Assessing Watershed Scale Responses to BMP Implementation

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http://va.water.usgs.gov/projects/ffx_co_monitoring.htm

Study Objectives

1. Generate long-term monitoring data to describe:
   - Current water-quality (sediment and nutrients) and quantity conditions,
   - Trends in water-quality and quantity,
   - Nutrient and Sediment Loads and Yields.
2. Evaluate relations between observed conditions/trends and BMP implementation.
3. Transfer the understanding gained to other less-intensively monitored watersheds.

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The Challenges

BMP induced changes are difficult to quantify at the watershed scale:

- **Environmental factors cause great variability**
  - **need to separate signal from noise,**
- **Lag times may be considerable,**

Numerous Samples + Continuous Data ✖ **Multiple Sites** ✖ **Extended Duration**

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Approach: Intensive Monitoring

- Operate four intensive monitoring stations
- 10+ years of data collection
  - Continuous-record stream gage
  - Continuous water-quality monitor (turbidity, pH, SC, DO, water temp)
  - Nutrients & Sediment Sampling
    - Automated sampler (storm samples)
    - Scheduled monthly sampling
  - Annual benthic monitoring

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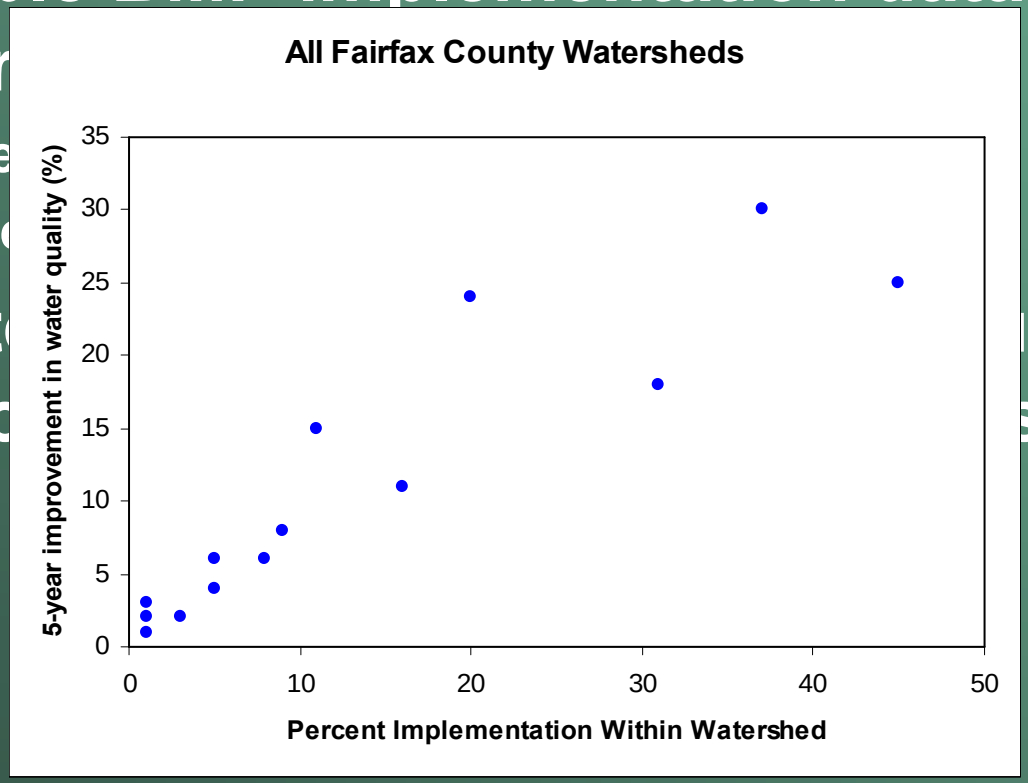
Approach: BMP Evaluation

- Assemble BMP implementation dataset for monitor
  - Exte
  - Typ
- Evaluat ality conditic s.



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Approach: Knowledge Transfer

- Operate 10 trend monitoring stations
  - Partial-record stream gage
  - Nutrient & sediment sampling
    - Scheduled monthly sampling
  - Annual benthic monitoring
- Evaluate relations between trend- and intensive monitoring sites

