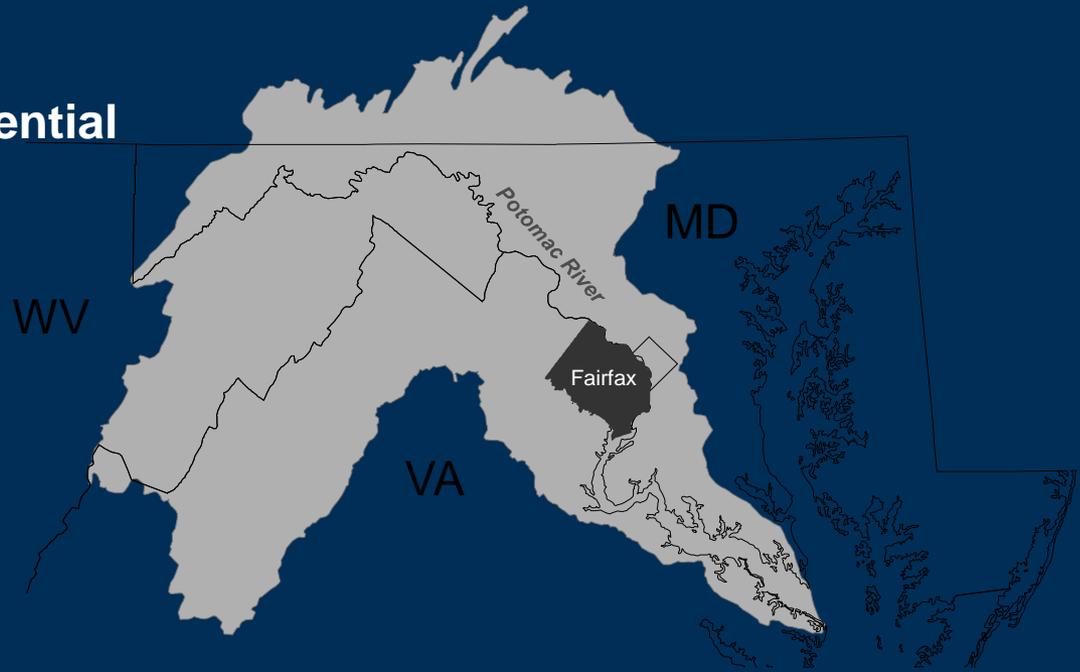# Assessing Watershed Scale Responses to BMP Implementation in Urban Areas

John Jastram

Virginia Water Science Center

Fairfax County, VA

- **Washington, DC Suburbs**
- **Potomac River Watershed**
- **Piedmont and Coastal Plain Provinces**
- **Highly urbanized**
  - **Medium Density Residential**
  - **Population 1 million**
    - **2,500/mi^2**

≋ **USGS**

Watershed Planning in Fairfax County

- **FY 2006 - Funding increase for Stormwater Management**
  - **1¢ per $100 property tax**
  - **Initiated development of Watershed Master Plans**
  - **BMP Project types:**
    - **Riparian plantings/restorations**
    - **Building/retrofitting stormwater management facilities**
    - **LID facilities – rain gardens, bio-retention, infiltration**
    - **Public involvement, education, outreach materials**
    - **Stream stabilizations and restorations**

- **FY 2012 – Additional** 1¢ **per $100 property tax proposed – Approx. $20 million**
  - **Fund implementation of Watershed Plans**

≋ **USGS**

Study Objectives

1. **Generate <u>long-term</u> 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.**

≈USGS

Study Phases

Phase 1	Phase 2

- **Phase 1**
  - **Ongoing**

  1. **Generate <u>long-term</u> monitoring data to describe:**
     - **Current water-quality conditions,**
     - **Trends in water-quality, Nutrient and Sediment Loads and Yields.**

- **Phase 2**
  - **Future**

  2. **Evaluate relations between observed conditions/trends and BMP implementation.**

  3. **Transfer the understanding gained to other less-intensively monitored watersheds.**

≋ **USGS**

Approach

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**

USGS

Approach: Intensive Monitoring

- **Operate four intensive monitoring stations**

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

Approach: BMP Evaluation

- **Assemble BMP implementation dataset for monitored watersheds.**
  - **Fairfax County Staff**
    - **Extent of BMP implementation.**
    - **Types of BMPs installed.**

