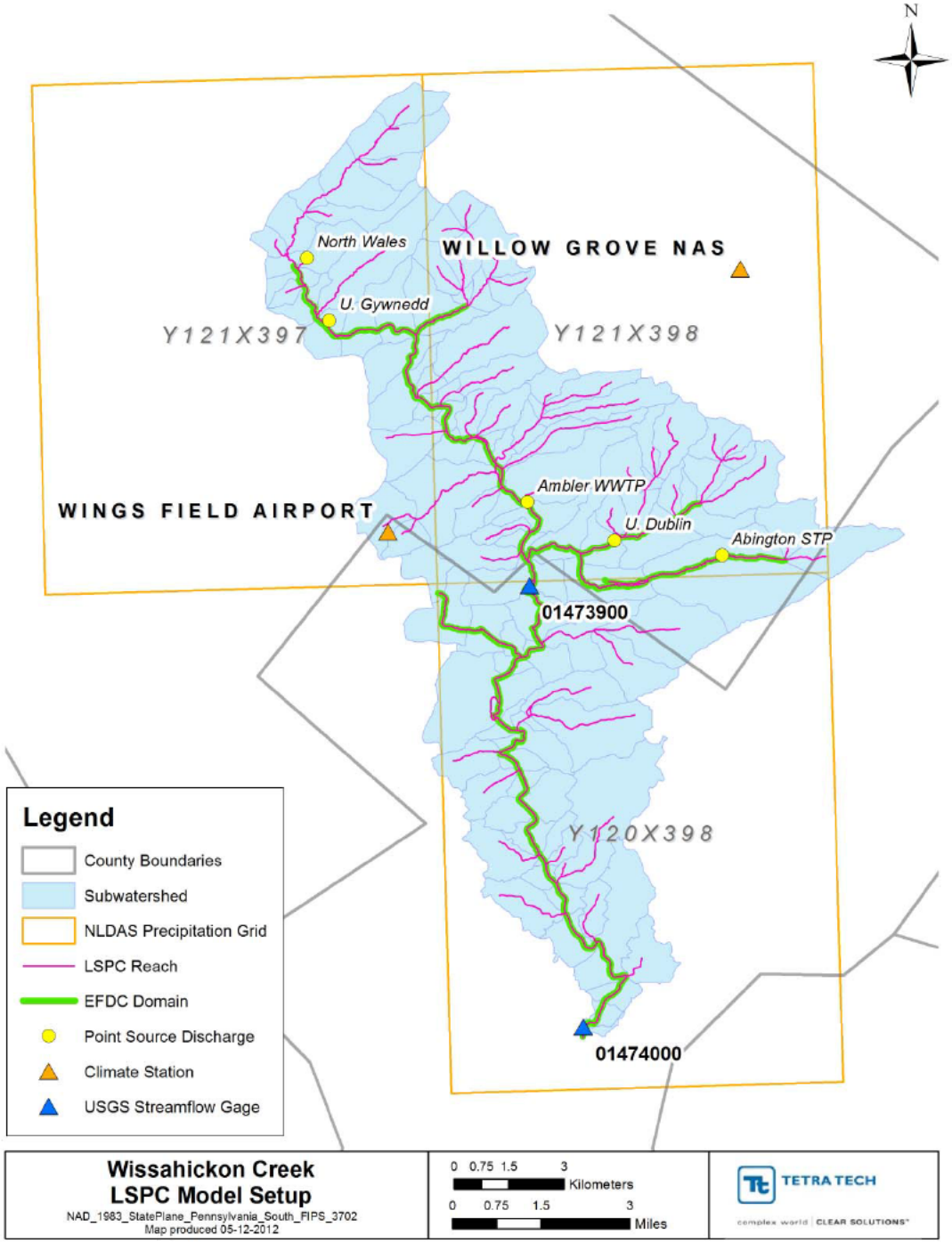
- Dynamic modeling increases resolution of nutrient loading
  - Spatial resolution: Nutrient loading dependent on physical morphology, source location
  - Temporal resolution: Meteorology, travel time

- Visualization can be useful in situations where influential watershed characteristics or dominant sources exist



MODEL SETUP

- 64 Square miles
- 118 Subwatersheds
- 22 Hydrologic response units (HRUs)
- Dynamic representation
- 3 Climate timeseries
  - Grid-based precipitation
- 2 USGS flow gages
- 5 Point major sources
- 1/1/2005-12/31/2005 is target time period



MODELING TIME PERIOD: DATA DENSITY

- 1/1/2005-12/31/2005 is target time period
- Streamflow data available through current
- Available ambient WQ data decreases after 2005.
  - PWD sonde data (10 stations), PWD grab sample data (2 stations)
  - PADEP

PCode	Parameter Name	Units	No. Obs	Mean	First Date	Last Date
CORRDEP	Corrected Depth	in	114085	17.13	2004-08-10	2005-11-21
DO	Dissolved Oxygen	mg/L	115510	8.56	2004-08-10	2005-11-21
PH	pH	pHU	115510	7.78	2004-08-10	2005-11-21
SPCOND	Specific Conductivity at 25 deg C	uMHO/cm	115510	812	2004-08-10	2005-11-21
TURB	Turbidity	NTU	55173	70	2004-08-10	2005-11-17
WTEM	Water Temperature	deg C	115510	17.54	2004-08-10	2005-11-21

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  - PADEP

PCode	Parameter Name	Units	No. Obs	Mean	First Date	Last Date
BOD30	BOD 30d	mg/L	118	6.91	2005-01-13	2005-09-08
BOD5	BOD 5d	mg/L	120	1.40	2005-01-13	2005-09-08
CBOD5	CBOD 5d	mg/L	118	1.06	2005-01-13	2005-09-08
CHLA	Chlorophyll-a	ug/L	97	3.01	2005-01-13	2005-09-08
DO	Dissolved Oxygen	mg/L	271	9.93	2005-01-13	2011-06-27
NO2	Nitrite	mgN/L	661	0.04	2005-01-13	2008-05-21
NO3	Nitrate	mgN/L	760	3.46	2005-01-04	2011-06-27
PH	pH	pHU	352	7.78	2005-01-04	2011-07-12
PO4	Orthophosphate	mgP/L	753	0.41	2005-01-04	2011-06-27
TKN	Total Kjeldahl Nitrogen	mgN/L	514	1.30	2005-01-13	2006-07-23
TNH3	Total Ammonia	mgN/L	641	0.13	2005-01-04	2011-07-12
TP	Total Phosphorus	mgP/L	440	0.70	2005-01-13	2008-05-21
TSS	Total Suspended Solids	mg/L	651	60.67	2005-01-13	2007-04-27
TURB	Turbidity	NTU	964	17.82	2005-01-04	2011-07-12

MODELING TIME PERIOD: DATA DENSITY

- 1/1/2005-12/31/2005 is target time period
- Streamflow data available through current
- Available ambient WQ data decreases after 2005.
  - PWD sonde data (10 stations), PWD grab sample data (2 stations)
  - PADEP (same 2 locations as PWD)

PCode	Parameter Name	Units	No. Obs	Mean	First Date	Last Date
DO	Dissolved Oxygen	mg/L	101	11.81	2002-02-07	2011-03-30
DOC	Dissolved Organic Carbon	mg/L	7	3.53	2009-10-08	2011-03-14
FLOWCFS	Flow	cfs	84	91.11	2002-02-07	2010-06-28
NO2	Nitrite	mgN/L	102	0.04	2002-02-07	2011-03-30
NO3	Nitrate	mgN/L	102	5.46	2002-02-07	2011-03-30
PH	pH	pHU	204	7.99	2002-02-07	2011-03-30
PO4	Orthophosphate	mgP/L	100	0.71	2002-04-08	2011-03-30
SPCOND	Specific Conductivity at 25 deg C	uMHO/cm	204	739	2002-02-07	2011-03-30
TN	Total Nitrogen	mgN/L	103	6.06	2002-02-07	2011-03-30
TNH3	Total Ammonia	mgN/L	102	0.05	2002-02-07	2011-03-30
TOC	Total Organic Carbon	mg/L	37	4.76	2002-02-07	2005-03-07
TP	Total Phosphorus	mgP/L	102	0.81	2002-02-07	2011-03-30
TSS	Total Suspended Solids	mg/L	102	10.94	2002-02-07	2011-03-30
WTEM	Water Temperature	deg C	102	12.95	2002-02-07	2011-03-30

MODELING TIME PERIOD: DATA DENSITY

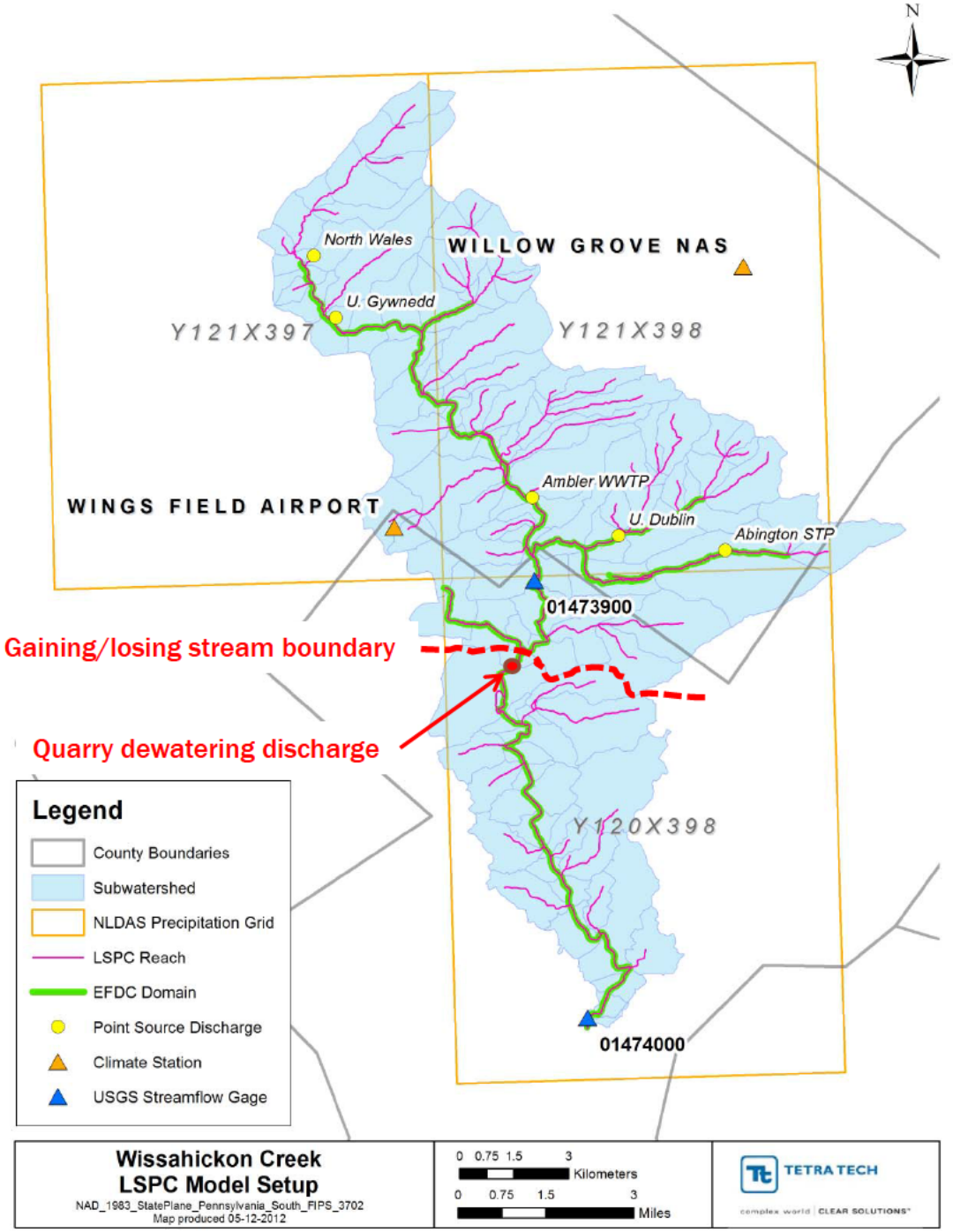
- 1/1/2005-12/31/2005 is target time period
- Streamflow data available through current
- Available ambient WQ data decreases after 2005.
  - PWD sonde data (10 stations), PWD grab sample data (2 stations)
  - PADEP
  - Additional data availability for 2005 include:
    - Permittee DMR data
    - PADEP Periphyton data from WQN field sheets
    - PWD Macroinvertebrate data (mainly 2005, into early 2006)

WISSAHICKON-SPECIFIC CONSIDERATIONS

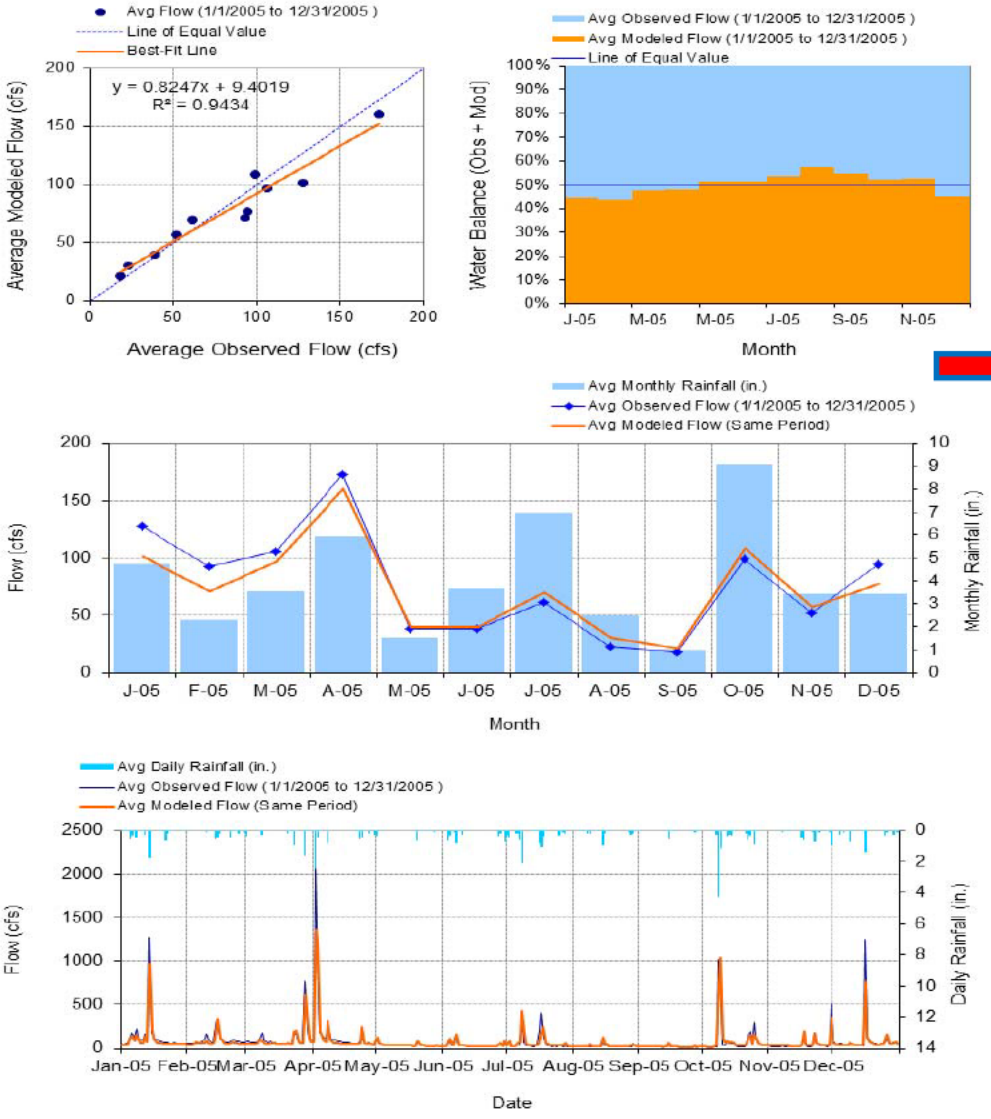
- Watershed straddles geologic "fall-line"
- Upper watershed characterized by losing streams
- Water lost upstream may be re-introduced downstream based on USGS report:

