Development of DO and Bacterial TMDLs of Little Mosquito, Assawoman, and Nassawadox Creeks along Virginia's Eastern Shore

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Public Meeting
June 23, 2015

Virginia Department of Environmental Quality

William & Mary VIMS

Why We Are Here

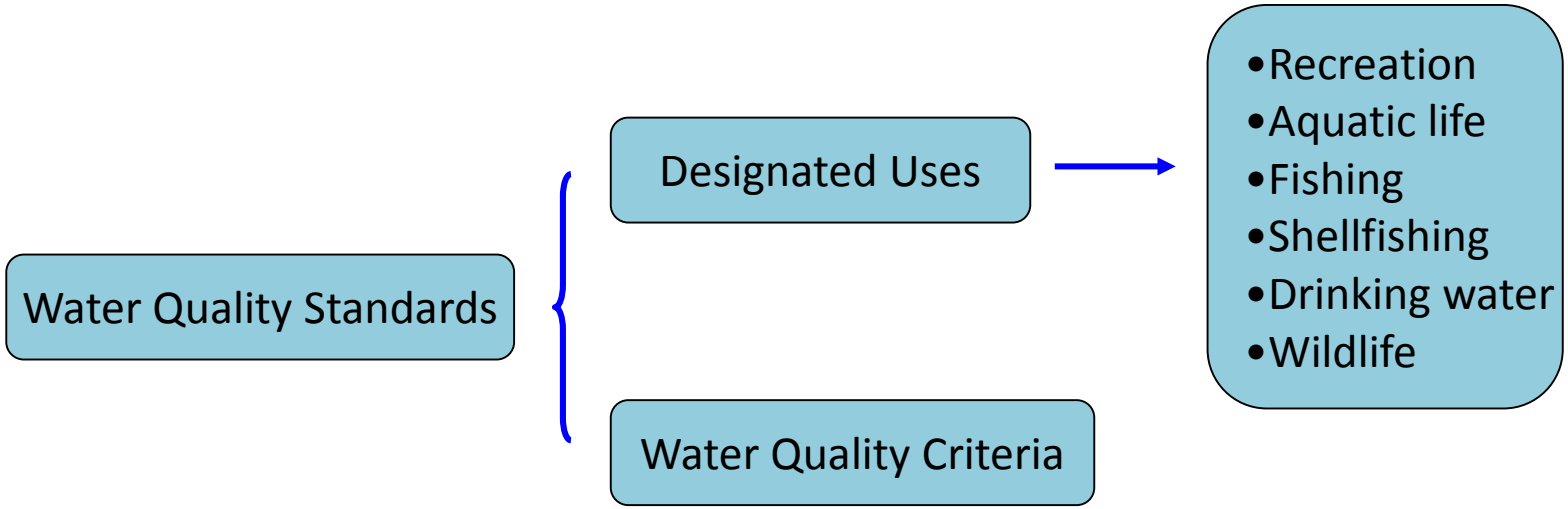
1. To learn about water quality of these creeks
2. To discuss the Total Maximum Daily Load (TMDL) development
3. To gather comments and encourage public participation

Outline

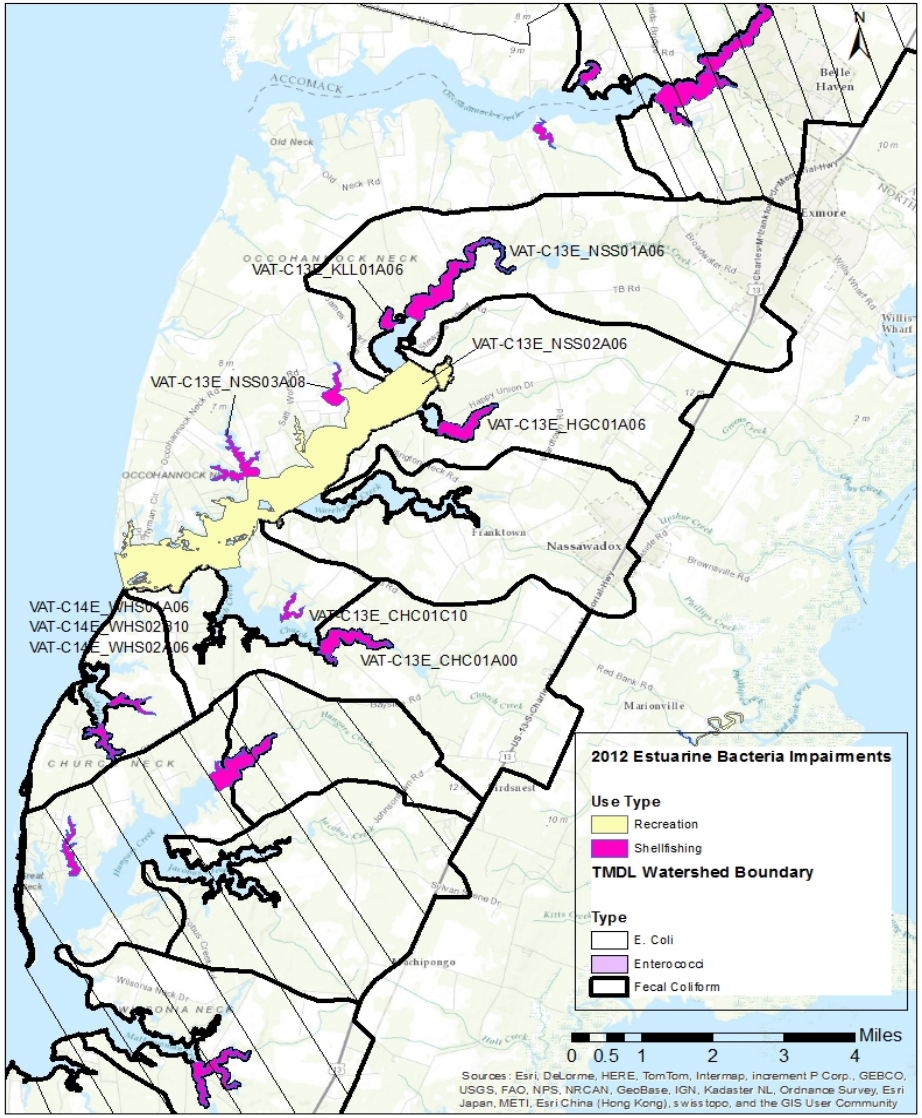
- The TMDL process
- Impaired waters and pollutants
- Procedures of pollutant source assessment
- Developed modeling approach
- Comments

The TMDL Process

- DEQ routinely monitors the quality of waters across the state and publishes a list of impaired waters every 2 years
- Virginia is required by law to establish a TMDL for each pollutant causing an impairment
- A TMDL is the amount of a particular pollutant that a stream can receive and still meet Water Quality Standards



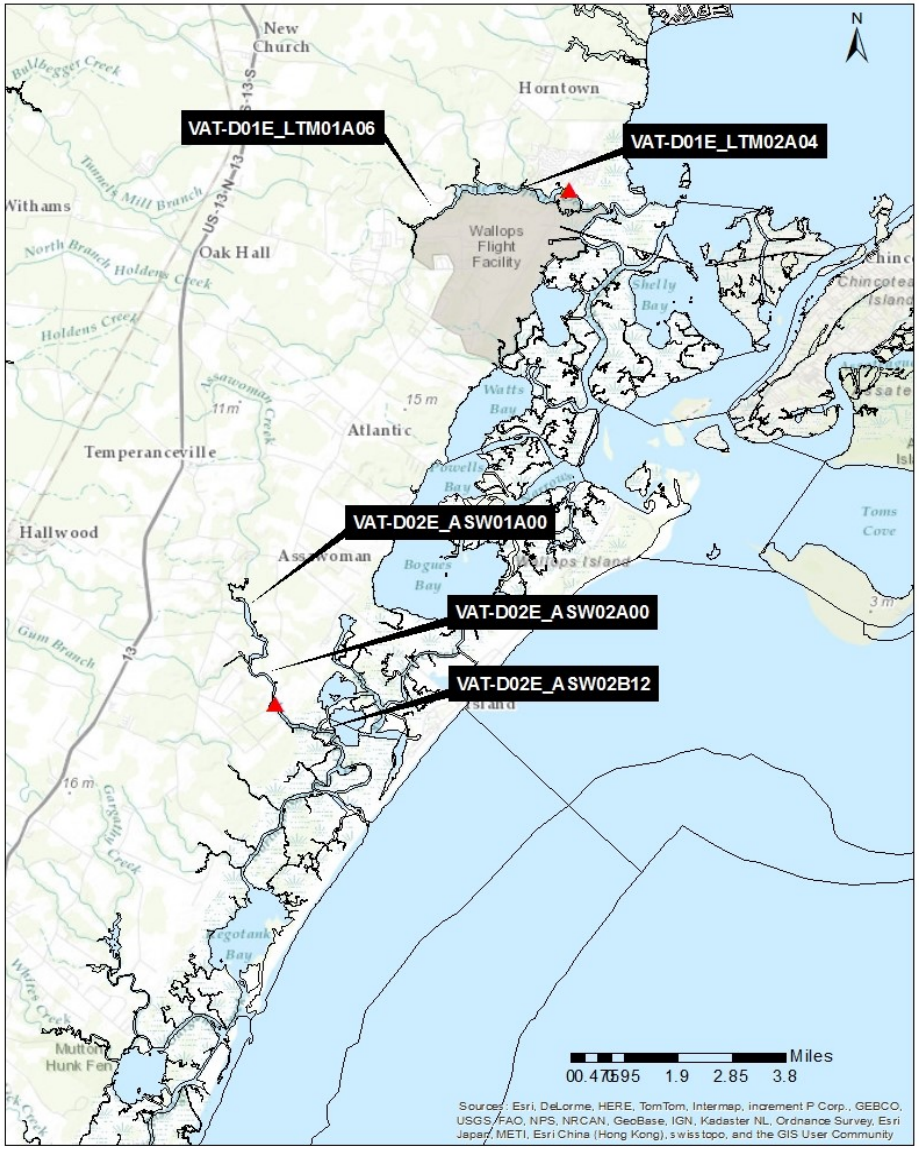
Impaired Waters of Nassawadox



Impaired Waters of Nassawadox

Assessment Unit	Water Name	Location Description	Cause Category	Cause Name	Size (miles^2)
1 VAT-C13E_ CHC01A00	Church Creek - Upper	In area of Elliotts Neck. Tributary to Nassawadox Creek. Portion of CBP segment CB7PH. DSS shellfish direct harvesting condemnation # 085-185 B (effective 20100629).	5A	Fecal Coliform	0.100
2 VAT-C13E_ CHC01C10	Church Creek - Middle	In area of Elliotts Neck. Tributary to Church Creek - Middle, UT North Cove. Portion of CBP segment CB7PH. DSS shellfish harvesting condemnation # 085-185 A	5A	Fecal Coliform	0.026
3 VAT-C13E_ HGC01A06	Holly Grove Cove- Upper	Located near Wellington Neck. From end of tidal waters downstream to end of DSS Condemnation. Portion of CBP segment CB7PH. DSS shellfish direct.	5A	Fecal Coliform	0.082
4 VAT-C13E_ KLL01A06	Kelley Cove	From end of tidal waters downstream to confluence with Nassawadox Cr. (area of TMDL-bact 6/07). Portion of CBP segment CB7PH. Portion of DSS shellfish	5A	Fecal Coliform	0.026
5 VAT-C13E_ NSS01A06	Nassawadox Creek – Upper	From end of tidal waters downstream to confluence with Kelly Cove (RM 5.2) area of TMDL-bact 6/07. Portion of CBP segment CB7PH. Portion of DSS shellfish direct harvesting condemnation # 085-110 D (effective 20100629).	5A	Fecal Coliform	0.178
6 VAT-C13E_ NSS02A06	Nassawadox Creek – Lower	Mainstem of lower portion of creek to mouth. Portion of CBP segment CB7PH. DSS (OPEN) shellfish direct harvesting condemnation # 085-110 & 085-185	5A	Enterococcus	2.070
7 VAT-C13E_ NSS03A08	Nassawadox Creek – Middle, N. Shore Tribs.	Mainstem of lower portion of creek to mouth. Portion of CBP segment CB7PH. DSS (OPEN) shellfish direct harvesting condemnation # 085-110 & 085-185 (effective 20100629).	5A	Fecal Coliform	0.140
8 VAT-C13E_ WHS02A06	Westerhouse Creek - Upper South Branch	In Church Neck area, west of Bridgetown. Upper portion of Westerhouse Creek South Branch. Portion of CBP segment CB7PH. Portion DSS shellfish direct	5A	Fecal Coliform	0.034
9 VAT-C13E_ WHS02B10	Westerhouse Creek - Middle Upper	In Church Neck area, west of Bridgetown. Upper portion of Westerhouse Creek South Branch. Portion of CBP segment CB7PH. Portion DSS shellfish direct	5A	Fecal Coliform	0.003
10 VAT-C13E_ WHS01A06	Westerhouse Creek - North Branch	In Church Neck area, west of Bridgetown. Portion of CBP segment CB7PH. DSS shellfish direct harvesting condemnation # 085-199 A (20070605).	5A	Fecal Coliform	0.033