- **Evaluate relations between water-quality conditions/trends and BMP activities.**
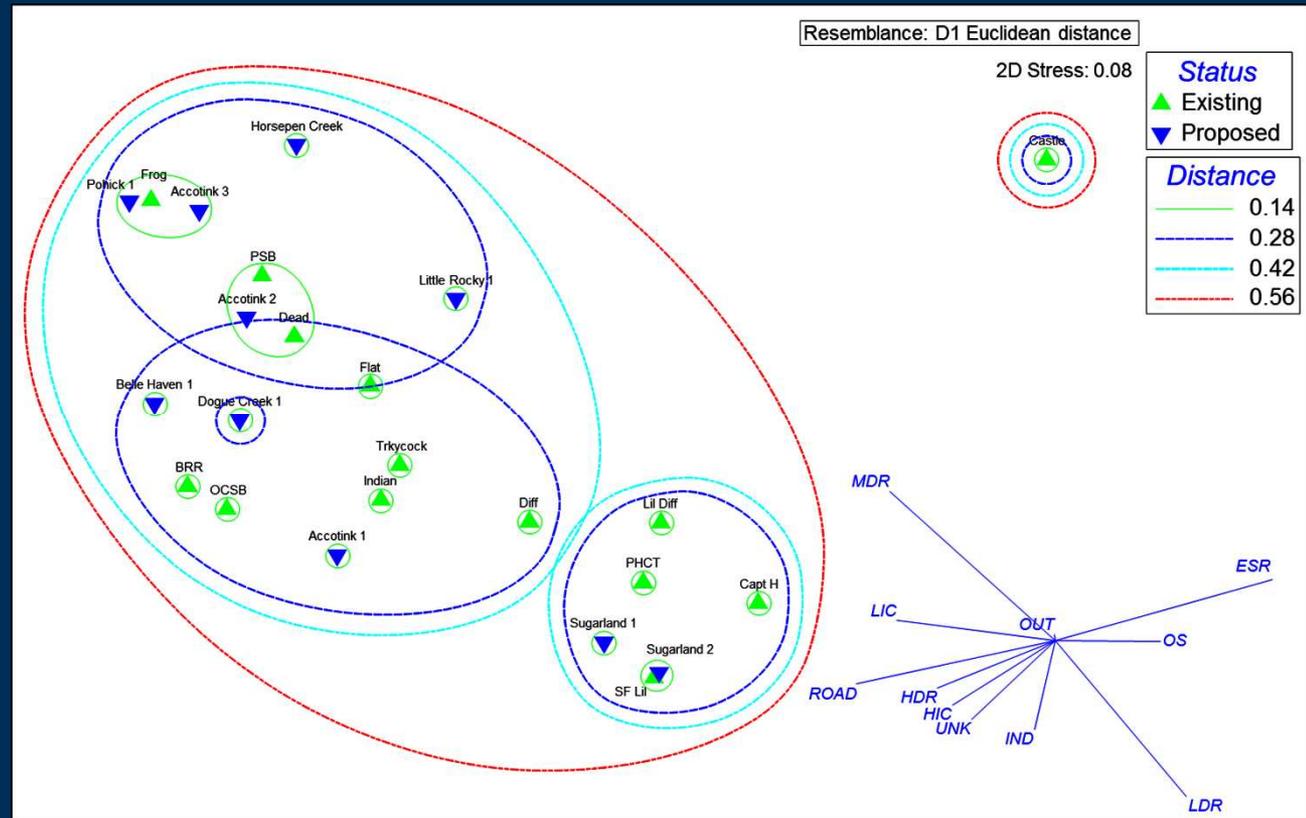 - **Statistical approach to be determined based on types of BMP measures provided.**

≋USGS

Approach: Knowledge Transfer

- **Operate 10 trend monitoring stations**

  - **Partial-record stream gage**
  - **Nutrient & sediment sampling**
    - Scheduled monthly sampling
  - **Annual benthic macroinvertebrate monitoring**