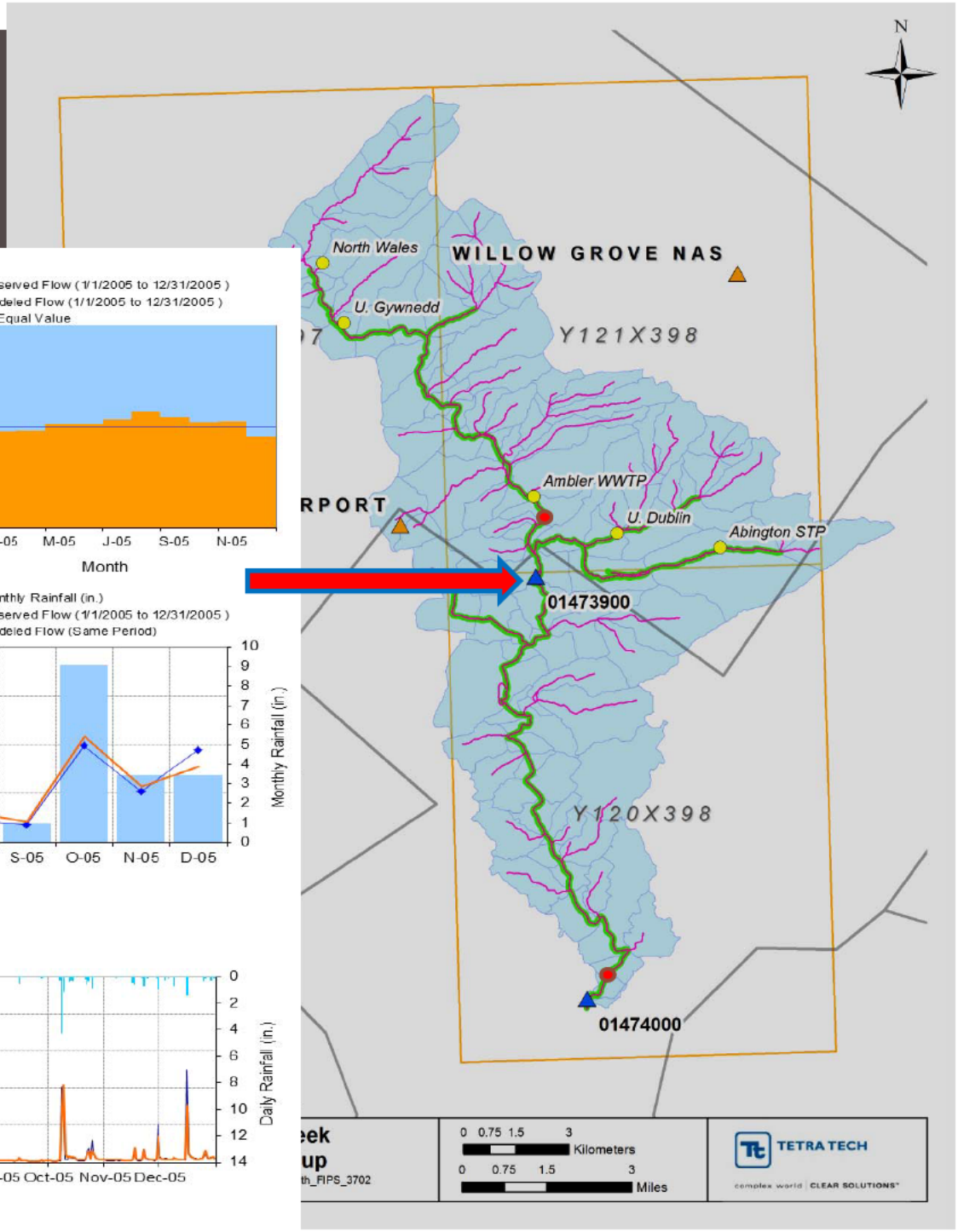
  Water Budgets for Selected Watersheds in the Delaware River Basin, Eastern Pennsylvania and Western New Jersey

  (USGS, 2005)
- Could not calibrate upstream and downstream USGS stations simultaneously
- Addressed the issue by modifying the LSPC code



LSPC HYDROLOGY





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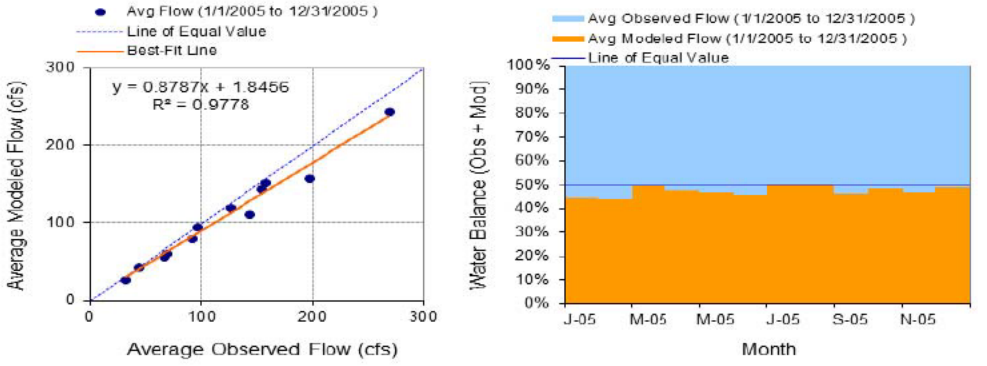
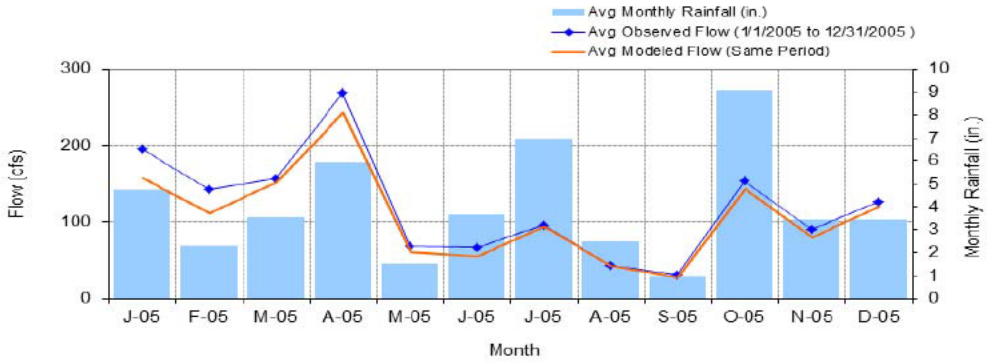
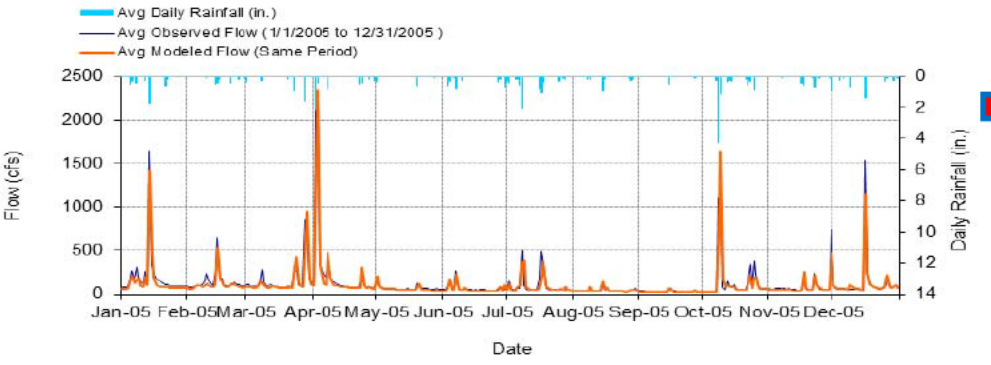
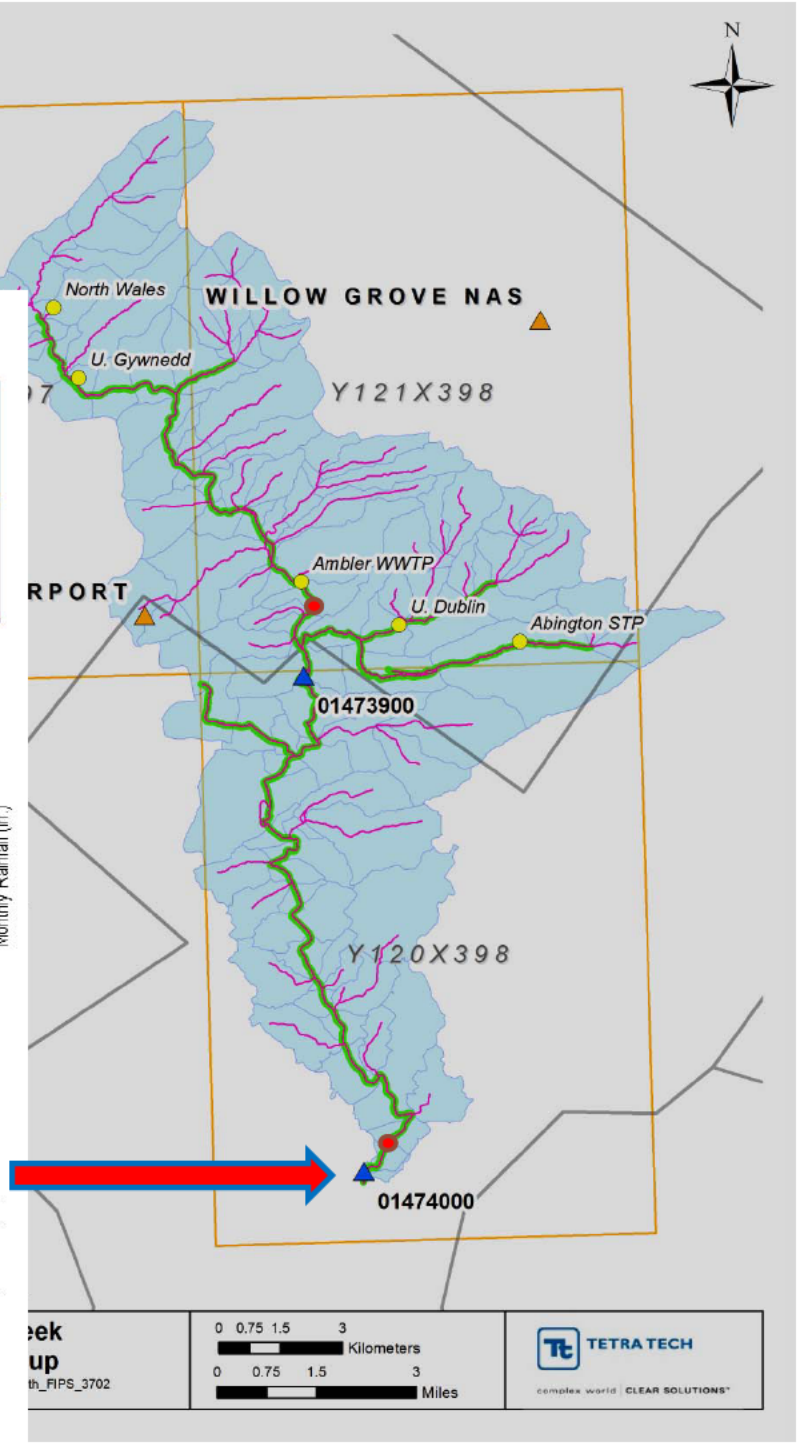
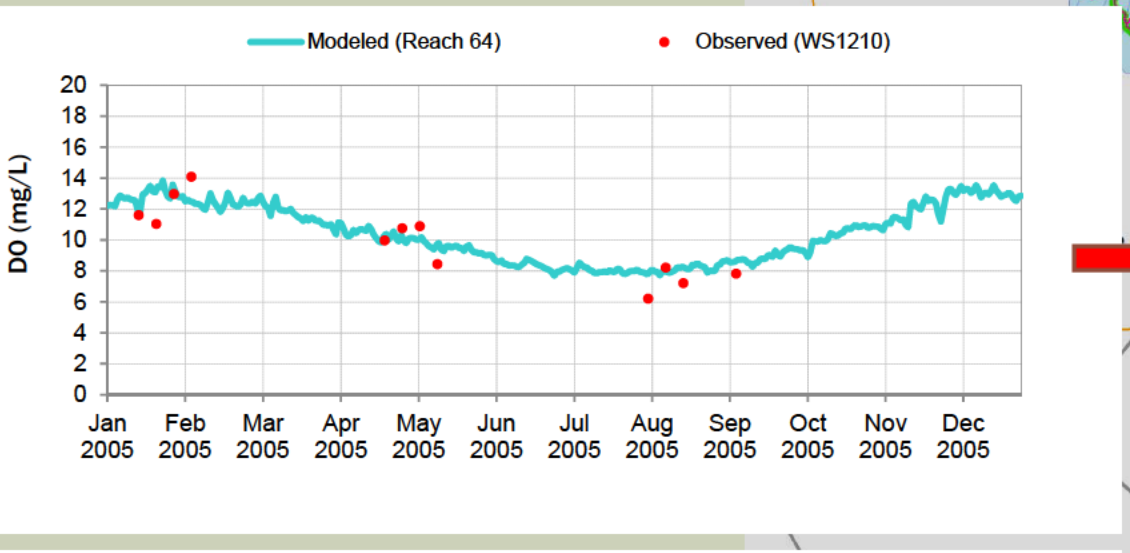