Impaired Waters of Little Mosquito and Assawoman



Impaired Waters of Little Mosquito and Assawoman

Assessment Unit	Water Name	Location Description	Cause Category	Cause Name	Size (miles^2)
1 VAT-D01E_ LTM01A06	Little Mosquito Creek - Upper	From headwaters downstream to confluence of Snead Branch. Area of DSS Prohibited (ADMINISTRATIVE-due to VPDES outfall @ VA0024457) condemnation 100-032 B (effective 2010-11-08).	5A	Dissolved Oxygen	0.07
2 VAT-D01E_ LTM02A04	Little Mosquito Creek - Lower	South shore trib. to mainstem Back R. Adjacent to Fox Hill area. DSS shellfish condemnation # 054-215 A (effective 20101115). CBP Segment MOBPH.	5A	Dissolved Oxygen	0.14
3 VAT-D02E_ ASW01A00	Assawoman Creek - Upper	From headwaters downstream to confluence of Pettit Branch (RM 3.4). Portion of DSS shellfish direct harvesting condemnation # 099-135A (effective 2005-12-12).	5A	Dissolved Oxygen	0.07
4 VAT-D02E_ ASW02A00	Assawoman Creek - Lower	From confluence of Pettit Branch downstream to end of Shellfish Condemnation. Portion of DSS shellfish direct harvesting condemnation # 099-135 (effective date 2009-10-22).	5A	Dissolved Oxygen	0.05
5 VAT-D02E_ ASW02B12	Assawoman Creek - Lower	From end of condemnation to mouth. Portion of DSS shellfish direct harvesting condemnation # OPEN 099-135 (effective date 2009-10-22).	5A	Dissolved Oxygen	0.01

Water Quality Criteria

Water Type	Use	Name	Criteria
Class II (tidal water) Class III (freshwater)	Shellfish	Fecal coliform	Geomean 14 counts/100ml 90th percentile: 49 counts/100ml using MPN or 31 counts/100ml using mTEC method
	Recreation	E. Coli (freshwater)	Geomean 126 counts/100ml Single Sample Max. 235 counts/100ml
		Enterococci (salt water)	Geomean 35 counts/100ml Single Sample Max. 104 counts/100ml

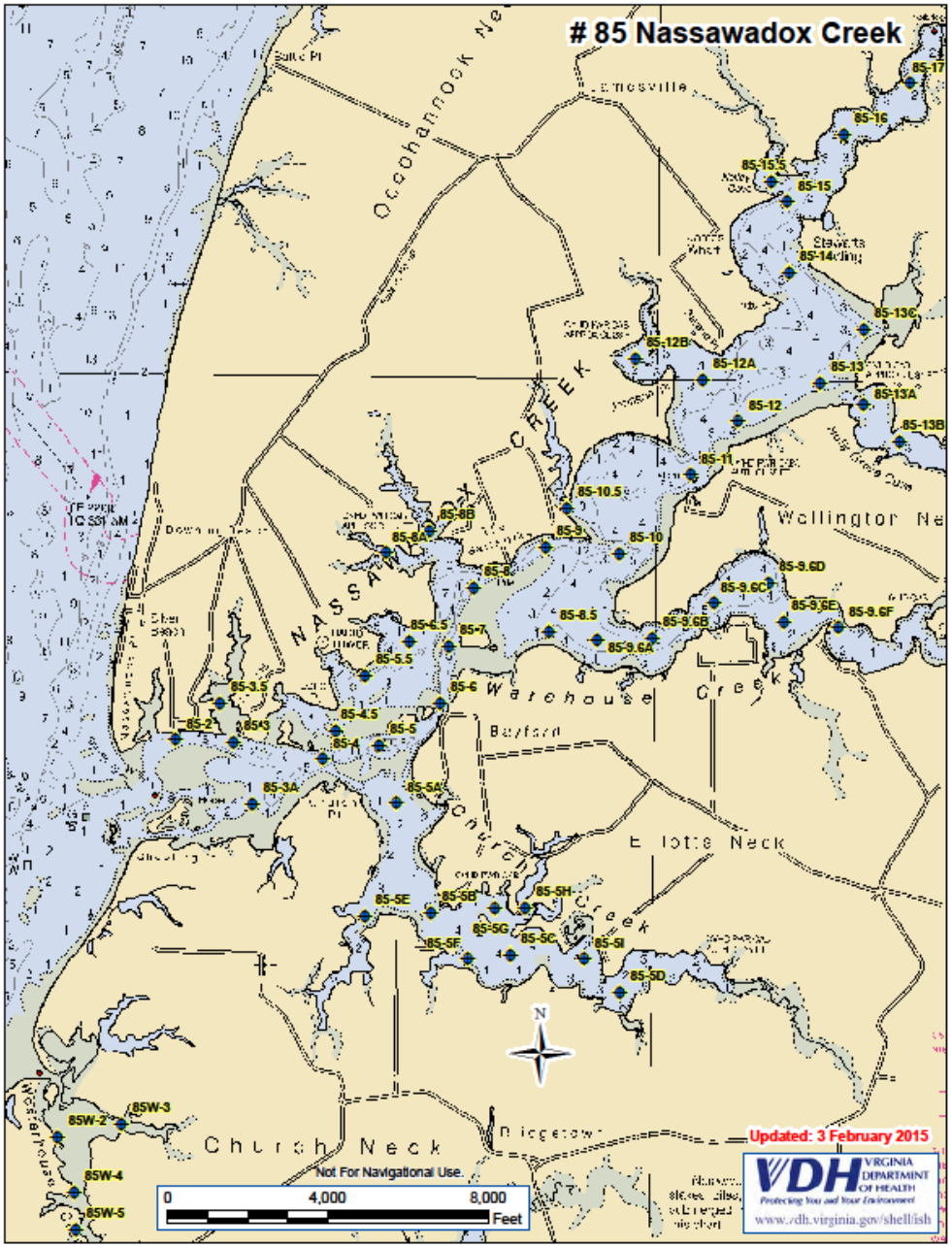
mTEC Method and New FC Criteria

- Since 2008 VDH-DSS has used the new mTEC direct plate counting method to measure fecal coliform concentrations instead of the MPN method. The new method reduces statistical uncertainty and provides a more accurate measurement of bacterial concentrations. Therefore, the 90th percentile criterion that we will be using is 31 cfu/100ml.

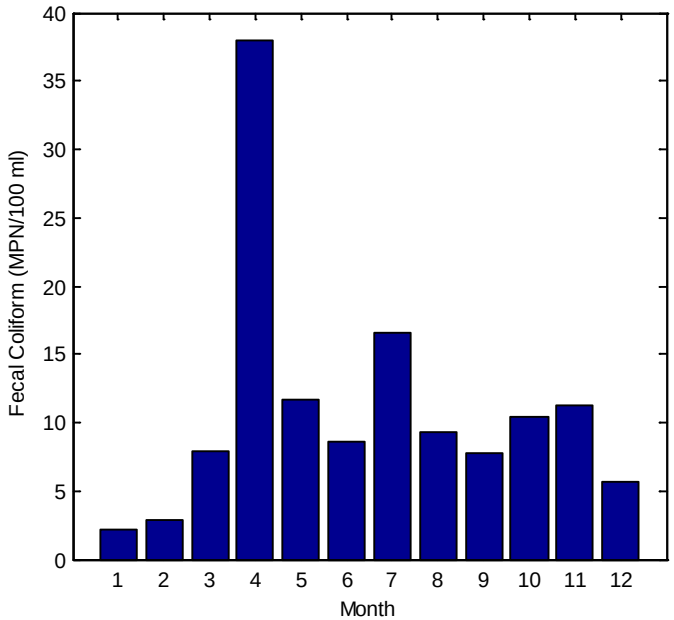
Water Quality Criteria

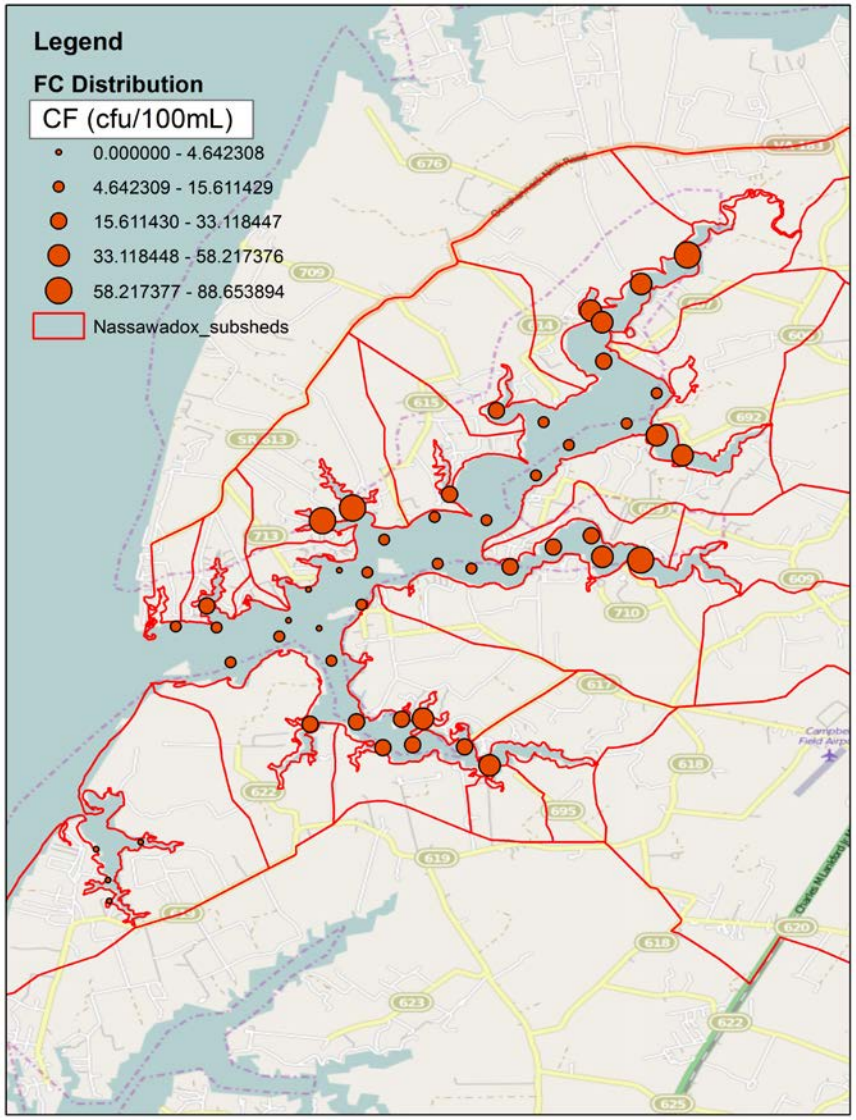
- Dissolved Oxygen Criteria (9VAC25-260-50)
  - Minimum of 4.0 mg/L
  - Daily average 5.0 mg/L

Observation Stations for Bacteria (VDH)