- **Evaluate relations between trend- and intensive monitoring sites**
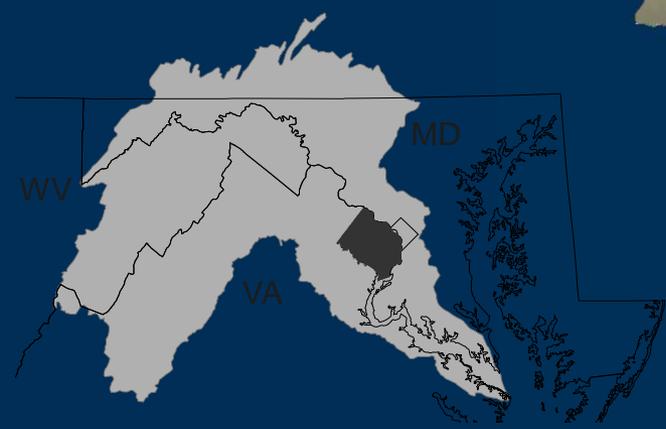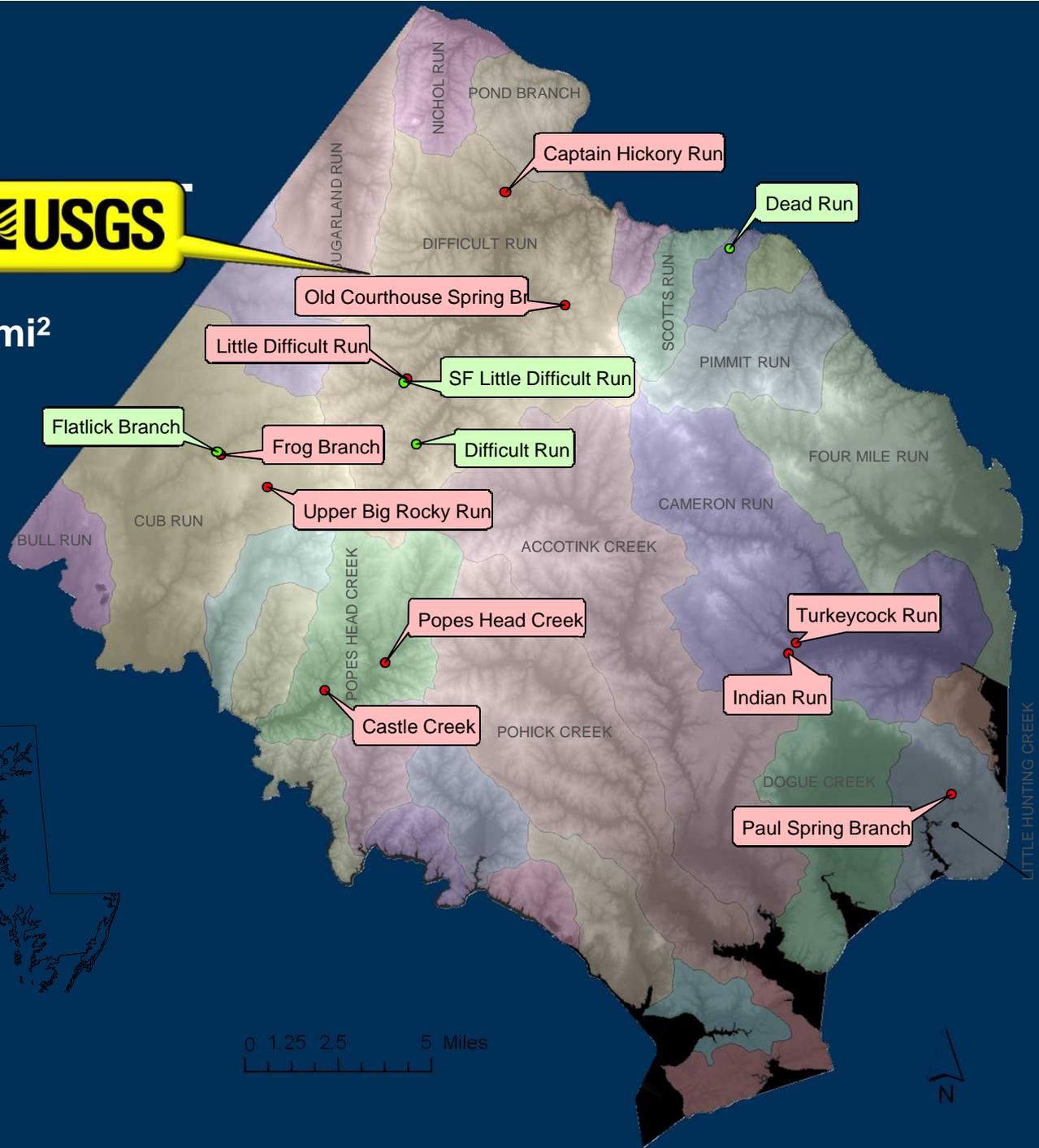
≋USGS

Site Selection

- **Goal: Ensure monitoring network effectively characterizes range of watershed types in Fairfax County**

- **Applied cluster analysis to classify sites based on watershed characteristics.**

- **All basins < 6 mi^2**

Network

USGS

All watersheds < 5 mi²

Captain Hickory Run

Dead Run

Old Courthouse Spring Br

Little Difficult Run

SF Little Difficult Run

Flatlick Branch

Frog Branch

Difficult Run

Upper Big Rocky Run

Popes Head Creek

Turkeycock Run

Indian Run

Castle Creek

Paul Spring Branch

NICHOL RUN
POND BRANCH
SUGARLAND RUN
DIFFICULT RUN
SCOTTS RUN
PIMMIT RUN
FOUR MILE RUN
CUB RUN
BULL RUN
CAMERON RUN
ACCOTINK CREEK
POPES HEAD CREEK
POHICK CREEK
DOGUE CREEK
LITTLE HUNTING CREEK

MD
WV
VA

0 1.25 2.5   5 Miles

N

Instrumentation

- Stage measurement system

- Datalogger/controller with Satellite Transmitter

- Refrigerated Sampler
  - 12 sample capacity

- Continuous Water-Quality Monitor

- Stage measurement orifice

- Sampler Intake

- Staff Plate

≋USGS

Sample Collection

- **Monthly Sampling - All 14 Sites**
  - **Grab samples**
- **Storm Sampling – 4 Intensive Sites**
  - **Refrigerated Autosamplers**
    - **Turbidity Threshold Sampling Algorithm**
  - **Cross-sectionally integrated comparison samples**
- **Analytes**
  - **Suspended Sediment**
  - **Nitrogen and Phosphorus (speciated)**

≋ **USGS**

Reduction of Uncertainty

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

≋ USGS

Turbidity Threshold Sampling

Integrate continuous water-quality monitor with autosampler to optimize sample collection

Algorithm for triggering autosampler (storm samples):

- Turbidity threshold (50 FNU)
- Stage Threshold (site specific)
- Stage Rate of Change (0.1 ft in 15 min)
- Time threshold (1 sample per 30 min period)