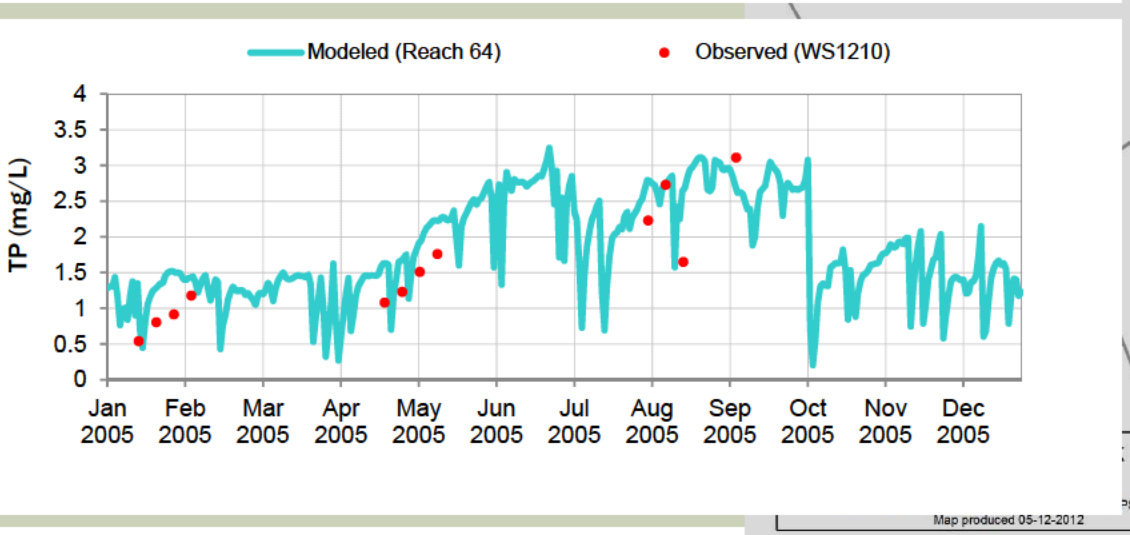


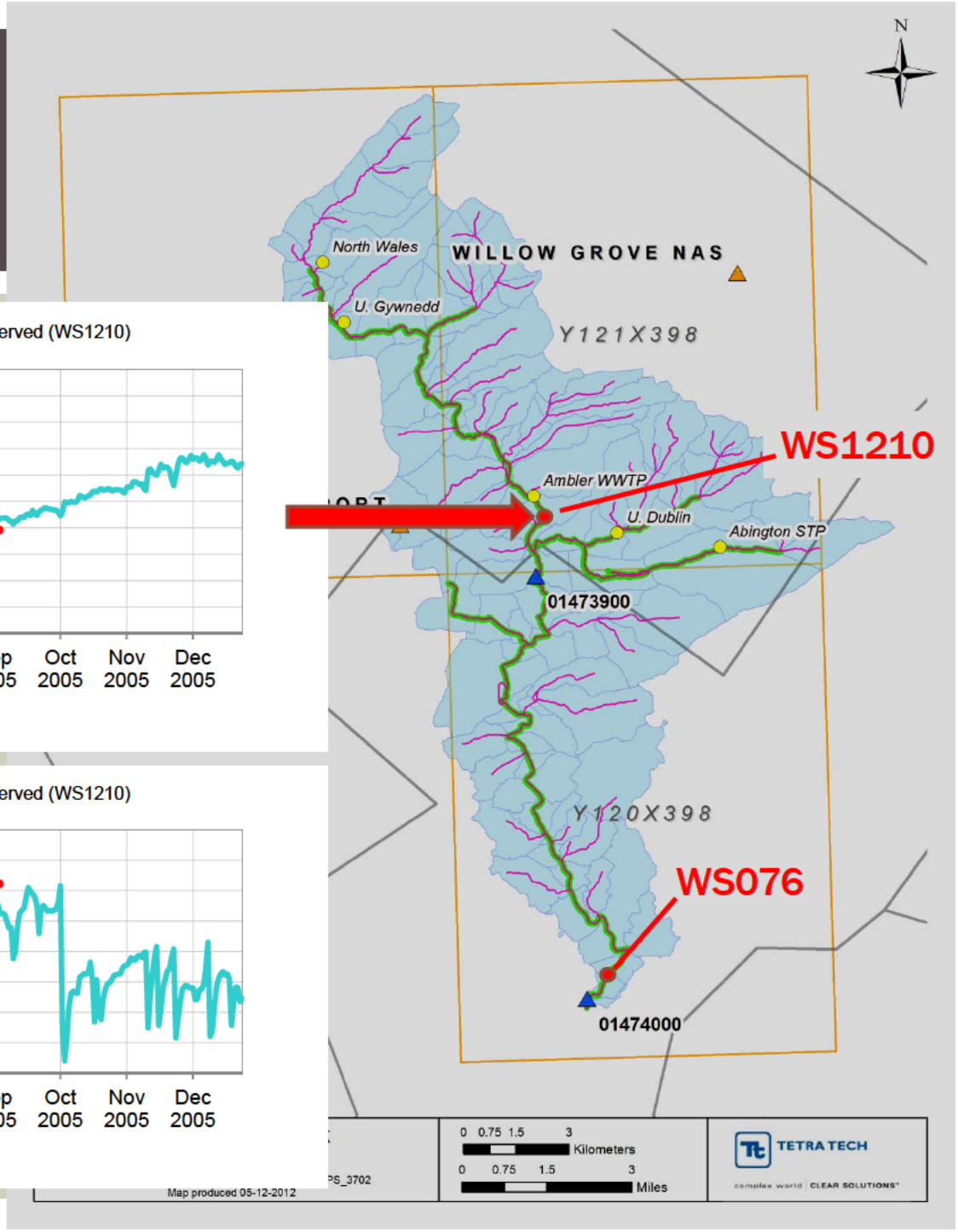




LSPC WATER QUALITY







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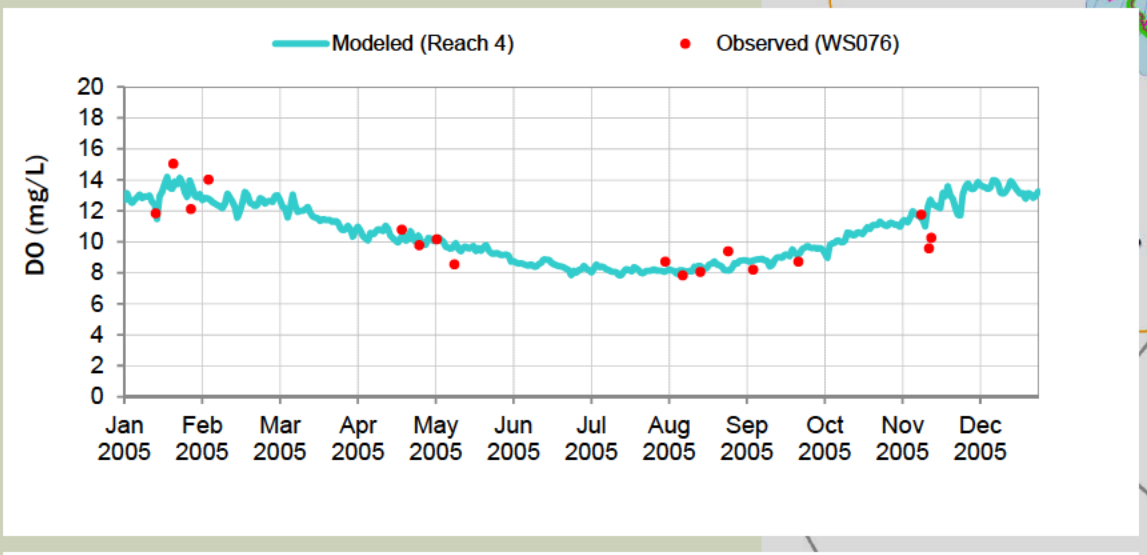
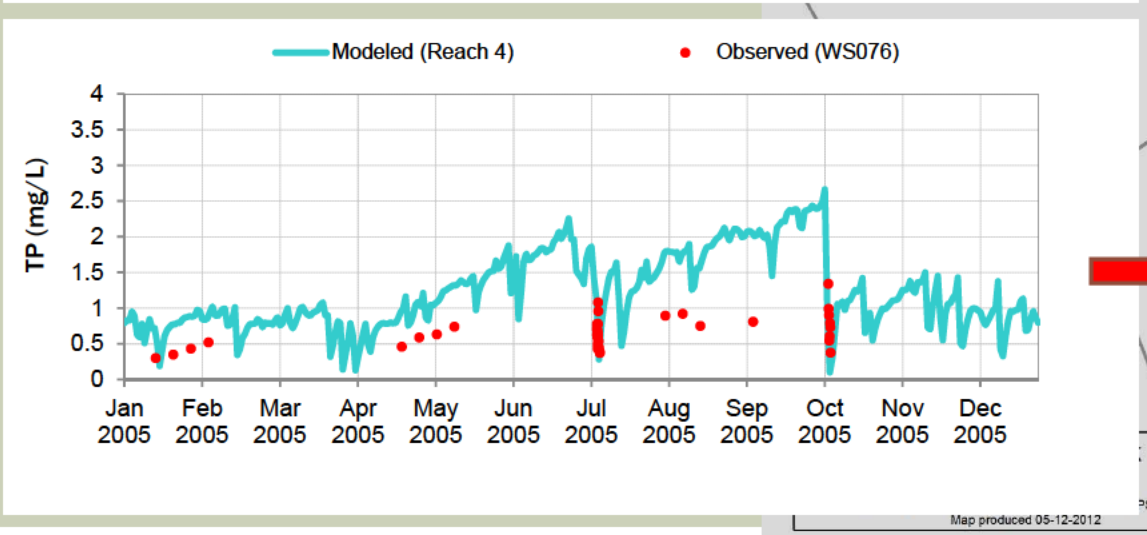
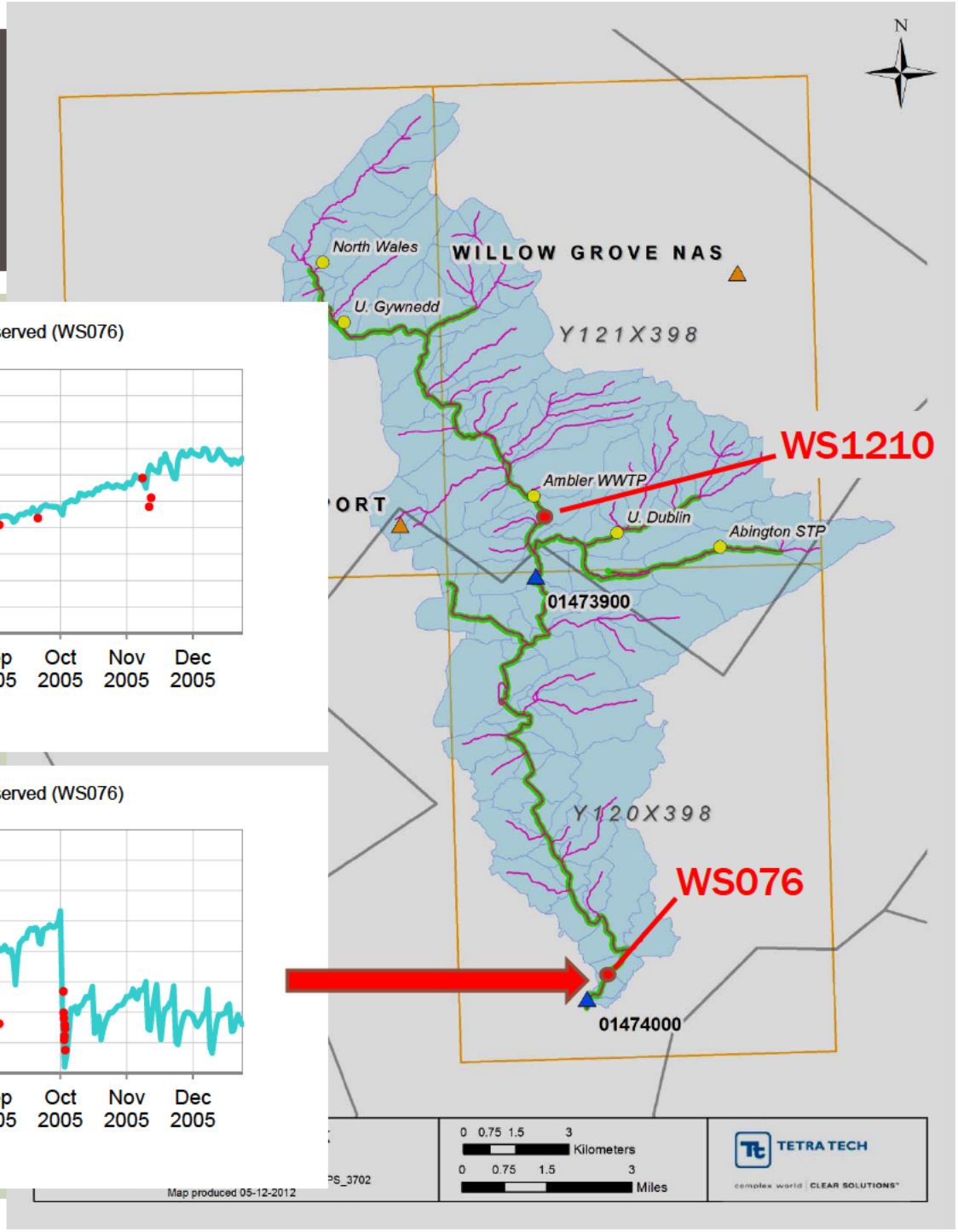
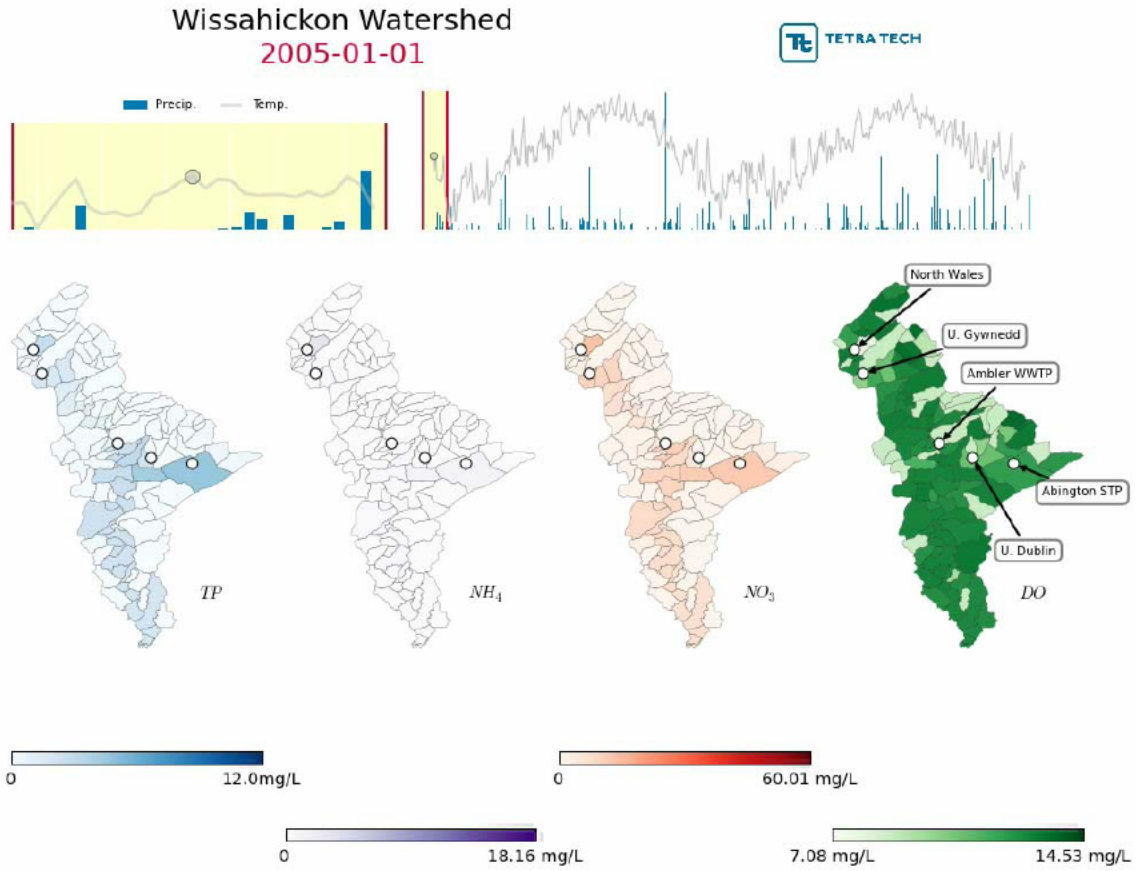






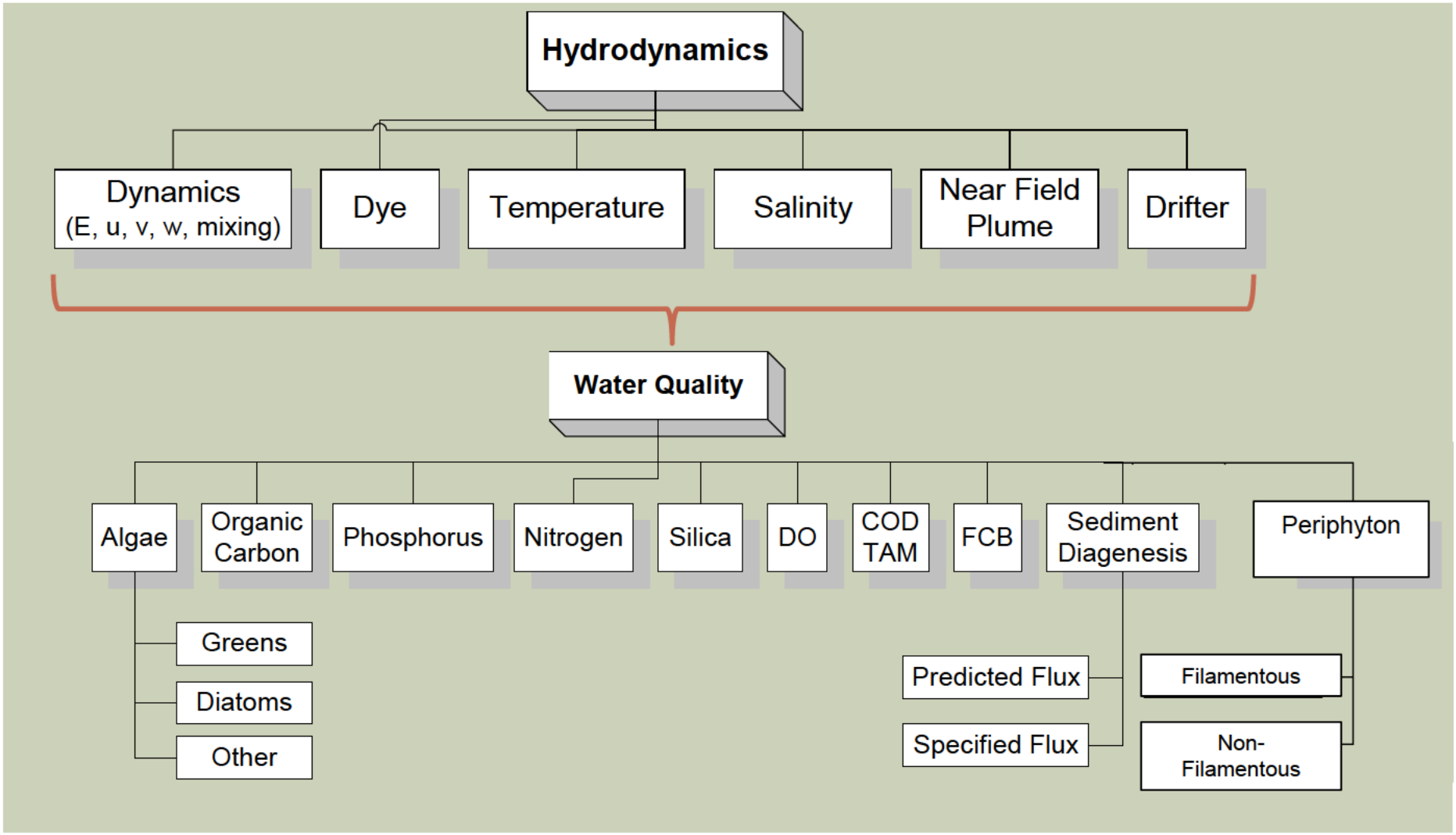
LSPC ANIMATION

- Animation shows watershed simulation results and concentrations applied to the EFDC receiving water model
- Mainstem concentrations are ultimately modeled by EFDC