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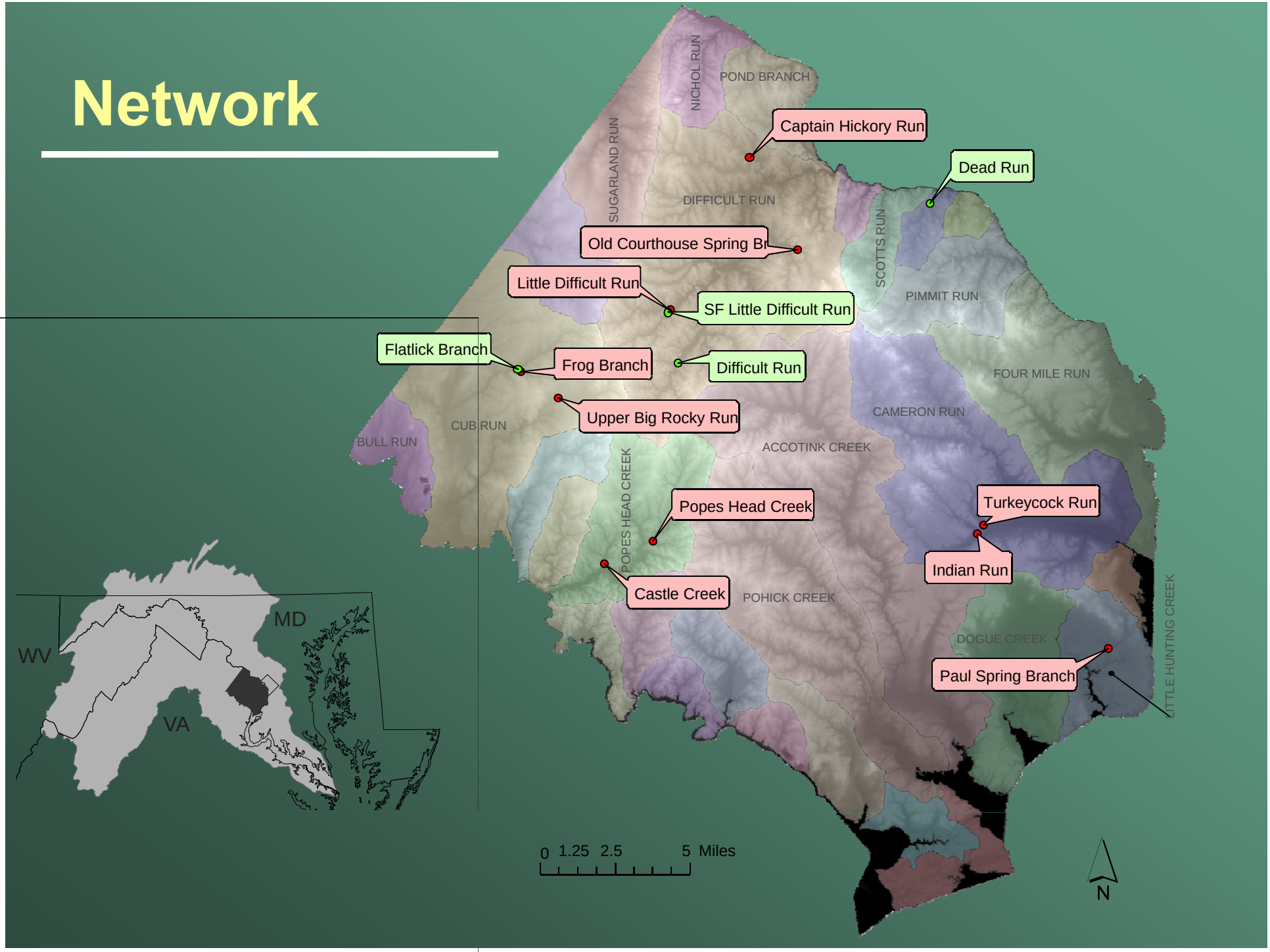
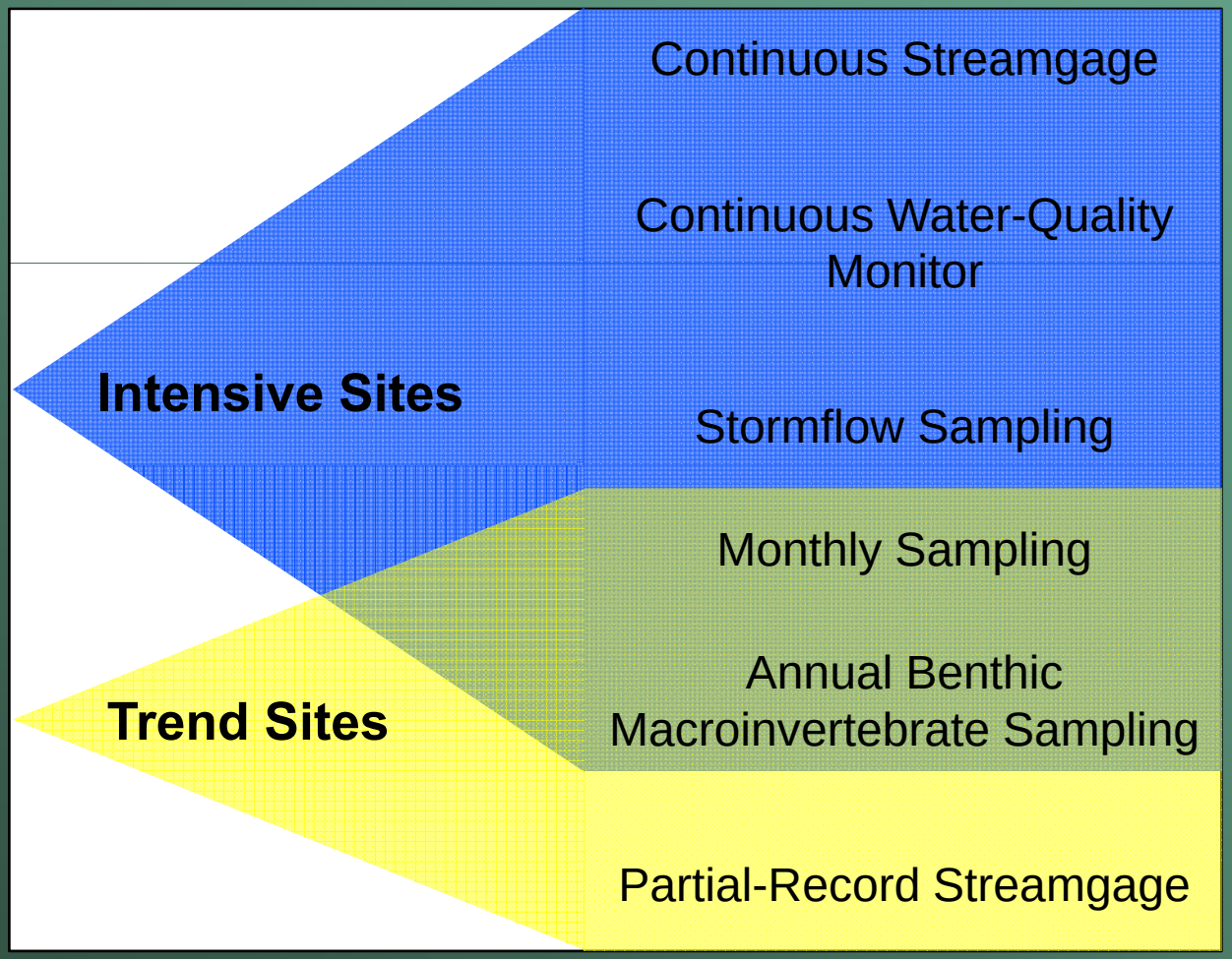
Network


NICHOL RUN
POND BRANCH
SUGARLAND RUN
Captain Hickory Run
Dead Run
DIFFICULT RUN
SCOTTS RUN
Old Courthouse Spring Br
Little Difficult Run
SF Little Difficult Run
PIMMIT RUN
Flatlick Branch
Frog Branch
Difficult Run
FOUR MILE RUN
Upper Big Rocky Run
CAMERON RUN
CUB RUN
BULL RUN
ACCOTINK CREEK
POPES HEAD CREEK
Popes Head Creek
Turkeycock Run
Indian Run
Castle Creek
POHICK CREEK
DOGUE CREEK
Paul Spring Branch
LITTLE HUNTING CREEK
MD
WV
VA
0 1.25 2.5 5 Miles
N

Measurements



Reduction of Uncertainty

- Data Collection
  - Temporally dense data collection
  - Turbidity Threshold Sampling
    - Integrate continuous sensors with autosampler to optimize storm sample collection