**Algorithm is refined as needed to optimize sample collection at each site.**
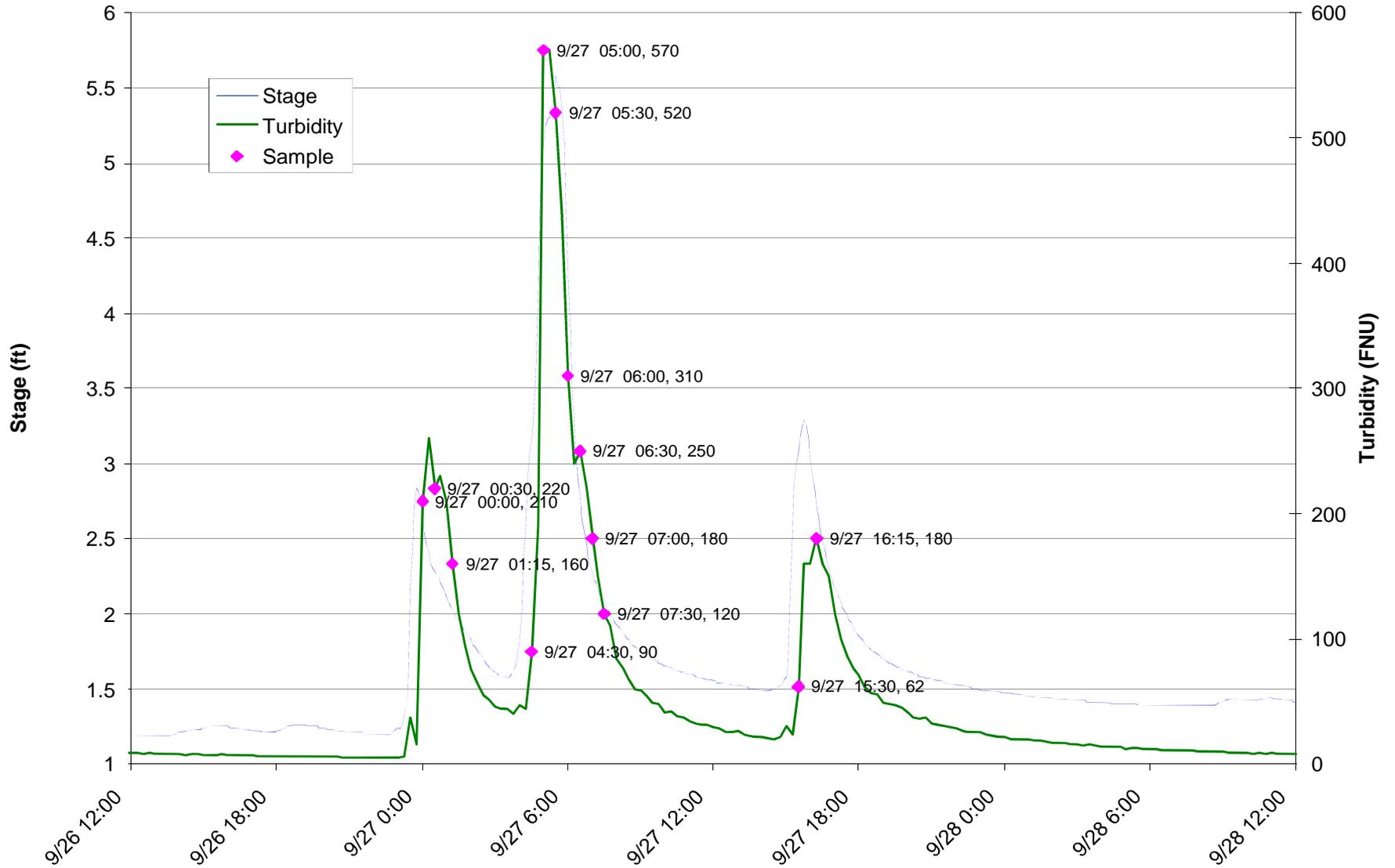
≋ USGS

Dead Run

Stage
Turbidity
Sample

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

Stage (ft)
Turbidity (FNU)