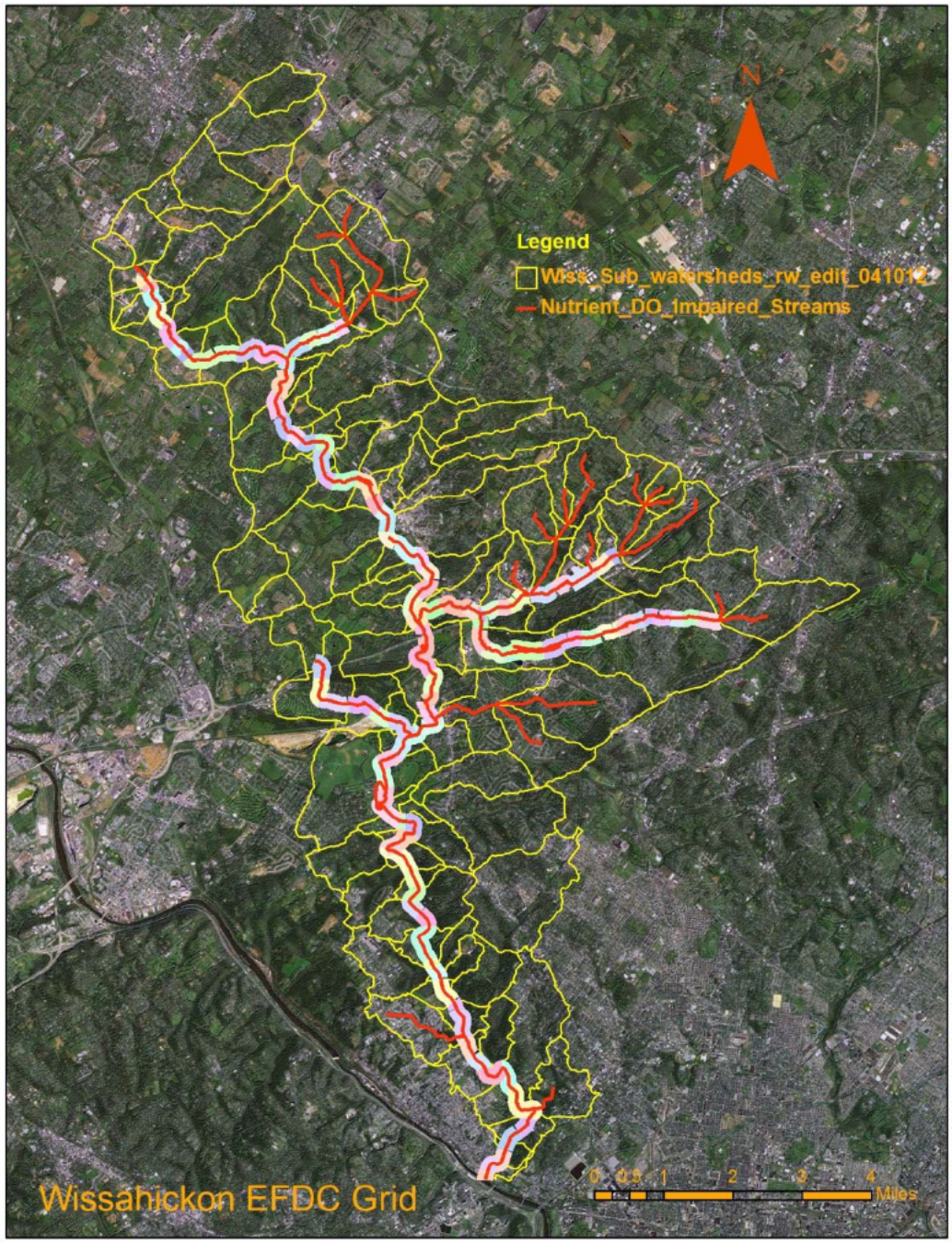
EFDC RECEIVING WATER QUALITY MODEL

EFDC MODEL CONFIGURATION



EFDC MODEL CONFIGURATION

- Based on the EFDC model developed in 2002
- 1-D grid
- Grid slightly extended to match the sub-watershed boundary on Sandy Run
- 120 Cells total
- Bottom elevations updated with surveyed cross section data
- TP is primary modeling pollutant, algae and DO modeled as checkpoints



EFDC BENTHIC ALGAE ROUTINES

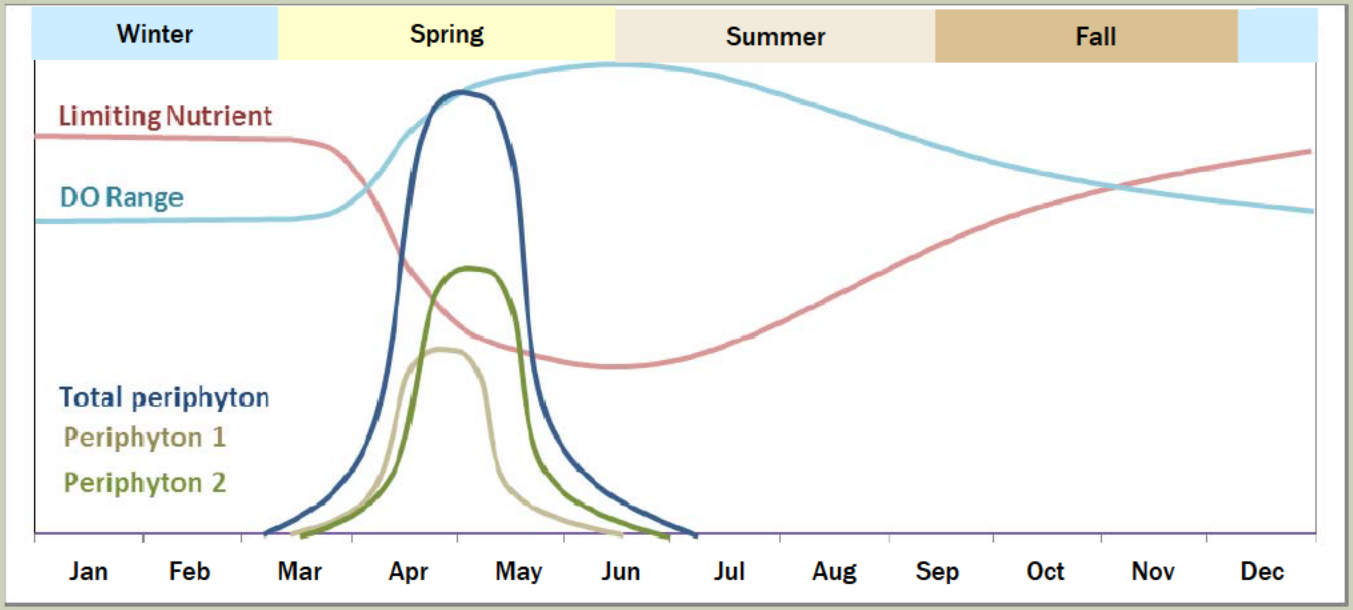
- The TMDL accounts for two types of benthic algae (filamentous periphyton and non-filamentous periphyton) in addition to macroalgae.
  - Simulated two groups to allow for competition between algal species and individual interaction with nutrients and substrate
  - Incorporated substrate availability factors, flood scour effects on periphyton
  - Incorporated time variable factor to approximate the seasonal change in canopy impacting shading effect on water temperature and periphyton light availability

EFDC BENTHIC ALGAE ROUTINES

- Periphyton species were parameterized by
  - Species growth, respiration, and grazing loss rate, nutrient half-saturation
- Calibrated algal parameter values used literature values and guidance from PADEP as a baseline- lack of observed filamentous/non-filamentous distribution data
- Anecdotal information points to presence of both (PADEP recommendation) in the Wissahickon watershed

	Filamentous (model species #1	Non- filamentous (model species #2	Literature min	Literature max
Growth (1/d)	0.7	0.7	0.62	4
Respiration (1/day)	0.03	0.03	0.02	0.2
Grazing (1/d)	0.035	0.035	0.005	0.1
P half-saturation (mg/L)	0.125	0.005	0.001	0.5

EFDC BENTHIC ALGAE ROUTINES



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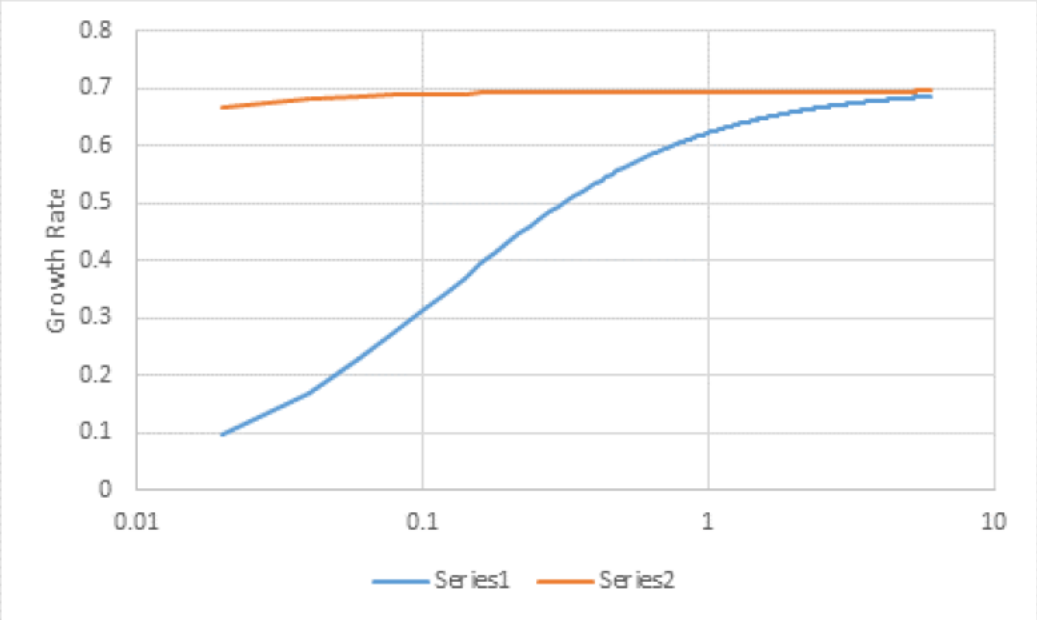

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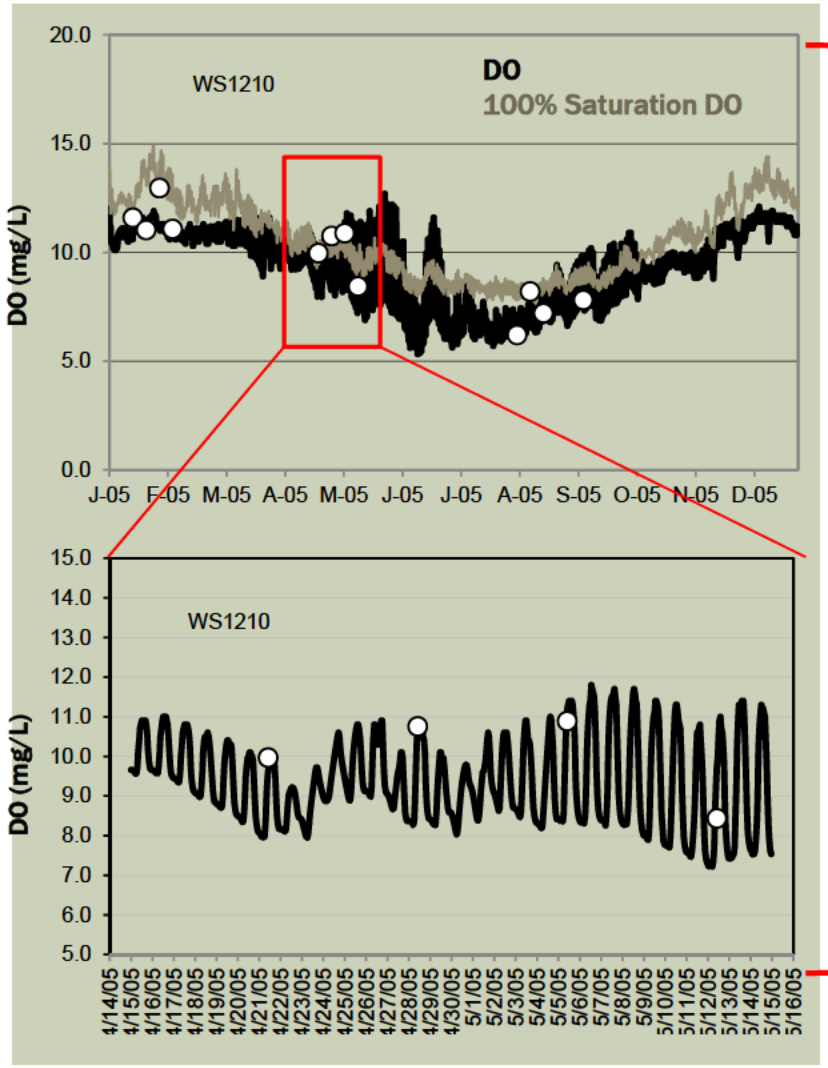
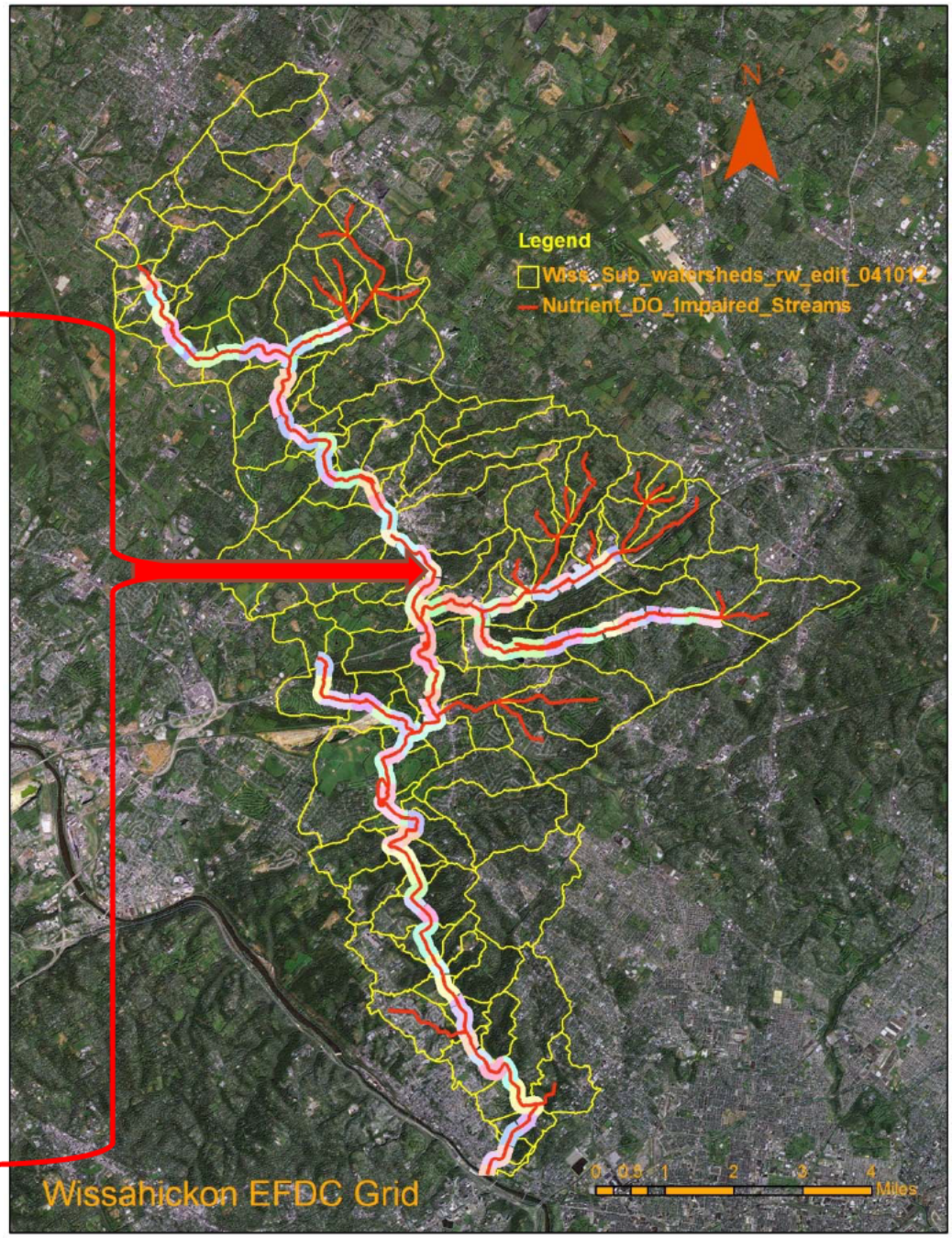
EFDC WQ CALIBRATION