Distribution of Mean FC Concentration

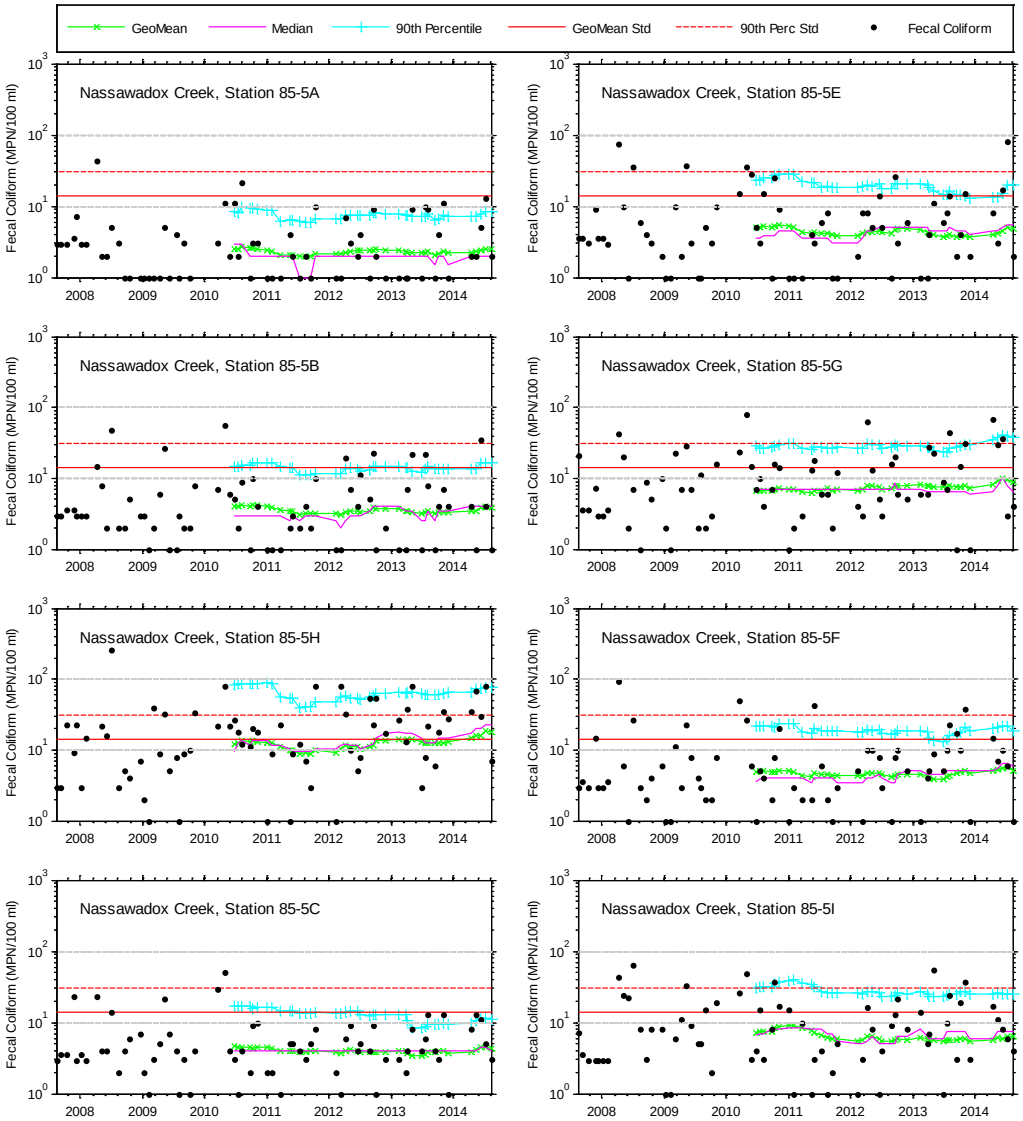


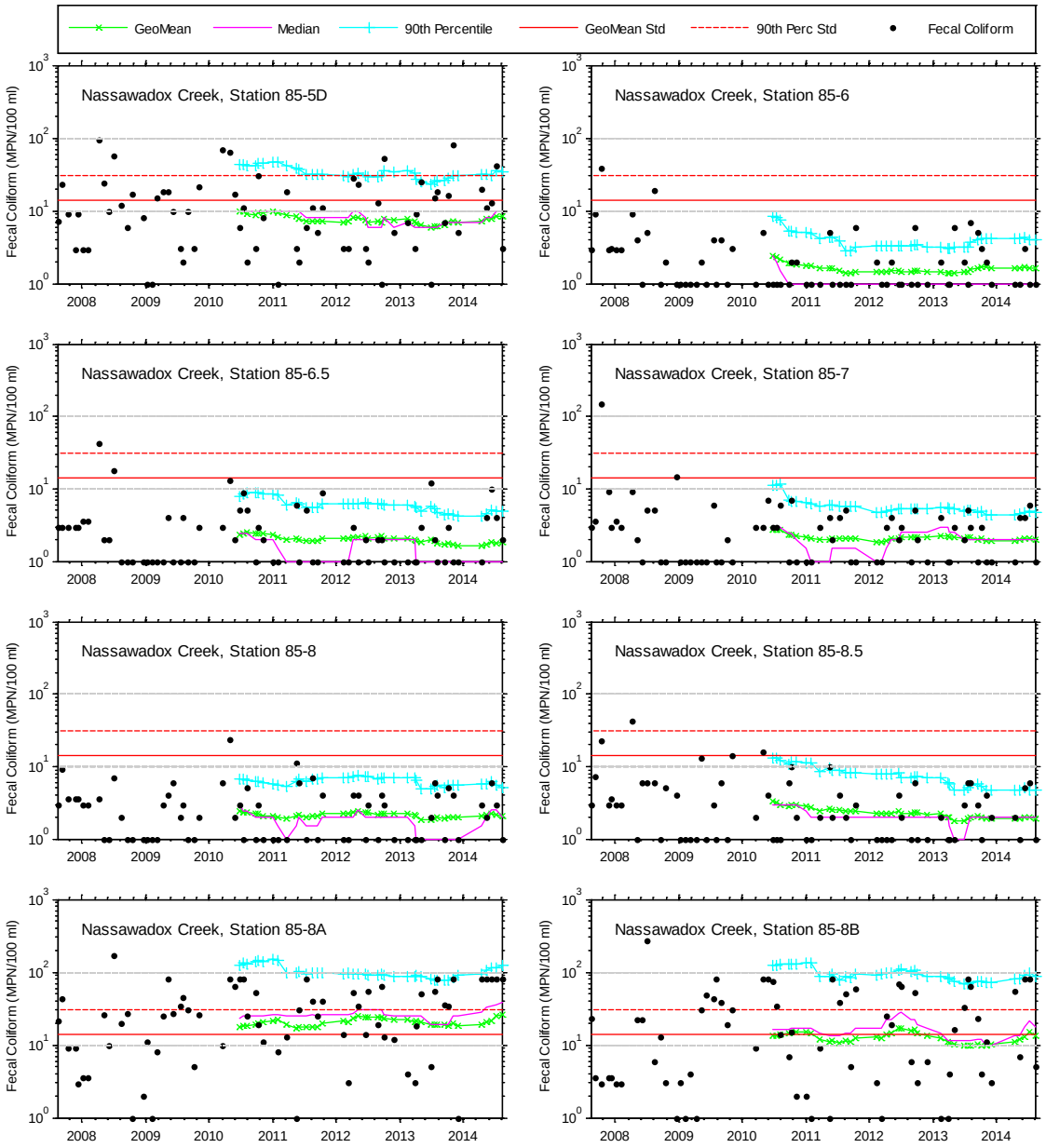


Examples of Violation Assessment

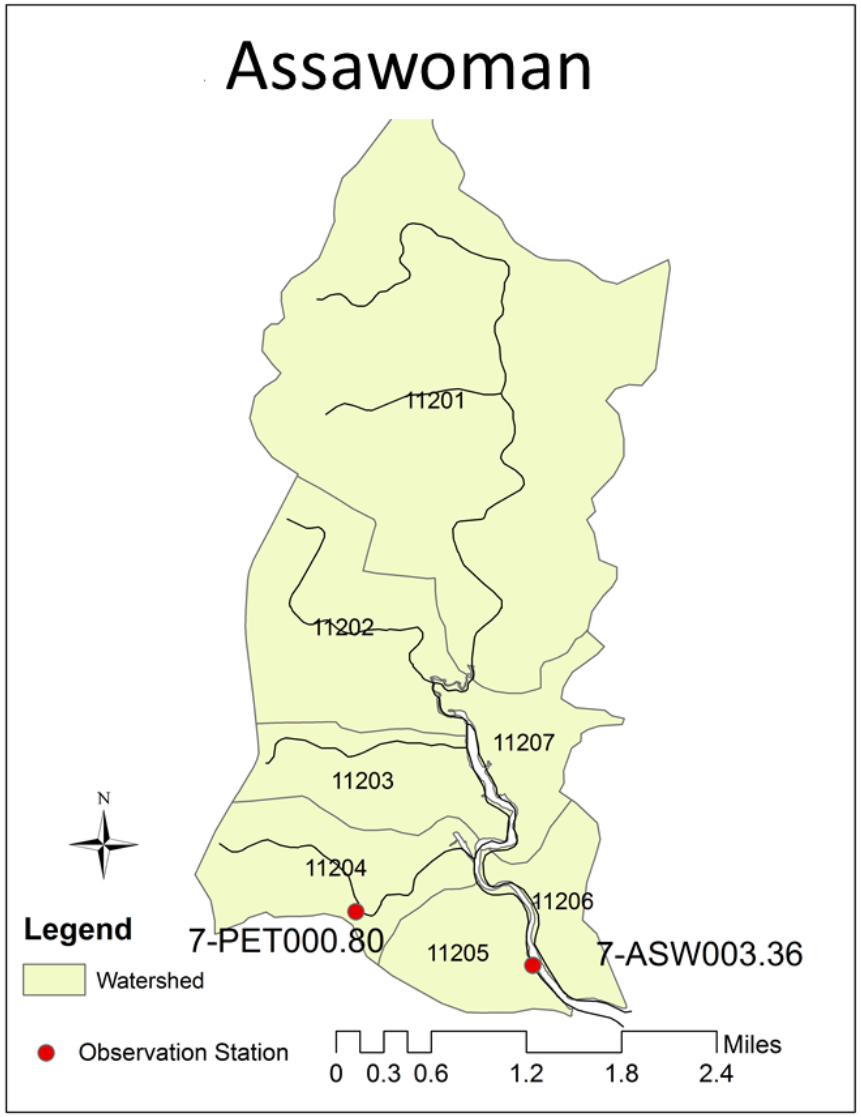
The mTEC method has been used to measure fecal coliform since 2008

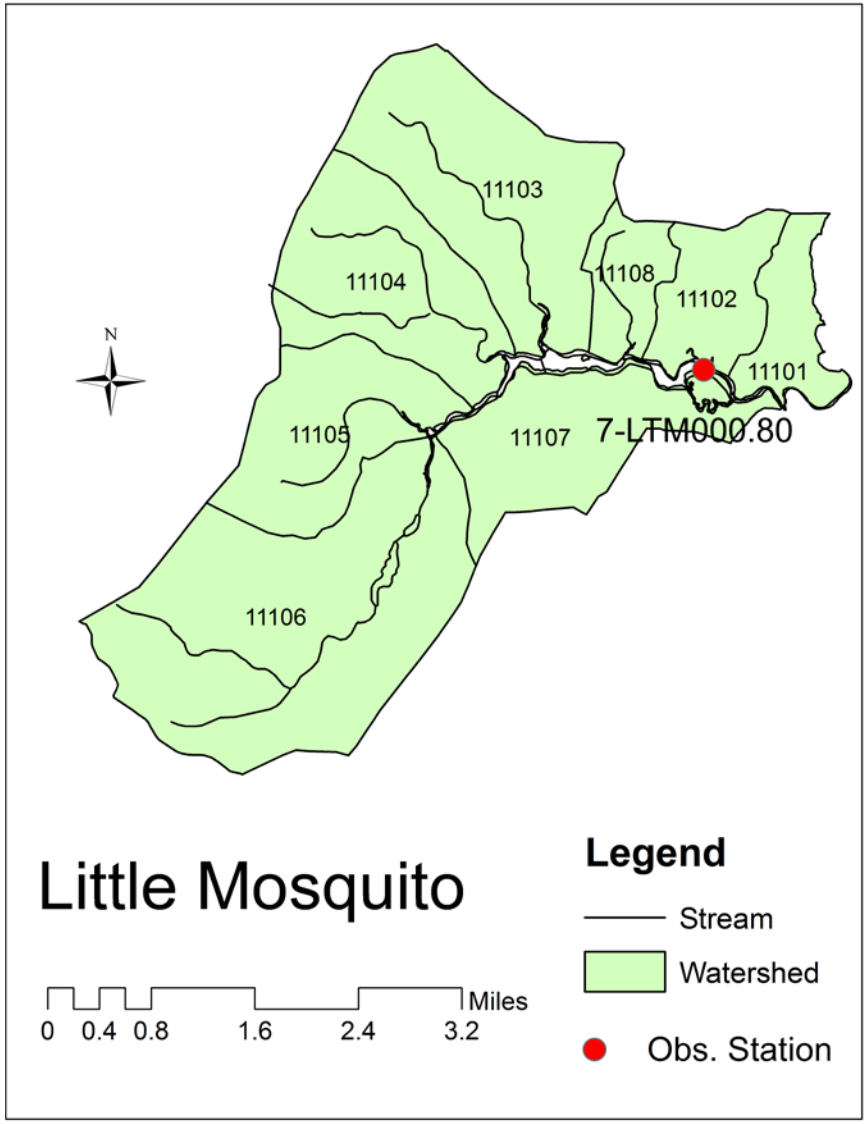
The new criterion of 31 is used for assessing the attainment of the 90th percentile for the existing condition



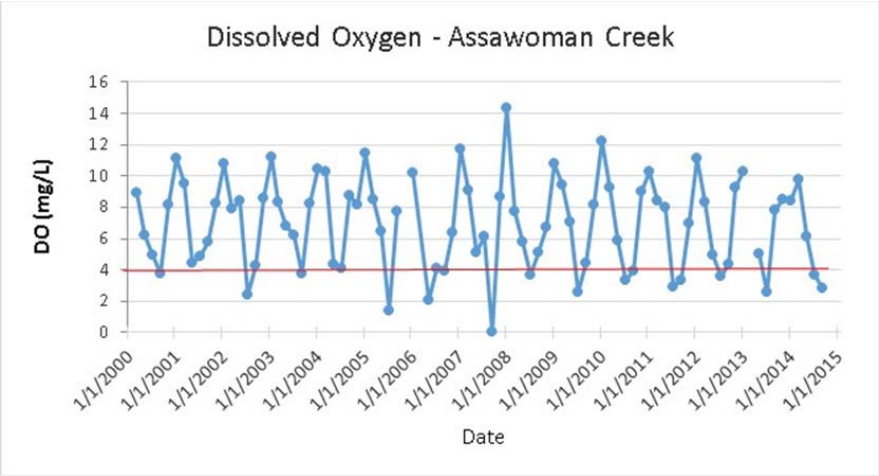

GeoMean
Median
90th Percentile
GeoMean Std
90th Perc Std
Fecal Coliform
Nassawadox Creek, Station 85-5D
Nassawadox Creek, Station 85-6
Nassawadox Creek, Station 85-6.5
Nassawadox Creek, Station 85-7
Nassawadox Creek, Station 85-8
Nassawadox Creek, Station 85-8.5
Nassawadox Creek, Station 85-8A
Nassawadox Creek, Station 85-8B
Fecal Coliform (MPN/100 ml)
10^0
10^1
10^2
10^3
2008
2009
2010
2011
2012
2013
2014