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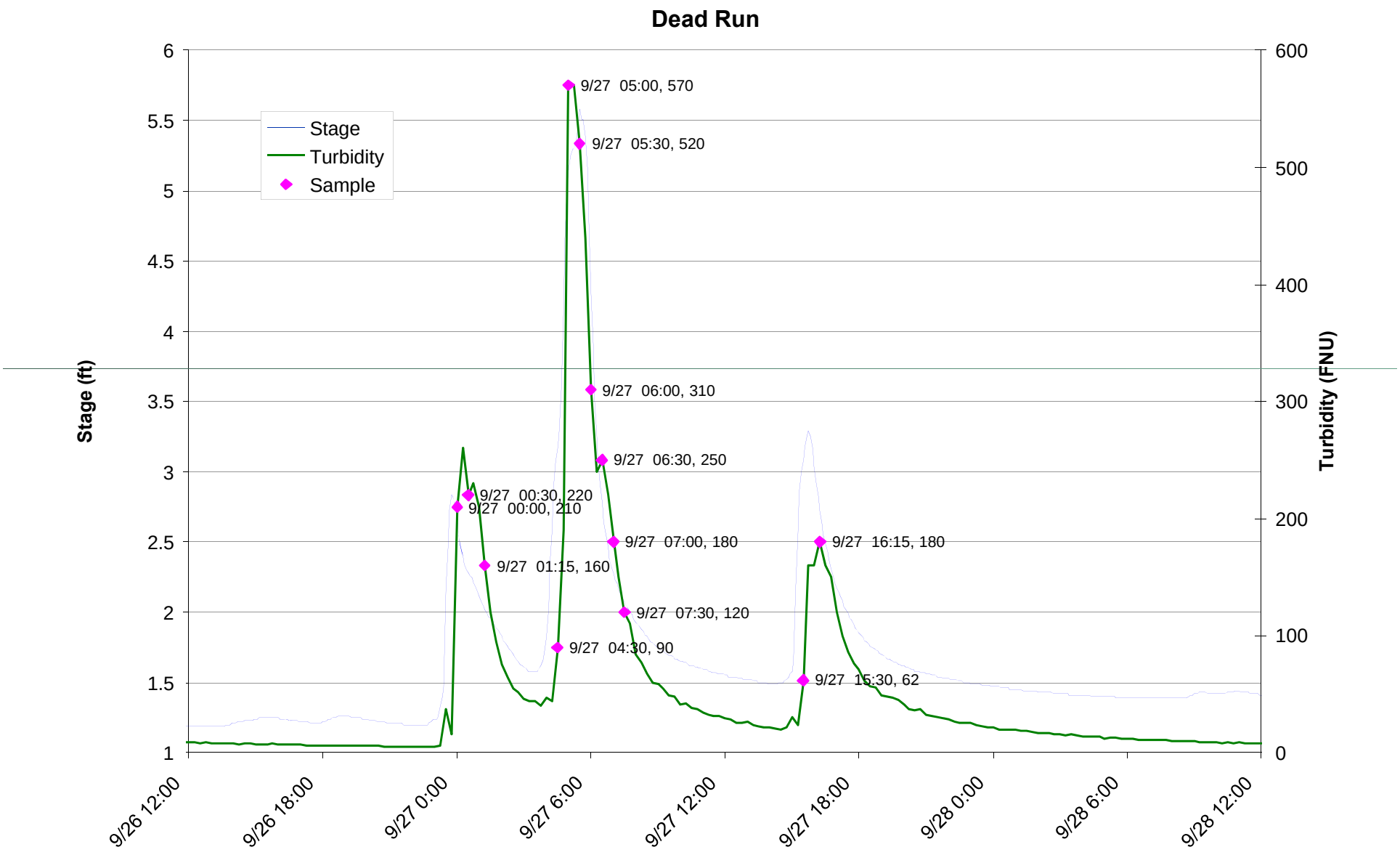
Dead Run
Stage
Turbidity
Sample
Stage (ft)
Turbidity (FNU)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
600
500
400
300
200
100
0
9/27 05:00, 570
9/27 05:30, 520
9/27 06:00, 310
9/27 06:30, 250
9/27 00:30, 220
9/27 00:00, 210
9/27 07:00, 180
9/27 16:15, 180
9/27 01:15, 160
9/27 07:30, 120
9/27 04:30, 90
9/27 15:30, 62
9/26 12:00
9/26 18:00
9/27 0:00
9/27 6:00
9/27 12:00
9/27 18:00
9/28 0:00
9/28 6:00
9/28 12:00

Reduction of Uncertainty

- Data Collection
  - Temporally dense data collection
  - Turbidity Threshold Sampling
    - Integrate continuous sensors with autosampler to optimize storm sample collection
- Data Analysis
  - Surrogate approaches coupled with continuous water-quality data

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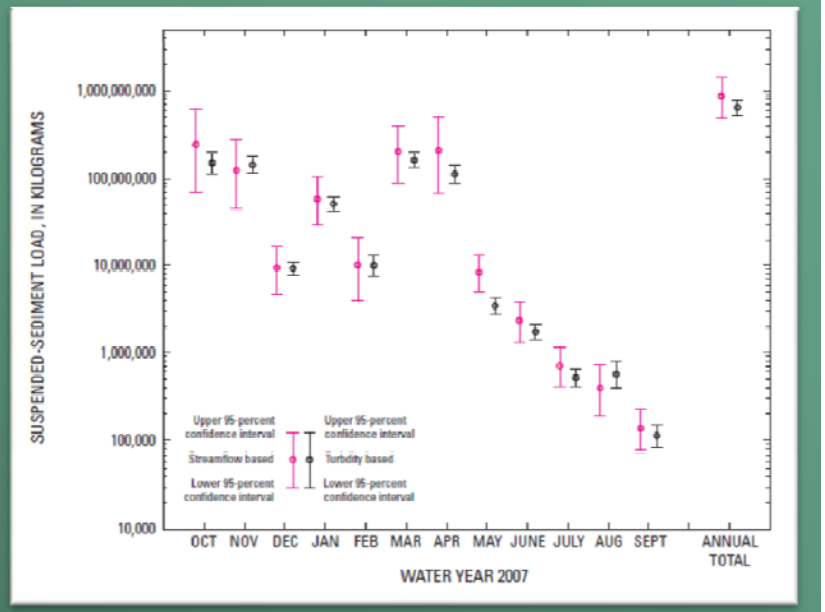
Surrogate Approaches
for continuous concentration and load estimation

- Estimate WQ Data using WQ Data
- Multivariate Regression
- More accurate and precise than flow based approaches
  - USGS Scientific Investigations Report 2009-5165



$$SSC = f^{-1}[\hat{\beta}_0 + \hat{\beta}_1 f(turbidity) + \hat{\beta}_j f(x_j) \ldots \hat{\beta}_k f(x_k) + \varepsilon]$$

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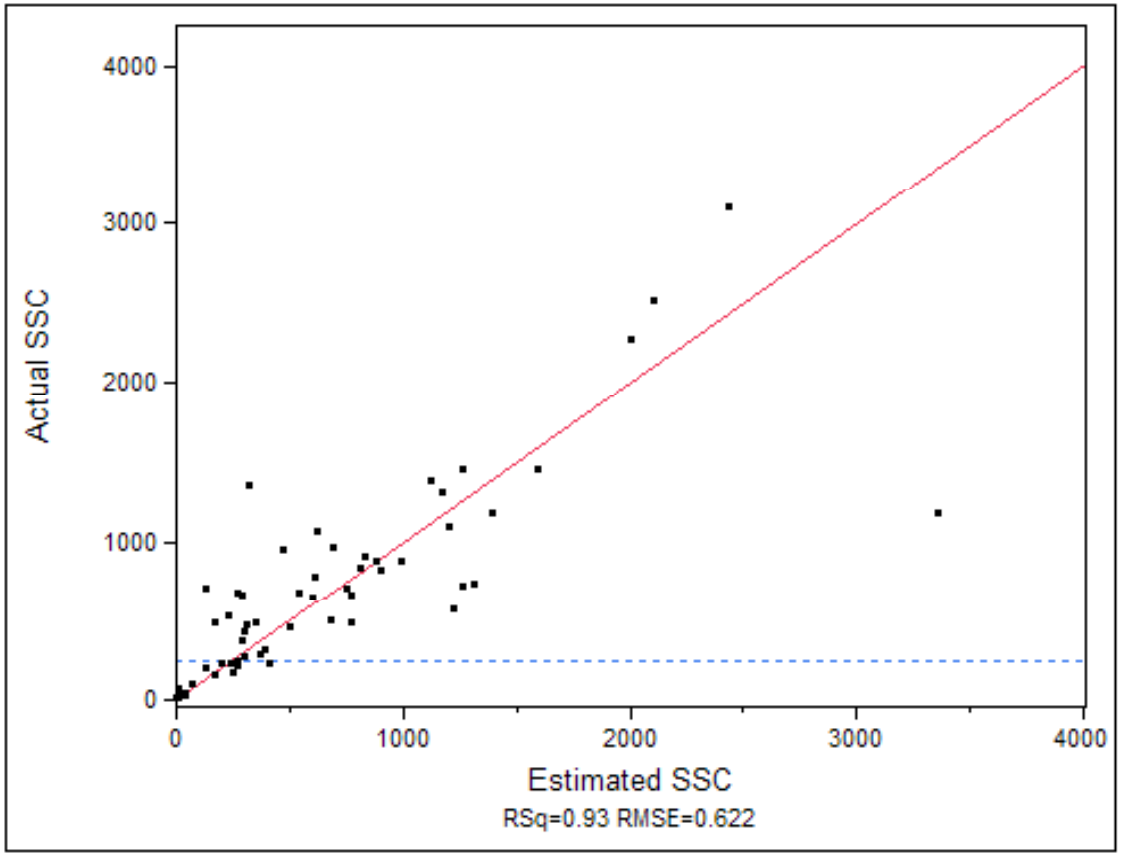