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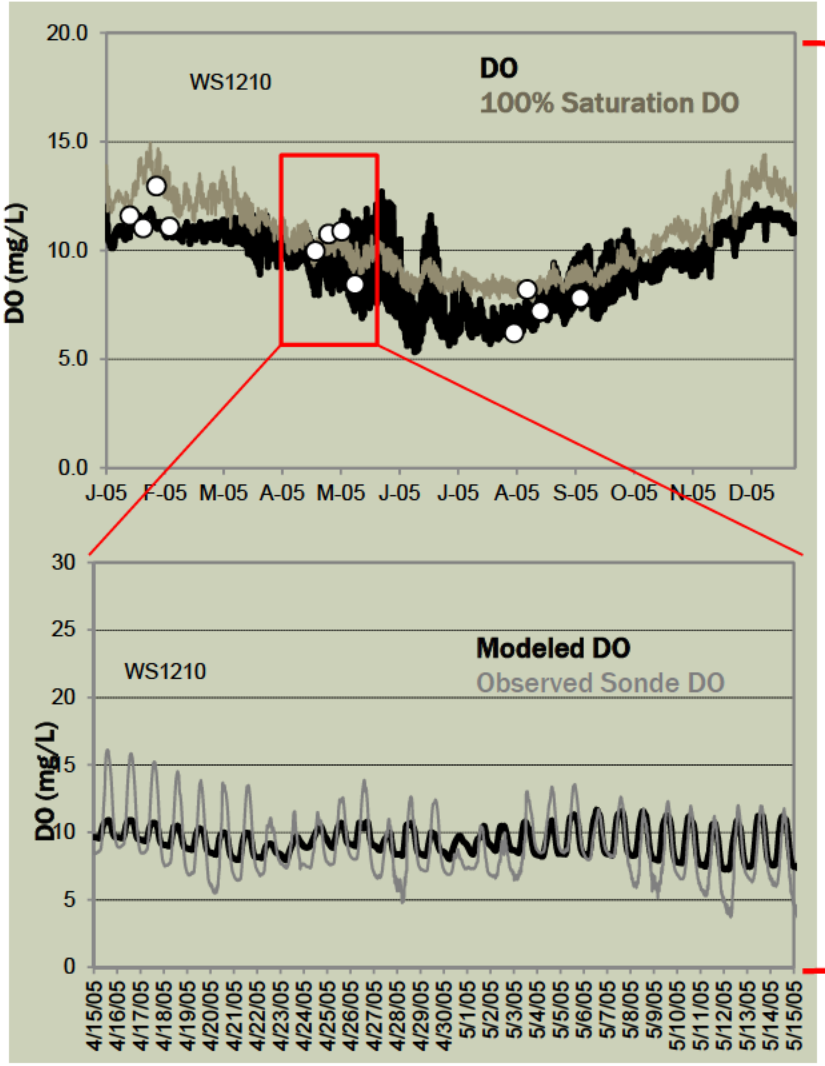

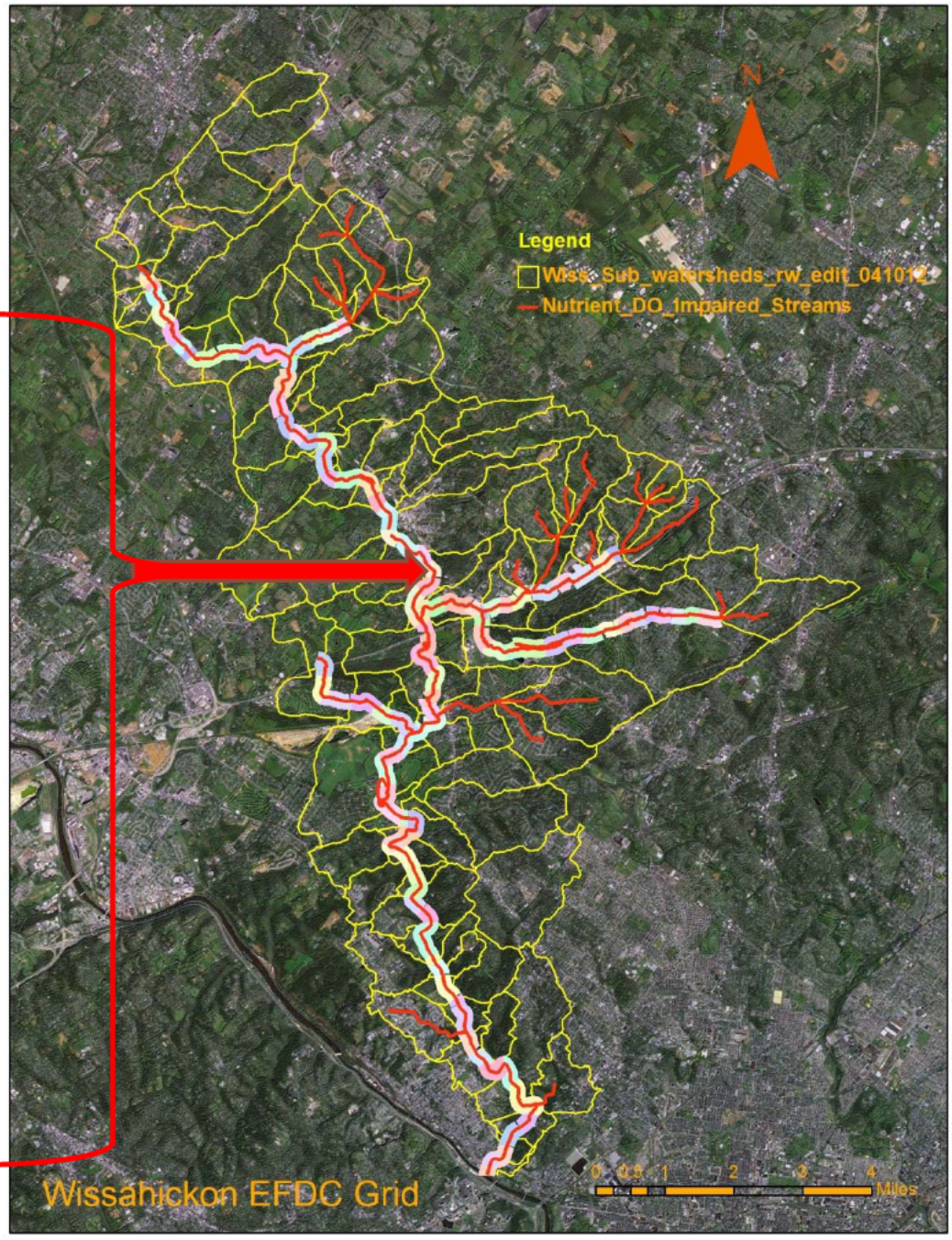

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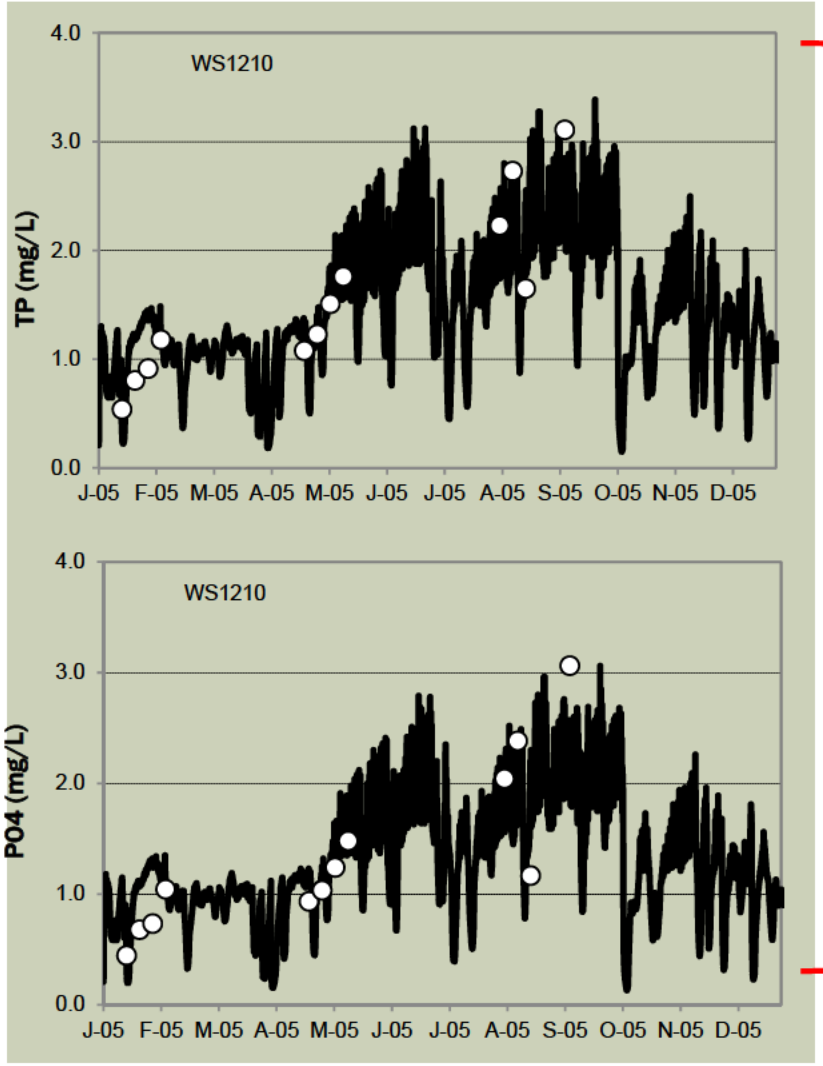

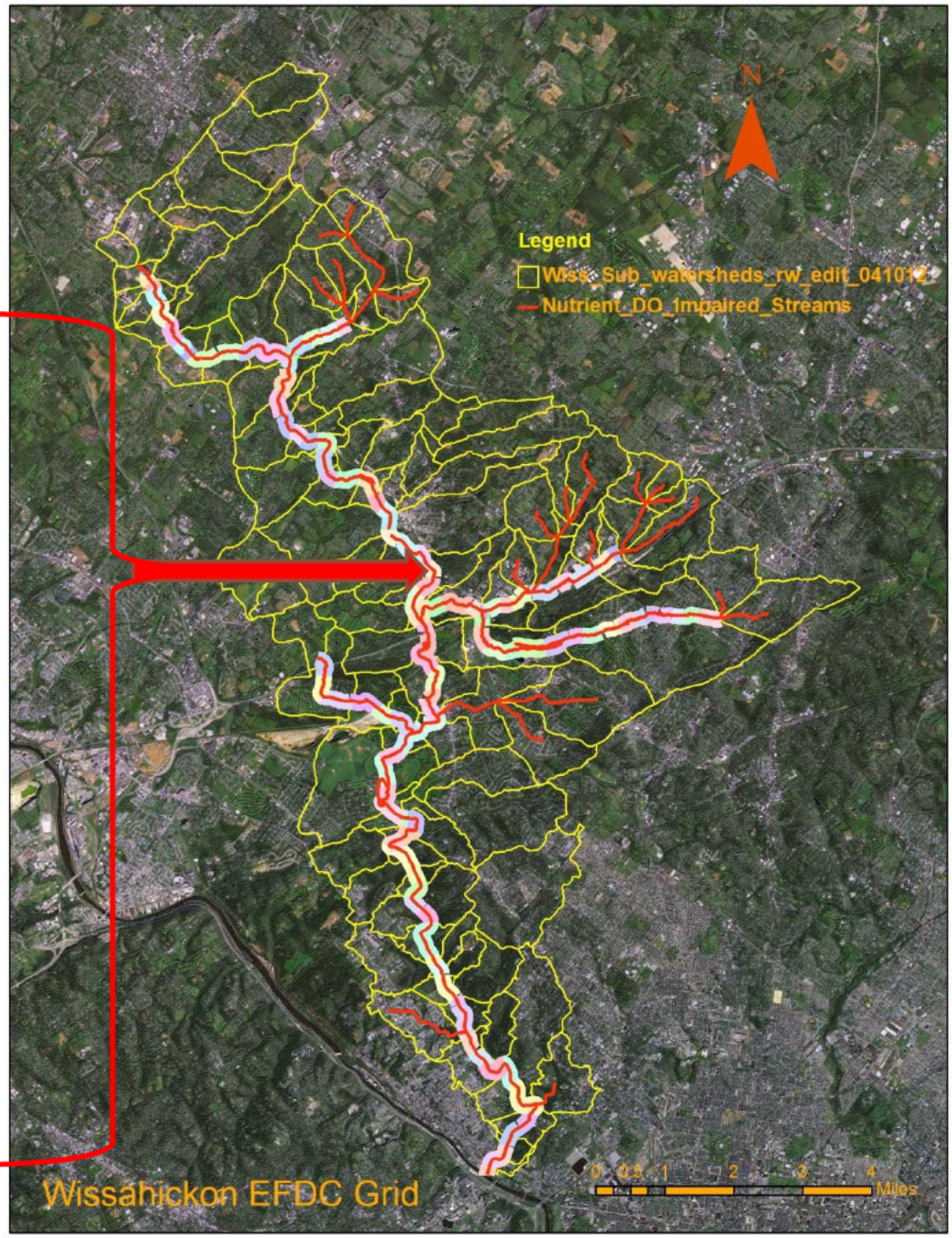

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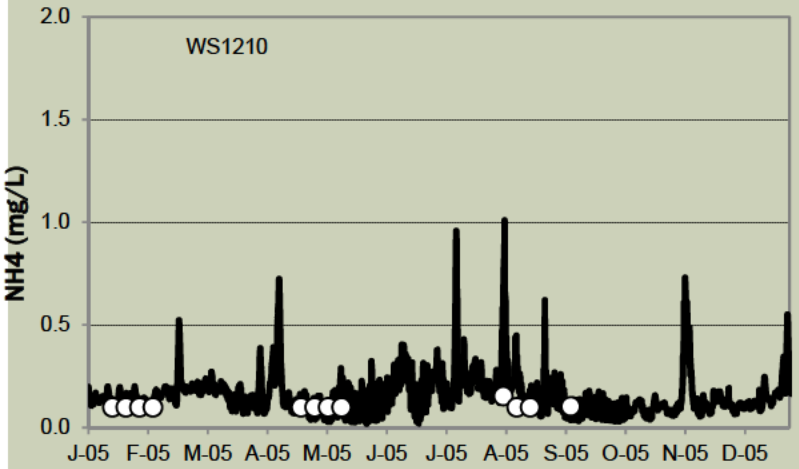