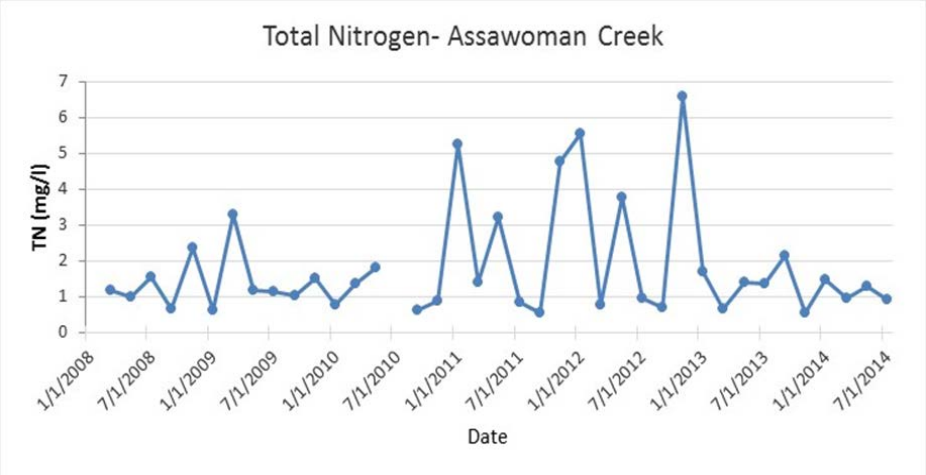
Observation Stations (DEQ)