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	0.6234086	0.179798	3.47	0.0009	.
Log(Turbidity)	0.7866	0.081047	9.71	<.0001	4.8584813
Log(Q)	0.3725171	0.090522	4.12	0.0001	4.8584813

R-square	0.925
R-square Adjusted	0.923
Root Mean Square Error	0.622
Mean of Response	5.492
Observations	74

Status

- Continuous water-quality and streamflow data since Fall 2007
  - 35,000+ measurements per year of 6-7 parameters
- Monthly and storm-event sampling since Spring 2008.
  - Over 1,250 sediment and nutrient samples collected.
- Preliminary data analysis….

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Loads and Yields

Load =

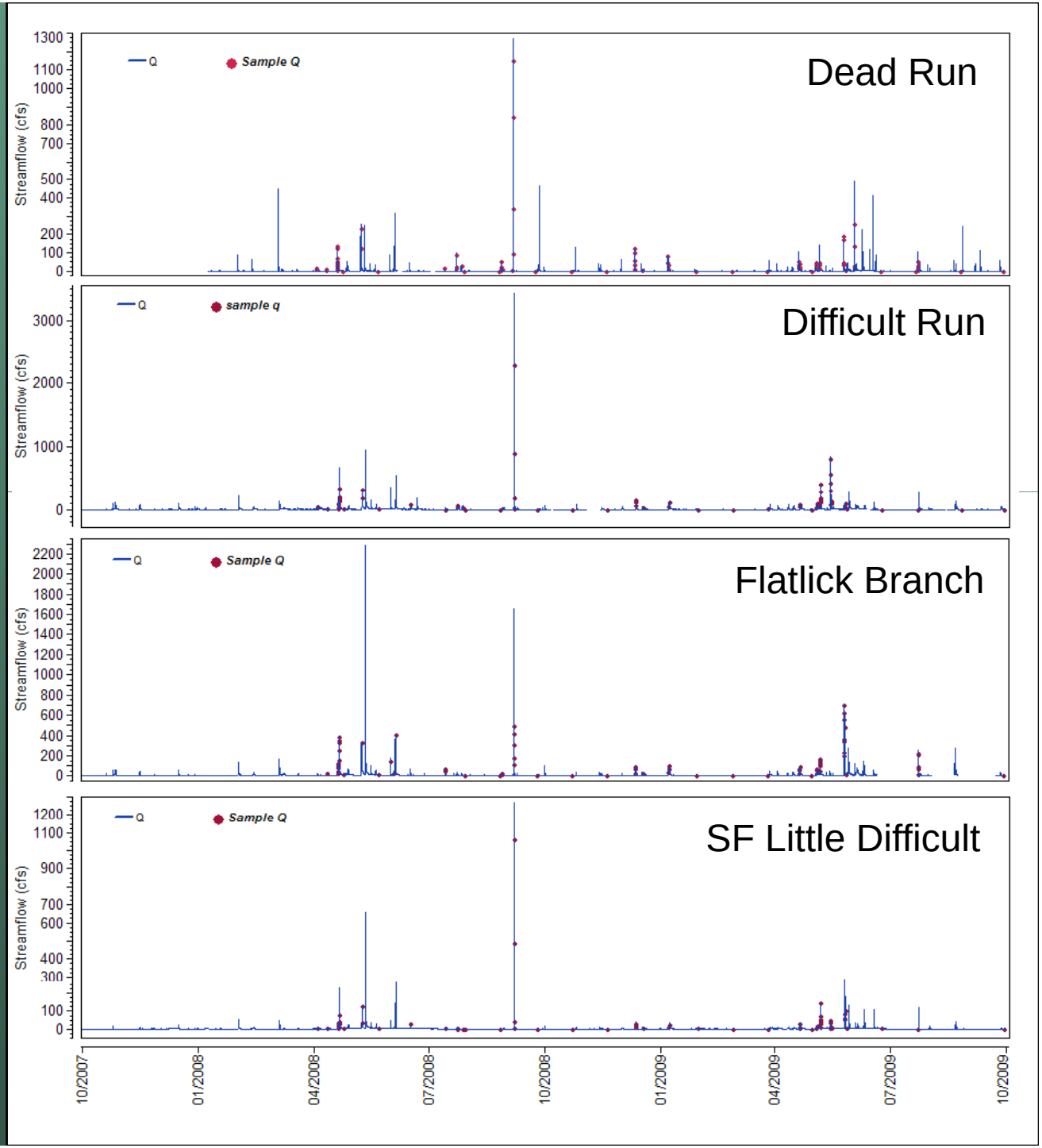
Concentration

X

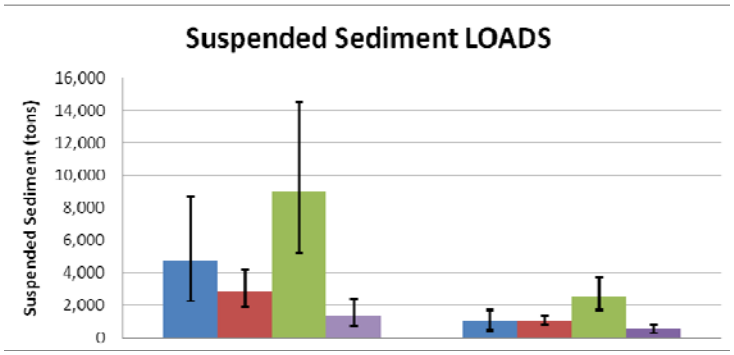
Flow

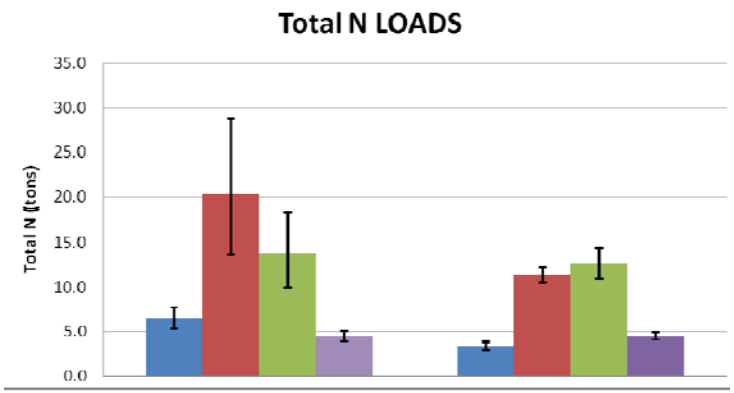
Yield =

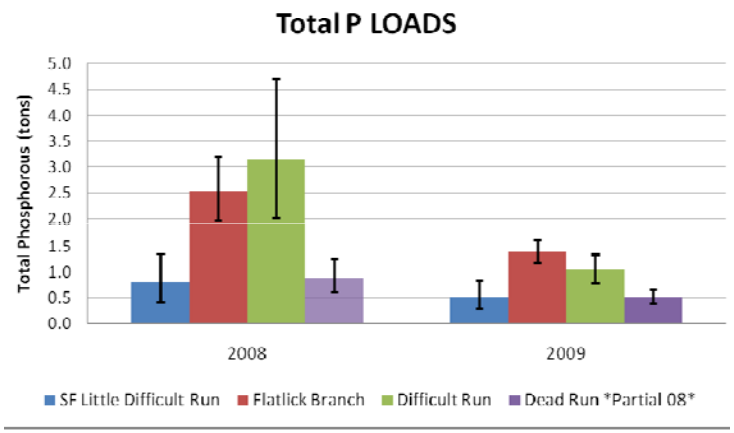
$$\frac{\text{Load}}{\text{Watershed Area}}$$