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**

≋USGS

Surrogate Approaches
for continuous concentration and load estimation

- **Estimate WQ Data using WQ Data**
- **Multivariate Regression**
  - **Best Subsets Regression**
- **More accurate and precise than flow based approaches**
  - **USGS Scientific Investigations Report 2009-5165**
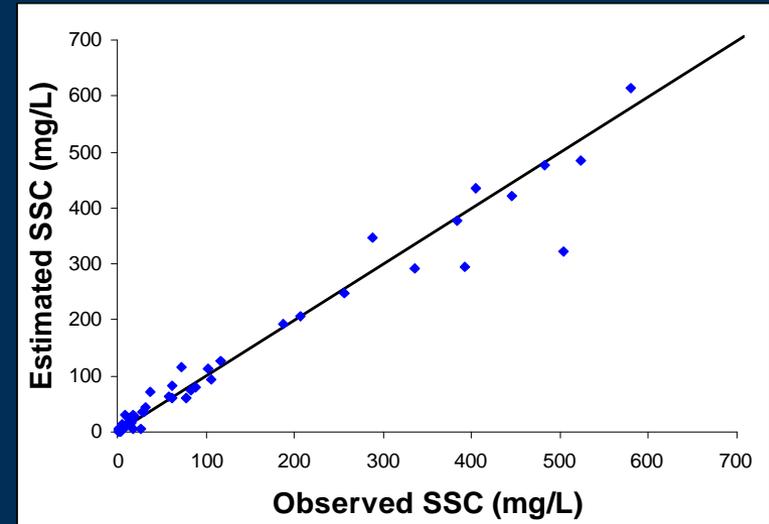
$$SSC = f^{-1}[\hat{\beta}_0 + \hat{\beta}_1 f(turbidity) + \hat{\beta}_j f(x_j)...\hat{\beta}_k f(x_k) + \varepsilon]$$
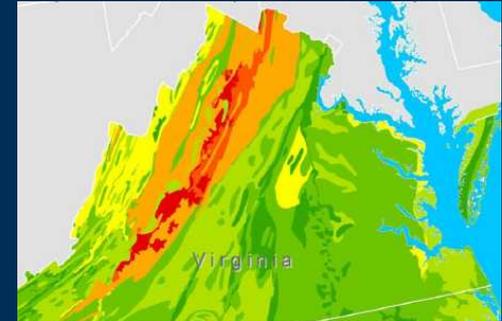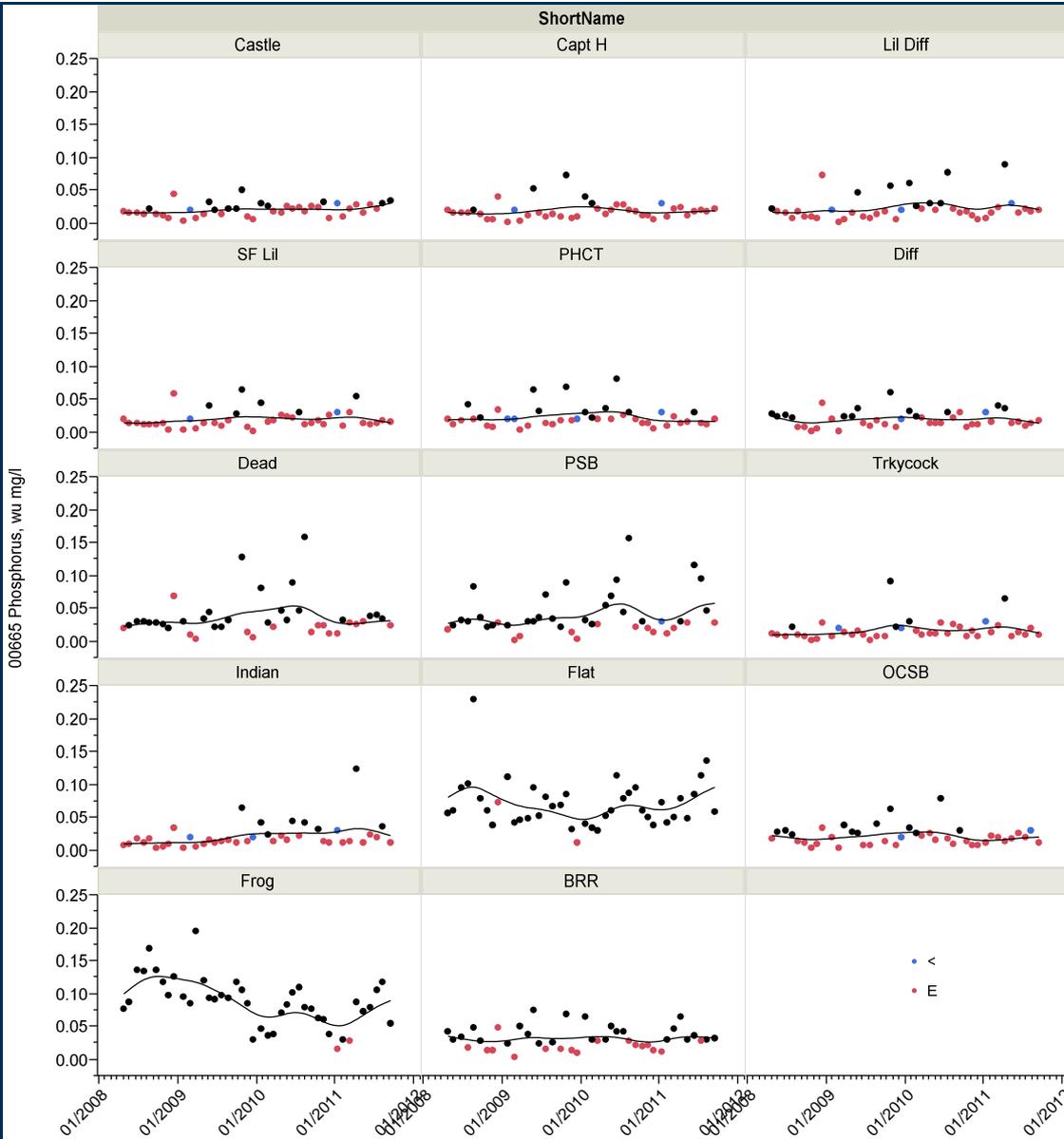
≈USGS

Status

- **Continuous water-quality and streamflow data since Fall 2007**
  - **35,000+ measurements per year of 6-7 parameters**
  - **Added continuous Dissolved Oxygen at 2 sites**

- **Monthly and storm-event sampling since Spring 2008.**
  - **Over 1,300 samples collected.**