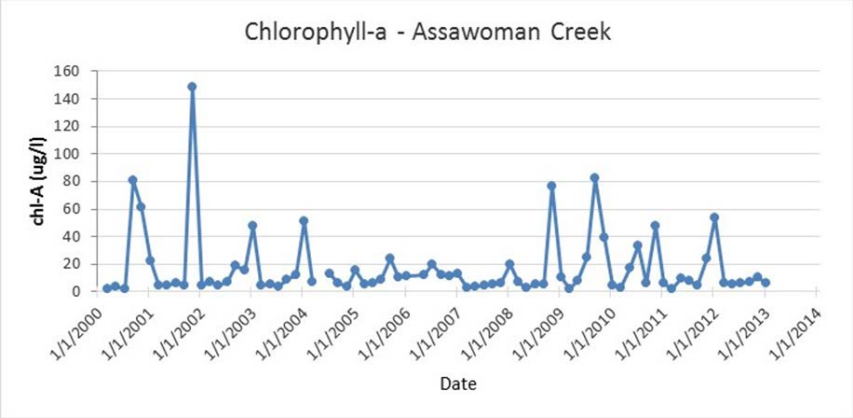


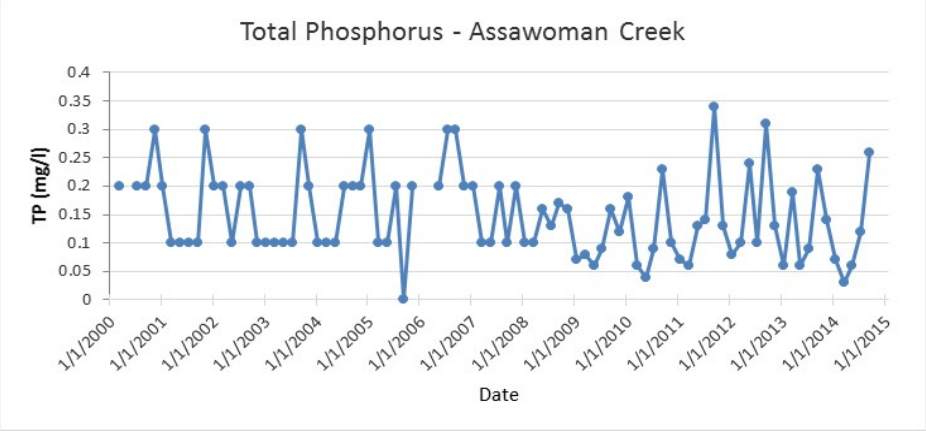


Water Quality Variable Distribution

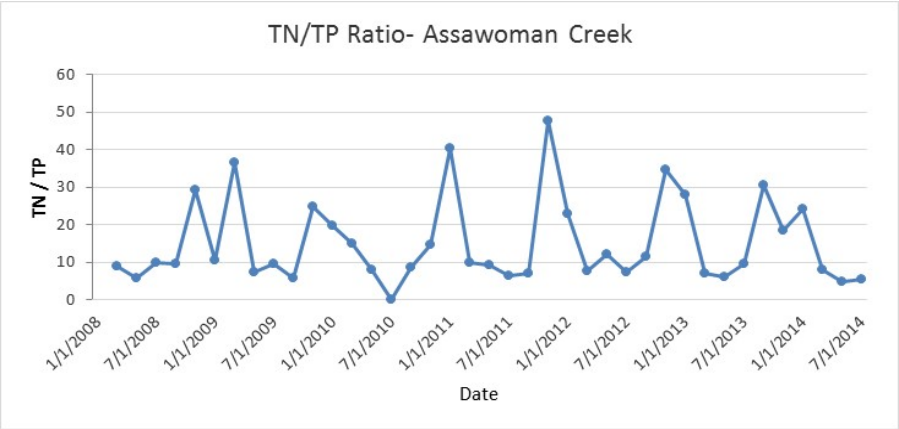


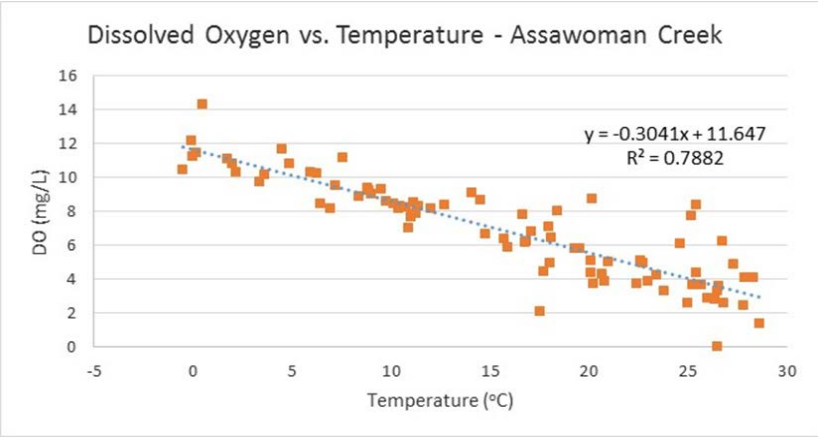


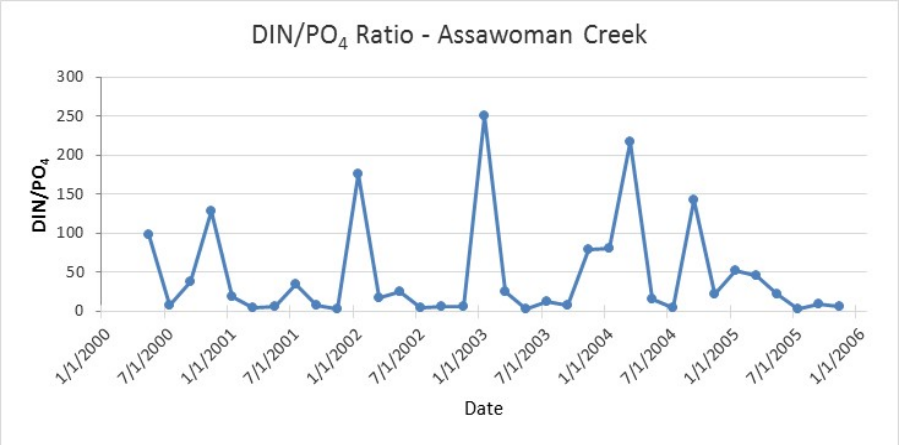


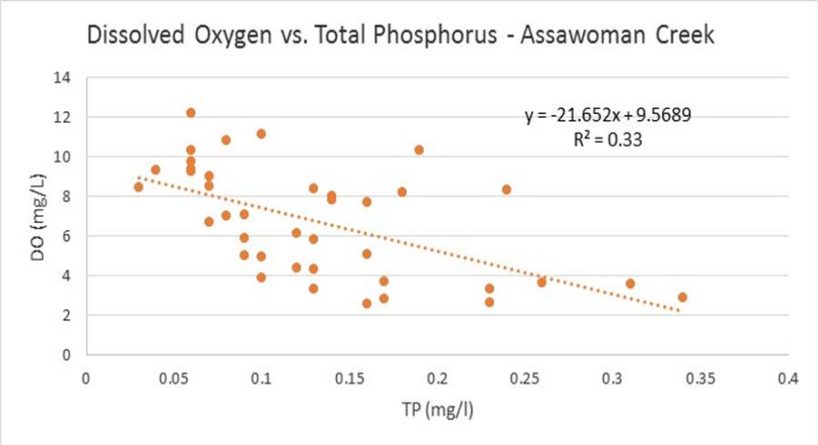


Correlations

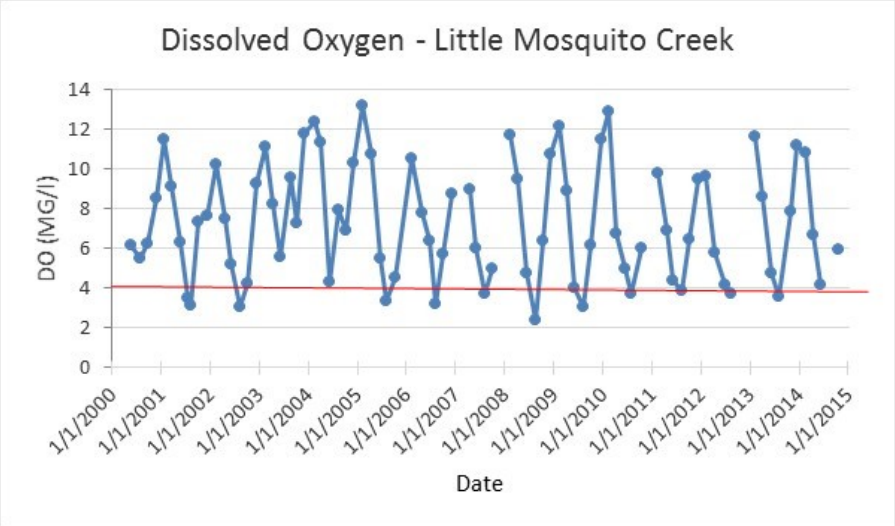


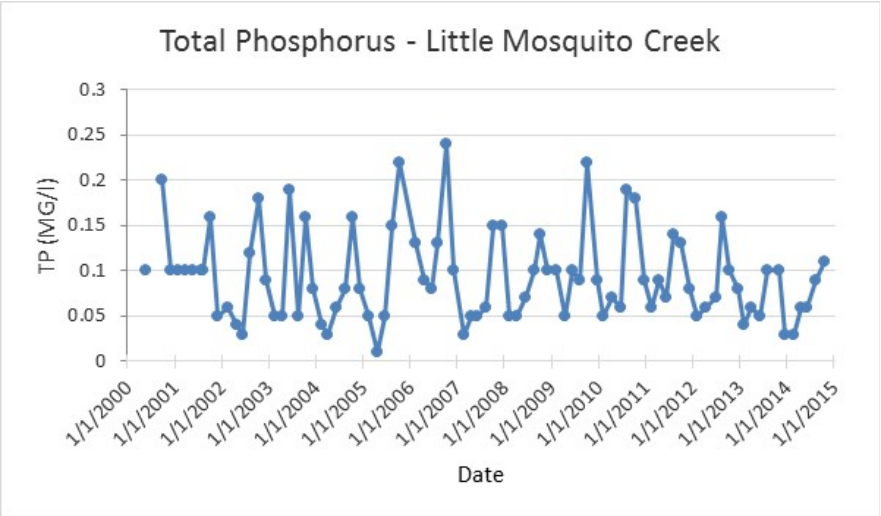


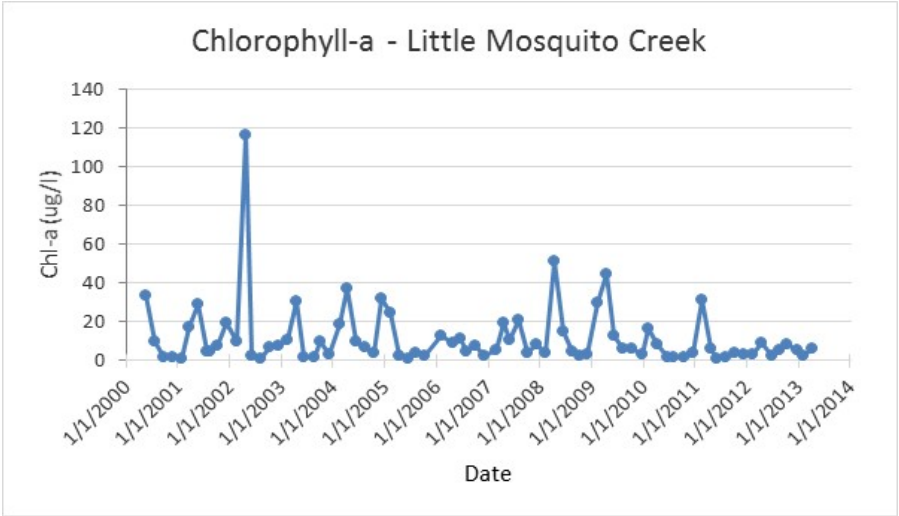


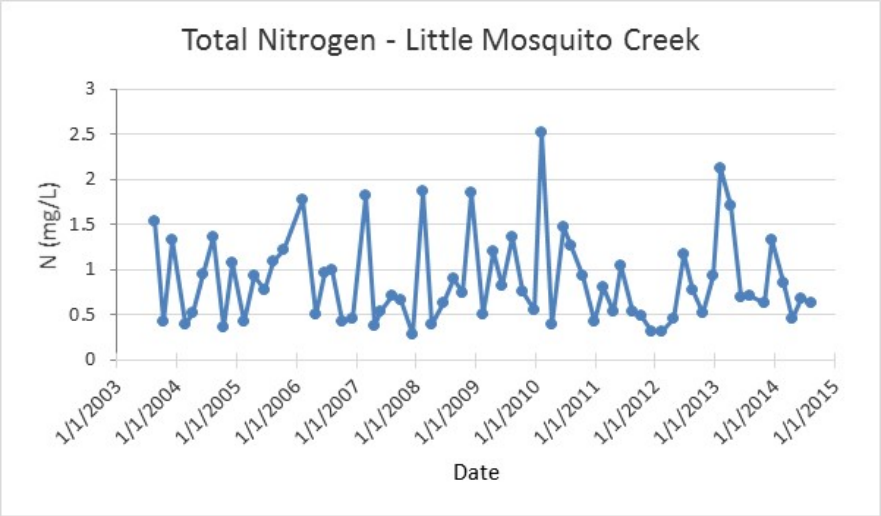


Water Quality Variable Distributions









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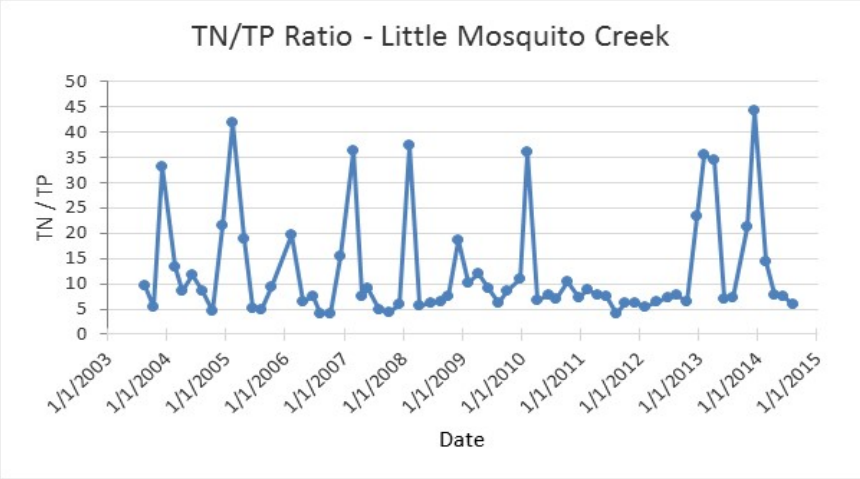
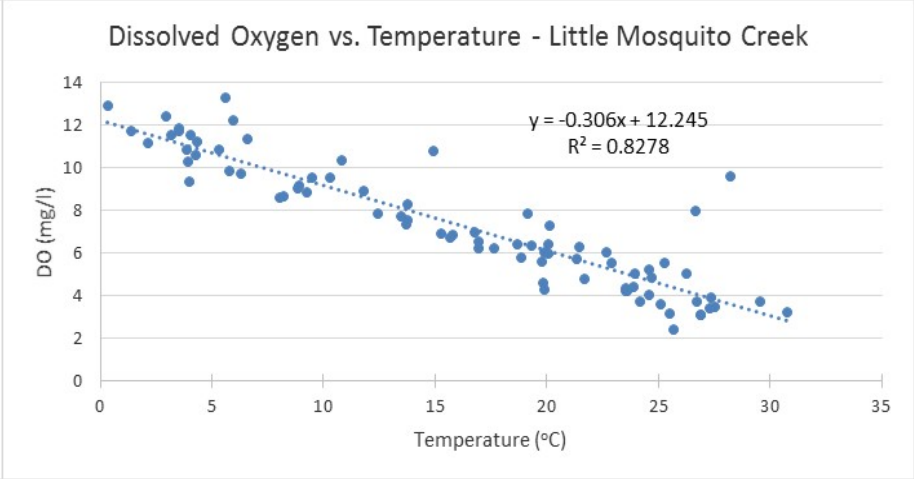
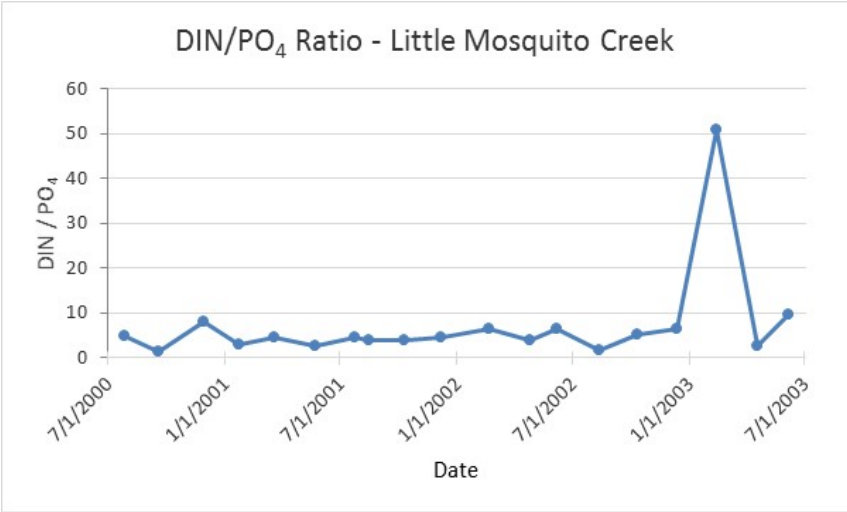
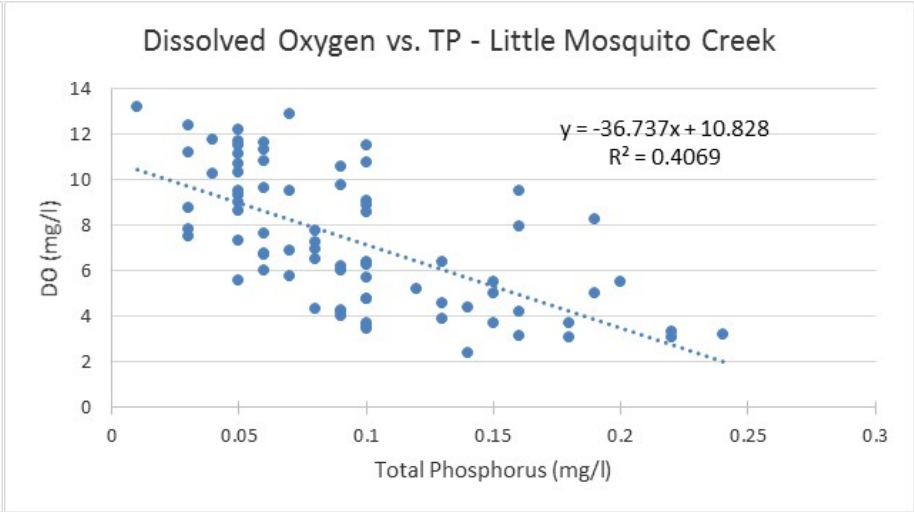
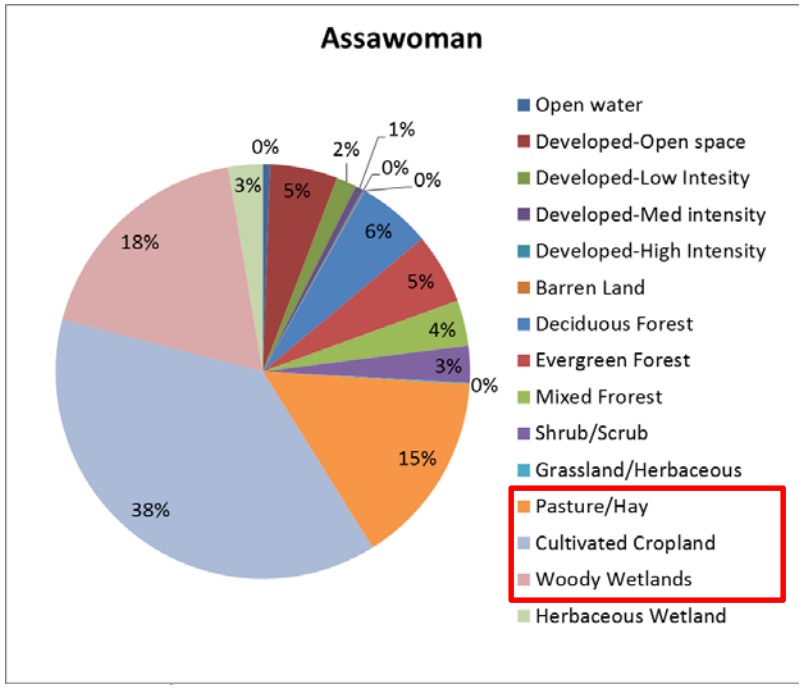