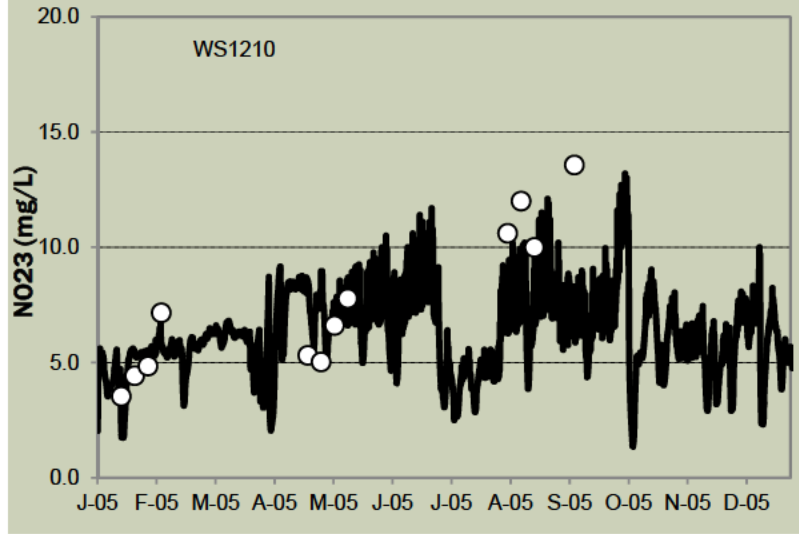

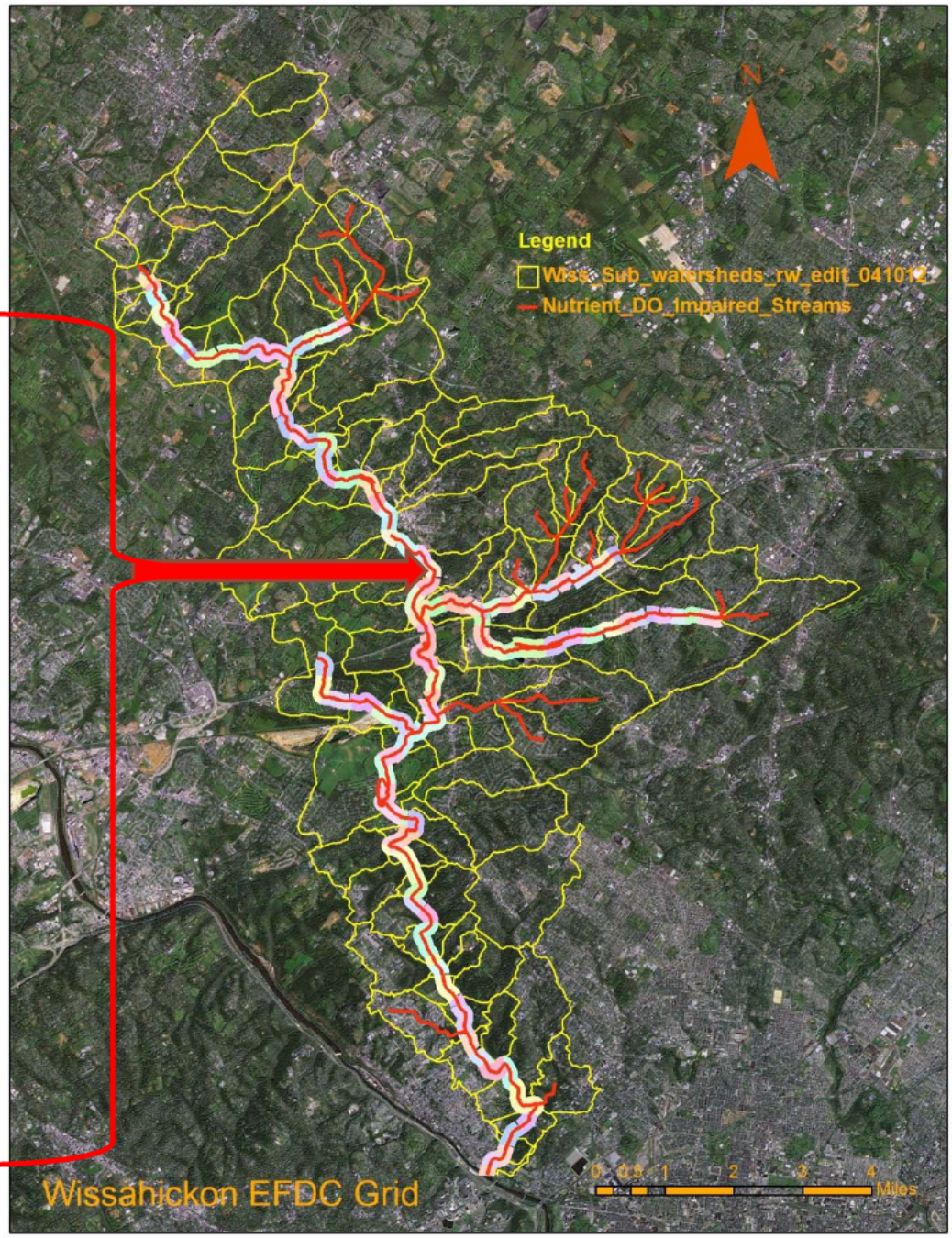

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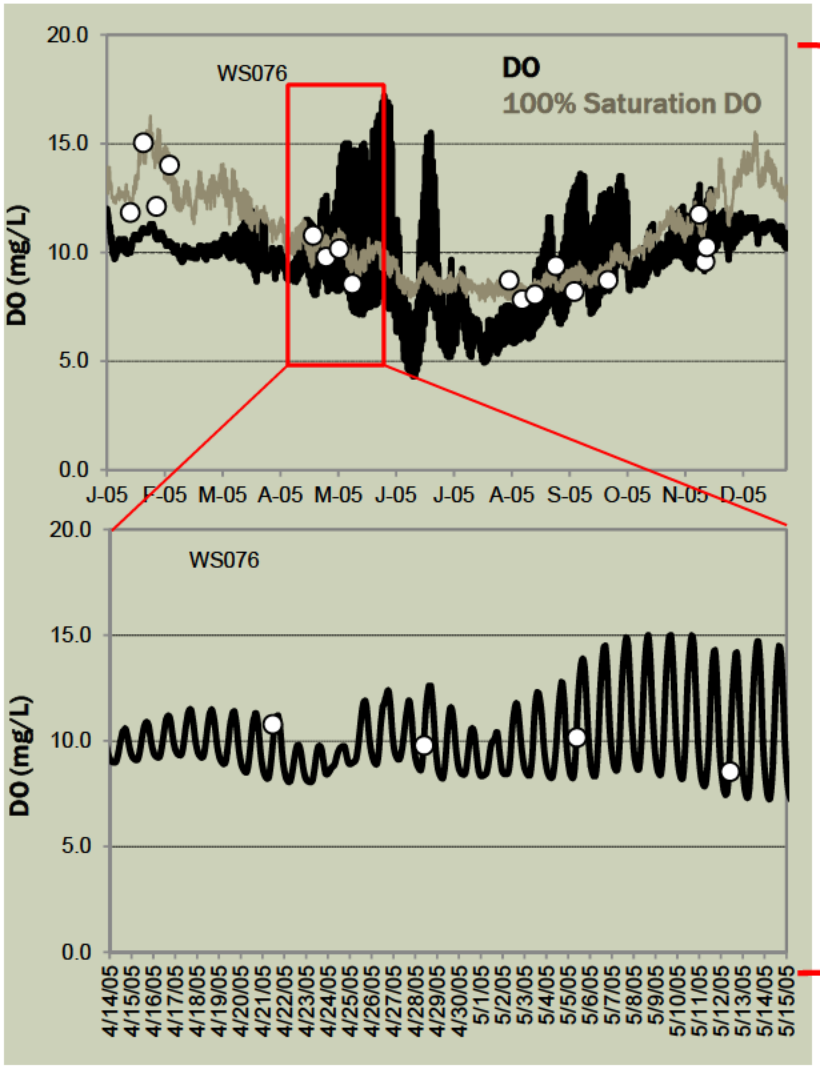

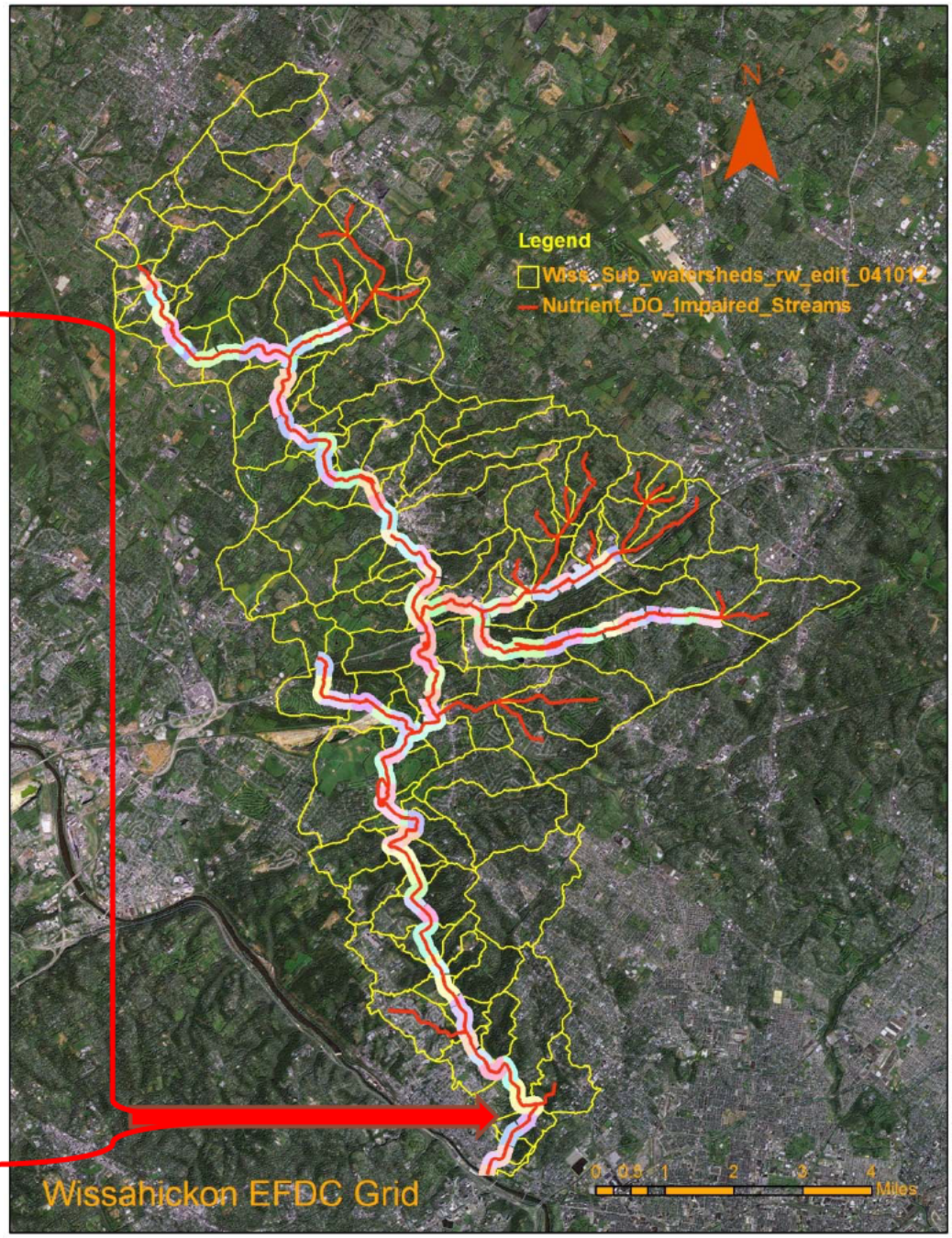

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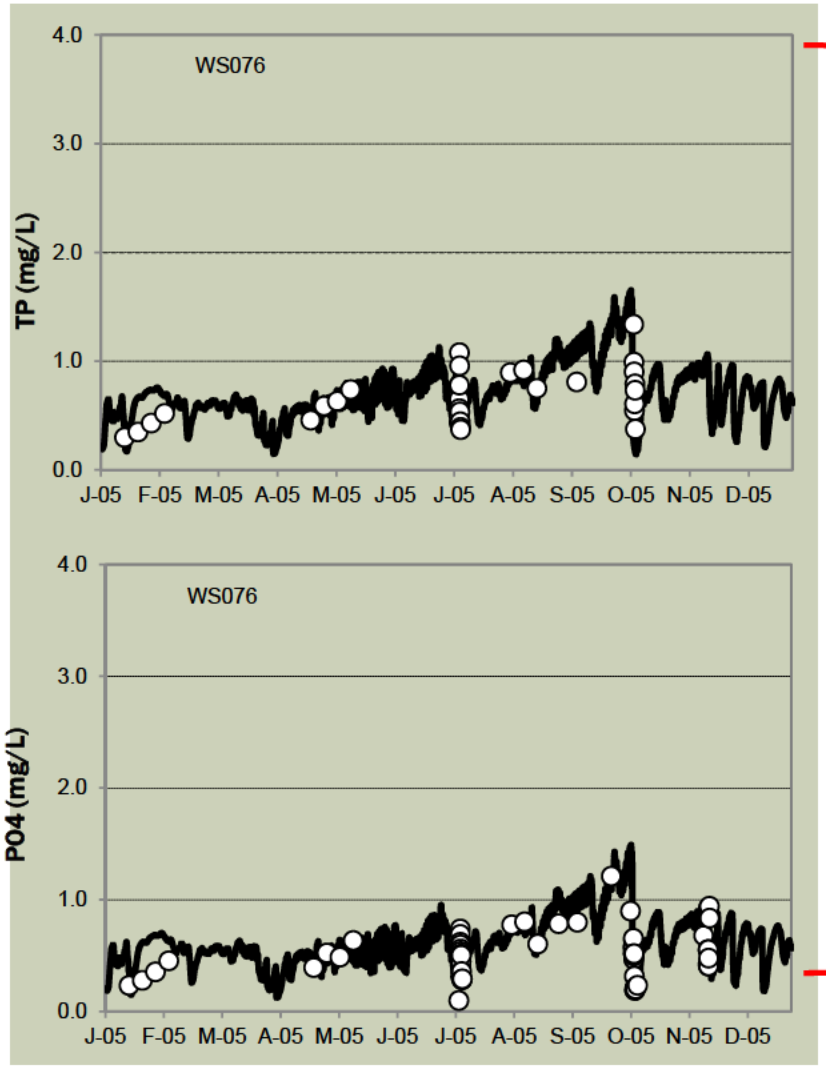
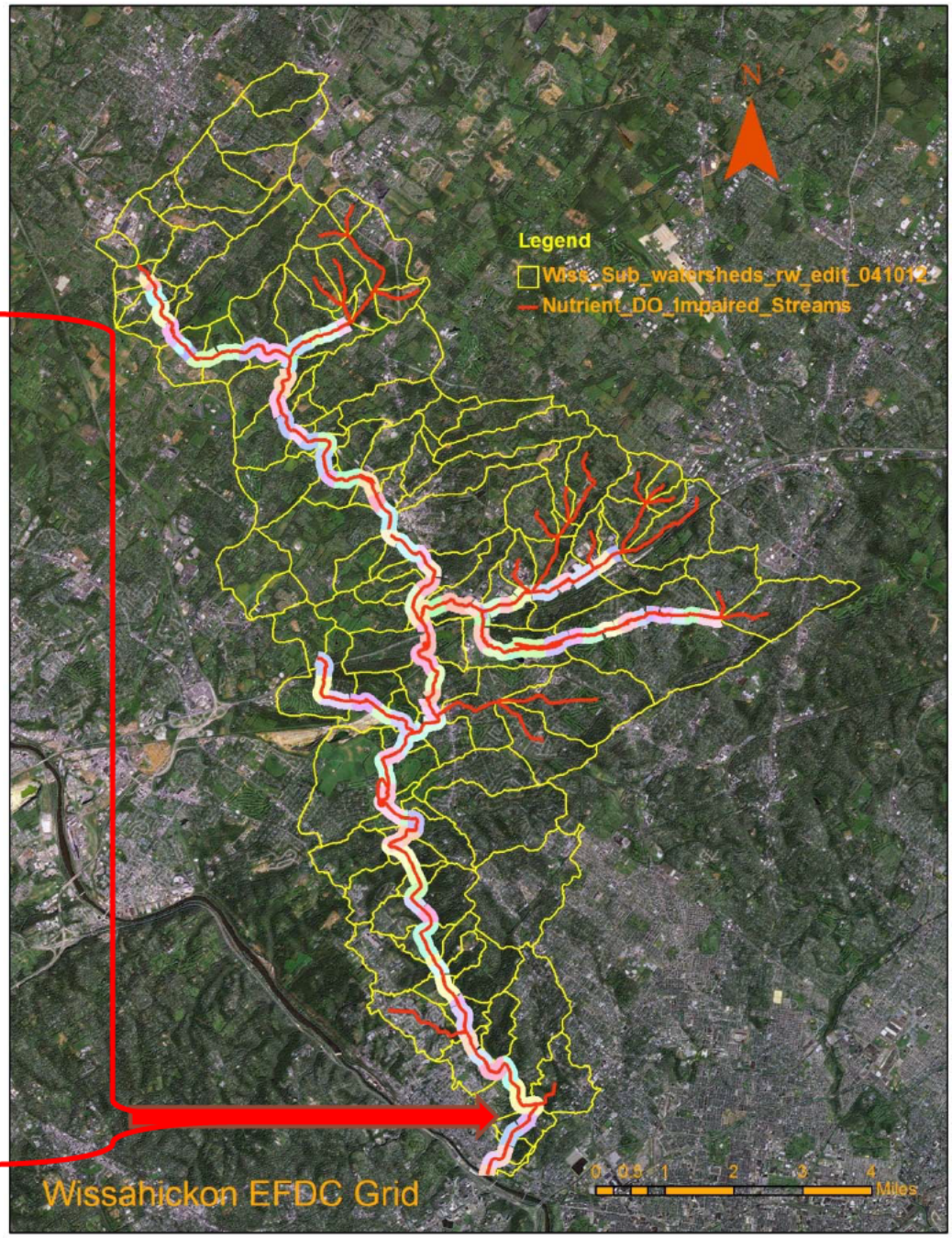
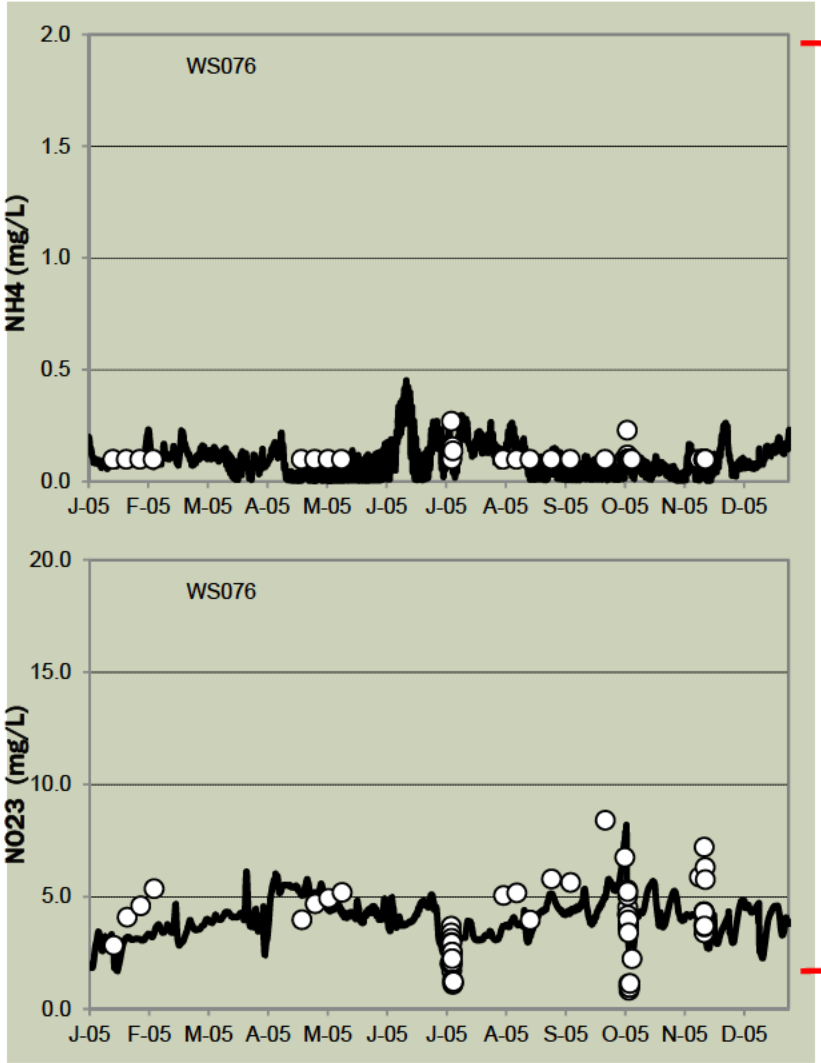
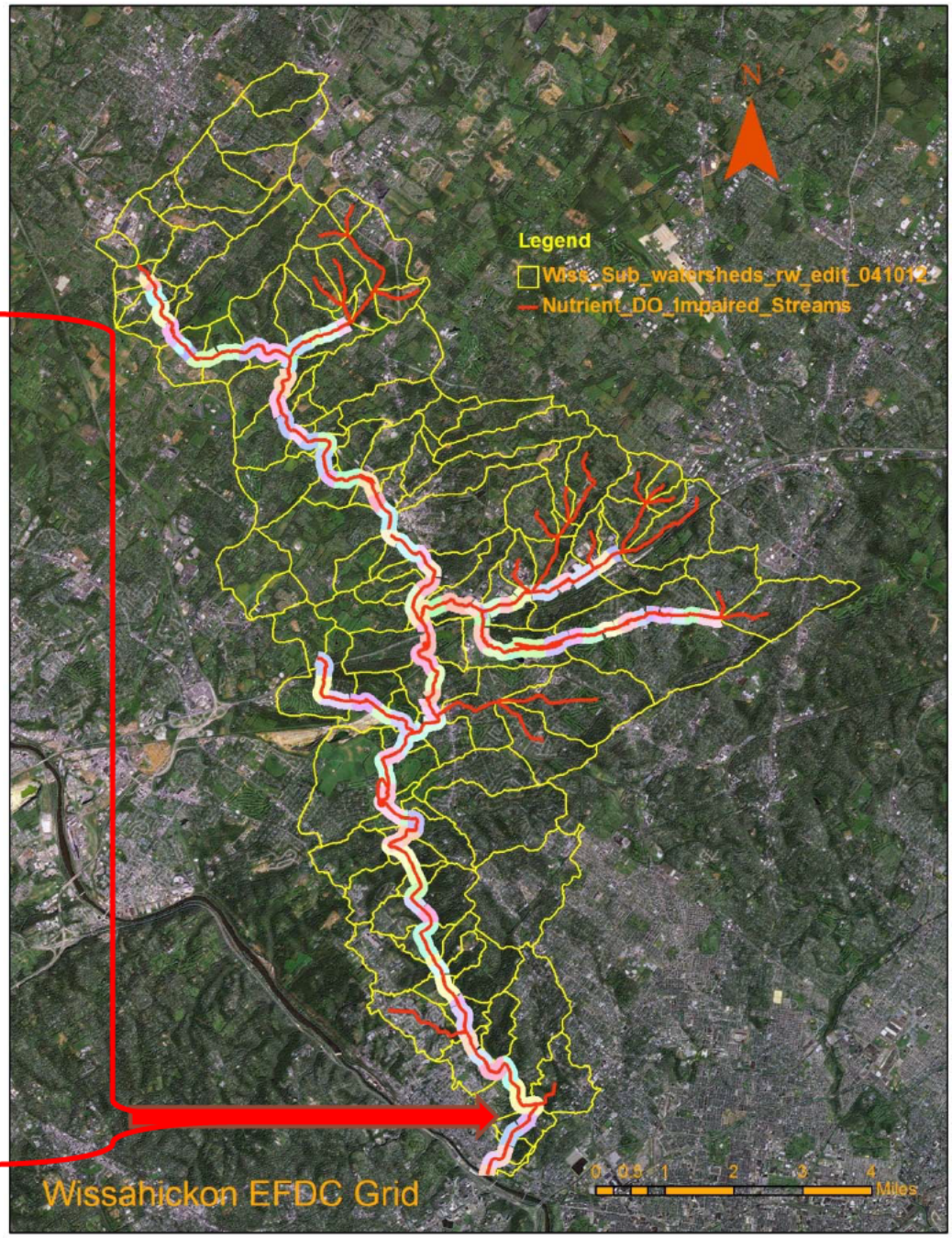