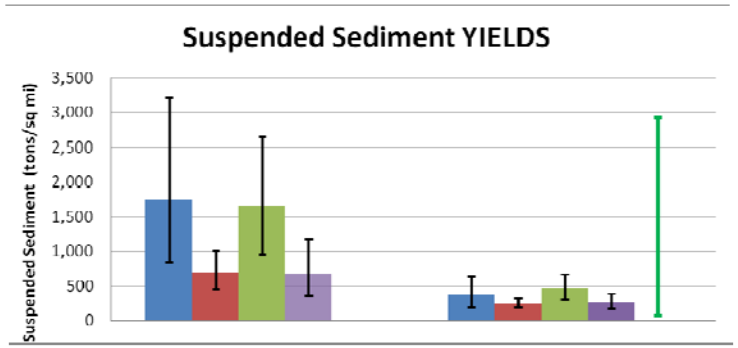


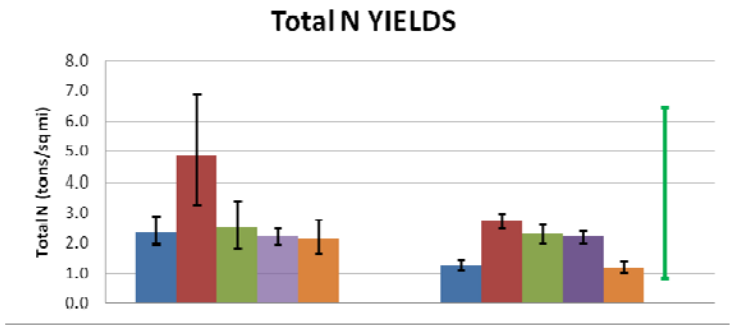
Annual Loads and Yields

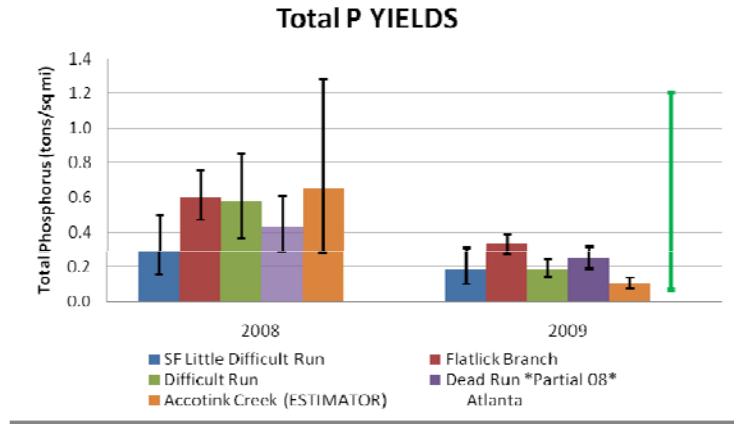




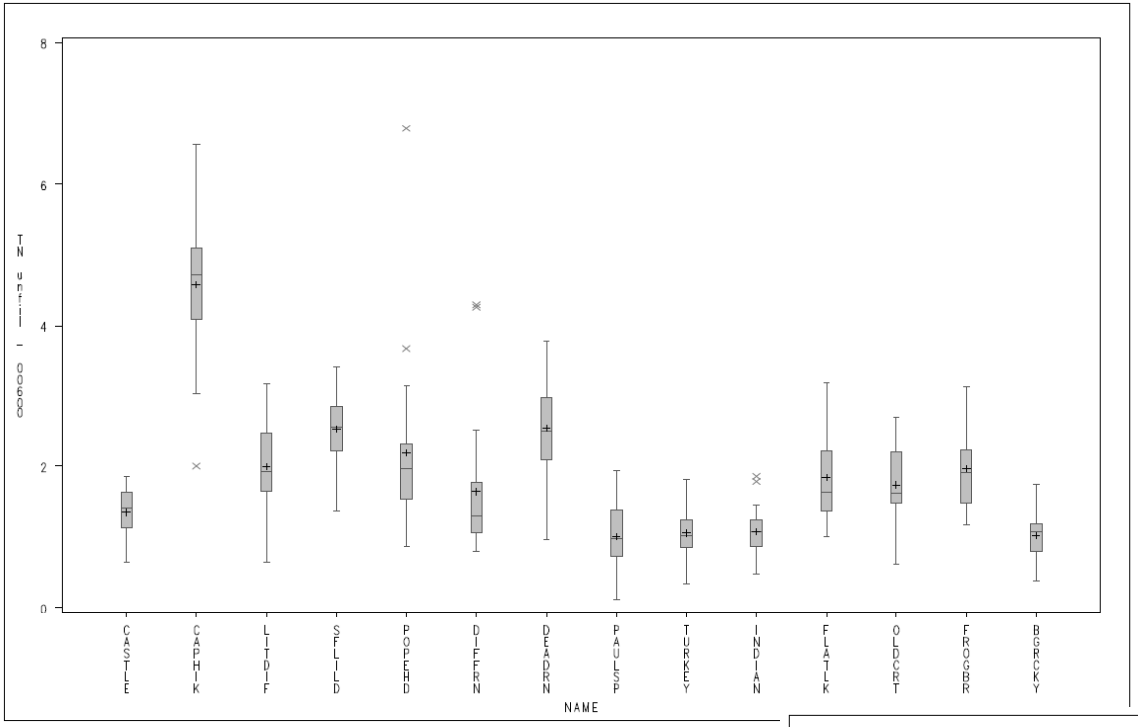


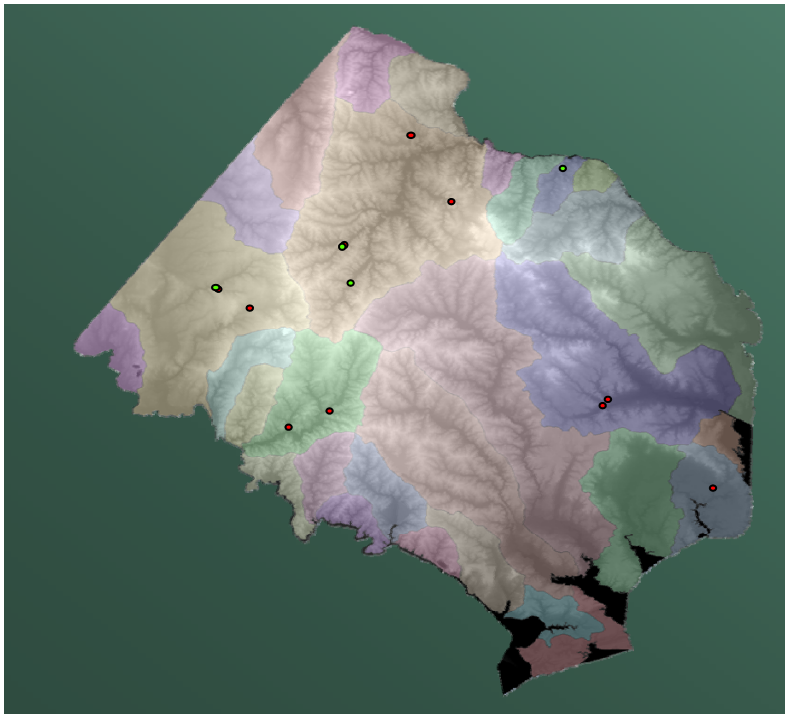


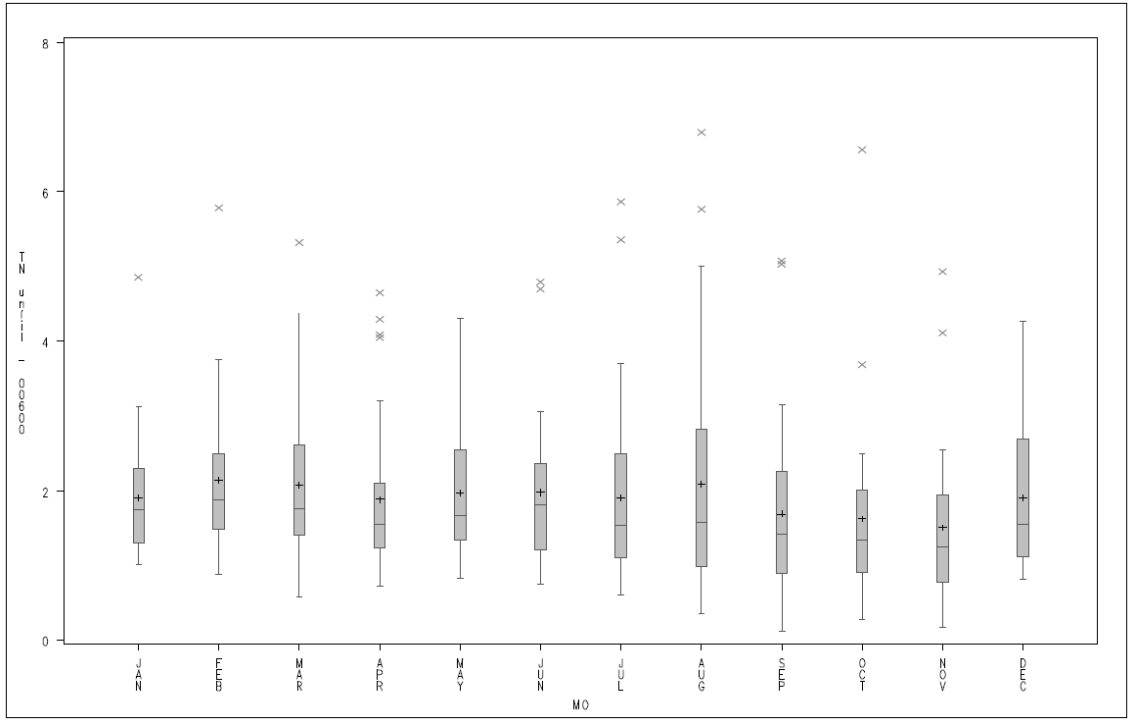




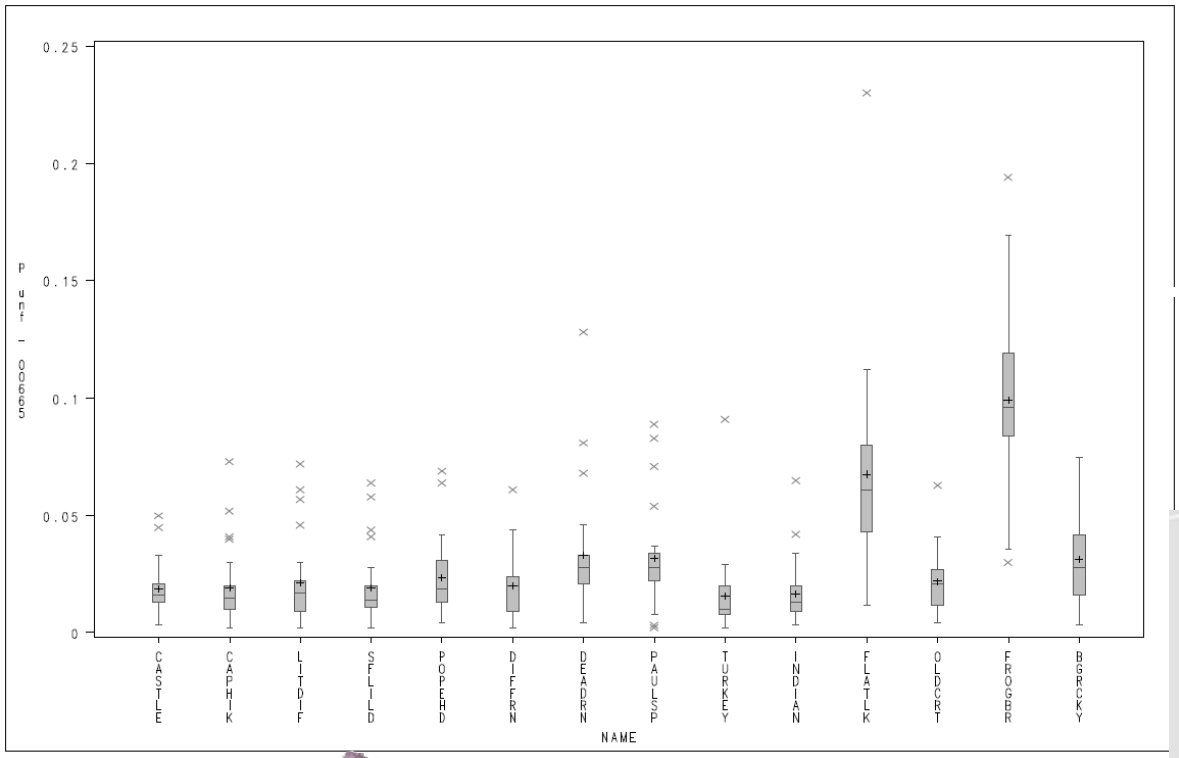
Total Nitrogen

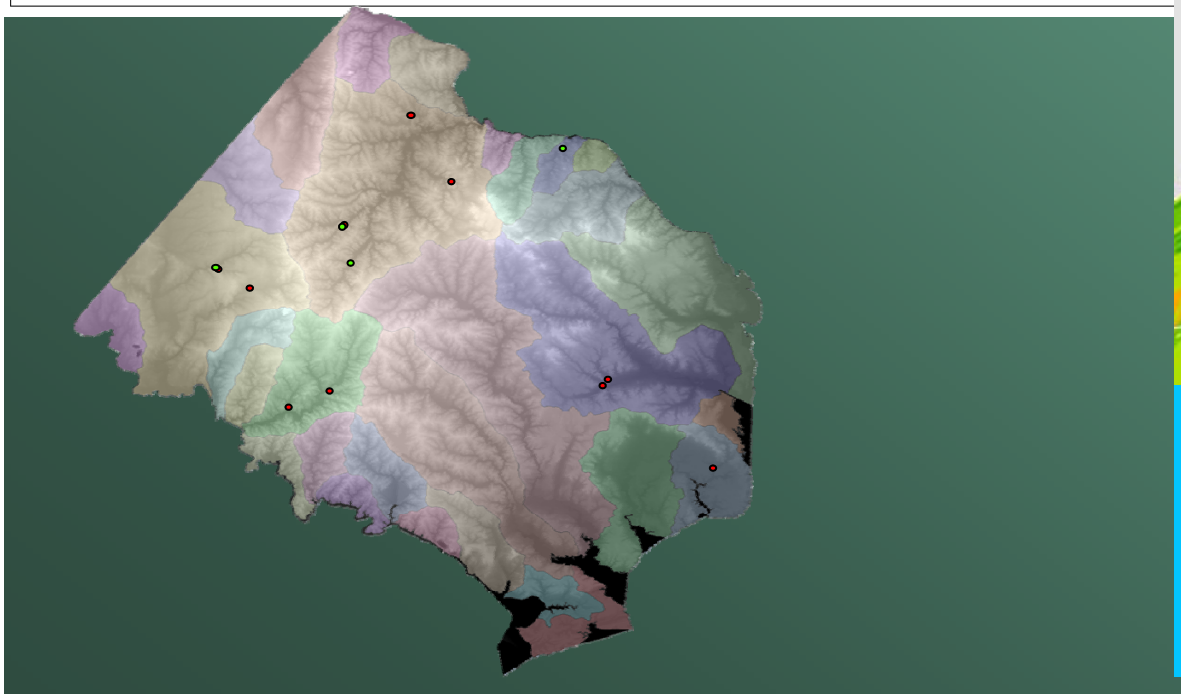


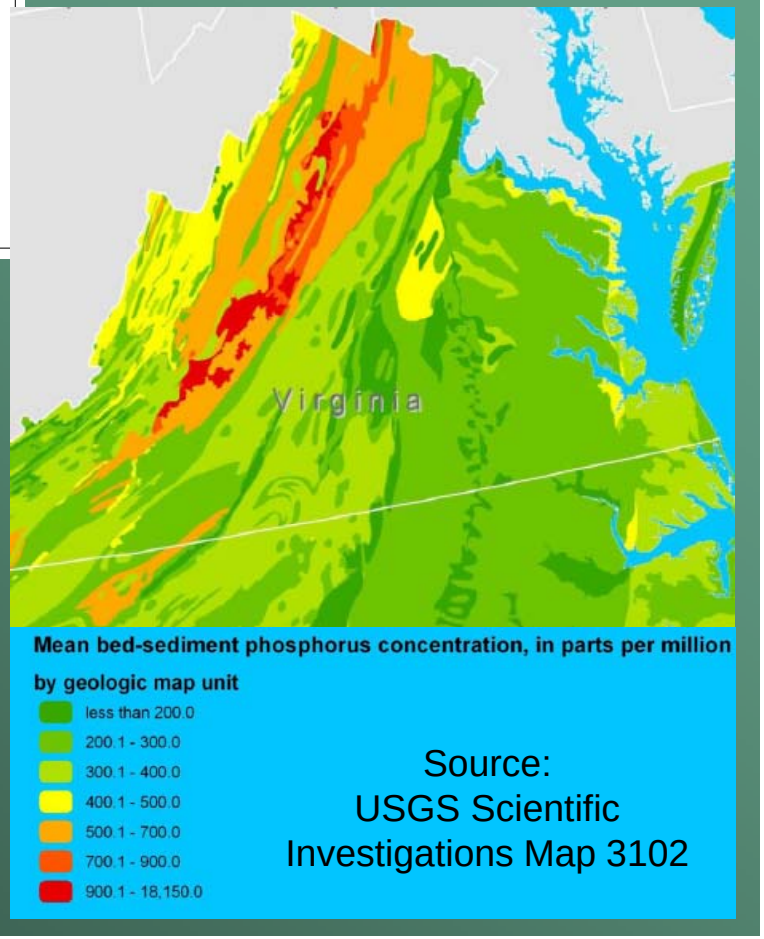




Total Phosphorus







Source:
USGS Scientific Investigations Map 3102

Data Dissemination

- Realtime data and sampling results via Google Map

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Water Quality Samples for Virginia

- Additional information:
  - Annual Water Data Reports: Water Years 2002-09
  - Historical instantaneous flow data for Virginia: Instantaneous Data Archive - IDA
  - National Weather Service Advanced Hydrologic Prediction Service: River forecasts

USGS 01646305 DEAD RUN AT WHANN AVENUE NEAR MCLEAN, VA

Available data for this site | Water-Quality: Field/Lab samples | GO

Fairfax County, Virginia
Hydrologic Unit Code 02070008
Latitude 38°57'34.8", Longitude 77°10'33.5" NAD27