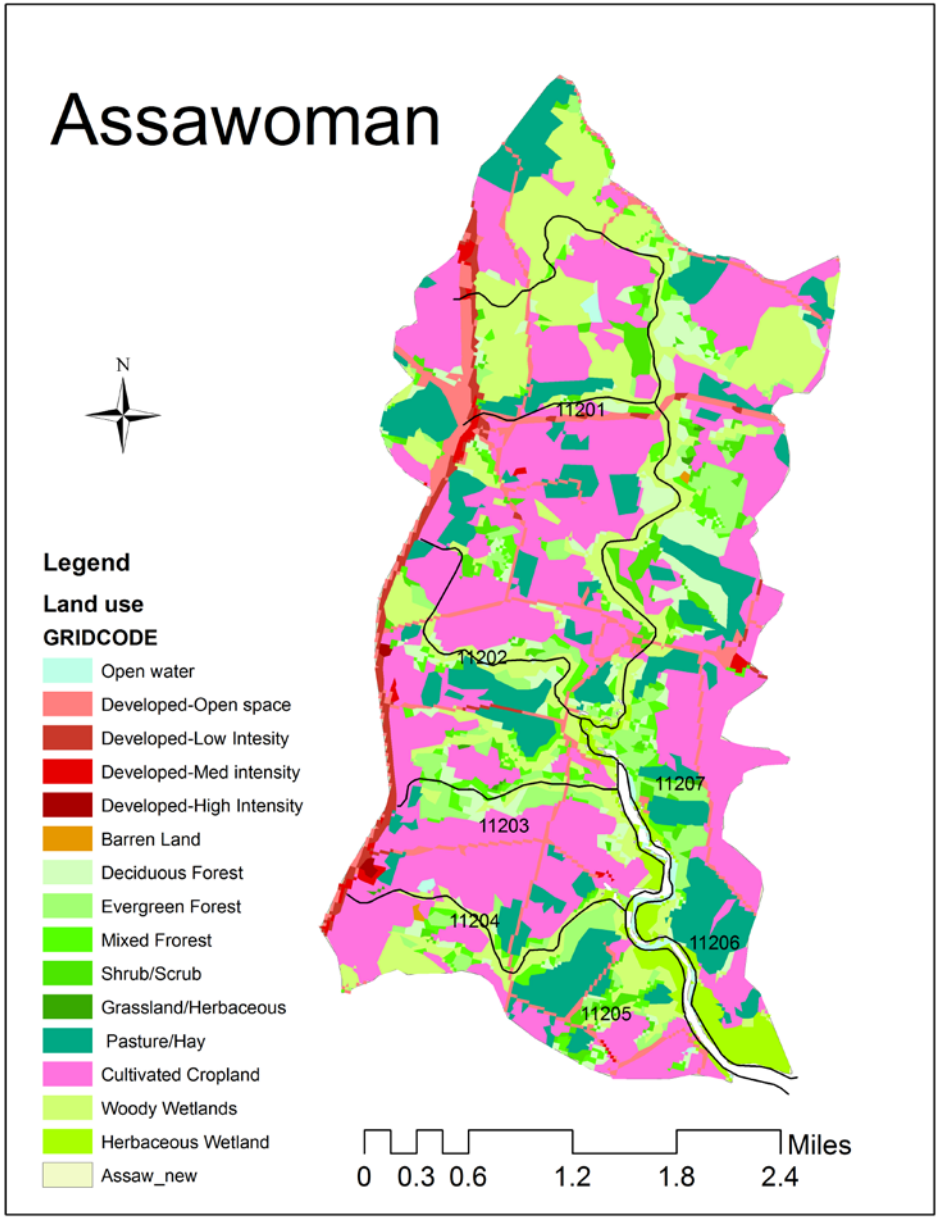




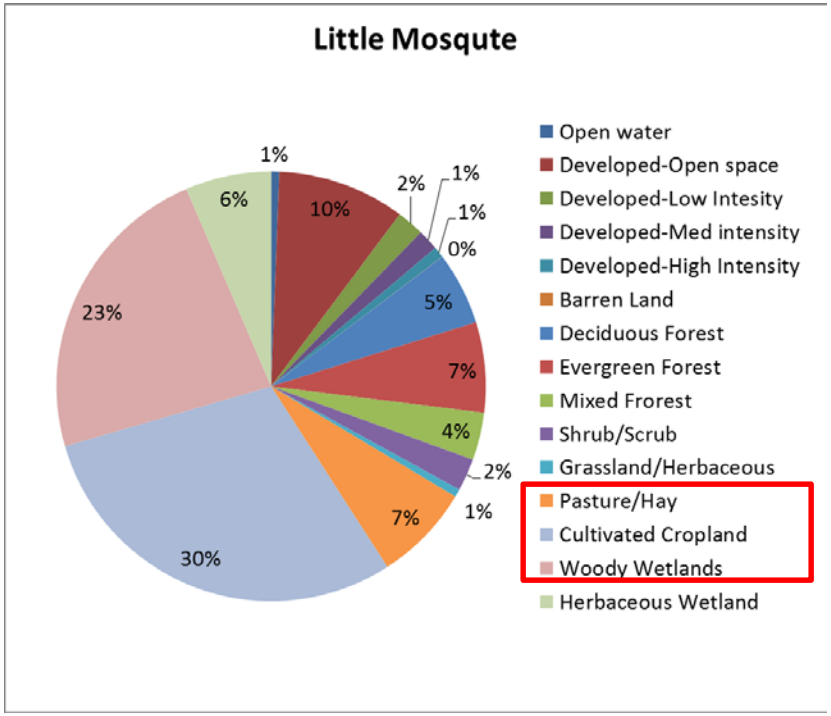


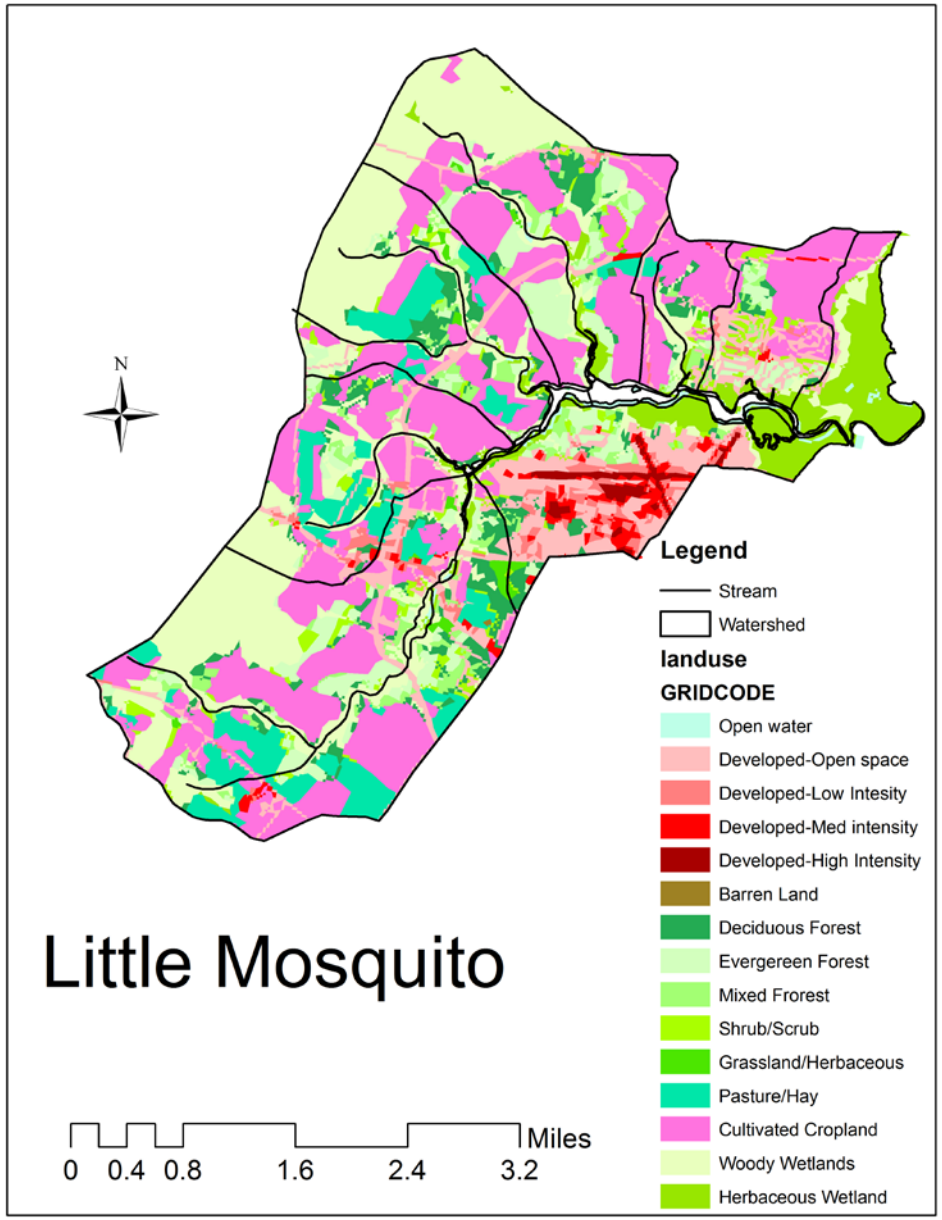
Land Use
(USGS NLCD 2011 data)





Land Use (USGS NLCD 2011 data)





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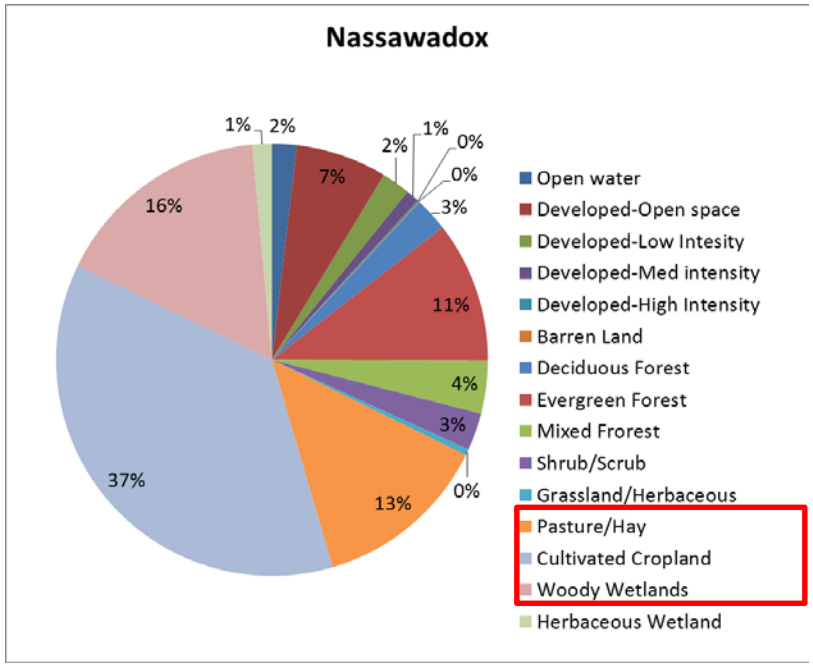
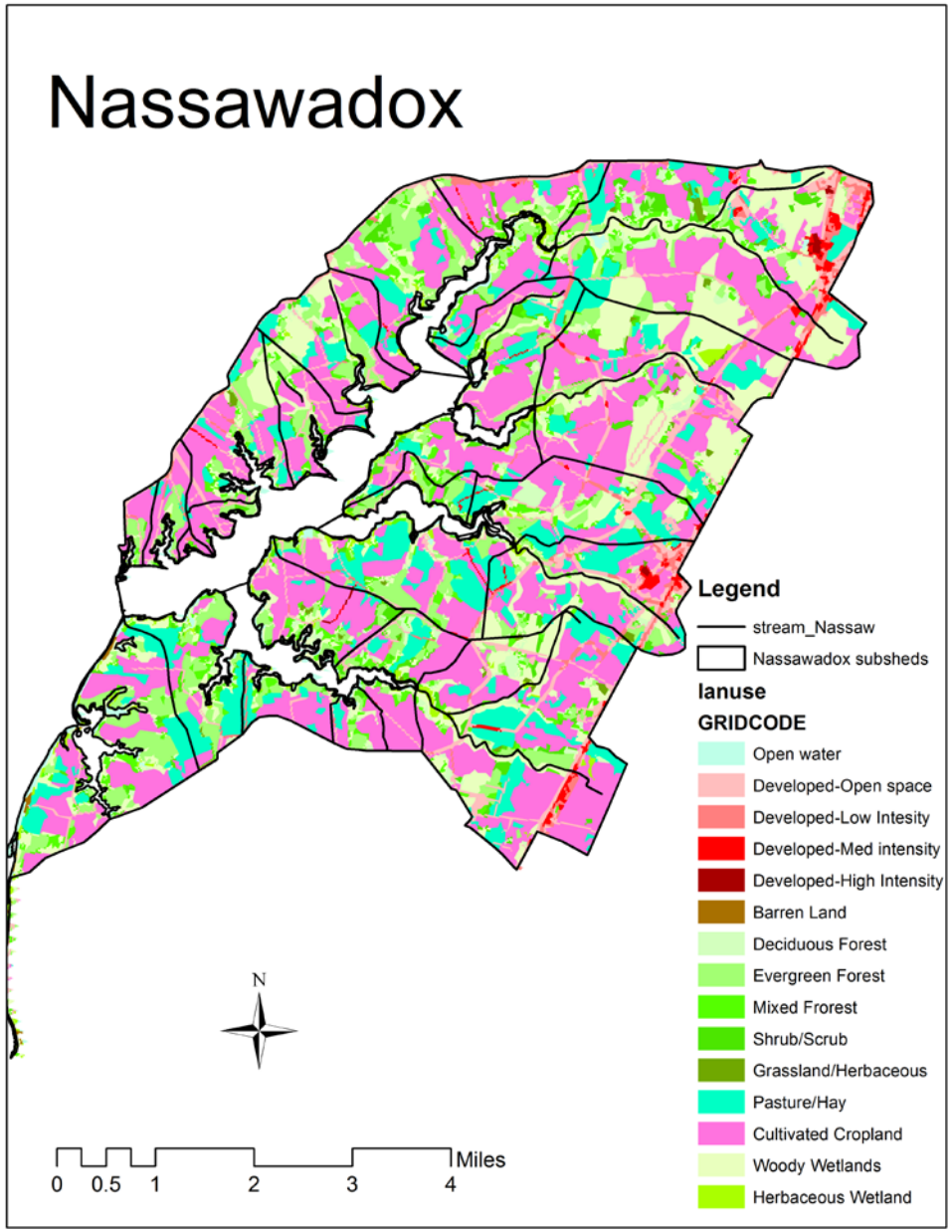
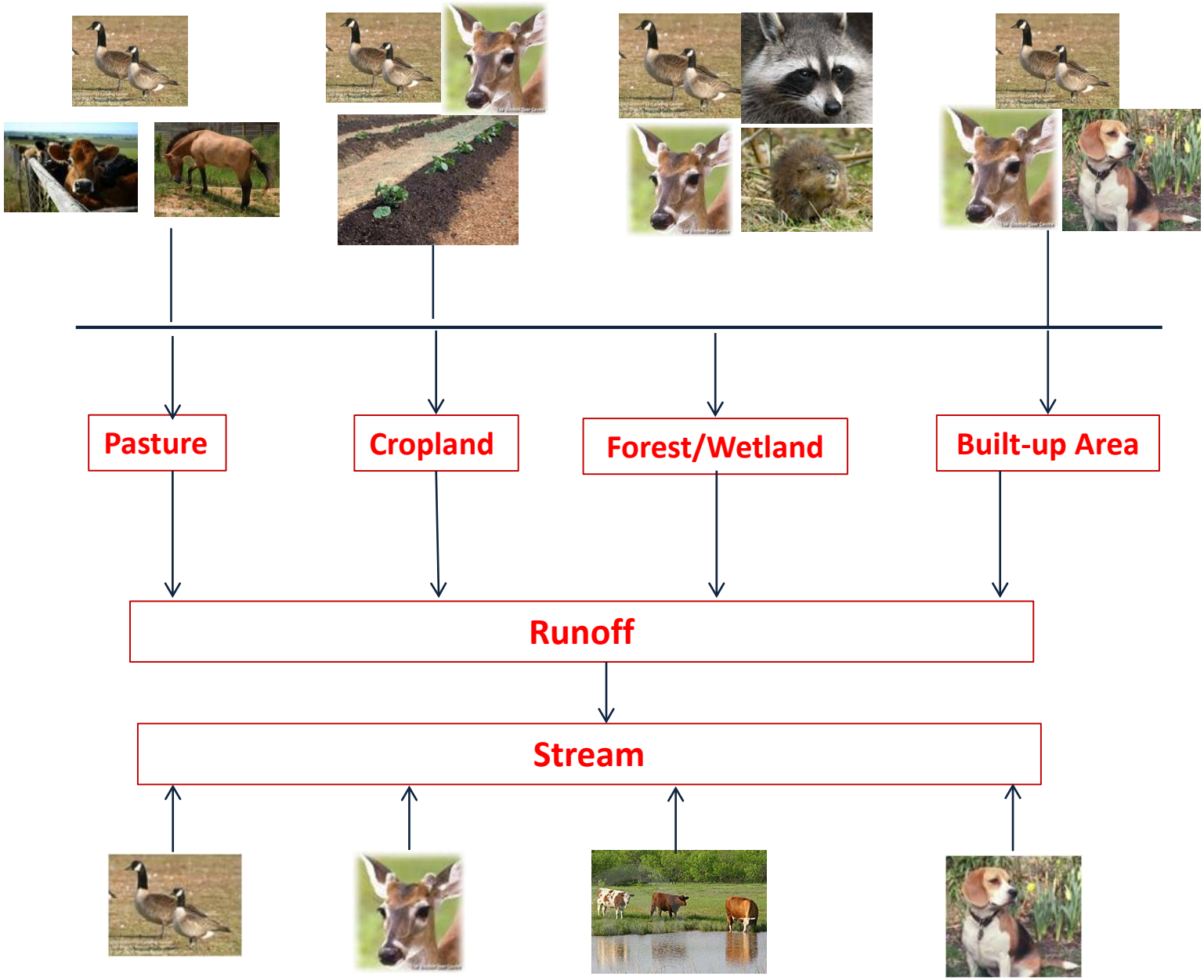