EFDC WQ CALIBRATION





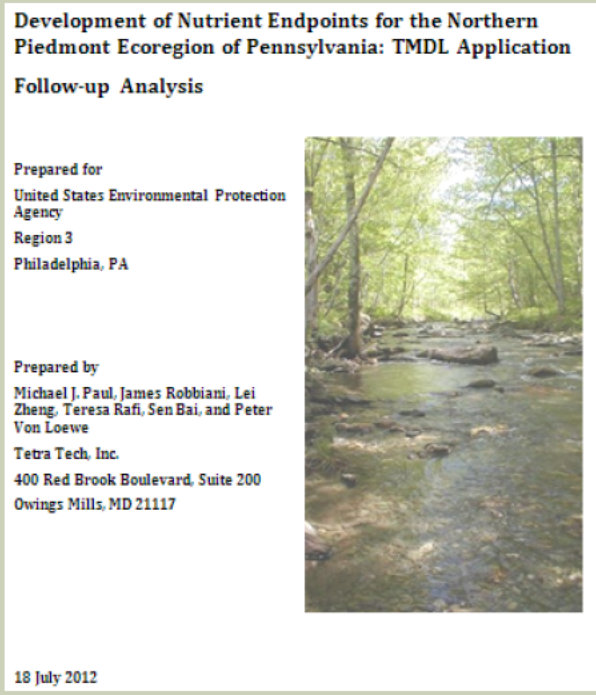
ALLOCATION SCENARIO

ALLOCATION METHODOLOGY

- 2005-2006 chosen as modeling period
- 2005 chosen as calibration period due to rich data monitoring data availability
  - Monitoring data used to calibrate model
  - Good calibration suggests good representation of Wissahickon system in 2005
- 2005-2006 Conditions used to derive allocations
  - Meteorological conditions
  - Land use
  - Discharge volumes and concentrations

ALLOCATION METHODOLOGY

- Allocation Scenario meets the average TP target of 0.04mg/L for the growing season, which is based on 2012 Nutrient Endpoint Guidance for the Northern Piedmont Ecoregion of PA.
- Only TP was reduced to meet the TP target (i.e ammonia, BOD were represented for nutrient dynamics, but were not reduced).
- DO and algal growth were simulated, but not used explicitly as allocation targets.
- Permitted point source discharges, land surface contributions, and septic contributions were reduced to meet the target.



Development of Nutrient Endpoints for the Northern Piedmont Ecoregion of Pennsylvania: TMDL Application

Follow-up Analysis

Prepared for

United States Environmental Protection Agency

Region 3

Philadelphia, PA

Prepared by

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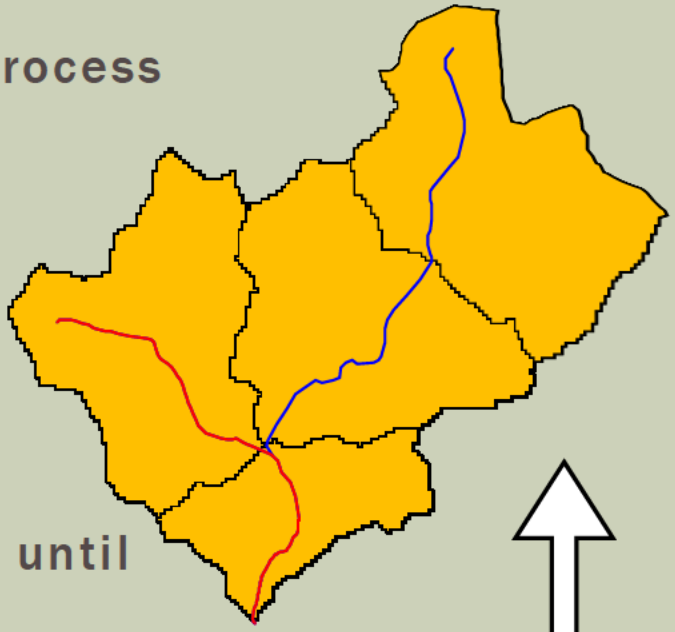
18 July 2012

ALLOCATION METHODOLOGY

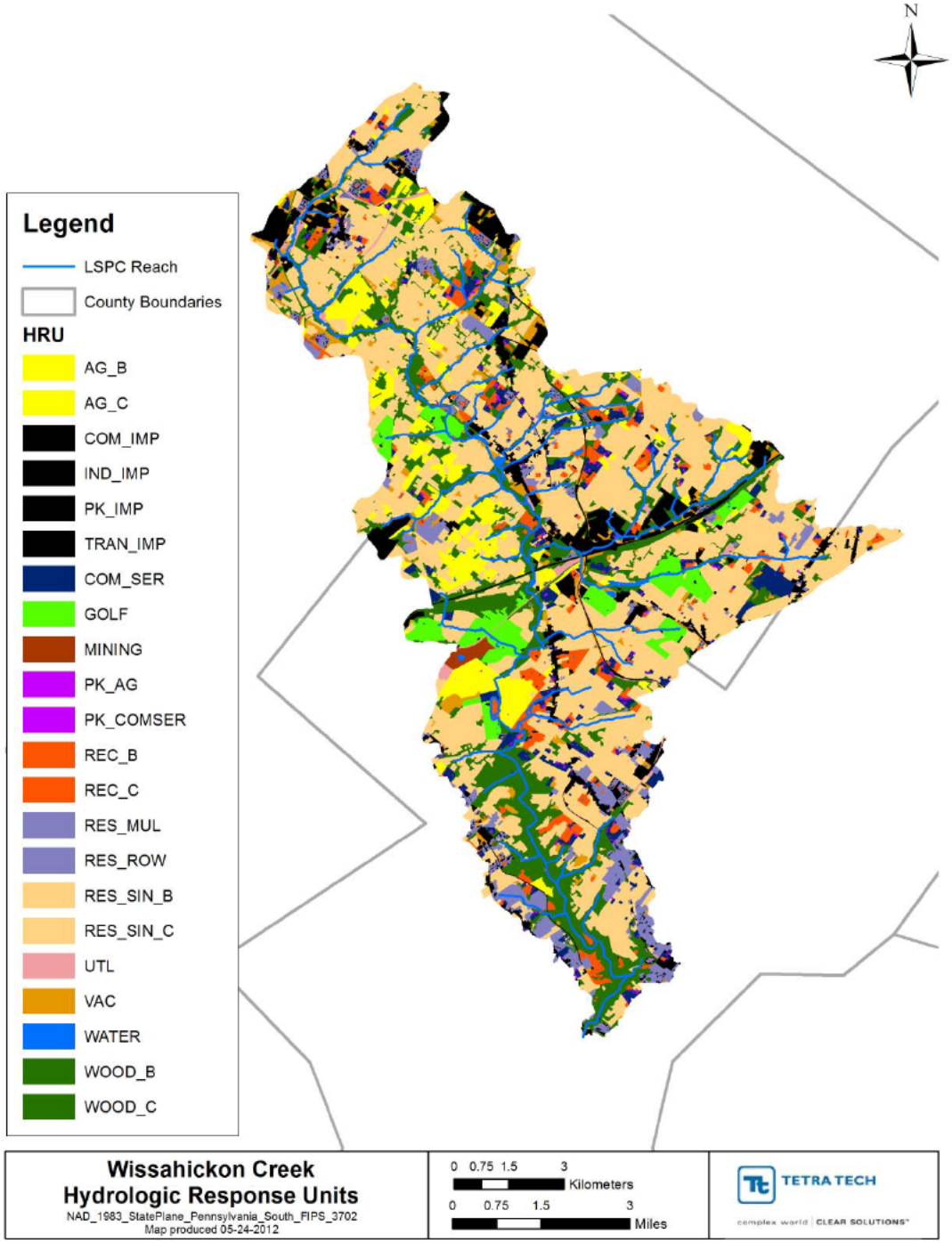
"Top-down" allocation process



- Phosphorus reduced in watershed model until target is met
  - Reduced land surface, interflow, and groundwater contributions by landuse
- LSPC loads applied to EFDC
  - Permitted point source discharges reduced
  - Revisit LSPC land use reductions if target can't be met

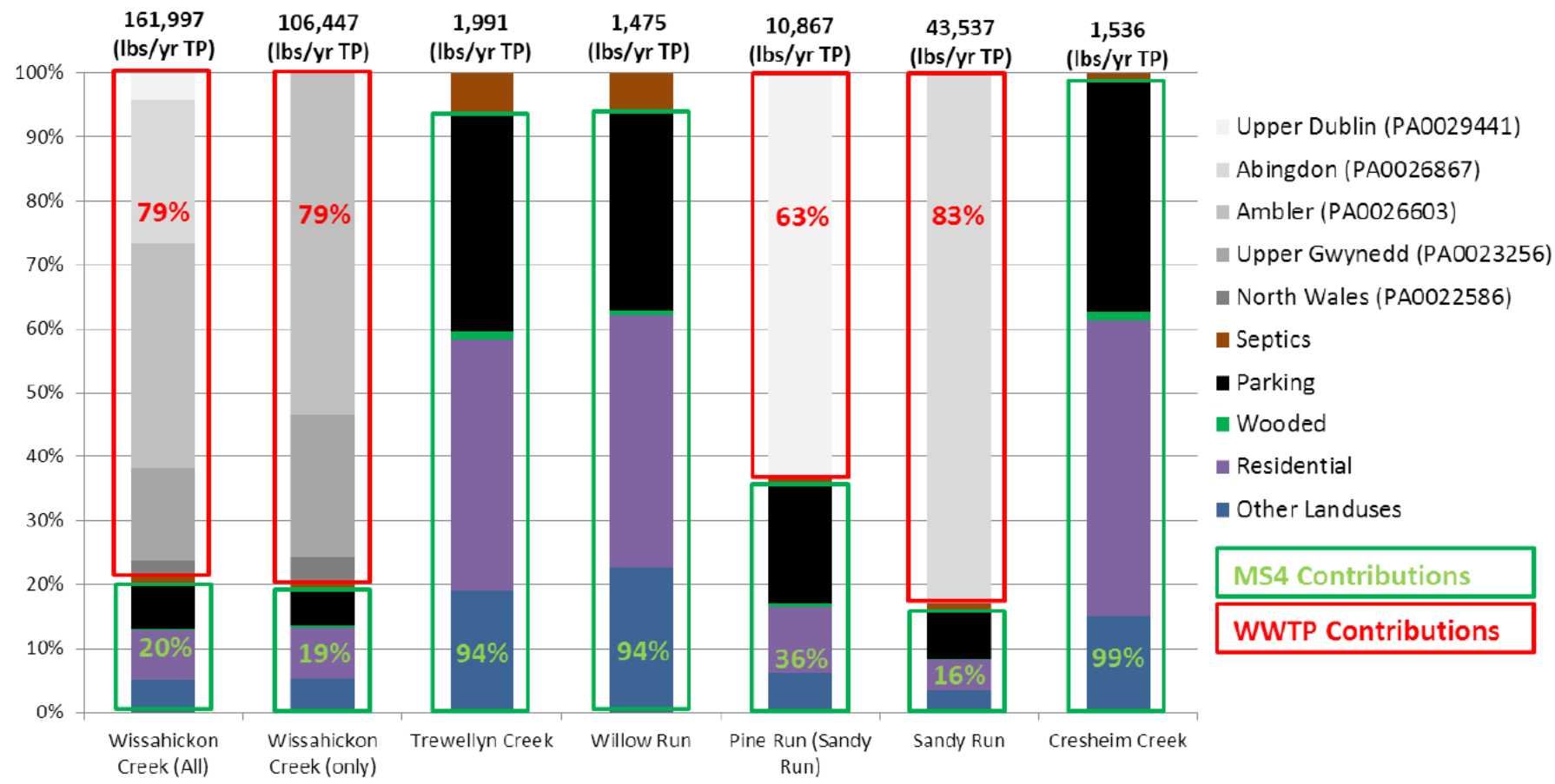
DIFFUSE SOURCES

- Landuse/landcover (all under MS4 jurisdiction)
  - Golf courses
  - Stormwater
  - Agriculture
  - Forested
- Septic Systems