Drainage area 2.05 square miles

Output formats

- Parameter Group Period of Record table
- Inventory of available water-quality data for printing
- Inventory of water-quality data with retrieval
- Tab-separated data, one result per row
- Tab-separated data one sample per row with remark codes combined with values
- Tab-separated data one sample per row with tab-delimiter for remark codes
- Reselect output format

Parameter Code	Count	Begin Date	End Date	Parameter Code Complete Name
00010	26	2008-04-24	2010-04-27	Temperature, water, degrees Celsius
00020	25	2008-04-24	2010-04-27	Temperature, air, degrees Celsius
00025	25	2008-04-24	2010-04-27	Barometric pressure, millimeters of mercury
00061	51	2008-10-22	2009-09-29	Discharge, instantaneous, cubic feet per second
00065	109	2008-04-03	2010-04-27	Gage height, feet
00095	26	2008-04-24	2010-04-27	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00191	26	2008-04-24	2010-04-27	Hydrogen ion, water, unfiltered, calculated, milligrams per liter
00300	26	2008-04-24	2010-04-27	Dissolved oxygen, water, unfiltered, milligrams per liter
00301	24	2008-04-24	2010-04-27	Dissolved oxygen, water, unfiltered, percent of saturation
00400	26	2008-04-24	2010-04-27	pH, water, unfiltered, field, standard units
00600	94	2008-04-24	2010-02-24	Total nitrogen, water, unfiltered, milligrams per liter
00601	94	2008-04-24	2010-02-24	Total nitrogen, suspended sediment, total, milligrams per liter
00602	94	2008-04-24	2010-02-24	Total nitrogen, water, filtered, milligrams per liter
00605	69	2008-08-28	2010-01-25	Organic nitrogen, water, unfiltered, milligrams per liter
00607	69	2008-08-28	2010-01-25	Organic nitrogen, water, filtered, milligrams per liter
00608	94	2008-04-24	2010-02-24	Ammonia, water, filtered, milligrams per liter as nitrogen
00613	94	2008-04-24	2010-02-24	Nitrite, water, filtered, milligrams per liter as nitrogen
00618	94	2008-04-24	2010-02-24	Nitrate, water, filtered, milligrams per liter as nitrogen
00623	94	2008-04-24	2010-02-24	Ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen
00625	94	2008-04-24	2010-02-24	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
00631	94	2008-04-24	2010-02-24	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen