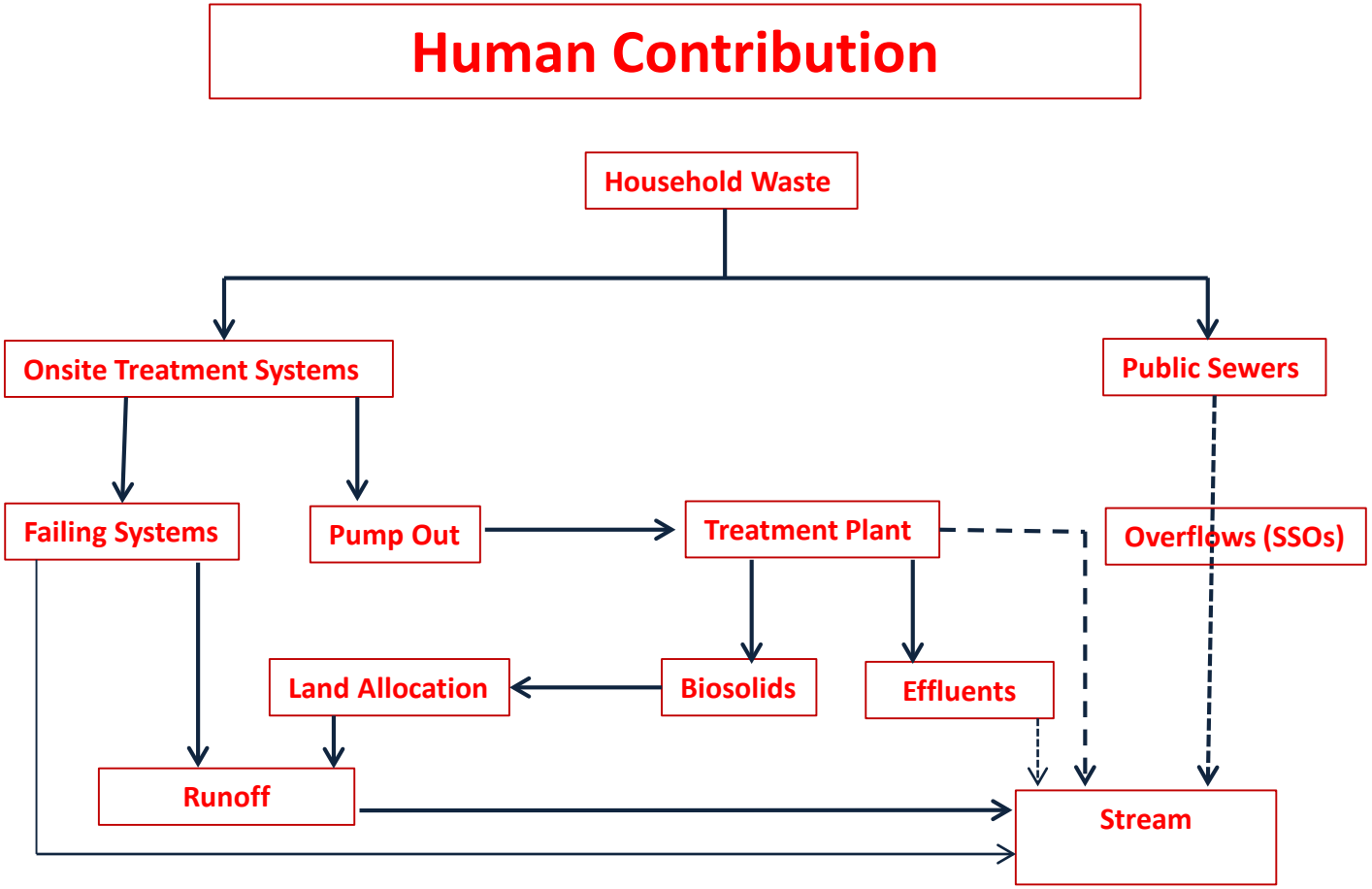
Procedures of Pollutant Source Assessment

- Sources
  - Agricultural
  - Humans
  - Pets
  - Livestock
  - Wildlife
- Approach
  - GIS land use data (land use, population, pets, septic systems)
  - Shoreline survey data
  - Field survey
  - Wildlife survey data (animal density, animal habitat)
  - Public inputs
  - Public meeting
  - Interview

Potential Sources



Source Assessment



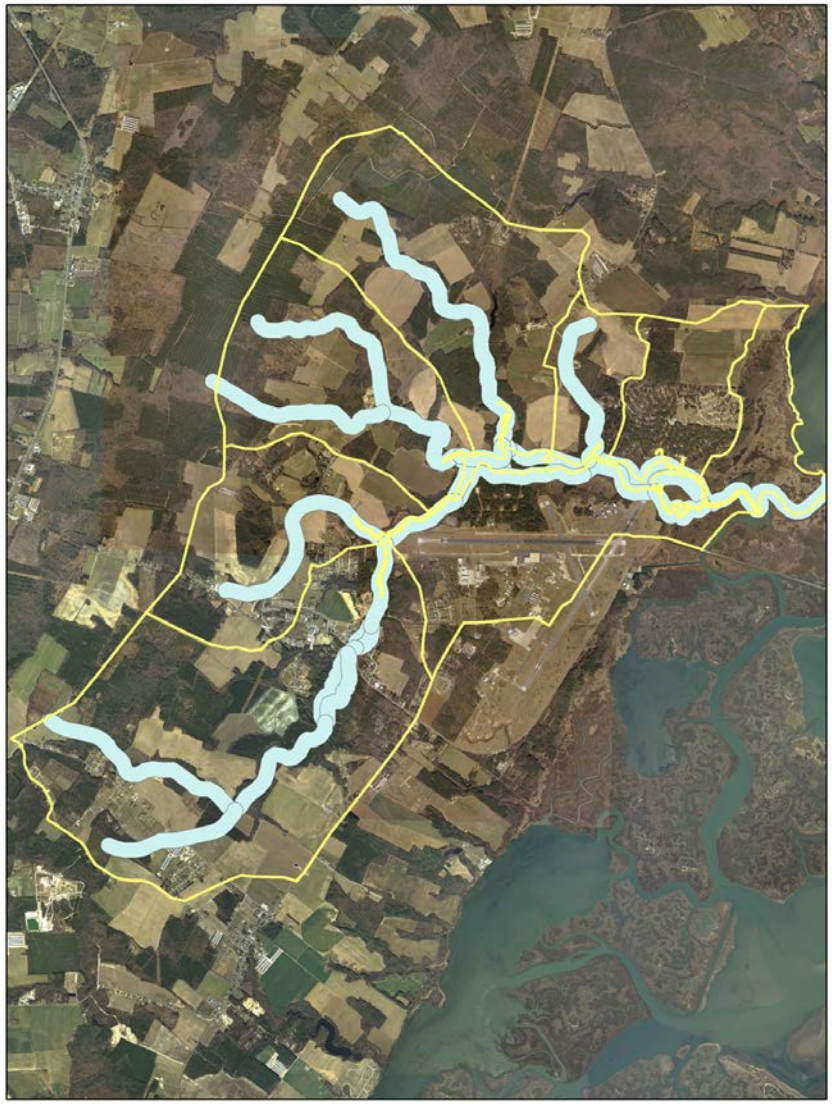
Wildlife Habitat

Wildlife Densities		
Wildlife type	Population Density	Habitat Requirements
Deer	0.047 animals/acre	Entire watershed, except open water and urban development
Raccoon	0.078 animals/acre	Forest and Wetland within 600 feet of streams and ponds
Raccoon	0.016 animals/acre	Upland Forest
Muskrat*	50/mile	Streams and Rivers
Nutria*	18.5/mile	Streams and Rivers
Residential Geese	0.02 animals/acre	Entire Watershed
Waterfowl	0.002 animals/acre	Entire Watershed

Bacteria Production

Name	FC (count/animal/day)
Ducks	2,430,000,000
Geese	49,000,000,000
Deer	500,000,000
Raccoons	125,000,000
Muskrat	250,000,000
Nutria	250,000,000
Dog (Fraction available for runoff 23%)	4,086,000,000

Wildlife Habitat



600 feet habitat near the streams.

Example of Source Estimation for Assawoman

Animal Type	Density	Sum	SWS_11201	SWS_11202	SWS_11203	SWS_11204	SWS_11205	SWS_11206	SWS_11207
Deer	0.047	317	163	45	25	32	19	14	18
Raccoon	0.078	114	66	13	5	10	7	9	3
Raccoon	0.016	23	14	3	1	2	1	2	1
Muskrat*	50	1443	837	163	64	129	91	116	42
Nutria*	18.5	534	310	60	24	48	34	43	16
Residential Geese	0.02	135	69	19	11	14	8	6	8
Waterfowl	0.002	13	7	2	1	1	1	1	1

* The existing of muskrat and nutria and density need to be verified

Watershed	Population	Number of House	Houses Public Sewer	Houses on Septic Systems	Houses on Other Means	Failing Septic Systems*
Assawoman	1171	418	36	353	29	42

* Based on 12% failure rate

Animal Type	Total
Cattle	22
Pigs	61
Chickens*	259.317
Horses	5
Sheep	3

Note these results are based on average density in Virginia and previous study of CCRM. We are collecting new current and verify these number