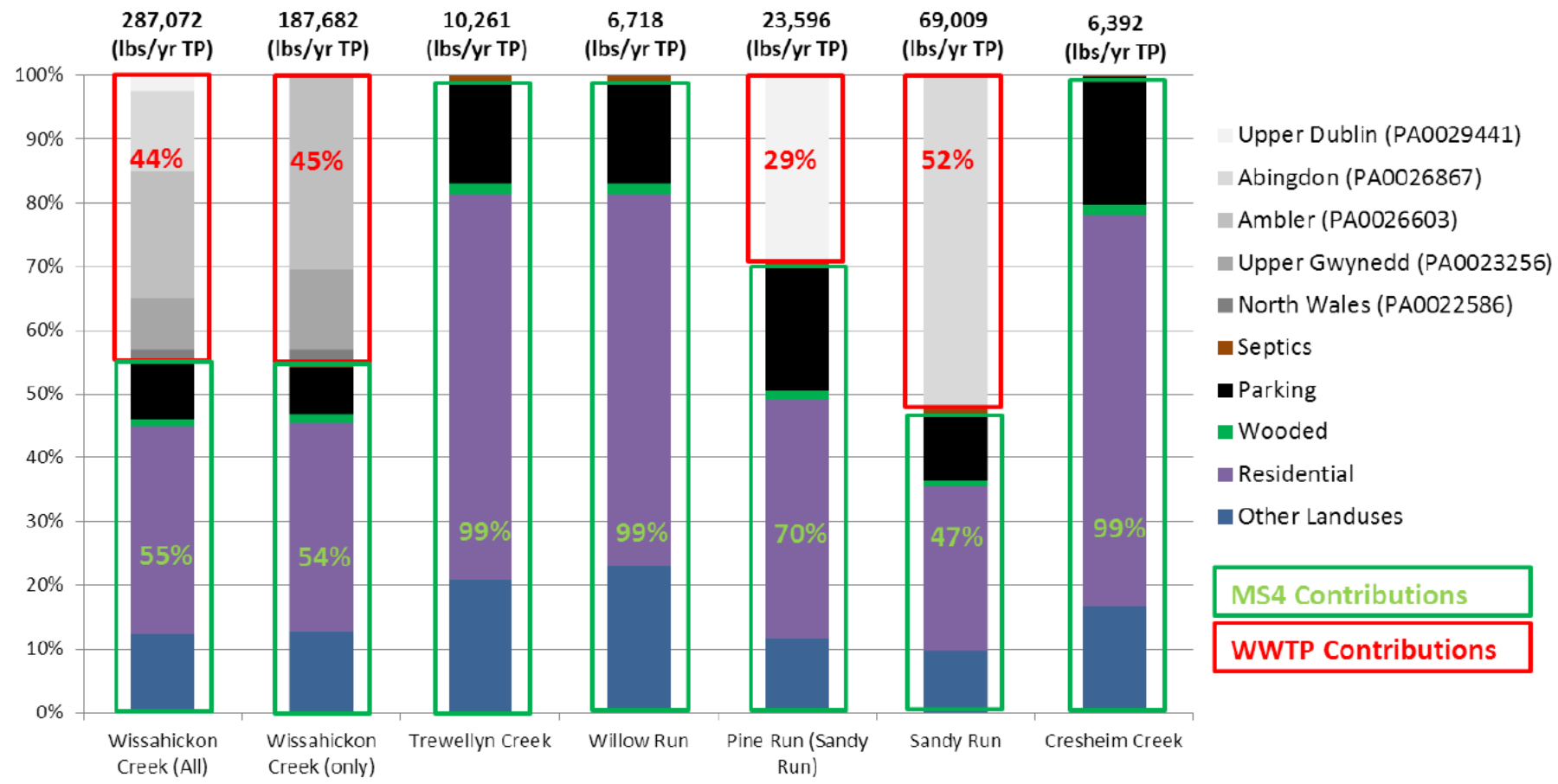
BASELINE LOAD DISTRIBUTION

Example TP Distribution during Low Flow Conditions (May 2005)



BASELINE LOAD DISTRIBUTION

Baseline Phosphorus Load Distribution by Source (2005-2006)



ALLOCATIONS:
PERMITTED FACILITIES

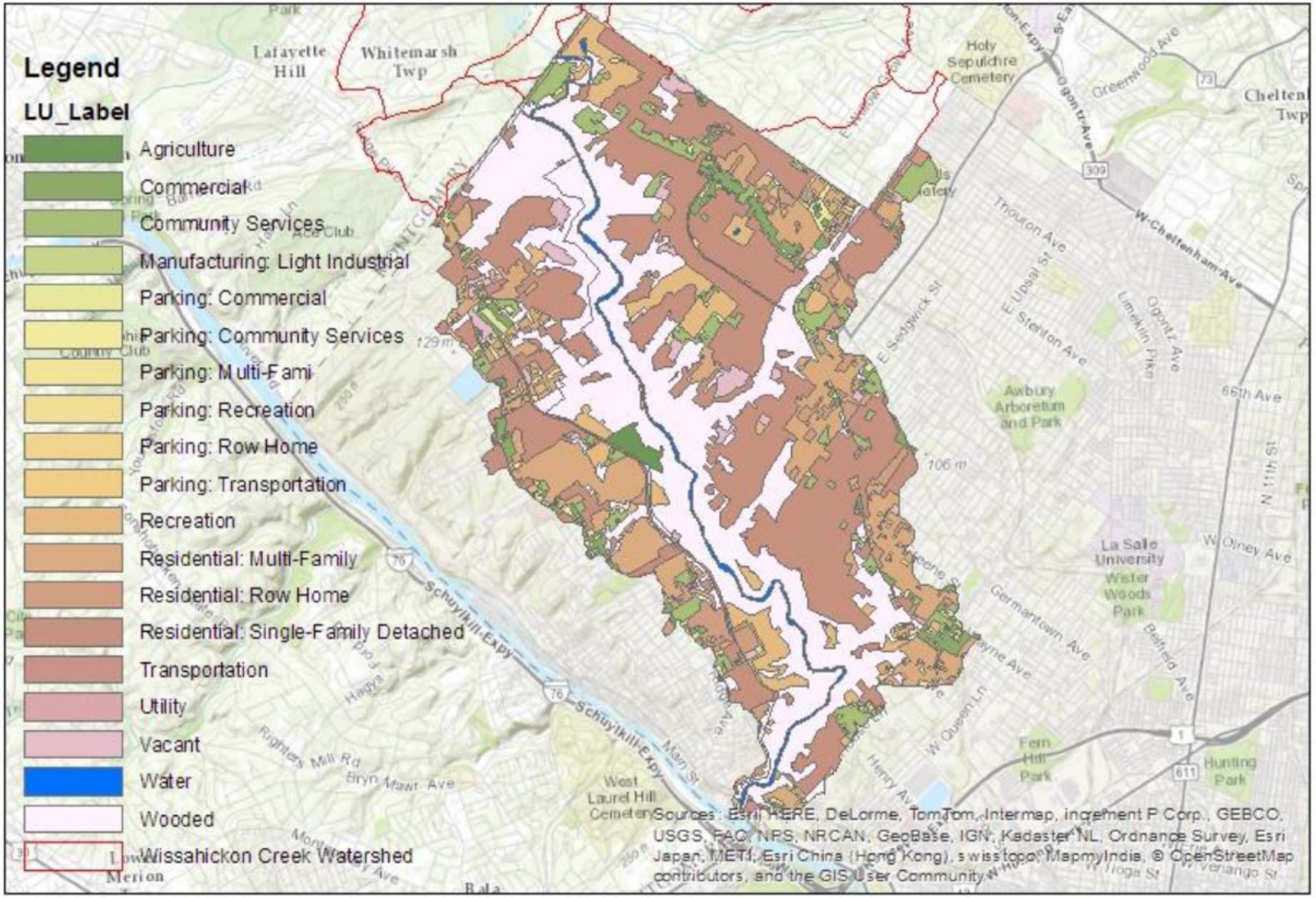
- Permitted dischargers reduced 97-99%
  - DMR data (2005-2006) used as baseline, does not account for improvements made since that time
  - Average baseline concentrations range from 2.73 mg/L TP (Upper Gwynedd) to 4.1 mg/L TP (Ambler)

Facility	Permit Number	Baseline TP Load (lbs/year)	Allocated TP Load (lbs/year)	Percent Reduction (%)
Abington WWTP	PA0026867	45734.00	361.45	99.2
Ambler WWTP	PA0026603	81115.00	798.63	99.0
North Wales WWTP	PA0022586	3976.08	47.71	98.8
Upper Dublin WWTP	PA0029441	9634.00	171.47	98.2
Upper Gwynedd WWTP	PA0023256	47311.00	282.58	99.4

ALLOCATIONS:
MUNICIPAL SEPARATE SEWER SYSTEMS (MS4s)

MS4	Permit Number	Baseline TP Load (lbs/year)	Allocated TP Load (lbs/year)	Percent Reduction (%)
Abington	PAG130012	9574.45	209.60	97.8
Ambler	PAG130036	2707.77	79.37	97.1
Cheltenham	PAG130054	576.99	27.82	95.2
Horsham	PAG130157	563.86	15.28	97.3
Lansdale	PAG130038	1912.30	26.03	98.6
Lower Gwynedd	PAG130072	23505.76	1458.61	93.8
Montgomery	PAG130016	5143.51	119.85	97.7
North Wales	PAG130005	1639.47	27.01	98.4
Philadelphia	PA0054712	24799.61	2404.14	90.3
Springfield	PAG130130	15038.23	641.87	95.7
Upper Dublin	PAG130075	30535.65	1587.65	94.8
Upper Gwynedd	PAG130031	12149.69	458.51	96.2
Upper Moreland	PAG130019	156.50	1.78	98.9
Whitemarsh	PAG130103	16595.84	1373.25	91.7
Whitpain	PAG130137	12295.91	784.40	93.6
Worcester	PAG130026	314.64	9.82	96.9

ALLOCATIONS:
PHILADELPHIA MS4

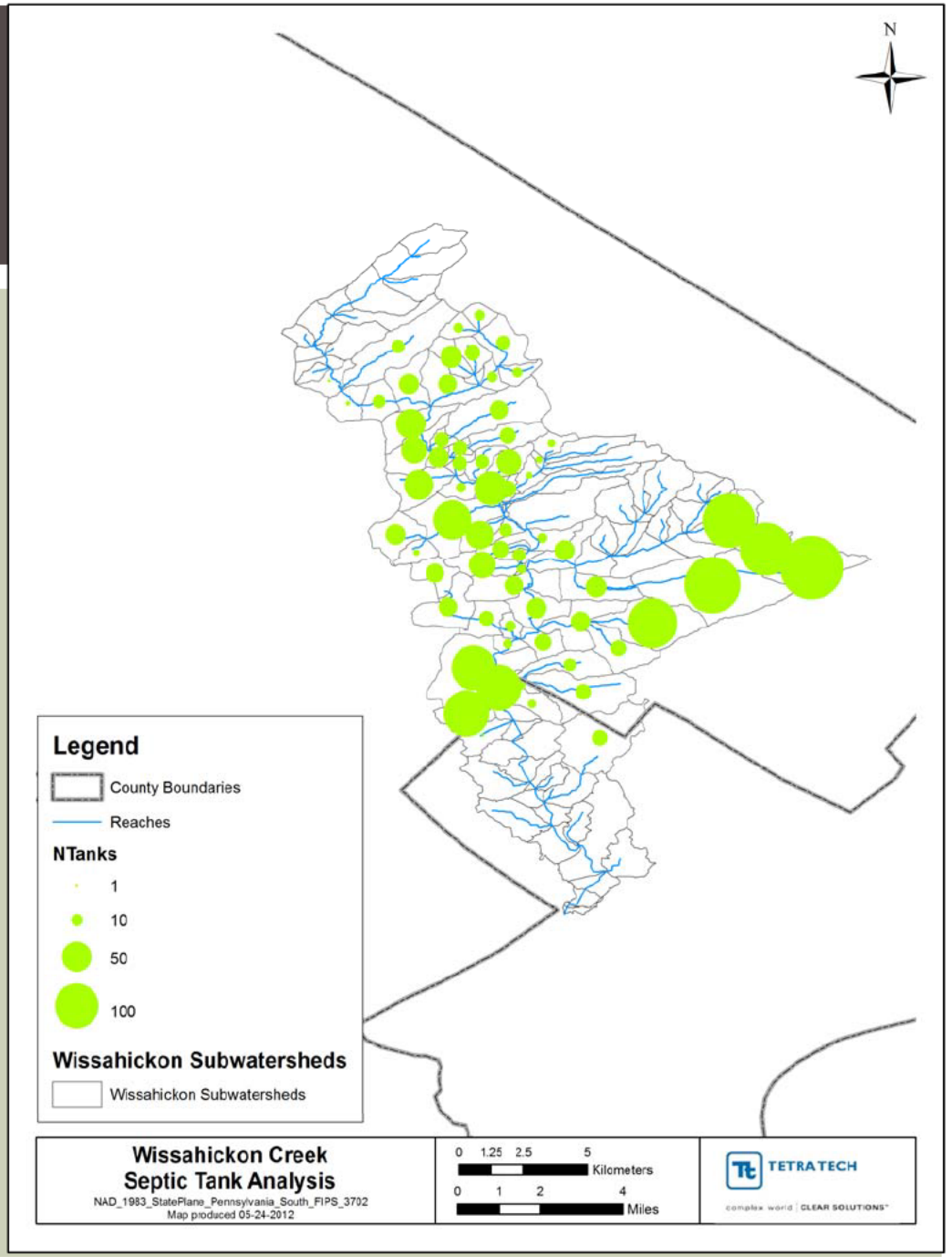


ALLOCATIONS:
PHILADELPHIA MS4

Summarized Land Use Group	Baseline TP Load (lbs/year)	Allocated TP Load (lbs/year)	Percent Reduction (%)
Agriculture	60.41	2.24	96.3
Residential	15391.04	613.22	96.02
Impervious Developed	3964.41	209.53	94.71
Pervious Developed	4053.91	249.31	93.85
Background	1329.84	1329.84	0.0
Total Aggregate MS4 WLA for Philadelphia	**24799.61**	**2404.14**	**90.3**

ALLOCATIONS:
SEPTIC SYSTEMS

- Septics represent <1% of total phosphorus load
- Septics are assumed to be functioning properly
- Septics reduced 88% uniformly
- Baseline load: 6.3lbs/day
- Allocated Load: 0.8lbs/day
- Reductions could be (may already be) addressed by connection to existing sewer system



TMDL

Source Group	Baseline TP Load (lbs/year)	Allocated TP Load (lbs/year)	Percent Reduction
Point Sources: WWTP	187,770.08	1,661.84	99.1
Point Sources: MS4	157,510.18	9,224.99	94.1
Nonpoint Sources	2,289.11	274.69	88.0
Total	**347,569.37**	**11,161.52**	**96.8**