- **General characterizations of water quality conditions…**

≈USGS
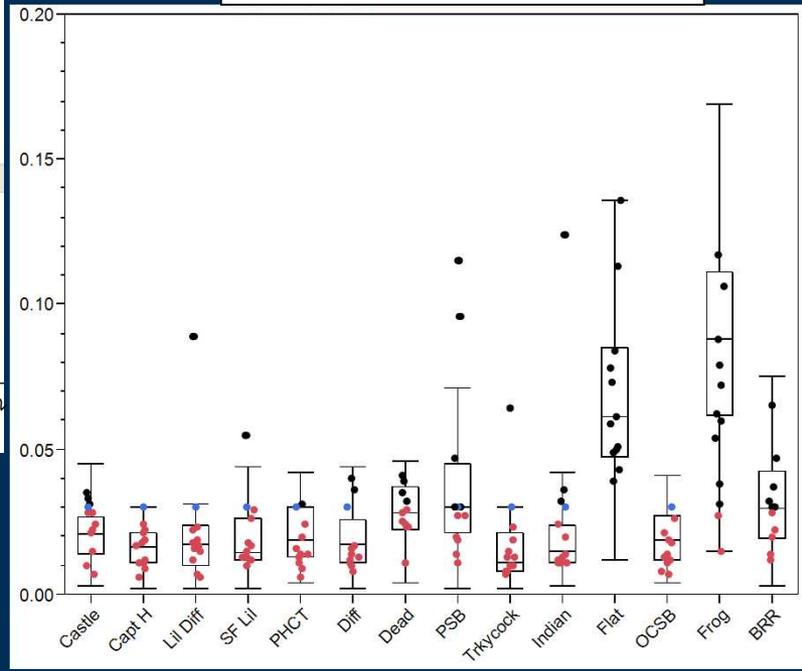
Nitrate
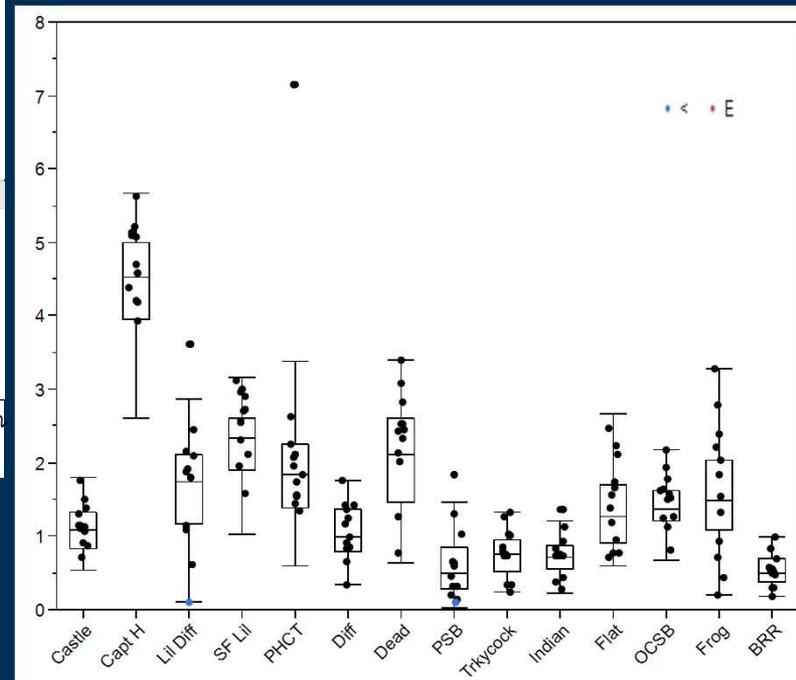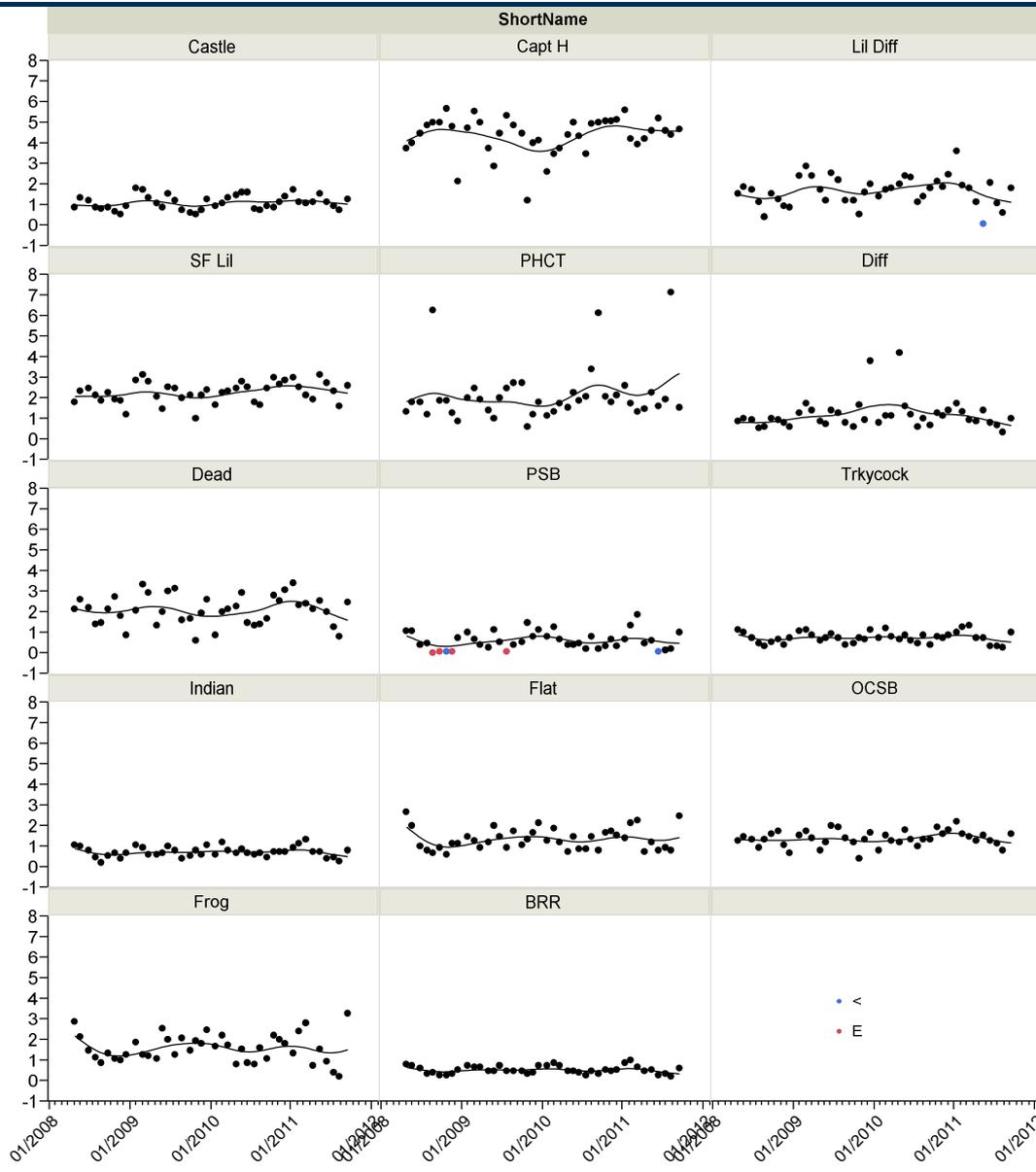
Total Phosphorus
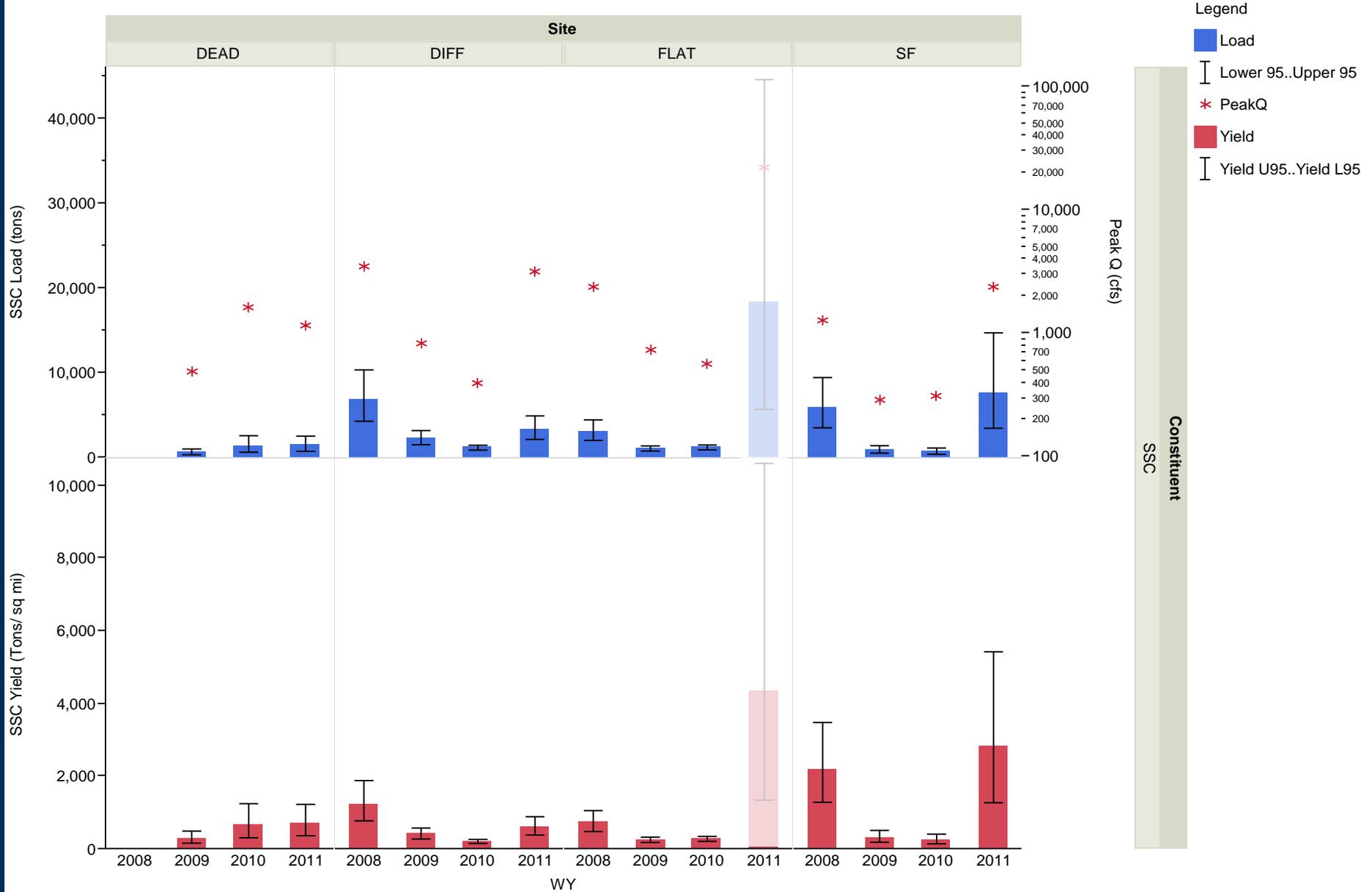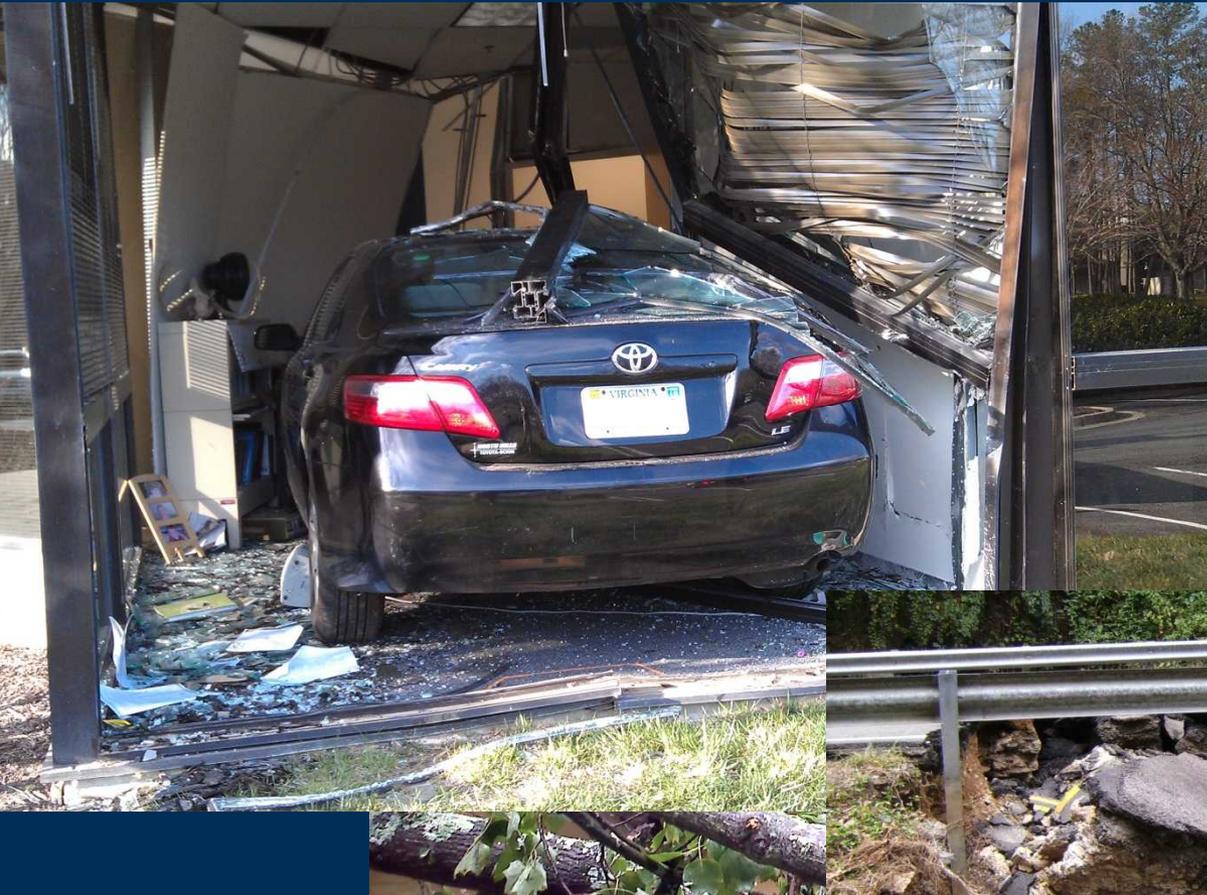
USGS Scientific Investigations Map 3102

Suspended Sediment Loads & Yields

Network Expansion

- **Spring/Summer 2012**
  - **1 Intensive Site**
  - **5 Trend Sites**
- **Improve spatial coverage**
- **Small basins with high implementation rates**

≋ USGS

Study Challenges

Near misses…
Direct Hits…

![USGS logo]

Looking forward…

- **5-year Agreement Renewal**
  - **Expected this summer**
- **Network Expansion**
  - **Expected this Spring/Early Summer**
- **BMP Data**
  - **County to provide implementation data to support analysis of BMP effects.**
- **Continued collaboration with NRP, Industry Academia, etc.**

≈USGS

USGS
science for a changing world

John Jastram

804-261-2648

jdjastra@usgs.gov

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