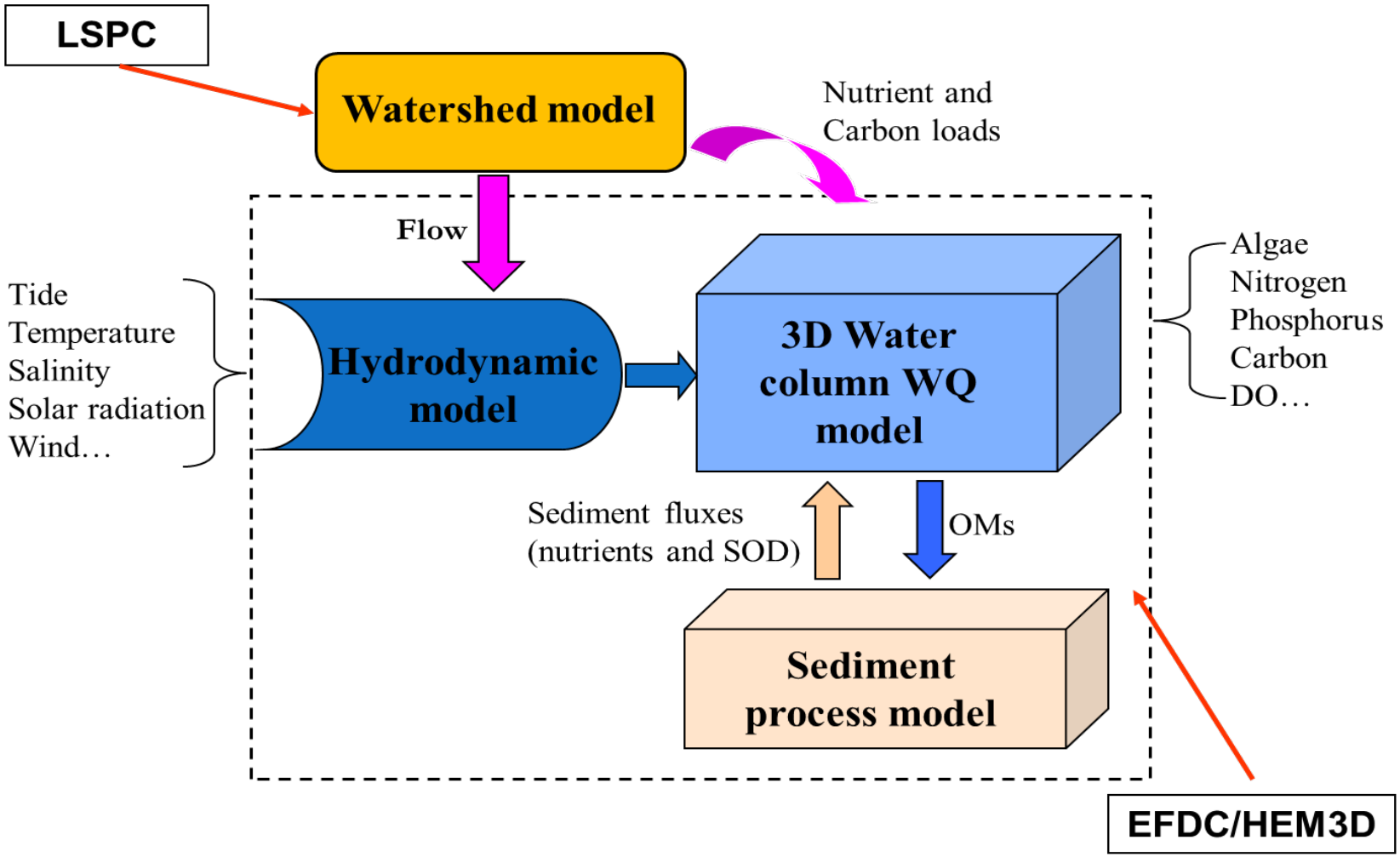
Modeling Approach

- Conduct source analysis
  - Estimate bacteria sources
  - Use Loading Simulation Program C++ (LSPC) to simulate watershed processes: flow and bacteria
- Use 3D hydrodynamic fluid environmental computation code (EFDC)
  - Simulate bacteria transport and fate

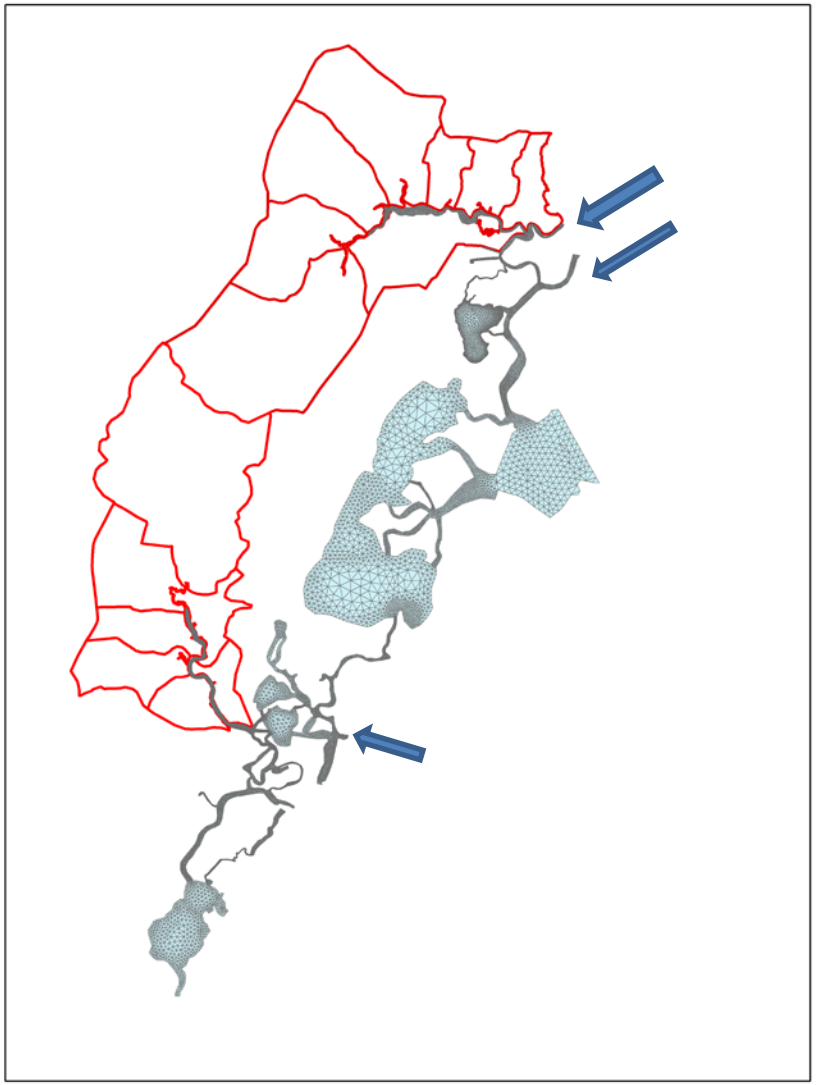
Model Simulation

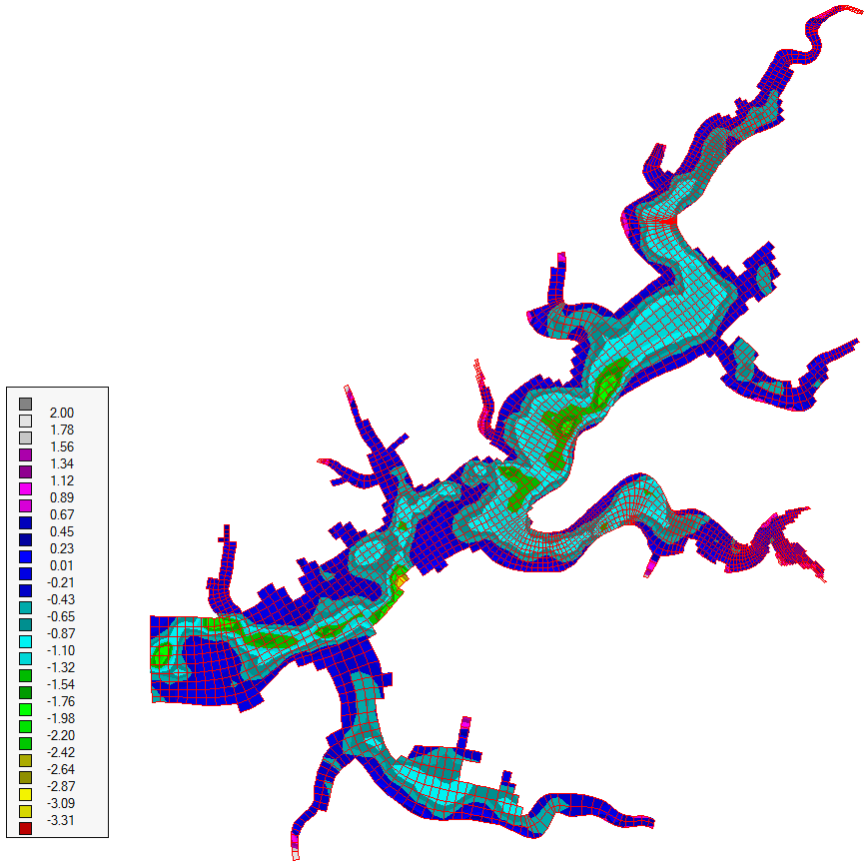
- Watershed Segmentation
  - Simulation flow, loading using Loading Simulation Program C^{++} (LSPC)
- Receiving water
  - grid generation
  - Simulate pollutant transport using Environmental Fluid Dynamic Computer Code (HEM3D/EFDC)
  - Simulate tide to generate boundary condition use SELFE model
- Both models are supported by USEPA

Modeling Approach



Three-dimensional Model Grid



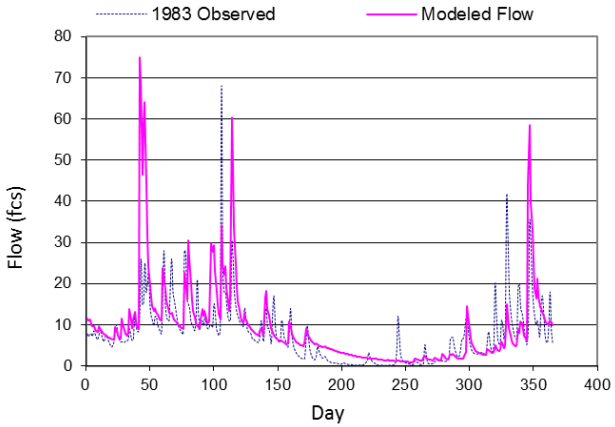


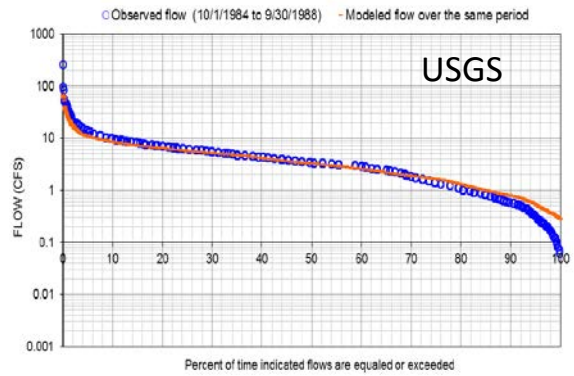
TMDL Development

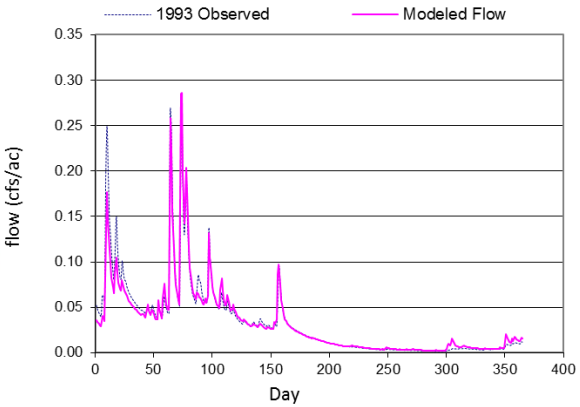
- Source analysis
- Use linked watershed and in-stream modeling approach
- Develop watershed model
- Simulate daily bacteria/nutrients loadings from watershed
- Conduct watershed model calibration
- Discharge loads to in-stream model
- Use in-stream water quality model for simulating bacteria transport and DO dynamics
- Calibrate water quality model
- Compute allowable loads and determine load reduction

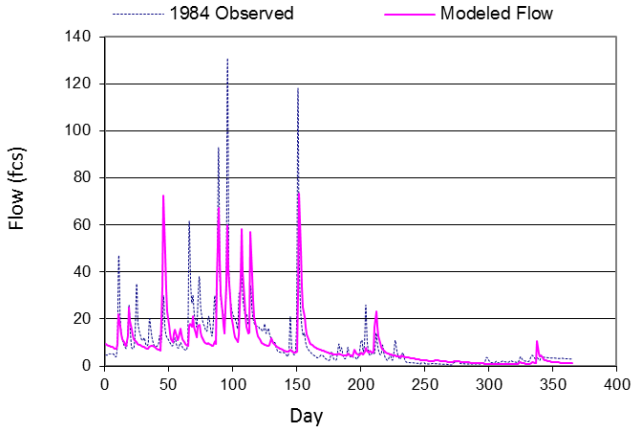
Watershed Model Calibration

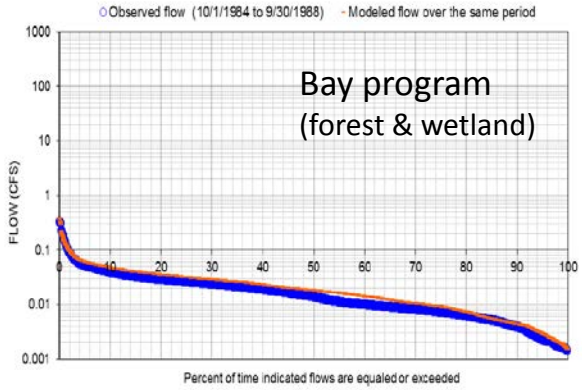
- Compare model results to nearby USGS station (USGS 01670000 BEAVERDAM SWAMP NEAR ARK, VA, 80-88)
- Compare to Bay Program watershed model results

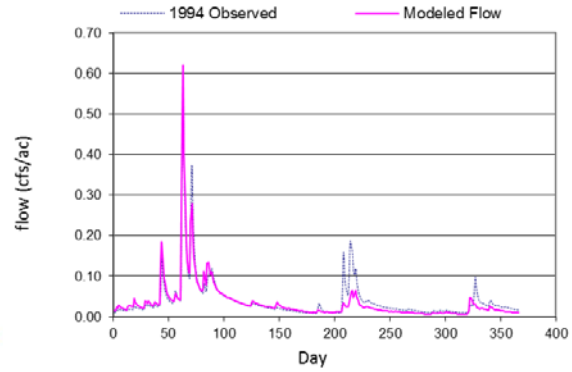












Questions and Comments

- Source estimation ?
- Loading estimation ?
- TMDL calculation ?
- Other questions/comments ?

Thanks!

Comments send to:
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