---- Provisional Data Subject to Revision ----
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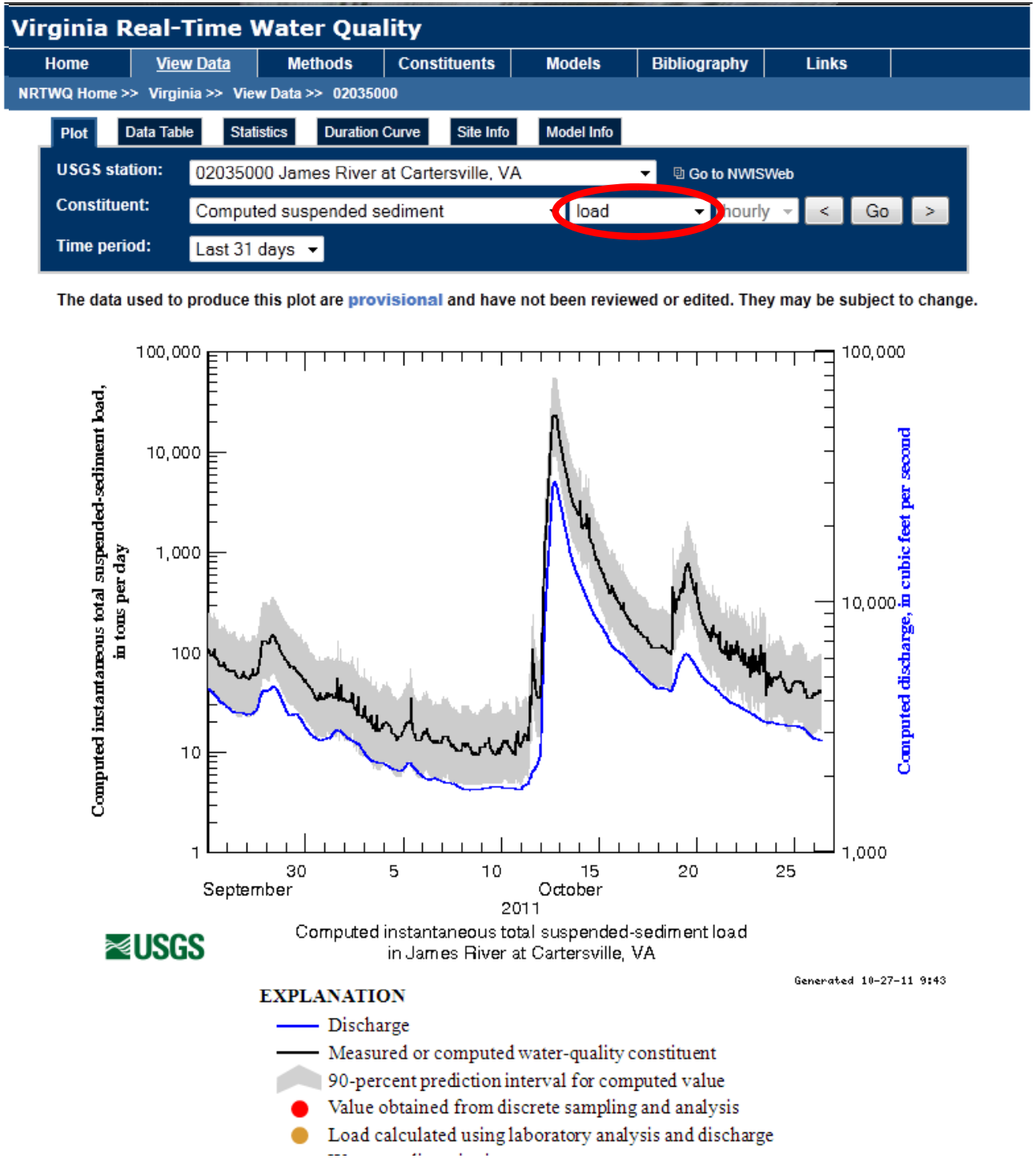
Virginia Real-Time Water Quality
Home
View Data
Methods
Constituents
Models
Bibliography
Links
NRTWQ Home >> Virginia >> View Data >> 02035000
Plot
Data Table
Statistics
Duration Curve
Site Info
Model Info
USGS station:
02035000 James River at Cartersville, VA
Go to NWISWeb
Constituent:
Computed suspended sediment
load
hourly
<
Go
>
Time period:
Last 31 days
The data used to produce this plot are provisional and have not been reviewed or edited. They may be subject to change.
Computed instantaneous total suspended-sediment load, in tons per day
Computed discharge, in cubic feet per second
100,000
10,000
1,000
100
10
1
30
5
10
15
20
25
September
October
2011
USGS
Computed instantaneous total suspended-sediment load
in James River at Cartersville, VA
Generated 10-27-11 9:43
EXPLANATION
Discharge
Measured or computed water-quality constituent
90-percent prediction interval for computed value
Value obtained from discrete sampling and analysis
Load calculated using laboratory analysis and discharge

Further Benefits of Monitoring

- Network will replace existing MS4 monitoring program in Fairfax County
- Generation of load estimates allows verification of allocations and understanding of actual loadings from localities
- Established monitoring infrastructure promotes collaboration
  - Additional USGS research
  - Field trial of HACH Continuous Nutrient Analyzers (w/ VA DEQ)
  - Field trial of S. Korean Continuous Nutrient Analyzers (w/ U. of Seoul)

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Monitoring Costs

- Annual O & M
  - ≈ $75k per station
    - Intensive Data Collection for Load and Trend Analysis
    - Savings may be realized through in-kind contributions
      - Lab analyses
      - Staff to retrieve storm samples
- Start-up
  - Highly variable depending on site-specific considerations
  - Instrumentation
    - ≈ $25k - $30k
  - Installation
    - ≈ $10k +

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Study Highlights

- Intensive Monitoring
  - As many as 500 samples/year across 14 sites
  - Continuous Water Quality at 4 sites (35,000+ measurements of 4+ parameters per year)
  - Use of surrogate relations to generate continuous estimates of SSC and nutrients with greater certainty
- Small Urban/Suburban Watersheds
  - 1-6 square miles
  - Varied watershed characteristics
- Long Term
  - 10+ years of data collection expected
- Many opportunities for add-on research and additional use of data
- Upcoming expansion of network

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USGS
science for a changing world

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http://va.water.usgs.gov/projects/ffx_co_monitoring.htm